IOWA CONSERVATION COMMISSION

FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

MAN-MADE LAKES FISHERIES INVESTIGATIONS

PROJECT NO. F-88-R-3

Study No. 403-2: Split Stocking Method in Iowa Farm Ponds

Study No. 503-5: Largemouth Bass in Three Man-Made Lakes

Study No. 504-3: Aquatic Vegetation Control By White Amur

Study No. 601-3: 14-Inch Size Limit on Largemouth Bass

Study No. 701-5: Production of 0-Age Fish

Study No. 702-4: Fish Populations in Large Reservoirs

PERIOD COVERED 1 JULY, 75 - 30 JUNE, 76

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

MAN-MADE LAKES FISHERIES INVESTIGATIONS

PROJECT NO. F-88-R-3

Study No. 403-2: Split Stocking Method in Iowa Farm Ponds

Study No. 503-5: Largemouth Bass in Three Man-Made Lakes

Study No. 504-3: Aquatic Vegetation Control By White Amur

Study No. 601-3: 14-Inch Size Limit on Largemouth Bass

Study No. 701-5: Production of 0-Age Fish

Study No. 702-4: Fish Populations in Large Reservoirs

TABLE OF CONTENTS

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 403-2

JOB NO.: 1

NAME: Evaluation of the Split Stocking Method in Iowa Farm Ponds

TITLE: Mortality of bluegill and largemouth bass

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Experimental farm ponds were stocked under the split stocking guidelines established in 1974 for the farm pond program. Fish populations in the ponds were investigated to determine mortality of bluegill and largemouth bass by two methods. Two ponds were drainable with actual mortality determined biannually. At the remaining ponds mortality was estimated by the geometric decrease in catch effort values using three types of sampling gear. Electrofishing catch rates of age 1 bluegill ranged from 0 to 176 fish per shocker hour and were greatest in May, July and August, while age 0 largemouth bass catch effort ranged from 0 to 81 fish per shocker hour. Tow net catch effort of young bluegill was highest in August, while seine catch values were greatest in September before declining. Mortality of age 1 bluegill in the drainable ponds was 23 and 80%, while age 0 bass mortality was 40 and 44%. Mortality of 0-age bluegill computed from catch effort statistics in the other ponds ranged from 16 to > 95%, but averaged 63%. Mortality of age 1 bluegill and age 0 bass computed from catch effort values was 60% and 54%, respectively.*

Prepared by: Larry Mitzner and
Kay Hill
Fishery Research Biologists

Date Prepared: 30 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

STUDY OBJECTIVE

To evaluate a split stocking method in Iowa farm ponds with bluegill and largemouth bass by measuring mortality, growth, fecundity and maturity of initially stocked fish in ten selected farm ponds during the first two years following stocking.

JOB 1 OBJECTIVE

To determine actual and relative mortality of stocked bluegill and largemouth bass in selected farm ponds.

INTRODUCTION

Private owned lands in Iowa contain more than 40,000 small man-made ponds that were constructed for a myriad of reasons. Individually, these impoundments are small bodies of water, but collectively they represent more than 17,000 surface acres of water that are an integral part of recreational angling in this state. Most of these ponds contain fish that were stocked by a governmental agency, private purchase or transferred from other waters. A recent survey of resident anglers indicated 11% of the fishing in Iowa occurred in farm ponds (see Fishing in Iowa, A Survey of Iowa Anglers, May, 1976; Iowa Conservation Commission Publication). The importance of farm ponds in the Southwest Region was even more evident where 16% of the respondents indicated a preference for this type of angling. Nearly one-half (47%) of the resident fishermen contacted in one district of the Southwest Region stated farm pond fishing was their first choice.

Farm pond stocking strategies have been extremely variable with respect to fish species, stocking rate, fish size and the order of planting. These factors are vital to development of an economical and practical plan for statewide stocking which will provide maximum benefits to pond fisheries.

A split season stocking regime was initiated in Iowa in 1974 that used an autumn stocking of 2,500 fingerling bluegill per hectare (1,000 per acre) followed by a spring planting of 250 largemouth bass advanced fry per hectare (100/acre). Fingerling channel catfish were also stocked with the bluegill at the same rate as bass. The rationale for this procedure was to allow development of a bluegill forage base prior to the first spawning of bass in the next year following the initial planting thereby strengthening the predator-prey relationship.

The intent of this study segment was to determine the annual mortality of bluegill and largemouth bass in the second year following split stocking.

STUDY BACKGROUND

The Iowa farm pond stocking program began in 1945 using a fall planting of 100 largemouth bass and 1,500 fingerling bluegill. All ponds were stocked upon owner request regardless of size, depth or watershed characteristics. From 1946-54, 300 bluegill and 100 largemouth bass fingerlings were planted in the autumn in ponds that met minimum requirements of 1/4 acre in surface area and 8 ft or over in maximum depth. Starting in 1954, 100 largemouth bass fingerlings and 10 pair of mature bluegill were planted in the fall. Collection and transportation of the bluegill was time consuming and costly so the program was adjusted in 1960 to stock 200 advanced fry bass per acre in newly constructed or renovated ponds. No bluegill were planted because of their low acceptance by pond owners. Minimum pond criteria were adjusted with the split season stocking procedure so that all ponds must be at least 1/2 acre in size, 8 ft minimum depth, fenced from livetock and contain an adequate grass covered buffer strip around the shoreline perimeter.

METHODS AND PROCEDURES

Ten experimental ponds that met all minimum stocking requirements were selected for intensive study. They were stocked with fish at the recommended rates in the autumn of 1974. Despite the fact all exceeded minimum requirements, two ponds in the Elk Grove area winterkilled. Two private ponds stocked at the same time were selected to replace these ponds.

Annual mortality of immature bluegill and largemouth bass was estimated by two methods. Two ponds, at a former warmwater fish hatchery, were completely drained in the spring following the autumnal stocking, survivors counted, ponds refilled and the fish restocked. Mortality in the other ponds was estimated in the usual fashion using the mean geometric decrease in catch effort values from standardized small mesh drag seine hauls, 0.5 m (19.7 in) diameter net tows and electrofishing the pond perimeter.

Fish population sampling was conducted once each month from April-October, 1975 in seven ponds in Lucas and Davis Counties, while ponds in Adair and Guthrie Counties were sampled biweekly from mid-May through mid-November.

Seine samples were made at four stations in each pond with replicate samples taken at each station. The hauls were made in equal quadrants with one seine end remaining at the water edge and the other stretched perpendicular to the shoreline and rotated toward shore.

The tow net was conical shaped, approximately 3 m (9.8 ft) long constructed with .8 mm (1/32 in) nylon mesh and a .5 m (1.6 ft) diameter metal ring to support the net opening. Each tow was made slightly below the surface about 6.1 m (20 ft) behind an outboard motor powered boat at a velocity of 1.2 m/sec (4 ft/sec). Three tows parallel to the shoreline and one open water tow were replicated twice in each pond during all sampling periods. Fish samples were immediately preserved in 5% buffered formalin and identified later by the larval fish taxonomic key by May and Gasaway (1967).

Electrofishing samples were obtained with a boat equipped with a 240 volt AC unit. The boat was slowly driven parallel with the shoreline with one technician attempting to retrieve all stunned fish with a body size sufficient to stay in a 6.5 mm (1/4 in) mesh dip net.

Comparisons of bluegill reproduction in the ponds was made by rating each pond from 1-10 based on the time of initial reproduction and the magnitude of fry production. Similar ratings were assigned for age 1 bluegill survival and age 0 largemouth bass survival. The rating for each criteria were then pooled for each pond for overall comparison.

DESCRIPTION OF STUDY PONDS

Five of the ponds studied were located on state-owned lands and six on privately owned lands. Two, which could be drained and refilled, were located at a fish hatchery and were previously used for several decades in fish production. Ten were constructed for the usual agricultural purposes such as livestock watering, erosion control, recreation, and so forth. All met the minimum requirements for fish stocking by the Iowa Conservation Commission. As previously stated, a winterkill in two of the Elk Grove Ponds precluded development of fish populations, which necessitated selection of two additional ponds, the Adair Pond and Anita Pond.

Surface area of the ponds ranged from .24 ha (.60 ac) in Wapello Pond 2 to .75 ha (1.86 ac) in the Coffey Pond. Storage volume varied from 2.95 $m^3 \times 10^3$ (2.4 ac/ft) and 19.00 $m^3 \times 10^3$ (15.41 ac/ft) in these ponds, respectively. Maximum depth ranged from 2.44 m (8 ft) in Wapello Ponds 1 and 2 to 6.4 m (21 ft) in the Coffey Pond. Mean depth varied from 1.22 m (4 ft) to 2.52 m (8.3 ft) in these ponds, respectively. Agricultural practices in the watershed ranged widely from quite intensive small grain row crops to grasslands. All of the ponds except the Wapello Ponds and Elk Grove Ponds were newly constructed impoundments. The latter were renovated with a chemical fish toxicant prior to stocking. Physical characteristics of individual ponds are listed in Table 1.

FINDINGS

ABUNDANCE OF AGE 1 AND 0 BLUEGILL AND AGE 0 BASS

Abundance of bluegill in the electrofishing sample decreased from August to September in Wapello Pond 1 (Table 2). Catch per unit effort decreased from 23 fish/shocking hour (F/SH) in April to 20 F/SH in May and June. Catches increased to 60 F/SH in August but declined to 20 F/SH in September when collection ceased. Largemouth bass were first collected in July at a rate of 75 F/SH, but in August mean catch effort decreased to 28 F/SH (Table 3). During the last collection period bass catch effort increased to 60 F/SH.

Table 1. Physical characteristics of the farm ponds used for study in the split method stocking evaluation.

Name	County location	Area		Volume		Maximum depth		Mean depth		Agricultural watershed use	Water source	Ownership
		ha	ac	$m^3 \times 10^3$	ac/ft	m	ft	m	ft			
Wapello 1	Davis	.28	.70	3.45	2.80	2.44	8.0	1.22	4.0	Grassland	Lake piped	State
Wapello 2	Davis	.24	.60	2.95	2.40	2.44	8.0	1.22	4.0	Grassland	Lake piped	State
Pierce	Lucas	.58	1.45	10.16	8.24	4.67	15.3	1.73	5.7	Pasture-Rowcrop	Runoff	Private
Coffey	Lucas	.75	1.86	19.00	15.41	6.40	21.0	2.52	8.3	Buffer-Rowcrop	Runoff	Private
Morr	Lucas	.72	1.79	15.10	12.25	4.26	14.0	2.06	6.8	Buffer-Rowcrop	Runoff	Private
Shelton	Lucas	.39	.97	8.69	7.05	5.50	18.0	2.21	7.3	Pasture	Runoff	Private
Anita	Adair	.40	.98	4.36	3.54	3.66	12.0	1.10	3.6	Pasture	Runoff	Private
Adair	Guthrie	.30	.74	3.15	2.56	3.25	10.7	1.05	3.4	Pasture	Runoff	Private
Elk Grove 1[a]	Guthrie	.72	1.80	7.74	6.12	3.35	11.0	1.05	3.4	Grassland	Runoff	State
Elk Grove 2	Guthrie	.72	1.80	9.50	7.71	3.36	12.0	1.32	4.3	Grassland	Runoff	State
Elk Grove 3[a]	Guthrie	.89	2.20	9.79	7.48	3.65	12.0	1.06	3.4	Grassland	Runoff	State

[a]Ponds were excluded from fish population studies due to winterkill.

Table 2. Electrofishing catch rates (F/SH) of age 1 bluegill in study ponds from April through November.

	April	May	June	July	August	September	October	November
Wapello 1	23	20	20	45	60	20		
Wapello 2	20	20	0	43	33	80		
Pierce	28	128	38	24	60	6		
Coffey	0	175	0	0	0	0		
Shelton	17	172	4	13	42	31		
Morr	10	46	104	64	36	16		
Anita			17	84	15	9	18	24
Adair		40	89	75	40	9	20	3
Elk Grove 2	22	32	84	102	82	87	58	42

Table 3. Electrofishing catch rates (F/SH) of age 0 largemouth bass in study ponds from June through November.

	June	July	August	September	October	November
Wapello 1		75	28	60		
Wapello 2		21	27	24		
Pierce		2	0	0		
Coffey		81	40	19		
Shelton		2	17	31		
Morr		20	28	24		
Anita	6	21	45	9	18	22
Adair	2	12	42	15	28	14
Elk Grove 2	4	8	18	58	13	20

Bluegill fry were found in tow net hauls during August and September in Wapello Pond 1 (Table 4). Catch rates of bluegill fry/tow net meter (F/TM) for these dates were 2.78 F/TM and .08 F/TM, respectively. Bluegill advanced fry were first collected with a seine in this pond, during August (Table 5). Relative abundance of bluegill advanced fry/seine haul (F/HL) was 1.5 F/HL in August and increased to 13.4 F/HL in September when collections ceased.

Table 4. Tow net catch rates (F/TM) of age 0 bluegill in study ponds from July through November.

	July	August	September	October	November
Wapello 1	0	2.78	.08		
Wapello 2	.23	40.25	.54		
Pierce	0	.24	0		
Coffey[a]	-	-	-	-	-
Shelton	< .01	.57	0		
Morr	.04	.69	0		
Anita	0	.20	.01	0	0
Adair	.16	.69	.92	2.28	.20
Elk Grove 2	.49	.22	.67	.32	.38

[a]Samples taken but no fish captured.

Table 5. Seine haul catch rates (F/HL) of bluegill advanced fry in study ponds from July through November.

	July	August	September	October	November
Wapello 1	0	1.5	13.4		
Wapello 2	0	0	2.1		
Pierce	0	.1	6.5		
Coffey	0	0	0		
Shelton	0	2.1	114.2		
Morr	0	3.5	4.0		
Anita	0	1.7	2.7	0	0
Adair	1.5	66.3	216.6	195.1	47.3
Elk Grove 2	1.5	6.3	69.0	347.0	106.5

Bluegill catches were more variable in the Wapello Pond 2 than in Wapello Pond 1. Bluegill catch rates remained at 20 F/SH through May, decreased to 0 in June, and peaked at 80 F/SH on the last sampling period. Bass catch rates fluctuated no more than 7 F/SH throughout the three month collection period. Bass were collected at a rate of 21 F/SH in July, 27 F/SH in August, and 24 F/SH during September.

Age 0 bluegill were captured with a tow net in Wapello Pond 2 for three months. Catch effort was .23 F/TM in July, 40.25 F/TM in August and decreased to .54 F/TM by September. Bluegill advanced fry were collected with a seine in September only, when relative abundance was 2.1 F/HL.

Age 1 bluegill were easily captured in the Pierce Pond during May, became least abundant in catches during September. Bluegill catch rates declined from 128 F/SH in May to 24 F/SH in July, increasing to 60 F/SH in August, but decreasing to 6 F/SH by September. Largemouth bass were collected only during the July sampling period when catch effort was 2 F/SH. Their absence in subsequent sampling periods is explained by either extreme mortality or gear avoidance, but the former is suspected because in 7 of the 9 study ponds largemouth catch effort increased in August and September and bass were collected in all other study ponds during the same period.

Bluegill fry were collected with the tow net in the Pierce Pond only during the August sampling period when they were captured at a rate of .24 F/TM. Bluegill advanced fry were found in seine hauls during August and September in this pond. Catch rates were .13 F/HL during the second sampling period, and increased to 6.5 F/HL in September.

Bluegill were collected by electrofishing only once in Coffey Pond, at a rate of 175 F/SH in May. Extreme mortality is suspected as no bluegill fry were collected in this pond, but reproduction occurred in all other study ponds. Toxic agricultural chemicals were the suspected causative agent because of heavy runoff in late May from the row crop watershed. Largemouth bass were most abundant in July (81 F/SH), but declined during remaining sampling periods; 40 F/SH in August and 19 F/SH in September.

No bluegill reproduction was observed in the Coffey Pond and catch data for both gear gave credence to this postulation. Bluegill adults were not collected by electrofishing after May because of suspected extreme mortality.

Age 1 bluegill were most easily captured during the second sampling period in Shelton Pond. Capture success of bluegill ranged from 171.6 F/SH in May to 4.2 F/SH in June. Capture success increased following two sampling periods to 41.7 F/SH in August, but declined to 31.3 F/SH in September. Largemouth bass catch success increased during three sampling periods from 2 F/SH in July to 17 F/SH in August and peaked in September at 31 F/SH.

Bluegill fry were captured in net tows only during August in the Shelton Pond when they were collected at a rate of .57 F/TM. Contrasting to tow net sampling, seines collected bluegill advanced fry during two months, August and September. Catch rates increased from nothing in July to 2.1 F/HL in August to 114.2 F/HL by September. The catch rate peaks for tow net data in August and seine haul peaks in September are explained by gear selectivity.

Age 1 bluegill were collected with an electroshocker during the entire sampling season in the Morr Pond. Ten fish per shocking hour were taken in April and 46 F/SH were captured in May. Bluegill were most abundant in June when they were caught at a rate of 104 F/SH. Catch effort decreased from 64 F/SH during July to 16 F/SH in September. Largemouth bass were collected from July through September at rates ranging from 20 to 28 F/SH. In July, largemouth bass were sampled at a rate of 20 F/SH, while the following month, they were more easily captured (28 F/SH). Sampling rates declined in September to 24 F/SH.

Bluegill fry were found in net tows during July and August in the Morr Pond. Catch rates were .04 F/TM and .69 F/TM for July and August, respectively. Seines were effective for capturing bluegill advanced fry during August and September. Catch/effort increased from 3.5 F/HL in August to 4 F/HL by September when collections ceased.

Electrofishing started in June and continued to mid-November in the Anita Pond. Age 1 bluegill were collected at rates ranging from 84 F/SH in July to 9 F/SH in September. Bluegill collection success increased during the last two sampling months to 24 F/SH in November. Largemouth bass were sampled for six consecutive sampling periods. Collection success rates increased from 6 F/SH in June to 45 F/SH two months later. From August to September catch rate decreased from 45 F/SH to 9 F/SH. Largemouth bass were more easily captured in late fall as catch rates increased from 9 F/SH in September to 22 F/SH during November.

Low bluegill fry numbers were observed in Anita Pond as capture rates with both gear type reveal. Fry were found in net tows only during August and September when catch rates were .20 F/TM and .01 F/TM. Advanced fry were seined at rates of 1.7 F/HL and 2.7 F/HL during August and September, respectively; the only sampling periods when fry were found.

Bluegill adults were collected from May to mid-November in the Adair Pond. Bluegill catch rates increased from 40 F/SH in the first sampling period to 89 F/SH in June. Collection rates declined to 75 F/SH on the third period to 9 F/SH by September. Bluegill were more abundant in catches on the sixth period, but catch rates reached a low of 3 F/SH on the last sampling period. Largemouth bass catch rates were variable during the sampling season, increasing from 2 F/SH in June to 42 F/SH by August. In the remaining periods bass were caught at rates of 15 F/SH in September, 28 F/SH in October and 14 F/SH during November.

Tow net sampling was initiated during July in the Adair Pond. Catch rates increased from .16 F/TM in July to 2.28 F/TM by October. Catch effort was .69 F/TM and .92 F/TM in August and September, respectively. Capturing efficiency decreased to .20 F/TM in November when collections ceased. Advanced fry were collected from July to November, and greatest catch efficiency was in September. Capture rates ranged from 1.5 F/HL in July to 216.6 F/HL in September. Catch effort decreased during the last two sampling periods when 195.1 F/HL were caught in October and 47.3 F/HL were caught during the last period.

Age 1 bluegill were captured during all sampling periods in Elk Grove Pond 2. Bluegill catch rates increased from 32 F/SH in May to 102 F/SH in July, but decreased to 42 F/SH on the last sampling period. Largemouth bass were most easily captured in September being caught at rates of 58 F/SH compared to 4, 8, and 18 F/SH for June, July and August, respectively. Capturing efficiency declined to 13 F/SH in October and increased to 20 F/SH in the last sampling period.

Bluegill fry were captured during all months in the Elk Grove Pond. Catch rates increased from .49 F/TM in July to .67 F/TM by September, but declined to .38 F/TM during November. Advanced fry data in the Elk Grove Pond differed from other pond data by revealing greatest fry numbers in October and November. Catch rates were 1.5 F/HL, 6.3 F/HL, 69.0 F/HL, 357.0 F/HL and 106.5 F/HL for each month, July through November, respectively.

Ratings of 1 through 10 were assigned to each pond for greatest numbers of age 0 bluegill, since largemouth bass growth appears to be partially dependent on a large forage supply. If two ponds had equal catch efforts, the pond with the earliest catch effort peak received the higher ranking since timelinesss of forage is important to small bass fingerling.

Rating for each pond ranged from 1 for the Coffey Pond where no fry were collected to an average rating of 9 for the Adair Pond (Table 6). Highest rankings for seine haul data were given to the Adair Pond, Elk Grove Pond and Shelton Pond in decreasing order and these ponds contained the largest bass on the last sampling date. Rankings for tow net data revealed Wapello Ponds 1 and 2 receiving highest rankings with Adair and Shelton Ponds achieving third and fourth. The Adair Pond received the highest average ranking with Wapello Pond 1 and Elk Grove Pond receiving second and third place. Shelton and Wapello Pond 2 were fourth and fifth while Coffey Pond received the lowest ranking.

Table 6. Numerical rankings of study ponds relative to bluegill fry abundance.

Pond	Seine haul	Tow net	Average
Wapello 1	7	9	8
Wapello 2	3	10	6.5
Pierce	6	4	5
Coffey	1	1	1
Morr	5	7	6
Shelton	8	5	6.5
Anita	4	3	3.5
Adair	10	8	9
Elk Grove	9	6	7.5

MORTALITY

Actual annual mortality rates were determined on Wapello Ponds 1 and 2 by counting the remaining fish at pond drainage. Four hundred seventy-two bluegill were stocked in Wapello Pond 1 on 29 April, 1974, and 363 were recovered on 5 May, 1975, giving an annual mortality rate of 23.1% (Table 7). Largemouth bass mortality was 40% since 63 bass of the 105 planted were recovered. Mortality for both species were higher in Wapello Pond 2. Bluegill mortality was 80.3%, while 44.3% of the bass perished.

Table 7. Actual mortality rates of age 1 bluegill and age 0 largemouth bass in Wapello Ponds 1 and 2 from 29 April, 1974 to 5 May, 1975.

Pond	Species	Number stocked	Number recovered	Mortality %
Wapello 1	Bluegill	472	363	23
	Bass	105	63	40
Wapello 2	Bluegill	540	106	80
	Bass	70	39	44

Estimated annual mortality rates from electroshocking results ranged from 24.6% in the Adair Pond to > 95% in the Coffey Pond (Table 8). Elk Grove Pond experienced low bluegill mortality, 25%, but age 1 bluegill mortality in the remaining 6 ponds ranged from 45.6% to 86.3%.

Table 8. Estimated mortality rates of age 1 bluegill and age 0 largemouth bass in nine selected farm ponds during 1975.

	Electroshocker		Seine	Tow net
Pond	Bluegill	Bass	Bluegill	Bluegill
Wapello 1	45.6	19.7		> 95.0
Wapello 2	81.1	63.2		> 95.0
Pierce	72.2	66.3		16.4
Coffey	> 95.0	51.3		--
Shelton	86.3			36.2
Morr	46.3	14.0		40.5
Anita	67.1	80.0	72.7	59.3
Adair	24.6	57.6	53.4	91.2
Elk Grove	25.0	77.6	69.2	52.7
Mean	60.3	53.7	65.1	60.7

Largemouth bass annual mortality estimates ranged from 14.6% in Morr Pond to 80% in Anita Pond, but all other estimates except Wapello Pond 1 (19.7%) ranged from 51.3% to 77.6%. Largemouth bass annual mortality estimates were 19.7% and 63.2% for Wapello Ponds 1 and 2, while actual bass mortality was 40% and 44.3%.

Bluegill fry annual mortality estimates were made from seine data on three ponds because sampling stopped in September on other ponds when catch/effort peaked. Annual estimated mortality of advanced bluegill fry ranged from 53.4% in Adair Pond to 72.7% in Anita Pond. Mortality estimates from tow net data ranged from 16.4% for the Pierce Pond to > 95% for both Wapello Ponds.

Average estimated annual mortality of different gear differed little. Bluegill adult average mortality for all ponds was 60.3%, while bass mortality was estimated at 53.7%. Bluegill advanced fry average mortality rate was 65.1%, and the average rate determined from tow net data was 60.7%.

DISCUSSION OF FINDINGS

Establishment of minimum pond requirements does not guarantee fish survival. Despite all ponds exceeding minimum requirements, fish perished in two Elk Grove Ponds from low dissolved oxygen concentration caused by winterkill conditions, while bluegill were eliminated in the Coffey Pond and largemouth bass experienced extreme mortality in Pierce Pond. Suspected cause of Coffey Pond bluegill mortality was agricultural chemical runoff, while cause of Pierce Pond largemouth bass mortality was unknown.

Annual estimated mortality differed from actual mortality in Wapello Ponds 1 and 2. Estimated age 1 bluegill mortality for these ponds was 45.6% and 81.1%, respectively, while actual mortality of 23.1% and 80.3% was recorded. Estimated and actual age 1 bluegill mortality rates were similar in Wapello Pond 2, but estimated mortality was twice the actual mortality in Wapello Pond 1. Largemouth bass mortality was slightly underestimated in Wapello Pond 1, but was overestimated nearly 50% in Wapello Pond 2. Seasonal catch efficiency influenced the estimated mortality error during one season, but if data from two seasons were available, error could be reduced by compensating for seasonal variance. Age 1 bluegill catch rates were highest in early summer because bluegill distributions were concentrated at spawning sites. Electrofishing relative abundance indices may have high variability because of seasonal fish distributions.

Mean estimated mortality rates of age 0 bluegill were similar for both gear types. Mean mortality rates of 60.7% for eight ponds determined from tow net data compared closely with the mean mortality rate of 65.1% determined with seine data from three ponds. The slight increase in mortality of bluegill fry > 14 mm (.52 in) TL would be expected if bass predation was the principal cause of bluegill fry mortality, because as bass grew, greater quantities of bluegill fry would be consumed.

Most tow net catch rate peaks were followed by seine haul catch rate peaks. Bluegill fry outgrowing and outswimming the tow net increased their vulnerability to the seine. Larger fry were retained by the seine while smaller fry passed through the mesh.

RECOMMENDATIONS

This investigation will continue in 1976 except actual mortality determinations will be eliminated.

LITERATURE CITED

May, E. and C. Gasaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma, with particular reference to Canton Reservoir, including a selected bibliography. Okla. Dept. Wildl. Conserv., Okla. Fish. Res. Lab., Bull. 5. 33 pp.

Ricker, W. 1975. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada, Bull. No. 191, 382 pp.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 403-2

JOB NO.: 2

NAME: Evaluation of the Split Stocking Method in Iowa Farm Ponds

TITLE: Fecundity and maturity of bluegill and largemouth bass

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Fecundity and age at maturity of age 1 bluegill stocked by the split stocking method in experimental ponds was determined from April-August. Average fecundity, expressed as mature ova per gram of body weight, ranged from 18 ova/g for mature bluegill in June to 198 ova/g in July. Thereafter, fecundity decreased to 165 ova/g in August, 21 ova/g in September and < 1 ova/g in October. Spawning first occurred during early July at 75% of the ponds, while spawning occurred by mid-July or early August in the remaining ponds. Bluegill maturity, fecundity and the influence on largemouth bass growth was discussed.*

Prepared by: Larry Mitzner and
Kay Hill
Fishery Research Biologists

Date Prepared: 30 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

JOB 2 OBJECTIVE

To determine fecundity and age of maturity of bluegill and largemouth bass in ten selected ponds.

INTRODUCTION

The maintenance of acceptable predator-prey relationships becomes increasingly difficult if adequate bass growth and recruitment declines from levels attained when the population was expanding following initial stocking. Adequate forage is required to provide adequate bass growth thereby eliminating a missing year class of bass. Sufficient bass growth is also needed in their first year to enable the bass to successfully spawn at age 1. With the current bass-bluegill farm pond stocking scheme, bluegill fry and fingerlings provide the only forage; therefore bluegill production is paramount. Estimation of bluegill fry production was necessary to determine the relationship between young bluegill produced and bass growth, but prior to achieving this goal, fecundity of adult bluegill and the age at maturity was needed to determine potential bluegill reproduction.

STUDY BACKGROUND

Bluegill fecundity and age at maturity under the split stocking guidelines were investigated by selecting study ponds and defining the reproductive biology of bluegill in these ponds. Ponds were selected to meet the pond program criteria and were similar to those stocked throughout the state. Bluegill fingerlings with a mean length of 25 mm (1 in) were stocked at 2,500/ha (1,000/ac) in September, 1974. In June, 1975 bass were stocked at 250/ha (100/ac) with a mean length of 36 mm (1.4 in).

METHODS AND PROCEDURES

Each month from May-October three age 1 male and female bluegill were randomly sampled by electrofishing from each pond. The fish were weighed, measured, and the gonads preserved for microscopic examination and ova enumeration. Observed condition, maturity of the gonads and nesting or spawning activity were recorded.

Volume and weight of each ovary was recorded and 10 mg was subsampled from the midsection. Individual ova in the subsample were separated from connective tissue, measured and enumerated and total ova were estimated by multiplying the weight ratio of ovary to subsample by ova/10 mg of ovary. Ova greater than .5 mm were considered mature using the criteria developed by James (1946).

FINDINGS

Mature ova produced by age 1 bluegill varied from 0-410 ova per gram of body weight (ova/g) with most of the mature ova collected in July and August (Table 9). Bluegill from Pierce and Morr Ponds sampled in June contained mature ova, while fish in the other ponds contained only immature ova. Fish collected from the Pierce Pond contained .5 ova/g while fish in Morr Pond produced 88 ova/g. Ova counts increased in four ponds during July. Wapello Ponds 1 and 2 yielded fish with 260 ova/g and 357 ova/g, respectively in July. Ova counts at 186 ova/g were identical for bluegill collected from Morr and Shelton Ponds during July. Ova numbers decreased in fish collected from the Wapello Ponds and by September fecundity was 1 and 82 ova/g at Ponds 1 and 2, respectively. Fish collected from the Pierce Pond contained few mature ova with .5, 0, 3, and 1 ova/g recorded for fish sampled in June, July, August, and September. Bluegill ova counts increased in Morr Pond from June to July and decreased to 22 ova/g by September. Shelton Pond showed slightly different results as ova counts increased to 410 ova/g in August, but in September mature ova were non-existent in the samples.

Table 9. Fecundity of bluegill in six study ponds from June to October expressed as mature ova per gram of body weight.

	June	July	August	September	October
Wapello 1	0	260	147	1	0
Wapello 2	0	357	101	82	3
Pierce	.5	0	3	1	0
Coffey[a]	-	-	-	-	-
Morr	88	186	[a]	22	0
Shelton	0	186	410	0	0

[a]No adult bluegill collected.

Initial spawning dates varied by nearly one month among study ponds. Fish were first observed spawning on 8 July in Morr Pond, and on 9 July in Shelton, Adair and Elk Grove Ponds with bluegill spawning in the Anita Pond two weeks later, on 22 July (Table 10). First observed bluegill spawning occurred on 6 August in Pierce Pond. No spawning occurred in Coffey Pond because adult bluegill were eliminated in late May. Suspected cause of the mortality was farm chemical runoff from the watershed. Spawning dates were uncertain in the Wapello Ponds, but the mature ova count and larval fish sampled indicated July spawning.

Table 10. Observed spawning dates of adult bluegill in study pond during 1975.

Pond	Initial spawning date
Wapello 1	a
Wapello 2	a
Pierce	August 6
Coffey	None
Morr	July 8
Shelton	July 9
Anita	July 22
Adair	July 9
Elk Grove	July 9

[a]Not observed.

DISCUSSION OF FINDINGS

Timeliness of bluegill spawning greatly affected largemouth bass growth. In Anita Pond, where spawning did not occur until 22 July, largemouth bass grew to a mean length of 136 mm (5.4 in), while in ponds with spawning in early July average bass length in October was 156 mm (6.1 in). Bluegill at Pierce Pond spawned later of any pond and ova counts and larval fish sampling showed young bluegill production was minimal. Spawning dates in Wapello Ponds undoubtedly occurred in early July, because large numbers of mature ova were recorded in July; largemouth bass growth was well above average.

RECOMMENDATIONS

The investigation will continue in 1976.

LITERATURE CITED

James, M. 1946. Histology of gonadal changes in the bluegill, *Lepomis macrochirus* Rafinesque, and the largemouth bass, *Huro salmoides* (Lecépède). J. Morph. 79(1):63-91.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 403-2

JOB NO.: 3

NAME: Evaluation of the Split Stocking Method in Iowa Farm Ponds

TITLE: Growth of bluegill and largemouth bass

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Total length of bluegill fingerlings stocked in October, 1974 at 2,500/ha (1,000/ac) were measured each month from April-November, 1975 to determine growth. Growth commenced in May when mean length of bluegill was 38 mm (1.5 in). By October when growth ceased body length of bluegill averaged 132 mm (5.2 in). Growth of largemouth bass was determined in the same ponds where they were stocked at 250/ha (100/ac) in June, 1976. Mean body length at stocking was 36 mm (1.4 in) which increased to 170 mm (6.7 in) by November. Bluegill growth was slowest at Coffey Pond and most rapid at Adair Pond, while bass growth was slowest at Pierce Pond and greatest at Shelton Pond. Ponds with greater age 0 bluegill abundance had the most rapid bass growth.*

Prepared by: Larry Mitzner and
Kay Hill
Fishery Research Biologists

Date Prepared: 30 June, 1976

Approved by: James Mayhew
Fishery Reserach Supervisor

JOB 3 OBJECTIVE

To determine growth of bluegill and largemouth bass stocked in ten ponds located in Davis, Lucas, and Guthrie Counties.

INTRODUCTION

The split stocking procedure provided for an autumn planting of 2,500 bluegill fingerling/ha (1,000 fingerling/ac) and 250 largemouth bass fingerling/ha (100 fingerling/ac) the following June.

Documentation of stocked bass and bluegill growth in Iowa by this schedule was initiated to determine if the autumn stocked bluegill reached maturity shortly after bass were stocked the following June, thereby producing forage for bass and stimulating rapid growth and maturity of bass within a year. The intent of this segment was to follow the growth of stocked bluegill and largemouth bass in the experimental ponds following initial planting.

STUDY BACKGROUND

Growth of bass and bluegill in ponds with reference to experimental stocking schemes has been extensively investigated, particularly in the southern states. Swingle (1950) investigated the dynamics of Alabama pond fish populations in the 1940's, while less intensive studies by investigators in the Midwest were conducted in the 40's and early 50's. Bass and bluegill growth statistics in Iowa farm ponds are rare. Carlander (1952), Fessler (1950) and Ruhr (1952) investigated standing crops of pond fishes in Iowa, but little information was available on growth. No information is available on growth rate as related to stocking strategy.

METHODS AND PROCEDURES

Electrofishing and seine samples were collected biweekly at the Anita, Adair, and Elk Grove Ponds from May through mid-November, and monthly at other ponds from April through September. All captured fish were measured to the nearest millimeter and weighed in aggregate for fish less than 100 mm (3.9 in) total length (TL), while fish larger than 100 mm ((TL) (3.9 in) were weighed individually to the nearest gram. Mean total length for each fish species was calculated each month during the season at each pond. Fish growth in the ponds was subjectively ranked from 1 to 10 using bass and bluegill lengths in October as the criteria, where a value of 10 represented fastest growth, while 1 was slowest growth.

FINDINGS

Fish growth in Wapello Ponds 1 and 2 were similar. Bluegill at Pond 1 had a mean length of 40 mm (1.6 in) at the first sampling period, attained 96 mm (3.8 in) in July and grew nearly 7 mm (.3 in) per month during the remaining season, reaching a mean length of 118 mm (4.6 in) (Table 11). Largemouth bass length increased about 42 mm/month (1.7 in/month) until mid-September when mean bass length reached 165 mm (6.5 in) (Table 12).

Table 11. Mean body length of bluegill in mm at nine ponds from June-October, 1975. Subtended values are in inches.

	June	July	August	September	October
Wapello 1	65 (2.6)	96 (3.8)	99 (3.9)	111 (4.4)	118 (4.6)
Wapello 2	[a]	102 (4.0)	105 (4.1)	127 (5.0)	134 (5.3)
Pierce	64 (2.5)	79 (3.1)	97 (3.8)	103 (4.1)	110 (4.3)
Coffey	[a]	[a]	[a]	[a]	[a]
Morr	64 (2.5)	79 (3.1)	97 (3.8)	106 (4.2)	129 (5.1)
Shelton	87 (3.4)	100 (3.9)	121 (4.8)	134 (5.3)	139 (5.5)
Anita	62 (2.4)	90 (3.5)	95 (3.7)	136 (5.4)	138 (5.4)
Adair	82 (3.2)	98 (3.9)	110 (4.3)	141 (5.6)	152 (6.0)
Elk Grove	71 (2.8)	91 (3.6)	117 (4.6)	120 (4.7)	134 (5.3)
Mean	71 (2.2)	92 (3.6)	105 (4.1)	122 (4.8)	132 (5.2)

[a]No fish sampling during the period.

Table 12. Mean body length of largemouth bass in mm at nine ponds from June-October, 1975. Subtended values are in inches.

	June	July	August	September	October
Wapello 1	37 (1.5)	84 (3.3)	120 (4.7)	166 (6.5)	161 (6.3)
Wapello 2	37 (1.5)	94 (3.7)	122 (4.8)	146 (5.7)	165 (6.5)
Pierce	41 (1.6)	[a]	[a]	[a]	[a]
Coffey	39 (1.5)	58 (2.3)	107 (4.2)	118 (4.6)	127 (5.0)
Morr	32 (1.3)	78 (3.1)	120 (4.7)	145 (5.7)	157 (6.2)
Shelton	38 (1.5)	97 (3.8)	144 (5.7)	205 (8.1)	216 (8.5)
Anita	[a]	71 (2.8)	109 (4.3)	129 (5.1)	137 (5.4)
Adair	[a]	90 (3.5)	119 (4.7)	184 (7.2)	225 (8.9)
Elk Grove	29 (1.1)	68 (2.7)	127 (5.0)	172 (6.8)	170 (6.7)
Mean	36 (1.4)	80 (3.1)	121 (4.8)	158 (6.2)	170 (6.7)

[a]No fish sampled during the period.

Bluegill length at the first measured in mid-April averaged 40 mm (1.6 in) in Wapello Pond 2, but exhibited little growth by mid-May. July sampling revealed bluegill averaged 102 mm (4.0 in) in length. At the last sampling period, mean bluegill length in Wapello Pond 2 was 134 mm (5.3 in). Largemouth bass growth rate accelerated during June from 37 mm (1.5 in) to 94 mm (3.7 in), but after July, growth rate declined to 20-24 mm (.9 in) a month. Mean length of bass in mid-October was 165 mm (6.5 in).

Bluegill collected in mid-April at Pierce Pond averaged 30 mm (1.2 in). By mid-May they had increased to 35 mm (1.4 in) and when bass were introduced in June, bluegill mean length was 64 mm (2.5 in). From July through October, bluegill grew steadily to a mean length of 110 mm (4.3 in). Largemouth bass collected in late June were 41 mm (1.6 in). No bass were collected during later sampling periods, because of extreme mortality of unknown cause.

Bluegill were collected at Coffey Pond only during the second sample period when they averaged 35 mm (1.4 in) in total length. Largemouth bass grew from 39 mm (1.5 in) in June to a mean length of 107 mm (4.2 in) during the August sample period. From August through October, bass grew 20 mm (.8 in), averaging 127 mm (5.0 in) at the last sample period. Poor sampling success of bluegill was probably due to total mortality since no bluegill fry were collected later in the season. Agricultural chemicals washed from the watershed was suspected as the probable cause of bluegill mortality from a pesticide application to row crops in the watershed in late May followed by heavy rains. Lack of bluegill young greatly attenuated largemouth bass growth.

Bluegill in Morr Pond attained a mean length of 25 mm (1 in) in mid-April and body length increased steadily through October when mean length was 129 mm (5.1 in). Largemouth bass fingerlings had a mean length of 32 mm (1.3 in) when introduced in late June and increased in length to 120 mm (4.7 in) by August. Bass growth rate declined in August and September and by mid-October, mean length was 157 mm (6.2 in).

Bluegill in the Shelton Pond attained a mean length of 30 mm (1.2 in) in April to 87 mm (3.4 in) in June. Bluegill exhibited steady growth through September reaching a mean length of 139 mm (5.5 in) in mid-October. Largemouth bass fingerlings with a mean length of 38 mm (1.5 in), at the June planting grew rapidly until 1 September when they were 205 mm (8.1 in) in length. Largemouth bass growth rate declined through October attaining a mean length of 216 mm (8.5 in) by late October.

Sampling started in June at the Anita Pond since this was an alternate pond replacing the winterkilled Elk Grove Ponds. Bluegill averaged 62 mm (2.4 in), increasing to 90 mm (3.5 in) in July and 95 mm (3.7 in) in August. Mean body length was 138 mm (5.4 in) by mid-November. Largemouth bass exhibited rapid growth throughout the first season reaching a mean of 141 mm (5.6 in) by mid-November.

The Adair Pond, also an alternate pond, produced the largest bluegills of any study pond. Bluegill collected in the third sample period had a mean length of 82 mm (3.2 in) and by August had growth to 110 mm (4.3 in). Bluegill growth averaged nearly 15 mm (.6 in)/month during the season resulting in a mean body length of 152 mm (6.0 in) in November. Largemouth bass sampled in July averaged 90 mm (3.5 in) in length and 225 mm (8.9 in) by October. No bass growth was recorded during the last month. Bass growth in this pond was exceeded only by Shelton Pond.

Elk Grove Pond bluegill attained a mean length of 134 mm (5.3 in) and largemouth bass averaged 172 mm (6.8 in) TL in the first season following stocking. Mean bluegill length was 32 mm (1.3 in) during the second sampling period and growth increased by an average of 17 mm (.7 in) each month of bluegill in mid-November was 134 mm (5.3 in). Largemouth bass length increased from 29 mm (1.1 in) in mid-June to 172 mm (6.8 in) in mid-September. No bass growth was recorded after mid-September.

Fish growth in the study ponds were compared where each ponds was subjectively ranked between 1 and 10. After each pond was ranked the indices were averaged for bass and bluegill.

Rankings of nine study ponds ranged from 2.5 to 9.5 (Table 13). Fish growth was greater in the Shelton and Adair Ponds each attaining a 9.5 rank. Bass growth was greater in Shelton Pond, but Adair Pond bluegill growth was better. Elk Grove Pond ranked second with 7.5 while Anita Pond received a score of 6.5. The other ponds in descending order were Wapello 1, Morr, Pierce and Coffey Ponds.

Table 13. Ranking of nine study ponds for fish growth.

Pond	Bass growth	Bluegill growth	Average
Pierce	2	3	2.5
Coffey	4	2	3.0
Wapello 1	7	4	5.5
Morr	6	5	5.5
Anita	5	8	6.5
Wapello 2	7	6	6.5
Elk Grove	8	7	7.5
Shelton	10	9	9.5
Adair	9	10	9.5

DISCUSSION OF FINDINGS

Watershed use had a profound influence on the growth of bluegill and largemouth bass in the experimental ponds. Therefore, it indirectly influenced maturity and the production of forage. Those ponds with climax vegetative cover, grassland, pasture and timber (Shelton, Elk Grove and Adair Ponds) in the watershed exhibited the most rapid growth, highest production and fastest maturity of bluegill. Conversely, those with intensive row crops in adjacent watersheds (Pierce, Coffey and Morr Ponds) had slow bluegill growth, poor reproduction and slow maturity. The application and runoff of agriculture chemicals into the Coffey Pond was probably responsible for entire loss of the stocked bluegill. Catastrophic loss of bass also occurred in Pierce Pond but the cause remains unknown.

Production of forage in the form of young bluegill was the main factor effecting bass growth. All ponds where bluegill matured early and reproduced also exhibited faster bass growth.

RECOMMENDATIONS

Documentation of bluegill and bass growth in the experimental pond will continue in the next study segment.

LITERATURE CITED

Carlander, K. 1952. Farm fish pond research in Iowa. J. Wildl. Mgmt. 16(3): 258-261.

Fessler, F. 1950. Fish populations in some Iowa farm ponds. Prog. Fish-Cult. 12(1):3-11.

Ruhr, C. 1952. Fish population of a mining pit lake, Marion County, Iowa. Iowa St. Coll. J. Sci. 27(3):55-77.

Swingle, H. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Ala. Poly. Inst. Agr. Expt. Sta. Bull. 274, 73 pp.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 403-2

JOB NO.: 4

NAME: Evaluation of the Split Stocking Method in Iowa Farm Ponds

TITLE: Water chemistry of ten farm ponds in Iowa

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Water quality parameters were measured at experimental ponds stocked under split stocking guidelines to identify variations in growth, fecundity and mortality between bass-bluegill populations. Agricultural practices in the watersheds were associated with water fertility where row cropping produced the highest fertility and turbidity. Highest concentrations of nitrates, nitrites, inorganic phosphates and highest turbidity were measured at Pierce, Coffey and Morr Ponds contrasted with lower levels in the remaining ponds. Fish survival and growth were greater at ponds with greassland and timber watersheds. Mean turbidity in these ponds was < 10 mg/ℓ, while nitrates, nitrites and inorganic phosphates were < .41, .02 and .41 mg/ℓ, respectively.*

Prepared by: Larry Mitzner and
Kay Hill
Fishery Research Biologists

Date Prepared: 30 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

JOB 4 OBJECTIVE

To document differences in water quality in ten farm ponds in Davis, Guthrie and Lucas Counties.

INTRODUCTION

Physical and chemical composition greatly influence the aquatic biota causing diverse population structure and production within each system. Such variations in growth rate, fecundity and mortality were anticipated for bluegill and largemouth bass populations in experimental farm ponds. Fish growth is readily influenced by abundance of benthos, zooplankton and phytoplankton, which are directly associated with watershed fertility. The single factor of turbidity greatly disrupts light penetration, limiting plankton growth.

Before the investigation commenced a sampling regimé was established whereby water quality parameters would be measured concomitantly with fish population statistics to identify confounding factors due to differences in physical and chemical characteristics of the ponds.

STUDY BACKGROUND

Published water quality statistics for farm ponds in Iowa are rare. Limited water quality data was available from man-made lakes investigations, but the information was purely limnological in nature and not usually related to fish population statistics, particularly for young bass-bluegill populations which were rapidly expanding. Measurement of water quality parameters at the experimental ponds commenced within a month of stocking and continued for 12 months.

METHODS AND PROCEDURES

Water samples were collected each month from November, 1974 through October, 1975 at two sampling stations in each pond. Dissolved oxygen, surface water temperature and Secchi disc readings were recorded at the time the samples were collected, but were not used in comparisons of water quality. Samples were refrigerated until laboratory analysis of alkalinity, inorganic and organic phosphate, nitrate, nitrite, and turbidity (FTU) were completed by standard procedures.

The magnitude of differences in water quality between ponds was determined by comparing the mean values.

FINDINGS

Alkalinity concentrations were higher in the Wapello Ponds than in any other study pond. Mean concentrations were 146 mg/ℓ and 135 mg/ℓ for Wapello Ponds 1 and 2, respectively (Table 14). All other study ponds had mean alkalinity concentrations ranging from 90 mg/ℓ to 118 mg/ℓ. Elk Grove Pond 3 water was lowest in alkalinity at 90 mg/ℓ.

Inorganic phosphate concentrations were similar in all study ponds except the Coffey Pond which had a mean of .46 mg/ℓ, higher than any pond. Pierce Pond samples had consistently lower phosphate levels with a mean of .26 mg/ℓ. Other study pond waters contained mean inorganic phosphate concentrations ranging from .29 to .44 mg/ℓ.

Organic phosphate levels for all ponds were similar with the exception of Coffey Pond and Elk Grove Pond 2, which was higher. Coffey Pond water contained organic phosphate levels at .46 mg/ℓ, while a mean concentration of .48 mg/ℓ was determined for Elk Grove Pond 2. Shelton Pond and Elk Grove Pond 1 contained lower organic phosphates with mean concentrations of .21 mg/ℓ. Values for other ponds ranged between .26 mg/ℓ for the Pierce Pond to .46 mg/ℓ for Coffey Pond.

Nitrate levels at all ponds, except Morr and Coffey Ponds, were similar. Morr and Coffey Ponds had high nitrate concentration, with means of 3.15 mg/ℓ and 3.33 mg/ℓ, respectively. Elk Grove Pond 3 water was lowest in nitrates, containing a mean concentration of .10 mg/ℓ. Mean nitrate concentrations of other ponds ranged from .14 mg/ℓ at Elk Grove Pond 1 to .77 mg/ℓ at Pierce Pond.

Nitrite concentrations were likewise higher in the Morr and Coffey Ponds than other study ponds. Mean nitrite levels in the two ponds were .086 mg/ℓ and .103 mg/ℓ, respectively. All other ponds contained mean nitrite levels ranging from .002 mg/ℓ to .021 mg/ℓ.

Turbidity levels were quite low for eight study ponds with levels of 30 FTU or lower. The Morr Pond had low water clarity with a mean of 66 FTU. Pierce and Coffey Ponds were second and third most turbid with FTU values of 30 and 26, respectively. The six remaining ponds had turbidity values $<$ 14 FTU.

Dissolved oxygen levels declined to 0 ppm in Elk Grove Ponds 1 and 3 resulting in extreme fish mortality.

DISCUSSION OF FINDINGS

Water chemistry parameters are influenced mainly by watershed soil types and land use. Pierce, Coffey and Morr Pond watersheds were mainly row crops, although all contained grass buffer strip around the perimeter. These ponds contained the highest nutrient parameters; nitrates, nitrites, inorganic phosphates and turbidity were higher than other ponds. Nitrate and nitrite levels were undoubtedly elevated from fertilizer applied on the surrounding farm land. Inorganic phosphates also increased because of agricultural land use practices. Higher turbidity resulted directly from erosion.

Table 14. Mean and 95% confidence intervals of six chemical and physical water quality parameters in study ponds from November, 1974 through October, 1975.

	Alkalinity mg/ℓ	Inorganic phosphate mg/ℓ	Organic phosphate mg/ℓ	Nitrate mg/ℓ	Nitrite mg/ℓ	Turbidity FTU
Wapello 1	146 ± 29	.34 ± .13	.28 ± .14	.36 ± .55	.002 ± .003	14.40 ± 15.71
Wapello 2	135 ± 21	.31 ± .11	.27 ± .16	.25 ± .32	.009 ± .010	8.83 ± 7.48
Pierce	106 ± 10	.26 ± .05	.34 ± .11	.77 ± .49	.014 ± .010	29.90 ± 21.21
Coffey	108 ± 17	.46 ± .47	.46 ± .24	3.15 ± 1.61	.103 ± .062	26.10 ± 12.22
Morr	101 ± 12	.44 ± .13	.43 ± .15	3.33 ± .87	.086 ± .050	66.25 ± 26.20
Shelton	122 ± 10	.29 ± .02	.21 ± .06	.41 ± .33	.012 ± .014	8.25 ± 3.93
Elk Grove 1	118 ± 24	.41 ± .12	.21 ± .08	.14 ± .20	.012 ± .015	9.65 ± 5.43
Elk Grove 2	117 ± 15	.37 ± .12	.48 ± .36	.26 ± .29	.021 ± .016	8.20 ± 3.46
Elk Grove 3	90 ± 7	.41 ± .08	.40 ± .11	.10 ± .15	.006 ± .007	10.11 ± 3.56

Wapello Ponds 1 and 2 contained higher alkalinity concentrations than other study ponds. These ponds were used as fish culture ponds prior to this study. The entire water source was piped directly from Lake Wapello and the higher alkalinity are partially, if not wholly, the result of introducing lake water.

Adult fish survival was highest in Adair and Elk Grove Ponds which had grassland and timber watershed. Best bluegill fry production was also recorded in ponds with grass or timber watersheds. Furthermore, largemouth bass growth was greater in these ponds. In one of the row crop watershed ponds (Coffey), there was no adult bluegill survival and consequently, no fry production; while in Pierce Pond, with row crop watershed, high largemouth bass mortality is suspected because bass were collected only once immediately after stocking.

RECOMMENDATIONS

The investigation will be terminated because the objectives were achieved.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: Life History and Dynamics of Largemouth Bass in Three Man-Made Lakes

PROJECT NO.: F-88-R-3

STUDY NO.: 503-5

TITLE: Life history of largemouth bass at three man-made lakes in Iowa

JOB NO.: 1

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Growth computations of largemouth bass at Red Haw Lake showed estimated lengths at ages 1-8 where 79, 149, 216, 284, 340, 388, 425 and 475 mm (3.1, 5.9, 8.5, 11.2, 13.4, 15.3, 16.7, and 18.7 in). Length-weight relationship was described where growth in weight was allometric. Condition factor (K) ranged from 1.41 for smaller bass to 1.94 for bass in the largest group. Bass at Bobwhite Lake grew faster during the first three years of life compared to the population at Red Haw. Growth from ages 3-5 was nearly identical, but decreased rapidly at Bobwhite Lake during ages 6-8. Estimated lengths for ages 1-8 were 94, 184, 261, 319, 375, 412, 432 and 455 mm (3.7, 7.3, 10.3, 12.5, 14.8, 16.2, 17.0 and 17.9 in). Length-weight relationship of bass at Bobwhite was likewise allometric, but condition factor was slightly greater than values at Red Haw Lake, particularly for larger bass.*

Prepared by: Larry Mitzner
Fishery Research Biologist

Approved by: James Mayhew
Fishery Research Supervisor

STUDY OBJECTIVE

To compare growth rate, body condition, length-weight relationship, age structure, natural mortality rate, exploitation rate and standing crop of adult largemouth bass populations and compare the contribution of stocked fingerling bass to the fishery at Red Haw Lake, Green Valley Lake and Bobwhite Lake which are characteristic of three distinct lake types, each having unique physical, chemical and biological characteristics.

JOB 1 OBJECTIVE

To determine the difference in life history statistics of largemouth bass including growth rate, body condition and length-weight relationship in three man-made lakes with different physical, chemical and biological characteristics.

INTRODUCTION

Largemouth bass is an important sport fish in Iowa, particularly in the south-central region man-made impoundments. A recent poll of Iowa fishermen showed largemouth bass ranked fifth in the statewide catch and third in the south-central region. Species preference by the polled respondents revealed the popularity of largemouth bass ranked very high and in some districts 24% of the anglers ranked largemouth bass as most preferred. Bass are even more popular in the south-central district where they ranked second in popularity, surpassed only by channel catfish.

Equally important, largemouth bass is the sole predator in many impoundments where they were introduced for panfish predation. Thus, largemouth bass provide a dual role in the fishery requiring optimized harvests and yet maintain adequate predator stock. Resource managers use a wide array of methods to execute strategies at lakes where bass populations are inadequate as predators and their contribution to the fishery is wholly unsatisfactory. But, before management strategies are developed criteria for problem recognition must be established.

The intent of this investigation was to provide vital statistics of largemouth bass populations which are representative of three discrete types of man-made impoundments in southern Iowa. The statistics are readily adapted to problem recognition in bass populations and form a basis for reliable, deductive management strategies.

STUDY BACKGROUND

Growth, computed from largemouth bass samples collected from 1971-1974, was greatest at Green Valley Lake, where mean length was 346 mm (13.6 in) at age 4 compared to 314 (12.3 in) at Bobwhite Lake and 275 (10.8 in) at Red Haw Lake at the same age. Length-weight regressions for these populations showed weight growth was always isometric at Red Haw Lake. At Bobwhite Lake growth was isometric from 1971-1972, but allometric from 1973-1974. Allometric growth occurred at Green Valley Lake in all years. Body condition (K) ranged from 1.39 for Red Haw bass in 1971 to 1.76 at Green Valley in 1973. The trend was for the best K-factors at Green Valley Lake, intermediate at Bobwhite Lake, and lowest at Red Haw Lake.

METHODS AND PROCEDURES

Collection methods in 1975 were identical with previous years, except Green Valley Lake was excluded due to drainage and fish renovation. Age, growth, length-weight regressions, body-scale regressions and condition factors were computed by the standard techniques.

FINDINGS

RED HAW LAKE

Length-weight relationship of largemouth bass in 1975 was best described by the regression equation

$$\text{Log } W = -5.487 + 3.256 \text{ Log } TL$$

where W was weight in grams (g) and TL was total body length in millimeters (mm).

The ponderal index measured by the K-factor was 1.41 and ranged from 1.04 for bass in the 111-136 mm (4.4-5.4 in) size class to 1.94 for the largest size class of 536-561 mm (21.1-22.1 in). There was a trend of larger K-factor with increasing body length.

Growth in length of bass at Red Haw Lake was back-calculated from the linear function

$$TL = 3.9 + 2.5 \text{ ScR}$$

where, TL represented total body length and ScR was the magnified (27 X) anterior scale radius in mm.

The estimated TL at each year of life was computed from 113 fish representing the 1967-1974 year classes. Calculated mean lengths for ages 1-8 was 79, 149, 216, 284, 340, 388, 425 and 475 mm (3.1, 5.9, 8.5, 11.2, 13.4, 15.3, 16.7 and 18.7 in) (Table 1).

Table 1. Estimated total length in mm of largemouth bass at the end of each year of life in Red Haw Lake. English equivalent values are subtended.

Year class	Number	Year of life 1	2	3	4	5	6	7	8
1974	2	80							
1973	29	102	184						
1972	50	68	148	218					
1971	13	81	152	229	293				
1970	6	66	114	194	263	311			
1969	7	82	154	226	300	345	384		
1968	5	79	146	226	289	343	378	403	
1967	1	73	142	206	275	362	401	448	475
Mean length in mm		79	149	216	284	340	388	425	475
		(3.1)	(5.9)	(8.5)	(11.2)	(13.4)	(15.3)	(16.7)	(18.7)
Mean weight in g		5	39	130	317	570	876	1,178	1,693
		(.011)	(.086)	(.29)	(.70)	(1.26)	(1.93)	(2.60)	(3.73)

Estimated weight at each year of life was computed from lengths using the length-weight relationship. At age 1 mean weight was 5 g (.01 lbs) increasing to 39 g (.09 lbs) at age 2. Thereafter, weight increased rapidly and by age 3 mean weight of bass was 130 g (.29 lbs). At ages 4-8 mean weight was 317, 570, 876, 1,178 and 1,693 g (.70, 1.25, 1.93, 2.60, and 3.73 lbs), respectively.

BOBWHITE LAKE

The length-weight relationship of largemouth bass at Bobwhite Lake was

$$\text{Log } W = -5.4382 + 3.2245 \text{ Log } TL$$

where the variable identification was the same as before. The regression coefficient differed significantly ($P < .05$) from 3.0 indicating continued allometric growth.

Body condition of bass at Bobwhite Lake ranged from 1.22 in the 236-261 mm (9.3-10.3 in) size group to 1.58 for bass between 461 mm and 511 mm (18.2-20.1 in). A significant increase ($P < .05$) in K-factor occurred as body length increased.

The body-scale regression for bass in Bobwhite Lake was

$$TL = 11.6 + 2.2\ ScR$$

where the variable designations were previously described.

Total lengths at the end of each year of life for ages 1-8 representing the 1967-74 year classes were 94, 184, 261, 319, 375, 412, 432 and 455 mm (3.7, 7.3, 10.3, 12.5, 14.8, 16.2, 17.0 and 17.9 in) (Table 2).

Table 2. Estimated total length in mm of largemouth bass at the end of each year of life in Bobwhite Lake. English equivalent values are subtended.

Year class	Number	Year of life 1	2	3	4	5	6	7	8
1974	5	84							
1973	8	90	189						
1972	34	94	199	271					
1971	23	95	197	260	307				
1970	12	91	181	273	353	398			
1969	9	107	192	278	344	397	435		
1968	7	101	182	261	326	391	434	455	
1967	1	93	149	221	263	315	366	409	455
Mean length in mm		94	184	261	319	375	412	432	455
		(3.7)	(7.3)	(10.3)	(12.5)	(14.8)	(16.2)	(17.0)	(17.9)
Mean weight in g		9	73	226	432	727	985	1,148	1,357
		(.02)	(.16)	(.50)	(.95)	(1.60)	(2.17)	(2.53)	(2.98)

Mean estimated weight at age 1 was 9 g (.02 lbs) increasing to 73 g (.16 lbs) at age 2 and 226 g (.50 lbs) at age 3. After age 3 weight increased rapidly and by age 4 mean weight was 432 g (.95 lbs). From age 5-8 mean weight increased to 727, 985, 1,148 and 1,357 g (1.60, 2.17, 2.53 and 2.98 lbs), respectively.

DISCUSSION OF FINDINGS

Comparison of largemouth bass statistics at Red Haw and Bowhite Lakes in 1975 showed growth and body condition were greater at Bobwhite, while the length-weight regressions were nearly identical. Growth in weight for both populations was allometric. This was the first year since the investigation started where allometric growth occurred for Red Haw bass compared to bass at Bobwhite Lake where allometric growth occurred since 1973.

Growth of Red Haw bass was slower during the first three years of life compared to those in Bobwhite Lake. Lengths at age 3 differed by nearly 20%, while the weight difference was approximately twofold. From age 3-5 growth rate was nearly identical, but during the sixth year of life growth at Bobwhite Lake decreased rapidly and by age 8 Red Haw bass were slightly greater in length and weight compared to bass at Bobwhite Lake.

The findings clearly show bass growth ranged widely between lakes with different physical and chemical features. More important these differences must be considered in management strategy because catch, mean weight of the catch, recruitment and yield are growth dependent. The growth rate of bass at Bobwhite Lake resulted in recruitment at a younger age, greater mean weight in the catch and greater catch and potential yield per recruit to the fishery.

Planned management becomes complex when growth rate of bass is considered as an independent variable. Yet, management results become more predictable when the growth statistics are accurate. Obviously, management outcome is drastically different if growth was considered identical between lakes. When different growth rates are used for different lakes the management techniques remain the same; only the degree of execution changes. To achieve optimum yield, catch regulations could become either more restrictive or permissive depending on the relationship of growth rate and related parameters. Regardless of the management scheme, growth is a vital component and the most accurate data must be included in valid management strategy.

RECOMMENDATIONS

Population statistics accrued during the investigation are mainly in unrelated form. That is, growth, population abundance, recruitment, natural mortality and fishing mortality were reported as individual entities, but the relationship of parameters and how they apply to problems have not been described.

Vital statistics of bass populations at the three study lakes should be compended and integrated into a completion report.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: Life History and Dynamics of Largemouth Bass in Three Man-Made Lakes

PROJECT NO.: F-88-R-3

STUDY NO.: 503-5

TITLE: Population dynamics of largemouth bass at three man-made lakes in Iowa

JOB NO.: 2

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Numerical abundance of largemouth bass at Red Haw Lake was 2,858 with confidence intervals at the 95% level of ± 1,694. Harvest was 2,245 with an average fishing success of .16 bass per hr ranging from .06 per hr in June and early July to .43 bass per hr in late September. Mean size in the catch was 284 mm (11.2 in) ranging from 165 mm (6.5 in) to 445 mm (17.5 in). Interviews showed 42% of the bass were released. The population at Red Haw Lake was dominated by the 1972 year class which contributed nearly 60% to the sample. Total annual mortality, computed by two methods was 48%. Minimum estimates of exploitation ranged from 4-19% with complimentary natural mortality of 34-45%. Standing stock estimates of largemouth bass yielded a population weight of 559 kg (1,230 lbs). The bass population at Bobwhite Lake was less abundant with an estimate of 581 and 95% confidence of ± 151. Population weight was dominated by ages 4-7 which contributed 76% to the biomass. Total weight of bass at Bobwhite Lake was 219 kg (485 lbs). Annual mortality rate of the population was 33%.*

Author: Larry Mitzner
Fishery Research Biologist

Approved by: James Mayhew
Fishery Research Supervisor

JOB 2 OBJECTIVE

Determine the difference in population dynamics of largemouth bass including population size, standing crop, age structure and exploitation of largemouth bass in three man-made lakes with different physical, chemical and biological characteristics.

INTRODUCTION

Measurement of largemouth bass population dynamics continued in 1975 at Red Haw and Bobwhite Lakes. Sampling was discontinued at Green Valley Lake where the fish population was renovated in 1974. Population estimates, age distribution, annual survival and fishing mortality were measured as before.

STUDY BACKGROUND

Abundance of largemouth bass in 1974 was greatest at Red Haw Lake with an estimate of 57 per ha (23 per ac) compared to a density at Bobwhite Lake of 9 per ha (4 per ac). Fishing effort and harvest at Red Haw was also higher with a yield of 1,521 fish weighing 567 kg (1,251 lbs). At Bobwhite Lake harvest accounted for 20 bass weighing 8 kg (17 lbs). Bass anglers were most successful at Red Haw where the catch rate was .32 bass per hr compared to .20 bass per hr at Bobwhite Lake. Annual survival of the populations ranged from 55% at Red Haw to 60% at Bobwhite Lake. The bass population at Red Haw Lake was characterized by high exploitation, high density and low natural mortality with slower growth with lower body condition contrasted to bass at Bobwhite Lake with low abundance, exploitation and natural mortality, but faster growth and higher condition factors.

METHODS AND PROCEDURES

Sampling methods and schedules were identical with previous years except sampling for largemouth bass at Red Haw Lake commenced earlier. Marking and recapture of bass started on 6 April and was temporarily discontinued on 22 May until late August.

FINDINGS

RED HAW LAKE

Population abundance was estimated from 6 April-26 September for bass > 228 mm (9 in). During the period 185 bass were marked; 286 were examined for marks of which 8 were recaptures. The cummulative population estimate stabilized in early September at approximately 2,000. When sampling was terminated on 26 September the estimate was 2,858. Confidence intervals for this estimate at the 95% level were ± 1,694.

Angler harvest was estimated as before from 15 April-30 September. During the period 7,803 anglers fished 14,347 hrs and caught 27,175 fish. Largemouth bass catch was 2,245 with an overall success rate of .16 bass per hr. Mean length of bass in the catch was 284 mm (11.2 in) and ranged from 165 mm (6.5 in) to 445 mm (17.5 in). Anglers were asked how many bass they caught, but later released. The results showed 42% of the bass caught were released. In all, 3,860 bass were caught; but, 1,615 were released yielding 2,245 to the harvest.

Overall catch rates were .16 bass per hr with greatest success in late September when catch effort was .43 bass per hr and a total harvest of 481 fish. The next most successful period was in late July when catch effort was .32 bass per hr. Lowest success was about .06 fish per hr in June and early July.

Age structure of largemouth bass at Red Haw Lake was dominated by the 1972 year class, comprising 57.5% of the sample. The 1973 year class comprised 23.3% of the population followed by the 1971 year class at 7.3%. Older age groups contributed < 4% to the sample.

Total annual mortality was estimated by two methods. First, mortality was computed from the age frequency distribution and second from the geometric decrease in tags returned by anglers.

Age distributions in 1971-1975 were combined by year class using the virtual population method, thus yielding a catch curve where error due to unequal recruitment was minimized. Instantaneous mortality was the slope of the descending limb of the catch curve.

The regression equation

$$\log_e Y = 4.60 - .63X$$

best described the relationship of % frequency (Y) and age (X). Total instantaneous mortality was .63 with an annual rate of 47%.

The second method was computed from the model in Ricker (1975) where three consecutive years of tagging and four years of angler returns were used to estimate annual mortality. Computations showed 48% of the population was lost annually which closely agreed with 47% estimated by the first method.

Exploitation was likewise estimated from tags returned by anglers from the equation (Ricker, 1975)

$$u_i = \frac{m_i R_i}{T_i M_i}$$

where u_i is annual rate of exploitation, m_i is the number of all recpatures reported in the i^{th} year after marking, R_i is the number of recaptures marked only in the i^{th} year, T_i is the cummulative number of recaptures reported after and including the i^{th} year of marking, and M_i is the number of fish marked in the i^{th} year. The estimates required complete reporting of tagged fish by anglers so the values were minimum estimates. Exploitation ranged from 3.4% in 1972 to 18.8% in 1975. Values in 1973 and 1974 were 7.7% and 9.6%.

Natural annual mortality was estimated as the difference between instantaneous total mortality and instantaneous fishing mortality, however, the value was slightly overestimated due to the underestimated exploitation rate. Natural mortality ranged from 34-45%.

Standing stock estimates for largemouth bass at Red Haw Lake were computed as the summation of products between numerical abundance and mean weight for each age group. Population abundance for age 1 bass was 46 with a mean weight of 5 g (.01 lbs) for a contribution of .23 kg (.5 lbs) to the biomass (Figure 1). Computations for other ages resulted in a total population weight of 559 kg (1,230 lbs). Age 3 bass contributed about 38% to the standing stock, while other year classes contributed no more than 14% to the total weight.

BOBWHITE LAKE

Sampling at Bobwhite Lake to estimate largemouth bass abundance started on 29 April and continued monthly through October. During this period 74 bass were marked; 208 were examined, of which 11 were recaptures. On 18 August the cumulative population estimate was 581 which decreased slightly to 494 by 31 October. Confidence at the 95% level of the last estimate was ± 151.

Instantaneous total mortality was determined by the catch curve method as before. The regression was computed for bass age 2 or older. After that age the bass were completely vulnerable to sampling gear. The regression equation was

$$\log_e Y = 4.20 - .40X$$

yielding a total instantaneous mortality rate of .40. The corresponding total annual mortality rate was 33%.

Population weight of largemouth bass at Bobwhite Lake was 219 kg (485 lbs) resulting in a density of 5.4 kg/ha (4.8 lbs/ac). Ages 4-7 comprised 76% of the biomass with age 6 most important contributing 48 kg (106 lbs) to the population (Figure 2). Age groups 4 and 5 each contributed 43 kg (95 lbs) to the biomass followed by age 3 at 40 kg (88 lbs). Other ages were less important contributing no more than 7 kg (15 lbs).

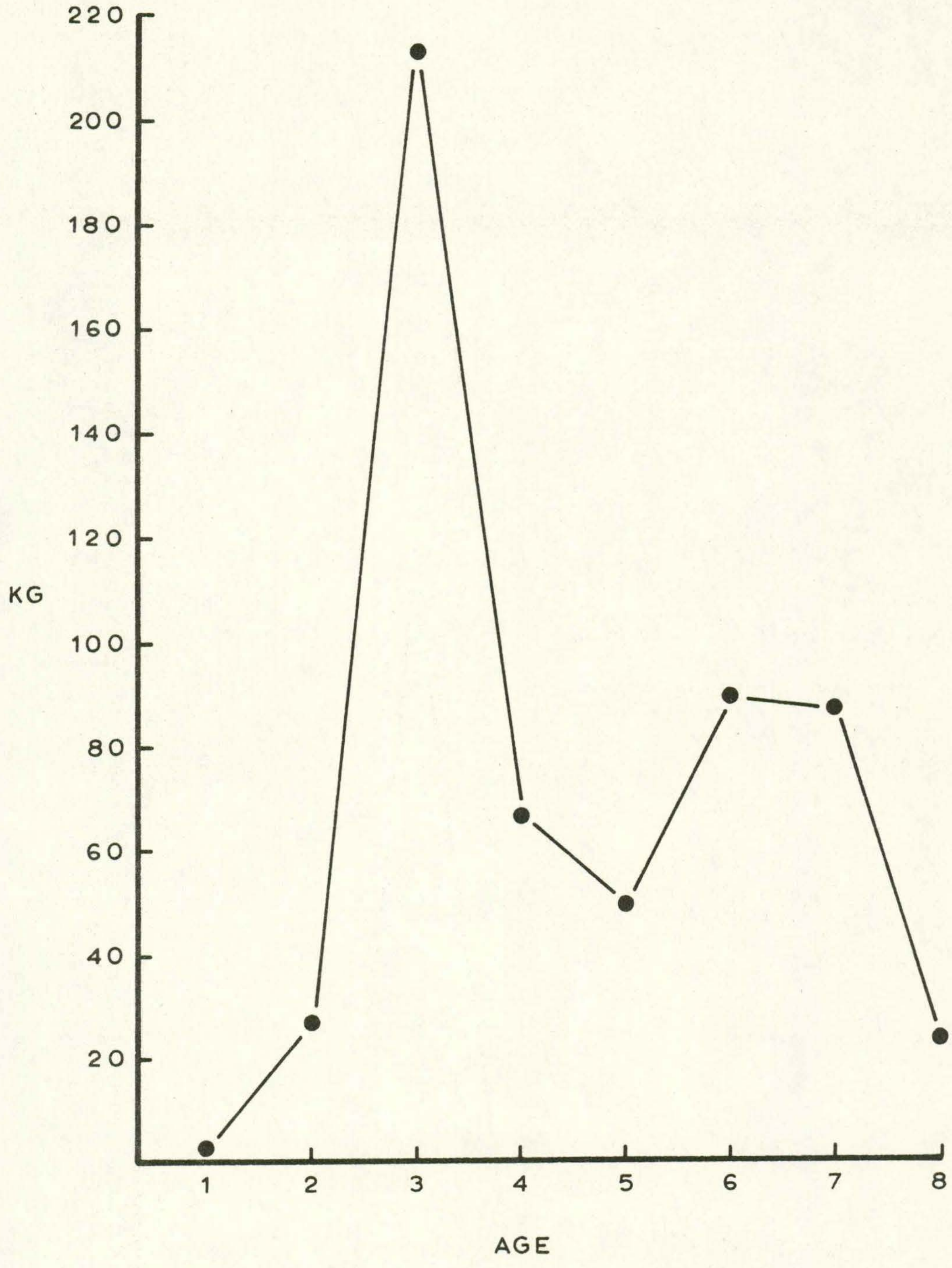

Figure 1. Distribution of biomass for largemouth bass at Red Haw Lake, 1975.

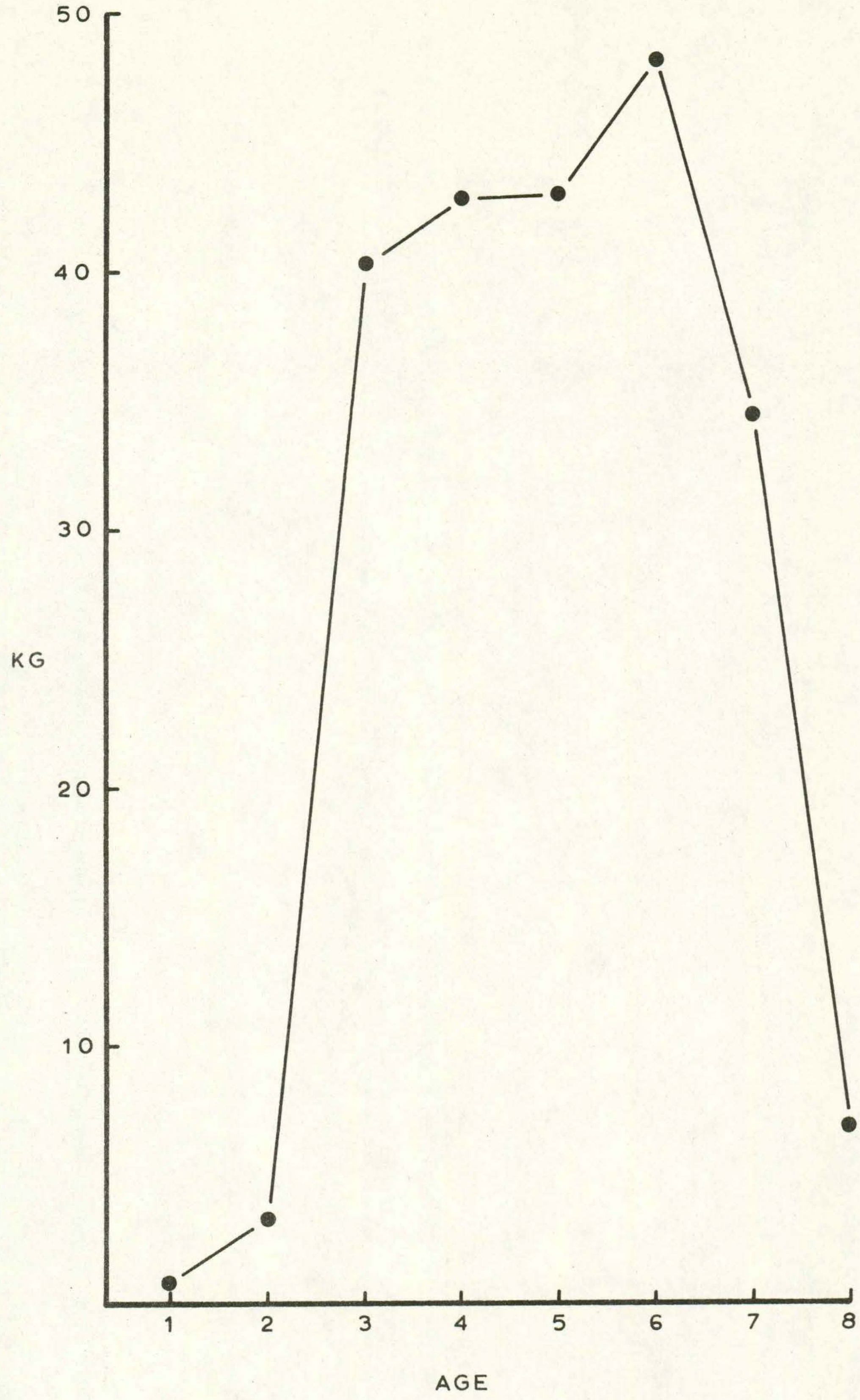

Figure 2. Distribution of largemouth bass population weight at Bobwhite Lake, 1975.

DISCUSSION OF FINDINGS

Population characteristics of bass at Red Haw Lake were vastly different compared to Bobwhite Lake. Numerical density showed the widest divergence in population traits. Bass at Red Haw were nearly 7 times more abundant than Bobwhite Lake. Standing stock of bass in Red Haw Lake was nearly 4 times greater.

Age structure of the bass population at Bobwhite Lake was dominated by older fish, whereas age 3 bass at Red Haw Lake comprised > 50% of the sample. Likwise, mortality estimates were a function of age distribution where annual survival rate of bass at Bobwhite was 67% compared to 53% at Red Haw Lake.

Bass harvest at Red Haw Lake appeared quite high, particularly when nearly as many fish were harvested as existed in the population. Yet exploitation rate computed from tag returns showed about 20% harvest. The anomaly was mainly due to sampling. Population size was estimated for fish > 230 mm (9 in), while the harvest estimate included all sizes. Minimum length reported in the harvest was 165 mm (6.5 in) with a mean length of 284 mm (11.2 in) compared to 318 mm (12.5 in) from the electrofishing sample.

Size in the catch was influenced by fairly slow growth and high natural mortality. Mean length of harvested bass would have been smaller, but 40% of the fish were returned and most of those were < 284 mm (11.2 in).

RECOMMENDATIONS

Population traits of largemouth bass in 1975, as in previous study segments, showed a definite trend at each study lake. Numerical density and population weight was greatest at Red Haw Lake with decreasing density at Bobwhite and Green Valley Lakes. The same trend was true for total, fishing and natural mortality whereby Red Haw Lake had the greatest biomass turnover with lower production potential at the other lakes.

Bass populations are well described for each study lake, but a comprehensive completion report should be prepared to define the relationship between population density, biomass, natural mortality, fishing mortality, recruitment and growth for each lake type.

LITERATURE CITED

Ricker, W. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board. Can. Bull. 191. 382 pp.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 503-5

JOB NO.: 3

NAME: Life History and Dynamics of Largemouth Bass in Three Man-Made Lakes in Iowa

TITLE: Contribution of stocked fingerling largemouth bass to the fishery in two man-made lakes

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Catch effort of age 0 bass at Red Haw averaged 25 per seine haul which was significantly greater ($P < .01$) than abundance indices from four previous years. Relative abundance of young bass at Bobwhite Lake was lowest since the inception of the investigation in 1971. Hatchery reared, age 0 bass stocked at Bobwhite Lake in October resulted in a highly significant ($P < .01$) increase in seine haul catches of young bass. Age 1 bass which were experimentally stocked the previous year also resulted in significantly ($P < .05$) increased relative abundance of the year class.*

Author: Larry Mitzner
Fishery Research Biologist

Approved by: James Mayhew
Fishery Research Supervisor

JOB 3 OBJECTIVE

Determine the contribution of fingerling largemouth bass stocked at a rate of 250 per ha to the fishery at two man-made lakes with different physical, chemical and biological characteristics.

INTRODUCTION

Successful reproduction and high survival of the young is prerequisite to adequate production in bass populations. Discounting epizootics and compensatory mortality such as deaths from low dissolved oxygen the number of adult bass in a population are capable of producing large numbers of viable eggs. Even with high depensatory mortality from fishing and natural causes there are usually enough remaining brood bass to adequately replace the population. The main problem in many fisheries is not the lack of spawners, but repression of spawning, poor egg viability and hatching, poor fry survival and excessive predation of the progeny. Regardless of the causes, the effect is the same: few bass attain catchable size or recruit into the predator population. Low reproductive success and survival of young ultimately determine the overall production of the adult population and even compensation by increased growth will not offset the loss in recruitment.

Management of bass population by supplemental stocking of fingerlings is one method of attempting to numerically increase the adult population. Experimental stocking and evaluation of 0-age abundance commenced at three lakes in 1971 to determine if the technique was effective. Reproductive success and progeny survival was monitored at Red Haw, Bobwhite and Green Valley Lakes in 1971-1975 with experimental stockings at Red Haw in 1973 and Bobwhite Lake in 1973-1975. Sampling continued in this segment as before except at Green Valley Lake where the population was renovated in 1974.

STUDY BACKGROUND

Catch effort of young largemouth bass ranged from 0 per seine haul (F/H) at Green Valley Lake in 1971 to 5.4 F/H at Red Haw in 1972. Catch effort values at Bobwhite Lake ranged from .8 F/H in 1973 to 2.0 F/H in 1974. Results of the experimental stockings showed abundance of young bass significantly ($P < .05$) increased in the seine hauls at Bobwhite Lake, but catch effort remained the same at Red Haw Lake. Reproductive success and survival of naturally produced young measured from seine samples was twice as great at Red Haw Lake compared to Bobwhite Lake.

METHODS AND PROCEDURES

The sampling schedule and methods were identical as in previous years. On 7 October, 1975, 3,618 fin clipped largemouth bass with a mean length and weight of 129 mm and 32 g were stocked at Bobwhite Lake. Catch effort values before and after stocking were determined in seine hauls from July-October, while electrofishing continued in April-June, 1976.

FINDINGS

Overall catch per effort of age 0 bass in seine hauls at Red Haw Lake was 25.1 per haul (F/H) with a range of 1 F/H at site 2 in September to 60 F/H at site 1 in August. Greatest catches were in August with a mean of 37.3 F/H followed by 21.0 F/H in September and 17.0 F/H in July (Table 3).

Table 3. Catch per effort of age 0 largemouth bass in number per seine haul at two man-made impoundments.

	Red Haw			Bobwhite		
	July	August	September	July	August	September
1971	.3	.3	.3	2.5	1.3	.5
1972	8.5	2.3	5.0	2.3	1.0	.3
1973	0	.3	1.5	0	.5	1.8
1974	4.8	3.5	5.8	0	5.8	.3
1975	17.0	37.3	21.0	0	.25	.25

Catch effort data was tested by analysis of variance procedure to determine if differences occurred in catch per effort of age 0 bass between years. At Red Haw Lake the differences were highly significant ($P < .01$) and further analysis by multiple range testing showed the mean catch effort in 1975 was greater than means in 1971-1974. Catch indices of young bass during the first four years of investigation were not significantly different at the 95% level.

Mean catch effort of age 0 bass at Bobwhite Lake was .2 F/H. The low index was due to hauls where no bass were caught; a single bass was caught in August and another in September.

Experimental stocking of fingerling bass in 1975 was confined to Bobwhite Lake because hatchery production was lower than anticipated precluding the stocking quotas for both lakes. Bobwhite Lake was chosen for stocking because of the lower abundance index of age 0 bass. At Red Haw fingerling stocking in a previous segment resulted in no change in the density of bass populations even with a fairly low density of naturally produced bass. Conversely, the survival of age 0 bass at Bobwhite Lake was at the lowest level since 1971, which presented a situation where fingerling stocking would have the greatest impact.

Seine hauls before and after stocking of 3,618 fin clipped fingerling bass showed there was a highly significant ($P < .01$) increase in abundance between stocked bass and naturally produced age 0 bass. In seine hauls 172 bass were examined of which 171 were hatchery produced fish.

Sampling with electrofsihing gear showed similar results. On 16 and 31 October, 153 0-age bass were examined of which 151 were fin clipped fish. Sampling continued in June, 1976, where 62 bass of the 1975 year class were collected with 57 identified as hatchery reared bass.

Sampling at Bobwhite Lake for age 1 bass which were stocked the previous year showed hatchery reared fish dominated the population. Eighteen bass were examined of which 16 were fin clipped, accounting for 89% of the sample.

DISCUSSION OF FINDINGS

Catch effort statistics of age 0 bass showed natural production and survival was far greater in Red Haw Lake. Supplemental stocking in 1973 showed no significant change in the apparent abundance of age 0 bass even when survival of naturally produced fish was at the lowest level during the investigation.

The opposite occurred at Bobwhite Lake where relative abundance of young bass averaged 85% less than that in Red Haw Lake. Sampling of bass after fingerling stocking at Bobwhite Lake in 1975 showed apparent abundance increased by over 100-fold. Similar results were shown in 1973 and 1974 where the abundance of 0-age bass increased significantly after stocking a minimum of 135 bass/ha (53/ac).

RECOMMENDATIONS

Relative abundance indices of naturally produced age 0 largemouth bass were determined at Red Haw, Bobwhite and Green Valley Lakes since 1971 thereby quantifying the magnitude of year class fluctuation. Experimental stocking of hatchery reared fingerling largemouth bass was evaluated at Red Haw and Bobwhite Lakes from four plantings. The findings should be compiled in a completion report with inferences made on the practicability of stocking fingerling bass with recommended stocking guidelines. Relative year class abundance of young bass should be related to population dynamics of adult populations where the effect of up to three consecutive year classes with poor survival can be assessed in the adult population.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 504-3

JOB NO.: 1

NAME: Evaluation of Biological Control of Nuisance Aquatic Vegetation by White Amur

TITLE: Standing crop of vascular plants, primary productivity and water quality at Red Haw Lake

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Mean aquatic plant biomass was 447 g/m^2 with a maximum of 658 g/m^2 in June and a minimum of 263 g/m^2 in September. Elodea dominated the species complex at 414 g/m^2 in June, while mean annual Ceratophyllum biomass was second in importance, but dominated the plant community in September at 237 g/m^2. Potamogeton was third in biomass weight and was most dense at 119 g/m^2 in June. Sample weights of Najas showed it was almost eliminated from the plant community; annual mean biomass was 7 g/m^2. Area of plant growth ranged from 2.4 ha (5.9 ac) in September to 7.4 ha (18.3 ac) in June. Maximum standing stock attained by the plant community occurred in June at 49 metric ton (54 T). Overall the biomass of plants was reduced nearly fourfold since white amur were introduced three years ago. Water quality parameters remained unchanged from previous study segments except for nitrogen (NO_2, NO_3) which declined significantly ($P < .01$) and turbidity and alkalinity which increased significantly ($P > .05$). Primary production ranged from -.34 g of carbon/m^2/day (G/D) to 4.2 G/D with an overall mean of 1.92 G/D. Greatest production occurred in March and April following ice-off, while lowest production was in September-November when the mean was 1.43 G/D. Production was highest at 1 m (.83 G/D) with decreasing values at 2-5 m. The estimated consumption of 192 metric ton (211 T) of vegetation by white amur in three years has had little affect on the lake ecosystem.*

Prepared by: Larry Mitzner
Fishery Research Biologist

Approved by: James Mayhew
Fishery Research Supervisor

STUDY OBJECTIVE

To evaluate the effectiveness of white amur to biologically control dense beds of nuisance aquatic vegetation in a 29 ha recreational lake in order to improve angler success along the shorelines, to describe the vital statistics of white amur with emphasis on food consumption, growth, condition and mortality, and measure the indirect impact of biological vegetation control on (a) primary productivity of phytoplankton, (b) water quality of the lake, and (c) sport fish harvest.

JOB 1 OBJECTIVE

To measure standing crop of common semi-rooted aquatic plants, primary production, and water quality in Red Haw Lake following introduction of white amur.

INTRODUCTION

The effectiveness of white amur to control aquatic vegetation is well documented, but research on some of the suspected effects of these fish on other ecosystem components are lacking. Most investigations were conducted in small pools and aquaria and the results are not readily applied to natural ecosystems. This investigation was continued in 1975 to document the life history of white amur with related investigations of macrophyte biomass, primary production and water quality at Red Haw Lake.

STUDY BACKGROUND

The maximum biomass of aquatic vegetation declined significantly ($P < .05$) from 2,438 g/m^2 in July, 1973 to 1,322 g/m^2 the following July. In 1974, vegetation biomass continued to decline steadily from 1,687 g/m^2 in June to 930 g/m^2 in September. Species composition was predominately *Potamogeton* in May and June and *Elodea* from July-September. Since white amur were introduced *Najas* was reduced from 778 g/m^2 in July, 1973 to 3 g/m^2 in 1974. *Potamogeton* decreased in weight from 1,400 g/m^2 in July, 1973 to 433 g/m^2 in 1974, while *Elodea* increased from 85 g/m^2 in July, 1973 to 871 g/m^2 in 1974. *Ceratophyllum* decreased slightly.

Water quality was monitored by measuring the concentration of phosphorus (P), nitrogen (NO_2 and NO_3), alkalinity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), water temperature and turbidity. Mean nitrate concentration was 1.0 mg/ℓ in 1974, which was significantly higher ($P < .05$) than .2 mg/ℓ in 1968 during an unrelated study. Other water quality parameters remained stable after white amur were introduced.

Primary production ranged from .41 $gC/m^2/day$ in June, 1974 to 3.03 $gC/m^2/day$ in December, 1974 with an overall mean of 1.87 $gC/m^2/day$. Highest production occurred near the surface ($\overline{X}$ = .74 $gC/m^3/day$). Production declined with depth and at 5 m averaged .33 $gC/m^3/day$.

METHODS AND PROCEDURES

Biomass and species composition of the plant community was estimated by identical procedures as in previous segments. Water quality and primary production procedures remained identical from the preceeding study segments.

FINDINGS

DISTRIBUTION AND BIOMASS OF MACROPHYTES

Biomass of aquatic macrophytes increased greatly in April, and by May the plant weight was 415 g/m^2. Maximum biomass was recorded in June at 658 g/m^2 (Table 1). During July-September biomass decreased steadily from 601 g/m^2 to 263 g/m^2. Mean annual plant biomass was 447 g/m^2.

The greatest macrophyte weight of 703 g/m^2 was recorded at Stations 3 and 7, while the lowest density occurred at Station 9 with a mean of 230 g/m^2. Macrophyte weights at other stations were more uniform, ranging between 320-498 g/m^2.

Elodea dominated the species complex of the plant community from May-July with 318 g/m^2, 414 g/m^2 and 361 g/m^2 (Table 2). In August and September, *Ceratophyllum* biomass was highest at 214 g/m^2 and 237 g/m^2, respectively. *Potamogeton* was most dense in June when biomass averaged 119 g/m^2, but by September it decreased to 2 g/m^2. *Najas* was never important in the plant community; greatest biomass was found during July with 18 g/m^2. Overall, *Elodea* dominated the species structure with 239 g/m^2 followed in order by *Ceratophyllum* with 153 g/m^2 and *Potamogeton* with 47 g/m^2. Overall mean biomass for *Najas* was 7 g/m^2.

The area inhabited by the plant community during 1975 increased outward from the shore and in areal size mainly because of greater water transparency when plant growth commenced. In May, growth was observed at a maximum depth of 2.4 m (8 ft) and a mean depth of 2 m (6.5 ft) (Table 3). The following month, mean depth was 2.4 m (8 ft) decreasing to 1.7 m (5.5 ft) in July, 1 m (3.4 ft) in August and .9 m (2.8 ft) in September.

The areal size at the euphotic zone was positively associated with water clarity and ultimately the plant growth outward from the shore. In May, the plant community covered 5.6 ha (13.8 ac) which increased to 7.4 ha (18.3 ac) in June. From June through September the area of coverage decreased from 5.2 ha (12.8 ac) to 2.4 ha (5.9 ac).

Table 1. Estimated weight of the aquatic vegetation in Red Haw Lake as g/m^2 during 1975.

Station	May	June	July	August	September	Mean
1	480	680	776	432	120	498
2	24	524	976	32	60	323
3	324	1,280	1,464	120	328	703
4	728	392	560	684	84	490
5	264	700	480	392	88	385
6	80	616	648	576	440	472
7	1,144	148	328	572	1,320	703
8	312	924	196	92	148	334
9	224	276	552	68	32	230
10	568	1,040	32	4	8	330
Mean	415	658	601	297	263	447

Table 2. Estimated weight of the four major plant taxa in Red Haw Lake as g/m^2 during 1975.

	Potamogeton	*Elodea*	*Ceratophyllum*	*Najas*
May	26	318	60	0
June	119	414	112	12
July	81	361	141	18
August	5	76	214	2
September	2	24	237	2
Mean	47	239	153	7

Table 3. Maximum depth of plant growth, extent of area covered by the plant community, biomass and total weight of the plant community in metric tons (Tons) at Red Haw Lake, 1975.

	Depth		Area		Biomass	Total weight	
	m	(ft)	ha	(ac)	g/m^2	MT	(T)
May	2.0	6.5	5.6	13.8	415	23	25
June	2.4	8.0	7.4	18.3	658	49	54
July	1.7	5.5	5.2	12.8	601	31	34
August	1.0	3.4	3.7	9.1	297	11	12
September	.9	2.8	2.4	5.9	263	6	7

Total weight of macrophytes was computed monthly as the product of areal coverage and plant biomass. Total wet weight of the plant community in May was 23 metric ton (MT) (25 T), increasing to 49 MT (54 T) in June decreasing to 31 MT (34 T) in July followed by a further decrease to 11 MT (12 T) and 6 MT (7 T) in August and September.

WATER QUALITY

Phosphates (P), nitrogen (NO_2 and NO_3), alkalinity, pH, biochemical oxygen demand (BOD), dissolved oxygen (DO), turbidity, and temperature were monitored in 1975 and compared with values in previous segments to identify changes caused by feeding and excretion of vast quantities of partially digested vegetation by the fish.

Organic phosphate concentrations at Red Haw Lake from March, 1975-February, 1976 ranged from .02 mg/ℓ at 4 m to 1.8 mg/ℓ at 8 m (Table 4). Overall mean during the period was 29 mg/ℓ. Organic phosphate concentration was rather uniform from .32 mg/ℓ at the surface, .27 mg/ℓ at 4 m and .31 mg/ℓ at 8 m. Organic phosphate concentrations varied from .30 mg/ℓ in January to 1.19 mg/ℓ in September.

Inorganic phosphates averaged .47 mg/ℓ and ranged from .08 mg/ℓ in September to 3 mg/ℓ in October. Differences in concentrations of inorganic phosphates between strata was greater than for organic phosphates. Concentrations were higher below the thermocline, averaging .70 mg/ℓ.

Nitrate nitrogen mean was .33 mg/ℓ. Lowest concentration at the surface was < .01 mg/ during March-June, while the highest values were found in November at all depths. Vertical disbursement of nitrates was fairly uniform; mean concentration at the surface was .29 mg/ℓ, while at 4 m and 8 m the values were .38 mg/ℓ and .31 mg/ℓ.

Table 4. Water quality at Red Haw Lake from March, 1975-February, 1976.

	Mean	Depth range	Period range
Organic P	.29	.27 - .32	.03- 1.19
Inorganic P	.47	.35 - .70	.21- 1.20
Nitrate N	.33	.29 - .38	0 - 2.00
Nitrite N	.01	.008- .011	0 - .03
Alkalinity	125	117 -141	92 -137
pH	7.54	7.18 - 7.91	6.65- 8.40
Turbidity (FTU)	10.6	7.7 - 14.0	3.03- 20.17
DO	7.14	3.95 - 10.25	2.68- 12.95
BOD	4.49	2.1 - 11.6	0 - 11.07
Temperature (C°)	11.46	7.46 - 13.16	3.17- 18.81

Nitrite nitrogen averaged .01 mg/ℓ and ranged from undetectable levels at all strata during much of the summer to .035 mg/ℓ at 8 m in January. From June-October nitrites were immeasurable, while highest overall concentrations occurred during winter and early spring. For example, nitrite concentration in December was .072 mg/ℓ and in April it decreased to .017 mg/ℓ and by June nitrites were nearly absent. Concentrations were slightly greater at 8 m with .13 mg/ℓ, while values at the surface and 4 m were .11 mg/ℓ and .10 mg/ℓ.

Alkalinity ranged from 103-171 mg/ℓ with a mean of 125 mg/ℓ. Seasonal concentrations were highest in October and January with 137 and 131 mg/ℓ, while September had the lowest monthly concentration with 92 mg/ℓ. Alkalinity was highest at 8 m with 141 mg/ℓ compared with 117 mg/ℓ at the surface and 4 m. The difference was particularly noticeable during stratification.

pH values during the study segment averaged 7.5 and ranged from 6.6 in February to 9.2 in June. Lowest pH values occurred from December-February when average pH was always < 7.0 compared to a maximum value of 8.4 in April. As depth increased, pH was consistently lower; at the surface, 4 m and 8 m corresponding means were 7.9, 7.5 and 7.2.

Turbidity (FTU) during the segment averaged 10.6 FTU and ranged from 2 FTU at the surface in May to 28 FTU at 8 m in August. The lowest average turbidity reading was 3 FTU in May while the highest was 20 FTU in December. Values from May-September at 4 m or greater in depth were < 4 mg/ℓ, while the maximum value, 14.4 gm/ℓ occurred in April at the surface. Overall turbidity was greatest at 8 m with a mean of 14 FTU, contrasted to clearer water at 5 m with a mean FTU of 8. Surface water clarity was intermediate at 10 FTU.

BOD was always higher at deeper sampling stations. Regardless of season, BOD was highest at 8 m where the annual mean was 12 mg/ℓ with means at the surface and 4 m of 4 and 2 mg/ℓ, respectively. Autumn and early winter BOD values were highest with the maximum in September of 11 mg/ℓ. Thereafter BOD decreased to 10 mg/ℓ in October, 9 mg/ℓ in November and < 1 mg/ℓ in December.

Each parameter was tested in a two-way classification analysis of variance to determine significant differences in means between sample years. The numerical values were normalized by a square root transformation. Parameter means were compared between March, 1974-February, 1975 and March, 1975-February, 1976. The periods, hereafter, are referred to as 1974 and 1975. Test results showed significant differences occurred between years for nitrates, nitrites, turbidity and alkalinity at the 95% level or greater. Other water quality parameters were not significantly different between 1974 and 1975.

PRIMARY PRODUCTION

Net phytoplankton photosynthesis from March, 1975 through February, 1976 averaged 1.92 g of carbon per m^2/day (G/D) (Table 5). Maximum production of 4.2 G/D occurred on 9 May, while minimum production was slightly negative at -.34 G/D on 24 October.

Fluctuations in primary production were quite large during the study segment. Maximum divergence occurred between 9 May and 23 May when production decreased from 4.2 G/D to .8 G/D. Other abrupt changes occurred in October-November where production on 10 October was 2.06 G/D decreasing to -.34 G/D on 24 October, but increasing to 1.91 G/D by 7 November. Similar fluctuations occurred in January-February.

Primary production accelerated following ice-off on 23 March and continued to increase steadily through late March and April, but declined precipitously during May attaining mean levels of 1.86 G/D in June-August and 1.43 G/D in September-November. After that the trend reversed. Primary production in December-February increased to 2.16 G/D, which was nearly equal to production in March-May.

Production was almost always highest at shallow depths with a mean of .83 G/D at 1 m. Photosynthetic activity decreased rapidly with depth and at 2 m mean production was .36 G/D followed by .29 G/D and .15 G/D at 3 amd 4 m. At 5 m production increased slightly to .29 G/D.

Analysis of variance was used to compare mean primary production between years and depths. No significant changes occurred during the 12 month interval, but the difference in primary production was significantly different ($P < .01$) at the different depth levels. Multiple range testing showed production at 1 m was greater than lower strata.

Table 5. Primary production in g carbon/m^3/day at Red Haw Lake.

	Depth in meters					
	1	2	3	4	5	Total
1975						
3/27	.21	.65	.75	.78	.59	2.98
4/11	1.25	.81	.25	.18	.46	2.95
4/25	1.09	.28	.41	.28	.53	2.59
5/09	1.56	1.34	.71	.28	.31	4.20
5/23	.66	.13	0	-.22	-.22	.35
6/06	1.00	.34	0	-.12	.12	1.34
6/20	1.96	.06	0	-.06	.15	2.11
7/03	.90	.75	.28	-.39	.31	1.85
7/18	1.12	.31	.43	.03	.06	1.95
8/01	.90	.50	.10	0	0	1.50
8/15	.71	1.00	.84	.18	.09	2.82
8/29	.41	.19	0	.81	.03	1.44
9/12	.88	.53	.09	.06	.06	1.62
9/26	1.09	.34	.13	.28	.09	1.93
10/10	1.47	-.28	.59	-.38	.66	2.06
10/24	0	-.25	0	-.06	-.03	-.34
11/07	.97	.22	.25	.13	.34	1.91
11/21	1.81	-.38	.06	-.06	0	1.43
12/05	1.09	.06	.38	.44	.28	2.25
12/22	0	.06	.13	1.19	.81	2.19
1976						
1/02	.06	.72	.66	.81	.03	2.28
1/16	1.06	.59	.25	.53	.44	2.87
1/31	.19	.16	.47	.50	-.09	1.23
2/13	[a]	[a]	.44	0	.32	[b]
2/27	.59	.16	.69	-1.5	2.19	2.13
3/12	-.31	.78	-.25	.16	.13	.51
Mean	.83	.36	.29	.15	.29	1.92

[a]No measurements recorded.

[b]Total not computed due to incomplete sample.

DISCUSSION OF FINDINGS

White amur introduction at Red Haw Lake was responsible for an extreme change in abundance and weight of vascular macrophytes. Before white amur were introduced the plant biomass averaged 2,438 g/m^2. A year later the biomass was reduced to 1,322 g/m^2 followed by a further reduction in 1975. During a three year period the overall plant mass was reduced by about 75%.

All plant groups decreased in biomass, but some were reduced more than others due to selective feeding by the fish. *Najas* was nearly eliminated from the plant community and the next most affected group was *Potamogeton*. *Ceratophyllum* and *Elodea* were reduced in abundance, but not nearly to the extent as the former groups. Food preference studies showed nearly the same order of selection by the fish.

The changes described for the macrophyte community required extensive grazing by white amur and resulted in vast quantities of partially undigested, nutrient-rich excreta, particularly at the mud-water interface. The estimated plant biomass consumed by white amur was 41 metric ton (MT) (45 T) in 1973, 63 MT (69 T) in 1974 and 88 MT (97 T) in 1975. Approximately 2-3% of this consumption was used for fish growth and body maintenance, while the remainder was organic waste. Some of the nutrients were immediately available for assimilation by phytoplankton, while the remainder underwent reduction and anerobic bacterial decomposition before they were available. In 1975, approximately 3 MT/ha (1.4 T/ac) of waste was produced by white amur, well within the range used by fish culturists in pond applications of animal manure at 2.3-11 MT/ha/yr (1-5 T/ac/yr).

Before white amur were introduced into Red Haw Lake dense beds of aquatic vegetation grew unimpeded during the summer followed by decomposition in autumn and winter releasing bound nutrients. Grazing by the amur was intensive from May-September with nutrients shunted into the ecosystem in the summer rather than autumn and winter. Ultimately the whole lake biota is influenced by the inflection of the nutrient cycle, and phytoplankton is the first component to respond to enrichment, particularly during summer.

Primary production increased slightly compared to 1974, but not during the summer as expected. Greatest production occurred during the winter and spring (December-May). It is entirely possible nutrients became chemically and biologically bound in the hypolimnion, particularly at the mud-water interface and were released during the autumnal turnover. Regardless of the seasonal change, photosynthesis values in 1975 were significantly lower than those reported by Corkum (1972) several years previous to the investigation.

Some chemical parameters showed an indication of accelerated eutrophication, while other parameters were contradictory. Alkalinity, pH, and turbidity increased, but nitrate and nitrite concentrations significantly decreased. Other parameters remained stable.

Inferences regarding the direct affect of white amur on aquatic macrophytes were conclusive. The reduction in biomass of the plant community was nearly fourfold during a 3-year period. The affect of biocontrol on eutrophication was less certain. Primary production of phytoplankton increased slightly, but lower than values reported in 1970 during an unrelated study. Water quality data was conflicting, some parameters showed increased enrichment while others were contrary. The aquatic vegetation at Red Haw was controlled by white amur, and the resultant affect on chemical and biological characteristics showed slight changes, yet the relationship of white amur and accelerated natural eutrophication is wholly unresolved.

RECOMMENDATIONS

Measurement of water quality, primary production and growth of vascular plants at Red Haw Lake should continue to define the affects of white amur on the whole ecosystem, particularly at the lowest trophic level.

LITERATURE CITED

Corkum, L. 1972. Primary productivity in Lake Red Haw, Lucas County, Iowa. Proc. Ia. Acad. Sci., 78(3,4):48-49.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: Evaluation of Biological Control of Nuisance Aquatic Vegetation by White Amur

PROJECT NO.: F-88-R-3

STUDY NO.: 504-3

TITLE: Vital statistics of white amur in Red Haw Lake

JOB NO.: 2

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: White amur stocked in 1973 attained a mean length and weight of 801 mm (31.5 in) and 5,810 g (12.8 lbs) by October, 1975. Maximum weight recorded was 8,000 g (17.7 lbs). Mean weight of white amur stocked the following year averaged 658 mm (25.9 in) at 3,500 g (7.7 lbs) by October. Condition factor (K) at mid-summer was 1.23. Food studies in June showed Potamogeton comprised 53% of the stomach contents by frequency followed in order of importance by Najas, 21%; Elodea, 16%; and Ceratophyllum, 3%. Unidentified food accounted for 7% of the contents, while insect larvae contributed .1% to the sample. By August Ceratophyllum was most frequent as a food item followed in order by Elodea, Potamogeton and Najas. Electivity indices showed Najas was most selected for followed closely by Potamogeton. Ceratophyllum was selected for in June, but the index was negative in August. Indices for Elodea were always negative. Estimated abundance of white amur at Red Haw Lake was 359 with a biomass of 60.3 kg/ha (54 lbs/ac).

Prepared by: Larry Mitzner
Fishery Research Biologist

Approved by: James Mayhew
Fishery Research Supervisor

JOB 2 OBJECTIVE

To determine the vital statistics of white amur including growth, condition, food consumption and mortality.

INTRODUCTION

Life history statistics of white amur have been described in numerous investigations where fish were confined in aquaria and small pools. Until recently few investigations were conducted in natural ecosystems. The early investigations were, of necessity, short term studies where growth, body condition, food preference, food consumption, energy balance, population biomass and water quality were measured. Regardless of the refinement and precision of the investigations they had little value to the actual fisheries management technique of biological control of white amur in lake systems.

This segment of the investigation was implemented to describe growth, body condition, food consumption, food preference and mortality of white amur that were stocked in Red Haw Lake to control nuisance aquatic vegetation.

STUDY BACKGROUND

White amur were initially introduced in July, 1973 at a mean length of 310 mm (12.2 in) and a body weight of 380 g (.83 lbs). Growth was extremely rapid thereafter and by 15 October, 1974 the fish attained a mean length of 702 mm (27.6 in) and weighed 4,263 g (9.4 lbs). Body condition (K) ranged from 1.16 in January-February to 1.22 in July-September, 1974. *Potamogeton*, *Ceratophyllum*, *Elodea* and *Najas*, which are the major plant groups in Red Haw Lake, served as the food source. *Najas* and *Ceratophyllum* had electivity indices of +.93 and +.24 while *Elodea* and *Potamogeton* were always near zero or negative. White amur biomass increased from 1,023 kg (2,260 lbs) in June, to 2,346 kg (5,180 lbs) by December, 1974. Known mortality was 55 fish, but greater mortality occurred from the 1974 planting where 41 dead fish were found within 15 days of introduction at Red Haw, undoubtedly many other dead fish were not observed.

METHODS AND PROCEDURES

The sampling schedule and methods in this segment were identical with previous segments except larger mesh gill nets (4-5 in) of monofilament style were used to capture white amur.

FINDINGS

GROWTH AND CONDITION OF WHITE AMUR

Growth was computed independently for each group stocked in 1973 and 1974. Most rapid growth occurred for younger fish stocked in 1974. Mean length when growth commenced in May, 1975 was 423 mm (16.6 in) and by October mean length increased to 658 mm (25.9 in). The range in length at the end of growth in 1975 was 620-696 mm (24.6-27.4 in). Mean growth increment in weight during the same period was 2,460 g (5.4 lbs) with an average weight in October of 3,500 g (7.7 lbs) and a range of 2,900-4,100 g (6.4-9.0 lbs) (Figure 1).

Growth increment of white amur stocked in 1973 was nearly equal. Mean length in May, 1975 was 702 mm (27.6 in) which increased to 801 mm (31.5 in) when growth ceased. White amur weight increased from 4,263 g (9.4 lbs) to 5,810 g (12.8 lbs) during the same period. Maximum weight was 8,000 g (17.7 lbs).

Condition factor (K) of white amur during the sample period was 1.23. The length-weight regression was best described by the equation

$$\log W = -4.6768 + 2.9067 \log TL$$

where W was weight and TL was total length.

FOOD CONSUMPTION BY WHITE AMUR

Food consumed by white amur was determined from ten alimentary tracts. Stomachs from three fish collected in January were empty. Mean volume of those taken from 5 June-26 August was 463 ml and ranged from 42-897 ml. Examination of contents showed aquatic vegetation was consumed almost exclusively along with occasional pieces of filamentous algae. Insect larvae continued to account for < .1% of the food items.

In June, *Potamogeton* was consumed most frequently accounting for 53% of the contents, while *Najas* was second most important at 21%. *Elodea* and *Ceratophyllum* contributed 16% and 3%, while 7% of the vegetation particles were unidentified.

Vegetation consumed in August was dominated by *Ceratophyllum*, 43%; *Elodea*, 19%; *Potamogeton*, 15%; and *Najas*, 9%. Thirteen percent of the sample was unidentified.

Najas continued to be the most selected plant with an index value of +.83 or greater. The electivity index for *Potamogeton* was +.49 in June followed by an increase to +.80 in August. *Elodea* ranked third by occurrence in utilization, but electivity was always negative, ranging from -.59 in June to -.14 in August. *Ceratophyllum* was selected quite highly for food in June (+.70), but decreased to -.25 in August.

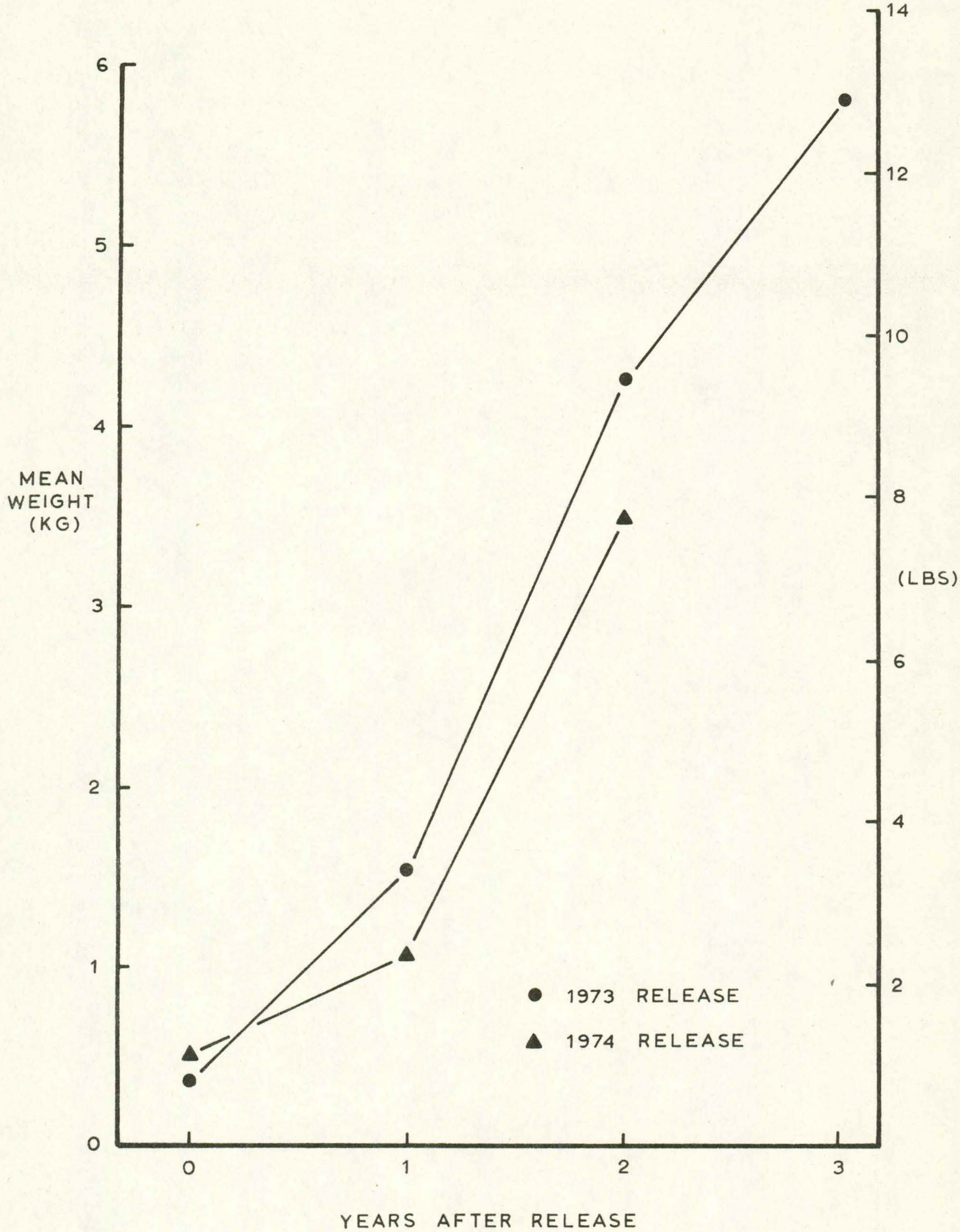

Figure 1. Growth in weight of white amur at Red Haw Lake in 1973-75.

POPULATION BIOMASS OF WHITE AMUR

Standing stock was estimated as the product of population abundance and the mean weight of each group released. Numerical abundance was impossible to assess because survival was unknown, so natural mortality had to be estimated. The fish were large at stocking which precluded mortality by predation. Likewise, fishing mortality was nil. These criteria existed for an unexploited population of bigmouth buffalo at Coralville Reservoir, Iowa, which had an annual natural mortality of 33% (Mitzner, 1972). Thus, this value was used to determine population abundance.

Estimated numerical abundance of the 1973 stocked white amur in October, 1975 based on an annual mortality of 33% was 221 with a mean weight of 5.81 kg (12.8 lbs). The standing crop at Red Haw was estimated at 44.3 kg/ha (39.5 lbs/ac). Similar estimates for white amur released in 1974 indicated 138 fish survived and had a mean weight of 3.50 kg (7.7 lbs). Estimated biomass was 16 kg/ha (15 lbs/ac). Combined, the populations had a standing stock of 60.3 kg/ha (54 lbs/ac). Without accounting for natural mortality, the biomass would be nearly twice this value.

DISCUSSION OF FINDINGS

White amur growth continued at a rapid rate, but decelerated slightly since the first introduction, particularly the 1973 group. Lower growth rate was undoubtedly a function of density where white amur biomass increased from 7 kg/ha (6 lbs/ac) at introduction in 1973 to 60 kg/ha (54 lbs/ac) three years later. Aquatic macrophyte density was reduced by about fourfold, which was reflected in the decline of food consumption. Food volume in the alimentary tract was reduced by 20% from the previous year.

Food habits were nearly identical compared with the previous segment; aquatic vegetation was by far the major food source. Early in the summer *Potamogeton* and *Najas* were more important, while in late summer *Elodea* and *Ceratophyllum* were prevalent. Electivity indices indicated the latter were less desirable as food items.

RECOMMENDATIONS

Computation of growth, body condition and biomass of white amur should continue, but food habits will be discontinued because the investigation has conclusively shown food preferences of white amur.

LITERATURE CITED

Mitzner, L. 1972. Population studies of bigmouth buffalo in Coralville Reservoir with special reference to commercial harvest. State Cons. Comm., Ia. Fish. Res., Tech. Series No. 72-3. 37 pp.

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-3		
STUDY NO.:	601-3	TITLE:	Evaluation of a 14-inch minimum length limit on largemouth bass
JOB NO.:	1		

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: Adult fish populations were sampled monthly with pound nets, experimental gill nets and a 230 volt A.C. electroshocker while an expandable sport fishery survey was conducted from April through August to determine the effects of a 14-inch size limit to control the harvest of bass; vital statistics of bass and related species; species composition; relative abundance; and harvest at Big Creek Lake. Net catches accounted for 6,450 fish weighing 1,510 kg. Black crappie dominated the total catch comprising 62%, white sucker was second, 19%; followed by bluegill, 7%; walleye, 4%, channel catfish, 2%; and bullhead, 2%. Although stocked sportfish dominated the numerical catch over 52% of the biomass was white sucker and carp. FND catches between pound and experimental gill nets differed for most species, with neither gear effective in taking bass. Body measurements and scales were collected from 150 largemouth bass, of three age groups, during the spring while 218 bass were sampled for seasonal growth in the autumn. Average back-calculated lengths were 146, 246, and 331 mm for ages I through III. Growth of all age groups was better in 1975 than for 1974 however seasonal growth calculations of age I bass was obviated because they were so poorly represented. Legal sized bass accounted for 9% of the spring electrofishing catch and less than 6% of the autumn sample. A Schnabel population estimate yielded 19,425 bass, age I through III, for a density of 56 bass/ha or 12 kg/ha, all three categories were the lowest recorded in three years of study. The sport fishery catch of 65,590 fish was dominated by stocked species for the first time. Black crappie predominated, 49,207 fish; bluegill was second, 9,841; followed by largemouth bass, 1,903; walleye, 1,706; and bullhead, 1,575. Anglers creeled an estimated 122 marked age III bass of 644 at large for an estimated exploitation rate of 19%. The 1972 largemouth bass year class continued to support the legal fishery. For the third consecutive season the size limit prevented an overharvest of bass when anglers caught and released over 64,000 sublegal bass for a catch rate of .45 bass/hr. Growth of bluegill and crappie was good when compared to that of older established Iowa waters.

Author: Vaughn L. Paragamian
Fishery Research Biologist

Date Prepared: 1 June, 1976

Approved by: James Mayhew
Fishery 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

Development of a sport fisheries, with a sustained popular angler interest, in new or renovated lakes is difficult if the appropriate predator-prey relationship is disrupted. The problem lies in the fact largemouth bass populations in recently stocked lakes are very susceptable to overharvest which creates several interrelated problems.

Initially, largemouth bass grow rapidly in newly stocked waters and control the numbers of bluegill and crappie progeny. Soon the bass grow to a size desired by many anglers and intensive fishing often results in an overharvest. This not only leaves poor bass fishing but the reduced predator stock is incapable of controlling bluegill and crappie populations within limits of available food for acceptable growth. Increased intraspecific competition for food yields the final outcome, retarded growth of bluegill and crappie.

Regulatory methods that could prevent the primary problem might include closed seasons; reduced creel limits; or a size limit on the predator stock. Information from other states indicates a size limit would provide the best method of protecting a largemouth bass population because it does not prevent fishermen from fishing.

Big Creek Lake, a recent man-made impoundment, was selected for investigation of an experimental 14-inch size limit on largemouth bass. This lake was recently stocked with bass, bluegill, black crappie and several other sport species and it is expected to have high fishing pressure. These facts should provide optimum conditions for this study.

STUDY BACKGROUND

Impoundment of Big Creek Lake was completed in 1972 and was stocked that year with largemouth bass, bluegill, channel catfish, blue catfish and muskellunge. The first three former species were stocked again in 1973 while black crappie and walleye were also added. Important species native to Big Creek included, white sucker, carp, bullhead, smallmouth bass, green sunfish and several species of *Notropis*.

Fish populations in Big Creek Lake have been sampled since 1973 with pound nets, experimental gill nets, and seine nets to determine relative abundance, species composition, size structure, and define the vital statistics of important species.

Native fish dominated the total net catch of 9,531 fish in 1973 and 6,453 fish in 1974. Green sunfish was the most prominent fish caught in 1973 making up 38% of the total catch, while black crappie was most abundant in 1974 comprising 29% of the total.

Largemouth bass were captured by electrofishing for tagging and numerical population estimates. Schnabel population estimates were 28,204 bass $\geq$ 170 mm (7 in) in 1973 and 42,791 bass of all sizes in the spring of 1974. Standing stocks were estimated at 19.8 kg (18 lbs) and 20.7 kg/ha (19 lbs/ac) for 1973 and 1974, respectively.

The Fish Management Branch conducted an expandable sport fishery survey from which exploitation, harvest, and angler success was estimated. Big Creek Lake sport fishery survey indicated the catch by anglers was dominated by green sunfish in 1973-74 with 10,362 and 13,570 fish, respectively. Bullhead contributed the greatest yield in 1973, 5.8 kg/ha (5.2 lbs/ac) while green sunfish was most important in 1974, 4 kg/ha (3.6 lbs/ac).

After members of the initial largemouth bass year class recruited to a legal size exploitation increased from < .001% in 1973 to 11% in 1974 while catch rates remained high at .77 and .85 bass/hr for the same years.

METHODS AND PROCEDURES

Collections of fish population statistics were conducted in the same fashion as outlined in prior annual reports. Only new methods or procedures are described in this section.

Population estimates were computed for each largemouth bass age group in the following manner. Schnabel population estimates were calculated for three distinct length groups, a random sample of bass scales were taken for age analysis to determine numerical representation of ages within length groups.

FINDINGS

NET SAMPLE CATCH STATISTICS

Introduced sport fish dominated the total net catch of 6,450 fish in 1975 (Table 1). Black crappie comprised the greatest portion, 62%; followed by white sucker, 19%; bluegill, 7%; walleye, 4%; and channel catfish, 2%. The catch of largemouth bass continued to decline from previous years.

Table 1. Combined catch composition of pound and experimental gill nets, Big Creek Lake, April through October, 1975.

	Number	Percent number	Weight (kg)	Percent weight	Mean weight (kg)
Crappie	4,019	62.3	438.4	29.0	.11
W sucker	1,219	18.9	640.4	42.4	.53
Bluegill	475	7.4	65.4	4.3	.14
Walleye	252	3.9	96.9	6.4	.39
Ch catfish	140	2.2	59.0	3.9	.42
Bullhead	130	2.0	37.4	2.5	.29
Carp	81	1.3	150.1	9.9	1.85
Other species[a,b]	105	1.6	16.1	1.1	
Total	6,450		1,509.8		

[a]Includes golden shiner, common shiner, creek chub, hog sucker, carpsucker, green sunfish and yellow perch.

[b]Mean weight not computed.

Despite the numerical preponderance of stocked speices the total weight of the catch, 1,510 kg (3,330 lbs), was dominated by white sucker and carp (Table 1). White sucker continued to dominate the catch in weight with 42%, followed by black crappie, 29%; carp, 10%; walleye, 6%; and channel catfish, 4%. Blue catfish and muskellunge were not seen.

Differences in catch success, measured as fish per net day (FND), between pound nets and experimental gill nets for many species was evident in catches of 1975 (Tables 2 and 3). Black crappie and bluegill were caught more frequently by pound net, white sucker, walleye and channel catfish were caught more often by experimental gill net, while both gear captured bullhead at a similar rate, and neither gear was effective for the capture of largemouth bass.

Table 2. Fish per net day and weight of gill net catches at Big Creek Lake, 1975.

	Sampling period									
	April		May		June		July		August	
Species	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND
Crappie	.7	.1	6.3	.5	9.0	.4	14.3	1.5	16.0	1.9
W sucker	25.0	10.5	18.7	8.1	21.7	10.5	12.0	5.9	23.3	9.9
Bluegill			1.0	.1	.3	< .1	.3	< .1		
Walleye	16.0	7.2	6.3	2.3	2.7	.7	2.7	.9	5.7	1.7
Ch catfish			3.0	.8	1.7	.4	6.3	2.1	6.0	2.4
Bullhead	.3	.1	3.0	.6	1.7	.5	2.0	.4	1.0	.3
Carp		< .1	1.0	2.0			.3	.4	.3	.4
G shiner	1.0	< .1	1.7	.1	.7	< .1	.3	< .1	4.0	.2
Lm bass	.3	.1					1.7	.3	2.0	.3
G sunfish			1.7	.1	1.0	.1	.3	< .1	.7	.1
C shiner	3.7	.5	.3	< .1			.7	< .1		
H sucker	.7	.1			.3	.1	.3	.1		
Y perch			.7	.1						
R carpsucker	.7	.7								
C chub	.7	.1								

Table 2. (Continued).

Species	September FND	September kg/ND	October FND	October kg/ND	Mean FND	Mean kg/ND
Crappie	15.7	1.9	6.7	.9	9.8	1.4
W sucker	17.0	7.4	26.7	14.6	20.6	9.5
Bluegill			.3	< .1	.3	< .1
Walleye	5.3	1.9	11.7	5.1	7.2	2.8
Ch catfish	3.3	1.9	1.7	.7	3.2	1.2
Bullhead	.3	.1	1.3	.6	1.4	.4
Carp	.3	1.2	.7	1.7	.4	.8
G shiner	1.3	.5			1.3	.1
Lm bass	.3	< .1	.7	.1	.7	.1
G sunfish	.3	< .1			.6	< .1
C shiner	.3	< .1			.7	.1
H sucker	.7	.4			.3	.1
Y perch					.1	< .1
R carpsucker					.1	.1
C chub					.1	< .1

Table 3. Fish per net day and weight of pound net catches at Big Creek Lake, 1975.

	Sampling period									
	April		May		June		July		August	
Species	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND	FND	kg/ND
Crappie	9.3	1.5	76.8	8.5	31.5	3.4	54.5	4.2	49.1	4.7
W sucker	28.3	16.4	5.7	3.1	8.4	4.8	4.8	2.7	7.9	4.1
Bluegill	3.6	.6	5.0	.7	8.9	1.1	6.6	.9	3.8	.7
Walleye	4.7	1.6	.5	.2	1.0	.4	1.0	.4	.4	.1
Ch catfish	.7	.3	.5	.2	1.0	.4	1.6	.8	.2	.1
Bullhead	.6	.2	1.7	.6	1.4	.5	2.2	.6	.5	.1
Carp	1.6	2.8	.9	1.7	.8	1.6	.8	1.2	.6	1.0
G shiner	.3	< .1			.6	< .1			.5	< .1
Lm bass	.5	.2	.1	< .1			.4	.1		
G sunfish	.2	< .1	.3	< .1	.2	< .1	.2	< .1	.1	< .1
C shiner	.3	< .1								
H sucker	.1	< .1			.1	.1			.2	.1
Y perch	.2	< .1								
R carpsucker	.1	.1								

Table 3. (Continued).

	Sampling period					
	September		October		Mean	
Species	FND	kg/ND	FND	kg/ND	FND	kg/ND
Crappie	55.4	7.1	61.3	6.8	48.3	5.2
W sucker	6.7	3.5	6.5	3.9	9.9	5.6
Bluegill	5.6	.7	8.3	1.2	5.9	.8
Walleye	.2	.1	1.0	.5	1.3	.5
Ch catfish	1.3	.8	1.1	.5	.9	.4
Bullhead	1.1	.3	1.5	.4	1.3	.4
Carp	1.3	2.4	.3	1.0	.9	1.7
G shiner			.2	< .1	.2	< .1
Lm bass	.2	< .1	.2	< .1	.2	.1
G sunfish	.1	< .1	.2	< .1	.2	< .1
C shiner					< .1	< .1
H sucker					.1	< .1
Y perch					< .1	< .1
R carpsucker					< .1	< .1

SIZE STRUCTURE OF LARGEMOUTH BASS

Body lengths, weights and scales were collected from about 50 bass of each year class for age and growth analyses. An additional 218 largemouth bass were captured in the autumn to calculate the growth increments for 1975. Age I bass captured in the spring for analysis ranged from 88 mm (3.5 in) to 150 mm (5.9 in) TL ($\overline{X}$ = 111 mm, SD 12) and weighed 7 g (.02 lbs) to 22 g (.05 lbs) ($\overline{X}$ = 15 g, SD 4) while age II bass ranged from 150 mm (5.9 in) to 240 mm (9.5 in) TL ($\overline{X}$ = 187 mm, SD 20) and weighed from 40 g (.09 lbs) to 168 g (.37 lbs) ($\overline{X}$ = 86 g, SD 31). Age III bass captured in the same period ranged from 253 mm (10.0 in) to 480 m (18.9 in) TL ($\overline{X}$ = 321 mm, SD 9) and weighed 200 g (.44 lbs) to 2,015 g (4.44 lbs) ($\overline{X}$ = 507 g, SD 382). Legal sized bass accounted for 9% of the total catch and 14% of the age III bass, 1972 year class (Table 4). Age I bass were so poorly represented that only two bass of the entire autumn sample were identified as members of the 1974 year class, $\overline{X}$ TL of 248 mm (9.8 in) and a $\overline{X}$ of 208 g (.46 lbs). Age II bass varied from 214 mm (8.4 in) to 285 mm (11.2 in) TL ($\overline{X}$ = 253 mm, SD 17) and weighed from 155 g (.34 lbs) to 314 g (.69 lbs) ($\overline{X}$ = 223 g, SD 42) while age III bass ranged from 297 mm (11.7 in) to 392 mm (15.4 in) TL ($\overline{X}$ = 326 mm, SD 28) and weighed from 340 g (.75 lbs) to 830 g (1.83 lbs) ($\overline{X}$ = 490 g, SD 148). Legal sized bass made up less than 6% of the bass over 175 mm and 20% of the age III fish. Young-of-the-year bass sampled in the autumn ranged from 102 mm (4.0 in) to 175 mm (6.9 in) TL ($\overline{X}$ = 144 mm, SD 17) and weighed from 14 g (.031 lbs) to 74 g (.163 lbs) ($\overline{X}$ = 144 g, SD 17).

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTORS OF LARGEMOUTH BASS

Length-weight relationships for each age of bass sampled in the spring of 1975 was

Age I $\log_{10}W = -4.56 + 2.80 \log_{10}TL$

Age II $\log_{10}W = -5.14 + 3.11 \log_{10}TL$

Age III $\log_{10}W = -5.31 + 3.18 \log_{10}TL$

while the autumn sample was

0-age $\log_{10}W = -5.73 + 3.40 \log_{10}TL$

Age II $\log_{10}W = -4.17 + 2.71 \log_{10}TL$

Age III $\log_{10}W = -5.49 + 3.25 \log_{10}TL$

Mean K-factors for bass captured early in the season were 1.06 (SD .04), 1.27 (SD .07), and 1.36 (SD .18) for ages I through III, respectively, while K-factors for the fall sample were 1.35 (SD .12), 1.36 (SD .09), and 1.37 (SD .13) for ages 0, II and III, respectively.

Differences in the slope values between age II and III bass were not significant for spring or autumn groups, while there were no seasonal differences within age groups (Table 5). A statistical comparison of the b-values in a t-distribution indicated the two regression lines did not differ. A second statistical comparison demonstrated coefficients of condition were the same in autumn as they were in spring for each age group.

Table 4. Length-frequency distribution of 300 largemouth bass (age III) captured in the spring at Big Creek Lake, 1975.

Length (mm)	Number	Percent
240-49	3	1.0
50-59	5	1.6
60-69	6	2.0
70-79	25	8.3
80-89	27	9.0
90-99	43	14.3
300-09	32	10.6
10-19	42	14.0
20-29	35	11.6
30-39	19	6.3
40-49	13	4.3
50-59	10	3.3
60-69	13	4.3
70-79	10	3.3
80-89	3	1.0
90-99	8	2.6
400-09	2	0.6
10-19	1	0.3
20-29	1	0.3
30-39		
40-49	1	0.3
50-59		
60-69		
70-79		
80-89	1	0.3

Table 5. Statistical comparison in a Students t-distribution of the slope in length-weight relationships of largemouth bass captured in spring and autumn, 1975.

	Age	b	t
Spring	II	3.11	2.03
	III	3.18	2.02
Autumn	II	2.71	2.00
	III	3.25	2.08

GROWTH OF LARGEMOUTH BASS

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

$$TL = -1.83 + 2.47\ ScR$$

where TL was the total length and ScR was scale radius. This relationship was used to back-calculate total length at each annulus for each age class (Table 6). Estimated average total lengths for ages I through III were 146 (5.7 in), 246 (9.7 in), and 331 mm (13.0 in).

Table 6. Average estimated total length in mm at each annulus for largemouth bass, Big Creek Lake, 1975.

		Age		
Year class	Number	I	II	III
1974	34	105		
1973	38	146	192	
1972	40	188	300	331
Unweighted mean		146	246	331

ESTIMATED POPULATION SIZE OF LARGEMOUTH BASS

A spring population estimate of 19,425 bass, age I through III, was the result of capturing 2,887 bass and recapturing 175 (Table 7). Population estimates were calculated by marking or tagging three size ranges of bass; $\leq$ 120 mm, > 120 mm and < 200 mm, and $\geq$ 200 mm. All bass under 120 mm were age I while 31% of the bass over 200 mm were age II and none of the age III bass were under 200 mm. From these data numerical sizes of each age group were computed to be 563 age I, 13,969 age II, and 4,893 age III.

Largemouth bass standing stock was estimated at 12 kg/ha (10.7 lbs/ac) from numerical population sizes and mean weights of each age group. The estimated density was 56 bass/ha (22 bass/ac).

Table 7. Schnabel population estimates and standing stock of largemouth bass in Big Creek Lake, April-May, 1975.

Size range and age	Catch	Marked	Recaptured	Population number	Confidence interval	Density (bass/ha)	Standing stock (kg/ha)
≤ 120 mm Age I	67	49	3	563	264 ∞	2	.03
> 120 mm and < 200 mm Age II	1,836	1,514	116	11,822	10,002 14,452	34	2.32
≥ 200 mm Age II & III	984	805	56	7,040[a]	5,579 9,539	20	9.70
Total	2,887	2,368	175	19,425		56	12.05

[a]30.5% are age II.

CATCH AND EXPLOITATION BY ANGLING

Sport fishery survey data from 1 April to 31 August, were expanded to compute total harvest, catch rates, angler pressure and exploitation of largemouth bass (Table 8). During the survey 8,521 fishermen were interviewed which was expanded to a total of 55,272 anglers that fished 143,155 hours (408 hr/ha) to catch 65,590 fish.

Table 8. Estimated angler harvest of fish species from Big Creek Lake, 1975.

Species	Number	Weight (kg)	Catch rate fish/hr	Percent weight
G sunfish	630	62.9	.005	.6
Bluegill	9,841	1,340.4	.07	12
Lm bass	1,903	1,563.5	.01	14
Sm bass	26	18.6	< .001	.2
B crappie	49,207	6,925.5	.34	61
Walleye	1,706	689.3	.01	6
B bullhead	1,575	407.5	.01	4
C catfish	282	144.7	.002	1
Carp	20	48.5	< .001	.4
W sucker	361	232.6	.003	2
C shiner	39	5.7	< .001	< .1
Total	65,590	55,499.1		

Stocked sport fish dominated the catch by number and weight for the first time since reservoir impoundment while native species declined. Black crappie was the most abundant fish by weight and number, 49,207 fish weighing 6,926 kg (15,272 lbs), while bluegill was second in numerical importance, 9,841 fish or 1,340 kg (2,955 lbs), followed by largemouth bass, 1,903 fish weighing 1,564 kg (3,449 lbs), walleye, 1,706 fish weighing 689 kg (1,519 lbs) and channel catfish, 282 fish weighing 145 kg (320 lbs). Bullhead was the most prevalent native fish caught, 1,575 fish weighing 408 kg (900 lbs), followed numerically by green sunfish, 630, and white sucker, 361.

Exploitation of largemouth bass nearly doubled over the previous year (Table 9). Anglers creeled 191 bass (legal and sublegal) of which 12 were marked in 1975, prior to the fishing season. From this figure an estimated 122 marked bass were captured of the 644 tagged bass from the 1972 year class. Exploitation was estimated at nearly 19%.

Table 9. Largemouth bass population estimates, exploitation and catch success for 1973 through 1975.

Year	Population estimate	Sublegals released	Catch rate (fish/hr)	Exploitation
1973	28,204	23,566	.77	< .001
1974	42,791	100,722	.85	.11
1975	19,425	64,420	.45	.19

Catch success declined by about 40% of what is was the previous year but catch and releases still greatly exceeded the population size (Table 9). Fishermen caught and released 64,420 sublegal bass or about three times the population size for a catch rate of .45 bass/hr. Undersized bass accounted for 27% of the catch of 191 fish. About 10% of the catch was less than 343 mm (13.5 in) the smallest of which was 197 mm (7.7 in).

ANNUAL SURVIVAL AND MORTALITY OF LARGEMOUTH BASS

Survival was computed for the 1972 largemouth bass year class in 1974 by comparing the proportion of tag returns of bass marked in two consecutive years, 1974 and 1975 (Ricker, 1975). Thirty tags were returned voluntarily by anglers and the clerk. Of these 21 were from 622 bass tagged in 1975 while 9 were of 579 marked in 1974. Survival (S) was calculated as

$$S = \frac{(9)(622)}{(579)(21)} = .4604 \times 100 = 46.04\%$$

Total annual mortality (A), the compliment of S, was 54%.

AGE AND GROWTH OF RELATED FISH SPECIES

Bluegill Length, weight and scales were taken from 49 bluegill during 1975. The sample ranged in length from 33 mm (1.3 in) to 220 mm (8.7 in) and weights of 1 g (< .01 lbs) to 232 g (.51 lbs). Length-weight relationship was described by the equation

$$\log_{10}W = -5.04 + 3.17 \log_{10}TL$$

K-factors ranged from 1.61 to 2.45 and averaged 2.06.

Body-scale relationship was represented by the equation

$$TL = 21 + .87\ ScR$$

This relationship was used to calculate total lengths at annulus for each age group (Table 10). Mean total lengths at each annulus were 50 (2.0 in), 121 (4,8 in), 176 (6.9 in) and 220 mm (8.7 in) for ages I through IV.

Table 10. Estimated total length in mm at each annulus for bluegill, Big Creek Lake, 1975.

Year class	Number	Age I	II	III	IV
1974	12	55			
1973	12	48	103		
1972	14	52	134	172	
1971	1	43	125	181	220
Grand average		50	121	176	220

Black Crappie Length, weight, and scales were collected from 56 black crappie during 1975. The range in length was 111 mm (4.4 in) to 200 mm (7.9 in) and weight from 20 g (.04 lbs) to 172 g (.38 lbs). Length-weight relationship was described by the equation

$$\log_{10}W = -5.56 + 3.3 \log_{10}TL$$

K-factors ranged from 1.24 to 1.76 with a mean of 1.50.

Body-scale relationship was represented by the function

$$TL = 50 + .84 \, ScR$$

This relationship was used to estimate total length at annulus for each age group (Table 11). Mean total length at each annulus was 109 (4.3 in), 158 (6.3 in), and 191 mm (7.5 in) for ages I through III.

Table 11. Estimated total length in mm at each annulus for black crappie, Big Creek Lake, 1975.

Year class	Number	Age I	II	III
1974	13	87		
1973	42	128	156	
1972	1	118	159	191
Grand average		109	158	191

DISCUSSION OF FINDINGS

A systematic increase in relative abundance of most sport fish from previous years was recorded in net catches. Black crappie exhibited the most dramatic numerical change rising from 2 to 22 to 48 FND, by pound net, from 1973 through 1975. Catch success of crappie was influenced primarily by a strong 1973 year class that initially recruited into net gear during 1974 and was wholly vulnerable in 1975. Catch success of bluegill increased from .8 to 4.6 to 6 FND, 1973 through 1975. Channel catfish catch success in gill nets, rose slightly from .6 to 1.6 to 3 FND, for the same years. Gill net catches of walleye varied somewhat; 6.5 to 9.6 to 7 FND for the same years.

Catch success of largemouth bass and green sunfish, by net gear continued to decrease. Net gear has proved to be an inefficient method of determining relative abundance of bass. However, population estimates, derived through electrofishing effort, confirmed a decline in bass density. Green sunfish will probably never be as abundant as they were in 1973.

Black bullhead, a fish sought after by many anglers, has also precipitously declined in relative abundance. Bullhead were caught at 19 FND by gill net in 1973, declined to 6 FND in 1974 and 1 FND in 1975.

In spite of the numerical preponderance of sport fish the total catch by weight is still dominated by nonsport fish. White sucker comprised the greatest portion in biomass contributing 16%, 44% and 42% of the catch by weight from 1973 through 1975. In addition, white sucker ranked second in numerical abundance during 1975. Carp, decreasing in importance numerically, ranked third in importance by weight during the same year. The few individuals that were caught were large sized when compared to other species. Thus, their importance by weight was strongly influenced by their larger body dimension.

The largemouth bass population in Big Creek Lake remained characterized by many sublegal bass and few legal fish. During the three years of this study no more than 12% of any electrofishing sample exceeded the legal length limit. This prodigy is not atypical, but probably true of bass populations controlled by a size limit and with similar intensive angling pressure.

Similarities in bass standing stock was noted for the first two years, but in the third year a 50% decline occurred. Standing stocks of 1973 and 1974 were 19 and 20 kg/ha while that of 1975 was 12 kg/ha. Estimated standing stock during the first two years of the fishery were probably measurements of the largemouth bass population at or near carrying capacity, since exploitation was nearly non-existent during 1973 and the estimate of 1974 was calculated before angling had an impact. A harvest of 5 kg/ha during the 1974 fishing season can account for a large portion of the difference while poor reproductive success and growth that same year can account for the remainder.

Bass population density followed the same trend as standing stocks. The lowest density recorded was that of 1975, 56 bass/ha, as compared to 80 and 110 bass/ha in 1973 and 1974. The primary reason for the drop in bass numerical density was the poor representation of the 1974 year class in the spring estimate of 1975. This year class was also poorly represented in the fall of the same year. Young-of-the-year and age II bass were very vulnerable to capture by electrofishing; whereas, age I fish were seldom seen, thus eliminating gear selectivity as an important bias.

Accelerated growth over the previous year was documented in 1975 for two year classes (Figure 1). By the autumn of 1975, 0-age bass attained a mean length of 144 mm as compared to 105 mm for the 1974 year class during their first year of life. Annual growth increments for age II bass increased from 46 mm in 1974 to 61 mm for 1975. An increase in forage (documented in Job 2) and availability was thought responsible for the improved growth. An insufficient sample of age I bass during autumn obviated growth comparisons. Annual growth increments for age III bass, since the 1973 season, has been somewhat ambiguous. The selective nature of the bass fishery for faster growing fish leaves slower growing individuals. For example, comparing back-calculated total length, for the 1972 year class, at age II and III of 300 mm, and 331 mm to the autumn 1975 (fourth growing season) mean length of 326 mm, it appears that for two seasons this year class grew only about 30 mm.

The initial largemouth bass year class stocked at Big Creek Lake has supported the legal fishery for two seasons. Nearly all of the bass reported in the survey in 1974 and 1975 originated in the 1972 year class. During each year a few sublegal bass from 1973 were kept by anglers. It is likely the 1972 year class will remain the principle contributor to the legal catch in 1976. Growth of the 1973 year class was insufficient to provide legal sized recruits until late 1976. This fact coupled with a much reduced density of the 1972 stock indicated a lower numerical harvest can be expected in 1976.

Exploitation rate for the 1972 year class nearly doubled over the previous year while the number and weight harvested was similar. Anglers caught 11% or 2,093 fish (1,300 kg) of the 1972 year class during the 1974 season. The following year exploitation increased to 19% but the numerical harvest of 1,903 fish (1,564 kg) did not exceed that of the previous season.

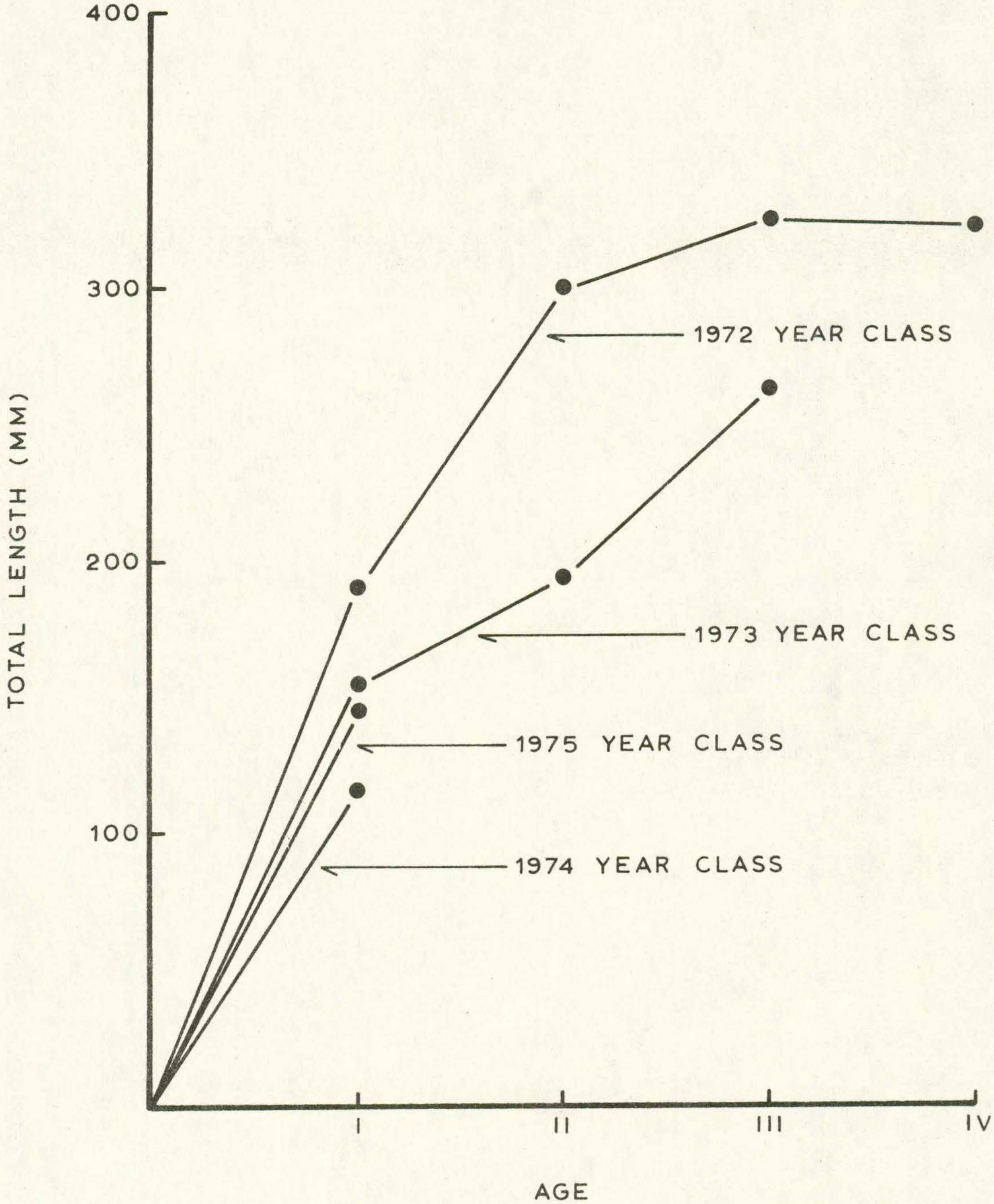

Figure 1. Estimated total lengths of the 1972, 1973, and 1974 year classes of largemouth bass. The last increment of each age group, except the 1974 cohort, is the observed mean length in the autumn of 1975.

Exploitation rate, calculated by expanding tag returns from survey data, may underestimate actual exploitation. Tag return data indicated exploitation to be about 19% of the 1972 year class. Exploitation calculated by comparing total bass harvest figures to population size yielded an estimate of 39%. The exact reason for the gross discontinuity is not understood at this time. Similar comparisons between data of 1974 provided nearly equal estimates. Further population data for the spring of 1976 should provide evidence as to which was the more accurate measurement.

The minimum length limit averted an overharvest of bass for the third successive year. During each study year the angler catch and release of sublegal bass nearly equalled or exceeded the numerical population size up to threefold.

Natural mortality of the 1972 year class remained the same from 1973 to 1974 at 43% while total mortality increased. An 11% increase in total mortality, 43% to 54%, was the same as that of exploitation rate, 0 to 11%. The phenomenon of competitive mortality apparently did not hold true for the largemouth bass population at Big Creek Lake since the introduction of fishing mortality in 1974 did not reduce natural mortality. Reasons for this observation will be considered at a later date.

Growth of bluegill at Big Creek Lake was equal to that in established Iowa water. Mayhew (1965) presented observed mean lengths of bluegill, age 0+ through VI+, from 71 artificial lakes in southern Iowa. Back-calculated lengths for bluegill from Big Creek Lake, age II and III, fell midway within minimum and maximum values and on or above mean values while age I fish, 50 mm (2 in), TL were below minimum values. However, growth of bluegill in their first year of life at Big Creek Lake is greater than lengths attained by fish at Bobwhite Lake, Red Haw Lake, and Williamson Pond, 45 (1.8 in), 46 (1.8 in), and 43 mm (1.7 in), respectively (Mitzner, unpublished). Two important points to keep in mind are that Big Creek Lake is a much newer impoundment than the former bodies of water and the bluegill population at Big Creek is still expanding. Thus, growth of bluegill will soon stabilize at Big Creek Lake with higher population densities, despite the presence of a large predator stock.

A dominant 1973 black crappie year class represents the bulk of the crappie population at Big Creek Lake. Adult crappie were stocked in 1973, the second year of impoundment, and this strong year class is the initial progeny of that stocking. Growth was acceptable, when compared to mean observed lengths for black crappie of other established Iowa lakes (Mayhew, 1965). One exception was during the first year of life at Big Creek Lake, when growth was below the minimum value. However, these comparisons are biased since fish used in Mayhew's study had additional time for growth because they were observed lengths after annulus formation. It is also reasonable to assume that growth rate will change at Big Creek Lake since the crappie population is also in a state of flux.

RECOMMENDATIONS

The study should continue to further define the impact of a 14-inch size limit on population dynamics of bass and vital statistics of related species. Of particular interest in the next study segment will be the contribution of the 1973 largemouth bass cohort to the legal fishery.

LITERATURE CITED

Mayhew, J. 1965. Comparative growth of four species of fish in three different types of Iowa artificial lakes. Ia. Acad. Science 72:224-229.

Ricker, W. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. 191. 382 pp.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 601-3

JOB NO.: 2

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

TITLE: Predator-prey relationship of largemouth bass and other Centrarchid species

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *The primary goal of this job is to describe the predator-prey relationship between bass and forage species with particular interest to forage abundance and sizes utilized by various sized bass. Forage fish populations were systematically sampled with a 15.2 m seine net. Food habits of largemouth bass were studied by direct examination of stomach contents of bass captured periodically by electrofishing. Seine hauls captured 20,620 fish, including young and adult minnows and young-of-the-year of seven species. Young bluegill dominated the total catch (91%) while minnows were second (9%). Other young fish (< 1%) sampled included black crappie, largemouth bass and green sunfish. Stomach contents of 42 bass ranging from 200-299 mm TL were examined, of which eight were empty. Fish was the most important food item consumed in number (70%) and weight (53%) while crayfish were of secondary importance. Stomach contents of 20 bass 300+ mm TL were examined, of these four were empty. Fish contributed the greatest numerical (62%) and weight (73%) portion in the diet. Centrarchids were the dominant fish species utilized by largemouth bass of both size groups while larger bass tended to consume larger food items.*

Author: Vaughn L. Paragamian
Fishery Research Biologist

Approved by: James Mayhew
Fishery 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 goal of this segment was to establish the status of the predator-prey relationship between largemouth bass and forage species, of which bluegill and black crappie were the most important in this study. Of paramount interest was the size at which forage fish species were utilized by various sized bass, their importance as food items, and the abundance of forage species.

Largemouth bass were established during the first two years of impoundment, simultaneously adult and young bluegill and crappie were stocked. Since then prey species density has been systematically sampled and food habits of various size groups of bass studied.

STUDY BACKGROUND

Relative abundance of forage species were sampled during 1973 and 1974 and food habits of largemouth bass monitored during the latter year only.

0-age green sunfish comprised 49% of the total seine catch of 11,766 fish in 1973, *Notropis sp.* made up 46%, while young bluegill and crappie made up 1%. Although bass food habits were not studied that year, it is likely green sunfish were an important food item since seasonal mortality of this species was over 80%.

Within the following season young-of-the-year bluegill became more important, contributing 24% of the total seine catch of 1,997 fish, but *Notropis sp.* dominated by providing 73%. Green sunfish declined to 2% and crappie represented < .1%.

Largemouth bass fed primarily on aquatic insects and entomostraca early in life and began eating fish at about 125 mm (5 in). Crayfish were an important food item to bass over 200 mm (7.8 in) early in the season, before most species spawned, but were soon replaced by fish as the dominant food. Analysis of all stomach samples from bass 200+ mm revealed fish represented 70% of the total by weight and crayfish was next at 21%. Few Centrarchids were identified among the fish food items, however, over 50% of the fish remains were unidentifiable.

METHODS AND PROCEDURES

Forage fish sampling followed the same procedure outlined in the previous annual report with one exception, only stomachs of largemouth bass 200+ mm TL were taken for content analysis.

FINDINGS

POPULATION ABUNDANCE OF PREY SPECIES

Seine hauls captured 20,620 fish, including adult and young *Notropis sp.* and 0-age members of seven other species (Table 12). Young-of-the-year bluegill made up 91% of the total catch. *Notropis sp.* was second with 9%, and black crappie < 1%. Green sunfish and largemouth bass contributed < 1%.

Table 12. Catch composition of seine hauls at each sampling site in Big Creek Lake, June through October, 1975.

	Sampling site							
	I		II		III		Total	
	N	%	N	%	N	%	N	%
Bluegill	4,770	84.6	8,123	95.0	5,778	89.9	18,671	90.6
Lm bass	1	< .1	13	.2	9	.1	23	.1
Crappie	2	< .1	19	.2	10	.2	31	.2
G sunfish	3	< .1	12	.1	14	.2	29	.1
Notropis sp.	862	15.3	371	4.3	617	9.6	1,850	9.0
Bullhead			10	.1			10	.1
Y perch			3	< .1			3	< .1
Sm bass			1	< .1	1	< .1	2	< .1
J darter			1	< .1			1	< .1
Total	5,638		8,553		6,429		20,620	

STOMACH CONTENT ANALYSIS OF LARGEMOUTH BASS

Stomachs of 42 bass ranging from 200-288 mm TL (7.9-11.4 in) ($\overline{X}$ = 299 mm, SD 24) were examined and eight were found empty (Table 13). Fish were the most important food item by number and weight, 70% and 53%, respectively. Crayfish were second by weight, 43%, and insects second by numerical importance, 29%.

Table 13. Stomach contents in percent for 34 largemouth bass ranging in total body length from 200-299 mm at Big Creek Lake, May through September, 1975.

	Percent by number	Percent by weight	Percent stomachs containing item
Centrarchidae[a]	34.8	18.3	26.5
Notropis sp.	1.5	9.0	8.8
Cyprinius carpio	.9	< .1	2.9
Unidentifiable fish	32.6	25.6	61.8
Total fish	69.8	52.8	73.5
Decapoda	1.5	43.1	11.8
Aquatic insects[b]	26.2	3.1	26.5
Terrestrial insects[c]	.9	.1	5.9
Unidentifiable insects	1.5	.9	8.8
Total insects	28.7	4.1	32.4

[a]Primarily black crappie and bluegill.

[b]Includes Corixidae, Anisoptera, and unidentifiable Diptera.

[c]Unidentifiable Colioptera.

0-age Centrarchids, primarily black crappie and bluegill, were ingested more frequently than any other group, 114 individuals weighing 11 g (.02 lbs) (Table 14). Shiners were found five times and weighed 5 g (.01 lbs), but were of lesser importance than 107 other fish, weighing 15 g (.03 lbs) that were digested beyond identification. Five crayfish, found in four stomachs, contributed 25 g (.05 lbs) which was a substantial portion, while 94 insects provided only 2 g (< .01 lbs).

Table 14. Stomach contents of 34 largemouth bass ranging in total body length from 200-299 mm at Big Creek Lake, May through September, 1975.

	Number of stomachs containing items	Number of items	Weight (g)	Mean weight of item (g)
Centrarchidae[a]	9	114	10.82	.10
Notropis sp.	3	5	5.29	1.06
Cyprinus carpio	1	3	.01	.01
Unidentifiable fish	21	107	15.12	.14
Total fish	25	229	31.25	.14
Decapoda	4	5	25.48	5.10
Aquatic insects[b]	9	86	1.84	.02
Terrestrial insects[c]	2	3	.04	.02
Unidentifiable insects	3	5	.54	.01
Total insects	11	94	2.42	.03
Vegetation	1	1	.07	.07

[a]Primarily black crappie and bluegill.

[b]Includes Corixidae, Anisoptera, and unidentifiable Diptera.

[c]Unidentifiable Colioptera.

Stomach contents of 21 bass ranging from 302-409 mm TL (11.9-16.1 in) ($\overline{X}$ = 340 mm, SD 36) were examined. Four of the stomachs were empty (Table 15). Fish were the primary food item by number and weight, contributing 62% and 76%, respectively. Insects made up 32% by number and 10% by weight, while crayfish comprised 4% and 13% in the same categories.

Larger bass utilized adult and 0-age members of several species of fish including bluegill and black crappie (Table 16). Fifty crappie and bluegill, weighing 109 g (.24 lbs), were removed from five stomachs while 22 unidentifiable fish, weighing 25 g (.06 lbs), were found in seven stomachs. Other species utilized less frequently, but contributing a substantial portion to the total weight, included white sucker, walleye, and largemouth bass. Five crayfish weighing 59 g (.13 lbs) were taken from four stomachs while aquatic insects were of a lesser importance, 14 items weighing 2 g (< .01 lbs) from four stomachs.

Table 15. Stomach contents in percent of 17 largemouth bass 300+ mm TL at Big Creek Lake, May through September, 1975.

	Percent by number	Percent by weight	Percent stomachs containing item
Micropterus salmoides	.8	10.6	5.8
Centrarchidae[a]	41.0	24.4	29.4
Notropis sp.	.8	.7	5.9
Catostomus commersoni	.8	25.2	5.9
Stizostedion vitreum	.8	9.4	5.9
Unidentifiable fish	18.0	5.7	41.2
Total fish	62.3	76.1	64.7
Decapoda	4.1	13.4	23.5
Aquatic insects[b]	11.5	.5	23.5
Terrestrial invertebrates[c]	19.7	9.9	11.8
Unidentifiable insects	.8	< .1	5.9
Total invertebrates[d]	32.0	10.4	35.3
Vegetation	.8	< .1	5.9
Organic material	.8	< .1	5.9

[a]Primarily black crappie and bluegill.

[b]Includes Ephermeroptera, Corixidae, and unidentified Diptera.

[c]Includes Annelida and Formicidae.

[d]Does not include Decapoda.

Table 16. Food items of 17 largemouth bass 300+ mm TL at Big Creek Lake, May through September, 1975.

	Number of stomachs containing items	Number of items	Weight (g)	Mean weight of item (g)
Centrarchidae[a]	5	50	108.53	2.17
Micropterus salmoides	1	1	47.00	47.00
Notropis sp.	1	1	3.14	3.14
Catostomus commersoni	1	1	112.00	112.00
Stizostedion vitreum	1	1	41.92	41.92
Unidentifiable fish	7	22	25.30	1.15
Total fish	11	76	337.89	4.45
Decapoda	4	5	59.48	11.90
Aquatic insects[b]	4	14	2.18	.16
Terrestrial invertebrates[c]	2	24	44.05	1.84
Unidentifiable insects	1	1	.04	.04
Total invertebrates	6	39	46.27	1.19
Vegetation	1	1	.04	.04
Organic material	1	1	.30	.30

[a]Primarily black crappie and bluegill.

[b]Included Ephmeroptera, Corixidae, and unidentifiable Diptera.

[c]Included Annelida and Formicidae.

DISCUSSION OF FINDINGS

Extreme yearly variations in forage density were recorded in seine catches from 1973 through 1975. The total seine catch of 1975 was the highest, 1973 was intermediate and 1974 was lowest.

Annual variations in forage density were due primarily to year class abundance of bluegill, green sunfish and *Notropis sp.* Seine net catches of 0-age bluegill progressively increased from 1973 through 1975. On the other hand, catches of young green sunfish decreased for the same years while the catch of *Notropis sp.* was at a peak in 1973 and declined slightly from 1974 to 1975.

Annual growth increments of largemouth bass appeared not only related to intra-species density but also to forage density. Mean total length of 0-age bass captured in the autumn of 1973 and 1975, years when total seine catches were highest were greater than the length of young bass caught during the same period in 1974. Growth increment of the 1973 largemouth bass cohort was greater for their third year of life (1975) than it was for their second (1974).

Fish continued to be the most important food item of largemouth bass 200+ mm TL (7.9 in) while crayfish are of secondary importance. Invertebrates (other than crayfish) contributed a large numerical portion, but were of little value since they comprised a small segment of the biomass consumed. In comparison to insects, fish provided 2% by number and 74% by weight in 1974 while insects contributed 94% and 2% in the same categories. During the same year crayfish comprised 4% by number and 21% by weight. Fish dominated the numerical and weight composition of stomach contents in 1975, while crayfish comprised 2% and 38% and insects 29% and 6%.

Centrarchids were the dominant fish consumed by largemouth bass at Big Creek Lake. Stomach analysis of bass in 1974 indicated bluegill, crappie, and green sunfish comprised over 50% of the identifiable fish food items. Stomach samples taken in 1975 revealed these species comprised over 98% of the identified fish, although green sunfish was not as important as the others. Shiners (*Notropis sp.*) ranked second in importance for both years. Cannabalism was recorded each year but it was not considered serious.

Larger bass utilized large fish food items while smaller bass consumed smaller fish. Mean weight of partially digested fish found in bass 300+ mm TL was 4.4 g (< .01 lbs) as compared to .14 g (.001 lbs) for smaller bass. For example, stomach samples from individual specimens taken in 1975 contained such items as a 112 g (.25 lbs) white sucker, 41 g (.09 lbs) walleye and a 47 g (.1 lbs) largemouth bass; while in 1974 bass of about the same size fed on crappie and green sunfish that averaged over 30 g (.07 lbs) and 58 g (.13 lbs). Lewis, et al., (1975) also found that the size of food items increased with bass size, but the biomass consumed compared to bass weight decreased. Snow (1971) noted that an increase in size of bluegill and crayfish eaten was positively correlated to an increase in bass size except with bullhead.

RECOMMENDATIONS

This segment of study will continue to determine the reproductive success of forage species and their importance to the diet of bass. Sampling will continue as outlined including the collection of stomachs only from bass 200+ mm TL.

LITERATURE CITED

Lewis, W., R. Heidinger, W. Kirk, W. Champany, and D. Johnson. 1975. Food intake of the largemouth bass. Trans. Amer. Fish. Soc. 103(2):277-280.

Snow, H. 1971. Harvest and feeding habits of largemouth bass in Murphy Flowage, Wisconsin. Wisc. Dept. Nat. Res. Tech. Bull. 50. 25 pp.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-3

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

STUDY NO.: 701-5

JOB NO.: 1

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: 0-age gizzard shad, crappie and bluegill populations were sampled with standardized meter net tows for 14 weeks at Lake Rathbun. The overall catch of gizzard shad was 294.6 per tow, the second highest recorded. Crappie abundance continued to decline to a mean of 2.3 fish per tow. Bluegill catch increased slightly to an average of 1.4 fish per tow. Spawning activity of gizzard shad was observed in early May, similar to 1972 and 1974. The first larval shad were captured in late May. Buck Creek embayment was the most important area for 0-age shad production. Initial crappie spawning was observed in late April and larvae were captured in the first sampling interval. Seasonal distribution of the catch was similar to other years with a single mode occurring in early June. Buck Creek embayment was also the most important area of the lake for crappie reproduction. Bimodal distribution of the bluegill catch continued this season. The first mode appeared in late May and the second in late July. For the first time most bluegill reproduction was found along the shoreline of the main pool. Highly significant ($P < .01$) differences in the horizontal and vertical distribution was found for all three fish species. Annual mortality of the 0-age fish population was estimated at 64% for gizzard shad, 65% for crappie and 88% for bluegill. Annual mortality this season was not significantly different from previous years. Total production was estimated as follows: gizzard shad, 9.68 kg/ha; crappie, .11 cg/ha; and bluegill, .04 cg/ha.

Author: James Mayhew
Fishery Research Supervisor

Date Prepared: 1 March, 1976

STUDY OBJECTIVE

To develop a predictive model of 0-age fish production in Lake Rathbun by identifying the physical and biological factors that control the abundance of young fish including (a) reservoir water level control management for flooding, (b) sedimentary turbidity, (c) water temperature and (d) planktonic fish-food organism abundance and availability.

JOB 1 OBJECTIVE

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

INTRODUCTION

Populations of 0-age fish were systematically sampled with standardized meter net tows at Lake Rathbun for the fifth consecutive year. The 14 week schedule started 5 May and terminated 4 August. Eight fish species from six families were captured this season, but analyses were limited to gizzard shad, crappie and bluegill because the numbers of other species captured were too low for meaningful results.

STUDY BACKGROUND

The standardized sampling regimen for 0-age fish started in 1971 following initial water impoundment in Lake Rathbun. Estimated numerical abundance, spatial distribution, annual mortality and production was compiled each season for gizzard shad, crappie and bluegill. Twelve fish species representing six families have been captured.

Overall mean catch of postlarval gizzard shad from 1971-74 was 14.6, 281.4, 315.8 and 281.7, respectively. Crappie catch means per net tow was 18.3 in 1971, 8.6 in 1972, 34.9 in 1973, and 3.2 in 1974. Mean catch of bluegill young was 116.6, 6.3, 13.7 and .5 per tow for the four seasons, respectively.

Spatial distribution of postlarval fishes was not uniform at all reservoir sampling locations. Abundance of young gizzard shad and bluegill was highest in the embayment and shoreline stations. 0-age crappie were most numerous in the embayment stations. In mid-summer postlarval fish became demersal in midwater habitat with the population density highest at these stations. Gizzard shad exhibit a further tendency for pelegic movement in late summer. Crappie young remained at deep levels in midwater throughout the summer. Bluegill larvae inhabited shallow water throughout the first year of life.

Catch means of 0-age fish, adjusted to uniform horizontal and vertical distribution, were used to extrapolate the numerical population size for each of the seven biweekly sampling periods. Maximum population density of postlarval gizzard shad ranged from 2,796 ± 2,726 per ha in 1971 to 80,311 ± 25,146 per ha in 1973. Crappie density varied from 226 ± 173 per ha in 1974 to 10,456 in 1973. Density of young bluegill attained the highest level in 1971 with 25,109 ± 14,689 per ha compared with the lowest maximum density of 73 per ha in 1974.

Annual mortality of 0-age gizzard shad ranged from 57% in 1974 to 84% in 1973. Crappie annual mortality varied from 32% in 1974 to 62% in 1973. Total mortality for postlarval bluegill ranged from 34% in 1972 to 58% in 1971, but was not estimated for 1974 because of a low catch. Higher annual mortality was always associated with higher population density.

Total annual production of postlarval shad through mid-August for 1971-74 was estimated at .40, 8.85, 9.81 and 12.01 kg/ha, respectively. Crappie production for this period was 1.56 cg/ha in 1971, 1.79 cg/ha in 1972, 8.31 cg/ha in 1973 and .11 cg/ha in 1974. Production of bluegill young ranged from < .01 cg/ha in 1974 to 4.51 cg/ha in 1971.

METHODS AND PROCEDURES

Collection methods for 0-age fish and procedures for analysis of the numerical data were identical with previous study segments.

FINDINGS

ABUNDANCE OF 0-AGE GIZZARD SHAD

The overall mean catch of postlarval gizzard shad this season was 294.6 per net tow, the second highest recorded catch success since inception of the study. Mean catch for previous study segments were 14.6 in 1971, 281.4 in 1972, 315.7 in 1973 and 281.7 in 1974. Comparison of all paired catch means showed the 1971 catch was significantly lower ($P < .01$) than all other seasons and the 1973 catch was significantly higher at the 95% level.

Temporal distribution of the numerical catch in 1975 by biweekly intervals was quite similar to the past four seasons (Figure 1). Inflection in the catch curve occurred during identical sampling intervals as 1972 and 1974 and one period earlier than in 1973. Shad spawning activity was observed in shallow water in the Buck Creek embayment near Station 9 on 8 May. Initial spawning presumably occurred somewhat prior to that time, probably 10 days or more. First postlarval shad appeared in the meter net tows during late May. Mean catch in this interval was 250.7 with a range at individual stations from 86 at Station 3B to 523 at Station 2B (Table 1). Modal catch occurred in early June averaging 1,432.9 larvae per net tow. The shoreline and embayment stations produced highest catches. Spawning activity ceased sometime during

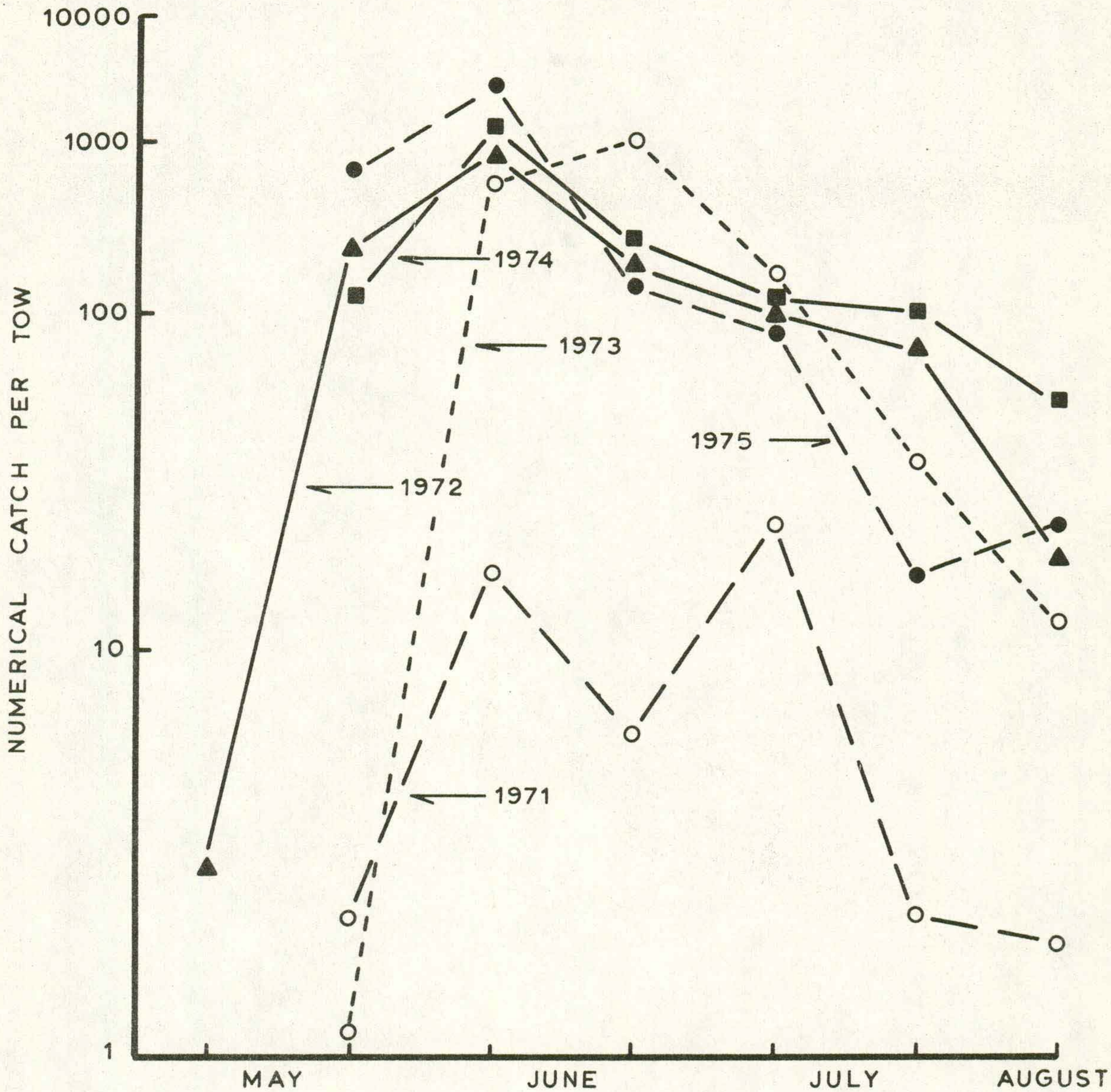

Figure 1. Mean numerical catch of 0-age gizzard shad in meter net tows, 1971-75.

Table 1. Mean numerical meter net tow catch of 0-age gizzard shad in biweekly periods at Lake Rathbun, 1975.

Sampling station	Depth	Sampling interval: Early May	Late May	Early June	Late June	Early July	Late July	Early August
2	A	0	283	1,005	47	16	15	1
	B	0	523	3,466	155	213	13	2
3	A	0	117	570	191	8	5	2
	B	0	86	590	240	91	5	10
4	A	0	223	90	49	7	5	16
	B	0	174	344	253	127	8	35
7	A	0	209	3,420	255	7	12	1
8	A	0	206	664	310	798	23	177
9	A	0	435	2,747	217	65	37	23
Mean			250.7	1,432.9	190.8	148.0	13.7	29.7
$S_{\bar{x}}$			47.8	456.9	30.6	84.5	3.5	18.8
Mean weight (g)			.002	.008	.024	.421	.850	2.372

this period and the catch of young shad followed the customary systematic decline until late July. Mean catch values from mid-June through conclusion of sampling in early August were 190.8, 148.0, 13.7 and 29.7 per net tow, respectively. Highest catch success of postlarval shad during the year occurred in the Buck Creek embayment and along the shoreline of the main pool. Mean catch in the Honey Creek embayment, which is usually high, was the lowest since the first year of study.

HORIZONTAL AND VERTICAL DISTRIBUTION OF 0-AGE GIZZARD SHAD

Analysis of variance in the numerical catch of postlarval shad was completed over the five seasons, and revealed continued unequal spatial distribution of juvenile fish in the reservoir. Highly significant variations ($P < .01$) occurred horizontally between midwater and shallow water habitats and vertically among the midwater sampling stations (Table 2).

Table 2. Partitioned sums of squares due to sampling station effect in the numerical catch of postlarval gizzard shad in meter net tows at Lake Rathbun, 1971-75. Catch values were transformed by $\log_e X + 1$.

Source of variation	df	SS	MS
Station	8	[77.69]	[9.71]**
Midwater vs shallow water	1	29.12	29.12**
Among midwater stations	(5)	(45.86)	(9.17)**
Shallow tows vs deep tows	1	39.74	39.74**
Station 2 vs 3, 4	1	2.42	2.42
Interaction with depth	1	.17	.17
Station 3 vs 4	1	.69	.69
Interaction with depth	1	2.84	2.84
Among shallow stations	(2)	(2.71)	(1.36)
Shoreline vs embayments	1	2.47	2.47
Honey Creek vs Buck Creek	1	.24	.24
Residual	240	270.15	1.13

**Significant at the 99% level.

Mean catch of postlarval shad in the shallow water stations was 359.8 per net tow compared with 176.6 per net tow at midwater stations. Among the midwater station the mean catch was 82.5 in surface net tows and 270.7 in deep strata net tows. Horizontal distribution among the midwater stations remained uniform despite large increased catches at Station 2B this year. Midsummer movement from shallow water stations to the deeper strata in midwater followed nearly the same pattern as previous years.

MORTALITY OF 0-AGE GIZZARD SHAD

Annual mortality for the 0-age shad population was 64% this season compared with 67% in 1971, 69% in 1972, 84% in 1973 and 57% in 1974. Difference in annual mortality between all years was not significant ($P > .05$). The daily rate of change in the population density due to mortality was estimated at $.074 \pm .062$ in 1975. For other sampling years the daily rate of change ranged from $.061 \pm .026$ in 1974 to $.130 \pm .011$ in 1973.

PRODUCTION OF 0-AGE GIZZARD SHAD

Total production of 0-age gizzard shad through mid-August 1975 was 9.68 kg/ha (Table 3). Production in prior years ranged from .40 kg/ha in 1971 to 12.01 kg/ha in 1974. By individual sampling interval production ranged from .40 kg/ha in late May to 5.31 kg/ha in late June.

Table 3. Production of 0-age gizzard shad in Lake Rathbun, 1975.

Sampling interval	Mean weight (g)	Instantaneous growth coefficient	Stock (N/ha)	95% Confidence interval	Stock biomass (kg/ha)	Mean biomass (kg/ha)	Production (kg/ha)
5/ 5-5/18	[a]		[a]	[a]	[a]		
		[a]				[a]	[a]
5/19-6/ 1	.0020		12,517	± 4,678	.03		
		1.39				.30	.40
6/ 2-6/15	.008		71,544	± 44,712	.57		
		1.10				.41	.45
6/16-6/29	.024		10,027	± 3,153	.24		
		2.87				1.85	5.31
6/30-7/13	.421		8,210	[b]	3.47		
		.70				2.02	1.41
7/14-7/27	.850		684	± 345	.58		
		1.03				2.05	2.11
7/28-8/10	2.372		1,483	[b]	3.52		
						Total production = 9.68 kg/ha	

[a]No gizzard shad captured in net tows.

[b]Confidence interval not computed.

The high numerical population density of 71,544 ± 44,712 per ha occurred in early June. By late July, the estimated population size declined to 684 per ha which varied no more than ± 345 at the 95% level of sampling probability. Estimated total population weight for sampling periods varied from .03 kg/ha in late May to 3.47 kg/ha during early July.

ABUNDANCE OF 0-AGE CRAPPIE

Fewer 0-age crappie were captured in 1975 than in any preceeding season. Overall mean catch was 2.3 fish per net tow compared to mean values of 18.3, 8.7, 34.9 and 3.2 from 1971-74. The highest mean catch within a sampling interval was 25 at Station 9 in early June (Table 4). Most of the early and late season meter net tows contained no young crappie, and only single specimens were taken at four stations.

Table 4. Mean numerical meter net tow catch of 0-age crappie in biweekly periods at Lake Rathbun, 1975.

		Sampling interval						
Sampling station	Depth	Early May	Late May	Early June	Late June	Early July	Late July	Early August
2	A	0	0	1	1	1	0	0
	B	0	0	1	1	0	0	0
3	A	0	0	1	1	0	0	0
	B	0	0	1	3	1	0	0
4	A	0	0	0	1	0	0	0
	B	0	0	1	3	11	1	1
7	A	0	0	0	12	0	0	0
8	A	1	0	1	1	0	0	0
9	A	0	1	25	7	2	0	0
Mean		.1	.1	3.4	3.3	1.7	.1	.1
$S_{\bar{x}}$		a	a	2.7	1.3	1.2	a	a
Mean weight			.004	.009	.0044	.0379	.074	.525

[a]Sample standard error not computed.

One postlarval crappie was captured at Station 8 in the first sampling interval, indicating initial spawning activity occurred in late April. During the next period two young crappie were captured at Station 9. Seasonal distribution of the catch was quite similar to other years, containing a single mode of 3.4 per net tow in early June (Figure 2). Peak crappie spawning activity in 1975 occurred during late May, somewhat later than 1971 and 1972, but earlier than last year. Catch success declined very slightly to 3.3 per net tow in late June. By early July mean catch declined to 1.7 per net tow, followed by two specimens taken in each of the following periods.

HORIZONTAL AND VERTICAL DISTRIBUTION OF 0-AGE CRAPPIE

Analysis of variance in the catch of postlarval crappie over all years showed highly significant ($P < .01$) differences in spatial distribution (Table 5). Catch mean for the shallow water stations was 28.9 per net tow compared to 5.8 per net tow for the midwater stations. Deep water tows in midwater averaged 7.9 crappie larvae per net haul; whereas, the mean catch was 3.6 for surface net tows. There was no significant difference in horizontal distribution among midwater and shallow water habitats.

Table 5. Partitioned sums of squares due to sampling station effect in the numerical catch of postlarval crappie in meter net tows at Lake Rathbun, 1971-75. Catch values were transformed by $\log_e X + 1$.

Source of variation	df	SS	MS
Station	[8]	[30.10]	[3.76]**
Midwater vs shallow water	1	12.54	12.54**
Among midwater stations	(5)	(15.83)	(3.17)**
Surface vs deep tows	1	12.76	12.76**
Station 2 vs 3, 4	1	.11	.11
Interaction with depth	1	.40	.40
Station 3 vs 4	1	.63	.63
Interaction with depth	1	1.93	1.93
Among shallow stations	(2)	(1.73)	(.87)
Embayment vs shoreline	1	1.46	1.46
Honey Creek vs Buck Creek	1	.27	.27
Residual	240	146.88	.61

**Significant at the 99% level.

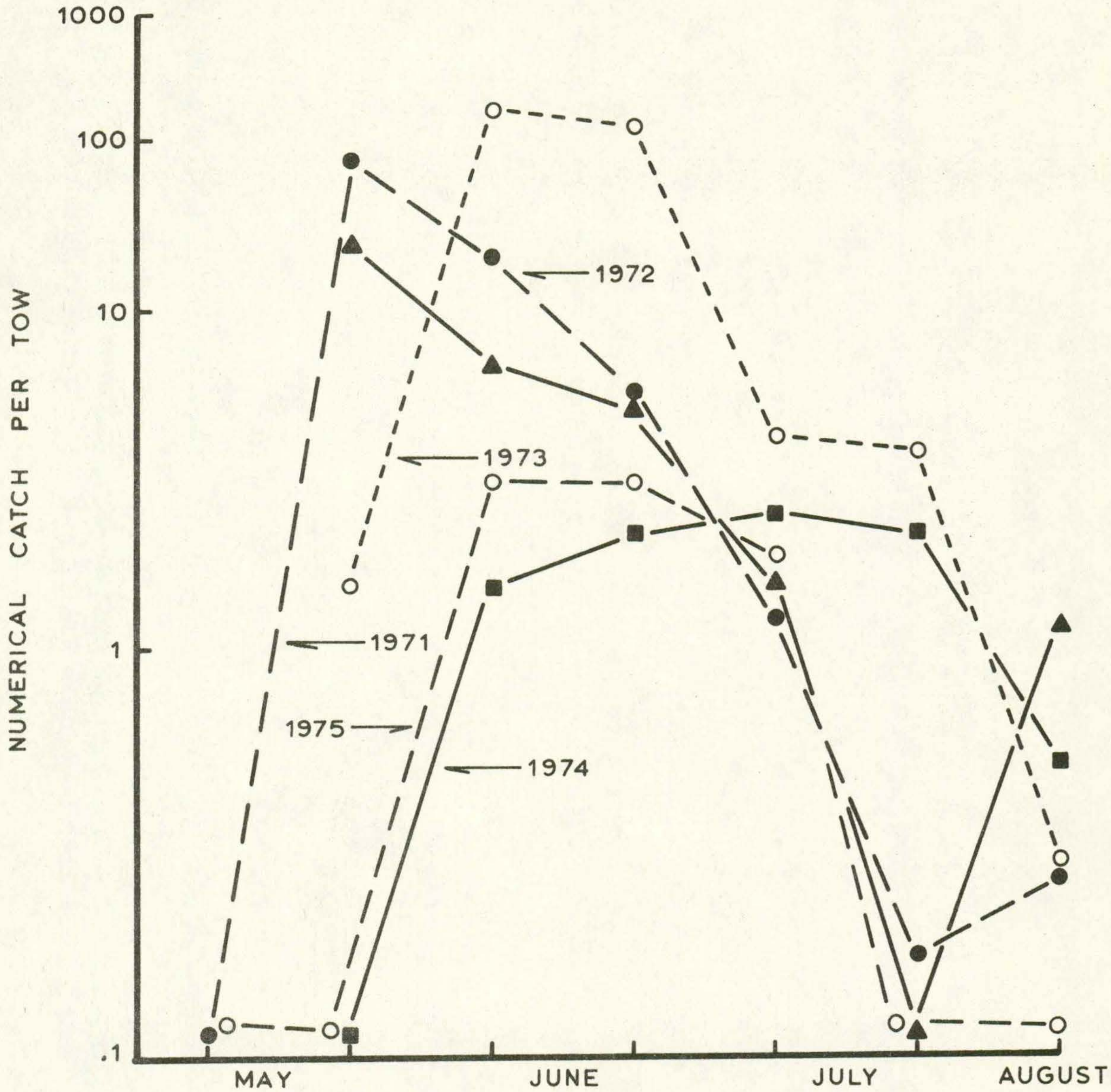

Figure 2. Mean numerical catch of 0-age crappie in meter net tows, 1971-75.

MORTALITY OF 0-AGE CRAPPIE

Estimated annual mortality of 0-age crappie in 1975 was .65 ± .57. Comparable values for the previous study segments were .54 ± .37 in 1971, .39 ± .27 in 1972, .62 ± .30 in 1973 and .39 ± .06 in 1974. Annual mortality between years was not significantly different at the 95% level. Daily change in the numerical population density due to mortality was estimated at .075 ± .061 in 1975. The daily change ranged from .028 ± .004 in 1974 to .069 ± .025 in 1973 in preceeding years.

PRODUCTION OF 0-AGE CRAPPIE

Postlarval crappie production for the season was estimated at .11 cg/ha, the lowest production recorded in all years of the study (Table 6). Production for the other years was 1.56, 1.79, 8.31 and .27 cg/ha, respectively. The highest 0-age crappie population density was recorded in late June at 173 ± 131 cg/ha. After that period population density decreased to 5 per ha in the last two biweekly intervals. Population weight for individual sampling periods never exceeded .03 cg/ha.

ABUNDANCE OF 0-AGE BLUEGILL

Overall mean catch of 0-age bluegill in 1975 was 1.4 per net tow. Comparable mean catch values for other years was 116.6 per tow in 1971, 6.3 in 1972, 13.7 in 1973 and .5 in 1974 (Table 7). Bimodal seasonal distribution from two discrete spawning periods continued this season (Figure 3). The first mode occurred in early June and the second in late July, nearly in the same periods as 1971 and 1972. First postlarval bluegill appeared in the catch during late May when two fish were captured at Station 2A. In the following period the mean catch per net tow was 1.8 with highest catches at Stations 8 and 9. By late June, catch declined to .2 larvae per net tow followed by an increase to 2.3 and 4.7 per net tow in the next sampling intervals. Catch success declined to .6 per net tow in the last sampling period. The highest bluegill catch recorded was 26 per net tow at Station 7 during the late July period.

DISTRIBUTION OF 0-AGE BLUEGILL

Analysis of variance in the numerical catch of 0-age bluegill over the five seasons showed heterogeneous spatial distribution (Table 8). Catch success in 1975 was .5 bluegill per tow at midwater stations and 3.1 for the shallow water stations ($P < .01$). For the first time young bluegill were more numerous along the shoreline of the main pool, averaging 4.7 per net tow. Previous highest catch success was attained at the embayment sampling stations. There was a significant difference ($P = .05$) in the horizontal distribution of 0-age bluegill in midwater, with the catch at Station 2 significantly higher than other midwater stations. Catch means for Station 2 over the five year period was 27.7 per net tow compared to 11.5 at Stations 3 and 4. There was no significant difference in the horizontal distribution between embayment and shoreline stations, nor in vertical distribution between surface and deep tows among midwater stations.

Table 6. Production of 0-age crappie at Lake Rathbun during 1975.

Sampling interval	Mean weight (g)	Instantaneous growth coefficient	Stock ($\hat{N}$/ha)	95% Confidence interval	Stock biomass (cg/ha)	Mean biomass (cg/ha)	Production (cg/ha)
5/ 5-5/18	[a]		[a]	[a]	[a]		
		[a]				[a]	[a]
5/19-6/ 1	.004		5	[b]	< .01		
		.81				< .01	< .01
6/ 2-6/15	.009		170	[b]	< .01		
		-.72				< .01	[c]
6/16-6/29	.0044		173	± 131	.01		
		2.15				.03	.06
6/30-7/13	.0379		94	[b]	.4		
		.67				.02	.01
7/14-7/27	.074		5	[b]	< .01		
		1.96				.02	.04
7/28-8/10	.525		5	[b]	.03		

Total production = .11 cg/ha

[a]No crappie captured in net tows.

[b]Confidence intervals not computed.

[c]Production not computed.

Table 7. Mean numerical meter net tow catch of 0-age bluegill in biweekly periods at Lake Rathbun, 1975.

		Sampling interval						
Sampling station	Depth	Early May	Late May	Early June	Late June	Early July	Late July	Early August
2	A	0	1	2	1	6	0	0
	B	0	0	0	0	5	0	0
3	A	0	0	0	0	0	1	0
	B	0	0	0	0	1	1	1
4	A	0	0	1	0	0	0	0
	B	0	0	1	0	0	0	0
7	A	0	0	1	1	2	26	3
8	A	0	0	6	0	0	7	0
9	A	0	0	5	0	7	7	1
Mean		0	.1	1.8	.2	2.3	4.7	.6
$S_{\bar{x}}$		[a]	.1	.79	.16	1.02	3.01	.35
Mean weight (g)			.001	.002	.004	.012	.028	.021

[a]Sample standard error not computed.

Table 8. Partitioned sums of squares due to sampling station effects in the numerical catch of postlarval bluegill in meter net tows at Lake Rathbun, 1971-75. Catch values were transformed by $\log_e X + 1$.

Source of variation	df	SS	MS
Station	[8]	[48.97]	[6.12]**
Midwater vs shallow water	1	40.74	40.74**
Among midwater stations	(5)	(6.50)	(1.30)*
Shallow tow vs deep tows	1	1.76	1.76
Station 2 vs 3, 4	1	.82	.82
Interaction with depth	1	2.42	2.42*
Station 3 vs 4	1	.95	.95
Interaction with depth	1	.55	.55
Among shallow stations	(2)	(1.73)	(.87)
Shoreline vs embayments	1	.26	.26
Honey Creek vs Buck Creek	1	1.47	1.47
Residual	240	139.72	.58

*Significant at the 95% level.

**Significant at the 99% level.

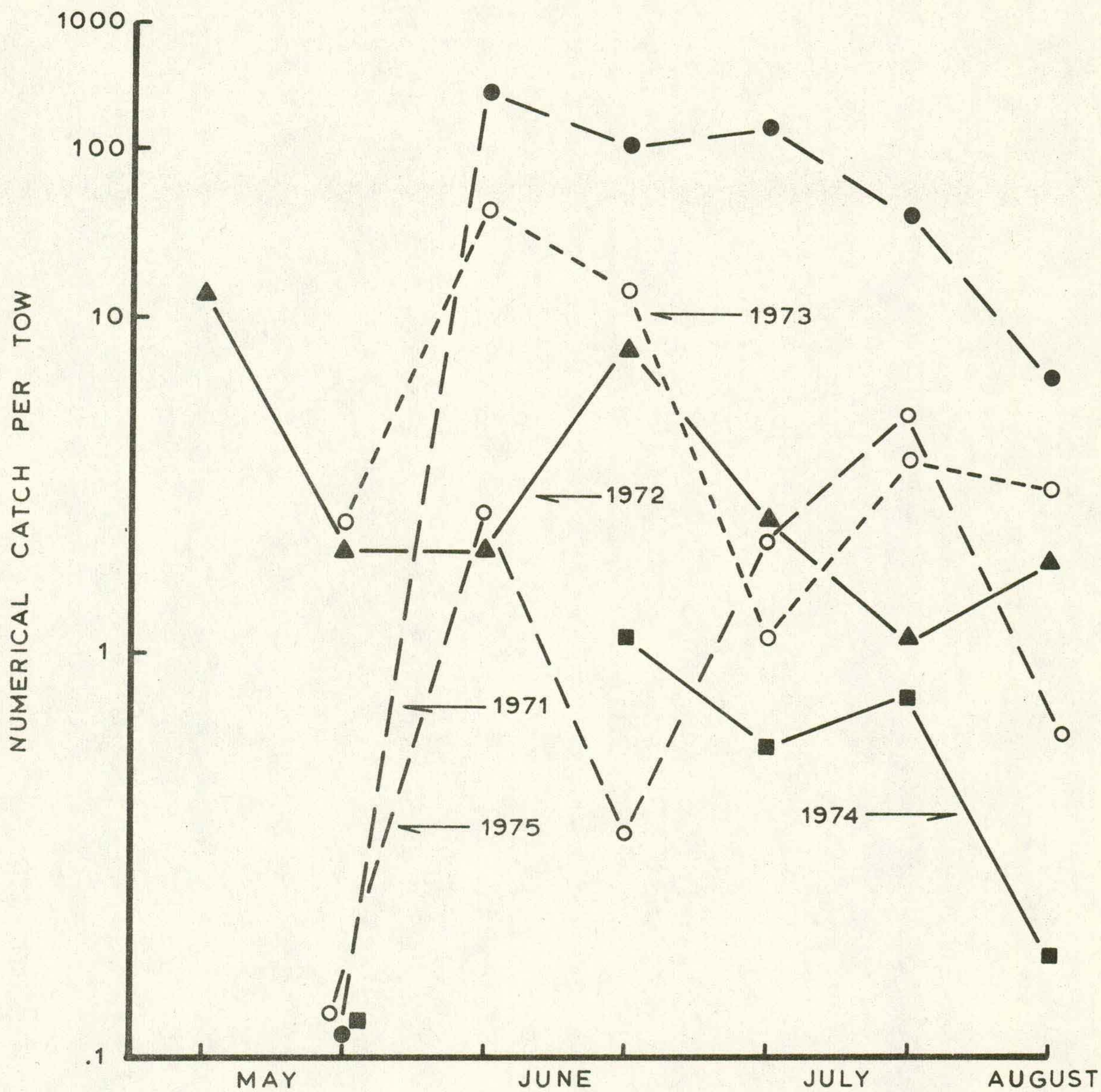

Figure 3. Mean numerical catch of 0-age bluegill in meter net tows, 1971-75.

MORTALITY OF 0-AGE BLUEGILL

Annual mortality of 0-age bluegill in 1975 was estimated at 88%, which would vary ±34% at the .05 level of sampling probability. In prior study segments annual mortality was 86% in 1971, 34% in 1972 and 35% in 1973. Low catch success last year precluded computation of mortality. The daily rate of change in the postlarval bluegill population this season was estimated at .149 ± .030.

PRODUCTION OF 0-AGE BLUEGILL

Total production of 0-age bluegill during the season was estimated at .04 cg/ha with the largest production between individual sampling period .05 cg/ha (Table 9). Comparable values for the 1971-73 seasons was 4.51, .54 and .33 cg/ha, respectively. No production estimate was made in 1974 due to the low catch of postlarval bluegill. The population density for sampling period ranged from 5 per in late May to 235 ± 150 in late July. Population weight was estimated at < .01 cg/ha in each period except for early July through early August when estimated standing crop ranged from .01 to .07 cg/ha.

DISCUSSION OF FINDINGS

The numerical abundance and production of 0-age gizzard shad and bluegill increased slightly from last year, while crappie continued to decrease, reaching the lowest numbers this year since inception of the study. Abundance and production of gizzard shad was the second highest recorded, while bluegill remained far below the elevated levels recorded during the 1971 and 1973 seasons, but significantly greater than the nearly total void found during 1974. Seasonal catch distribution of all three species was similar to that established in early study segments. Gizzard shad commenced reproduction activity on about 5 May and continued for approximately 56 days. Crappie started spawning around 26 April and concluded activity on about 2 June. The catch curve of both fish species showed a unimodal spawning chronology, the same as in other seasons. Bluegill continued to exhibit two separate periods of intense reproduction. The initial activity occurred around 11 May and continued through early June, and the second lasted from early July through mid-July.

Over the first four years of sampling at the midwater stations non-uniform horizontal distribution along with highly significant unequal vertical distribution of gizzard shad caused concern regarding the precision of population density estimates and the need for further partitioning this habitat into smaller sampling sectors. After addition of the 1975 catch data to the previous catch statistics, the analysis of variance indicated smaller sampling fractions were not necessary at this time. But, added catch disparity of 0-age gizzard shad in this habitat during future seasons might cause compulsory division into smaller fraction to achieve uniform distribution. Crappie and bluegill did not show this tendency needing only adjustment of catch means between the different habitat types.

Table 9. Production of 0-age bluegill at Lake Rathbun in 1975.

Sampling interval	Mean weight (g)	Instantaneous growth coefficient	Stock ($\hat{N}$/ha)	95% Confidence interval	Stock biomass (cg/ha)	Mean biomass (cg/ha)	Production (cg/ha)
5/ 5-5/18	[a]		[a]	[a]	[a]		
		[a]				[a]	[a]
5/19-6/ 1	.001		5	[b]	< .01		
		.693				< .01	[c]
6/ 2-6/15	.002		90	± 40	< .01		
		.694				< .01	[c]
6/16-6/29	.004		11	[b]	< .01		
		1.098				.01	.01
6/30-7/13	.012		128	± 55	.02		
		.847				.05	.04
7/14-7/27	.028		235	± 150	.07		
		-.287				.04	-.01
7/28-8/10	.021		30	± 20	.01		
						Total production = .04 cg/ha	

[a]No bluegill captured in net tows.

[b]Confidence interval not computed.

[c]Production not computed.

Crappie abundance and production continued the downward trend apparent over the past three seasons. Catches of young crappie were infrequent during most of this season, particularly in later periods. The decline was attributed mainly to very low spawning success in the Honey Creek embayment. Heretofore, large portions of the young crappie population was produced in this embayment. However, in 1974 and 1975 the number of young captured in the net tows at this station ranked near the lowest. Most crappie reproduction occurred in Buck Creek and along the dam face (Station 2) during 1975. Without high reproduction in Honey Creek it appears doubtful if strong year classes of crappie can develop in Lake Rathbun and the future of this fishery has become wholly dependent upon this embayment for perpetuation.

RECOMMENDATIONS

Systematic sampling of postlarval fish populations should continue for one additional season using identical methods and procedures for collection of fish samples and numerical data analysis.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-3

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

STUDY NO.: 701-5

JOB NO.: 2

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Overall catch means of Cladocera in standardized net plankton tows this season was 16.88 N/ℓ, continuing the upward trend that has occurred since the record low catches in 1973. Seasonal catch distribution of Cladocera was identical with 1972 and 1974 with the modal catch of 84.11 N/ℓ recorded in late May. For the first time the catch of Cladocera was higher at shallow water stations. Highly significant (P < .01) differences in the horizontal and vertical distribution was found for Cladocera. Mean Copepoda catch for the year was 6.28 N/ℓ, which was slightly lower than the previous season. Temporal catch distribution was nearly identical with other seasons. Highest population density of Copepoda occurred in late May and early June. Highly significant (P < .01) differences in the horizontal distribution of Copepoda was found between the midwater and shallow water stations and among the shallow water stations. Copepoda abundance in the net tows was significantly higher along the shoreline of the main pool than in embayments.*

Author: James Mayhew
Fishery Research Supervisor

Date Prepared: 1 March, 1976

JOB 2 OBJECTIVE

To measure the abundance and distribution of zooplankton organisms used for food by 0-age gizzard shad, crappie and bluegill.

INTRODUCTION

Zooplankton populations that are used for food by 0-age fish were sampled for the fifth consecutive season by standardized net plankton tows. The sampling period started on 3 May and continued through 3 October. Taxa enumerated were *Cladocera* and *Copepoda*, including nauplii stages of the latter past Stage IV.

STUDY BACKGROUND

Systematic sampling of zooplankton populations were conducted at Lake Rathbun from 1971-74. The purpose of the study segment was to determine the relationship between the abundance and distribution of taxa utilized for food by 0-age fishes and the abundance, distribution and production of the fishes. Food habit studies previously conducted on postlarval gizzard shad, crappie and bluegill revealed *Cladocera* and *Copepoda* were the major food items. Selectivity of these taxa for food varied during the season with each fish species.

The numerical abundance of *Cladocera* declined during the first three years, followed by an increase in 1974. Overall mean catch of *Cladocera* from 1971-74 was 21.4, 10.5, 6.3 and 13.2 N/ℓ, respectively. *Copepoda* showed a similar decline from 24.2 N/ℓ, 4.1 N/ℓ, 2.8 N/ℓ, and 6.7 N/ℓ for the same years. Highest zooplankton density always occurred early in the season, followed by a systematic decline for the remainder of the samples. All years had the identical unimodal temporal catch curve. After young fish became abundant in shallow water habitat, *Cladocera* and *Copepoda* density decreased markedly. There was direct proportionality between the abundance of 0-age gizzard shad and *Cladocera*, with the high abundance of shad resulting in low density of zooplankton.

METHODS AND PROCEDURES

Collection methods and procedures for enumeration of zooplankton were identical with last year. Analysis of variance in catch means was the same as before except the expected mean square reflected additional sampling.

FINDINGS

ABUNDANCE AND DISTRIBUTION OF CLADOCERA

The overall mean numerical catch of *Cladocera* in net tows during 1975 was 16.88 N/ℓ, the second highest density recorded, and maintained the systematic population increase since the low density in 1973. Individual mean net plankton counts ranged from 0, in many early and late season periods, to 201.84 N/ℓ, at Station 8 in late May (Table 10). Seasonal catch distribution was similar to other years, except the modal catch means in late May (84.11 N/ℓ) and early June (74.97 N/ℓ) were the highest ever recorded (Figure 4). By late July, *Cladocera* population density reverted to more seasonal levels, usually containing less than a single organism per liter. In the last two sampling intervals mean catch increased to 2.36 and 2.32 N/ℓ, respectively.

For the first time since the initial year of zooplankton sampling, 1971, the shallow water stations, particularly Station 8 (Honey Creek embayment) contained the highest density of *Cladocera*. Population density was previously elevated in midwater, presumably from intense gizzard shad predation in shallow water.

The analysis of variance in numerical catch means between sampling stations showed three highly significant ($P < .01$) sources of disparity in the horizontal and vertical distribution of *Cladocera* (Table 11). Differences in mean catch in the horizontal attitude occurred between the shallow and midwater stations. Mean numerical catch for the shallow water stations was 14.3 N/ℓ and 12.5 N/ℓ for the midwater net tows. Highly significant ($P < .01$) horizontal differences was also found between the shoreline catch mean, 17.51 N/ℓ, and the embayment stations, 12.71 N/ℓ. Within the midwater habitat the mean catch was 14.18 N/ℓ in deep tows was significantly higher than the 12.47 N/ℓ in the surface tows.

ABUNDANCE AND DISTRIBUTION OF COPEPODA

Copepoda population density in net plankton tows was about equal to last season, averaging 6.28 N/ℓ compared to 6.65 N/ℓ in 1974. The maximum catch of *Copepoda* in a single sampling period was 49.13 N/ℓ at Station 2B in late May, while most of the tows contain two or fewer organism after the late July interval (Table 12). Temporal catch distribution showed nearly the identical seasonal pattern of previosu years (Figure 5). Mean catch of *Copepoda* in the net plankton tows was 3.67 N/ℓ in early May, increasing to 25.66 and 25.36 N/ℓ in the following two periods, culminating in a systematic decline to low population densities of 1.00 N/ℓ or less from late July through early September. In the last two sampling intervals slight increases to 1.11 and 1.18 N/ℓ were recorded.

Significantly higher ($P < .01$) population densities of *Copepoda* were again found at midwater sampling stations compared with shallow water stations (Table 13). Mean catch in surface tows in midwater was 9.80 N/ℓ compared to 6.96 N/ℓ at the shallow stations. Highly significant ($P < .01$) differences occurred in the catch means between the embayment stations, 5.72 N/ℓ, and along the shoreline in the main pool, 9.44 N/ℓ. No significant difference in the vertical distribution of *Copepoda* among midwater stations was observed.

Table 10. Numerical catch of *Cladocera* in number per liter captured in net plankton tows at Lake Rathbun, 1975.

		Sampling interval										
Station	Depth	Early May	Late May	Early June	Late June	Early July	Late July	Early August	Late August	Early September	Late September	Early October
2	A	2.63	42.49	66.41	26.54	6.62	0.0	0.0	0.0	0.0	1.32	0.0
	B	1.32	26.54	39.83	15.94	5.30	0.0	0.0	1.32	0.0	1.32	5.32
3	A	0.0	83.70	83.67	7.97	3.96	0.0	0.0	0.0	1.32	3.98	1.32
	B	0.0	41.17	94.29	13.27	15.93	2.63	0.0	2.63	0.0	1.32	3.98
4	A	1.32	95.60	51.77	15.94	1.32	0.0	0.0	1.32	2.63	3.98	1.32
	B	0.0	70.40	61.05	13.23	6.64	1.32	0.0	0.0	0.0	2.66	5.32
7	A	0.0	168.71	118.20	21.24	5.30	0.0	0.0	0.0	1.32	3.98	1.32
8	A	2.63	201.84	78.35	5.26	0.0	0.0	1.32	0.0	0.0	1.32	2.32
9	A	2.63	26.57	81.02	5.30	0.0	0.0	0.0	0.0	0.0	1.32	0.0
Mean		1.17	84.11	74.97	13.85	5.01	.44	.15	.59	.59	2.36	2.32
$S_{\bar{x}}$		.43	22.20	8.30	2.52	1.72	.33	.15	.34	.34	.46	.73

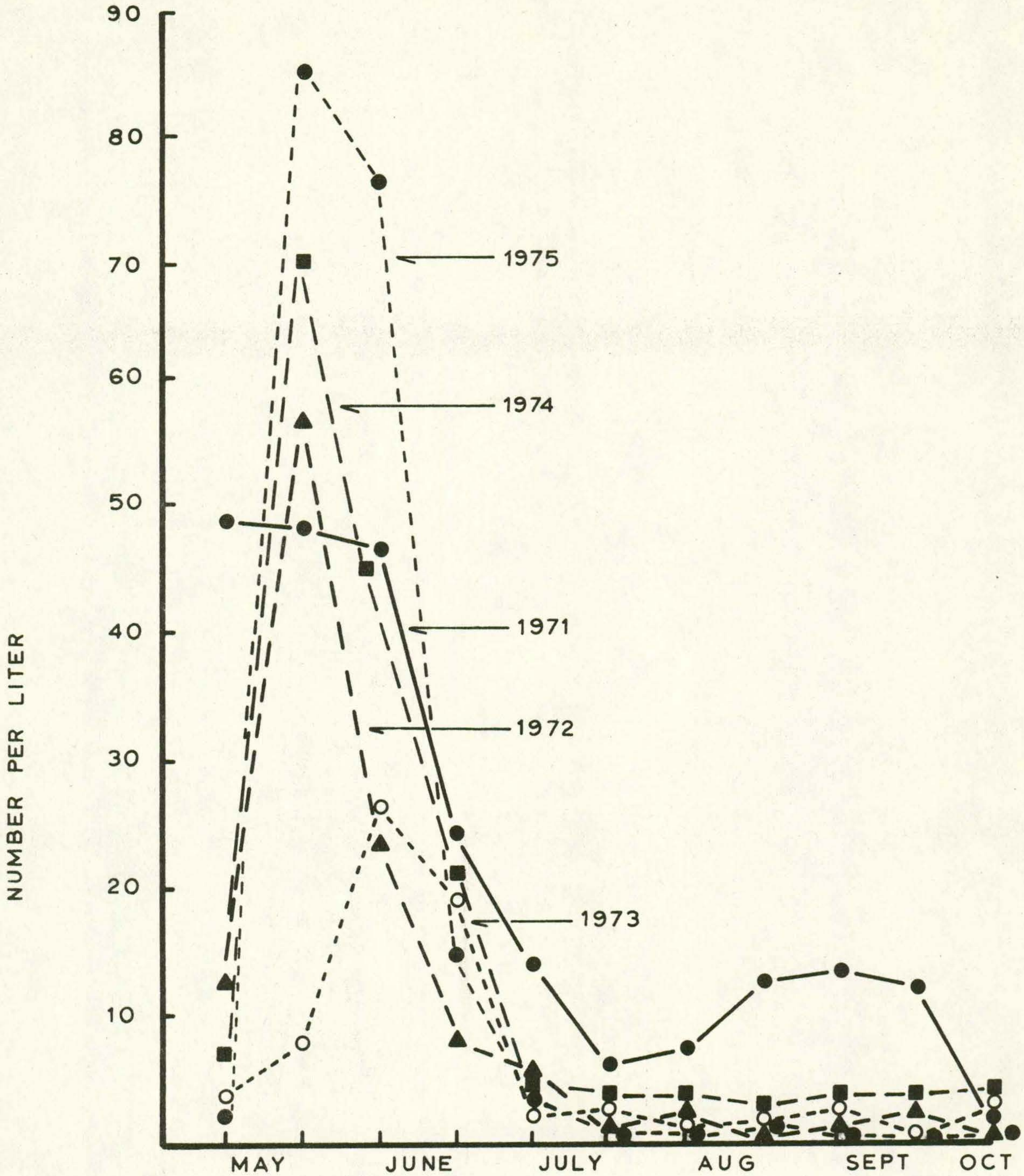

Figure 4. Seasonal catch distribution of *Cladocera* in net plankton tows at Lake Rathbun, 1971-75.

Table 11. Partitioned sums of squares due to sampling station effect in the numerical catch of *Cladocera* in net plankton tows, Lake Rathbun, 1971-75. Catch values were transformed by $\log_{10}X + 1$.

Source of variation	df	SS	MS
Station	8	[4.51]	[.56]**
Midwater vs shallow water	1	1.67	1.67**
Among midwater stations	(5)	(2.25)	(.45)**
Surface vs deep tows	1	1.77	1.77**
Station 2 vs 3, 4	1	.09	.09
Interaction with depth	1	.18	.18
Station 3 vs 4	1	< .01	< .01
Interaction with depth	1	.21	.21
Among shallow stations	(2)	(.58)	(.29)**
Shoreline vs embayments	1	.53	.53**
Honey Creek vs Buck Creek	1	.05	.05
Residual	400	26.78	.07

Table 12. Numerical catch of *Copepoda* in number per liter captured in net plankton tows at Lake Rathbun, 1975.

		Sampling interval										
Station	Depth	Early May	Late May	Early June	Late June	Early July	Late July	Early August	Late August	Early September	Late September	Early October
2	A	7.27	41.16	40.51	9.27	3.98	1.32	0.0	0.0	.66	0.0	0.0
	B	4.62	49.13	30.54	35.77	5.31	0.0	0.0	0.0	1.99	.66	.66
3	A	4.62	28.51	29.22	3.28	3.98	0.0	.66	0.0	.66	0.0	1.99
	B	3.29	37.16	30.51	4.64	3.32	0.0	0.0	0.0	1.99	2.66	1.33
4	A	.66	15.28	39.83	5.28	2.66	0.0	.66	.66	0.0	2.66	1.33
	B	2.65	16.59	19.23	4.62	1.98	.66	0.0	1.33	1.33	1.99	2.66
7	A	3.99	27.87	19.89	3.97	2.64	.66	0.0	0.0	0.0	1.33	0.0
8	A	5.28	8.60	13.25	0.0	.66	0.0	0.0	1.33	.66	.66	1.33
9	A	.66	6.63	5.28	.66	1.98	0.0	0.0	0.0	0.0	0.0	1.33
Mean		3.67	25.66	25.36	7.50	2.95	.29	.15	.37	.81	1.11	1.18
$S_{\bar{x}}$		.76	5.27	4.19	3.87	.49	.17	.10	.21	.28	.39	.37

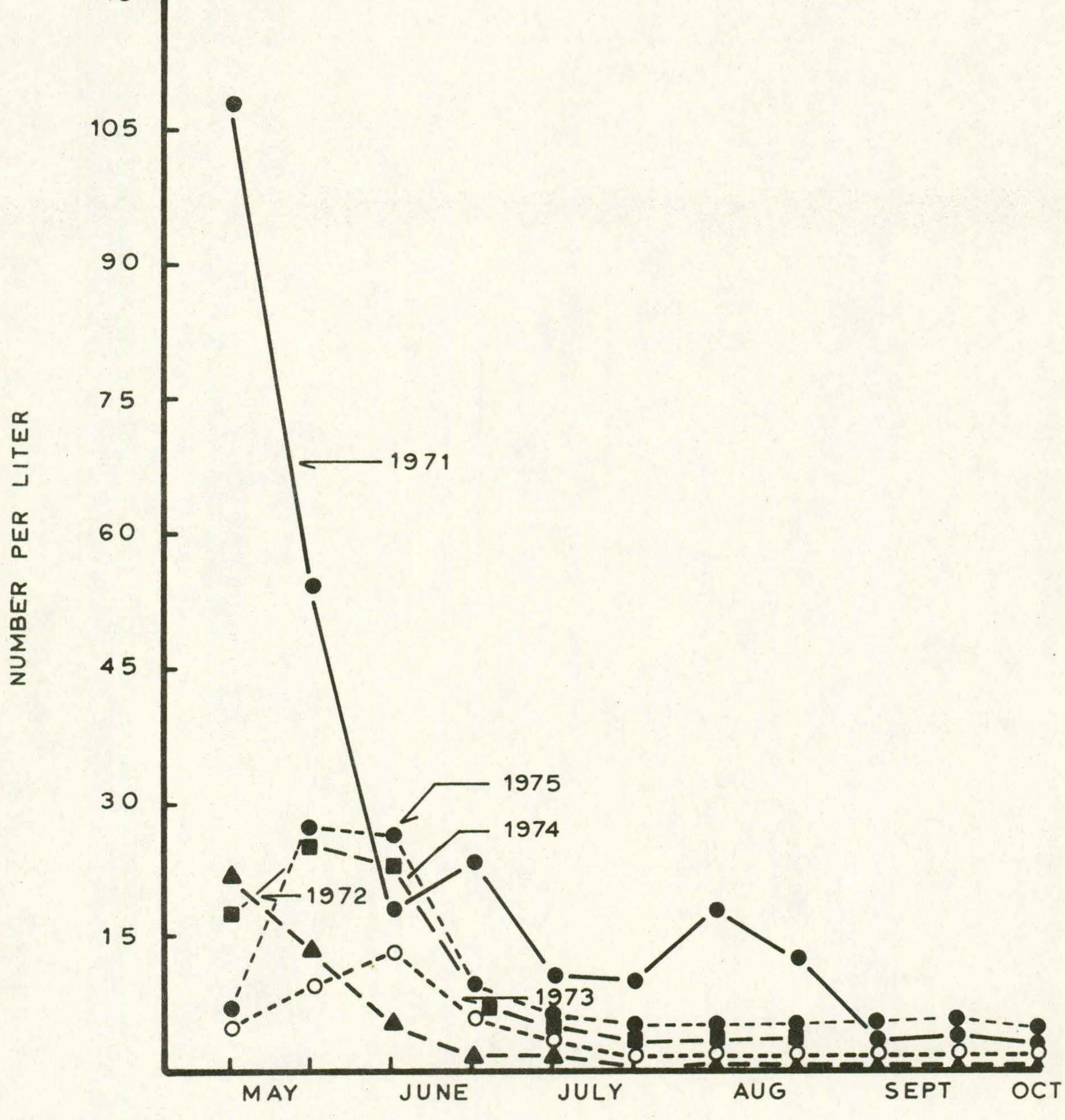

Figure 5. Seasonal catch distribution of *Copepoda* in net plankton tows at Lake Rathbun, 1971-75.

Table 13. Partitioned sums of squares due to sampling station effect in the numerical catch of *Copepoda* in net plankton tows, Lake Rathbun, 1971-75. Catch values were transformed by $\log_{10}X + 1$.

Source of variation	df	SS	MS
Station	8	[3.06]	[.38]**
Midwater vs shallow water	1	2.16	2.16**
Among midwater stations	(5)	(.33)	(.07)
Surface vs deep tows	1	.23	.23
Station 2 vs 3, 4	1	.03	.03
Interaction with depth	1	.01	.01
Station 3 vs 4	1	.01	.01
Interaction with depth	1	.05	.05
Among shallow stations	(2)	(.57)	(.29)**
Shoreline vs embayments	1	.57	.57**
Honey Creek vs Buck Creek	1	< .01	< .01
Residual	400	22.25	.06

**Significant at the 99% level.

DISCUSSION OF FINDINGS

The *Cladocera* population density continued to increase from the lowest recorded abundance in 1973, reaching the second highest population level since inception of the study. On the other hand, *Copepoda* population density decreased slightly from last season, but abundance of this taxa in net plankton tows was relatively high compared with other seasons except 1971. Highest population levels of both zooplankton taxa were found at midwater stations and, in general, associated with the density of predatory fish species. Population levels of gizzard shad had a profound effect upon *Cladocera* abundance. This year the occurrence of larval shad was highest along the shoreline of the main pool (Station 7) and the Buck Creek embayment. *Cladocera* density was lowest at these sampling stations. *Copepoda* were most abundant at the midwater sampling stations, but production of crappie, their major predator, was so low no meaningful relationship could be established, except both the numerical population abundance of postlarval crappie and *Copepoda* were similar to 1974.

Seasonal distribution of the zooplankton density followed the same pattern as in 1972 and 1974 with a single mode that occurred in early June. The modal catch was higher in 1975 than any of the previous seasons. Most of the increase resulted from elevated populations that occurred in the shallow water stations, particularly Honey Creek embayment (Station 8) where 0-age gizzard shad density was the lowest ever recorded. Temporal distribution of the catch of *Copepoda* also followed the distribution last year and was about one sampling period later than in 1972. Greatest population density of *Copepoda* was recorded in late May and early June. After early July, *Copepoda* were unimportant in the catch of zooplankton in the net tows.

RECOMMENDATIONS

Sampling of *Cladocera* and *Copepoda* population density to determine abundance and distribution should continue on the identical schedule using the same analytical procedures.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

NAME: 0-Age Fish Production at Lake Rathbun

PROJECT NO.: F-88-R-3

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

STUDY NO.: 701-5

JOB NO.: 3

Period Covered: 1 July, 1975 through 30 June, 1976

ABSTRACT: *Simple and multiple linear regression models were tested to determine which flood control parameter were significantly linearly related to 0-age fish abundance and zooplankton density. Four of the 15 simple linear relationships were significant at the 95% level or greater. They were: gizzard shad vs flushing rate, Cladocerans vs flushing rate, Cladocerans vs water temperature and flushing rate vs Copepods. Several of the two and three component models that included flushing rate and water temperature as covariates were also significant, but little improvement was gained in predictability of the multiple variable models over the simple linear models. The inter-relationship between some of the parameters and 0-age fish abundance and zooplankton abundance are discussed.*

Author: James Mayhew
Fishery Research Supervisor

Date Prepared: 1 March, 1976

JOB 3 OBJECTIVE

To identify and evaluate the factors that directly and indirectly influence the success or failure of 0-age fish production and use these factors to develop a predictive model of fish production.

INTRODUCTION

Physical characteristics of the reservoir related to flood water management have been measured each season since 1971. The parameters kindred to flood control have two common components, the temporary storage of excess water runoff within the basin, followed later by downstream release in a controlled flow. Temporary impoundment of flood water effects certain physical properties of reservoir water quality, such as temperature and turbidity, which in turn alters the biota. These parameters were measured in consort with storage volume and discharge rate to determine their influence upon 0-age fish and zooplankton populations.

In the first three years, the seasonal physical characteristics of the reservoir, including storage volume, discharge rate, water temperature and turbidity were compiled without endeavors toward identification of the factors that influenced fish production or develop predictive models. Simple linear regression models were tested in 1974 to define significant relationships between the numerical abundance of 0-age gizzard shad, crappie and bluegill; the population density of cladocerans, calanoid copepods and cyclopoid copepods; and the discrete characeteristics of the reservoir due to flood control regimens. Reservoir flushing rate, which measured the hydraulic retention time, was computed as the unique descriptor for the magnitude of flood control operations. Use of this value, expressed as the number of days required to empty the impoundment at the prevailing discharge rate, was advantageous over individual measurements because it combined both components of flood water control into a single parameter.

The main emphasis during this study segment was to test more complex linear regression models. With inclusion of datum from an additional year, two and three variable models were tested, although precision remains speculative due to the large error mean square from the small number of observations.

STUDY BACKGROUND

The extent of flood control operation at Lake Rathbun varied quite widely since initial impoundment to multi-purpose pool elevation in 1971. In that year, water retention for flood control was small, the maximum elevation attained was less than one-half meter above conservation pool. Maximum flood water storage occurred in 1973, when the reservoir remained above conservation pool level for nearly seven consecutive months and the water level reached more than five meters above the lower pool elevation during two separate periods.

Mean annual storage volume of the reservoir during the first four years between 1 April and 31 October was as follows: 1971, 307.4 million m^3; 1972, 319.2 million m^3; 1973, 468.7 million m^3; and 1974, 333.0 million m^3. Concurrently, mean outflow discharge from the reservoir for these years was 5.01 m^3/sec, 8.26 m^3/sec, 19.29 m^3/sec and 10.63 m^3/sec, respectively. Flushing rate was 708, 447, 281 and 362 days for these years. Mean surface water temperature for each of the seasons was 22.9°C in 1971, 22.1°C in 1972, 22.6°C in 1973 and 22.1°C in 1974. Turbidity for the same periods was 1.4 FTU, 5.5 FTU, 16.3 FTU and 13.5 FTU, respectively.

Preliminary simple Pearson product moment correlation analyses for all variable combinations showed significant relationships between four of the 20 pairs tested. These were: 0-age gizzard shad abundance vs flushing rate, 0-age gizzard shad abundance vs water temperature, *Cladocera* density vs flushing rate and *Cladocera* density vs water temperature. Correlation analyses of all independent variables revealed highly significant intraclass correlation between flushing rate and water temperature. However, flushing rate was considered the paramount variable since increasing the hydraulic retention time of water in the reservoir would raise the water temperature, but the compliment effect was physically impossible. None of the flood water control parameters influenced the numerical abundance of crappie and bluegill in meter net tows, nor the density of calanoid or cyclopoid copepods in the net plankton tows. Other factors unrelated to flood water management were presumably more important to the abundance of these species, and these parameters were not measured.

Simple linear regression analyses of 0-age gizzard shad abundance and cladocern density on flushing rate and water temperature showed significant linearity at the .05 level of sampling probability or greater. The effects of flushing rate and water temperature were depensatory to the abundance of 0-age gizzard shad. As flushing rate increased, hydraulic retention time decreased, water temperature was proportionately higher and the catch of 0-age gizzard shad in the meter net tows decreased linearly. The interaction of the parameters with cladoceran density was contrary. With increased reservoir flushing rate and higher water temperature the density of cladocerans in the net plankton tows increased linearly at a significant rate. Two causative interrelationships were postulated; either shad predation was more important to cladoceran abundance than reservoir operation for flood control, or large numbers of cladocerans were flushed from the reservoir during more intensive flood control regimens.

METHODS AND ANALYTICAL PROCEDURES

Water storage volume in the reservoir and outfall discharge data were obtained from the Reservoir Project Office for each day between 1 April and 31 October. Flushing rate was computed for each biweekly sampling period as the quotient of the mean storage volume within the period in millions of m^3 and mean outflow discharge in m^3/sec, and was expressed in days of hydraulic retention time. Minimum discharge in past years was .35 m^3/sec, but in late summer the Rathbun Fish Hatchery, which receives its water supply from the reservoir, began operation requiring an additional .70 m^3/sec outflow. Minimum discharge after early August was 1.25 m^3/sec. Flushing rate for the entire season was derived by averaging the flushing rates for the biweekly sampling periods.

Surface water temperature and turbidity samples were collected at the net plankton tow stations each week. Biweekly mean and seasonal averages were computed for each parameter in the same manner as the foregoing procedure.

A linear regression plane was fitted to the empirical data by an iterative least squares procedure starting with a single variable function for each parameter, then pairing all independent variables in successive two component models, finally combining all parameters into a three variable model. The linear regression model followed the usual function:

$$\hat{Y} = \beta 0 + \beta_n X_n + \cdot \cdot \cdot + \beta_{n-1} X_{n-1} + \varepsilon$$

where

$\hat{Y}$ = the numerical catch of 0-age gizzard shad, *Cladocera* and *Copepoda* in standardized net tows.

X_n = effects of reservoir flushing rate, water temperature, and turbidity,

and

ε = random residuals resulting from fitting the regression plane drawn from a normally distributed population.

The regression coefficients were tested for significant linearity ($\beta_n = 0$) at the 95% level or greater from the least square analysis of variance, where the F-ratio was obtained from the mean squares due to regression and the deviation mean square. Coefficients of determination (R^2) were computed for each regression trial to delineate the proportion of variation in the abundance of 0-age gizzard shad, *Cladocera* and *Copepoda* that was explained by variations in reservoir operation parameters.

FINDINGS

Storage volume of flood water in Lake Rathbun averaged 327.8 million m^3 from 1 April through 31 October, 1975, which was the third lowest storage during this period since impoundment (Table 14). Range in storage volume for other seasons was 307.4 million m^3 in 1971 to 468.7 million m^3 in 1973. Outflow discharge was the second lowest, averaging 7.37 m^3/sec for this period. The lowest mean discharge of 5.37 m^3/sec in 1971, whereas the highest discharge of 19.29 m^3/sec was recorded in 1973. Flushing rate this season varied from 146 days in late June and early July to slightly over 2,000 days during September and October. Mean retention time for the season was 514 days. Previously, average seasonal flushing rate ranged from 225 days in 1973 to 708 days during the period in 1971.

The maximum surface water temperature was 28.7°C at Station 8 in early July, while the minimum of 13.6°C was recorded at the midwater sampling stations in early May. Overall mean surface water temperature was 22.4°C for the season, compared to 21.6°C in 1973 and 22.9°C during 1971. Seasonal turbidity coursed from 4 FTU in early August to 58 FTU in early September. Mean turbidity was 13.8 FTU in contrast to ranges of 1.4 FTU during 1971 and 16.3 FTU in 1973.

Table 14. Mean annual storage volume, outflow discharge, flushing rate, water temperature and turbidity in Lake Rathbun from 1 April through 31 October, 1971-75.

	Storage volume in millions m^3	Outflow discharge in m^3/sec	Flushing rate in days	Water temperature in °C	Turbidity in FTU
1971	307.4	5.01	708	22.9	1.4
1972	319.2	8.26	447	22.1	5.5
1973	468.7	19.29	281	21.6	16.3
1974	333.0	10.63	362	22.1	13.5
1975	327.8	7.37	514	22.4	13.8

Tests for intraclass correlation between all independent variables showed three significant relationships of the 10 paired components (Table 15). Outflow discharge from the reservoir was positively related to storage volume. As storage volume of flood waters increased, as expected, the amount of water discharge through the control structure also increased. However, the retention time of water in the reservoir was not significantly correlated with the volume stored nor the volume discharged. Both parameters were negatively associated with flushing rate. Water temperature was negatively correlated with outflow discharge at the 95% level and positively correlated at the 99% level with flushing rate. The relationships mainly evolved from the fact that as retention time of water increased in the reservoir either from reduced outflow or lowered flushing rate, water temperature became higher.

Table 15. Simple Pearson product moment intraclass correlation between independent variables of the water regimen at Lake Rathbun.

	Storage volume	Outflow discharge	Flushing rate	Water temperature	Turbidity
Storage volume	1.00				
Outflow discharge	.97**	1.00			
Flushing rate	-.72	-.86	1.00		
Temperature	-.80	-.90*	.98**	1.00	
Turbidity	.66	.73	-.81	-.74	1.00

*Significant at the 95% level.

**Significant at the 99% level.

The mean catch of 0-age gizzard shad in 1975 was 295.1 per tow (Table 16). Previously, the seasonal catch means ranged from 131.6 in 1971 to 315.0 per tow in 1973. Crappie abundance this season was the lowest ever recorded, averaging 2.3 per tow. Crappie catches have ranged from 3.2 per tow during 1974 to 33.9 per tow in 1973. Bluegill abundance increased slightly to 1.4 per net tow over the record low catch of .4 per net tow last season. The maximum catch of larval bluegill occurred in 1971 when a mean of 116.6 were caught per net tow. The mean *Cladocera* density this season was 16.8 N/ℓ. Mean seasonal ranges in other years were 6.3 N/ℓ during 1973 to 21.4 N/ℓ in 1971. *Copepoda* density this year was 6.3 N/ℓ, compared to previous seasonal ranges of 2.8 N/ℓ in 1973 and 24.2 N/ℓ in 1971.

Table 16. Numerical catch of 0-age fish and population density of zooplankton in standardized net tows in Lake Rathbun, 1971-75.

	0-age fish			Zooplankton (N/ℓ)	
	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
1975	295.1	2.3	1.4	16.8	6.3

Regression analyses for the one, two and three variable models of 0-age fish abundance on reservoir operation parameters revealed flushing rate was the only covariate factor that was linearly related to gizzard shad density at a significant level (Table 17). With increased flushing rate during intensified flood control regimens and the attending decreased hydraulic retention time of water storage, the occurrence of larval shad in net tows decreased in a linear fashion. About 77% of the variability in 0-age gizzard shad abundance in net tows was attributable to variations in reservoir flushing rate with the simple regression model. Slight improvement in model predictability was achieved by including the other reservoir operation parameters, all three variables increased the R^2 value to 83%, but the two and three variable models were not significantly linear at the 95% level of probability. Reservoir operations for flood control and related factors had no significant influence on production of 0-age crappie and bluegill. Presumably other factors that were not measured were more important, although there was some positive association between the accelerated flood control and higher density of larval crappie and bluegill. But, the relationship was not a linear function.

Table 17. Simple and multiple regression coefficients, standard error and coefficients of determination for linear regression models using the numerical catch of 0-age gizzard shad as the dependent variable and factors related to reservoir operation as the independent variable.

Number of independent variables	Variables	b values	Standard error	R^2
1	Flushing rate	-.40*	.12	.77
1	Water temperature	-132.44	45.89	.74
1	Turbidity	9.74	3.65	.70
2	Flushing rate	-.40	.68	.77
	Water temperature	.61	231.83	
2	Flushing rate	-.26	.23	.82
	Turbidity	4.26	5.92	
2	Water temperature	-80.86	67.77	.82
	Turbidity	5.23	5.10	
3	Flushing rate	-.07	1.03	.83
	Water temperature	-60.67	307.27	
	Turbidity	4.88	8.80	

*Significant at the 95% level.

Neither water temperature nor turbidity in single or multiple variable models influenced the numerical abundance of 0-age fish.

Flushing rate and water temperature exerted a profound positive influence on the density of *Cladocera* in net plankton tows (Table 18). The cause and effect relationship between cladoceran density and reservoir operations was as follows: as flushing rate of the reservoir increased during flood control regimens, water retention time decreased, water temperatures cooled, and the *Cladocera* population density became significantly greater. Simple linear regression models of reservoir flushing rate on *Cladocera* density were significant at the 95% level and water temperature on *Cladocera* density was significant at the 99% level. Variability in flushing rate explained about 86% of the variation in cladoceran density while water temperature variability explained 96% of the variation. The simple regression model using turbidity as the independent variable was not significant.

Multiple linear regression models containing flushing rate and water temperature were significant at the 95% level or greater, except in the model of flushing rate on turbidity, which was not significant ($P > .05$). The

Table 18. Simple and multiple linear regression coefficients, standard error and coefficients of determination for regression models using the numerical density of *Cladocera* in standardized net plankton tows as the dependent variable and factors related to reservoir operation as independe variables.

Number of independent variables	Variables	b values	Standard error	R^2
1	Flushing rate	.033*	.008	.82
1	Water temperature	11.92**	1.36	.96
1	Turbidity	-.55	.42	.36
2	Flushing rate	-.022**	.015	.98
	Water temperature	19.17	5.28	
2	Flushing rate	-.049	.018	.87
	Turbidity	.36	.46	
2	Water temperature	14.42**	.71	.99
	Turbidity	.25	.05	
3	Flushing rate	-.007*	.008	.99
	Water temperature	16.42	2.43	
	Turbidity	.22	.07	

*Significant at the 95% level.

**Significant at the 99% level.

significant multiple linear regression models all yielded R^2 values of 98% or greater, but little improvement in predictability was gained by including turbidity in the three variable model over the two component model using flushing rate and water temperature. In fact, precision of the simple linear regression model using water temperature as the independent variable was nearly equal to the multiple variable models.

Copepoda density in the net plankton tows was positively related to flushing rate (Table 19). As flood control intensified, flushing rate increased, hydraulic retention time decreased and the catch of copepods increased at a significant linear rate. The simple regression model using *Copepoda* density and flushing rate as covariates was significant at the 95% level and variations in the latter parameter explained about 78% of the variability. Neither water temperature nor turbidity influenced *Copepoda* abundance in the simple models, and none of the two variable models were significant.

Table 19. Simple and multiple linear regression coefficients, standard error and coefficients of determination for regression models using the numerical density of *Copepoda* in standardized net plankton tows as the dependent variable and factors related to reservoir operation as independent variables.

Number of independent variables	Variables	b values	Standard error	R^2
1	Flushing rate	.047*	.015	.78
1	Water temperature	16.03	5.16	.76
1	Turbidity	-1.03	.53	.56
2	Flushing rate	.021	.055	.90
	Water temperature	10.67	18.80	
2	Flushing rate	.043	.030	.78
	Turbidity	-.14	.78	
2	Water temperature	12.97	8.95	.78
	Turbidity	-.31	.67	
3	Flushing rate	.092	.012	.99
	Water temperature	.78	3.59	
	Turbidity	1.25	.12	

*Significant at the 95% level.

Linearity of the three variable model was significant at the 95% level. About 99% of the variation in the density of copepods in the net plankton tows was attributable to variability of all three flood operation parameters. Improvement in the predictability of three variable model was not significant over the simple regression model using flushing rate as the independent variable, because of the low association of water temperature and turbidity to *Copepoda* density.

DISCUSSION OF FINDINGS

Reservoir flushing rate was the most significant factor to influence the abundance of 0-age gizzard shad and *Copepoda*, while water temperature and flushing rate were paramount to *Cladocera* density. However, these variables were so closely intraclass correlated by measuring one, the effect of the other was also apparent. Flushing rate, which measured the retention time of water in the reservoir, seemed the most important parameter since water temperature was dependent on flushing rate, but flushing rate was independent of water temperature.

Storage volume of flood water in the reservoir was not directly interrelated to fish production in any of the linear regression models, but indirectly it appeared closely associated to 0-age fish abundance. The strongest year classes of gizzard shad, crappie and bluegill occurred in 1973 concommitantly with the most intense flood control regimen, except for the numerous bluegill young captured in the first year following impoundment of the reservoir to conservation pool elevation. When the reservoir is filled to 3 m or above the multiple purpose pool, vast lowlands in the upper basin and embayments are flooded creating profuse habitat that promotes spawning success and prolarvae survival. In part, this process is undoubtedly measured through flushing rate, because storage volume is an integral component of hydraulic retention time. But, the storage of water by itself seems to have little effect on fish production.

The exact nature of the relationship between 0-age fish and zooplankton density remains unclear at this time. Spatial distribution of both was quite similar with highest populations occurring initially near shore and embayment stations followed by latent demersal abundance in midwater. Temporal distribution was also similar with the highest population density of both taxa appearing in early summer. Later in the season zooplankton population density at embayment station became very sparse, presumably from predation. In 1974, *Cladocera* populations were nearly non-existent after midsummer at embayment stations.

There was a significant inverse relationship between cladocerans, copepods and hydraulic retention time, which might indicate vast quantities of zooplankton were also being flushed from the reservoir during peak outflow discharge. This factor combined with predation by 0-age fish in the embayment and near shore could significantly reduce zooplankton populations. Flushing of large amounts of plankton is quite common in the large mainstream reservoirs on the Missouri River during periods of high storage volume and accelerated outflow discharge.

RECOMMENDATIONS

Sampling of 0-age fish and zooplankton population should continue one additional season to enlarge the sample size to refine the multiple variable regression models.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-3

STUDY NO.: 702-4

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, 1975 through 30 June, 1976

ABSTRACT: *Fish populations were sampled monthly by pound net, experimental gill net and seine net to determine relative abundance, species composition, reproductive success, age structure and vital statistics of important species. At Lake Red Rock 8,565 fish weighing 2,827 kg were caught by pound and experimental gill net. River carpsucker dominated the numerical catch by comprising 26% of the total followed by carp, 22%, crappie, 20% and bullhead, 11%. A major portion of the biomass consisted of river carpsucker, 33%, followed by carp, 21%, crappie, 18%, and northern pike and bigmouth buffalo, both at 6%. Stocked fish including largemouth bass, walleye and northern pike decreased in relative abundance from previous years and contributed less than 5% of the total numerical catch. A commercial fishery at Lake Red Rock was responsible for the harvest of over 469,000 kg of fish and reduced mean weights of bigmouth buffalo and carp. Seine hauls captured 1,633 young of 16 species and 0-age and adult Cyprinids. Native 0-age largemouth bass, walleye and northern pike were captured but supplemental stocking of these species seems necessary to maintain the populations. At Lake Rathbun test netting captured 6,390 fish weighing 1,808 kg. The total numerical catch was dominated by crappie, 37%, followed by carp, 27%; white bass, 10%; and bullhead, 10%. Carp contributed over 45% of the weight and crappie 25%. Stockings of fish at Lake Rathbun made an initial impact early in the reservoir's history but have not made a positive change since. White bass has increased substantially in relative abundance but is the only exception. Seine hauls captured 3,115 0-age fish of 11 species and young and adult Cyprinids. Gizzard shad contributed 85% of the seine catch. Vital statistics of important species at each lake are presented.*

Author: Vaughn L. Paragamian
Fishery Research Biologist

Date Prepared: 1 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

STUDY OBJECTIVE

To determine the effects of reservoir operations for flood control and stocking large numbers of predatory fish species on abundance, species composition, age structure, and growth of important fish populations in Lakes Red Rock and Rathbun.

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

Southern Iowa's future sport and commercial fisheries lies in large onstream impoundments. Several of these reservoirs are already a reality, however, they were constructed primarily for flood water storage and water conservation.

Initially sport fish populations were developed and maintained by stockings of hatchery reared fish. Water management of these large bodies of water may have a colossal impact on the sport and non-sport fish populations. In order to develop a fish management program, additional information is needed on the changes that occurred in the fish populations after impoundment, the impact of floodwater management, and the importance of the fish stockings.

STUDY BACKGROUND

Lake Red Rock, located on the Des Moines River in Marion County, was impounded in 1969. Northern pike, walleye, and largemouth bass were planted from 1969 through 1973, at varying rates and sizes.

Non-sport fish dominated the net catch during the six years following impoundment. The numerical catch consisted primarily of carp, river carpsucker and bigmouth buffalo, nearly 83%, during 1970 and 1971. From 1972 through 1974 the catch of carp and river carpsucker ranged from 25 to 31% and 17 to 19%, respectively while bigmouth buffalo ranged from 2 to 8%. Crappie was the most abundant sport fish contributing 13 to 21% of the total numerical catch. Stocked sport fish showed a dramatic increase in relative abundance after plantings. From the 1972 season through the 1974 season largemouth bass increased from < 1 FND to 7 FND, northern pike increased by the same values and walleye expanded from < 1 FND to 8 FND. A commercial fishery was developed at Lake Red Rock during October of 1973. From that period through December, 1974 over 444,665 kg of carp, river carpsucker and bigmouth buffalo were harvested. It seems likely the commercial fishery will have an important impact on these populations in future years.

The Chariton River was impounded in 1969 to create Lake Rathbun. Stocked sport fish include walleye, largemouth bass, muskellunge, channel catfish, striped bass and white bass. Sport fish consistently comprised 71 to 73% of the net catch during 1972 through 1974. White crappie is the most important species followed by bullhead, walleye and largemouth bass. Carp comprised 15 to 20% of the numerical catch and 22 to 38% of the biomass for the same years.

METHODS AND PROCEDURES

Sampling procedures were the same as described in prior reports.

FINDINGS

LAKE RED ROCK

Species Composition of Net Catches During the 1975 sampling period pound and experimental gill nets captured 8,565 fish weighing 3,904 kg (Table 1). River carpsucker dominated the numerical catch, by providing 26% as well as the total weight, 33%. Carp was second in both categories, 22% by number and 21% by weight followed by crappie, 20% and 18%, respectively, while bullhead comprised 11% by number and 5% by weight. Other species frequently caught included gizzard shad and bigmouth buffalo. Sport fish caught, other than crappie, included channel catfish, walleye, largemouth bass, and northern pike; consolidated they comprised 6% of the numerical catch.

Catch success (FND) decreased for most species and all non-sport fish from the previous year (Table 2). Declines were recorded for carp (41 FND), crappie (35 FND), bigmouth buffalo (7 FND), river carpsucker (44 FND), channel catfish (4 FND), walleye (6 FND), northern pike (3 FND) and largemouth bass (3 FND). Only channel catfish (4 FND) and bullhead (33 FND) increased in relative abundance.

Seine hauls captured 1,633 fish including 16 different species of young fish and various species of adult and young Cyprinids (other than carp and goldfish) (Table 3). 0-age gizzard shad cominated the seine catch, 49%, while young crappie were second, 12%, followed by white bass, 9%, and Cyprinids, 9%.

AGE STRUCTURE AND GROWTH

Largemouth Bass An April and May length-frequency distribution was compiled for 16 bass (Table 4). Length distribution ranged from 276 mm to 441 mm TL. Two major modes were recorded within the distribution at 306-321 mm and 366-381 mm. Age class representation was 37% age III and 63% age IV.

Table 1. Combined catch composition of trap and experimental gill nets, Lake Red Rock, April through October, 1975.

	Number	Percent number	Weight (kg)	Percent weight	Mean weight (kg)
Carp	1,881	21.9	597.3	21.1	.32
Crappie[a]	1,730	20.2	520.1	18.4	.30
B bullhead	984	11.4	133.1	4.7	.13
B buffalo	334	3.9	166.7	5.9	.50
R carpsucker	2,222	25.9	926.1	32.7	.42
C catfish	85	.9	27.8	.9	.33
G shad	365	4.2	23.2	.8	.06
F drum	125	1.4	21.7	.7	.17
Walleye	120	1.4	55.7	1.9	.46
Bluegill	70	.8	11.6	.4	.16
G sunfish	10	.1	.7	< .1	.08
N pike	117	1.3	181.9	6.4	1.56
Lm bass	128	1.4	74.4	2.6	.58
F catfish	2	< .1	1.5	< .1	.76
N redhorse	2	< .1	1.3	< .1	.65
W bass	386	3.3	82.7	2.9	.21
Y bass	4	< .1	.6	< .1	
Total	8,565		2,827.1		

[a]Black and white crappie.

Table 2. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Red Rock, 1972, 1973, 1974 and 1975.

Species	Pound net (FND)				Experimental gill net (FND)				Combined catch (FND)			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Carp	39.7	34.1	54.4	32.8	13.5	4.9	7.3	7.8	53.2	39.0	63.7	40.6
B & W crappie[a]	15.6	13.8	47.9	31.2	8.7	5.6	4.9	3.4	24.3	19.4	52.8	34.5
B bullhead	22.3	21.0	17.9	13.0	15.4	14.3	10.1	20.0	37.7	35.3	27.9	33.0
B buffalo	11.3	2.7	8.8	6.0	.7	.4	.9	.7	12.0	3.0	9.7	6.7
R carpsucker	22.9	18.3	40.2	40.2	5.3	4.5	9.1	3.5	29.1	22.8	49.2	43.7
C catfish	1.4	.9	1.1	.6	3.4	1.1	2.1	3.7	4.8	2.0	3.2	4.3
G shad	3.1	.2	12.7	2.3	18.7	2.0	22.6	17.2	21.8	2.1	35.3	19.5
F drum	3.3	2.5	1.3	1.5	9.2	6.2	2.0	3.3	12.4	8.7	3.3	4.7
Walleye	.2	.1	1.3	1.0	.2	6.2	6.4	4.8	.4	6.3	7.7	5.8
Bluegill	1.1	1.3	3.1	1.3	< .1	.2	.1	0	1.1	1.4	3.2	1.3
G sunfish	< .1	.9	.4	< .1	.5	1.9	.3	.4	.5	2.7	.7	.5
N pike	.2	.6	2.4	2.0	.3	3.9	4.7	.8	.4	4.5	7.1	2.7
Lm bass	.4	1.4	3.5	2.2	.6	2.3	3.0	.5	.9	3.7	6.5	2.7
Goldfish	.1	.6	1.5	0	< .1	.4	0	0	.1	1.0	1.5	0
F catfish	.1	< .1	.1	< .1	.1	.1	.1	0	.1	.1	.1	< .1
N redhorse	.2	< .1	.2	< .1	.3	.1	.1	0	.5	.1	.2	< .1
W & Y bass[b]	.4	1.4	8.0	5.9	.2	1.1	19.4	5.0	.6	2.5	27.4	10.9
S gar	< .1	.2	.1	0	.7	.2	.1	0	.7	.4	.2	0
Notropis sp.	< .1	< .1	0	0	.2	.4	.2	0	.2	.4	.2	0
R sunfish	< .1	.1	< .1	0	< .1	< .1	0	0	< .1	.1	< .1	0
W sucker	< .1	< .1	0	0	< .1	.1	0	0	< .1	.1	0	0
Y perch	< .1	< .1	< .1	0	< .1	.1	0	0	< .1	.1	< .1	0
Total	122.3	100.1	205.1	140.0	78.7	55.6	93.4	71.1	201.0	155.6	298.5	211.1

[a]Primarily black crappie.

[b]Primarily white bass.

Table 3. Species composition of 0-age fish by sampling station at Lake Red Rock, 1975.

	Station													
	I		II		III		IV		V		VI		Total	
Species	N	%	N	%	N	%	N	%	N	%	N	%	N	%
G shad	295	77.8	72	29.9	78	45.9	35	41.2	162	46.7	163	39.8	805	49.3
Cyprinids[a]	72	19.0	40	16.6	18	10.6	15	17.6	6	1.7	2	.5	153	9.4
W bass	5	1.3	23	9.5	7	4.1	3	3.5	7	2.0	28	6.8	73	4.5
Lm bass	2	.5			2	1.2	1	1.2	7	2.0	7	1.7	19	1.2
R carpsucker	4	1.1	10	4.1	1	.6	21	24.7	29	8.4	66	16.1	131	8.0
F drum	1	.3	2	.8	29	17.1	8	9.4	85	24.5	28	6.8	153	9.4
Walleye			3	1.2	2	1.2			5	1.4	3	.7	13	.8
Crappie[b]			71	29.5	13	7.6	1	1.2	5	1.4	108	26.3	198	12.1
C catfish			9	3.7	12	7.1			4	1.1	1	.2	26	1.6
Bluegill			11	4.6	6	3.5			1	.3			18	1.1
Carp					1	.6			27	7.8	1	.2	29	1.8
G sunfish					1	.6					1	.2	2	.1
Sm bass							1	1.2					1	.1
B buffalo									7	2.0	2	.5	9	.5
W sucker									1	.3			1	.1
B bullhead									1	.3			1	.1
F catfish									1	.3			1	.1
Total	379		241		170		85		348		410		1,633	

[a]All Cyprinids other than carp and goldfish.

[b]Included black and white crappie.

Table 4. Length-frequency distribution of largemouth bass at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
276-291	1	6	
291-306	1	6	
306-321	3	19	III
321-336	1	6	
336-351	1	6	
351-366	1	6	
366-381	6	38	IV
411-426	1	6	
426-441	1	6	

Lengths, weights and scales were collected from 41 bass during 1975. They ranged from 182 to 424 mm TL and weights of 182 to 1,250 g. The length-weight relationship was described by the equation $\log_{10}W = -4.76 + 2.98 \log_{10}TL$.

K-factors ranged from .95 to 2.11 with a mean of 1.54.

Body-scale relationship was described by the equation

$$TL = -8.59 + 2.29\ ScR$$

From this relationship mean total lengths at annulus were 111, 244, 329, and 389 mm for ages I through IV (Table 5).

Table 5. Average estimated total length (mm) at each annulus for largemouth bass at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV
1974	53			
1973	118	231		
1972	101	233	319	
1971	169	268	339	389
Unweighted mean	111 (39)	244 (38)	329 (18)	389 (3)

Northern Pike A length-frequency distribution of 17 pike was tabulated for catches of April and May (Table 6). Northern pike ranged from 306 to 671 mm TL with four modes apparent. These modes were represented as ages I through IV, 30, 30, 24 and 18%, respectively.

Table 6. Length-frequency distribution of northern pike at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
306-321	3	18	I
321-336	2	12	
516-531	1	6	
546-561	3	18	II
561-576	1	6	
576-591	1	6	
606-621	2	12	III
621-636	1	6	
641-656	0	0	
656-671	3	18	IV

Body measurements and scales were taken of 49 pike in 1975. These fish ranged from 357 to 760 mm TL and weights of 241 to 2,810 g. The length-weight relationship was described by the equation $\log_{10}W = -6.14 + 3.33 \log_{10}TL$.

K-factors during 1975 ranged from .52 to .75 while the mean was .61.

Body-scale relationship was described by the equation

$$TL = -118.7 + 6.9\ ScR + (-0.01)\ ScR^2$$

From this relationship mean total lengths at annulus were 334, 490, 589 and 692 mm for ages I through IV (Table 7).

Walleye A length-frequency distribution was tabulated for 19 walleye captured in April and May, 1975 (Table 8). Lengths of these walleye ranged from 186 to 426 mm TL and was comprised of one major mode, 336 to 396 mm TL. This mode was comprised primarily of age III fish, 75% with the remainder represented by ages I, II, and IV.

Lengths, weights and scales were collected from 51 walleye in 1975. They ranged in length from 189 to 513 mm TL and weights of 60 to 1,460 g. Length-weight relationship was described by the equation $\log_{10}W = -5.91 + 3.35 \log_{10}TL$.

K-factors during 1975 ranged from .78 to 1.08 while the mean was .97.

Table 7. Average estimated total length (mm) at each annulus for northern pike at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV
1974	345			
1973	385	568		
1972	330	478	596	
1971	274	425	582	692
Unweighted mean	334 (47)	490 (43)	589 (18)	692 (3)

Table 8. Length-frequency distribution of walleye at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
186-201	1	5	I
216-231	1	5	
306-321	1	5	II
336-351	4	21	
366-381	6	32	III
381-396	4	21	
396-411	1	5	
411-426	1	5	IV

Body-scale relationship was described by the equation

$$TL = 22.19 + 2.80\ ScR$$

From this relationship average back-calculations at each annulus were 168, 297, 382, 440 and 496 mm for ages I through IV (Table 9).

Table 9. Average estimated total length (mm) at each annulus for walleye at Lake Red Rock, 1975.

Year class	Age I	II	III	IV	V
1974	92				
1973	154	266			
1972	187	311	373		
1971	186	285	372	420	
1970	224	326	401	460	496
Unweighted mean	168	297	382	440	496
	(49)	(48)	(46)	(14)	(2)

Black Crappie A length-frequency distribution was tabulated of 246 black and white crappie captured during April and May of 1975 (Table 10). Five modes were found within the distribution of 141-381 mm TL with age class representation as 6% age II, 45% age III, 25% age IV, with the remainder age V and older.

Table 10. Length-frequency distribution of crappie at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
141-156	1	< 1	
186-201	7	3	
201-216	5	2	II
216-231	25	10	
231-246	22	9	
246-261	53	21	III
261-276	22	9	
276-291	44	17	IV
291-306	20	8	
306-321	33	13	V
321-336	12	5	
336-351	9	4	
351-366	2	1	
366-381	1	< 1	

Lengths, weights and scales were collected from 50 black crappie during the 1975 seasons. They ranged in lengths of 134 to 294 mm TL and weights of 29 to 460 g. Length-weight relationship was described by the equation $\log_{10}W = -5.80 + 3.41 \log_{10}TL$.

K-factors during 1975 ranged from 1.21 to 1.78 with a mean of 1.51.

The body-scale relationship was described by the linear equation

$$TL = 22.70 + 1.73\ ScR$$

From this relationship mean total lengths at each annulus were 83, 153, 205 and 255 mm for ages I through IV (Table 11).

Table 11. Average estimated total length (mm) at each annulus for black crappie at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV
1974	49			
1973	87	145		
1972	90	154	206	
1971	104	160	205	255
Unweighted mean	83	153	205	255
	(45)	(44)	(37)	(2)

Channel catfish A length-frequency distribution of 11 channel catfish ranging from 126-411 mm TL was compiled for catches of April and May, 1975 (Table 12). Definitive modes did not appear within this distribution but ages I through VI are probably represented by at least one fish.

Body measurements and pectoral spines were collected from 45 channel catfish during 1975. These fish ranged from lengths of 171 to 545 mm TL and weights of 31 to 1,320 g. Length-weight relationship was described by the equation $\log_{10}W = -5.94 + 3.31 \log_{10}TL$.

K-factors in 1975 ranged from .59 to .86 while the mean was .73.

The body-pectoral spine relationship was described by the direct proportion TL = 4.76 SpR. From this relationship back-calculations at annulus were 86, 161, 235, 312, 375, 451, and 504 mm TL for ages I through VII (Table 13).

Table 12. Length-frequency distribution of channel catfish at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence
126-141	1	9
216-231	1	9
246-261	1	9
261-276	2	18
276-291	2	18
291-306	1	9
306-321	1	9
351-366	1	9
396-411	1	9

Table 13. Average estimated total length (mm) at each annulus for channel catfish at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age						
	I	II	III	IV	V	VI	VII
1973	114	206					
1972	110	208	278				
1971	77	160	263	325			
1970	65	131	203	307	369		
1969	82	132	213	287	362	436	
1968	67	128	219	328	395	466	504
Unweighted mean	86	161	235	312	375	451	504
	(45)	(45)	(35)	(25)	(12)	(4)	(1)

Carp A length-frequency distribution of 247 carp captured during April and May of 1975 was compiled (Table 14). Carp ranged from 171 to 486 mm TL with seven modes apparent. Age class representation was 14% age II, 37% age III, 16% age IV, 18% age V, 8% age VI, and 7% age VII.

Table 14. Length-frequency distribution of carp at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
171-186	1	< 1	
186-201	7	3	
201-216	17	7	II
216-231	10	4	
231-246	6	2	
246-261	23	9	
261-276	24	9	
276-291	42	16	III
291-306	11	4	
306-321	18	7	IV
321-336	5	2	
336-351	26	10	
351-366	11	4	
366-381	19	7	V
381-396	8	3	
396-411	16	6	VI
411-426	5	2	
426-441	9	4	VII
441-456	4	2	
456-471	3	1	
471-486	1	< 1	

Weights, lengths and scales were sampled from 51 carp during the 1975 season. These fish ranged from 216 to 548 mm TL and weights of 129 to 1,900 g. Length-weight relationship was described by the equation $\log_{10}W = -3.51 + 2.42 \log_{10}TL$.

K-factors spanned from 1.08 to 1.31 with a mean of 1.16.

Body-scale relationship was described by the relationship

$$TL = 12.50 + 1.56\ ScR$$

From this relationship back-calculations at annulus were 100, 191, 268, 343, 383, 416, and 433 mm TL for ages I through VII (Table 15).

Bigmouth Buffalo Formation of a spring length-frequency distribution was the result of capturing 19 bigmouth buffalo during April and May, 1975 (Table 16). These fish ranged from 186 to 471 mm TL with two modes present. Age structure was comprised of 63% age II and 37% age IV and V.

Table 15. Average estimated total length (mm) at each annulus for carp at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1973	119	212					
1972	92	181	252				
1971	129	217	286	362			
1970	104	205	324	395	429		
1969	74	185	274	334	394	442	
1968	83	148	205	280	326	389	433
Unweighted mean	100	191	268	343	383	416	433
	(45)	(45)	(32)	(13)	(8)	(6)	(2)

Table 16. Length-frequency distribution of bigmouth buffalo at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
186-201	1	5	
201-216	3	16	
216-231	5	26	II
246-261	3	16	
366-381	1	5	
381-396	1	5	IV
426-441	3	16	V
441-456	1	5	
456-471	1	5	

Body measurements and scales were collected from 51 bigmouth buffalo within the 1975 sampling period. These fish ranged from 247 to 500 mm TL and weights of 220 to 2,700 g. Length-weight relationship was described by the relationship $\log_{10}W = -5.14 + 3.13 \log_{10}TL$.

K-factors ranged from 1.44 to 1.76 with an average of 1.53.

Body-scale relationship was described by the equation

$$TL = 42.82 + 1.73\ ScR$$

From this relationship back-calculations at annulus were 156, 255, 336, 405, 442, and 505 mm TL (Table 17).

Table 17. Average estimated total length (mm) at each annulus for bigmouth buffalo at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI
1973	146	231				
1972	183	255	331			
1971	184	273	352	424		
1970	127	205	278	354	416	
1969	137	311	385	437	467	505
Unweighted mean	156	255	336	405	442	505
	(51)	(51)	(21)	(14)	(8)	(2)

River Carpsucker A length-frequency distribution of 103 river carpsucker was compiled during the April and May sampling periods of 1975 (Table 18). These fish ranged from 186 to 426 mm while ages represented by this distribution are 4% age II, 52% age III, 38% age IV, and 7% age V.

Body measurements of 48 river carpsucker were recorded for age and growth analysis. Fish from this sample ranged from 160 to 382 mm TL and weights of 43 to 690 g. Length-weight relationship was described by the equation $\log_{10}W = -5.05 + 3.05 \log_{10}TL$.

K-factors ranged from 1.06 to 1.39 while the mean was 1.19.

Body-scale relationship was described by the function

$$TL = 27.82 + 1.76\ ScR$$

Mean back-calculations of total lengths were 100, 203, 285, 332, and 363 mm TL for ages I through V (Table 19).

Table 18. Length-frequency distribution of river carpsucker at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
186-201	1	1	
201-216	1	1	II
216-231	2	2	
231-246	0	0	
246-261	0	0	
261-276	6	6	
276-291	13	13	
291-306	10	10	
306-321	20	19	III
321-336	8	8	
336-351	20	19	IV
351-366	10	10	
366-381	5	5	
381-396	1	1	V
396-411	4	4	
411-426	2	2	

Table 19. Average estimated total length (mm) at each annulus for river carpsucker at Lake Red Rock, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V
1974	100				
1973	101	198			
1972	115	206	284		
1971	97	207	282	327	
1970	86	200	290	336	363
Unweighted mean	100	203	285	332	363
	(48)	(47)	(38)	(14)	(2)

White bass Vital statistics were not collected for white bass, but a length-frequency distribution of 42 fish was recorded during the spring of 1975 (Table 20). These fish ranged from 156 to 216 mm TL and were represented as one primary mode within 186 to 201 mm. This mode was dominated by a strong 1974 year class, age I.

Table 20. Length-frequency distribution of white bass at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
156-171	6	15	
171-186	12	29	
186-201	22	54	I
201-216	2	5	

Bullhead A length-frequency distribution of bullhead was recorded during the April and May sampling periods (Table 21). Four dominant modes are present: 126 to 141, 156 to 186, 201 to 246, and 246 to 291 mm. Spines were not taken for age analysis but from data in Carlander (1969) ages assigned were 3% age I, 39% age II, 22% age III, 24% age IV, and 12% age V and older.

Table 21. Length-frequency distribution of bullhead at Lake Red Rock, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
81- 96	1	< 1	I
96-111	5	2	
111-126	3	1	II
126-141	69	28	
141-156	15	6	III
156-171	28	11	
171-186	22	9	
186-201	32	13	
201-216	9	4	
216-231	30	12	IV
231-246	10	4	
246-261	15	6	V
261-276	2	1	
276-291	4	2	
291-306	1	< 1	
306-321	2	1	

LAKE RATHBUN

Species Composition of Net Catches Test netting by pound and experimental gill nets in 1975 captured 6,390 fish weighing 1,808 kg at Lake Rathbun (Table 22). Crappie dominated the numerical catch comprising 37% while they ranked second by weight at 25%. Carp comprised the greatest proportion of biomass, 45%, and were second in importance by number, 27%. White bass was third in importance by number and weight, 10% and 6%, respectively, while bullhead ranked fourth numerically, 10%, followed by gizzard shad, 8%, and channel catfish, 2%.

Combined catch success of 173 FND by pound and experimental gill net was the lowest recorded for the four years of this study (Table 23). Crappie were caught at 57 FND, carp was 37 FND, walleye declined to 5 FND, while white bass and channel catfish increased to 15 and 8 FND, respectively.

Pound nets captured more fish per net day than the experimental gill net, 101 versus 72 FND, but the difference was not as marked as previous years (Table 23). Crappie, white bass and carp were captured more frequently by pound nets while gill nets were more effective for the capture of walleye, catfish, bullhead and gizzard shad.

Table 22. Combined catch composition of pound and experimental gill nets, Lake Rathbun, April through October, 1975.

	Number	Percent number	Weight (kg)	Percent weight	Mean weight (kg)
Crappie[a]	2,382	37.2	450.0	24.9	.18
Carp	1,726	27.0	820.7	45.4	.47
B bullhead	615	9.6	55.6	3.0	.09
G shad	536	8.3	70.3	3.8	.13
W bass	616	9.6	108.8	6.0	.17
C catfish	152	2.3	76.0	4.2	.50
Walleye	124	1.9	98.2	5.4	.79
Bluegill	68	1.0	5.4	.3	.08
G sunfish	7	.1	.4	< .1	.06
Lm bass	7	.1	7.1	.4	1.02
B buffalo	82	1.2	69.9	3.8	.85
R carpsucker	42	.6	42.0	2.3	1.00
W sucker	5	< .1	1.3	< .1	.27
F drum	14	.2	.9	< .1	.06
Y bass	9	.1	.2	< .1	.03
OS bass	5	< .1	< .1	< .1	< .01
Total	6,390		1,807.7		

[a]Primarily white crappie.

Table 23. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Rathbun, 1972-75.

Species	Pound net (FND)				Experimental gill net (FND)				Combined catch (FND)			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Carp	30.2	51.2	25.5	31.0	6.3	3.2	5.7	5.9	36.5	54.5	31.3	36.9
B & W Crappie[a]	61.8	45.7	127.2	40.7	16.7	19.0	19.9	16.0	78.5	64.7	147.0	56.7
Bullhead	13.7	13.3	10.8	8.8	4.0	26.4	16.6	10.8	17.7	39.7	27.4	19.5
B buffalo	3.4	4.1	1.3	1.5	.2		< .1	< .1	3.6	4.1	1.3	1.6
R carpsucker	.7	.4	1.2	.7		.1		.2	.7	.5	1.2	1.0
C catfish	8.7	6.1	1.1	.9	11.4	11.1	5.9	7.4	20.1	17.2	6.9	8.3
Walleye	6.4	3.3	3.7	1.6	17.9	7.4	5.2	3.0	24.3	10.7	8.9	4.6
G shad	4.7	8.6	6.0	4.1	25.4	6.6	20.9	22.8	30.1	15.2	27.0	26.9
Bluegill	6.4	2.3	4.4	1.2	.1	.1	.6	.2	6.4	2.4	5.1	1.4
G sunfish	12.9	.8	1.1	.1	1.1	.8	.4	< .1	14.0	1.6	1.6	.2
Lm bass	.3	.2	.3	.1	.7	.3	.6	< .1	1.0	.5	1.0	.2
W bass	.2	.5	2.0	10.4	.1	.9	3.7	4.6	.2	1.4	5.8	15.0
W sucker	.1	.1	< .1	< .1	.7	.2	.1	0	.7	.2	.2	< .1
G shiner	0	0	< .1	0		.1	.1	0		.1	.1	0
Y bass	0	0	< .1	0			< .1	.6			< .1	.6
F drum	0	0	0	< .1				.9				.9
OS bass	0	0	0	0				.4				.4
Total	137.4	136.4	185.3	101.1	98.3	76.2	80.0	72.1	235.7	212.7	265.3	173.2

[a]Primarily white crappie.

Seine hauls captured 3,115 young of 11 species and several species of young and adult Cyprinids (Table 24). Gizzard shad cominated the total seine catch by contributing 85% while Cyprinids were second at 9%. White bass and hatchery reared 0-age ocean striped bass ranked third, 2%, followed by largemouth bass and walleye, both representing 1%.

AGE STRUCTURE AND GROWTH

Walleye During the netting periods of April and May a length-frequency distribution of 30 walleye was compiled (Table 25). This distribution, ranging from 171-516 mm TL, consisted of five age groups and dominated by two with age III forming a mode at 396-426 mm and representing 39% and age V, 441-471 mm, comprising 38%, the remainder consisted of ages I, II and IV.

Lengths, weights and scales were collected from 51 walleye during 1975. They ranged from 191 to 558 mm TL and weights of 52 to 1,410 g. Length-weight relationship was described by the equation $\log_{10}W = -5.23 + 3.06 \log_{10}TL$.

K-factors ranged from .77 to .94 with a mean of .83.

Body-scale relationship was described by the linear function

$$TL = 48.13 + 2.74\ ScR$$

From this relationship mean back-calculated total length at annulus were 194, 317, 383, 439 and 487 mm TL for ages I through V (Table 26).

White Crappie A length-frequency distribution of 553 white crappie was compiled during the April and May periods (Table 27). These fish ranged from 76 to 325 mm TL and were represented by one prominent mode from 201 to 300 mm. This distribution was comprised of < 1% age I, 1% age II, 35% age III, and 64% age IV and older.

Body measurements and scales were taken from 64 white crappie in 1975. These fish ranged in length from 122-296 mm TL and weights of 18-282 g. Length-weight relationship was described by the equation $\log_{10}W = -5.21 + 3.11 \log_{10}TL$.

K-factors ranged from 1.00-1.16 with a mean of 1.10.

Body-scale relationship was described by the equation

$$TL = 37.38 + 2.03\ ScR$$

From this relationship back-calculations at each annulus were 88, 164, 224, and 252 mm TL for ages I through IV (Table 28).

Largemouth Bass An insufficient sample of largemouth bass was collected during the 1975 netting season to compile a length-frequency distribution. However, body measurements and scales were taken from 25 largemouth bass captured during a test electrofishing day. These fish ranged from lengths of 249-456 mm TL and weights of 190 to 1,680 g. Length-weight relationship was described by the equation $\log_{10}W = -5.38 + 3.22 \log_{10}TL$.

Table 24. Species composition of 0-age fish by sampling station at Lake Rathbun, 1975.

	Station													
	I		II		III		IV		V		VI		Total	
Species	N	%	N	%	N	%	N	%	N	%	N	%	N	%
G shad	553	89.5	409	78.5	92	64.8	288	92.3	293	75.9	1,013	89.2	2,648	85.0
Cyprinids[a]	26	4.2	73	14.0	30	21.1	6	1.9	78	20.2	61	5.4	274	8.8
OS bass	9	1.5	26	5.0	9	6.3					8	.7	52	1.7
W bass	10	1.6	9	1.7	4	2.8	4	1.3	9	2.3	34	3.0	70	2.2
Y bass	2	.3									2	.2	4	.1
Lm bass	6	1.0					13	4.2			6	.5	25	.8
Walleye	4	.6	3	.6	5	3.5			3	.8	9	.8	24	.8
C catfish					2	1.4			3	.8	1	.1	6	.2
Bluegill	7	1.1											7	.2
Bullhead			1	.2									1	< .1
Carp	1	.2					1	.3					2	.1
F drum											2	.2	2	.1
Total	618		521		142		312		386		1,136		3,115	

[a]All Cyprinids other than carp.

Table 25. Length-frequency distribution of walleye at Rathbun Lake, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
171-186	1	3	I
186-201	1	3	
366-381	2	6	II
381-396	1	3	
396-411	7	23	III
411-426	5	16	
426-441	1	3	IV
441-456	5	16	
456-471	4	13	V
471-486	1	3	
486-501	1	3	
501-516	1	3	

Table 26. Average estimated total length (mm) at each annulus for walleye at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V
1974	183				
1973	192	359			
1972	225	346	411		
1971	173	277	364	431	
1970	195	288	373	446	487
Unweighted mean	194 (51)	317 (39)	383 (37)	439 (24)	487 (19)

Table 27. Length-frequency distribution of white crappie at Lake Rathbun, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
76- 99	1	< 1	I
101-125	0	0	
126-150	1	< 1	
151-175	4	< 1	II
176-200	8	1	
201-225	37	7	III
226-250	153	28	
251-275	255	46	IV+
276-300	82	15	
301-325	12	2	

Table 28. Average estimated total length (mm) at each annulus for white crappie at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV
1974	75			
1973	73	138		
1972	98	179	228	
1971	107	174	219	252
Unweighted mean	88 (63)	164 (55)	224 (45)	252 (14)

K-factors ranged from 1.30-1.77 while the mean was 1.51.

Body-scale relationship was described by the equation

$$TL = -0.14 + 2.39\ ScR$$

From this relationship mean back-calculated lengths at each annulus were 133, 202, 263 and 308 mm for ages I through IV (Table 29).

Table 29. Average estimated total length (mm) at each annulus for largemouth bass at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV
1974	154			
1973	117	207		
1972	122	201	276	
1971	139	196	251	308
Unweighted mean	133 (25)	202 (22)	263 (19)	308 (9)

Channel Catfish A length-frequency distribution of 32 channel catfish was tabulated during April and May of 1975 (Table 30). Catfish within this distribution ranged from 246 to 516 mm TL while two major modes were recorded 306-321 mm and 336-351 mm. Other fish were scattered within the distribution. Age class representation was 14% age III, 52% age IV, 3% age V, 14% age VI, and 6% age VII.

Body measurements and spines were taken of 52 channel catfish during the 1975 sampling season. These fish ranged from lengths of 172 to 664 mm TL and weights of 30 to 3,360 g. Length-weight relationship was described by the equation $\log_{10}W = -5.38 + 3.12 \log_{10}TL$.

K-factors ranged from .59-1.15 with a mean of .90.

Body-spine relationship was described by the function

$$TL = 4.96\ SpR$$

From this relationship mean back-calculated lengths at each annulus were 77, 178, 259, 336, 416, 477, and 546 mm TL for ages I through VII (Table 31).

Carp During the April and May sampling periods 340 carp were used to construct a length-frequency distribution (Table 32). Carp within this distribution ranged from 201 to 531 mm TL. One dominant mode was recorded from 246 to 336 mm while two lesser modes were recorded at 366-381 mm and 396-411 mm. Age class representation was 71% age II, 8% age III, 10% age IV, and the remainder age V and older.

Lengths, weights, and scales were taken from 50 carp for age and growth analysis. These fish ranged in length from 244 to 548 mm TL and weights of 152 to 1,750 g. Length-weight relationship was described by the equation $\log_{10}W = -4.47 + 2.80 \log_{10}TL$.

K-factors ranged from .95-1.18 with a mean of 1.05.

Table 30. Length-frequency distribution of channel catfish at Rathbun Lake, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
246-261	3	8	III
261-276	1	3	
276-291	2	6	
291-306	3	8	
306-321	8	22	IV
321-336	0	0	
336-351	7	19	
351-366	0	0	
366-381	0	0	
381-396	1	3	V
396-411	0	0	
411-426	0	0	
426-441	1	3	
441-456	1	3	VI
456-471	3	8	
471-486	0	0	
486-501	0	0	VII
501-516	2	6	

Table 31. Average estimated total length (mm) at each annulus for channel catfish at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1973	94	203					
1972	94	243	321				
1971	69	164	243	322			
1970	86	193	263	328	375		
1969	76	154	241	331	400	438	
1968	45	109	228	362	471	516	546
Unweighted mean	78	178	259	336	416	477	546
	(50)	(50)	(49)	(46)	(45)	(6)	(1)

Table 32. Length-frequency distribution of carp at Lake Rathbun, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
201-216	1	< 1	
246-261	29	9	
261-276	37	11	
276-291	87	26	II
291-306	36	11	
306-321	44	13	
321-336	16	7	
336-351	15	4	
351-366	6	2	
366-381	14	4	III
381-396	7	2	
396-411	20	6	IV
411-426	9	3	
426-441	9	3	
441-456	3	1	V+
456-471	3	1	
471-486	1	< 1	
486-501	2	1	
501-516	0	0	
516-531	1	< 1	

Body-scale relationship was described by the equation

$$TL = -13.36 + 1.65\ ScR$$

From this relationship mean back-calculated lengths at each annulus were 146, 246, 339, 438, 500, and 484 mm TL for ages I through VI (Table 33).

River Carpsucker Sample size of river carpsucker at Lake Rathbun was insufficient to construct a length-frequency distribution.

Body measurements were taken from 29 fish for age and growth analysis. These fish ranged from lengths of 303 to 445 mm TL and weights of 390 to 1,350 g. Length-weight relationship was described by the function $\log_{10}W = -5.10 + 3.10 \log_{10}TL$.

K-factors ranged from 1.29 to 1.49 while the mean was 1.41.

Body-scale relationship was best described by the equation

$$TL = 79.90 + 1.64\ ScR$$

From this relationship mean back-calculations at each annulus were 153, 244, 312, 368, 395, and 422 mm TL for ages I through VI (Table 34).

Table 33. Average estimated total length (mm) at each annulus for carp at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI
1974	176					
1973	156	266				
1972	113	283	380			
1971	134	262	368	431		
1970	130	200	279	461	543	
1969	168	221	327	421	457	484
Unweighted mean	146	246	339	438	500	484
	(50)	(46)	(14)	(8)	(2)	(1)

Table 34. Average estimated total length (mm) at each annulus for river carpsucker at Lake Rathbun, 1975. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI
1973	162	281				
1972	155	269	356			
1971	159	257	349	393		
1970	163	238	327	369	399	
1969	126	177	218	342	391	422
Unweighted mean	153	244	312	368	395	422
	(29)	(29)	(23)	(14)	(3)	(1)

Bigmouth Buffalo An insufficient sample of bigmouth buffalo were captured to compile a length-frequency distribution or calculate age and growth data.

White Bass Body measurements and scales were not taken from white bass but a length-frequency distribution was compiled for 41 fish during April and May, 1975 (Table 35). Two primary modes were recorded from 141-156 mm and 246-261 mm. Age class representation was determined by comparing the length distribution of white bass from Lake Rathbun to back-calculated lengths of fish from Lewis and Clarke Lake, South Dakota (Ruelle, 1971). Age class representation of white bass was 10% age I, 24% age II, 56% age III and 10% age IV.

Table 35. Length-frequency distribution of white bass at Lake Rathbun, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
96-111	4	10	I
111-126	0	0	
126-141	0	0	
141-156	9	22	II
216-231	1	2	
231-246	4	10	
246-261	19	46	III
261-276	0	0	
276-291	2	5	IV
291-306	2	5	

Gizzard Shad A length-frequency distribution of 189 gizzard shad was tabulated during the April and May sampling of 1975 (Table 36). This distribution was dominated by a single mode, 231-246 mm, and the distribution was comprised entirely of age I fish. Ages of gizzard shad at Lake Rathbun were not determined but lengths were compared to data in Carlander (1969).

Table 36. Length-frequency distribution of gizzard shad at Lake Rathbun, for April and May, 1975.

TL (mm)	Number	Percent occurrence	Age of interval
201-216	3	2	
216-231	25	13	
231-246	114	60	I
246-261	35	19	
261-276	7	4	
276-291	5	3	

DISCUSSION OF FINDINGS

LAKE RED ROCK

River carpsucker surpassed carp to become the most important species in the combined catch of 1975. During previous years carp ranked first at 30%, 31% and 25% of the total catch from 1972-74 then dropped slightly to 22% in 1975. River carpsucker ranked third or fourth, behind bullhead and crappie, in 1972-74 and comprised 17%, 17% and 19%, respectively, then increased to 26% in 1975. Recruitment of a strong 1972 year class is partially responsible for the increase in river carpsucker importance.

The impact of the commercial fishery at Lake Red Rock was first documented in 1975 by changes in fish population statistics from previous years. The selective character of the commercial fishery for larger buffalo and carp, species more desirable for market value than river carpsucker, has resulted in a reduced mean size and decline in importance in the numerical catches of the former two species in this study. Commercial fishermen harvested 44,665 kg of bigmouth buffalo, carp, river carpsucker and freshwater drum during 1974 and 442,029 kg of bigmouth buffalo, 27,484 kg of carp, and only 361 kg of river carpsucker in 1975. Early in this study the mean weight of bigmouth buffalo increased from .71 to .86 to .87 kg, 1972-74, then dropped to .50 kg in 1975. During the same periods carp varied from .32 to .50 to .44 kg and then declined to .32 kg while river carpsucker rose and stabilized from .27 to .42 kg. The representation of buffalo in the combined catch ranged from 2% to 8% from 1972-75. Despite the fact a strong 1974 year class of bigmouth buffalo recruited to net gear late in 1975 an increase in numerical importance was not recorded.

Sport fish increased in importance from the first year when they represented 32% of the catch, but since have represented 42 to 44% from 1973-75. Crappie continued as the dominant sport fish at Lake Red Rock comprising 20% of the total numerical catch in 1975 while in past years they represented from 13 to 21%. Bullhead varied contributing from 11 to 22% from 1972-74. White bass occurrence ranged from < 1 to 6%. Individually, other sport fish including walleye, northern pike, channel catfish, and largemouth bass generally represented less than 2% numerically within each annual catch.

Annual catch success (FND) of important species has remained variable and increases in percent representation in the total numerical catch does not necessarily project increased catch success. For example, catch success of river carpsucker was 29, 23, 49 and 44 FND for 1972-75. River carpsucker was the most numerous species caught at Lake Red Rock in 1975, it was third in importance the previous year, yet the catch success was lower in 1975 than 1974 despite recruitment of a strong 1972 year class. A further example is illustrated by comparison of the lowest catch success of carp, 39 FND recorded in 1973. But, carp were still the dominant species representing 31% of the total catch that year. A factor controlling catch success of all fish populations simultaneously is suspected.

Relative abundance of stocked fish at Lake Red Rock appears dependent on plantings of hatchery fish, catch success increased substantially but decreased two years after termination of stockings. Northern pike increased from .4 to 4.5 to 7.1 FND from 1972-74 then decreased to 2.7 FND in 1975. Largemouth bass increased from .9 to 3.7 to 6.5 FND then dropped to 2.7 while walleye expanded from .4 to 6.3 to 7.7 FND then fell to 5.8 FND for the same years, respectively.

Natural reproduction of all sport fish populations, that were initially developed by stockings, were recorded in 1975 net catches but catches were low. Seine hauls captured 19 young largemouth bass and 20 walleye while two 0-age northern pike were taken by experimental gill net.

Largemouth bass is the only species producing substantial numbers of young-of-the-year, but considerable variations in success is apparent. During non-stocking years, 1972, 1973 and 1975, seine hauls captured 87, 354 and 19 young fish, respectively, while 595 bass were caught in 1974. Variations in environmental factors are probably paramount as important factors to successful bass reproduction.

Few young walleye were seen in seine net hauls, but the highest total catch was recorded in a stocking year. Walleye were planted at Lake Red Rock during 1973 and 20 young fish were captured that year. During non-stocking years, 1972, 1974 and 1975, seines caught 8, 0 and 13 young walleye, respectively. Some spawning habitat exists for walleye, but the complete dependence of the population on natural reproduction is questionable.

Of the three species of sport fish most important to this study the northern pike has the most limited potential for sustaining a native population. 0-age northern pike were captured by seine net only during a year they were stocked, 1973, when 15 were seen yet none were caught during a second stocking year, 1972. The larger fingerling size of most fish stocked in 1972, in comparison to fry stockings, is thought responsible for the absence in seine hauls. In addition, while several year classes of largemouth bass and walleye are caught in net gear two dominant cohorts appear in the northern pike population, the 1972 and 1973 year classes. Since reservoir populations of northern pike are generally dependent on innundation of vegetation by high waters (Hassler, 1969) it is likely extreme variations in spawning success will occur at Lake Red Rock since suitable habitat is available only during high reservoir stages.

Annual total seine haul catches varied considerably during this study while species diversity remained about the same. From 1972-75 seine hauls captured 8,954, 10,391, 12,379 and 1,633 fish of 14, 18, 14 and 16 species, respectively, in addition to adult and young Cyprinids.

Gizzard shad dominated the total seine catch for three of four years of this study. Gizzard shad comprised 51%, 9%, 70% and 49% of the total seine catch from 1972-75, respectively, but were outranked by bullhead in 1973 when they comprised 67% of the total.

Significant deviations in age and growth statistics were not noted for this segment of study.

LAKE RATHBUN

White crappie dominated the numerical catch at Lake Rathbun during three of four years and carp comprised the greatest portion of the biomass. Crappie contributed 41%, 37%, 64% and 37% of the numerical catch from 1972-75 followed by carp at 20%, 38%, 13% and 27% for the same periods. Carp provided 38%, 51%, 45% and 22% of the biomass from 1972-75 while crappie provided 22%, 20%, 57% and 25% of the weight. All other species including bullhead, walleye, largemouth bass, and white bass contributed 10% or less to each category in each year.

A substantial share of the difference in total catch success between pound nets and experimental gill nets each year was due to the catches of a few species. Catches of crappie and carp by pound nets are higher than by experimental gill net and some species caught more frequently by gill nets are not frequently caught by either gear e.g., walleye, channel catfish and adult gizzard shad. Crappie has ranged from 41 to 127 FND for pound nets while that of experimental gill net was 16 to 20 FND. Gizzard shad is the most numerous species caught by gill net and was caught at 7 to 23 FND while mean annual pound net catches ranged from 4 to 9 FND.

Total seine haul catches at Lake Rathbun varied each year but differences were not as dramatic as those at Lake Red Rock. For 1972-75 seine catches of 0-age fish at Lake Rathbun were 2,644, 6,080, 4,311, and 3,115 fish of 7 to 11 species in addition to adult and young Cyprinids.

Gizzard shad constituted the major fragment of the total seine catch each year. Gizzard shad comprised 85% to 88% followed by Cyprinids contributing about 10% annually. Other fish provided less than 3%, but young white bass usually ranked third at .5% to 3%.

Stockings of sport fish made an impact on the species composition of Lake Rathbun when it was first impounded but has not provided positive changes since. Catch success of walleye systematically declined from 24 to 5 FND from 1972-75 while channel catfish has varied from 20 to 17 to 7 to 8 FND for the same years. Largemouth bass abundance cannot be measured effectively by net gear but their importance to the fishery has declined in recent years (Bruce, 1976). 0-age striped bass were captured by seine net and experimental gill net but older ages were never taken. On the other hand white bass have increased after the adult stockings in 1972, from .2 to 15.0 FND. Although stockings of fish at Lake Rathbun seems almost ineffective the existing populations would probably decline considerably in its absence.

RECOMMENDATIONS

Test nettings within recent years of this study indicate a stable species composition at Lakes Red Rock and Rathbun. Fish stockings at Lake Rathbun are not making changes in the species structure and fish are no longer stocked at Lake Red Rock. An important change at either reservoir is not foreseen, with the only exception being the impact of the commercial fishery at Lake Red Rock. Growth and other vital statistics of fish at each reservoir are generally consistent. Continued collections of field data would be redundant and time should be allowed for critical evaluation of data and synthesis of information in the form of a completion report.

LITERATURE CITED

Bruce, J. 1976. Survey of fishing provided by a large on-stream impoundment. Pages 197-200 in 1975 Job Completion Reports 1976 Management Plan and Stocking Guidelines. State Conservation Comm., Des Moines, Ia.

Carlander, K. 1969. Handbook of freshwater fisheries biology. Iowa State University Press, Ames, Iowa. Vol. 1. 752 pp.

Hassler, T. 1969. Biology of the northern pike in Oahe Reservoir, South Dakota 1959 through 1965. U.S. Fish and Wildl. Serv., Tech. Paper 29, 13 pp.

Ruelle, R. 1971. Factors influencing growth of white bass in Lewis and Clarke Lake. Pages 411-423 in G. E. Hall, ed. Reservoir Fisheries and Limnology. Amer. Fish. Soc. Spec. Publ. No. 8.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 702-4

JOB NO.: 2

NAME: Effects of Flood Water Management and Fish Species Introductions 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 operations data were obtained from U.S. Corps of Army Engineers Project Offices. At Lake Red Rock deviation from multipurpose pool ranged from +.1 to +6.4 m with a sum of +12.6 m, mean discharge rate was 250.7 CMS and the mean flushing rate was 22 days. At Lake Rathbun deviation from multipurpose pool ranged from 0 to +.3 m while the sum was +.7 m, mean discharge rate was 7.2 CMS and mean flushing rate was 515 days.*

Author: Vaughn L. Paragamian
Fishery Research Biologist

Date Prepared: 1 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

JOB 2 OBJECTIVE

To determine the impact of reservoir operations for floodwater management on fish populations and reproduction.

INTRODUCTION

Parameters of reservoir operations have been collected to relate their influence on fish population characteristics and stocking since 1971 at Lakes Red Rock and Rathbun. This segment covers the 1975 collection.

STUDY BACKGROUND

Reservoir operations of Lakes Red Rock and Rathbun are continuously monitored by the U.S. Corps of Army Engineers. These records were compiled for each study year to determine their effects on the characteristics of fish populations and the success of fish plantings.

Lake Red Rock was at or near conservation pool elevation during 1972 but was contrasted by instable elevations of 1973 and 1974. Monthly deviations from conservation pool in 1972 was +5.0 m; 1973 was a record high, +72.3 m while 1974 was intermediate at +26.6 m. Discharge rates averaged 195 CMS (cubic meters per second) in 1972, 491 CMS in 1973, and 251 CMS in 1974. During 1972 flushing rate ranged from 28 to 102 days with a mean of 45 days; in 1973 it ranged from 34 to 167 days with a mean of 105 days, while in 1974 it ranged from 30 to 100 days with a mean of 34 days.

Stable pool elevations were recorded at Lake Rathbun in 1972 and 1974 but were disimilar to unstable elevations of 1973. Monthly sum of deviations from conservation pool were +1.5 m for 1972, +17.6 m in 1973, and +2.4 m in 1974. Mean discharge rates were 2.7 CMS in 1972, 21.1 CMS in 1973, and 9.3 CMS in 1974. Flushing rates in 1972 ranged from 203 to over 5,000 days with a mean of 710 days; in 1973 it ranged from 88 to 2,652 days with a mean of 208 days, and in 1974 it ranged from 91 to 2,390 days with a mean of 412 days.

FINDINGS

LAKE RED ROCK

Pool elevations of Lake Red Rock were within one meter of conservation pool for four of the seven months (Table 37). The greatest deviation was +6.4 m (21 ft) which occurred in May, 1976, minor deviations were +2.8 m (9 ft) and +2.1 m (6.9 ft) of June and July, respectively. Sum of monthly deviations from

Table 37. Mean monthly water level elevations, deviation in meters from multipurpose pool elevation, and discharge at Lakes Red Rock and Rathbun, 1975. Authorized multipurpose pool elevation is 221 m at Red Rock and 276.6 m MSL at Rathbun.

	Red Rock			Rathbun		
Sampling period	Mean elevation	Deviation	Mean discharge (CMS)	Mean elevation	Deviation	Mean discharge (CMS)
April	222.0	+ 1.0	449	275.9	+ .3	22.2
May	227.4	+ 6.4	313	275.7	+ .1	4.2
June	223.8	+ 2.8	461	275.7	+ .1	5.0
July	223.1	+ 2.1	391	275.8	+ .2	16.7
August	221.1	+ .1	75	275.5	0	.7
September	221.1	+ .1	49	275.6	0	.7
October	221.1	+ .1	17	275.6	0	.7
Maximum elevation	227.4					
Minimum elevation	221.1					
Mean elevation	222.8					
Mean discharge			250.7			7.2
Sum of deviations		+12.6			+ .7	

conservation pool was +12.6 m (41.3 ft). Mean discharge rates ranged from 461 CMS (16,255 CFS) in June to a low of 17 CMS (10,190 CFS) in October with a mean of 250.7 CMS (8,840 CFS). Flushing rate ranged from 3.8 to 77 days for April and October with a season mean of 22 days.

LAKE RATHBUN

Pool elevation of Lake Rathbun approached precise maintenance of multipurpose pool in 1975. Maximum deviation from conservation pool was only a +.3 m (.9 ft) attained in July while half of the remaining months were at pool level with a deviation sum of +.7 m (2.3 ft). Discharge rate ranged from 22.2 CMS (783 CFS) in April to .7 CMS (25 CFS) for August through October while the mean was 7.2 CMS (254 CFS). Flushing rate ranged from 146 to 2,000 days with a mean of 515 days.

DISCUSSION OF FINDINGS

Lake Red Rock is a fluctuating reservoir with extensive variations within all reservoir operation parameters. Prominent measurements in most categories occurred in 1973 when discharge rate exceeded 662 CMS, monthly mean peak elevation was +15.4 m above multipurpose pool, and mean flushing rate was 105 days. The year 1972 marked the stablest year with a sum of deviations of only +5.0 m while 1974 and 1975 were intermediate.

Findings for Lake Rathbun identify it as a relatively stable reservoir maintained near multipurpose pool. Reservoir operations of 1973 contrasted those of all other years. In that year deviation from conservation pool reached +4.1 m while the sum of deviations was +17.6 m, discharge rate averaged 21.1 CMS and mean flushing rate was 208 days. Other years were relatively stable with sum of deviations of +1.5, +2.4, and +.7 m for the years 1972, 1974 and 1975, respectively. Mean discharge rate for the same years were 2.7, 9.3, and 7.2 CMS.

RECOMMENDATIONS

Four years of reservoir operations data were collected at Lakes Red Rock and Rathbun. Each reservoir developed a distinct characteristic with periods of extremely high elevations and conservation pool levels. Recording additional years of water management operations would be repetitions, thus, termination of this project is recommended to allow time for critical evaluation of findings in relation to other aspects of this study and a subsequent completion report.

ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-2

STUDY NO.: 702-4

JOB NO.: 3

NAME: Effects of Flood Water Management and Fish Species Introductions 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, 1975 through 30 June, 1976

ABSTRACT: *Survival of stocked sportfish to adult size was documented in net catches and seasonal survival of fish stocked within that year and native reproduction is recorded in seine catches. Fish stocked at Lake Rathbun included 11,000,000 walleye fry and 55,000 striped bass. No fish were stocked at Lake Red Rock in 1975.*

Author: Vaughn L. Paragamian
Fishery Research Biologist

Date Prepared: 1 June, 1976

Approved by: James Mayhew
Fishery Research Supervisor

JOB 3 OBJECTIVE

To determine the success of introductions of sport fish species and their biological impact upon indigenous fish populations.

INTRODUCTION

Flood water control reservoir fish populations are largely dependent on hatchery reared fish. The initial success of these stockings can be measured in recruitment into the fishery, but the reasons for variation in the catch due to the impact of flood water management is unknown. This segment will determine the effect of flood water management on stocked and native fish.

STUDY BACKGROUND

Since impoundment, five nonendemic species of fish were stocked into Lake Rathbun and three native species stocked in Lake Red Rock. In general, initial stockings at Lake Rathbun, 1969 through 1971, were successful, except for striped bass; however, since these first stockings subsequent plants did not change the species composition nor did they increase the relative abundance of most populations. Stockings at Lake Red Rock from 1970 through 1973 increased the abundance of all species stocked.

FINDINGS

Sport fish were not stocked at Lake Red Rock in 1975. Lake Rathbun was planted with 11,000,000 walleye fry and 55,000 striped bass fingerling.

DISCUSSION OF FINDINGS

After initial stockings at Lake Red Rock catch success of walleye, largemouth bass and northern pike, from 1972 through 1974, increased but after stockings terminated in 1973, FND decreased despite some natural reproduction. These data are documented and described in detail in Job 1 of this report.

Some species stocked at Lake Rathbun, during earlier years, have established naturally sustained populations while others continue to decrease in relative abundance despite stocking and natural reproduction. These data are also documented in Job 1 of this report.

RECOMMENDATIONS

Six years of fish stocking records for Lakes Red Rock and Rathbun were tabulated while data for reservoir operations and test nettings were compiled for four consecutive years. Stockings ceased at Lake Red Rock in 1973 and recent plantings at Lake Rathbun did not change the species composition. Ample information is now available to fulfill the objective of this job. With these facts at hand termination of field collections is recommended to allow time for data analysis and preparation of a completion report.