IOWA CONSERVATION COMMISSION
FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

MAN-MADE LAKES FISHERIES INVESTIGATIONS

PROJECT NO. F-88-R-2

IOWA

CONSERVATION COMMISSION

Study No. 601-2: Evaluation of the 14-Inch Size Limit on Largemouth Bass at Big Creek Lake

Study No. 701-4: 0-Age Fish Production at Lake Rathbun

Study No. 702-3: Effects of Flood Water Management and Fish Species Introductions on Fish Populations in Large Reservoirs

PERIOD COVERED 1 JULY, 74 - 30 JUNE, 75

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE:	Iowa	NAME:	Evaluation of the 14-Inch Size Limit on Largemouth Bass at Big Creek Lake
PROJECT NO.:	F-88-R-2		
STUDY NO.:	601-2	TITLE:	Vital statistics of populations of largemouth bass, bluegill and crappie under a 14-inch largemouth bass minimum size limit
JOB NO.:	1		

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *Periodic sampling of adult fish populations were carried out with pound nets, experimental gill nets and a 230 volt A.C. boom shocker. The Fish Management Branch carried out an expandable sport fishery survey. Net gear accounted for 1,866 fish of which 29% were black crappie, 26% white sucker, 15% green sunfish, 7% black bullhead and 6% bluegill. Largemouth bass comprised only 2% and walleye increased to 5%. FND between pound and experimental gill nets were different and largemouth bass were not caught by either net gear efficiently. Body lengths and weights were collected from 100 bass of each year class during spring sampling. Autumn sampling accounted for lengths and weights of an additional 228 bass. Age I bass captured averaged 163 mm in the spring and 183 mm in the fall while age II bass averaged 309 mm and 315 mm for the same periods. Legal sized bass accounted for 7% of the spring sample and 3% of the autumn sample. A Schnabel population estimate yielded 42,791 bass for a density of 110 bass/ha or 20.7 kg/ha. Estimated average back calculated total lengths at each annulus were 174 mm and 315 mm for ages I and II. Differences in the slope values between length-weight relationships of age I and II bass were significant for spring and autumn samples while there were no seasonal differences within age groups. Native fish dominated the sport fishery, however stocked species increased substantially. Green sunfish provided the greatest yeild in number and weight, 13,570 fish, followed by bullhead 4,554 fish, bluegill, 3,007 fish, crappie, 2,995 fish and largemouth bass, 1,738 fish. Anglers caught an estimated 131 marked bass from the 1,155 at large for an exploitation rate of 11%. Fishermen also caught and released over 100,000 sublegal bass at a rate of .85 bass/hr. A largemouth bass survival of 44% was calculated for 1973 and total annual mortality was estimated at 56%. Bluegill and crappie growth was good compared to fish from older established waters.*

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Date Prepared: 1 June, 1975

Approved by: James Mayhew
Fisheries Research Supervisor

STUDY OBJECTIVE

To evaluate the effectiveness of a 14-inch length limit to regulate the harvest of largemouth bass at Big Creek Lake and measure the impact of increasing the size of the largemouth bass population on the abundance of bluegill and crappie.

JOB 1 OBJECTIVE

To evaluate the effectiveness of a 14-inch minimum length limit in regulating sport fishery exploitation and to describe the vital statistics of largemouth bass, bluegill and crappie at Big Creek Lake.

INTRODUCTION

Evaluation of a 14-inch minimum size limit on largemouth bass will be continued at Big Creek Lake. Study will be performed in the same manner as the previous annual report.

STUDY BACKGROUND

Species native to Big Creek Lake prior to impoundment included smallmouth bass, largemouth bass, green sunfish, black bullhead, river carpsucker, white sucker, creek chub, carp, common shiner, and several species of *Notropis*. In addition, largemouth bass, bluegill, black crappie, walleye, muskellunge, channel catfish and blue catfish were planted in 1972 and 1973.

During 1973 fish populations were sampled with pound nets, experimental gill nets, and seine net hauls to determine relative abundance, species composition, size structure, and some vital statistics of several species. Electrofishing was used to capture largemouth bass for tagging and numerical estimation of the population size. The Fish Management Branch of the Iowa Conservation Commission conducted a creel survey from which exploitation, harvest and angler success was estimated.

Fish species native to Big Creek prior to impoundment, except smallmouth bass, dominated the combined catch of 9,531 fish with the pound and experimental gill nets. Green sunfish was the most abundant species caught with 3,542 fish or 38% of the total, followed by black bullhead, 1,769 or 19%; carp, 1,103 or 12%; and largemouth bass, 800 or 9%.

During the season 1,037 largemouth bass of the 1972 year class (age I) were captured. They ranged from 170 (7 in) to 400 mm (16 in) in total length and weighed 67 g (.05 lbs) to 1,247 g (2.8 lbs). Less than 1% (4 fish) were legal length. A Schnabel population estimate yielded 28,204 (95% confidence intervals were 20,955-43,122) largemouth bass $\geq$ 170 mm (7 in) for a population density of 80 bass/ha (73/a), or a standing stock of nearly 20 kg/ha (18 lbs/a).

Big Creek Lake sport fishery survey data indicated the green sunfish was caught most frequently, 30 fish/ha (12 fish/a) or 3.2 kg/ha (2.9 lbs/a) and the black bullhead contributed the greatest yield, 5.8 kg/ha (5.2 lbs/a) or 15 fish/ha (6 fish/a). All other species caught comprised < 1 fish/ha (< .5 fish/a) or < .1 kg/ha.

Few largemouth bass were creeled although many were caught. Exploitation of largemouth bass was nearly immeasurable while 23,566 bass were caught and released for a catch rate of .77 bass/hour.

WATER CHEMISTRY PARAMETERS

Eleven water chemistry parameters were monitored monthly since impoundment. All water quality components determined in 1974 were similar to those found in 1973.

Documentation of dissolved oxygen (DO), temperature, and basin slope has provided evidence of two morphologically distinct regions. Big Creek Lake stratified chemically and thermally at the deeper lower region each year about late May to September. Serious dissolved oxygen depletion (less than 3 mg/l) below 6 m (20 ft) occurred only during July. Severe stratification was not recorded for the shallower upper region but low amounts of DO were found below 6 m (20 ft) during July and August.

METHODS AND PROCEDURES

Sampling of fish populations was continued in the same manner as outlined in the previous annual report. Only new methods or procedures are described in this section.

After capture, the procedure of handling fish was as follows: largemouth bass, bluegill and black crappie were measured in total length (TL), weighed and scales collected from a sample of about 50 fish. Most bass 200+ mm were tagged with a Floy anchor tag, the right pelvic fin clipped to determine tag loss and the fish released. For population and exploitation estimates bass 200+ mm that were not tagged had the left pelvic fin excised while smaller bass had the bottom lobe of the caudal fin clipped. Other species caught by nets were enumerated, weighed and released.

A numerical population estimate of largemouth bass $\geq$ 200 mm (age II) and < 200 mm (age I) was calculated by the Schnabel multiple census mark and recapture technique (Ricker, 1958).

In the spring of 1974 Big Creek Lake was divided into two distinct regions and population estimates of bass 200+ mm made in each, the two estimates were later combined. An estimate of bass < 200 mm was made of the entire reservoir.

The Fish Management Branch of the Iowa Conservation Commission conducted an expandable creel survey at Big Creek Lake from 15 April to 1 September, 1973 and 1 April to 1 September, 1974. In 1974 the creel survey clerk was requested to maintain a daily record of all largemouth bass harvested (including sublegal bass), their total length, area caught and to denote any fin clip or tag numbers. Additional data obtained through the survey were used to estimate the harvest of various fish species.

Exploitation was calculated from the proportion of estimated marked fish creeled by fishermen compared to the number of marked fish at large (Ricker, 1958).

Vital statistics of bass, bluegill and crappie were described by standard fisheries technique.

FINDINGS

SAMPLE CATCH STATISTICS

Indigenous fish comprised the greatest portion of the 1974 net gear catch of 6,453 fish, although the abundance of stocked species increased over the previous year (Table 1). Black crappie was the most abundant fish, 1,866 (29%) followed in order of descending abundance by white sucker, 1,651 (26%), green sunfish, 981 (15%), black bullhead, 481 (7%), bluegill, 376 (6%). Largemouth bass catch declined to 103 (2%) while walleye increased to 325 (5%).

Continued dominance by indigenous fish species in the 1974 catch of 1,567 kg (3,451 lbs) was recorded, however, white sucker, 696 kg (1,533 lbs, 44%), replaced carp, 245 kg (540 lbs, 16%), as the most important fish by weight (Table 2). Black crappie was third, 181 kg (399 lbs, 12%), followed by black bullhead, 138 kg (304 lbs, 9%), and green sunfish, 91 kg (200 lbs, 6%). Introduced species including walleye, bluegill and channel catfish were more numerous during the second year although largemouth bass were less common. Blue catfish and muskellunge were not captured.

Unlike the previous year FND between pound and experimental gill net catches for most species were not very similar (Tables 2 and 3). Black crappie was the most abundant fish caught, 22 FND by pound net and 8 FND by experimental gill net. The white sucker, second in numerical occurrence, was caught at 26 FND by experimental gill net and 14 FND by pound net. The experimental gill net was the most effective tool for the capture of walleye, 10 FND as opposed to 2 FND by pound net. Bluegill, carp and green sunfish were caught at higher rates by pound nets while black bullhead was caught more effectively by experimental gill net. Largemouth bass and channel catfish were caught by both gear at similar rates.

Table 1. Species composition of the combined catch in pound and experimental gill nets at Big Creek Lake, April through October, 1973 and 1974.

Species	Number		Percent number		Weight (kg)		Percent weight		Mean weight (kg)	
	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974
Carp	1,103	198	11.8	3.1	1,053.9	244.6	47.7	15.6	.95	1.24
G sunfish	3,542	981	37.9	15.2	247.9	90.9	11.2	5.8	.07	.09
B bullhead	1,769	481	18.9	7.4	300.9	138.0	13.6	8.8	.17	.29
Lm bass	800	103	8.6	1.6	116.0	35.1	5.2	2.2	.14	.34
W sucker	1,080	1,651	11.5	25.6	360.3	695.6	16.3	44.4	.33	.42
B crappie	149	1,866	1.6	28.9	9.7	180.5	.4	11.5	.06	.10
Bluegill	62	376	.7	5.8	7.2	43.3	.3	2.8	.12	.12
R carpsucker	99	6	1.1	< .1	39.8	4.6	1.8	.3	.40	.76
C catfish	26	118	.3	1.8	3.8	28.5	.2	1.8	.14	.24
Walleye	148	325	1.6	5.0	18.2	67.0	.8	4.3	.12	.21
Notropis sp.[a]	433	330	4.6	5.1	36.4	36.5	1.6	2.3	.08	.11
Sm bass	7		.1		.3		< .1		.01	
B buffalo		2		< .1		.6		< .1		.30
Miscellaneous[b]	133	1	1.4	< .1	16.8	< .1	.8	< .1	.39	.04
Total	9,351	6,453			2,211.2	1,567.0				

[a]Most were *N. cornutus*.

[b]Includes creek chub, madtom (*Noturus sp.*), yellow perch (*Perca flavescens*), and stone roller (*Campostoma anomalum*).

Table 2. Fish per net day (FND) and weight (kg) of gill net catches at Big Creek Lake, 1974.

	Sampling period															
	April		May		June		July		August		September		October		Mean	
	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND
Carp			.3	< .1	2.7	4.2	.3	.2			4.0	6.0			.9	1.3
B crappie	2.7	.2	10.3	< .4	17.7	.6	6.0	.3	4.0	.2	7.5	.6	4.7	.3	7.6	.3
B bull-head	17.7	11.2	7.7	1.8	4.3	1.2	9.0	2.2	1.3	.4	1.5	.4	1.3	.3	6.4	1.6
Lm bass	2.3	.5	1.7	.3	2.7	.6	1.0	.3	1.3	.4			.3	< .1	1.4	.3
W sucker	22.0	9.2	36.3	19.2	23.3	9.1	17.0	6.8	23.3	8.7	32.5	13.2	26.7	12.5	25.6	11.2
Walleye	26.7	4.7	12.0	2.2	7.3	1.5	5.0	1.1	6.3	1.5	3.5	.9	4.0	1.2	9.6	1.9
C catfish	.7	.2	.7	.2	3.0	.8	2.0	.7	.3	.1	3.5	1.4	2.0	.5	1.6	.5
Bluegill	1.0	< .1			1.3	.1					2.5	.3	.3	< .1	.6	< .1
G sunfish	28.0	2.7	13.7	1.1	7.0	.5	6.0	.4	3.3	.1	2.0	.2	2.3	< .1	9.2	.7
Notropis *sp.*	29.3	3.3	24.7	1.7	9.0	1.2	9.3	1.2	10.0	1.1			8.0	.8	13.6	1.4
C chub	1.4	.2	.7	< .1	.3	< .1									.4	< .1
Noturus *sp.*					.3	.1									< .1	< .1

Table 3. Fish per net day (FND) and weight (kg) of pound net catches at Big Creek Lake, 1974.

	Sampling period															
	April		May		June		July		August		September		October		Mean	
	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND
Carp	6.3	11.1	1.2	1.5	2.3	1.9	1.4	2.0	2.6	2.9	1.1	1.2	.8	1.3	2.3	2.8
G sunfish	28.0	2.5	21.2	2.3	14.7	1.5	4.0	.3	2.1	.2	1.8	.1	27.3	3.2	11.3	.6
B bull- head	11.7	3.3	8.6	2.8	2.0	.4	4.9	1.5	.8	.2	2.2	.6	< .1	< .1	4.5	1.3
Lm bass	2.8	1.2	1.8	.7	1.3	.4	.4	.1	< .1	< .1			< .2	.1	.9	.4
W sucker	17.2	9.8	21.7	10.3	26.4	13.2	3.3	1.3	7.2	3.2	15.0	6.2	12.0	7.4	14.4	6.0
B crappie	8.1	2.2	14.1	1.9	46.0	3.0	33.8	1.7	8.8	1.4	23.9	1.7	21.7	2.4	21.7	2.2
Bluegill	9.0	1.1	3.4	.5	4.9	4.7	6.8	.6	1.2	.1	4.8	.6	15.4	1.8	4.6	.5
R carp- sucker					.3	.2	.2	.2							< .1	< .1
C catfish	1.4	.2	.7	.2	.9	< .1	2.0	.5	.7	.2	1.4	.3	.4	.5	1.1	.2
Walleye	1.2	.2	3.8	.7	2.0	.4	1.7	.4	1.1	.2	1.0	.3	5.1	1.2	1.8	.4
C shiner	1.7	.2	1.3	.3	1.3	.1					.8	< .1	< .1	< .1	.7	.1
C chub	.5	< .1	.2	< .1											.1	< .1
B buffalo									.2	< .1					< .1	< .1

SIZE STRUCTURE OF LARGEMOUTH BASS

Body lengths, weights and scales were collected from 100 bass of each year class, during spring sampling, of which 50 were randomly selected for age and growth analysis. Autumn sampling accounted for lengths and weights of an additional 228 largemouth bass. Age I bass captured in the spring ranged from 129 (5.1 in) to 205 mm (8.1 in) TL ($\bar{X}$ = 163 mm, ± 19) and weighed 23 (.05 lbs) to 100 g (.22 lbs) ($\bar{X}$ = 51 g, ± 19) while age II bass ranged from 247 (9.7 in) to 364 mm (14.3 in) TL ($\bar{X}$ = 309 mm, ± 28) and weighed from 186 (.41 lbs) to 997 g (2.2 lbs) ($\bar{X}$ = 439 g, ± 165). About 7% of the bass sampled were of legal length (14 inches or 356 mm) of which 12% were age II bass. Age I bass captured in the autumn ranged from 139 (5.5 in) to 238 mm (9.4 in) ($\bar{X}$ = 183 mm, ± 19) and weighed from 30 (.07 lbs) to 150 g (.33 lbs) ($\bar{X}$ = 81 g, ± 28) while age II bass ranged from 250 (9.9 in) to 403 mm (15.9 in) ($\bar{X}$ = 315 mm, ± 27) and weighed from 230 (.55 lbs) to 1,320 g (2.9 lbs) ($\bar{X}$ = 445 g, ± 184). Legal sized bass accounted for 3% of the autumn sample (Table 4). 0-age bass caught in the autumn had a mean TL of 99 mm (3.9 in), ± 14 and a mean weight of 12 g (.03 lbs), ± 4.

ESTIMATED POPULATION SIZE

A spring population estimate of 42,791 largemouth bass was the result of combining estimates of the two age groups (Table 5). The capture of 1,090 age I bass and recapture of 17 yielded an estimate of 28,597 fish while the capture of 1,263 age II bass and recapture of 48 provided an estimate of 13,194 fish.

Largemouth bass standing stock was estimated at 20.7 kg/ha (17.3 lbs/a), calculated from the combined population estimates of the two age classes and mean weights. A numerical density of 110 bass/ha (46 bass/a) was computed.

Bias of sampling error, due to unequal recapture ratios in each respective area, was not statistically significant. After arcsin transformation of recapture proportions (Snedecor and Cochran, 1967) of age I and II fish, a one way classification of analysis of variance verified the hypothesis that there was no difference in proportions at the .05 level of significance. As a result of these findings, population estimates were calculated by mark and recaptures of fish from the entire reservoir.

GROWTH

Body-scale relationship for largemouth bass was described by the equation

$$TL = 10.81 + 2.46\ ScR$$

This relationship was used to back-calculate total lengths at each annulus by age class (Table 6). Estimated average body lengths at age I and II was 174 mm (6.8 in) and 315 mm (12.4 in), respectively. Mean increments were 191 (7.5 in) and 124 mm (4.9 in) for the 1972 year calss and 153 mm (6 in) for the 1973 year class.

Table 4. Length-frequency distribution of 146 age I bass (130-239 mm) and 83 age II bass (250-380+ mm) captured in the fall at Big Creek Lake, 1974.

Length(mm)	Number	Percent
130-139	1	.43
140-149	3	1.31
150-159	8	3.49
160-169	20	8.73
170-179	32	13.97
180-189	31	13.53
190-199	17	7.42
200-209	17	7.42
210-219	12	5.24
220-229	4	1.74
230-239	1	.43
240-249		
250-259	1	.43
260-269	2	.87
270-279	2	.87
280-289	11	4.80
290-299	15	6.55
300-309	7	3.05
310-319	13	5.67
320-329	12	5.24
330-339	7	3.05
340-349	4	1.74
350-359	7	3.05
360-369	1	.43
370-379		
380+	1	.43

Table 5. Schnabel population estimates and standing stock of largemouth bass in Big Creek Lake from catches by pound net, experimental gill net and electrofishing.

Sample period	Size range and age	Catch (C)	Marked (M)	Recaptured (R)	Population number (N)	95% Confidence interval	Density bass/ha	Standing stock (kg/ha)
April to October, 1973	≥ 170 mm (I)	1,619	1,334	32	28,204	20,955-43,122	80	19.76
April to May, 1974	< 200 mm (I)	1,090	1,053	17	28,597	19,383-54,509	81	4.16
	≥ 200 mm (II)	1,263	1,144	48	13,194	10,284-18,399	38	16.50
	Total	2,353	2,197	65	42,791	29,206-76,382	110	20.65

Table 6. Average estimated total length (mm) at each annulus for largemouth bass, Big Creek Lake, 1974.

		Age	
Year class	Number	I	II
1973	39	153	
1972	49	191	315
Grand mean		174	315

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTORS

Length-weight relationships of bass sampled in the spring were

Age I $\log_{10}W = -4.99 + 3.02 \log_{10}TL$

Age II $\log_{10}W = -7.52 + 4.09 \log_{10}TL$

and the autumn collection was

Age I $\log_{10}W = -5.08 + 3.08 \log_{10}TL$

Age II $\log_{10}W = -6.68 + 3.73 \log_{10}TL$

K-factors for bass captured early in the season were 1.12 ($\pm$ .03) and 1.46 ($\pm$ .14) for ages I and II, respectively, while K-factors for the fall samples were 1.26 ($\pm$ .12) and 1.36 ($\pm$ .16) for the same ages.

Differences in the slope values between age I and II bass were significant for spring and autumn samples while there were no seasonal differences within age groups (Table 7). A statistical comparison of the b-values in a t-distribution rejected the null hypothesis in the first test revealing the two regression lines differed significantly. A second statistical comparison was conducted to evaluate the hypothesis that coefficients of condition were the same in autumn as they were in spring for each age class. The null hypothesis was rejected, and seasonal conditions were different within each age class. Condition was higher for age class I bass in the fall whereas condition was higher for age class II bass in the spring.

Table 7. Statistical comparison of length-weight relationships of largemouth bass captured in spring and autumn, 1974.

	Age	b	95% C.I.	S_b	t
Spring					
	I	3.01	± .297	.138	2.160
	II	4.20	± .304	.139	2.179
Autumn					
	I	3.08	± .274	.137	2.00
	II	3.73	± .270	.135	2.00

ANGLER CATCH AND EXPLOITATION

Big Creek Lake sport fishery survey data from 15 April to 30 August were expanded to determine total harvest, catch rates, angler pressure, and exploitation rate of largemouth bass (Table 8). In that period it was estimated 75,261 fishermen had fished 118,496 hours and caught 27,960 fish at .24 fish/hour.

Table 8. Estimated angler harvest of various fish species from Big Creek Lake, 1974.

Species	Number	Weight (kg)	Catch rate fish/hr	Percent weight
G sunfish	13,570	1,415.8	.11	24.5
Bluegill	3,007	477.3	.02	8.3
Lm bass	1,738	1,300.8	.02	22.5
Sm bass	65	39.0	< .01	.7
B crappie	2,995	421.2	.02	7.3
Walleye	404	117.4	< .01	2.0
B bullhead	4,554	1,342.6	.04	23.3
C catfish	164	55.8	< .01	1.0
Carp	58	124.8	< .01	2.2
W sucker	627	391.3	.01	6.8
C shiner	747	88.1	.01	1.5

Native fish continued to dominate the fishery during the second season, but the contribution by stocked species increased substantially. Green sunfish provided the greatest yield in number and weight, 13,570 fish weighing 1,416 kg (3 119 lbs). Black bullhead was second in both categories, 4,554 fish weighing 1,343 kg (2,958 lbs). Bluegill ranked third in numerical importance, 3,007 fish, followed by black crappie, 2,995 fish, and largemouth bass, 1,738 fish.

Bass exploitation was considerably higher during the second angling season. Over 11% of all the anglers that had fished Big Creek Lake were contacted in the survey. These fishermen harvested 199 largemouth bass (legal and sublegal) of which 15 were marked, fin clipped or tagged, prior to the fishing season. From this figure an estimated 131 marked bass were caught from the 1,155 at large yielding an exploitation rate of 11.34%. A second rate of exploitation of 13.17% was calculated from the estimates of age II population size (13,194) and bass harvest (1,738).

Overharvest of bass was prevented for the second season despite the fact some sublegal bass were taken. Anglers caught and released an estimated 100,722 sublegal bass at a rate of .85 fish/hour. Sublegal bass accounted for 44% of the fish in the fishery. Most of these fish were within 13 mm (1/2 in) of the minimum length of 356 mm (14 in), while 10% of the bass observed were < 343 mm (13.5 in). The smallest was 165 mm (6.5 in).

SURVIVAL AND ANNUAL MORTALITY

A largemouth bass annual survival of 43.88% was calculated for 1973 from the return of tagged bass marked both years (Ricker, 1958). Thirty-seven tags were voluntarily returned by anglers. Of these, 21 came from the 1,334 bass tagged in 1973 and 16 from 446 tagged in 1974. The survival rate (S) was calculated from the function as

$$S = \frac{(21)(446)}{(1,334)(16)} = .4388 \times 100 = 43.88\%$$

Captured fin clipped bass were not included in the computations since anglers voluntarily returning tags could not recognize this mark.

Annual mortality was estimated at 56.12% for 1973.

AGE AND GROWTH

Bluegill Body measurements and scales were taken from 48 bluegills during 1974. They ranged in length from 132 (5.2 in) to 226 mm (8.9 in) and weights of 45 (.1 lbs) to 272 g (.6 lbs). Length-weight relationship was represented by the equation

$$\log_{10}W = -5.32 + 3.28 \log_{10}TL$$

K-factors ranged from 2.04 to 2.36 while the mean was 2.19.

Body-scale relationship was represented by the function

$$TL = .15 + 1.75\ ScR$$

This relationship was used to estimate total length at annulus for each age group (Table 9). Mean total lengths at each annulus were 88 (3.5 in), 158 (6.2 in), 178 (7 in), 208 (8.2 in), and 224 mm (8.8 in) for ages I through V.

Table 9. Estimated total length (mm) at each annulus for bluegill, Big Creek Lake, 1974.

		Age				
Year class	Number	I	II	III	IV	V
1973	4	81				
1972	43	28	167			
1969	1	96	149	178	208	224
Grand average		88	158	178	208	224

Black Crappie Lengths, weights and scales were taken from 48 black crappie during 1974. They ranged in length from 120 (4.7 in) to 267 mm (10.5 in) and weights of 22 (.05 lbs) to 336 g (.74 lbs). Length-weight relationship was described by the equation

$$\log_{10}W = -5.41 + 3.24 \log_{10}TL$$

K-factors ranged from 1.17 to 1.67 with a mean of 1.41.

Body-scale relationship was represented by the equation

$$TL = 3.99 + 1.91\ ScR$$

This relationship was used to estimate total length at annulus for each age group (Table 10). Mean total lengths at each annulus were 117 (4.6 in), 153 (6.0 in), 215 (8.5 in), 237 (9.3 in), and 255 mm (10 in) for ages I through V.

Table 10. Estimated total length (mm) at each annulus for black crappie, Big Creek Lake, 1974.

		Age				
Year class	Number	I	II	III	IV	V
1973	39	118				
1972	5	106	150			
1971	1	147	170	274		
1970	2	122	152	186	239	
1969	1	88	157	191	234	255
Grand average		116	157	217	237	255

DISCUSSION OF FINDINGS

Relative abundance of fish stocked in 1972 and 1973 increased threefold in in total net catches from 1973 to 1974. In 1973 only 13% of the 9,351 fish caught that year were stocked species while in 1974 they contributed 49% of the total catch of 6,453 fish.

Black crappie attained the most dramatic increase in relative abundance of all stocked fish. During 1973 net gear captured 149 black crappie while the following year 1,866 fish were captured. Adult crappie were introduced during 1973. During 1974, age I crappie, progeny of adults stocked in 1973, recruited into the size range large enough to be caught by net gear, thus they were the primary reason for the rapid increase in relative abundance.

Increased abundance of bluegill in net catches of 1974 was also due to recruitment of younger fish. Fingerlings stocked in the fall of 1972 had a mean calculated length of 28 mm; these bluegill were too small to be caught during the greater portion of 1973. In 1974 they were large enough to be caught, at a minimum length of about 130 mm (5.1 in).

Recruitment of other sportfish stocked at an early age was also documented by an increase in relative abundance. Channel catfish, stocked as advanced fry in 1972 and fingerling in 1973, increased as did walleye, stocked as fingerlings, during 1973.

While relative abundance of some Centrarchids increased that of largemouth bass and green sunfish decreased. Mean FND catches of bass by pound and experimental gill net decreased from 7.7 and 9.1 FND in 1973 to .9 and 1.4 FND, respectively in 1974. Variability in sampling error and bass behavior preclude any explanations for differences in FND. Green sunfish abundance during 1973 was anticipated as was their decline in 1974. Evidence from other Iowa waters and several California reservoirs (LaFounce, et. al., 1964; Abell and Fisher, 1953) has shown continued stocking and establishment of closely related Centrarchid species will have a profound effect on green sunfish populations.

Stocking success of two other sport fish has been questionable. Blue catfish and muskellunge have not been caught by net gear or angling, however, one muskellunge of about 650 mm (25.6 in) was temporarily stunned during spring electrofishing.

Non-sport fish made up the greatest proportion by weight, over 60%, in the net catches despite the fact two species declined in relative abundance. Carp was the most important fish by weight in 1973, 48%, and river carpsucker made up 2%. Carp and river carpsucker dropped in abundance during 1974, 16% and .3%, respectively. The factor contributing to the predominance of non-sport fish was the increase in abundance of white sucker. White sucker became the most important species by weight in 1974, 44%, whereas it contributed 16% in 1973.

The largemouth bass population of Big Creek Reservoir consists mainly of sublegal bass, < 356 mm in body length (14 in). At no time during electrofishing operations did more than 8% of the sample consist of bass larger than 355 mm (13.9 in). All legal bass seen were of the 1972 year class, age II, or possibly older native bass. During the previous year few bass of legal length were seen.

Bass standing stock estimates of 1973 and 1974 were similar as were estimates of age I bass for both years. The standing stock estimate of 1973 (age I bass) was 19.8 kg/ha (16.4 lbs/a) while the combined estimate in 1974 of both age groups was 20.7 kg/ha (17.1 lbs/a). The population size of age I bass in 1973 was estimated at 28,204 fish, in 1974 it was estimated to be 28,597 bass.

Since impoundment growth rate of largemouth bass has systematically decreased for each successive age class. This phenomenon can be graphically presented by comparing back-calculated lengths of the 1972 and 1973 year class, their mean lengths at the end of the 1974 growing season and the mean length of the 1974 year class for the same period (Figure 1). The latter fact is also responsible for a distinct gap between the length frequency distribution of the 1972 and 1973 year classes (Table 4).

The size limit on largemouth bass successfully prevented an overharvest for two consecutive years. During the first year of implementation the population was estimated at 28,204 bass, and in that year 23,566 bass were caught and released. The second creel survey season documented a 383% increase in angler use with the catch and release estimate of 100,722 sublegal bass. In that year mark and recapture operations provided an estimate of 42,791 bass.

Angler harvest during the second season was substantially higher than the first. Fishermen caught an estimated 26 largemouth bass during 1973 for an exploitation of < .001%. The next season anglers caught 131 marked bass, estimated harvest was 1,738 bass, and exploitation increased to 11%. These bass were wholly from the 1972 year class. A second exploitation estimate of 13% for that year was calculated from the age II population size and harvest. The similarity of estimates calculated by two different methods indicated the estimates may be very accurate.

Many bass were lost to natural mortality in 1973. Total mortality was estimated at 56% for 1973 and because fishing mortality was nearly nonexistent natural mortality was the primary cause of death. This relationship leads to the assumption that natural mortality deprived anglers from harvesting many of these

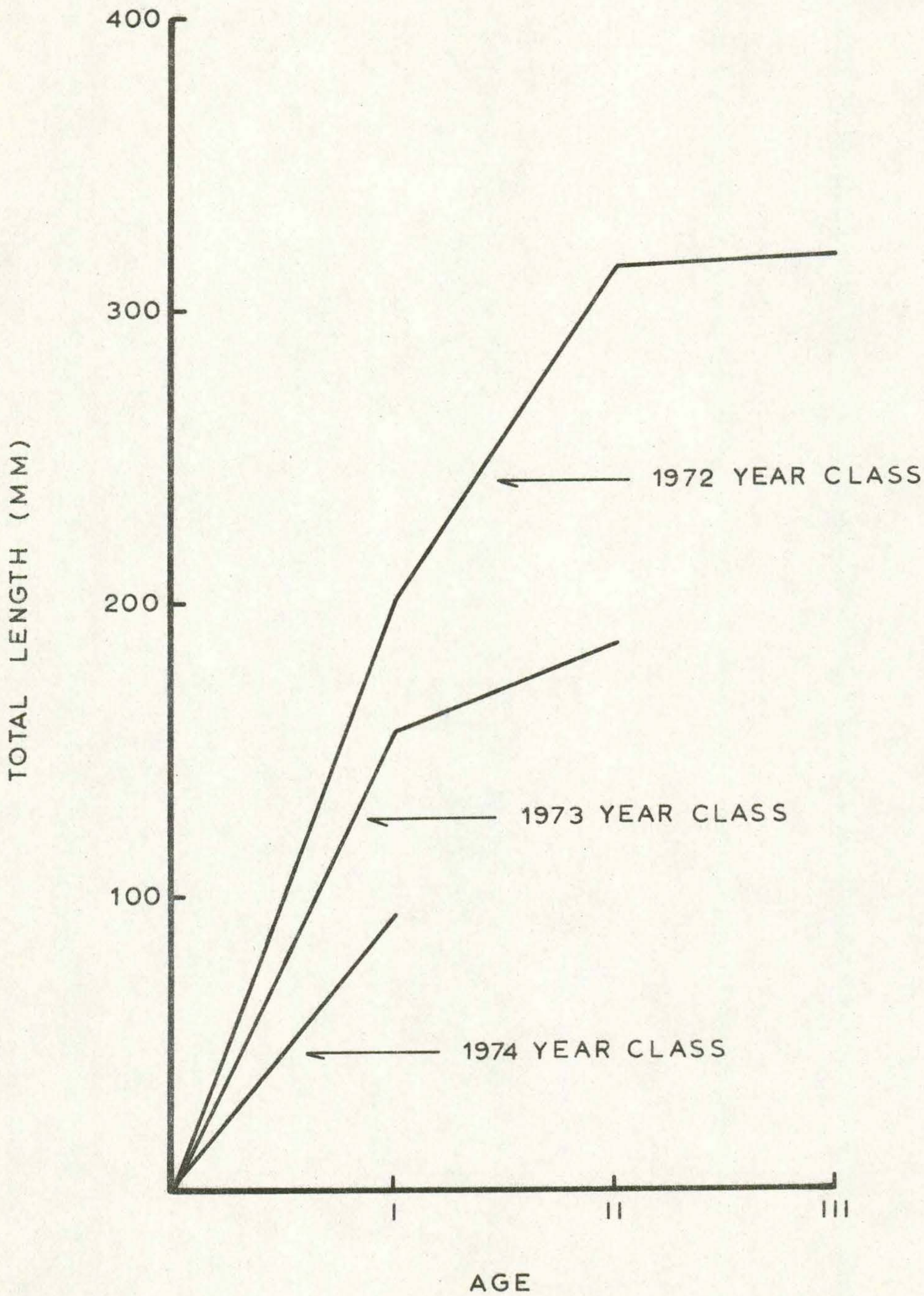

Figure 1. Estimated total length of the 1972 and 1973 year class of largemouth bass. The last increment of each age is the empirical length of the 1972, 1973 and 1974 year class in the autumn of 1974.

bass during 1974. The virtue of this assumption will be cleared following determination of the optimum body size for the population. Any recommendations would be premature, however, indications of slowed growth for subsequent year classes of bass raises the question as to the applicability of the 356 mm (14 in) size limit. With slower growth it will take longer, from up to 6 years for the bass to attain legal length.

Acceptance of the 14-inch size limit by some anglers is also debatable at this time. Signs posted at all access points on the reservoir inform fishermen of the size limit and the reasons for its application. Despite the signs and several news releases some anglers continued to harvest sublegal bass at a minimum of 44% of the total catch in 1974.

The largemouth bass fishery at Big Creek Lake appears to have the attributes of Lee's phenomenon. Early signs of this prodigy appears in Figure 1. Growth of the 1972 year class appeared to have ceased between age II and III. Once a bass reaches about 330 mm (13.5 in) its life expectancy was greatly reduced by the intense fishing pressure. The fastest growing bass are thereby culled from the population leaving slower growing individuals. Experienced bass fishermen frequently report catching 20-40 bass in a single day in order to catch the limit of five.

Growth of bluegill at Big Creek Lake is excellent when compared to other Iowa impoundments. Bluegill sampled at Big Creek Lake were primarily of two year classes, native age I of the 1973 year class and age II bluegill stocked in 1972 as fingerling. Bluegill from Red Haw Lake, Bobwhite Lake and Williamson Pond attained lengths of 45 (.8 in), 46 (.8 in) and 43 mm (.7 in), respectively at the end of their first year of life (Mitzner, unpublished) while native bluegill at Big Creek Lake attained 81 mm (3.2 in). Native bluegill were also larger than the hatchery fish after one year of growth. However, an important factor to keep in mind is that the populations compared are of older established lakes while Big Creek Lake is a new impoundment.

Black crappie growth during their first year of life at Big Creek Lake was best when compared to two other Iowa waters. Five year classes of black crappie were represented within the sample of fish aged from Big Creek. Only the 1973 year class was a native class, these fish had attained a TL of 118 mm (4.6 in) after one year of growth while at Red Rock Reservoir black crappie averaged 84 mm (3.3 in) (Paragamian, unpublished) and at Red Haw Lake they averaged 76 mm (3 in) (Mitzner, unpublished).

RECOMMENDATIONS

Population estimates will be made of the entire reservoir rather than treatment as two discrete areas since no statistical difference was noted between these habitats. Study will continue as Big Creek Lake in the manner outlined.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 601-2

JOB NO.: 2

NAME: Evaluation of the 14-Inch Size Limit on Largemouth Bass at Big Creek Lake

TITLE: Predator-prey relationships in a newly established reservoir with a multi-species prey base

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *Forage populations were systematically sampled with a seine net while food habits of largemouth bass was obtained by direct examination of stomachs from bass captured periodically by electrofishing. Seine hauls captured 1,997 fish, including 0-age of five species in addition to adult and young Notropis sp. Notropis sp. comprised the greatest portion of the catch (73%), bluegill young were second (24%) followed by green sunfish (2%). Stomachs of 49 immature bass < 200 mm were examined of which 12 were empty. Aquatic and terrestrial insects comprised the greatest portion of the diet by weight and were second by number. Entomostraca were the most abundant by number, but contributed little by weight, and fish, including postlarval bluegill, were second by weight. Stomach contents of 72 largemouth bass 200 mm+ were investigated and 29 were empty. Fish, including crappie and green sunfish, were the most important food items by weight while crayfish were second. Although insects and entomostraca were most abundant they contributed little by weight. Crayfish were important to the diet of bass early in the season but their importance decreased after most fish spawned.*

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Fisheries Research Biologist

Date Prepared: 1 June, 1975

Approved by: James Mayhew
Fisheries Research Supervisor

JOB 2 OBJECTIVE

To measure the impact of increasing the size of the largemouth bass population on the abundance of other fish populations with emphasis on bluegill and crappie.

INTRODUCTION

The objective of this study segment is to establish the predator-prey relationship between largemouth bass and prey species, primarily bluegill and crappie. A predator population of bass was established at Big Creek Lake during the same period in which adult and fry bluegill and crappie were stocked. Densities of the prey species are systematically sampled while stomach samples of bass are collected periodically.

Utilization of bluegill and crappie is of utmost importance. The foundation of the proper predator-prey relationship rests on the assumption that crowding of prey species is controlled by the predator. Thus, growth of bluegill and crappie, usually density dependent, is maintained at an acceptable rate.

STUDY BACKGROUND

During 1973 0-age forage species were sampled with a seine net and the data obtained was to be used in conjunction with food habit analysis of largemouth bass. However, bass captured during the study were not killed for stomach analysis. Extenuating circumstances involved with low recaptures of bass during population estimation prohibited killing of bass. Few young bluegill or crappie were captured and were probably of minimal value as food items of bass. Green sunfish were the most abundant species caught in seine hauls and it was likely were very important food items of bass. A seasonal mortality of over 80% was calculated for young green sunfish.

Problems involving a bass population estimate did not evolve in 1974 and food habit studies were carried out as designed.

METHODS AND PROCEDURES

Forage populations were sampled with a seine net, 15.2 x 1.8 m with 6 mm bar measure mesh (50 ft x 6 ft x 1/4 in), at three designated sampling areas during 10 biweekly periods, extending from mid-June through mid-October. The seining procedure consisted of a 45 m (150 ft) haul followed immediately by a repetition through the same area. All fish caught in the seine haul were identified, with the exception of *Notropis sp.* enumerated, preserved in 10% formalin and later weighed at the laboratory.

Information on the food habits of largemouth bass was obtained by direct examination of stomachs from bass captured by electrofishing. Bass were collected periodically during population studies in spring and on seine haul days of summer and autumn. On each collection day about 15 bass were killed, 10 bass 200+ mm (7.9 in) and 5 bass < 200 mm. After capture bass were measured, weighed, stomachs removed and preserved in 10% formalin for later analysis in the lab. Stomach items were observed under a 1 to 6X dissecting scope, identified, enumerated and weighed.

FINDINGS

POPULATION ABUNDANCE OF PREY FISH

Seine hauls captured 1,997 fish, including 0-age of five species in addition to adult and young *Notropis sp.* (Table 11). *Notropis sp.* comprised the greatest portion of the catch, 1,466 fish (73%). Bluegill young were second in numerical abundance, 471 (24%), followed by green sunfish, 48 (2%). Few largemouth bass, black crappie or smallmouth bass were seen in the seine haul catches, their total accounted for < 1%.

Catch curves, constructed the previous year for green sunfish and largemouth bass, could not be used since none of the fish captured displayed an exponential relationship with time.

STOMACH ANALYSIS

Largemouth Bass (< 200 mm) Stomachs of 49 young largemouth bass were investigated, of which 12 were empty (Table 12). Aquatic and terrestrial insects comprised the greatest portion of the diet by weight and were second by number, 5.0 g (.01 lbs) and 1,380 items respectively, while fish were second by weight, 4.8 g (< .01 lbs) and crayfish were third, 3.6 g (< .01 lbs). Entomostraca were the most abundant numerically comprising 61% of the items.

The spring sample, April through June, consisted of 16 stomachs of largemouth bass ranging from 115 (4.5 in) to 188 mm (7.4 in) TL ($\overline{X}$ = 158 mm ± 23), 8 stomachs were empty (Table 13). Fish, including bluegill and *Notropis sp.*, were the most important food items by weight comprising 67% of the total. A variety of aquatic and terrestrial insects were second, 19%, followed by crayfish, 14%. Insects provided the greatest numerical portion of the items (69%) found in stomachs containing food. Fish were second in numerical abundance with 23%, and crayfish third with 8%.

The summer and autumn sample, July to mid-November, consisted of 33 stomachs of largemouth bass ranging from 130 (5.1 in) to 187 mm (7.4 in) TL ($\overline{X}$ = 154 mm ± 17), 4 stomachs were empty (Table 14). Insects were the most important food item by weight (37%), fish were second (31%) and crayfish were third (24%). Entomostraca were the most abundant items by number (62%) while insects were second (37%).

Table 11. Catch composition of seine hauls at each sampling site in Big Creek Lake, June through October, 1974.

	Sampling site							
	I		II		III		Total	
Species	Number	Percent	Number	Percent	Number	Percent	Number	Percent
G sunfish	17	4.4	30	1.9	1	1.7	48	2.4
Notropis sp.	324	84.8	1,099	70.7	43	71.7	1,466	73.4
Lm bass	2	.5					2	.1
Sm bass	6	1.6			3	5.0	9	.4
B crappie			1	< .1			1	< .1
Bluegill	33	8.6	425	27.3	13	21.7	471	23.6
Total	382		1,555		60		1,997	

Table 12. Food items of 37 largemouth bass < 200 mm, Big Creek Lake, April through October, 1974.

	Number of stomachs containing items	Number of items	Weight (grams)	$\overline{X}$ weight
Bluegill	4	4	1.278	.320
Notropis sp.	3	3	.996	.332
Unidentifiable fish	11	21	2.487	.118
Total fish	15	28	4.761	.283
Decapoda	3	3	3.569	1.190
Cladocera and *Ostracoda*	6	2,281	1.210	< .001
Aquatic insects[a]	21	205	2.753	.013
Terrestrial insects[b]	7	7	.380	.054
Unidentifiable insects	10	1,168	1.870	.002
Total insects	38	1,380	5.003	.003
Hydra	1	2	.002	.001
Vegetation	1	1	.010	.010

[a]Included Zygoptera, Tricoptera, Corrixidae, Chironomidae, Ephemeroptera and unidentified Diptera.

[b]Included Hemiptera, Lepidoptera and Coleoptera.

Table 13. Food items, by percent, of 8 largemouth bass < 200 mm, Big Creek Lake, April through June, 1974.

	% of item by number	% of item by weight	% of stomachs containing item
Notropis sp.	15.38	57.35	25
Unidentifiable fish	7.69	9.67	12
Total fish	23.07	67.02	37
Decapoda	7.69	14.12	13
Aquatic insects[a]	46.15	17.73	38
Terrestrial insects[b]	23.07	1.10	38
Total insects	69.22	18.83	50

[a]Included Zygoptera, Tricoptera, Corrixidae, Chironomidae, Ephemeroptera and unidentified Diptera.

[b]Included Hemiptera, Lepidoptera and Coleoptera.

Table 14. Food items, by percent, of 29 largemouth bass < 200 mm, Big Creek Lake, July through early November, 1974.

	% of item by number	% of item by weight	% of stomachs containing item
Bluegill	.10	11.52	14
Notropis sp.	.02	3.20	3
Unidentifiable fish	.54	16.65	34
Total fish	.67	31.38	41
Decapoda	.05	23.75	7
Cladocera and *Ostracoda*	61.98	10.90	31
Aquatic insects[a]	5.40	14.24	62
Terrestrial insects[b]	.10	2.76	14
Unidentifiable insects	31.73	16.85	34
Total insects	37.23	32.85	72
Vegetation	.02	.09	3

[a]Included Zygoptera, Tricoptera, Corrixidae, Chironomidae, Ephemeroptera and unidentified Diptera.

[b]Included Hemiptera, Leidoptera and Coleoptera.

Largemouth Bass (200 mm+) Stomach contents of 72 largemouth bass 200 mm+ were examined and 29 were empty (Table 15). Fish were the most important food item by weight (228 g) (.5 lbs) while crayfish were second (84 g) (.18 lbs). Although aquatic insects and Entomostraca comprised a great portion by numerical importance, 703 and 697 items, respectively, they contributed little by weight, 4.8 (< .01 lbs) and .2 g (< .005 lbs).

Table 15. Food items of 43 largemouth bass 200 mm+, Big Creek Reservoir, April to mid-November, 1974.

	Number of stomachs containing items	Number of items	Weight (grams)	$\overline{X}$ weight
Crappie	2	2	59.284	29.642
G sunfish	2	2	115.95	57.975
Lm bass	1	1	9.563	9.563
Cyprinids	2	2	12.549	6.274
Unidentifiable fish	9	9	30.858	3.429
Total fish	16	16	228.208	14.263
Decapoda	18	20	83.600	4.180
Cladocera	2	697	.390	.005
Aquatic insects[a]	14	703	2.972	.004
Terrestrial invertebrates[b]	7	40	1.866	.047
Vegetation	2	2	.040	.020
Unknown matter	3	3	.973	.324

[a]Includes Corixidae, unidentifiable Diptera, Chironomidae, Zygoptera and Ephemeroptera.

[b]Included Annelida, Orthoptera, Leidoptera, unidentifiable Anisoptera, Formicidae, Coleoptera and Lampyridae.

The spring sample was comprised of 37 largemouth bass stomachs ranging in body size from 258 (10.1 in) to 328 (12.9 in) mm TL ($\overline{X}$ = 305 mm ± 19). Fourteen were empty (Table 16). Fish contributed 63% to the diet by weight while crayfish was 35%. Crayfish were found in 61% of the stomachs containing food items while fish were found in 22%.

The summer and autumn sample consisted of 35 stomachs of largemouth bass ranging from 203 (7.9 in) to 377 (14.8 in) mm TL ($\overline{X}$ = 307 mm ± 53), of which 15 were empty (Table 17). Fish remained the primary food item by weight, 88%, while crayfish fell to 9%. A greater portion of the stomachs contained fish, 55%, as opposed to 20% for crayfish.

Table 16. Food items, by percent of 23 largemouth bass 200 mm+, Big Creek Lake, April through June, 1974.

	% of item by number	% of item by weight	% of stomachs containing item
Centrarchids	1.35	60.30	13
Cyprinids	.45	2.11	4
Unidentifiable fish	.45	1.06	4
Total fish	2.25	63.47	22
Decapoda	6.75	35.33	61
Cladocera and *Ostracoda*	60.36	.09	4
Aquatic insects[a]	13.51	.23	26
Terrestrial invertebrates[b]	16.66	.84	17
			39
Vegetation	.45	< .01	4

[a]Includes Corixidae, unidentifiable Diptera, Chironomidae, Zygoptera and Ephemeroptera.

[b]Included Annelida, Orthoptera, Leidoptera, unidentifiable Anisoptera, Formicidae, Coleoptera and Lampyridae.

Table 17. Food items, by percent, of 20 largemouth bass 200 mm+, Big Creek Lake, July to mid-November, 1974.

	% of item by number	% of item by weight	% of stomachs containing item
Centrarchids	.28	53.88	10
Cyprinids	.14	7.55	5
Unidentifiable fish	1.15	26.68	40
Total fish	1.57	88.11	55
Decapoda	.72	8.56	20
Aquatic insects[a]	96.97	2.30	40
Terrestrial insects[b]	.43	.08	15
Total insects	97.40	2.38	45
Vegetation	.14	.02	5
Unknown matter	.43	.90	15

[a]Included Corixidae, unidentifiable Diptera, Chironomidae, Zygoptera and Ephemeroptera.

[b]Included Orthoptera, Lepidoptera, unidentifiable Anisoptera and Coleoptera.

DISCUSSION OF FINDINGS

Total catch of forage fish species in 1974 was reduced nearly 81% from the 1973 samples and was comprised of fewer species. During 1973 seine samples caught 11,766 fish from 11 species. Forty-nine percent were green sunfish and 46% *Notropis sp.* The following season seine hauls caught 1,997 fish from six species, of which 73% were *Notropis sp.*

Green sunfish was succeeded in abundance by bluegill during the second season. Seine hauls caught 471 bluegill during 1974 as compared to 43 fish the previous year while 5,710 green sunfish were captured that year and only 48 in the second season. Reproductive success of other Centrarchids was poor in 1974. Few largemouth or smallmouth bass were seen and only 1 young black crappie was captured. Catch success of 0-age largemouth bass between 1973 and 1974 is not comparable since nearly 82,000 young bass were stocked during the earlier year.

At Big Creek Lake seine hauls do not monitor black crappie reproductive success. Reproductive success of black crappie during 1973 was described as low in comparison to other Centrarchids (Paragamian, unpublished) yet age I crappie were abundant in pound and experimental gill net catches of 1974. Pelagic behavior of larval crappie was thought responsible for this observation.

Throughout the 1974 season fish and crayfish were the main constituents in the diet of bass 200 mm+. They comprised over 98% of the combined weight of all food items consumed and were found in 75 to 80% of the stomachs that contained food items Invertebrates, excluding crayfish, were the most abundant food items found and appeared in many stomachs. However, invertebrates contributed little in total biomass.

Crayfish played an important role in the diet of bass early in the season but their importance by weight was overshadowed by larger fish found in a few stomachs. Early in the sampling season small fish were seldom seen since many species did not spawn until later. With the absence of young fish many more bass consumed crayfish than fish. Snow (1962) reported crayfish were the most important food items of largemouth bass at Murphy Flowage, Wisconsin. Centrarchids were second in importance followed by bullhead. Bluegill were utilized more frequently only after an artificial drawdown of Murphy Flowage reduced the crayfish stock. In a pond predation study by Lewis and Helms (1964) crayfish were more vulnerable to bass predation than bluegill and green sunfish.

The importance of crayfish to the diet of bass decreased during the summer and autumn while fish were utilized more frequently. This trend was associated with two factors; by July most fish had spawned thus young fish were more abundant and crayfish stocks were probably reduced by predation. Seine hauls documented the increase in abundance of 0-age fish during the summer but crayfish were seldom captured and were not monitored.

Utilization of bluegill and black crappie as prey by larger sublegal bass is of primary importance to this study. Crappie and green sunfish were found in the stomachs of bass, however, bluegill were not identified. This does not indicate bluegill were not eaten; 9 of 16 fish seen in stomachs were digested beyond identification. Most of the unidentifiable fish were found during a sampling period when postlarval bluegill were abundant in seine hauls. In addition, a few bass captured during electrofishing regurgitated partially digested bluegill; these bass were not captured for food habit studies.

Largemouth bass < 200 mm TL, captured for stomach analysis, were all age I and in a stage of food habit transition. This stage is described as one in which bass are gradually shifting from a diet of Entomostraca and aquatic insects to larger food items (Murphy, 1949; Mraz et al., 1961; Applegate and Mullan, 1967; Hodson and Strawn, 1968).

Most food item groups were important to immature bass. The degree of importance was dependent upon frequency of occurrence, quantity consumed, weight of food item and nutritional value. Nutritional value of food items were not described in this study. In decreasing order of relative importance as food items were insects, fish, crayfish and Entomostraca. Insects were second in numerical importance, second in weight and occurred most frequently. Fish was third in numerical importance, contributed the greatest proportion by weight, but were found in fewer stomachs than insects. Crayfish contributed the least by number, ranked third by weight and had the lowest frequency of occurrence. Entomostraca were the most abundant numerically but contributed the least by weight and were found in few stomachs.

0-age bluegill were utilized by young bass during the summer and autumn months. Larval and postlarval bluegill were found in young bass stomachs soon after seine hauls revealed their presence in July. Four bluegill were identified among 28 fish found in 15 stomachs. However, 21 other fish found were digested beyond identification and it was likely some of these were bluegill.

RECOMMENDATIONS

The project will be continued in the same manner as in the previous segments, however, stomachs will not be collected from bass < 200 mm.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-2

TITLE: Abundance, distribution, mortality and production of 0-age fish

STUDY NO.: 701-4

JOB NO.: 1

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: Populations of postlarval gizzard shad, crappie and bluegill were sampled with standardized meter net tows for 14 weeks at Lake Rathbun. Overall mean catch of 0-age shad declined slightly to 281.7 per tow, while crappie and bluegill were taken in record low numbers, averaging 3.2 and < 1.0 per tow. Seasonal distribution of catches for all three fish species was nearly identical to 1972, when low catches of postlarval crappie and bluegill were recorded. The horizontal and vertical distribution of young fish in the reservoir showed little change, except for gizzard shad in the midwater habitat. For the first time the catch data indicated additional movement of gizzard shad toward the surface in midwater by late summer. Annual mortality was the lowest ever recorded for gizzard shad and crappie. Total production of 0-age fish for the season was estimated at 33.55 kg/ha for gizzard shad, .072 kg/ha for crappie and .015 kg/ha for bluegill.

Author: James Mayhew
Fisheries Research Supervisor

Date Prepared: 1 March, 1975

STUDY OBJECTIVE

To develop a multivariate model of fish production and predict year class strength yearly in the season in Lake Rathbun by measuring the influence of factors which control year class abundance including planktonic fish food organism abundance and distribution, reservoir water level control management, sedimentary turbidity and water temperature.

JOB 1 OBJECTIVE

To measure the numerical abundance, spatial distribution, annual mortality and production of 0-age gizzard shad, crappie and bluegill in Lake Rathbun.

INTRODUCTION

Sampling of 0-age fish populations with a standardized meter tow net continued in 1974 at Lake Rathbun. The 14 week sampling schedule commenced on 6 May and terminated 11 August. Ten fish species from five families were captured, but only gizzard shad, crappie and bluegill catches were included in the numerical analyses. Postlarval channel catfish and bullhead were not captured this year. Low catches of 0-age bluegill precluded determination of their annual mortality and distribution.

STUDY BACKGROUND

Populations of 0-age fish were sampled weekly for 14 weeks by standardized meter net tows in 1971-73 to determine the numerical abundance, spatial distribution, annual mortality and production. Catch data for gizzard shad, crappie and bluegill were sufficient for numerical analysis from a total catch of 12 fish species, representing five families.

Gizzard shad abundance increased systematically from an average catch of 14.2 per tow in 1971 to 314.2 in 1973. Crappie abundance fluctuated, attaining the highest density in 1973 when the mean catch per net tow was 33.9 to the lowest in 1972 with a mean catch of 7.7 per net tow. Bluegill abundance declined sharply after the first year when the average catch was 116.1 per tow to 6.3 in 1972 and 13.7 in 1973.

Postlarval fish were not equally horizontally and vertically distributed throughout the reservoir. Highest population density was found in large embayments and shallow water habitat along the shoreline. In midsummer, young shad and crappie were pelagic and most numerous in the midwater portion of the lake, concentrating into deeper stratum up to 7 m. Bluegill remained in shallow water during most of the first year of life.

Annual mortality of postlarval shad ranged from 65% to 83% each season. In 1971, a late autumn and early winter die-off was observed in most regions of the lake. Crappie mortality ranged from 39% in 1972 to 62% in 1973. Bluegill mortality ranged from 34% in 1972 to 58% in 1971. A large portion of annual mortality of 0-age fish was presumably from predation.

Annual production of 0-age gizzard shad was .99 kg/ha in 1971, 29.00 kg/ha in 1972 and 28.60 kg/ha in 1973. Production of crappie ranged from .38 kg/ha in 1971 to 2.06 kg/ha in 1973. Bluegill production ranged from .06 kg/ha in 1972 to 1.15 kg/ha in 1971.

METHODS AND PROCEDURES

Collection methods and analytical procedures were identical with the 1971-73 study segments (Mayhew, 1974).

FINDINGS

ABUNDANCE OF 0-AGE GIZZARD SHAD

The overall numerical catch mean of postlarval gizzard shad in 1974 was 281.7 per meter net tow (Table 1). Comparable yearly catch means for the 1971-73 sampling period was 14.6, 281.4 and 315.8 per tow, respectively. Testing of the current catch means with an orthogonal contrast series with other years showed the catch value was significantly different at the 95% level from only the 1971 mean.

Initial spawning activity of mature shad was observed in a small cove in Honey Creek Bay on 4 May. Vigorous activity was noted in nearly all shallow water areas of the lake about dusk on 18 May. The first larval shad appeared in the meter net tows during the second May sampling period. Mean catch per net tow in this interval was 131.8 ranging from 0 at Station 2 to 661 at Station 7. Catch values were significantly greater at the shallow water stations in this period. Modal catch of shad larvae was attained in the early June interval with a mean catch of 1,052.4 per net tow. Individual station catch ranged from 137 at Station 4A to 2,915 at Station 9 during this interval. Again, catch success of larval shad was significantly greater at shallow water stations. Spawning activity was nearly completed by late June which was followed by systematically decreasing catch values until sampling ceased in mid-August. The numerical catch means were 395.8 in the fourth sampling interval followed by 185.3, 131.3 and 75.7 in the fifth through seventh periods. Seasonal catch distribution (Figure 1) conformed closely with the 1972 curve except the number caught in the last period this year was greater. Inflections in the catch curve occurred at exactly the same period for both years.

Table 1. Numerical catch of 0-age gizzard shad in meter net tows at Lake Rathbun, 1974.

		Sampling interval						
Sampling station	Depth	5/6-5/19	5/20-6/2	6/3-6/16	6/17-6/31	7/1-7/14	7/15-7/28	7/29-8/11
2	A	0	0	335	341	88	20	3
	B	0	0	184	994	226	51	2
3	A	0	14	463	88	97	121	20
	B	0	46	587	1,106	222	222	32
4	A	0	2	137	71	117	138	6
	B	0	1	500	279	304	208	19
7	A	0	661	2,003	123	130	24	3
8	A	0	254	2,348	213	235	249	47
9	A	0	208	2,915	347	249	147	549
Mean		0	131.8	1,052.4	395.8	185.3	131.3	75.7
$S_{\overline{X}}$		0	73.7	354.1	128.5	26.0	28.6	59.4
Mean weight (g)			.0026	.0092	.0246	.0648	.535	1.659

HORIZONTAL AND VERTICAL DISTRIBUTION OF 0-AGE GIZZARD SHAD

Factorial analysis of variance in the numerical catch of 0-age shad was complete over all four years. The results of the analysis showed continued unequal horizontal and vertical distribution of larval shad throughout the reservoir. Highly significant difference between catch means ($P < .01$) occurred horizontally between the shallow and midwater stations and vertically among midwater sampling stations (Table 2). Catch means for the tow net stations over all years were as follows: Station 2A, 63.7; Station 2B, 193.5; 3A, 93.4; 3B, 192.6; 4A, 56.9; 4B, 403.1; 7A, 251.9; 8A, 388.0 and 9A, 366.1. Catch mean ratios for shallow water vs midwater sample was 2.00:1, while deep tows vs surface tows among the midwater habitat had a catch ratio of 3.67:1.

Significant variation in the horizontal distribution of postlarval shad was noted for the first time among midwater sampling stations. Partitioning of the sample variance among the midwater stations into discrete factorial components by orthogonal contrasts indicated the transformed catch means at Station 2 were

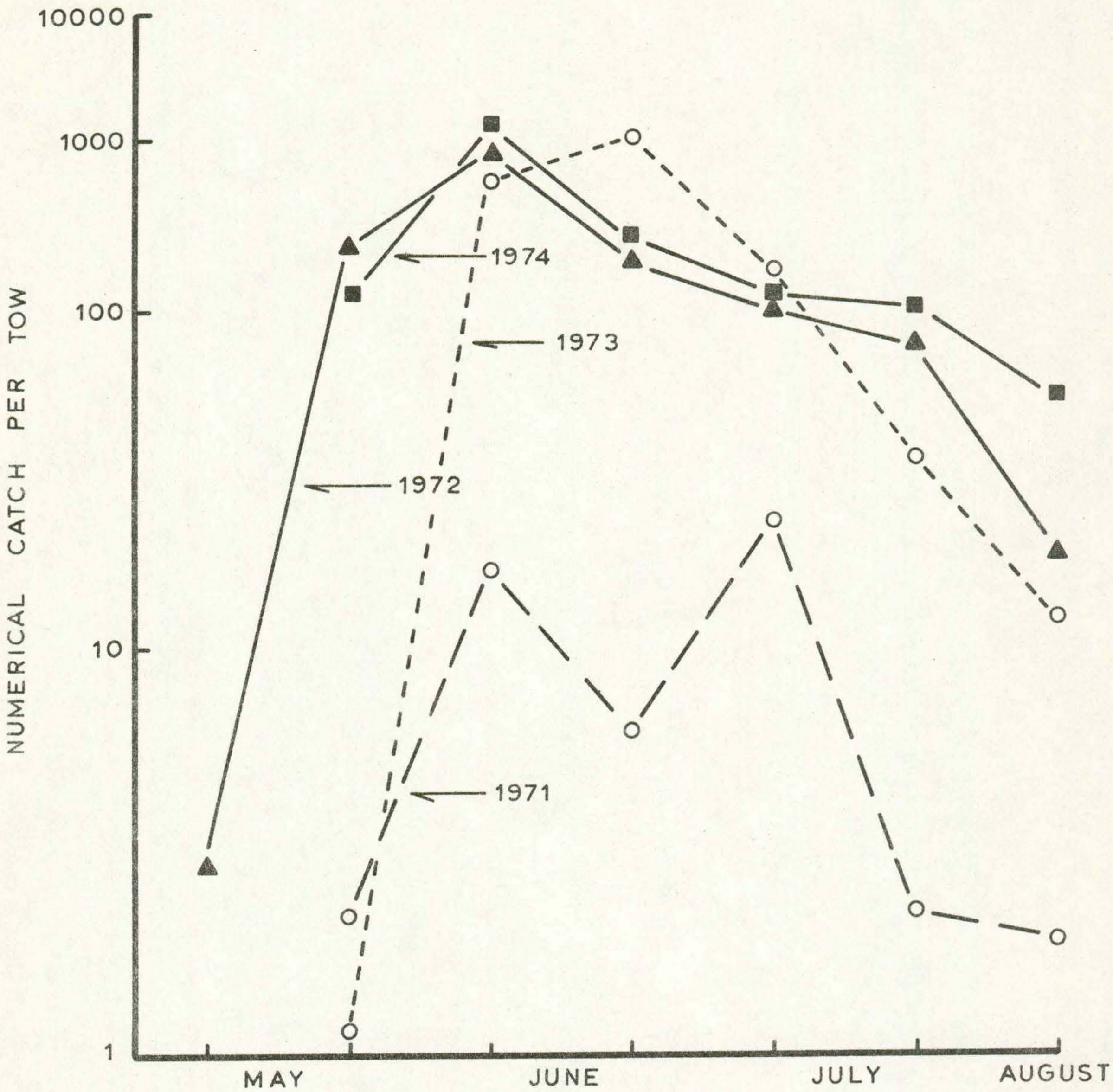

Figure 1. Mean numerical catch of 0-age gizzard shad in meter net tows, 1971-74.

Table 2. Factorial analysis of variance in the numerical catch of 0-age gizzard shad in meter net tows at Lake Rathbun, 1971 through 1974. Values were transformed by $\log_e X + 1$.

Source of variation	df	SS	MS
Year	3	209.41	69.80**
Station	[8]	[65.90]	[8.24]**
Midwater vs shallow stations	1	22.60	22.60**
Among midwater stations	(5)	(42.26)	(8.45)**
Shallow vs deep tows	1	33.74	33.74**
Station 2 vs 3 & 4	1	4.83	4.83*
Interaction with depth	1	.16	.16
Station 3 vs 4	1	1.01	1.01
Interaction with depth	1	2.52	2.52
Among shallow stations	(2)	(1.04)	(.52)
Shoreline vs embayments	1	.46	.46
Honey Creek vs Buck Creek	1	.58	.58
Year x station	24	37.20	1.55
Period	6	707.38	117.90**
Year x period	18	204.89	11.38**
Residual	192	227.01	1.18
Total (corrected)	251	1,451.79	

*Significant at the .05 level of probability.

**Significant at the .01 level of probability.

significantly lower than other midwater stations at the 95% level. The observed pooled means for the midwater samples for all years were 128.6 at Station 2, 143.5 at Station 3 and 230.0 at Station 4.

Temporal intra-reservoir distribution of postlarval shad in 1974 followed identical directions with other years. Spawning occurred in the shallow water along the main pool shoreline and large embayment, with the latter most important (Mayhew, 1974). Following attainment of 10-15 mm in body size pronounced movement occurred toward deeper stratum in midwater habitat. In 1974, a late season change in the size distribution of the catch indicated secondary vertical movement related to postlarval age occurred toward the midwater surface after the fish attain 17-24 mm body length and a weight of .10-.25 g.

Mean weight of shad captured in late June was .028 g in the deep water tows and .022 g in surface tows (Table 3). By early July the mean weight of fish in the deep tows was .065 g compared to .031 g in surface hauls. Mean body weight of shad in late July tows was .491 g at the surface and .341 g in deep water. In early August the trend of smaller shad in surface tows was reversed with the mean weight nearly twofold that of deep tows, 1.496 g compared with .773. Postlarval shad remained most numerous in the deeper stratum, but the older and large shad were prevalent in surface samples. Size of shad remaining in the shallow water continued greater than the other habitats, but the lack of change in the size structure indicated there was no tendency for shad to return to shallow water in late summer.

Table 3. Mean body weight in grams of 0-age gizzard shad captured in meter net tows in 1974.

	Sampling interval						
Stations	5/6-5/19	5/20-6/2	6/3-6/16	6/17-6/31	7/1-7/14	7/15-7/28	7/29-8/11
Midwater surface (2A, 3A, 4A)	-	.002	.008	.022	.031	.491	1.496
Midwater deep (2B, 3B, 4B)	-	.004	.007	.028	.065	.341	.773
Shallow (7, 8, 9)	-	.002	.010	.025	.099	.772	2.517

MORTALITY OF 0-AGE GIZZARD SHAD

The instantaneous mortality rate for the postlarval shad population was estimated at .85 ± .36 in 1974. Comparable values for the first three years of the study were 1.12 ± .31 in 1971, 1.16 ± .25 in 1972 and 1.82 ± .15 in 1973. Annual mortality was .57 ± .30 for the current population compared to .67 ± .12, .69 ± .22, and .84 ± .14 in previous years, respectively. The daily rate of change in 1974 of 0-age shad populations was .041 ± .021. The range for the other sampling years was .048 ± .019 in 1971 to .060 ± .001 in 1973. Differences in mortality rates between all years was not significant ($P > .05$).

PRODUCTION OF 0-AGE GIZZARD SHAD

Estimated total production of postlarval shad in Lake Rathbun in 1974 was 33.55 kg/ha (Table 4). Previous production was estimated at .99 kg/ha in 1971, 29.00 kg/ha in 1972 and 28.60 kg/ha in 1973. By individual sampling interval production ranged from 1.03 kg/ha in the late May period to 15.62 kg/ha in early July.

The greatest numerical population density of 172,715 N/ha was recorded during the 6/3-6/16 interval. At the .05 level of sampling probability this value would vary by more than ± 58,113. The lowest population estimate, 9,268 ± 7,246 young shad was recorded in the last sampling period. Stock biomass ranged from .05 kg/ha in late May to 15.38 kg/ha in early August.

ABUNDANCE OF 0-AGE CRAPPIE

The mean number of postlarval crappie captured in the meter net tows in 1974 was the lowest recorded since the beginning of the study. The overall catch mean was 3.2 per tow compared to 18.3 in 1971, 8.7 in 1972 and 34.9 in 1973. This season the maximum catch for a single tow was 16 fish at Station 7 in early June (Table 5). Many of the early season net tows contained no young crappie.

Initial crappie spawning activity was observed in the upper portion of Buck Creek embayment near Station 9 in early May. Accelerated activity was noted in almost all large embayments and along shallow water shorelines by mid-May. The first postlarval crappie were captured at Station 9 during the late May sampling period. Catch success increased slightly from 2.3 in the third interval to 4.3 in early July followed by a systematic decline to 4.1 per tow in late July to .8 per tow in early August. Seasonal catch distribution was unimodal as in previous years (Figure 2), but the mode in 1974 occurred two or three sampling periods later in the season and was at least eightfold lower.

The reservoir water level progressively increased throughout the crappie spawning season reaching a maximum of 1.72 m (5.5 ft) above conservation pool elevation during mid-June. Effects of increasing water levels on crappie spawning success and larvae survival is undocumented in fisheries literature, but it appears to have caused considerable early embryonic mortality and lower numbers of postlarval crappie during early season samples. Despite the lowered initial reproduction the catch of young in the last sampling period was the second highest recorded.

HORIZONTAL AND VERTICAL DISTRIBUTION OF 0-AGE CRAPPIE

The factorial analysis of variance in catch success of 0-age crappie over all years showed significant difference in the spatial distribution at the 99% level (Table 6). Overall mean catch for the midwater station surface tows was 5.5 at Station 2A, 3.3 at Station 3A and 3.8 at Station 4A. Comparable values for the deep tows at these stations were 12.7 at Station 2B, 7.2 at Station 3B and 8.0 at Station 4B. Difference in the vertical catch means was significant at the .01 level of probability with a ratio of 1:2.2 in the catch values for surface vs deep tow.

Table 4. Production of 0-age gizzard shad in Lake Rathbun, 1974.

Sampling interval	Mean weight (g)	Instantaneous growth coefficient	Stock $(\hat{N}/ha)$	95% Confidence interval	Stock biomass (kg/ha)	Mean biomass (kg/ha)	Production (kg/ha)
5/6 -5/19	[a]		[a]	[a]	[a]		
		[a]				[a]	[a]
5/20-6/2	.0026		18,700	± 10,462	.05		
		1.26				.82	1.03
6/3 -6/16	.0092		172,715	± 58,113	1.59		
		.98				1.53	1.50
6/17-6/31	.0246		59,707	± 19,384	1.47		
		.97				1.57	1.53
7/1 -7/13	.0648		25,900	± 3,634	1.68		
		2.11				7.40	15.62
7/14-7/27	.535		16,494	± 3,598	8.82		
		1.13				12.10	13.67
7/28-8/10	1.659		9,268	± 7,246	15.38		
						Total production = 33.35 kg/ha	

[a]No gizzard shad captured in net tows.

Table 5. Numerical catch of 0-age crappie in meter net tows at Lake Rathbun, 1974.

		Sampling interval						
Sampling station	Depth	5/6-5/19	5/20-6/2	6/3-6/16	6/17-6/31	7/1-7/14	7/15-7/28	7/29-8/11
2	A	0	0	0	11	1	0	0
	B	0	0	2	1	2	0	2
3	A	0	0	0	2	2	1	0
	B	0	0	0	1	2	2	0
4	A	0	0	0	0	3	2	0
	B	0	0	2	2	3	13	2
7	A	0	0	16	0	1	2	2
8	A	0	0	0	5	13	7	1
9	A	0	1	1	12	12	10	0
Mean		0	.1	2.3	3.8	4.3	4.1	.8
$S_{\overline{x}}$		0	0	1.7	1.5	1.6	1.6	.3
Mean weight (g)		0	.005	.003	.008	.033	.053	.201

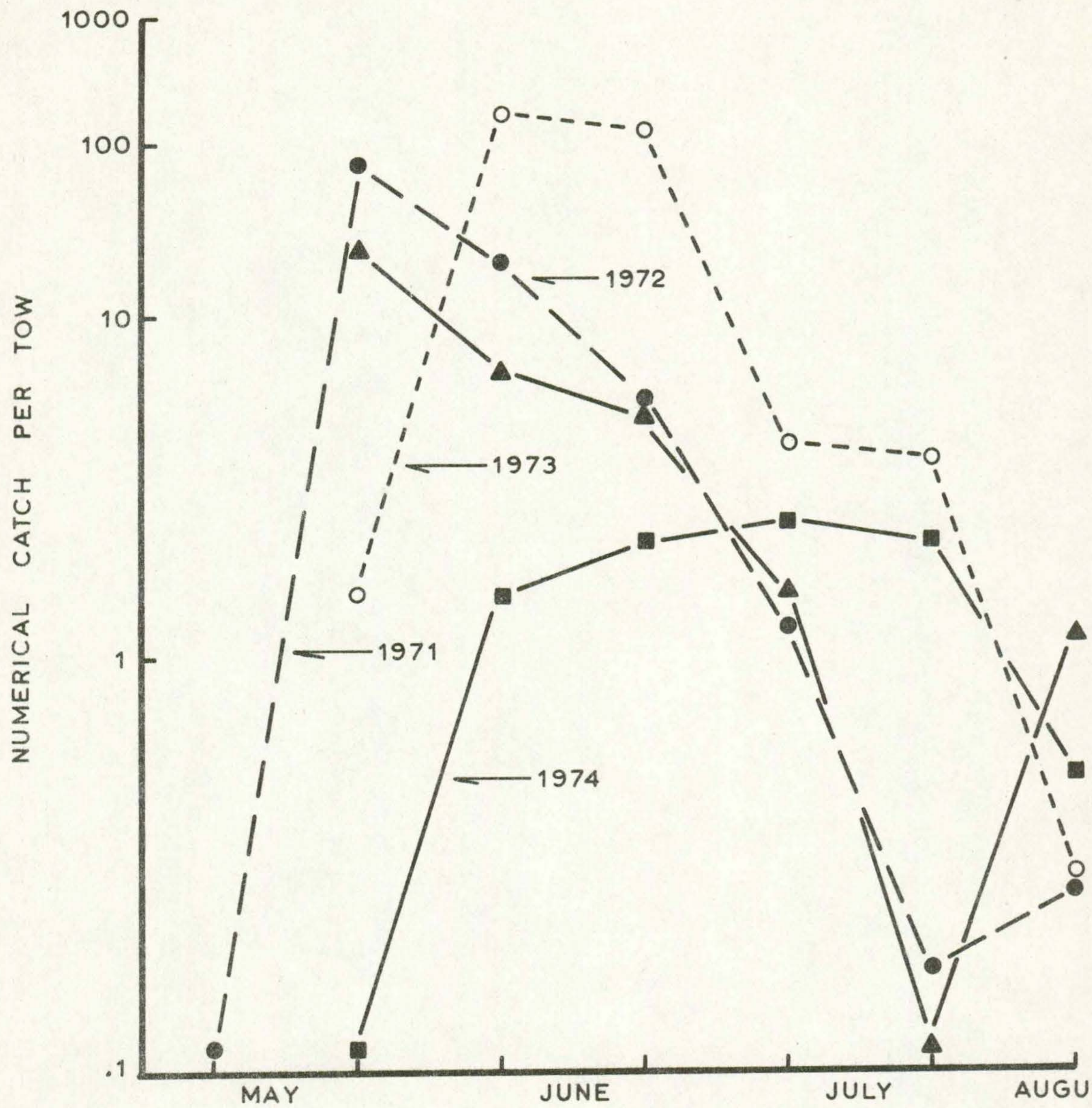

Figure 2. Mean numerical catch of 0-age crappie in meter net tows, 1971-74.

Table 6. Factorial analysis of variance in the numerical catch of 0-age crappie in meter net tows at Lake Rathbun, 1971 through 1974. Values were transformed by $\log_e X + 1$.

Source of variation	df	SS	MS
Year	3	17.05	5.68**
Station	[8]	28.45	3.56**
Midwater vs shallow water	1	12.70	12.70**
Among midwater stations	(5)	(14.67)	(2.93)*
Shallow vs deep tows	1	12.51	12.51
Station 2 vs 3 & 4	1	.32	.32
Interaction with depth	1	.07	.07
Station 3 vs 4	1	.36	.36
Interaction with depth	1	1.41	1.41
Among shallow stations	(2)	(1.08)	(.54)
Shoreline vs embayments	1	1.06	1.06
Honey Creek vs Buck Creek	1	.02	.02
Year x station	24	13.46	.57
Period	6	158.42	26.40**
Year x period	18	134.30	7.46**
Residual	192	133.65	.69
Total (corrected)	251	485.33	

*Significant at the .05 level of probability.

**Significant at the .01 level of probability.

Catch means for the shallow water stations was 7.2 at Station 7, 79.4 at Station 8 and 19.3 at Station 9. There was a highly significant difference ($P < .01$) between mean catch values in the shallow water vs midwater habitats with the former nearly fivefold greater. There was no significant difference in the horizontal distribution of postlarval crappie within either habitat component. Although catch means were significantly different at the .01 level between tows at different depth levels, postlarval crappie movement from the shallow water spawning habitat to midwater was indiscernable from the data. The most logical explanation of this characteristic seemed to be that crappie produced in the shallow water along the shoreline of the main pool were moving to midwater in mid-season, but those produced in the large embayment remained throughout the summer.

MORTALITY OF 0-AGE CRAPPIE

Estimated annual mortality of postlarval crappie in 1974 was .39 ± .06. Comparable values for the preceding three seasons were: .54 ± .37 in 1971, .39 ± .27 in 1972 and .62 ± .30 in 1973. Annual mortality between sampling years was not significantly different at the 95% level. Daily change in the population density was .023 in 1974, which would vary no more than ± .004.

PRODUCTION OF 0-AGE CRAPPIE

Total production of postlarval crappie in 1974 was estimated at .072 kg/ha, the lowest since inception of the study (Table 7). Production values for 1971-73 were .382, .450 and 2.056 kg/ha, respectively. Population biomass for individual sampling intervals in 1974 ranged from < .001 kg/ha in late May to .033 kg/ha in the late July interval. Stock biomass has ranged up to a maximum of .668 kg/ha in late June samples of 1973. Numerical population density ranged from 13 postlarval crappie per ha in the late June period to 673 ± 243 N/ha in early July in 1974. Heretofore, the greatest population density recorded was 26,223 N/ha in early June samples during 1973.

ABUNDANCE, DISTRIBUTION AND PRODUCTION OF 0-AGE BLUEGILL

The total catch of postlarval bluegill during 1974 was 29 fish, the lowest ever recorded and continued the general downward trend of 0-age bluegill abundance (Table 8). Overall mean catch in other years were 116.6 per net tow in 1971, 6.3 in 1972 and 13.7 in 1973. Seasonal distribution of the catch was bimodal, as in other years, with the greatest catch success occurring in late June and July. Catch modes appeared at the same intervals as in 1972, and about two periods later than other years (Figure 3). In 1974, the first postlarval bluegill, a single specimen, was taken in late May at Station 3A. The following period no young fish were captured. Highest mean catch for the year was 1.2 per net tow in the late June period, followed by a decline to .8 per tow in early July, increasing to .9 per tow in late July, then declining again to .2 per tow in the last sampling interval. The maximum catch for a single net tow was 5 fish at Station 8 in the late June period. Over 70% of the net tows during the entire season contained no postlarval bluegill.

Small numerical catches of bluegill postlarvae precluded determination of distribution and mortality for this year. Adjustment of the sampling fraction in bluegill catch means for computation of population density was based on the 1971-73 data. Population density ranged from 16 N/ha in late May to 183 N/ha in the early June sampling interval. Population biomass was < .001 kg/ha in all periods except early August, when it was .005 kg/ha. Total production of 0-age bluegill during the season was .015 kg/ha and ranged from < .001 kg/ha in early samples to .013 in the last sampling interval.

Table 7. Production of 0-age crappie in Lake Rathbun, 1974.

Sampling interval	Mean weight (g)	Instantaneous growth coefficient	Stock ($\hat{N}$/ha)	95% Confidence interval	Stock biomass (kg/ha)	Mean biomass (kg/ha)	Production (kg/ha)
5/6 -5/19	[a]		[a]	[a]	[a]		
		[a]				[a]	[a]
5/20-6/2	.005		13	[b]	< .001		
		- .51				.00	
6/3 -6/16	.003		330	± 246	.001		
		.98				.003	.003
6/17-6/30	.008		618	± 258	.005		
		1.42				.014	.020
7/1 -7/13	.033		673	± 243	.022		
		.47				.0275	.0129
7/14-7/27	.053		617	± 236	.033		
		1.33				.027	.0360
7/28-8/10	.201		104	± 42	.021		
					Total production = .072 kg/ha		

[a]No fish captured in interval.

[b]Confidence interval not computed.

Table 8. Catch of 0-age bluegill at Lake Rathbun, 1974.

		Sampling interval						
Sampling station	Depth	5/6-5/19	5/20-6/2	6/3-6/16	6/17-6/30	7/1-7/13	7/14-7/27	7/28-8/4
2	A	0	0	0	3	0	2	0
	B	0	0	0	0	0	1	0
3	A	0	1	0	0	0	0	0
	B	0	0	0	0	0	0	0
4	A	0	0	0	1	3	1	1
	B	0	0	0	0	0	0	0
7	A	0	0	0	0	2	2	1
8	A	0	0	0	5	1	1	0
9	A	0	0	0	2	1	1	0
Mean		0	.1	0	1.2	.8	.9	.2
$\bar{x}_{wgt}$			.009		.0038	.0067	.0100	.170

DISCUSSION OF FINDINGS

The numerical abundance of 0-age gizzard shad decreased slightly from the all-time high in 1973, but the catch of postlarval crappie and bluegill decreased significantly to the lowest number recorded since inception of the study. Seasonal distribution of the gizzard shad and bluegill closely followed the catch periodicity in 1972 when previously low catch values were recorded. The uniformity in catch statistics between the two years would indicate the mechanism responsible for lower numbers of young fish occurred in both seasons. The seasonal catch curves show postlarval fish appeared in the net tows about one sampling earlier than years with highest catch values. Early reproduction of crappie was nearly completely lost in the embryonic stages, presumable during increased water storage during peak spawning activity.

Despite lowered initial reproduction, both gizzard shad and crappie population density at the conclusion of sampling was higher than any previous season. These facts indicate, with lower annual mortality high populations of postlarval fish are not always essential to the development of strong year classes, but there is also some inferences that low mortality is related to low populations since annual mortality was always lowest in years with smaller populations.

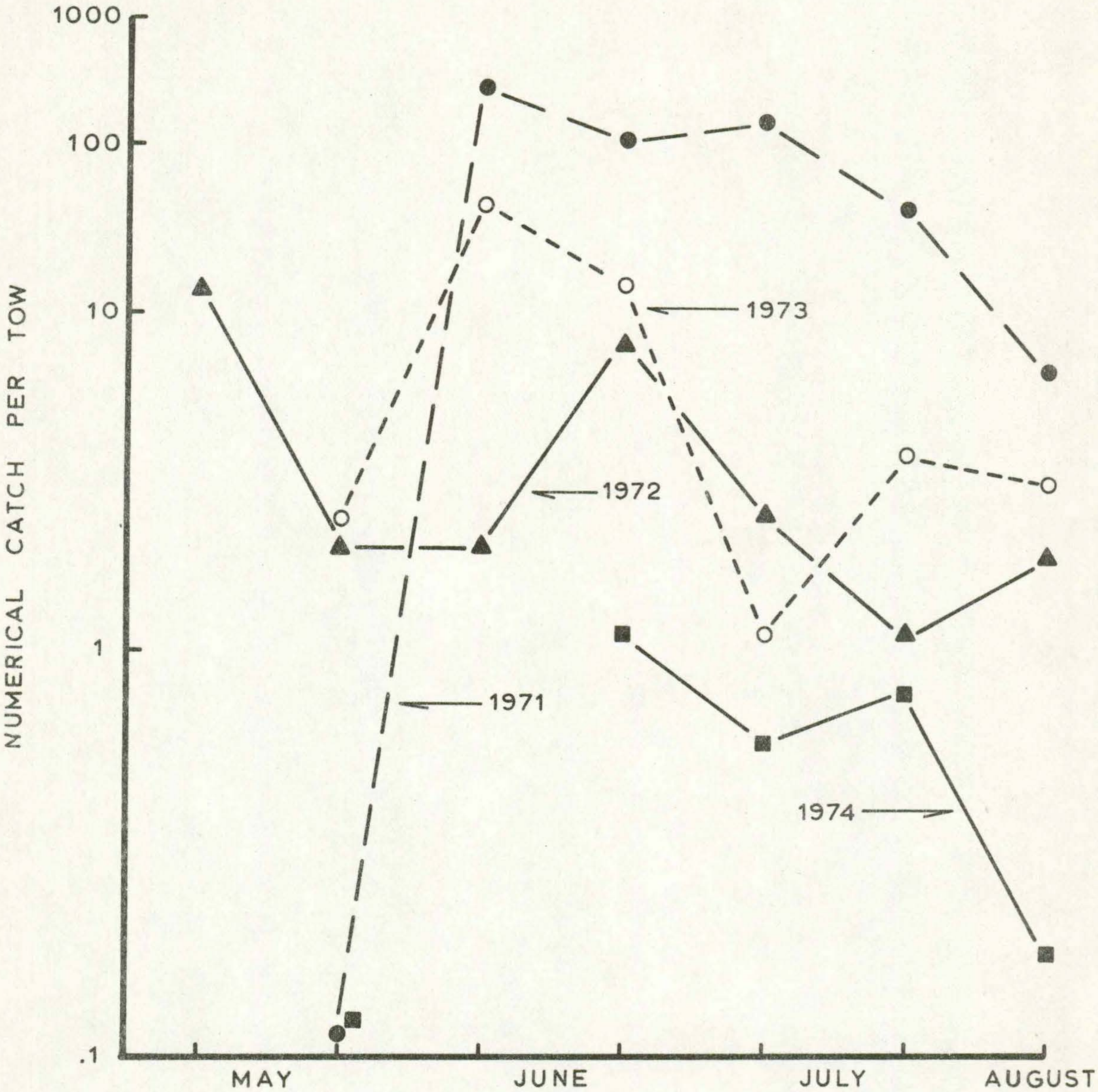

Figure 3. Mean numerical catch of 0-age bluegill in meter net tows, 1971-74.

A major change in the horizontal distribution of postlarval gizzard shad within the midwater habitat might require additional adjustment in sampling fractions for computing postlarval population density. This year catch means in the lower reservoir stations were significantly lower than the mid- and upper reservoir sampling stations. Spatial distribution of 0-age crappie remained identical with previous years.

Total production of postlarval gizzard shad this season was the highest ever recorded despite the reduced numerical population density. The increase was due to greater growth in body weight and higher survival of larger young fish. Low reproduction of postlarval crappie and bluegill reduced total production to record low levels in 1974. Crappie production has a history of fluctuating periodically and low production in a single season is not serious. But, over the past four seasons bluegill have become decreasingly unimportant until at present they are of minor consequence for sport fish or forage in Lake Rathbun.

RECOMMENDATIONS

Sampling of postlarval fish populations should continue using identical methods and procedures for the collection of fish samples and analysis of the numerical catch data. Changes in the horizontal distribution of postlarval gizzard shad should be evaluated in detail to determine if alteration of sampling fractions are necessary for computing the population density.

LITERATURE CITED

Mayhew, J. 1974. Abundance, distribution, mortality and production of 0-age fish. Annual D-J Performance Report. Project 4-11-R-1. Iowa Conservation Commission. 83 p.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-2

TITLE: Abundance, distribution and utilization of planktonic fish food organisms

STUDY NO.: 701-4

JOB NO.: 2

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: The numerical abundance of Cladocera in standardized net plankton tows was 13.2 N/l in 1974, reversing the downward trend over the previous three years. Seasonal abundance followed nearly the same distribution having a single mode of 68.56 N/l in the late May sampling period. Copepoda population density showed a similar trend of reversing low populations in the last two seasons. The mean number captured this year was 6.65 N/l compared to 4.06 N/l in 1972 and 2.70 N/l in 1973. Temporal distribution of Copepoda was nearly identical with other years and attained the highest density of 5.06 N/l in the late May samples. The horizontal and vertical distribution of Cladocera was different in 1974 than in previous years. Higher numbers of organisms were captured in midwater, and nearly a complete absence was recorded in net tows in the shallow water stations after mid-June. The lack of organisms in this habitat was attributed to predation by postlarval gizzard shad. Examination of the stomach contents of 0-age bluegill indicated Cladocera and Copepoda were the principle food items. Copepoda were selected for food in early sampling periods and Cladocera in later samples. By late July postlarval bluegill fed entirely on Cladocera. The relationship between 0-age gizzard shad and bluegill for food are discussed.

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Fisheries Research Supervisor

Date Prepared: 1 March, 1975

JOB 2 OBJECTIVE

Determine the abundance and distribution of planktonic fish food organisms and the utilization of these organisms by 0-age fish.

INTRODUCTION

Systematic sampling of zooplankton populations that are used for food by postlarval fish was continued in 1974. Collections were started on 2 May and continued for consecutive 22 weeks, terminating on 4 October. Only *Cladocera* and *Copepoda* were enumerated this year because *Rototoria* was not consumed by the 0-age fish species included in the study. Utilization of *Cladocera* and *Copepoda*, including C. *nauplii* advanced past stage IV, was determined for postlarval bluegill during this segment. The relationship between the abundance of 0-age fish and zooplankton was analyzed by linear and correlation regression.

STUDY BACKGROUND

Zooplankton samples were collected weekly for 22 weeks with standardized net plankton tows during 1971-73. The numerical abundance of *Cladocera* declined in the period from an overall mean of 21.4 per liter in 1971 to 6.3 per liter in 1973. *Copepoda* showed nearly the same trend from a maximum density of 24.2 per liter in 1971 declining to 2.8 per liter in 1973. *Rototoria* was also enumerated by were seldom used for food by 0-age fish.

Seasonal abundance of *Cladocera* and *Copepoda* was quite similar, varying mostly in numerical density rather than seasonal production Highest populations always occurred early in the season. After young fish became abundant in the shallow water habitat, *Cladocera* and *Copepoda* were seldom found in net tows. There was direct proportionality between the abundance of 0-age gizzard shad and *Cladocera*, with the shad controlling the abundance of the food organism.

Food habit studies revealed *Cladocera* and *Copepoda* were the principle organisms consumed by gizzard shad and crappie, but at different times of the season. Shad selected *Copepoda* in early life stages, changing to *Cladocera* at about 24 mm body length. First food of postlarval crappie was *Cladocera*, followed by a change to mostly *Copepoda* at about 13 mm.

METHODS AND PROCEDURES

Collection methods and plankton enumeration procedures were identical with the previous years, except *Rototoria* were excluded from the counts. The analysis variance in catch means was completed in the same manner as before, but the expected means square reflected the additional year of sampling. Food consumption studies for 0-age bluegill follow the same procedure as earlier studies for gizzard shad and crappie.

FINDINGS

ABUNDANCE AND DISTRIBUTION OF CLADOCERA

The numerical abundance of *Cladocera* in 1974 was 13.2 N/1 reversing the systematic decline from 21.3 N/1 in 1971, 10.5 N/1 in 1972 and 6.3 N/1 in 1974. Zooplankton catches at individual sampling stations from 0 at most shallow water stations after early July to 102.26 N/1 at Station 4B (Table 9). The most notable change in abundance of *Cladocera* from previous seasons was the nearly complete absence of these organisms at Station 7, 8 and 9 after the late June sampling interval. In 42 net plankton tows from 28 June through 4 October only a single specimen was captured at the shallow water stations.

Seasonal abundance of *Cladocera* followed the same distribution as the other years. Highest density occurred in the late May net tows when the average catch was 68.56 N/1 (Figure 4). Catch means in subsequent sampling intervals declined as follows: early June, 36.93 N/1; late June, 20.62 N/1; early July, 6.32 N/1; late July, .73 N/1; early August, .88 N/1; late August, .73; early September, 2.20 N/1; and late September, 1.02 N/1. Seasonal distribution of *Cladocera* in 1974 closely followed that recorded in 1972.

Cladocera continued to show highly significant variation ($P < .01$) in horizontal and vertical distribution (Table 10), although some changes in the distribution occurred when the 1974 catch statistics were analyzed with that from previous study years. Catch means at the midwater and shallow water stations were significantly different at the 99% level. Overall mean catch was 12.37 N/1 at shallow water stations compared to 13.06 N/1 at midwater stations. During the first three seasons, significant variations were noted among the shallow water habitats with highest counts occurring in the embayments. After adding the 1974 distribution data, the difference in catch means between these habitat types became insignificant. Highly significant ($P < .01$) variation continued in the vertical distribution of *Cladocera* among the midwater stations. Catch means for the surface net tows was 11.7 N/1 compared to 14.4 N/1 for the deep tows.

ABUNDANCE AND DISTRIBUTION OF COPEPODA

The overall mean catch of *Copepoda* in net plankton tows during 1974 was 6.65 N/1 compared to earlier catch means of 24.20 N/1 in 1971, 4.06 N/1 in 1972 and 2.79 N/1 in 1973. Range in catch values was from 0 to a maximum of 51.57 N/1 at Station 3B during early May sampling (Table 11). Seasonal abundance of *Copepoda* was somewhat different during this year compared to earlier seasons. Numerical catch was quite higher, averaging 17.93, 23.44 and 19.00 N/1 during the first three sampling intervals (Figure 5). In late June, *Copepoda* abundance declined sharply to 5.85 N/1 followed by rather stabilized abundance that varied slightly above or below 1 N/1 until the last interval when no *Copepoda* were captured.

Factorial analysis of variance in the mean numerical catch of *Copepoda* revealed continued heterogenous horizontal and vertical distribution of these organisms (Table 12). Highly significant differences occurred in catch means between the midwater and shallow water stations. Mean catch of *Copepoda* at the shallow water station over all years was 7.87 N/1 and for the midwater tow the

Table 9. Catch of *Cladocera* in net plankton tows at Lake Rathbun, 1974.

		Sampling interval										
Station	Depth	5/2-5/16	5/17-5/30	6/1-6/13	6/14-6/27	6/28-7/11	7/12-7/25	7/26-8/8	8/9-8/22	8/23-9/4	9/5-9/18	9/19-10/4
2	A	7.81	78.35	31.87	10.60	9.25	0.00	0.00	0.00	0.00	6.62	0.00
	B	5.30	83.34	37.18	17.22	14.59	0.00	0.00	3.98	0.00	3.98	1.32
3	A	6.61	61.09	17.77	17.22	5.26	1.32	0.00	0.00	0.00	2.63	1.32
	B	10.60	86.32	23.87	15.90	19.89	2.63	3.98	0.00	5.30	1.32	0.00
4	A	5.26	66.39	62.41	38.49	2.63	0.00	0.00	3.98	0.00	1.32	6.62
	B	9.27	102.26	54.44	15.92	5.26	2.63	3.98	0.00	1.32	2.63	0.00
7	A	3.98	65.04	26.54	53.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	A	5.30	22.56	42.48	7.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	A	3.98	51.77	35.83	9.30	0.00	0.00	0.00	0.00	0.00	1.32	0.00
Mean		6.45	68.56	36.93	20.62	6.32	.73	.88	.88	.73	2.20	1.02
$S_{\overline{x}}$		.77	7.67	4.80	5.04	2.34	.37	.58	.58	.58	.69	.72

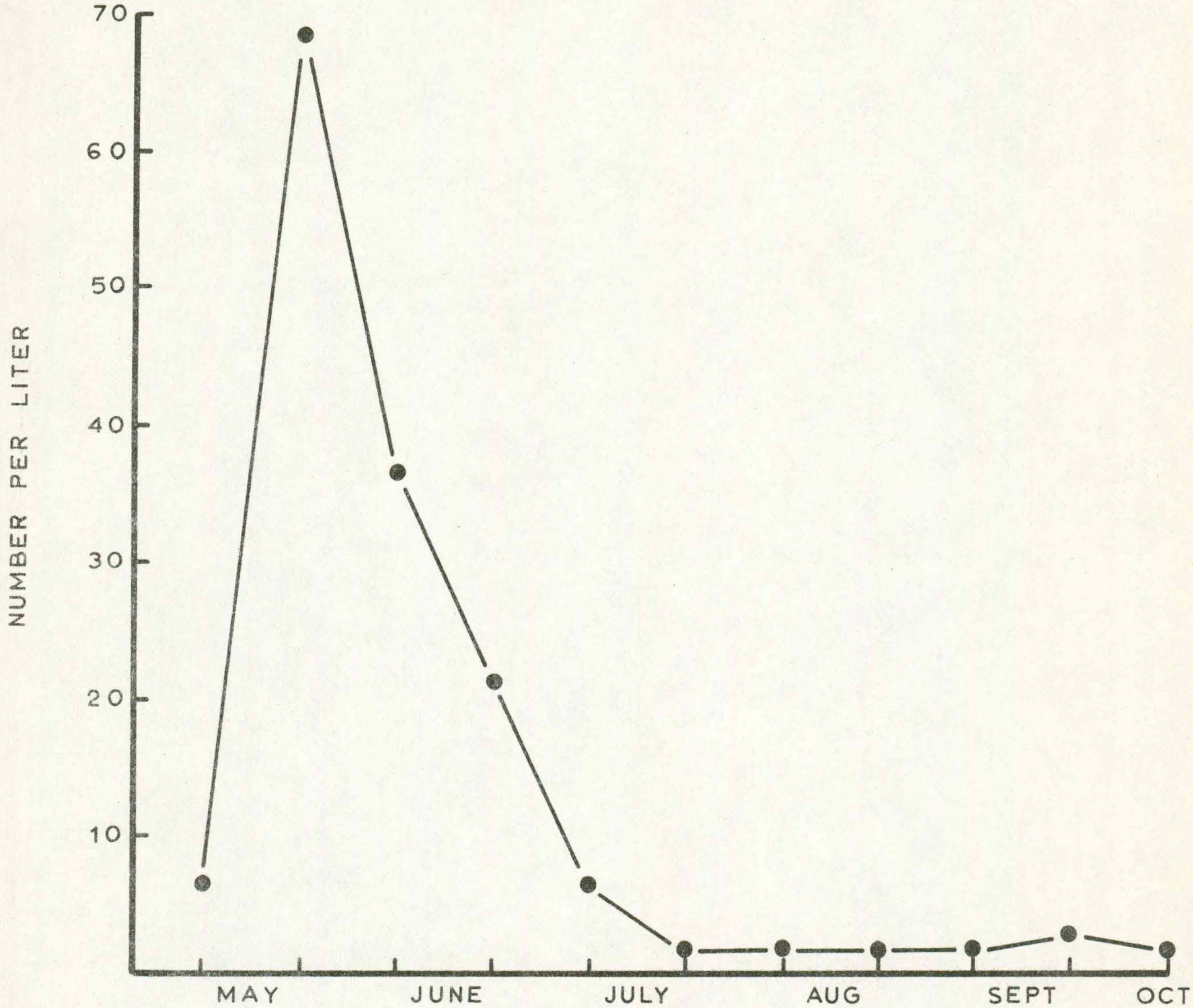

Figure 4. Seasonal abundance of *Cladocera* in net plankton tows at Lake Rathbun, 1974.

Table 10. Factorial analysis of variance in the catch of *Cladocera* in net plankton tow at Lake Rathbun, 1971-74. Data are transformed by $\log_{10} X + 1$.

Source of variation	df	SS	MS
Year	3	19.411	6.470**
Station	(8)	(4.431)	(.553)**
Midwater vs shallow water	1	1.700	1.700**
Among midwater	5	2.448	.489**
Among shallow water	2	.283	.142
Year x station	24	2.087	.087
Period	10	75.940	7.594**
Year x period	30	15.377	.513**
Residual	320	21.813	.068
Total (corrected)	395	139.059	

**Significant at the .01 level.

Table 11. Catch of *Copepoda* in net plankton tows at Lake Rathbun, 1974.

Station	Depth	Sampling interval 5/2-5/16	5/17-5/30	6/1-6/13	6/14-6/27	6/28-7/11	7/12-7/25	7/26-8/8	8/9-8/22	8/23-9/4	9/5-9/18	9/19-10/4
2	A	14.59	35.83	21.20	1.32	2.63	0.00	0.00	0.00	0.00	0.00	0.00
	B	11.79	37.18	15.90	1.32	10.60	0.00	0.00	0.00	1.32	2.63	0.00
3	A	45.24	18.57	15.90	1.32	3.98	1.32	0.00	0.00	2.63	2.63	0.00
	B	14.31	51.77	23.87	13.27	7.97	0.00	0.00	0.00	0.00	1.32	0.00
4	A	19.63	22.56	15.94	7.97	1.32	0.00	0.00	1.32	0.00	0.00	0.00
	B	12.31	11.92	17.22	19.51	6.62	1.32	1.32	1.32	1.32	1.32	0.00
7	A	27.88	15.90	30.53	1.32	0.00	0.00	0.00	1.32	1.32	1.32	0.00
8	A	13.12	13.27	13.23	0.00	0.00	0.00	0.00	1.32	1.32	0.00	0.00
9	A	2.50	3.98	17.22	6.62	0.00	0.00	0.00	2.63	1.32	0.00	0.00
Mean		17.93	23.44	19.00	5.85	3.68	.29	.15	.89	1.03	1.02	0.00
$S_{\bar{x}}$		4.09	5.06	1.79	2.25	1.30	.19	.14	.31	.29	.36	0.00

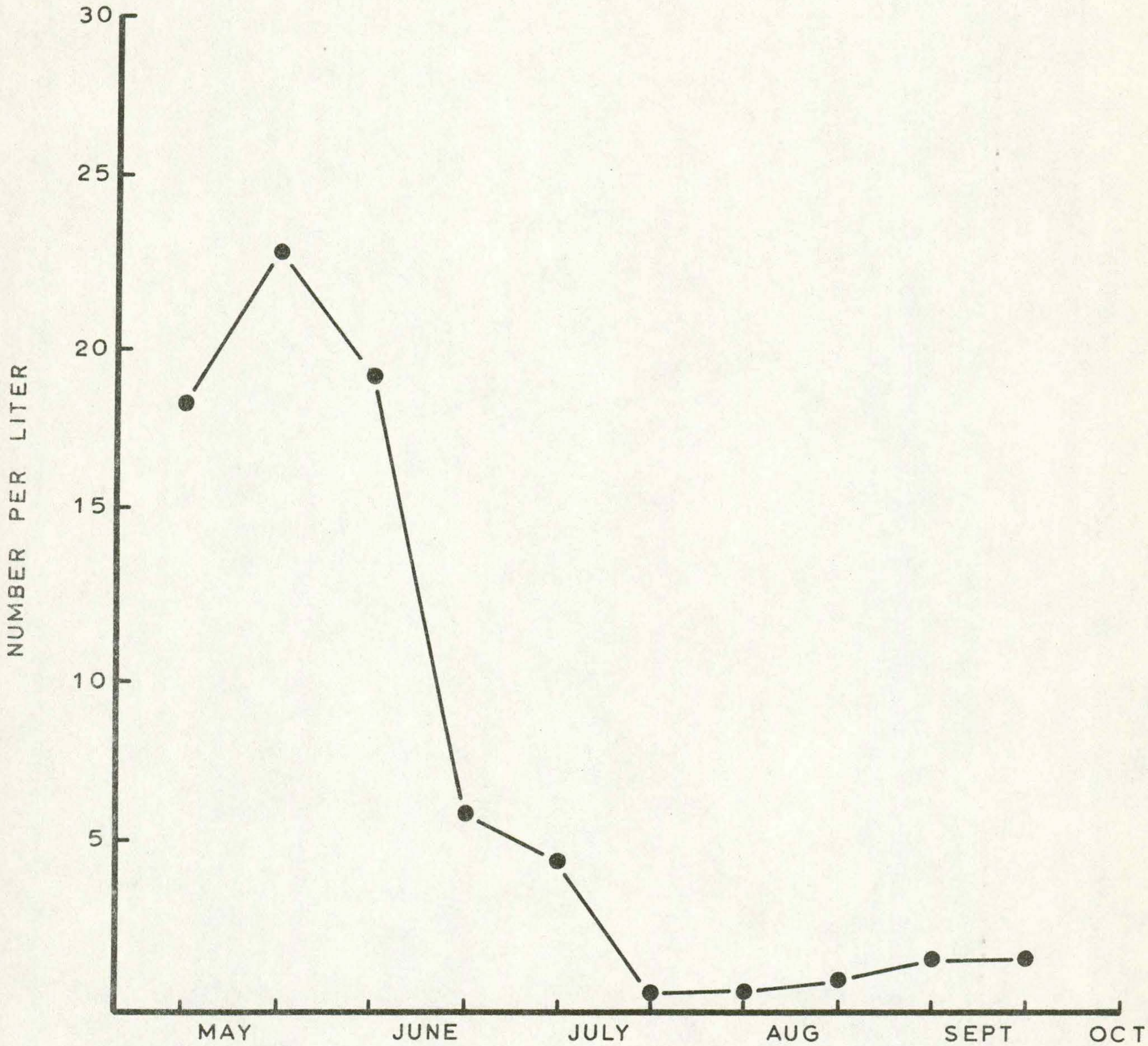

Figure 5. Seasonal abundance of *Copepoda* in net plankton tows at Lake Rathbun, 1974.

Table 12. Factorial analysis of variance in the catch of *Copepoda* in net plankton tows at Lake Rathbun, 1971-74. Data use transformed by $\log_{10}X + 1$.

Source of variation	df	SS	MS
Year	3	37.420	12.473**
Station	(8)	(2.136)	(.267)**
Midwater vs shallow water	1	1.413	1.413**
Among midwater	5	.276	.055
Among shallow water	2	.447	.224*
Year x station	24	1.501	.063
Period	10	59.533	5.953**
Year x period	30	12.909	.430**
Residual	320	18.473	.058
Total (corrected)	395	131.971	

*Significant at the .05 level.

**Significant at the .01 level.

mean was 10.19 ($P < .01$). There was also significant difference in the horizontal distribution of *Copepoda* within the shallow water habitat. Overall mean catch was 10.43 N/1 at Station 7, along the shoreline of the main pool, 6.03 N/1 at Station 8 in the Honey Creek embayment and 7.17 N/1 at Station 9 in the Buck Creek area. Tests of these paired values by orthogonal contrast showed the Station 7 catch was significantly higher than catch values in the embayments at the 95% level. *Copepoda* were uniformly distributed in all attitudes among the midwater stations.

UTILIZATION OF ZOOPLANKTON FOR FOOD BY 0-AGE BLUEGILL

Stomach contents from the entire 1974 catch of 0-age bluegill was microscopically examined to determine the utilization of zooplankton for food. Electivity of zooplankton for food by this fish species was determined by the Ivlev (1961) procedure.

Postlarval bluegill first appeared in the net tows during mid-June and continued in the catch during the two following intervals. Stomach contents from 29 bluegill were examined from the three periods. Eight fish were captured in late June, 14 during early July and 7 in late July (Table 13). Body length ranged from 4-7 mm and averaged 5.2 mm in the first interval; 4-17 mm range and 6.3 mm mean in the second period; 8-12 mm range and 9.3 mm mean in the last period.

Table 13. Number, range and mean body length of postlarval bluegill used for food consumption studies in 1974.

Sampling interval	Number of stomachs examined	Total body length in mm: Range	Mean
6/17-6/30	8	4- 7	5.2
7/1 -7/13	14	4-12	6.3
7/14-7/27	7	8-12	9.3

Twenty of the 29 bluegill examined consumed zooplankton in their diet. Of the 9 fish that had empty stomachs 2 were captured in the late June samples, 6 in the early July period and 1 in the late July interval (Table 14). Postlarval bluegill consumed only *Cladocera* and *Copepoda*, including *C. nauplii* advanced past stage IV. *Copepoda* were slightly more numerous in the diet in late June, 51% compared to 49% for *Cladocera*. However, as body size increased *Cladocera* became increasingly more important for food until in late July feeding was exclusive for *Cladocera*. In the early July period *Cladocera* comprised 69% and *Copepoda* 31% of the diet.

Table 14. Percent composition and number of stomachs examined containing zooplankton for postlarval bluegill in 1974.

Sampling interval	Number of stomachs examined	Number containing food items	*Cladocera* Number	*Cladocera* %	*Copepoda* Number	*Copepoda* %
6/17-6/30	8	6	45	49	47[a]	51
7/1 -7/13	14	8	38	69	17	31
7/14-7/27	7	6	32	100	0	0

[a]*C. nauplii* comprised 19% of the *Copepoda* found in the stomachs.

Electivity indices for zooplankton used as food by postlarval bluegill showed positive selectivity of *Copepoda* in the late June period, when the fish averaged 5.2 mm in body length. *Cladocera* were also consumed but the negative electivity value indicated they were not being sought as food. By the early July sampling period *Cladocera* were being positively selected for food by bluegill, while *Copepoda* were being incidentally eaten. Mean body length of the postlarval bluegill in this period was 6.3 mm. In the last period only *Cladocera* were found in the stomach contents. The mean body length of fish in this period was 9.3 mm.

Table 15. Electivity index of zooplankton found in the stomach content of postlarval bluegill in 1974.

Sampling interval	Electivity index *Cladocera*	Electivity index *Copepoda*
6/17-6/30	- .22	+ .38
7/1 -7/13	+ .45	- .58
7/14-7/27	+1.00	-1.00

RELATIONSHIP BETWEEN 0-AGE FISH AND ZOOPLANKTON ABUNDANCE

The interrelationship between the numerical abundance of 0-age fish and zooplankton was analyzed by making simple plots of the overall catch mean of 0-age fish each year on the catch mean of zooplankton for the same year. If the relationship appeared visually close, further analysis was made by regression and correlation procedures to test the significance. The overall catch mean of postlarval fish was chosen over total production as an expression of population density because the latter was grossly affected by the time fish spawned.

Only one significant relationship, an inverse association between postlarval gizzard shad and *Cladocera* appeared from the analysis. Crappie and bluegill abundance had no apparent effect upon zooplankton abundance. As postlarval gizzard shad density increased there was a significant linear decrease in the density of *Cladocera* (Figure 6). Based on the initial four years of sampling, increasing the overall numerical catch mean of postlarval shad in the tows by 100 units would decrease the occurrence of *Cladocera* in the net plankton tows by slightly over 12 units. The relationship can best be described by the linear function

$$y = 410.9 - 12.3x$$

where, y = mean number of 0-age shad captured per standardized meter net tow and x = mean number of *Cladocera* per liter in standardized net plankton tows. The sample standard deviation from regression ($S_{y.x}$) was 20.6 and the correlation coefficient (r) was .957, which was significant at the .05 level of sampling probability.

DISCUSSION OF FINDINGS

The overall numerical abundance of *Cladocera* and *Copepoda* this season reversed the systematic downward trend observed in the first three years of sampling. Both taxa attained second highest population density levels, surpassed only by the first year. However, the increase in zooplankton populations, especially *Cladocera*, occurred at only midwater sampling stations. *Cladocera* populations in the shallow water tow, particularly the embayment stations, were lower in 1974, and were for the most part absent in most net tows after postlarval gizzard shad became numerous in these areas. The low populations of zooplankton at these stations was evidently due to predation by this fish species. *Copepoda* population abundance at shallow water stations did not show a similar precipitous decline, but postlarval crappie, which is their main consumer, was not present in high numbers this season.

Comparison of the food habits of 0-age fish in Lake Rathbun indicated quite severe competition for zooplankton by postlarval gizzard shad and bluegill. In fact, the evidence is fairly strong that gizzard shas might be primarily responsible for the continuous decline of bluegill in the lake following initial impoundment. Both fish species are consuming identical zooplankton species at nearly the same periods of the year. Further, both fish species occupy the same

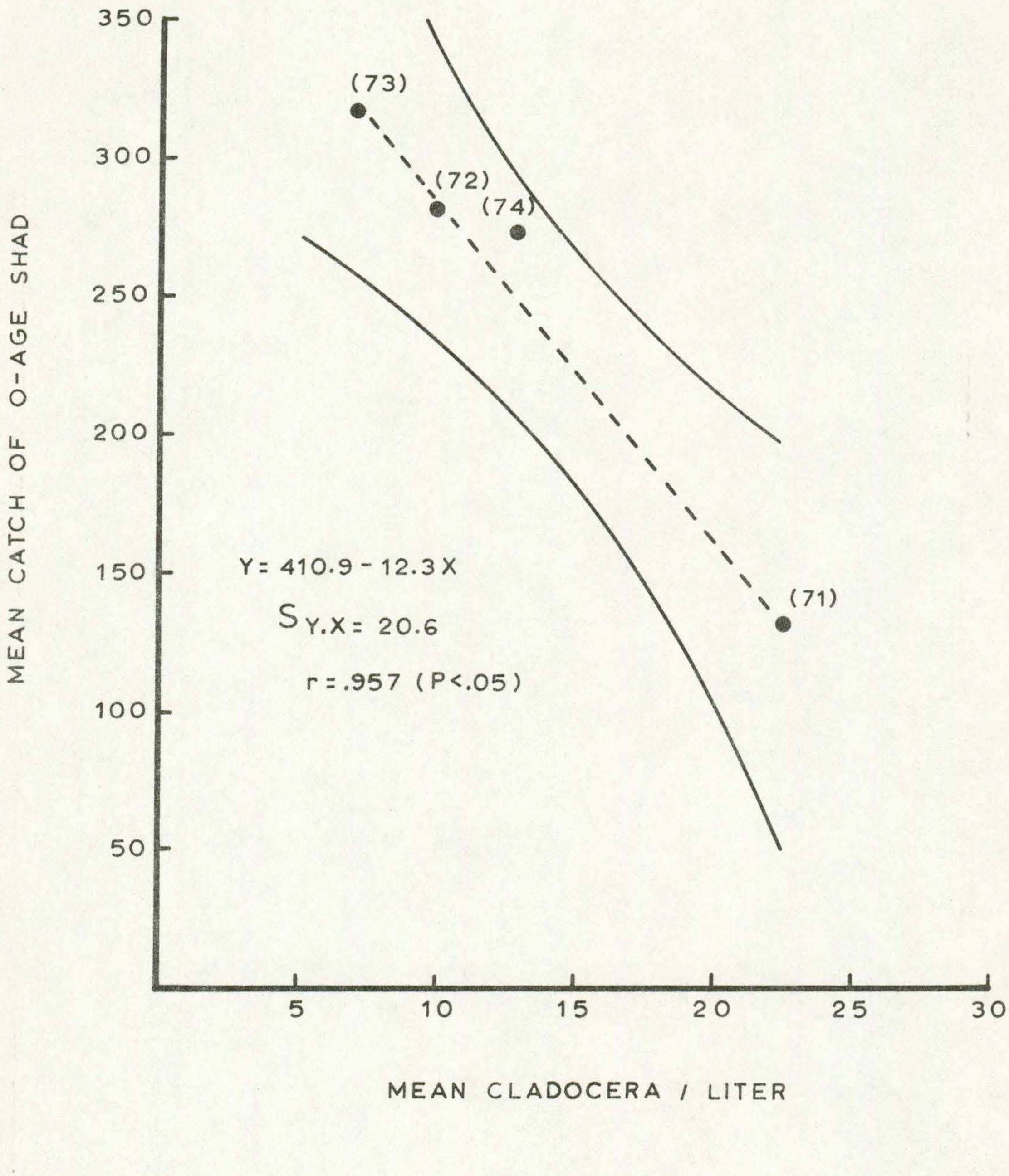

Figure 6. Relationship between mean number of 0-age gizzard shad per meter net tow and mean number of *Cladocera* per net plankton tow.

habitats, except postlarval bluegill remain in shallow water throughout the first summer, while gizzard shad become pelagic in mid-season. By the time gizzard shad become pelagic a majority of the zooplankton population has been consumed leaving other fish species without food. Postlarval crappie also forage the same zooplankton as gizzard shad and bluegill, but at entirely opposite times of the season.

RECOMMENDATIONS

Sampling of zooplankton population to further define the abundance and distribution should continue using the identical schedule and analytical procedures.

LITERATURE CITED

Ivlev, V. 1961. Experimental ecology of feeding of fishes. Yale Univ. Press, New Haven. 302 p.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-2

TITLE: Identification and evaluation of the factors that influence 0-age fish production

STUDY NO.: 701-4

JOB NO.: 3

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *Simple linear regression analyses were conducted to test significant relationships between the reservoir water regimen and the numerical density of 0-age fish and zooplankton fish food organisms. Storage volume, flushing rate, water temperature and turbidity were used as measures of reservoir operations for flood control. Four relationships were found significant. These were: gizzard shad vs flushing rate, gizzard shad vs temperature, Cladocera vs flushing rate, and Cladocera vs temperature. Flushing rate and temperature were also intraclass correlated. Some postulations of the interrelationship between these 0-age gizzard shad, Cladocera and reservoir operations are discussed. Operation of the reservoir to maintain a flushing rate of 415 days would produce the maximum population density of postlarval gizzard shad with the available zooplankton food supply.*

Author: James Mayhew
Fisheries Research Supervisor

Date Prepared: 1 March, 1975

JOB 3 OBJECTIVE

To identify and evaluate the factors that directly and indirectly influence the abundance of 0-age fish and use these variables to develop preliminary models of fish production.

INTRODUCTION

The operation of Lake Rathbun for flood water management potentially effects the biota in many direct and indirect ways. Temporary water impoundment or accelerated water release at critical life stages of young fish might result either in success or failure of an entire year class. Consequences might also appear in more subtle ways by causing changes in the presence of organisms vital to the survival of 0-age fish, such as planktonic fish food organism. Through operation of the reservoir at optimum levels the possibility exists for stabilized production of 0-age fish or at least create environmental conditions that would likely produce stronger fish year classes. But, first the factors that influence fish production must be recognized.

Measurements of parameters related to flood water control have been collected each season since 1971. In one way or another each parameter was related to temporary storage of flood water. Some of the parameters were directly associated with the water regimen, such as storage volume and flushing rate. Other factors, such as water temperature and turbidity were less closely associated to water storage, but were important to fish production and effected by reservoir operations for flood management.

The main emphasis in this project segment was to test simple linear relationships between the abundance of 0-age fish and zooplankton fish food organisms as the dependent variables and the reservoir operation parameters; storage volume, flushing rate, temperature and turbidity as the independent variables. Preliminary intraclass correlation tests between the independent variables were also completed. All of these analyses were prefatory evaluations of the effects of reservoir operations on the production of 0-age fish and planktonic fish food organism and must not be misinterpreted as final conclusions. Additional data must be obtained before complex models can be developed.

STUDY BACKGROUND

Activity during the first three project segments was confined to the collection of data without any attempt to relate the water regimen to the population density of 0-age fish and zooplankton. The first two years of impoundment were characterized by low level storage of water for flood control. In 1973, major flooding occurred in the watershed and water impounded to record levels extending over nearly a seven month period. Flood control procedures were initiated in early February and the reservoir remained above conservation pool elevation until mid-September.

Mean water volume storage in the three seasons ranged from 2.011 million m^3 in 1971 to 3.066 million m^3 in 1973. Flushing rate varied from 277 days in 1973 to 702 days in 1971. Mean water temperature for these project segments were 22.9°C in 1971, 22.1°C in 1972 and 21.6°C in 1973. Turbidity varied from 1.4 FTU in 1971 to 16.3 FTU in 1973.

METHODS AND PROCEDURES

Daily water storage volume and outlet discharge data were obtained from the Reservoir Project Office from 1 April through 31 October each year. Means were computed for each parameter for biweekly periods that corresponded with the fish and zooplankton sampling intervals. Several times outflow discharge was reduced to very low volume for reasons not related to flood control and these values were excluded. Closure to low flow during flood control procedures was of short duration, less than one day, and had little effect on storage volume. When discharge rate was changed more than once each day the rates were averaged.

Flushing rate was merely a measurement of the time water was stored in the reservoir and represented the best description of reservoir operation. It was computed from the quotient of storage volume and discharge rate over a single day. The mean for the season was calculated by obtaining the grand average from the biweekly mean rate in the same manner as storage volume. Flushing rate can be altered by either changing outflow discharge or storage volume. As flushing rate of the reservoir increased storage time decreased at a proportional rate, and vice versa. However, the relationship between flushing rate and storage volume should not be misinterpreted as exactly proportional because the lake basin does not form a perfect cone, curving in a concave configuration toward the water surface.

Surface water temperature was recorded at each meter net tow and net plankton sampling location with a Whitney Underwater Thermometer. Temperature at the stations were averaged for the biweekly interval and the seasonal grand average computed from biweekly means.

Turbidity was measured at the surface sampling stations each week with a Hach Model 1860A turbidimeter. Values were expressed in Formazin turbidity units (FTU). Seasonal mean turbidity was computed in the same manner as temperature.

Simple least squares regression procedures were used to determine the relationship between the abundance of 0-age fish, zooplankton and the reservoir water regimen. Numerical density of fish was selected over biomass production because the latter contained instantaneous growth and mean biomass as equation components. Both factors were influenced by spawning time and were more variable than numerical density. Delayed spawning greatly reduced the mean weight of fish at comparable sampling periods in years with earlier reproduction.

The regression model was the standard least squares equation

$$Y = \alpha + \beta x + \varepsilon$$

where, Y was the standardized measure of 0-age fish and zooplankton density, x was the unique effects of water volume storage, flushing rate, water temperature and turbidity and ε was the random variable drawn from a normally distributed series. Significants for regression was tested in the usual t-distribution at the .05 level of sampling probability using the standard error of the regression coefficient. Confidence intervals were computed from the sample standard deviation. Simple product moment correlation coefficients were computed in the usual fashion for all independent variables to test intraclass correlation.

FINDINGS

Mean water storage volume for the four years were as follows: 1971, 2.011 million m^3; 1972, 2.079 million m^3; 1973, 3.066 million m^3 and 1974, 2.166 million m^3 (Table 16). Comparable flushing rate for these years was 702, 376, 277 and 412 days, respectively. Mean water temperatures were 22.9°C, 22.1°C, 21.6°C and 22.1°C for these seasons. Turbidity means for these years were 1.4 FTU, 5.5 FTU, 16.3 FTU and 13.5 FTU.

Table 16. Mean annual storage volume, flushing rate, water temperature and turbidity in Lake Rathbun, 1971-74.

	Storage volume (million m^3)	Flushing rate (days)	Water temperature (°C)	Turbidity (FTU)
1971	2.011	702	22.9	1.4
1972	2.079	376	22.1	5.5
1973	3.066	277	21.6	16.3
1974	2.166	412	22.1	13.5

Simple product moment correlation analyses between the independent variables showed a highly significant positive correlation ($P < .01$) between flushing rate and water temperature (Table 17). As flushing rate increased storage time of water in the reservoir decreased producing lower mean water temperature. Significant intraclass correlation was lacking between the other independent variables. However, a sample size of four years was quite small and required high minimum values to achieve significant levels. Additional sampling might generate significant relationships in the future.

Numerical density of 0-age fish and zooplankton in net tows varied widely from year to year and between species. Overall mean catch of postlarval shad was 131.6 per tow in 1971, 281.3 in 1972, 315.0 in 1973 and 281.7 in 1974 (Table 18). The mean catch per tow of 0-age crappie was 17.3 in 1971, 7.7 in 1972, 33.9 in 1973 and 3.2 in 1974. Postlarval bluegill catch means for the four years was 116.6, 6.3, 13.7 and .4, respectively. Catch means for *Cladocera* in standardized net plankton tows was 21.4 N/l in 1971, 10.5 in 1972, 6.3 in 1973 and 13.2 in 1974. *Copepoda* catch means for comparable seasons were 24.2, 4.1, 2.8 and 6.7 N/l, respectively.

Table 17. Matrix of simple product moment intraclass correlation coefficients between independent variables of the water regimen at Lake Rathbun.

	Storage volume (million m^3)	Flushing rate (days)	Water temperature (°C)	Turbidity (FTU)
Storage volume	1.0			
Flushing rate	-.603			
Temperature	-.536	.958[a]	1.0	
Turbidity	.775	-.734	-.876	1.0

[a]Significant at the 99% level.

Table 18. Numerical catch means per standardized net tow of 0-age fish and zooplankton used as the dependent variables in regression analysis.

	Postlarval fish			Zooplankton	
	G shad	Crappie	Bluegill	*Cladocera*	*Copepoda*
1971	131.6	17.3	116.6	21.4	24.2
1972	281.3	7.7	6.3	10.5	4.1
1973	315.0	33.9	13.7	6.3	2.8
1974	281.7	3.2	.4	13.2	6.7

Twenty simple linear regressions were tested to determine the relationship between the parameters associated with reservoir operation and the abundance of 0-age fish and zooplankton population. Four were found significant at the .05 level or higher. These were: gizzard shad vs flushing rate, gizzard shad vs temperature, *Cladocera* vs flushing rate and *Cladocera* vs temperature. Neither 0-age crappie or bluegill numerical abundance nor *Copepoda* density was significantly related to reservoir operation. Some loose associations were apparent, but presently they were not significant at the level required.

GIZZARD SHAD VS FLUSHING RATE

Postlarval gizzard shad abundance decreased at a linear rate as flushing rate of the reservoir increased (Figure 7). The relationship can be best described by the function

$$Y' = 434.0 - .42\ x$$

where Y' = expected mean number of shad per standardized tow and x = mean flushing rate of the reservoir. Correlation coefficient of this expression was .981 ($P < .01$). Sample standard deviation was 13.8.

GIZZARD SHAD VS TEMPERATURE

Water temperature also caused a depensatory effect on postlarval gizzard shad abundance. As mean water temperature in the reservoir increased the mean number of shad in standardized tow decreased at a significant linear rate (Figure 8). The relationship can be described by the least squares equation

$$Y' = 3520.9 - 147.4x$$

where Y' = mean catch of postlarval shad per tow, and x = mean water temperature in °C. The correlation coefficient was .965 and was significant at the 95% level. Sample standard deviation of the regression coefficient was 18.4.

CLADOCERA VS FLUSHING RATE

Flushing rate exerted a compensatory effect on *Cladocera* density. As flushing rate increased and water storage time decreased the density of *Cladocera* increased at a linear rate (Figure 9). The relationship can be expressed by the function

$$Y' = -886.0 + .032x$$

where, Y' = mean catch of *Cladocera* in standardized net plankton tows and x = mean flushing rate of the reservoir. The correlation coefficient for this linear equation was .981 ($P < .05$) and the sample standard deviation, 1.372.

CLADOCERA VS TEMPERATURE

Mean water temperature of the reservoir also showed a positive linear relationship with *Cladocera* density (Figure 10). Increased water temperature meant larger catches of *Cladocera* in the net plankton tows. The linear equation that best described this relationship was

$$Y' = -245.6 + 11.66x$$

where, Y' = mean catch of *Cladocera* in standardized net plankton tows and x = mean water temperature of the reservoir. The correlation coefficient was .963 and was significant at the 95% level. Sample standard deviation of the regression coefficient was .963.

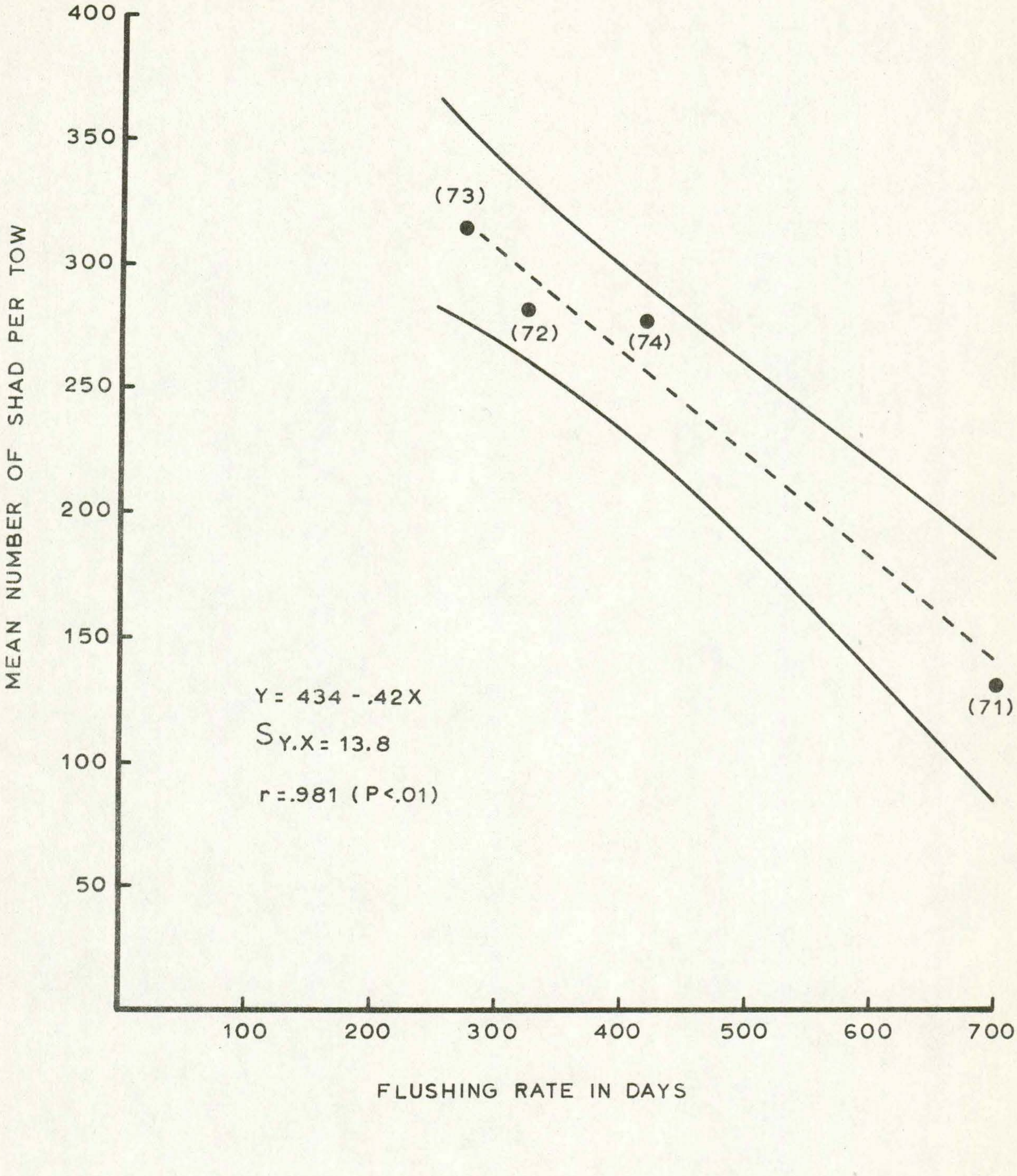

Figure 7. Relationship between mean number of gizzard shad per meter net tow and flushing rate. Broken line denotes predicted values and solid lines the 95% confidence intervals.

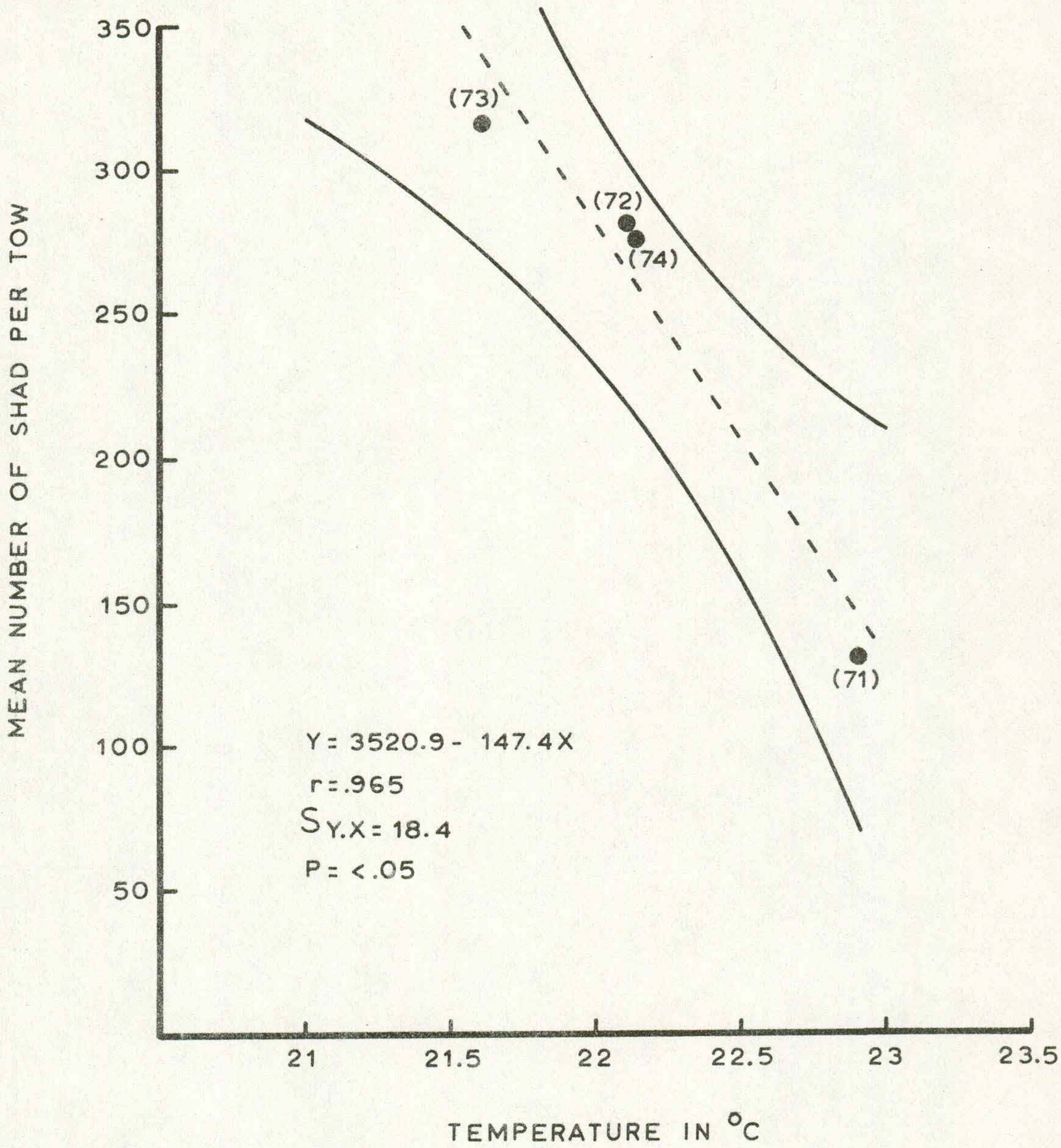

Figure 8. Relationship between mean number of gizzard shad per meter net tow and mean water temperature. Broken line denotes predicted values and solid lines the 95% confidence intervals.

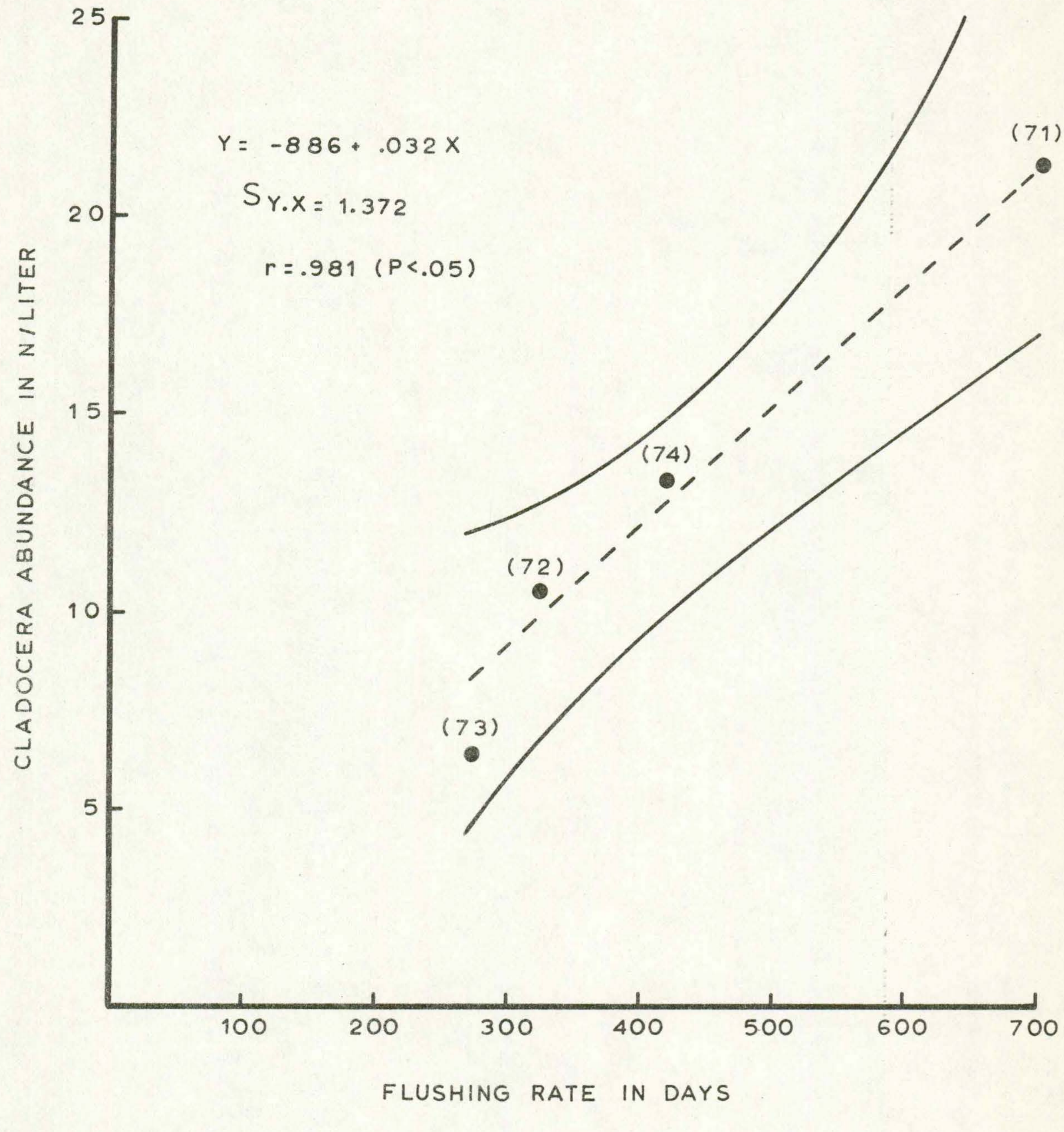

Figure 9. Relationship between *Cladocera* density in net plankton tows and reservoir flushing rate. Broken line denotes predicted values and solid lines the 95% confidence intervals.

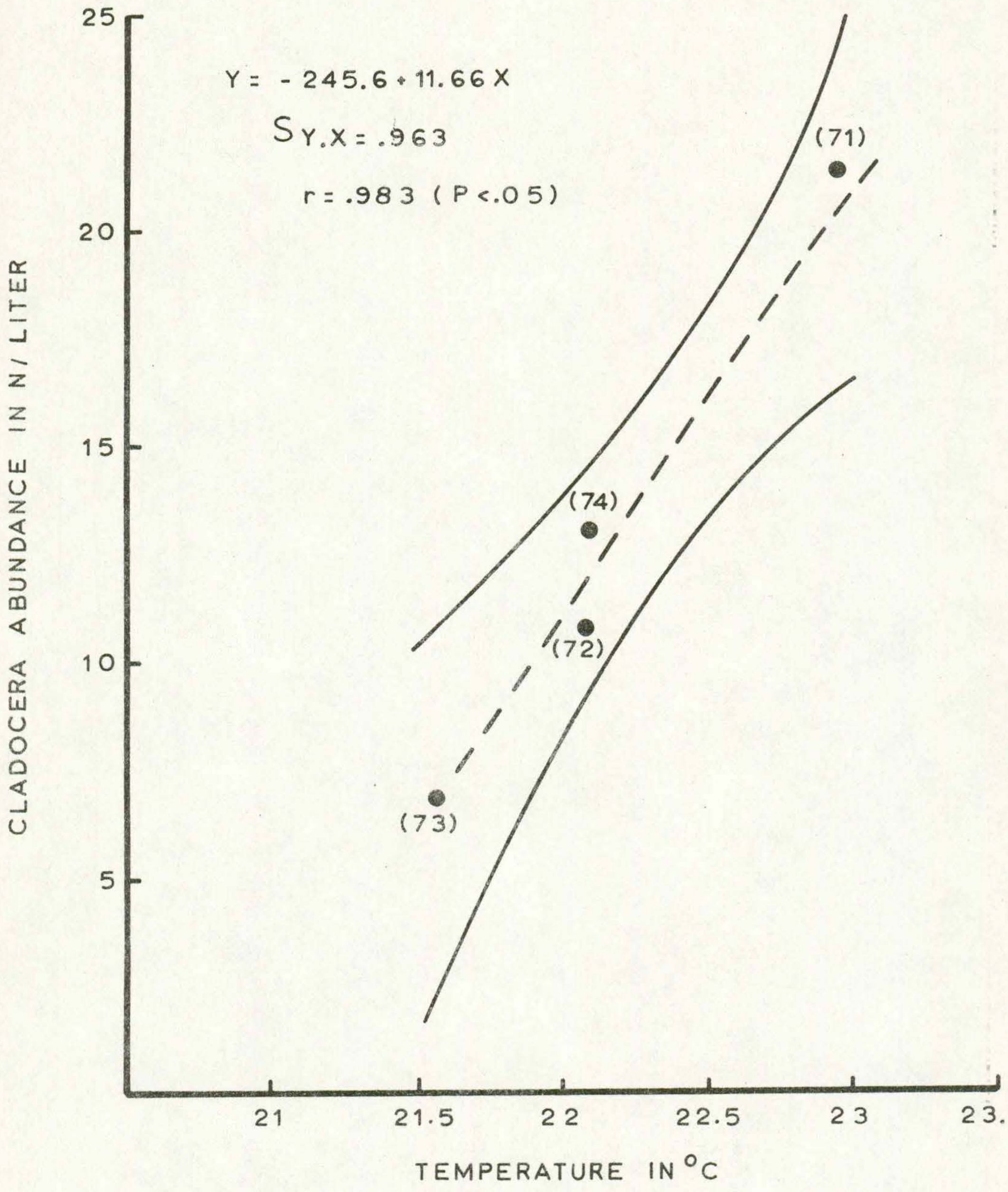

Figure 10. Relationship between *Cladocera* density in net plankton tows and water temperature in the reservoir. Broken line denotes predicted values and solid lines the 95% confidence intervals.

DISCUSSION OF FINDINGS

Preliminary results of the simple regression analysis to discern the relationship between the reservoir water regimen and 0-age fish and zooplankton abundance revealed flushing rate and water temperature significantly influenced the density of gizzard shad and *Cladocera* populations. Storage volume and turbidity showed a general tendency for association with fish production and zooplankton abundance, but the association was not significant precluding use of these variables for predictive functions. Postlarval crappie and bluegill population abundance was apparently independent of the effects of reservoir operation. *Copepoda* abundance showed some affinity for influence from flood control procedures, but the relationship was not significant at the probability level required for precise and accurate predictions.

All independent variables were related in some way to temporary storage of flood water followed by controlled release of the impounded water. However, flushing rate and water temperature were the only variables with significant intraclass correlation. This relationship was highly significant, and in affect, by measuring the influence of one of these factors the other was paralleled. Flushing rate was without doubt the principal force, because changing outflow discharge in turn altered water temperature by changing water storage time. But, changes in water temperature could not alter flushing rate.

Postlarval gizzard shad abundance increased at a significant linear rate as flushing rate decreased. By and large this seemed to be a function of increased water levels. Each time flood water was impounded above conservation pool elevation, flushing rate decreased and the mean number of postlarval shad increased in the meter net tows. No meaningful conclusion could be made with the available data other than years with increased storage of water for flood control also had the highest abundance of postlarval shad, and abundance could be predicted at the .05 level of sampling probability from reservoir flushing rate and water temperature. Crappie and bluegill production was not statistically predictable from these variables, but cursory observations during the past year indicated flooding during spawning might have caused numerous nest abandonment in the Honey Creek embayment.

Severe bank erosion from wave action along lengthy stretches of the main pool shoreline rendered most of this habitat wholly unsuitable for reproduction of substrate nesting fish species. Natural terrace benching forms at the water line causing the immediate bank to erode or slide into shallow waters along the shoreline. Continouous fluctuation of water levels for flood control compounded the erosion causing extended cutting into the banks. Composition of the immediate shoreline was exposed clay type soil and these areas are denude of vegetation. Even if terrestrial vegetation became established on these spoil banks, the first time reimpoundment occurred the cover would soon perish and erosion would continue unabated. The process causes nearly total relience for reproduction of nesting fish species in large embayments and protected shallow water coves. Dependent on this type of habitat for the production of young is somewhat precarious since a catastrophic occurrence originating in the watershed would enter these areas first and the propensity would be greater.

Flushing rate and temperature had a compensatory effect on the population density of *Cladocera*. As flushing rate increased the catch of *Cladocera* in net plankton tows increased linearly. The reason for a relationship of this nature is not clear at this time, is because it is generally the consensus from other studies in Midwest reservoirs that decreased storage time means lower basic productivity and zooplankton population density. One postulation with some strong supportive evidence was that the relationship between flushing rate and postlarval gizzard shad forms the base on which the entire biological framework rests, and *Cladocera* abundance was influenced by shad density rather than flushing rate since postlarval shad are the principal predator of this organism. As stated previously, the relationship between flushing rate and shad abundance was depensatory, while the relationship between *Cladocera* and flushing rate was compensatory. By decreasing flushing rate due to impoundment for flood control the shad population density increased in linear fashion. The increased density of postlarval shad meant proportionately higher predation by the fish on *Cladocera* populations thereby lowering their abundance.

Additional supportive information of the gross effects of high postlarval shad populations on *Cladocera* density was discernable in the samples collected from shallow water stations during 1974. The maximum postlarval shad density averaging over 2,600 fish per tow occurred in early June. Concomitant net plankton tows indicated *Cladocera* were numerous at these locations. The gizzard shad at the prevailing life stage consumed mostly *Copepoda*, although *Cladocera* were increasingly important in the diet. By late June, the postlarval density decreased to about 300 per net tow, but *Cladocera* were selected for food in large quantitites. After this sampling period only one *Cladocera* was captured in the remaining 42 shallow water tows. Apparently shad predation was of the magnitude that their primary prey was nearly extirpated. *Cladocera* population were also low in midwater, but not to the point of non-existance.

The inference must be drawn from this conjecture that year class abundance of young shad will be ultimately controlled by *Cladocera* density, since the latter is the primary fish food organism. But, except in the shallow water embayments in 1974, this point was never attained in Lake Rathbun probably for several reasons. First, although *Cladocera* were the main food item of postlarval shad other zooplankton were available and consumed. Second, postlarval shad did not remain in shallow water throughout the first year of life. Movement toward a pelagic existance occurred at 11-20 mm body length and coincided with the lower zooplankton populations in shallow water. Third, shad density was continously reduced by natural mortality, presumably from predation by piscivorous fish species. Evidence was quite apparent that young bluegill are competing for food in the same habitat with gizzard shad and their numerical abundance might be controlled by shad density. The impact of the competition on postlarval bluegill is compounded by the behavioral tendency to remain in shallow water during the entire first year of life. By mid-summer shad may have consumed most of the zooplankton in this habitat.

Operation of the reservoir to maintain downstream flood control while at the same time optimize habitat conditions for 0-age fish production would require manipulation of the flushing rate. Food availability for gizzard shad production would be an important consideration in devising operational plans. Optimum conditions would be established by providing the maximum zooplankton density for the largest population of fish. Based on the four years of data collected, the ideal flushing rate would be 415 days. Manual manipulation requirements for stabilization of flushing rates at this level are unknown at this time. Impoundment of flood water would be prerequisite, since the flushing rate at conservation pool elevation and minimum outflow is more than 2,000 days. The data further indicated exceeding the 415 day flushing rate would be more important to the reservoir biota than a lesser outflow.

RECOMMENDATIONS

Refinement of the predictive equations using additional data are recommended for further study. Some preliminary multiple variable regressions might be contemplated in the next project segment.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 702-3

JOB NO.: 1

NAME: Effects of Flood Water Management and Fish Species Introductions on Fish Populations in Large Reservoirs

TITLE: Vital statistics of fish populations in Lake Red Rock and Lake Rathbun following initial impoundment

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *The objective of this study was to measure changes in species composition, abundance, size distribution, age structure and growth of fish in Lakes Red Rock and Rathbun. Adult fish populations were sampled by means of pound and experimental gill nets while younger fish were caught by seine net. Net gear captured 11,954 fish weighing 4,075 kg at Lake Red Rock. Carp dominated, comprising 25% of the numerical catch and over 31% of the weight. Crappie were second in abundance making up 21% of the numerical catch followed by river carpsucker (19%), black bullhead (9%), gizzard shad (8%) and white bass (6%). Sport fish comprised < 5% of the catch although catch success of largemouth bass, northern pike and walleye increased from previous years. The importance of non-sport fish in the total catch of future years may be influenced by the opening of Lake Red Rock to commercial fishing. Seine hauls accounted for 12,379 0-age fish and Cyprinids. Gizzard shad was the most abundant species caught (69%) followed by crappie (12%) and white bass (6%). At Lake Rathbun, 10,721 fish were caught weighing 2,587 kg. Crappie were the most abundant fish contributing 64% of the numerical catch and 57% of the biomass. Carp was second in numerical importance with 13% followed by black bullhead (7%), gizzard shad (6%), and walleye (3%). Catch success of walleye and channel catfish has continued to decrease from previous years while largemouth bass has remained about the same. Seine hauls at Lake Rathbun captured 4,311 0-age fish and Cyprinids. Young gizzard shad dominated the catch (87%) followed by Cyprinids (9%), white bass (3%) and ocean striped bass (< 1%). Length-weight relationships, K-factors, body scale regression, length-frequency distributions and age class structure of important species of each lake are presented.*

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Date Prepared: 1 June, 1975

Approved by: James Mayhew
Fisheries Research Supervisor

STUDY OBJECTIVE

To measure the changes in abundance, species composition, size distribution, age structure and growth in important fish populations following impoundment of Lakes Red Rock and Rathbun and evaluate the impact of reservoir operations for flood control on fish poeulations and determine the effects of stocking large numbers of predatory fish species on the indigenous fish populations.

JOB 1 OBJECTIVE

To measure changes in species composition, abundance, size distribution, age structure and growth of fish in Lakes Red Rock and Rathbun.

INTRODUCTION

Large reservoirs that were constructed for temporary flood water storage and control offer a substantial fishery resource to this state. Unpredictable and instable water levels generally compound management of the sport fishery. Initially, sport fish populations were developed in the reservoirs and are maintained by continued stocking of hatchery fish. Further information is necessary, to develop a fishery management program, on the changes which occurred in the fish populations following impoundment and to what extent the populations are being influenced by flood water management and fish stocking programs.

STUDY BACKGROUND

Lake Red Rock was impounded in 1969 on the Des Moines River in Marion County. Following impoundment stocking of game fish species at Lake Red Rock has been limited to walleye, northern pike and largemouth bass at varying rates and sizes.

Net samples in Lake Red Rock during the five years following impoundment indicated the fish composition was dominated by non-sport fish. Carp, river carpsucker and bigmouth buffalo made up nearly 83% of the numerical catch during the first three years. During 1972 and 1973 period carp and river carpsucker made up 38% and 17% of the catch each year while bigmouth buffalo fell from 8% to 2%. Bullhead replaced channel catfish as the most abundant game fish species making up 13% of the fisheries the first three years of impoundment. During the 1972 and 1973 period channel catfish were less numerous making up only 2% and 1% of the catch. Despite the intensive stocking efforts none of the sport fish species comprised more than 2% of the numerical catch.

Lake Rathbun is located in the upper Chariton River basin near Centerville, Iowa. Walleye, white bass, channel catfish, ocean striped bass and muskellunge have been stocked. Sample netting in the reservoir during 1972 with fyke nets, experimental gill nets and small mesh seine showed game fish species made up nearly 71% of the catch. Crappie were the most abundant species with 41% followed by bullhead, 11%; walleye, 7%; and bluegill, 4%. Carp was the most prevalent non-sport species comprising about 20% of the catch. Carp made up the most biomass at 38% of the catch.

During the third year of impoundment (1973) netting results indicated the carp had surpassed all fish species at 38% of the total numerical catch. Crappie made up 37%, bullhead 15%, gizzard shad 7%, channel catfish 7% and walleye 4%.

METHODS AND PROCEDURES

Sampling procedures were the same as previously described with the exception of reducing sampling sites from three to two. Analysis of variance of catch statistics from 1972 and 1973 showed sampling sites and number of daily samples could be reduced by one-third without lowering accuracy or precision.

FINDINGS

LAKE RED ROCK STUDIES

Species Composition of Net Catches In 1974 pound and experimental gill nets captured 11,954 fish weighing 4,075 kg (Table 1). Carp was the most abundant species comprising 25% of the numerical catch and over 31% of the weight. Crappie (primarily black crappie) were second in abundance making up over 21% of the catch and 14% of the sample biomass while river carpsucker contributed 19% of the numerical catch and 22% of the weight. Other species frequently caught included black bullhead, gizzard shad, and white bass. The combined catch of sport fish stocked in the reservoir was < 5% of the numerical catch.

In 1974, the combined catch success of 299 FND in pound and experimental gill nets was the highest recorded over the three year study period (Table 2). Non-sport fish including carp, 64 FND; river carpsucker, 49 FND; and gizzard shad, 35 FND increased in catch success while bigmouth buffalo, 10 FND, dropped. Crappie increased the most from 19 FND in 1973 to 53 FND in 1974, while walleye, 7.7 FND; northern pike, 7.1 FND; and largemouth bass, 6.5 FND all continued to increase over previous years. Channel catfish, which decreased from 4.8 FND in 1972 to 2.0 FND in 1973, increased slightly in 1974 to 3.2 FND. Black bullhead continued to decline from 38 FND in 1972 to 35 FND in 1973 and 28 FND in 1974.

Table 1. Combined catch composition of pound and experimental gill nets, Lake Red Rock, April through October, 1974.

Species	Number	Percent number	Weight (kg)	Percent weight	Mean weight (kg)
Carp	2,931	24.5	1,279.84	31.4	.44
Crappie[a]	2,558	21.4	573.27	14.1	.22
B bullhead	1,070	8.9	190.01	4.7	.18
B buffalo	471	3.9	410.22	10.1	.87
R carpsucker	2,213	18.5	896.41	22.0	.40
C catfish	85	.7	34.02	.8	.40
G shad	975	8.2	142.18	3.5	.14
F drum	95	.8	9.52	.2	.10
Walleye	158	1.3	48.45	1.2	.31
Bluegill	161	1.3	12.70	.3	.08
G sunfish	27	.2	2.27	< .1	.08
N pike	192	1.6	238.79	5.9	1.24
Lm bass	226	1.9	127.66	3.1	.56
Goldfish	79	.7	18.42	.4	.23
F catfish	4	< .1	2.35	< .1	.59
N redhorse	10	< .1	5.14	.1	.51
W bass	681	5.7	78.63	1.9	.12
Y bass	8	< .1	1.13	< .1	.14
S gar	5	< .1	3.42	< .1	.68
Y perch	1	< .1	0.14	< .1	.14
R sunfish	1	< .1	0.14	< .1	.14
W sucker	0		0		
Notropis sp.	3	< .1	0.04	< .1	.01
Total	11,954		4,074.73		

[a]Included white crappie and black crappie.

Table 2. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Red Rock, 1972, 1973 and 1974.

Species	Pound net (FND)			Experimental gill net (FND)			Combined catch (FND)		
	1972	1973	1974	1972	1973	1974	1972	1973	1974
Carp	39.7	34.1	54.4	13.5	4.9	7.3	53.2	39.0	63.7
B & W Crappie[a]	15.6	13.8	47.9	8.7	5.6	4.9	24.3	19.4	52.8
B bullhead	22.3	21.0	17.9	15.4	14.3	10.1	37.7	35.3	27.9
B buffalo	11.3	2.7	8.8	.7	.4	.9	12.0	3.0	9.7
R carpsucker	22.9	18.3	40.2	5.3	4.5	9.1	29.1	22.8	49.2
C catfish	1.4	.9	1.1	3.4	1.1	2.1	4.8	2.0	3.2
G shad	3.1	.2	12.7	18.7	2.0	22.6	21.8	2.1	35.3
F drum	3.3	2.5	1.3	9.2	6.2	2.0	12.4	8.7	3.3
Walleye	.2	.1	1.3	.2	6.2	6.4	.4	6.3	7.7
Bluegill	1.1	1.3	3.1	< .1	.2	.1	1.1	1.4	3.2
G sunfish	< .1	.9	.4	.5	1.9	.3	.5	2.7	.7
N pike	.2	.6	2.4	.3	3.9	4.7	.4	4.5	7.1
Lm bass	.4	1.4	3.5	.6	2.3	3.0	.9	3.7	6.5
Goldfish	.1	.6	1.5	< .1	.4	0	.1	1.0	1.5
F catfish	.1	< .1	.1	.1	.1	.1	.1	.1	.1
N redhorse	.2	< .1	.2	.3	.1	.1	.5	.1	.2
W & Y bass[b]	.4	1.4	8.0	.2	1.1	19.4	.6	2.5	27.4
S gar	< .1	.2	.1	.7	.2	.1	.7	.4	.2
Notropis sp.	< .1	< .1	0	.2	.4	.2	.2	.4	.2
R sunfish	< .1	.1	< .1	< .1	< .1	0	< .1	.1	< .1
W sucker	< .1	< .1	0	< .1	.1	0	< .1	.1	0
Y perch	< .1	< .1	< .1	< .1	.1	0	< .1	.1	< .1
Total	122.3	100.1	205.1	78.7	55.6	93.4	201.0	155.6	298.5

[a]Primarily black crappie.

[b]Primarily white bass.

Pound nets continued to catch more fish, 205 FND, than the experimental gill net, 93 FND (Table 2) and catch rates within species were also higher for pound nets. Carp, black crappie, black bullhead, bigmouth buffalo, river carpsucker and largemouth bass were all caught at higher rates by pound nets while experimental gill net captured channel catfish, gizzard shad, northern pike and walleye at higher rates.

Seine haul catches at Lake Red Rock accounted for 12,379 young-of-the-year fish (Table 3). Gizzard shad contributed 70% of the catch while crappie was second in numerical abundance with 12%. Other species represented included white bass, 6.2%; bigmouth buffalo, 3.6%; and largemouth bass, 2.8%.

AGE STRUCTURE AND GROWTH

Largemouth Bass A length-frequency distribution of largemouth bass was compiled for 49 fish caught during April, May and June (Table 4). Length distribution ranged from 223 to 464 mm TL. Two major modes were recorded within the distribution at 223-298 mm and 298-388 mm. Age class representation was .3% age I, 36% age II, 56% age III and 3% age IV.

Lengths, weights and scales were collected from 47 largemouth bass in 1974. They ranged from 223 to 464 mm TL and weights of 172 to 1,224 g. The length-weight relationship was described by the equation $\log_{10}W = -4.32 + 2.81 \log_{10}TL$.

K-factors ranged from .86 to 1.95 while the mean was 1.61.

Body-scale relationship was described by direct proportion TL = 2.39 ScR. From this relationship mean total lengths at each annulus were estimated at 157, 277, 335, and 414 mm for ages I through IV, respectively (Table 5).

Northern Pike Length-frequency distribution of northern pike was compiled from April through May in 1974 for 49 fish (Table 6). Length distribution ranged from 344-911 mm TL.

Two modes were found within the 1974 length-frequency distribution at 419-594 mm and 595-719 mm. Age class representation assigned from back calculated total lengths at annulus was 72% age I, 26% age II and 2% age V.

Lengths, weights and scales were collected from 47 northern pike in 1974. They ranged from 344 to 911 mm and weights of 226 to 4,717 g. The length-weight relationship was described by the equation $\log_{10}W = 5.62 + 3.16 \log_{10}L$.

K-factors in 1974 ranged from .56 to .79 with a mean of .65.

Body-scale relationship was described by the direct proportion TL = 4.50 ScR. From this relationship mean total lengths at each annulus were calculated as 388, 534, 720, 759 and 812 mm for age I through V (Table 7).

Walleye A length-frequency distribution of walleye captured in the April and May netting periods of 1974 was tabulated for 42 fish (Table 8). Size of walleye ranged from 209 to 590 mm TL. A single mode was found within the length-frequency distribution at 284-459 mm. This mode was comprised of 48% age II and 45% age III walleye. Other ages contributed little to the structure, age I (5%) and age IV (2%).

Table 3. Species composition of 0-age fish by sampling station at Lake Red Rock, 1974.

Species	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
G shad	1,727	82.4	721	71.9	1,300	75.0	2,641	93.5	796	37.8	1,435	54.8	8,620	69.6
Cyprinids[a]	54	2.6	111	11.1	73	4.2	35	1.2	121	5.7	83	3.2	477	3.8
Crappie[b]	3	.1	39	3.9	4	.2	7	.2	1,003	47.6	437	16.7	1,493	12.1
W bass	210	10.0	83	8.3	111	6.4	55	1.9	92	4.4	221	8.4	772	6.2
Lm bass	16	.8	21	2.1	23	1.3	47	1.7	48	2.3	199	7.6	354	2.8
Bluegill							1	< .1	2	< .1	5	.2	8	< .1
Carp	5	.2			33	1.9	4	.1	5	.2	16	.6	63	.5
B buffalo	75	3.6	24	2.4	172	9.9	18	.6	4	.2	154	5.9	447	3.6
C catfish	1	< .1			3	.2	7	.2	1	< .1			12	< .1
B bullhead							1	< .1	4	.2	1	< .1	6	< .1
F drum	2	< .1	4	.4	5	.3	7	.2	3	.1	30	1.1	51	.4
R carpsucker		< .1			9	.5			27	1.3	36	1.4	73	.6
G sunfish	1	< .1											1	< .1
B darter[c]							1	< .1					1	< .1
W sucker									1	< .1			1	< .1
Total	2,095		1,003		1,733		2,824		2,107		2,617		12,379	

[a]All Cyprinids other than carp and goldfish.

[b]Included black and white crappie.

[c]*Percina maculata*.

Table 4. Length-frequency distribution of largemouth bass at Lake Red Rock for April, May and June, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
223-238	3	6	
238-253	6	12	
253-268	5	10	II
268-283	2	4	
283-298	2	4	
298-313	2	4	
313-328	2	4	
328-343	6	12	
343-358	5	10	III
358-373	5	10	
373-388	4	8	
388-403	0		
403-418	2	4	
418-433	2	4	
433-448	0		
448-463	0		
463-478	1	2	IV

Table 5. Average estimated total length (mm) at each annulus for largemouth bass at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1973	106			
1972	148	276		
1971	171	268	335	
1970	202	287	335	414
Average	157 (47)	277 (46)	335 (9)	414 (1)

Table 6. Length-frequency distribution of northern pike at Lake Red Rock for April, May and June, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
344-369	1	2	
369-394	0		
394-419	0		
419-444	1	2	
444-469	5	11	
469-494	9	19	I
494-519	9	19	
519-544	3	6	
544-569	4	9	
569-594	4	9	
594-619	2	4	
619-644	5	11	II
644-669	2	4	
669-694	1	2	
694-719	1	2	
719-744	0		
744-794	1	2	
894-919	1	2	V

Table 7. Average estimated total length (mm) at each annulus for northern pike at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV	V
1973	384				
1972	384	529			
1969	557	671	694	721	758
Average	388 (49)	534 (28)	720 (1)	759 (1)	812 (1)

Table 8. Length-frequency distribution of walleye at Lake Red Rock for April, May and June, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
209-234	2	5	I
234-259	0		
259-284	0		
284-309	2	5	
309-334	4	10	
334-359	14	33	II
359-384	13	31	III
384-409	3	7	
409-434	2	5	
434-459	1	2	
459-484	0		
484-509	0		
509-534	0		
534-559	0		
559-584	0		
584-609	1	2	IV

Lengths, weights and scales were collected from 41 walleye in 1974. They ranged in lengths of 209 to 590 mm and weights of 90 to 1,905 g. Length-weight relationship was best described by the linear function $\log_{10}W = -4.23 + 2.69 \log_{10}TL$.

K-factors in 1974 ranged from .49 to 1.13 with a mean of .92.

Body-scale relationship was described by the linear equation TL = 2.59 + 3.28 ScR. From this relationship mean total lengths at annulus formation were calculated as 139, 280, 400, and 577 mm for ages I through IV (Table 9).

Black Crappie A length-frequency distribution of black crappie captured in April and May netting periods of 1974 was compiled for 41 fish (Table 10). Size of black crappie ranged from 126 to 325 mm TL. Three modes were found within the 1974 length-frequency distribution; 151-225 mm, 226-275 mm and 276-325 mm. Age class representation was 64% age II, 23% age III and 15% age IV.

Lengths, weights and scales were collected from 47 crappie. They ranged in lengths of 164 to 345 mm and weights of 31 to 780 g. Length-weight relationship was best described by the equation $\log_{10}W = -6.42 + 3.69 \log_{10}TL$.

K-factors in 1974 ranged from 1.24 to 1.97 while the mean was 1.6.

Table 9. Average estimated total length (mm) at each annulus for walleye at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1973	108			
1972	160	271		
1971	117	218	315	
1970	170	351	485	577
Average	139 (41)	280 (40)	400 (18)	577 (1)

Table 10. Length-frequency distribution of black crappie at Lake Red Rock for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	7	17.1	
176-200	13	31.7	II
201-225	6	14.6	III
226-250	7	17.1	
251-275	2	4.9	
276-300	3	7.3	IV
301-325	3	7.3	

The body-scale relationship was described by the linear equation $L = 4.26 + 2.07\ ScR$. From this relationship mean total lengths at each annulus were calculated as 84, 158, 226 and 287 mm for ages I through IV, respectively (Table 11).

Table 11. Average estimated total length (mm) at each annulus for black crappie at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1973	85			
1972	73	156		
1971	85	157	214	
1970	93	160	237	287
Average	84 (47)	158 (36)	226 (27)	287 (6)

Channel Catfish A length-frequency distribution of channel catfish captured in the April, May and June periods of 1974 was compiled for 44 fish (Table 12). Size range of channel catfish ran from 170 to 642 mm TL. Three length frequency modes were found at 245-345 mm, 345-420 mm and 420-545 mm. Age class structure was 2% age II, 38% age III, 43% age IV, 13% age VI, and 4% age V and older.

Lengths, weights and pectoral spines were collected from 44 channel catfish in 1974. These fish ranged in lengths of 170 to 642 mm and weights of 90 to 2,562 g. Length-weight relationship was best described by the equation $\log_{10}W = -4.96 + 2.95 \log_{10}TL$.

K-factors in 1974 ranged from .83 to 1.06 with a mean of .85.

The body-pectoral spine relationship was described by the direct proportion L = 3.06 SpR. From this relationship back calculations at annulus were 68, 152, 240, 317, 385, 374 and 438 mm for ages I through VII, respectively (Table 13).

Carp A length-frequency distribution of carp captured during the April and May periods of 1974 was compiled for 244 fish (Table 14). Length distribution ranged from 151 to 625 mm TL. Three length-frequency modes were noted within the distribution at 151-325 mm, 326-475 mm and 476-550 mm. Age class representation was 5% age I and II, 47% age III, 40% age IV and 5% age V and older.

Lengths, weights and scales were collected from 47 carp in 1974. These fish ranged in lengths of 168 to 427 mm and weights of 49 to 839 g. Length-weight relationship was best described by the equation $\log_{10}W = -5.19 + 3.11 \log_{10}TL$.

K-factors ranged from .91 to 1.42 with a mean of 1.22.

Table 12. Length-frequency distribution of channel catfish at Lake Red Rock for April, May and June, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
170-195	1	2	II
195-220	0		
220-245	0		
245-270	3	7	
270-295	7	14	III
295-320	6	14	
320-345	3	7	
345-370	6	14	
370-395	10	23	IV
395-430	1	2	
430-445	1	2	
445-470	3	7	V
470-495	1	2	
495-520	1	2	
520-545	1	2	
620-645	1	2	VII

Table 13. Average estimated total length (mm) at each annulus for channel catfish at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1972	60	138					
1971	77	179	309				
1970	59	150	230	349			
1969	66	158	247	340	436		
1967	80	135	175	263	334	374	438
Average	68 (44)	152 (44)	240 (43)	317 (35)	385 (9)	374 (1)	438 (1)

Table 14. Length-frequency distribution of carp at Lake Red Rock for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	4	1.6	
176-200	8	3.3	II
201-225	12	4.9	
226-250	12	4.9	
251-275	35	14.3	
276-300	38	15.6	III
301-325	28	11.5	
326-350	11	4.5	
351-375	29	11.9	IV
376-400	26	10.6	
401-425	17	7.0	
426-450	12	4.9	
451-475	6	2.4	
476-500	1	.4	
501-525	3	1.2	V
526-550	1	.4	
551-575			
576-600			
601-625	1	.4	

The body-scale relationshp was described by the linear function TL = 4.40 + 1.57 ScR. From this relationship mean total lengths at each annulus were calculated as 93, 177, 254 and 348 mm for ages I through IV, respectively (Table 15).

Bigmouth Buffalo A length-frequency distribution of bigmouth buffalo captured during the April and May periods of 1974 was calculated from 38 fish (Table 16). Length distribution ranged from 151 to 525 mm TL. A single mode was described between 351-525 mm with a peak at the 426 to 450 mm class, although two fish were assigned to smaller classes. Age class representation in the length-frequency distribution was masked because of the faster growing 1970 and 1971 year classes.

Lengths, weights and scales were collected from 46 bigmouth buffalo in 1974. They ranged in length from 210 to 541 mm and weights of 122 to 2,381 g. Length-weight relationship was described by the linear equation $\log_{10}W = -4.89 + 3.03 \log_{10}TL$.

K-factors ranged from 1.38-1.62 with a mean of 1.51.

Table 15. Average estimated total length (mm) at each annulus for carp at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1973	128			
1972	65	198		
1971	86	159	258	
1970	94	174	250	348
Average	94 (47)	177 (41)	254 (32)	348 (11)

Table 16. Length-frequency distribution of bigmouth buffalo at Lake Red Rock for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	1	2.6	I
197-200			
201-225	1	2.6	II
226-250	0		
251-275	0		
276-300	0		
301-325	0		III
326-350	0		
351-375	2	5.3	IV
376-400	3	7.9	V
401-425	7	18.4	VI
426-450	15	39.5	VII
451-475	5	13.2	VIII
476-500	2	5.3	
501-525	2	5.3	

The body-scale relationship was described by the regression equation TL = 27.1 + 1.69 ScR. From this relationship mean total lengths at each annulus were calculated as 153, 238, 302, 351, 376, 411, 436 and 447 mm for ages I through VIII, respectively (Table 17).

Table 17. Average estimated total length (mm) at each annulus for bigmouth buffalo at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII	VIII
1973	129							
1972	157	272						
1971	174	260	333					
1970	187	257	345	408				
1969	172	237	280	348	388			
1968	156	223	284	345	394	446		
1967	119	174	237	288	333	374	442	
1966	127	246	337	364	389	413	430	447
Average	153	238	302	351	376	411	436	447
	(46)	(36)	(27)	(17)	(11)	(7)	(3)	(1)

River Carpsucker A length-frequency distribution of river carpsucker captured during the April and June periods of 1974 was compiled for 148 fish (Table 18. Length distribution ranged from 151-425 mm. Two modes were found 151-200 mm and 201-425 mm.

Lengths, weights and scales were collected from 50 river carpsucker in 1974. They ranged in lengths of 200 to 460 mm and weights of 158 to 1,133 g. Length-weight relationship was described by the function $\log_{10}W = -3.58 + 2.47 \log_{10}TL$.

K-factors ranged from .99-1.27 with a mean of 1.15.

The body-scale relationship was described by the equation TL = 2.20 ScR. From this relationship mean total lengths at each annulus were calculated as 74, 166, 248, 314, 356, 389 and 402 mm TL for ages I through VII, respectively (Table 19).

Table 18. Length-frequency distribution of river carpsucker at Lake Red Rock for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	3	2.0	II
176-200	1	.7	
201-225	2	1.4	
226-250	9	6.1	
251-275	21	14.2	III
276-300	32	21.6	
301-325	28	18.9	IV
326-350	25	16.9	
351-375	20	13.5	VI
376-400	6	4.0	VII
401-425	1	.7	

Table 19. Average estimated total length (mm) at each annulus for river carpsucker at Lake Red Rock, 1974. Sample size is subtended.

Year class	Age						
	I	II	III	IV	V	VI	VII
1972	88	208					
1971	81	189	291				
1970	74	184	274	337			
1969	59	151	238	316	361		
1968	75	125	213	300	360	397	
1967	65	141	225	302	347	380	402
Average	74	166	248	314	356	389	402
	(50)	(50)	(48)	(24)	(11)	(5)	(3)

Black Bullhead In 1974 a length-frequency distribution of 133 black bullhead, caught in April and May, was compiled. Bullhead caught during the two net periods ranged from 151 to 325 mm TL (Table 20). One mode was tabulated within the distributin, with a peak at the 226 to 250 mm class. Over 80% of the distribution was due to the dominant 1971 year class. Bullhead spines were not aged, ages were assigned from back calculated lengths for bullhead found in Carlander (1969).

Table 20. Lengh-frequency distribution of black bullhead at Lake Red Rock for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	1	1	
176-200	11	8	
201-225	15	11	
226-250	53	40	IV
251-275	39	29	
276-300	13	10	
301-325	1	1	
326-350			

Gizzard Shad Few adult gizzard shad were caught during the April and May net periods, however, a length-frequency distribution was compiled for 24 fish. These fish ranged from 126-200 mm and were entirely comprised of the 1973 year class.

LAKE RATHBUN STUDIES

Species Composition of Net Catches During 1974 pound and experimental gill nets captured 10,721 fish weighing 2,587 kg (Table 21). Crappie was the most abundant fish comprising 64% of the numerical catch and 57% of the biomass. Carp was second in numerical importance with 13% and by weight with 22%. Black bullhead followed in importance representing 7% of the numerical catch and 3% of the weight while walleye contributed 3% of the total catch by number and 7% by weight.

Combined catch success by pound and experimental gill nets was 265 FND, the greatest recorded for the three years of this study, and has been variable within species between years (Table 22). Net catches of crappie fluctuated from 79 FND to 65 FND to 147 FND from 1972-74. White bass increased from .2 FND to 1.4 FND to 5.8 FND for the same years. Walleye catch success has gradually decreased from 24 FND to 11 FND to 8.9 FND from 1972-74 while channel catfish has

Table 21. Species composition in catches of fish by pound and experimental gill nets in Lake Rathbun from April through October, 1974.

Species	Number	Percent number	Weight (kg)	Percent weight	Mean weight (kg)
Carp	1,408	13.1	564.4	21.8	.40
Crappie[a]	6,890	64.3	1,465.4	56.7	.21
B bullhead	792	7.4	83.3	3.2	.10
C catfish	138	1.3	53.2	2.0	.38
Walleye	266	2.5	176.6	6.8	.66
G shad	606	5.6	62.1	2.4	.10
W bass	158	1.5	36.6	1.4	.23
R carpsucker	61	.6	47.9	1.8	.78
B buffalo	67	.6	56.3	2.2	.84
Bluegill	239	2.2	20.5	.8	.08
G sunfish	65	.6	5.6	.2	.09
Lm bass	25	.2	13.3	.5	.53
W sucker	4	< .1	.9	< .1	.22
Y bass	2	< .1	.2	< .1	.10
Total	10,721		2,586.3		

[a]Included white crappie and black crappie.

Table 22. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Rathbun, 1972-74.

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

[a]Primarily white crappie.

followed the same trend from 20 FND to 17 FND to 6.9 FND for the same seasons. Carp were caught at 37 FND in 1972 increased to 55 FND in 1973 and decreased to 31 FND in 1974. Largemouth bass were caught at 1 FND or less on these years.

Pound nets caught nearly twice as many fish as experimental gill nets, 185 FND as compared to 80 FND and were species selective (Table 22). Crappie, bluegill, carp, bigmouth buffalo and river carpsucker were caught more frequently by pound nets while walleye, channel catfish, bullhead, white bass and gizzard shad were caught more often by experimental gill nets.

Seine hauls at Lake Rathbun captured 4,311 0-age fish and various species of Cyprinids (Table 23). The preponderance of the catch was 0-age gizzard shad, while Cyprinids were second followed by white bass, ocean striped bass and channel catfish. Fish seldom captured included largemouth bass, crappie, freshwater drum, bullhead and walleye.

AGE STRUCTURE AND GROWTH

Walleye A length-frequency distribution of 21 walleye was recorded in the spring of 1974 (Table 24). Walleye length ranged from 351-525 mm with the greatest proportion between 401-475 mm.

The distribution consisted of a single mode comprised of the 1970 and 1971 year classes, age III and IV.

Body measurements and scales were collected from 50 walleye in 1974. Walleye ranged in total length from 360-572 mm and weights of 385-1,814 g. Length-weight relationship was described by the equation $\log_{10}W = -6.64 + 3.60 \log_{10}TL$.

K-factors ranged from .79 to 1.09 with a mean of .91.

Body-scale relationship was described by the equation TL = 5.95 + 2.98 ScR. From this relationship mean total lengths at annulus were calculated for each age group (Table 25). Mean back calculated lengths at each annulus were 188, 307, 380 and 441 mm for ages I through IV.

White Crappie In the net period of April and May a length-frequency distribution of 297 white crappie was tabulated (Table 26). Lengths ranged from 151-325 mm with one mode recorded within the distribution. The single mode was comprised of age II, III and IV white crappie with considerable overlap within the distribution.

Lengths, weights and scales were taken from 49 white crappie in 1974. They ranged in length from 137-321 mm TL and weights of 40-498 g. Length-weight relationship was described by the equation $\log_{10}W = -4.99 + 3.05 \log_{10}TL$.

K-factors ranged from 1.15 to 1.79 with a mean of 1.45.

Body-scale relationship was described by the linear function TL = 17.27 + 2.14 ScR. From this relationship mean total length at annulus were back calculated for each respective age group (Table 27). Mean back calculated lengths at each annulus were 87, 178, 242 and 281 mm for ages I through IV, respectively.

Table 23. Species composition of 0-age fish at Lake Rathbun, 1974.

Species	Station 1 N	1 %	2 N	2 %	3 N	3 %	4 N	4 %	5 N	5 %	6 N	6 %	Total N	Total %
G shad	512	82.3	309	75.0	685	96.1	163	89.1	284	88.2	1,783	86.8	3,736	86.7
Cyprinids	63	10.1	75	18.2	14	2.0	12	6.6	11	3.4	230	11.2	405	9.4
W bass	38	6.1	12	2.9	8	1.1	3	1.6	18	5.6	38	1.8	117	2.7
S bass	2	.3	25	6.1	3	.4			1	.3			31	.7
C catfish	3	.5			3	.4			4	1.2	1	< .1	7	.2
Bullhead									1	.3			1	< .1
Crappie[a]	1	.2											1	< .1
Lm bass							3	1.6					3	< .1
Bluegill	1	.2											1	< .1
Walleye	2	.3											2	< .1
F drum									3	.9	2	< .1	5	.1
G sunfish							2	1.1					2	< .1
Total	622		421		713		183		322		2,054		4,311	

[a]Included black and white crappie.

Table 24. Length-frequency distribution of walleye at Lake Rathbun for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
351-375	3	14	II
376-400	3	14	
401-425	6	29	III
426-450	3	14	
451-475	4	19	IV
476-500	1	5	
501-525	1	5	

Table 25. Average estimated total length (mm) at each annulus for walleye at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1972	219	363		
1971	174	306	403	
1970	170	251	358	441
Average	188 (50)	307 (50)	380 (32)	441 (21)

Table 26. Length-frequency distribution of white crappie at Lake Rathbun for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
151-175	8	3	
176-200	11	4	
201-225	29	10	II
226-250	87	29	III
251-275	118	40	
276-300	43	15	IV
301-325	1	< 1	

Table 27. Average estimated total length (mm) at each annulus for white crappie at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1973	73			
1972	80	181		
1971	86	171	238	
1970	110	183	247	281
Average	87 (49)	178 (48)	242 (25)	281 (8)

Largemouth Bass Largemouth bass at Rathbun Reservoir were not caught at a sufficient rate to compile a length-frequency distribution. However, lengths, weights and scales were collected from 17 bass. They ranged in length from 228-490 mm and weights of 154-1,632 g. Length-weight relationship was described by the equation $\log_{10}W = -6.63 + 3.71 \log_{10}TL$.

K-factors ranged from 1.13-2.07 while the mean was 1.57.

Body-scale relationship was described by the equation TL = 40.67 + 1.95 ScR. This relationship was used to calculate mean total length at annulus for each respective age group (Table 28). Mean back calculated lengths at each annulus were 165, 265, 349 and 437 mm for ages I through IV.

Table 28. Average estimated total length (mm) at each annulus for largemouth bass at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1972	124	240		
1971	148	226	301	
1970	224	330	398	437
Average	165 (17)	265 (17)	349 (15)	437 (4)

Channel Catfish Few channel catfish were captured during spring of 1974; however, a length-frequency distribution of 12 fish was constructed. These fish ranged from 226-400 mm with 84% within 301-400 mm, this portion of the distribution was comprised of the 1970 year class.

Body measurements and spines were collected from 49 channel catfish in 1974. They ranged in length from 238-483 mm and weights of 176-952 g. The length-weight relationship was described by the equation $\log_{10}W = -3.95 + 2.56 \log_{10}TL$.

K-factors ranged from .76-1.34 with a mean of .89.

Body-spine relationship was described by the direct proportion TL = 2.92 SpR. From this relationship mean total length at each annulus were back calculated for each respective age group (Table 29). Mean back calculated lengths at each annulus were 102, 246, 302 and 341 mm for ages I through IV.

Table 29. Average estimated total length (mm) at each annulus for channel catfish at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1971	108	289	333	
1970	95	203	271	341
Average	102 (49)	246 (49)	302 (49)	341 (48)

Carp A length-frequency distribution was compiled for 120 carp during the April and May netting periods (Table 30). These fish ranged from 226-600 mm with two modes present, 226-375 mm and 376-475 mm. One fish was within the 576-600 mm class. Age class representation was about 79% age II and 20% age III and IV with a single fish age V+.

Table 30. Length-frequency distribution of carp at Lake Rathbun for April and May, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
226-250	2	2.7	
251-275	16	13.3	
276-300	37	30.8	II
301-325	30	25.0	
326-350	16	13.3	
351-375	6	5.0	
376-400	1	1.8	III
401-435	4	3.3	
426-450	4	3.3	IV
451-475	3	2.5	
576-600	1	.8	V+

Body measurements and scales were collected from 47 carp during 1974. These fish ranged from lengths of 264 to 589 mm and weights of 226 to 952 g. Length-weight relationship was described by the transformation $\log_{10}W = -3.25 + 2.32 \log_{10}TL$.

K-factors ranged from .94-1.17 while the mean was 1.11.

Body-scale relationship was described by the equation TL = 1.63 ScR. From this relationship mean total length at annulus were computed for each respective age group (Table 31). Mean back caluclated lengths at each annulus were 171, 264, 381 and 438 mm for ages I through IV.

River Carpsucker River carpsucker were not caught in sufficient quantity to compile an early season length-frequency distribution; however, a distribution was constructed for the complete sampling season (Table 32). These fish ranged from 276-456 mm with two modes present; 276-336 mm and 351-456 mm. Age class structure was 12% age II, 68% age II and IV and 19% age V and older.

Table 31. Average estimated total length (mm) at each annulus for carp at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1973	224			
1972	194	289		
1971	158	279	386	
1970	108	225	375	438
Average	171 (47)	264 (31)	381 (16)	438 (5)

Table 32. Length-frequency distribution of river carpsucker at Lake Rathbun, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
276-291	1	2	
291-306	1	2	
306-321	2	4	II
321-336	2	4	
336-351	0		
351-366	5	11	
366-381	10	22	III
381-396	9	20	IV
396-411	7	15	
411-426	5	11	V
426-441	2	4	
441-456	2	4	

Lengths, weights and scales were taken from 46 river carpsucker. These fish ranged from lengths of 276-444 mm and weights of 317-1,317 g. Length-weight relationship was described by the equation $\log_{10}W = -4.75 + 2.96 \log_{10}TL$.

K-factors ranged from 1.33 to 1.57 with a mean of 1.43.

Body-scale relationship was described by the direct proportion L = 2.16 ScR. From this relationship mean total lengths at annulus were calculated for each respective age group (Table 33). Mean back calculated lengths at each annulus were 118, 243, 326, 366 and 352 mm for ages I through V.

Table 33. Average estimated total length (mm) at each annulus for river carpsucker at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	II	III	IV	V
1972	124	309			
1971	117	254	364		
1970	92	222	355	406	
1969	138	186	259	326	352
Average	118	243	326	366	352
	(46)	(46)	(35)	(11)	(1)

Bigmouth Buffalo Few bigmouth buffalo were caught during the early periods, consequently a length-frequency distribution was compiled for 46 fish captured throughout the season (Table 34). They ranged in size from 285-450 mm with one mode within the range of 331-450 mm, while four fish were recorded within the 285-300 mm class. Age class representation was 4% age II and 96% older.

Lengths, weights and scales were taken from the same fish used for length-frequency analysis, their lengths were the same while weights ranged from 362-1,360 g. Length-weight relationship was described by the equation $\log_{10}W = -2.30 + 5.74 \log_{10}TL$.

K-factors ranged from 1.30-1.55 while the mean was 1.48.

Body-scale relationship was described by the equation TL = 20.55 + 1.74 ScR. From this relationship mean total lengths at annulus were calculated for each respective age group (Table 35). Mean back calculated lengths at each annulus were 197, 312, 385 and 432 mm for ages I through IV.

Table 34. Length-frequency distribution for bigmouth buffalo at Lake Rathbun, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
285-300	2	4	II
301-315	0		
316-330	0		
331-345	3	7	
346-360	7	15	
361-375	7	15	III
376-390	10	22	
391-405	10	22	
406-420	3	7	
421-435	3	7	IV
435-450	1	2	

Table 35. Average estimated total length (mm) at each annulus for bigmouth buffalo at Lake Rathbun, 1974. Sample size is subtended.

Year class	Age I	II	III	IV
1973	210			
1972	199	319		
1971	189	291	368	
1970	191	327	403	432
Average	197 (46)	312 (43)	385 (13)	432 (3)

Gizzard Shad A length-frequency distribution of 53 gizzard shad was compiled for the spring catches (Table 36). These fish ranged from 201-275 mm and consisted of age I fish. Scales of shad were not aged, but were assigned ages from data in Carlander (1969).

Table 36. Length-frequency distribution for gizzard shad at Lake Rathbun, 1974.

TL (mm)	Number	Percent occurrence	Age of interval
201-225	24	45	
226-250	21	40	I
251-275	8	15	

DISCUSSION

LAKE RED ROCK

Non-sport fish have dominated the total catch by pound and experimental gill nets at Lake Red Rock since impoundment. Mayhew (1972) documented this condition when he reported carp was the predominant species caught and contributed 69% of the weight in net catches. Bigmouth buffalo and river carpsucker were also important numerically and by weight. During the years of the current study (1972-1974) carp continued to dominate the catch by number and weight. River carpsucker ranked third in numerical abundance each year and was third in weight one year and second in two years. Bigmouth buffalo were important by weight ranking second two years and fourth one year, although they were not nearly as abundant as other non-sport fish.

The importance of non-sport fish in the total catch of future years may be influenced by the opening of Lake Red Rock to commercial fishing. In October, 1973, Lake Red Rock was opened to commercial fishing. Tabulation of mandatory commercial fishing reports from October, 1973 through December, 1974, provided a total harvest of 444,665 kg of carp, river carpsucker, bigmouth buffalo and freshwater drum (personal communication, Robert Middendorf). Breakdown of the harvest by species cannot be done precisely. The fishing report was categorized by species, but commercial fishermen do not use recommended common names and often lump carp and carpsucker into one.

Sport fish have systematically represented a greater proportion of the overall net catch in each successive year. They have represented 34%, 42% and 44% of the total catch from 1972-74. Crappie represented a preponderance of the sport fish catch of 1974 but were second in numerical abundance in previous years. Bullhead always provided an important proportion of the catch but steadily declined in abundance. White bass were third in importance followed in lesser abundance by channel catfish and stocked species including largemouth bass, walleye and northern pike.

Stocking of young sport fish during 1971-73 was the primary reason for their increase in catch success during this study. Northern pike have increased from .4 FND to 4.5 FND to 7.1 FND for the years 1972-74. Many age I and II pike were captured during 1974. Walleye and largemouth bass have displayed a similar trend extending from .4 FND to 6.3 FND to 7.7 FND and .9 FND to 3.7 FND to 6.5 FND, respectively. Age II and III fish predominated the catch of bass and walleye in 1974.

Of the three species of sport fish stocked at Lake Red Rock only the largemouth bass appears to be able to sustain a native population. Young largemouth bass were common in seine hauls every year. Contrary, 0-age northern pike were not seen in seine hauls during years they were not stocked while only a few young-of-the-year walleye were seen in two of three seasons including one season they were not stocked. Reproductive habitat in Lake Red Rock is nonexistent for northern pike and limited for walleye. It is likely northern pike and walleye populations will be almost entirely dependent on hatchery reared fish.

Generally, adult or heavy bodied fish species were selected and caught at higher catch rates by the pound net than the experimental gill net. Catch success by experimental gill net may not have been as high but this gear caught a greater range of sizes, of the same species, and some small fish not caught in the pound net. Pound nets were the most effective gear for catching carp, bigmouth buffalo, river carpsucker, bullhead and crappie while the experimental gill net caught more channel catfish, walleye, northern pike, gizzard shad and usually more largemouth bass.

Total catch of seine hauls increased for each successive year of this study and the year class strength of the various species caught was entirely different. Seine hauls captured 8,954 fish in 1972, 10,391 in 1973 and 12,379 in 1974. Gizzard shad, usually the most abundant species caught, varied from a low of 952 fish in 1972 to a high of 8,620 in 1974. In 1972, only 5 bullhead were caught while 6,988 were captured in 1973 and 6 in 1974. During 1972, 167 0-age black crappie were caught followed by 135 in 1973 and 1,493 in 1974. These are extreme examples, but similar results were found with other fish. The role of reservoir operations and year class strength will be discussed in detail in the completion report of this study.

A comprehensive discussion of life history parameters of each species is not described in this report. However, several similarities that seem to be common among the populations can be brought out.

Growth rate of several species in the first year of life appears to have decreased since impoundment. This phenomenon has been recognized for largemouth bass, black crappie, bigmouth buffalo, river carpsucker and carp, although the 1973 year class of carp have had exceptional growth.

An ecological void was created when the Des Moines River was altered from a lotic environment to a lentic condition in the form of the reservoir. With the absence of large predators and the vacuous state, native fish populations brought on two dominant year classes. Strong 1970 and 1971 year classes of carp, river carpsucker, bigmouth buffalo, channel catfish and bullhead were followed throughout this study.

Distinguishing ages within length-frequency distributions of several species was arduous because of the overlap in year classes. Accelerated growth of young, age III and IV, river carpsucker and bigmouth buffalo tended to overlap class intervals with older fish to form fewer but larger modes.

Body-scale equations of some species possessed negative intercept values. An insufficient or nonexistent subsample of young or small largemouth bass, northern pike and river carpsucker was responsible. Those species that had adequate numbers of small or young fish within subsamples did not show this condition. Thus, an alternate relationship was selected from the SHAD (Mayhew, 1973) printout using a zero origin which was not used for these species in the previous report.

LAKE RATHBUN

Sport fish species dominated the numerical catch each study year at Lake Rathbun and contributed the greatest portion of the catch by weight during two of three seasons. Sport fish comprised 63 to 79% of the net catch from 1972 through 1974 and contributed 51% by weight in 1972, 37% in 1973 and 73% in 1974.

Crappie are the most important sport fish at Lake Rathbun. They dominated the numerical catch of 1972 and 1974 and were second in 1973. Since impoundment of Lake Rathbun two strong year classes of crappie were produced in 1970 and 1972. The 1970 year class was the first age group after impoundment and dominated all length-frequency distributions. Mayhew (unpublished) reported mean catch rates for 0-age crappie of the 1971 and 1973 year classes were higher than those for the 1972 age group but instantaneous mortality was also higher. As a result the catch of 0-age crappie for the last sampling date in 1972 was higher than it was for a similar period in 1971 or 1973. Few crappie from the 1972 year class appeared in the 1974 spring length-frequency distribution. As the season progressed their abundance became more apparent as many more crappie recruited into the net gear.

Walleye are fading out of the fishery at Lake Rathbun despite intensive stocking each year. Poor survival of all subsequent stockings since 1971 is evident. Catch success of walleye has declined from 24 FND to 11 FND to 9 FND from 1972-74. Walleye stocked in 1970 and 1971 appeared as one mode within all length-frequency distributions and young walleye are seldom seen in seine hauls.

It is likely largemouth bass will always be an incidental species at Lake Rathbun in spite of stocking. Catch success of bass has neither declined or increased, ranging from .5 FND to 1 FND from 1972-74.

Abundance of channel catfish also declined and seems dependent on stocking of hatchery fish. Catch success of channel catfish has declined from 20 FND to 17 FND to 7 FND from 1972-74. Within the age and growth subsample only two age groups were represented, 48 were age IV and one age III. Catfish were stocked in 1969 and 1970 and natural reproduction has been insufficient. 0-age channel catfish were never seen in seine hauls until 1974 when 7 were captured.

Trophy fish stocked at Lake Rathbun include the striped bass and muskellunge. Adult striped bass and muskellunge were never caught in net gear; however, three muskellunge were reported by anglers during the 1974 season. Although optimism concerning stockings of striped bass have waned 31 young-of-the-year striped bass, stocked in 1974, were caught in seine hauls compared to 2 in 1972 and none in 1973.

At Lake Rathbun white bass is the only stocked sport fish capable of sustaining sufficient natural reproduction to increase its population density. Each year, since adult white bass were introduced in 1971, 0-age fish are captured more frequently, increasing from 5 fish in 1972 to 33 in 1973 to 117 in 1974. Relative abundance of adults has also increased from 1972-74, from .2 FND to 1.4 FND to 5.8 FND, respectively.

Carp are the primary non-sport fish at Lake Rathbun, others are of minor importance. Carp dominated the total catch in weight every year except 1974 was the most abundant species caught in 1973 and was second in 1972 and 1974. Catch success of carp has varied from 31 FND in 1974 to 55 FND in 1973. Definable trends in year class abundance are not apparent at this time.

Considerable variation in the total catch by seine hauls between study years was exhibited while the species composition has remained about the same. The total numerical catch has fluctuated from 2,644 fish in 1972 to 6,080 in 1973 to a catch of 4,311 in 1974. Gizzard shad have dominated the catch representing up to 87% of the total. Cyprinids, excluding carp, have provided about 9% of the catch while other species were represented but less numerous.

Problems involving intercept values in the body-scale relationships encountered in the Lake Red Rock study were non-existent, despite the fact samples of sport fish used for age and growth determinations were deficient in small sized fish. Since many samples were biased toward larger and older fish it was nearly impossible to determine if growth of subsequent year classes slowed.

RECOMMENDATIONS

Back calculations of TL at annulus computed in 1974 were similar for determinations of the same year class in most fish for prior study years. However, error in ageing a few fish was serious. To avoid further discontinuity one experienced man will age scales and a second experienced man will verify a subsample of assigned ages.

The project should be continued in the same manner as in the previous segments.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 702-3

JOB NO.: 2

NAME: Effects of Flood Water Management and Fish Species Introduction on Fish Populations in Large Reservoirs

TITLE: Determine the impact of reservoir operations for flood water management on fish populations

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *Daily reservoir elevation and discharge data were obtained from U.S. Corps of Army Engineers Project Offices. At Lake Red Rock deviation from multipurpose pool ranged from -.1 to +11.7 m while sum of deviation was +26.6 m, mean discharge rate was 251 CMS and the mean flushing rate was 34 days. At Lake Rathbun deviation from multipurpose pool ranged from -.1 to +1.3 m while the sum of deviations was +2.4 m, mean discharge rate was 9.3 CMS and mean flushing rate was 412 days. This study will continue until sufficient information is collected to provide a valid statistical analysis of their relation or relationships to fish populations.*

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Date Prepared: 1 June, 1975

Approved by: James Mayhew
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JOB 2 OBJECTIVE

To determine the impact of reservoir operations, for flood water management, on fish populations and their reproduction. Reservoir operation parameters of importance are: (1) reservoir elevation and deviation from authorized multipurpose pool, (2) discharge rate and (3) flushing rate.

INTRODUCTION

The primary objective of this portion of study is to document reservoir operations and their relation to changes or trends occurring in reservoir fish populations.

STUDY BACKGROUND

Water management operations of Lakes Red Rock and Rathbun are continuously monitored by personnel of the U.S. Corps of Army Engineers. These records are available and were compiled for each study year.

Relatively stable water conditions of Lake Red Rock during 1972 were contrasted by high water elevations in 1973. Deviation from multipurpose pool in 1972 ranged from +.2 m to a peak elevation of +1.8 m while the sum of monthly deviations was +5.0 m. Discharge rates ranged from .3 CMS to 7.5 CMS with a mean of 196 CMS. Flushing rate ranged from 28 to 102 days with a mean of 45 days. During 1973 deviation from multipurpose pool ranged from +.6 m to +15.4 m with a sum of deviations of +72.3 m, discharge rates ranged from 211 CMS to 662 CMS with a mean of 491 CMS and flushing rate ranged from 34 to 167 days with a mean of 105 days.

Lake Rathbun was usually near authorized multipurpose pool elevation throughout 1972 but was above during 1973. Deviation from multipurpose pool elevation during the 1972 season ranged from 0 to +.7 m while the season sum was +1.5 m, mean monthly discharge rates ranged from .3 CMS to 7.5 CMS and the mean was 2.7 CMS and flushing rates ranged from 203 to over 5,000 days and the season mean was 710 days. Deviations in 1973 ranged from +.9 m to +4.1 m with a sum of +17.6 m, discharge ranged from 11.3 CMS to 28.6 CMS with a mean of 21.1 CMS and flushing rate ranged from 88 to 2,652 days with a mean of 208 days.

FINDINGS

LAKE RED ROCK

Water level elevation of Lake Red Rock during 1974 was a meter or more above multipurpose pool during four of seven months of study (Table 38). Pool elevation was -.1 m during April and ascended to a peak of +11.7 m by June and declined to +.2 m by September. The sum of deviations from multipurpose pool was 26.6 m. Mean monthly discharge rate ranged from 459 CMS in June to 15 CMS in October while the mean was 251 CMS. Flushing rate ranged from 30 to 100 days and the mean was 34 days.

LAKE RATHBUN

Water level elevation at Lake Rathbun never varied by much more than a meter from multipurpose pool (Table 38). Pool elevation was +.3 m during May, rose to +1.3 m in June, then declined to -.1 m during August and was maintained at that point through October. The sum of deviations from multipurpose pool was +2.4 m. Mean monthly discharge rate ranged from 29.1 CMS in June to 1.4 CMS from August through October while the mean was 9.3 CMS. Flushing rate ranged from 91 to 2,390 days, and the mean was 412 days.

DISCUSSION OF FINDINGS

Flood water management of Lakes Red Rock and Rathbun are contrasting. Lake Red Rock is characterized by a varying discharge rate, fluctuating pool elevation and a high flushing rate, taking as little as 4 days in 1974. On the other hand, Lake Rathbun is relatively stable, usually within a meter of conservation pool elevation and a low flushing rate, as long as 2,390 days in a period of 1974.

RECOMMENDATIONS

Collection of water management operation data should continue to define their association with reservoir species population characteristics.

Table 37. Mean monthly water level elevations, deviation in meters from multipurpose pool elevation, and discharge at Lakes Red Rock and Rathbun, 1974. Authorized multipurpose pool elevation is 221 m at Red Rock and 275.5 m MSL at Rathbun.

	Red Rock			Rathbun		
Sampling period	Mean elevation	Deviation	Mean discharge (CMS)	Mean elevation	Deviation	Mean discharge (CMS)
April	220.9	- .1	342	---	---	---
May	225.7	+ 4.7	342	275.8	+ .3	4.6
June	232.7	+11.7	459	276.8	+ 1.3	29.1
July	229.3	+ 8.3	446	276.3	+ .8	17.6
August	222.3	+ 1.3	128	275.4	- .1	1.4
September	221.2	+ .2	24	275.4	- .1	1.4
October	221.5	+ .5	15	275.4	- .1	1.4
Max. elevation	232.7			276.8		
Min. elevation	220.9			275.4		
Mean elevation	224.8			275.9		
Mean discharge			251			9.3
Sum of deviations		+26.6			+ 2.4	

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 702-3

JOB NO.: 3

NAME: Effects of Flood Water Management and Fish Species Introduction on Fish Populations in Large Reservoirs

TITLE: Determine the success of introductions of fish species and their biological impact upon indigenous fish populations

Period Covered: 1 July, 1974 through 30 June, 1975

ABSTRACT: *Catch statistics of pound and experimental gill nets documented survival to adult sizes while young fish were caught in seine hauls. A table of stockings at each reservoir prior to 1974 was presented in an earlier report. Sport fish were not stocked at Lake Red Rock in 1974 while 11 million walleye fry and 45,000 ocean striped bass fingerling were stocked at Lake Rathbun. Although only 2 0-age walleye were caught in seine hauls 32 young ocean striped bass were seen, the highest figure recorded for that species in three years of stocking.*

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Date Prepared: 1 June, 1975

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JOB 3 OBJECTIVE

Determine the success of introductions of fish species and their biological impact upon indigenous fish populations.

INTRODUCTION

Large reservoirs provide a potential sport fishery resouce that usually can be obtained through stocking predatory sport fish. Often though the success of these stockings is unknown and the physical impact of flood water management is seldom resolved. This study is designed to determine these unknowns.

STUDY BACKGROUND

Five nonendemic species have been stocked into Lake Rathbun and three in Lake Red Rock, at varying rates, since they were impounded. At Lake Rathbun initial stockings of most species during 1969 through 1971 were very successful; however, subsequent stockings were in vain. Fish planting at Lake Red Rock from 1970 through 1973 increased the abundance of each species stocked.

FINDINGS

No sport fish were stocked at Lake Red Rock in 1974. At Lake Rathbun 11 million walleye fry and 45,000 ocean striped bass fingerling were stocked.

DISCUSSION OF FINDINGS

Success of introductions of sport fish at Lake Red Rock and Lake Rathbun was discussed in Job 1 of this report. Continued increase in densities of northern pike and walleye at Lake Red Rock in future years is unlikely since stocking of sport fish was discontinued in 1974.

Survival of ocean striped bass stocked in 1974 at Lake Rathbun appears to be greater than previous years. Seine hauls captured 32 0-age ocean striped bass during the summer, the highest total catch ever recorded for that species.

RECOMMENDATIONS

Continuation of the project to determine the effects of fish stocking on endemic fish populations.