IOWA CONSERVATION COMMISSION
FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION
ANNUAL PERFORMANCE REPORT
LARGE RESERVOIR FISHERIES INVESTIGATIONS
PROJECT NO. F-91-R-1

IOWA
CONSERVATION COMMISSION

Study No. 507.1 - Inter-Relationships of Forage Fish Species and Predator Populations in Lake Rathbun

Job No. 1: Abundance, distribution and size structures of forage populations in Lake Rathbun
Job No. 2: Predator population abundance in Lake Rathbun
Job No. 3: Utilization of the forage fish population by predators in Lake Rathbun

PERIOD COVERED : 1 JULY 1977 - 30 JUNE, 1978

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-91-R-1

STUDY NO.: 507.1

JOB NO.: 1

NAME: Inter-Relationships of Forage Fish Species and Predator Populations in Lake Rathbun

TITLE: Abundance, distribution and size structures of forage populations in Lake Rathbun

Period Covered: 1 July, 1977 through 30 June, 1978

ABSTRACT: Forage fish populations at Rathbun Lake were monitored with an otter board trawl in June-September and cove rotenone samples in August. Gizzard shad was the most numerous forage species. Trawl sampling yielded a population estimate of 447,262 in July while August cove sampling showed juvenile shad abundance was 5,617/ha (2,273/ac). Young crappie were second in importance with estimates of 150,567 from the trawl sample. The cove sample yielded 391/ha (158/ac). Freshwater drum were nearly as abundant as crappie with population estimates of 150,000 for trawl and 366/ha (148/ac) for cove samples. Juvenile bluegill, bullhead, channel catfish, largemouth bass, white bass, carpsucker, walleye, carp, green sunfish, orangespotted sunfish, madtom and Notropis *comprised the remaining 447 fish/ha (181/ac). Length-frequency distributions of the forage population showed growth of gizzard shad was slow where mean length in August was 60 mm (2.4 in). Forage fish which were smaller than shad in the August sample were bluegill, bullhead, minnows, largemouth bass and carpsucker. Eight forage species were larger than gizzard shad. Comparison of sampling methods was discussed with reference to temporal and spatial distribution of the forage populations and the length-frequency distributions obtained by each method.*

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Date prepared: 30 June, 1978

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STUDY OBJECTIVE

To increase utilization of forage fish by predator fish populations in Lake Rathbun by using floodwater control regimes to alter the abundance, size structure and diversity of forage fish populations.

JOB 1 OBJECTIVE

To determine the abundance, distribution and size structure of forage fish populations in Lake Rathbun.

INTRODUCTION

Fish populations in large onstream Iowa impoundments are characterized by a low prey species diversity and high diversity of predators (Paragamian, 1977). At Lake Rathbun gizzard shad and crappie are the only species which consistantly produce large numbers of young fish of forage size (Mayhew, 1977). The predator population is made up of at least five piscivorous species including walleye, largemouth bass, crappie, white bass and channel catfish. Thus predator well-being is dependent upon two forage populations and a failure in reproduction of forage species could drastically reduce production in the predator population.

Stevens (1964), Bayless (1966) and Rainwater (1975) have shown predator populations which depend mainly upon Clupeids are limited by the production attained by these populations. Production in the prey populations, although high, may become totally unavailable to the predators simply by forage growth. This is particularly true of trophic systems primarily dependent on gizzard shad as forage. Mayhew (1977) showed shad growth was density dependent and density was directly related to floodwater management; thus, increasing shad density by manipulation of factors related to flood control would provide abundant forage in addition to allowing greater vulnerability over a longer period.

The purpose of this investigation is to describe the trophic relationship between prey and predator to ensure maximum forage utilization by controlling abundance, size structure and diversity in the forage fish through fish management programs and floodwater control regimes.

STUDY BACKGROUND

Rathbun Lake is a 4,452 ha (11,000 ac) multipurpose reservoir that impounds 93 miles of the Chariton River near Rathbun, Iowa. The Army Corps of Engineers operates and maintains the reservoir for flood control, and for recreation and navigational releases for the Missouri River. The lake has a shoreline length of 290 km (180 mi) and is located in Appanoose, Monroe, Lucas and Wayne Counties. Storage volume at 276 m (904 ft elevation is $2.64 \times 10^8 m^3$ (213,000 ac/ft) with a maximum depth of 16 m (53 ft). The earthen-fill dam and impoundment receives surface runoff from 1,422 km^2 (549 mi^2); minimum operational release is about 1 CMS (10 CFS), while maximum capacity is 142 CMS (5,000 CFS). Pre-impoundment investigations by Mayhew (1969) provided detailed information on physical characteristics of the reservoir and water quality parameters and fish populations in the Chariton River. Post-impoundment water quality studies were completed in 1971-1973 (Mayhew, 1974).

The Chariton River, its tributaries and backwaters were treated with rotenone in the autumn of 1969 before the river was impounded. When the impoundment was filling in 1969, channel catfish were stocked followed in 1970 with walleye, channel catfish, largemouth bass and musky. The same species were stocked in 1971 in addition to white and striped bass. Since then, walleye and striped bass have been annually stocked. Striped bass plants were discontinued after 1976 and largemouth bass were stocked in the autumn of 1977.

Post-impoundment fisheries investigations commenced in 1971 (Mayhew, 1977; Paragamian, 1977). The former investigation identified factors associated with floodwater operational procedures which influenced the production of forage fish and fish-food organisms. The latter investigation documented the development of fish populations with reference to abundance, species composition, size distribution, age structure, reproductive success, growth and stocking success.

METHODS

The forage fish population at Rathbun Lake was sampled with an otter board trawl from June-September and by cove rotenone samples in August. Trawling commenced on 13 June and continued weekly through 28 September with tows at five locations designated as stations 2, 3, 4, 9 and 10 (Figure 1). Stations 2, 3 and 4 were located in the main pool; stations 9 and 10 were in Buck Creek embayment. Trawling depth at stations 2 and 3 was 3.5 m (12 ft) and 7.5 m (25 ft) with the lower strata identified with the suffix B. At station 4 tows were made at 3.5 m (12 ft) and 6 m (20 ft). The embayment stations were sampled only at 3.5 m (12 ft).

Hauls were made a speed of 1.5 m/sec (4.92 ft/sec) for a duration of 10 minutes. Towing distance was measured with a digital flow meter. The water volume passing through the trawl was computed to adjust all samples to the same volume regardless of depth.

The semi-balloon otter board trawl had a cross-sectional area of 13 m^2 (140 ft^2) at the foot and head rope. The front section of the net was 25 mm (1/2 in) bar mesh, while the cod end contained 3 mm (1/8 in) woven mesh. Cross-sectional area at the mouth of the cod end was 994 cm^2 (154 in^2). The mouth was held open by a bouyed head rope, a weighted foot rope and two lateral hydrofoils. Depth at which the net was towed was determined with an echosounder. Thereafter, towing warp length and angle were used to standardize tow depth.

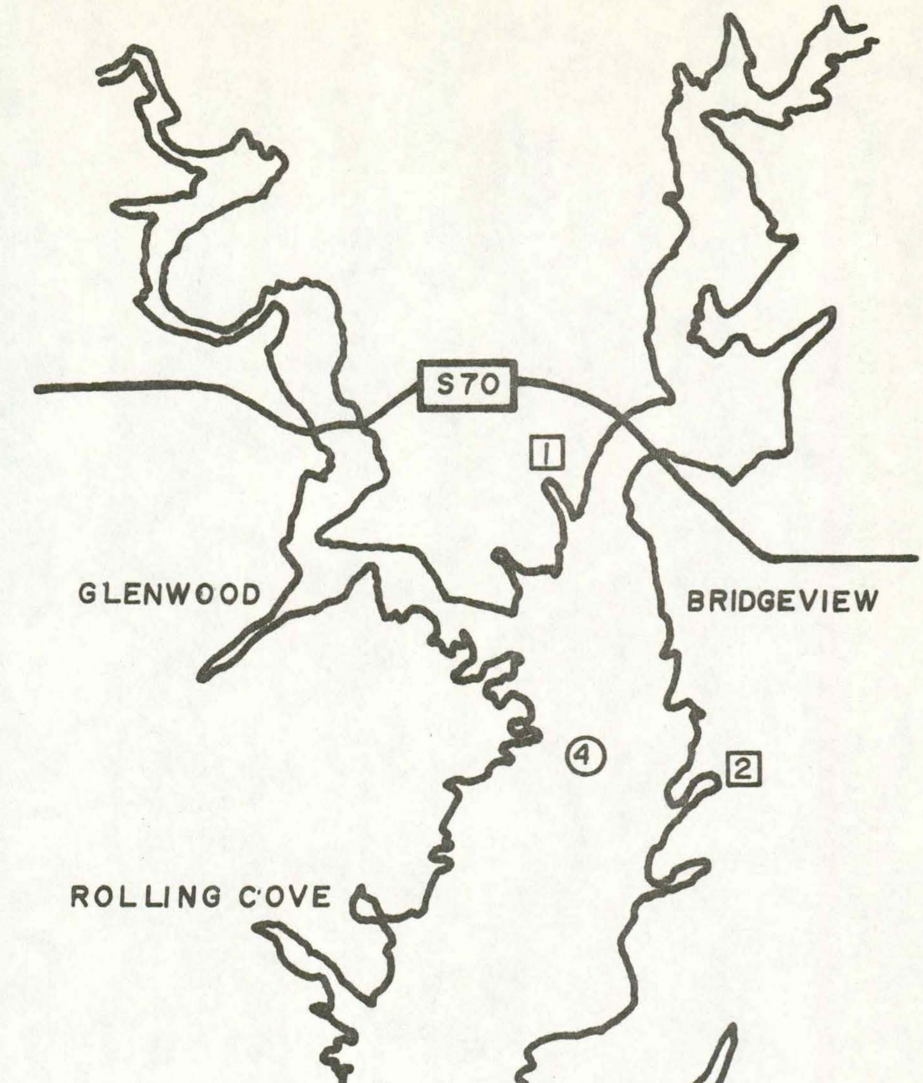

Figure 1. Stations sampled with trawl and rotenone at Rathbun Lake, where circles denote trawl stations and squares denote coves.

Fish captured were preserved in 2.5% buffered formalin for later sorting, identification, enumeration and measurement. Twenty-five fish from each sample were measured to the nearest mm and the aggregate sample weighed.

Six coves were sampled with rotenone in August using procedures described by Hayne (1967) (Figure 1). The first and second coves were sampled on 2 and 3 August, while the third cove was sampled on 9 August. The fourth and fifth coves were sampled on 15 and 16 August. The last sample occurred on 23 August. A block net of 13 mm (1/2 in) bar mesh was placed across the cove mouth to prevent fish from escaping or, later, dead fish from drifting out of the area. The net was placed before 6 AM and the rotenone was applied before 8 AM.

Cove size ranged from 1.23 ha (3.04 ac) to .43 ha (1.08 ac) with a range in volume of 14,000 m^3 (11.4 ac/ft) to 4,000 m^3 (3.2 ac/ft) Rotenone was applied through a weighted, perforated hose to assure even distribution. Dosage was approximately 5 ppm (1.6 gal per ac/ft). All fish were picked up for three consecutive days and during the first day fish were weighed in aggregate by species; total lengths were measured to the nearest cm from subsamples. Fish picked up during the second and third day were enumerated by species. The composite sample for all coves were adjusted to account for species and size selectivity, distribution within the lake and the probability of successfully recovering dead fish within a three day period as determined by Hayne (1967).

FINDINGS

TRAWLING

Juvenile fish taken in the trawl samples included nine species of 2,174 fish. Gizzard shad were by far the most dominant making up 67% (1,371) of the catch. Second most important was freshwater drum at 17% (380) followed by crappie at 16% (338). Forty-four walleye (2%) were captured. The remainder of the catch contained channel catfish, carp, bluegill, buffalo and white bass; each contributing < 1% to the sample.

Gizzard Shad The catch of juvenile shad averaged 9.9 fish per haul (F/H). Shad were most abundant in Buck Creek embayment with greatest catch effort at station 9. Mean shad catch at that station was 29.2 F/H (Table 1). Catch effort at station 10 located at the lower end of Buck Creek embayment was 16.1 F/H and was far greater than stations outside Buck Creek. The trend in catch during the sampling period, at stations 9 and 10, were nearly identical. Greatest success occurred during late June and early July at 91.1 F/H and 72.3 F/H for stations 9 and 10, respectively. A second peak in abundance occurred in early August; thereafter, catch effort decreased until sampling ceased in late September.

Catch success at main pool stations decreased progressively closer to the dam, particularly within the upper strata. Mean catch effort at station 4A was 15.6 F/H followed by stations 3A and 2A with average catches of 5.4 F/H and 4.2 F/H, respectively. Catches within the lower strata were far lower than within the upper strata and the trend of decreasing catch effort toward the dam was not consistent. Greatest catches occurred at station 3B with a mean of 5.4 F/H, while poorest catches were at 2B with .4 F/H. Station 4B catches averaged 3.0 F/H.

Table 1. Catch of juvenile gizzard shad in 10 minute standardized trawl hauls at Rathbun Lake, 1977.

Station	Depth	13 June- 20 June	27 June- 6 July	11 July- 19 July	25 July- 1 Aug	8 Aug- 15 Aug	22 Aug- 30 Aug	6 Sept- 12 Sept	21 Sept- 28 Sept	Mean
2	A	0	5.0	0	27.9	.5	.5	0	0	4.2
	B	0	0	0	.9	0	.5	0	1.7	.4
3	A	1.4	0	5.5	12.0	14.7	2.3	3.2	3.7	5.4
	B	0	0	.5	22.5	17.1	1.4	.9	.5	5.4
4	A	61.6	4.6	.9	35.4	17.9	3.3	.5	.9	15.6
	B	0	2.3	0	19.4	.9	0	.5	.5	3.0
9	A	57.5	91.1	.5	58.9	4.6	2.3	3.3	15.2	29.2
10	A	1.9	72.3	0	15.6	35.5	1.9	.5	.9	16.1
Mean		15.3	21.9	.9	24.1	11.4	1.5	1.1	2.9	9.9

Shad catch effort was consistently greater in the upper strata where the overall mean at stations 2A, 3A and 4A was 8.4 F/H compared to catch effort in the deeper strata of 2.9 F/H. At station 4 catch effort was always greater within the upper strata while at station 2 catches were always greater at strata A. At station 3A six of the eight sample periods yielded higher catches than at station 3B.

Analysis of variance in a one-way classification showed catch effort for shad in trawl samples was significantly different ($p < .05$) between sampling locations and depth strata. Further evaluation by least significant difference testing showed catch effort at stations 9, 10 and 4A was significantly greater ($p < .05$) than the remaining sampling locations. Comparison of mean catches between depth strata showed catches at 3.5 m (12 ft) were significantly greater. There was no significant difference in areal distribution of trawl tows in the main pool.

Based upon these findings the population of gizzard shad was estimated separately in three discrete strata by volumetric expansion of mean catches in each sample period. The components included stations within the upper 3.5 m (12 ft), stations between 3.5-6.0 m (12-20 ft) and stations below 6.0 m (20 ft). The volume of a standardized 10 minute haul was 11,782 m^3 and the expansion factor for each strata was the volume within the strata divided by the volume in a single haul. For example, the 0-3.5 m (0-12 ft) strata contained $1.33 \times 10^8 m^3$ with an expansion factor of 11,303. Volume within the 3.5-6.0 m (12-20 ft) strata was $5.83 \times 10^7 m^3$ and the corresponding factor was 4,946. The deepest strata, > 6.0 m (20 ft), had a volume and expansion factor of $5.64 \times 10^7 m^3$ and 4,784, respectively. Total population estimate for each period was attained by summing the values for each strata.

The population estimate of juvenile shad ranged from 17,308 in mid-July (95% confidence interval of ± 318,745) prior to the time they were fully vulnerable to the gear to 447,262 (± 185,369) in late July. In early August, the population was reduced to about 210,000 (± 161,633). During the next period the estimate declined to 30,000 (± 15,824) and by mid-September the estimated shad population was 20,417 (± 14,694).

Mean length of gizzard shad in the weekly trawl samples increased from 36 mm (1.4 in) on 13 June to 82 mm (3.2 in) on 12 September (Figure 2). Average length in the catch decreased during the latter part of September and was undoubtedly influenced by the small sample size in those periods or the influence of a second hatch entering the gear. Length distribution at the first sampling period was quite compressed because the gear was selective for faster growing shad. Range in length at that time was 31-53 mm (1.2-2.1 in). During the period of maximum vulnerability to the trawl in mid-July the range in length increased: 48-96 mm (1.9-3.8 in). Through the remainder of the sampling season the average length increased, but the range in length remained about the same. Mid-June through mid-July mean weight increased at a linear fashion from .54 g to 1.75 g. During the reaminder of July shad growth accelerated, but slowed during August and by the last sample period mean weight was 3.40 g. Maximum shad weight attained during the season occurred in mid-September at 4.45 g.

Instantaneous mortality was computed by fitting a least squares regression to the transformed shad abundance caught in the trawl from the time of full gear vulnerability until sampling ceased in late-September (Figure 3). Instantaneous mortality from 25 July through 28 September was .33 or an estimated 30% mortality during each weekly period.

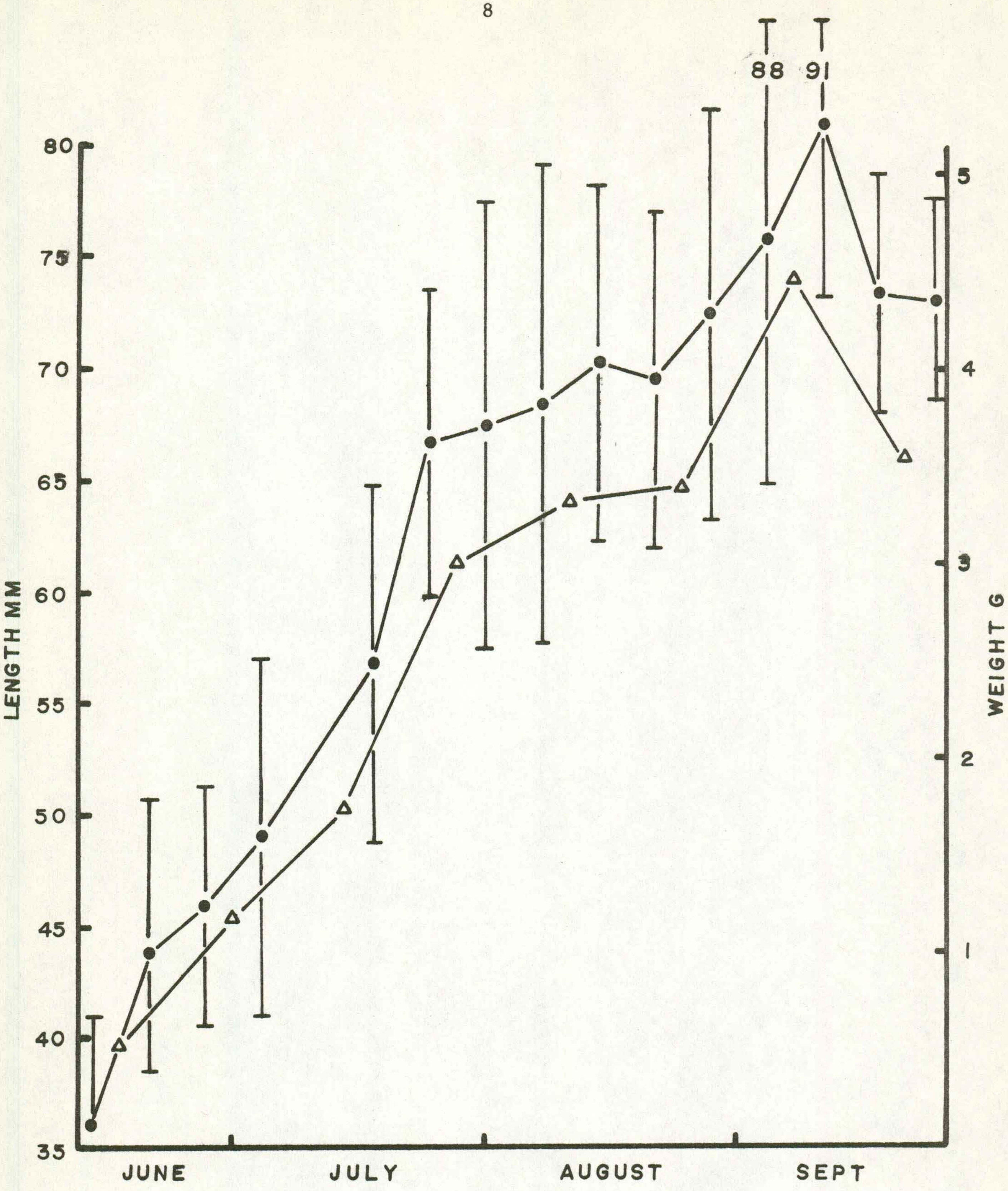

Figure 2. Mean length (solid circles) and weight (open triangles) of juvenile gizzard shad from trawl samples in 1977 at Rathbun Lake. Vertical lines show ± one standard deviation from the sample mean.

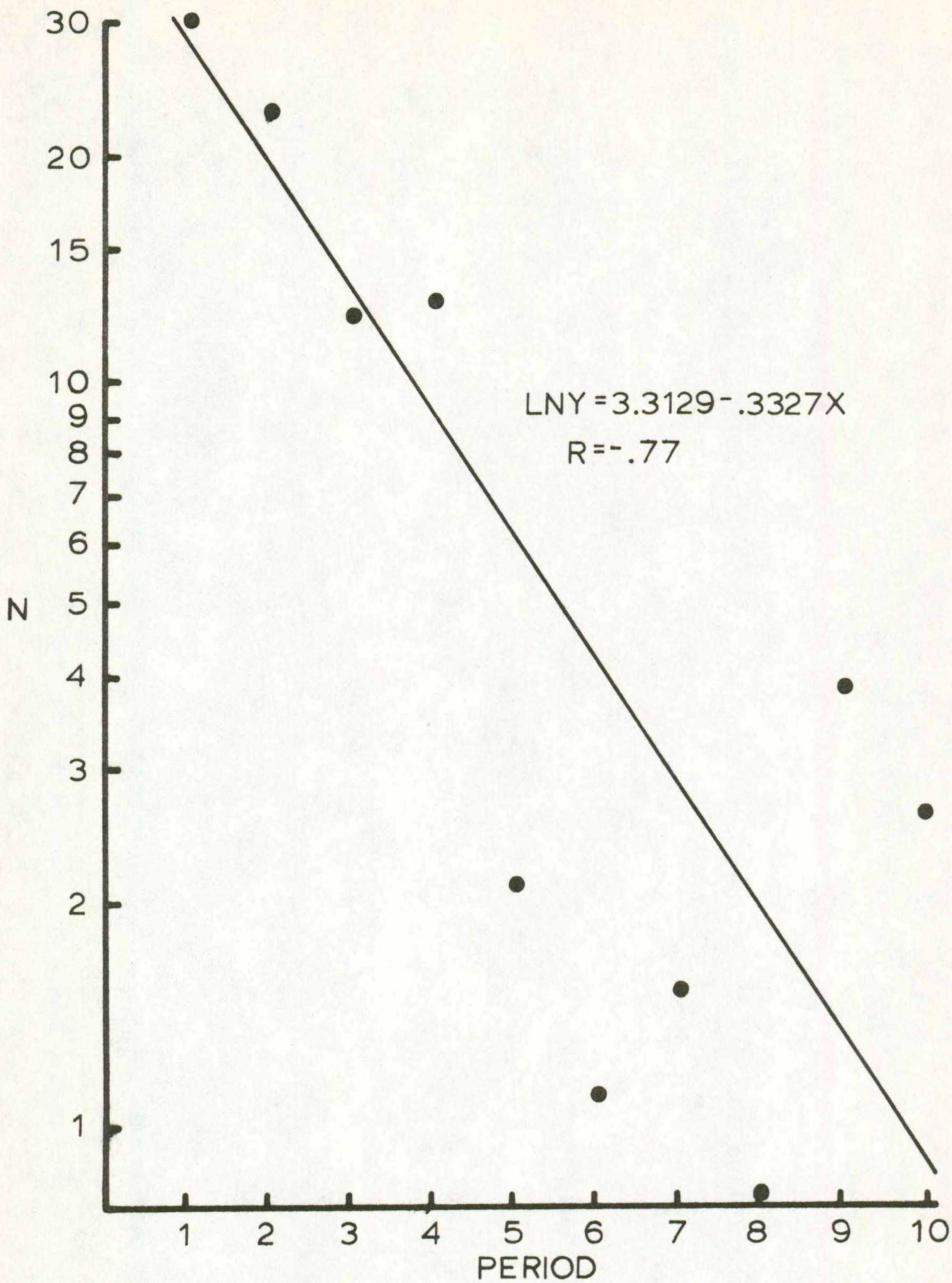

Figure 3. Catch curve of gizzard shad in trawl samples at Rathbun Lake in July-September, 1977.

Crappie Mean catch of juvenile crappie in the trawl was 2.4 F/H with greatest success in upper Buck Creek (station 9) at 12.1 F/H. Crappie were taken at the other stations, but in comparison catch effort was low. Greatest catch success for other stations was at 2B where the overall mean was 1.6 F/H. Excluding station 9, the highest single catch was 6.0 F/H at 2B in late July.

Station 9 was, by far, the most productive. In mid-June catches there were at least 5 times greater than catches at other stations. This trend continued and by late July catches at station 9 were 7 times greater than any other station. In August and September catch effort at station 9 decreased and was nearly equal to the remaining sample stations.

Catches were greatest at each sampling location and depth in late July when mean catch effort was 7.4 F/H (Table 2). Catch effort in previous periods was lower, but increased gradually forming a dome-shaped catch curve. In mid-June mean catch was 1.5 F/H increasing to 2.5 F/H in early July. During mid-July success again increased to 3.6 F/H. After late July there was a precipitous decline in catch to .7 F/H where it remained near this level until late September when there was a slight increase to 2.1 F/H.

Distribution of juvenile crappie between sampling depth levels was fairly uniform. Except for station 9 differences in catch-effort were quite small regardless of location. Furthermore, there was no particular trend in depth distribution with reference to period.

Analysis of variance showed there was a significant difference ($p < .05$) in mean crappie catch success between locations, but not between depths. Mean catch success was significantly greater only at station 9.

Population estimates of crappie ranged from 6,005 in early September to 150,567 in late July. Estimates prior to maximum trawl vulnerability showed a gradual increase from 26,068 (± 23,397) in mid-June, 51,652 (± 57,758) in early July and 70,502 (± 72,565) in mid-July. After maximum vulnerability was attained the population estimate decreased nearly 10-fold in two weeks; in early August the estimate was 13,695 (± 7,347). The following sample period showed a slight increase to 14,896 (± 10,625) followed by a decrease in mid-September to 6,005 (± 3,730). The final estimate in late September was 39,904 (± 25,997).

Mean length of juvenile crappie during the first sample period was 20 mm (.8 in). The increase in mean length from June-September was nearly linear with an increase of about 5 mm (.2 in) per period. By early August mean length increased to 65 mm (2.6 in), while mean length in the catch on 28 September was 95 mm (3.7 in) (Figure 4). Length distribution in the samples showed a narrow range during the early periods. For example, the range in size from smallest to largest in mid-June was 9 mm (.4 in). As crappie became fully vulnerable to the gear by late July the range was at least 25 mm (1 in). When sampling ceased the range had increased to 57 mm (2.2 in) between smallest and largest crappie in the sample.

Crappie weight increased at a geometric rate between sample periods. Mean weight within the first sample period was .13 g and by 1 July had increased to .39 g. Mean weight in mid-July and late July were .83 g and 1.70 g, respectively. Thereafter, the mean weight of juvenile crappie increased approximately 50% between biweekly periods.

Table 2. Catch of juvenile crappie in 10 minute standardized trawl hauls at Rathbun Lake, 1977.

Station	Depth	13 June-20 June	27 June-6 July	11 July-19 July	25 July-1 Aug	8 Aug-15 Aug	22 Aug-30 Aug	6 Sept-12 Sept	21 Sept-28 Sept	Mean
2	A	0	.5	3.2	2.7	1.4	1.8	.9	0	1.3
	B	0	3.0	2.2	6.0	.5	.5	0	.5	1.6
3	A	.5	.5	.5	.5	0	0	0	1.9	.5
	B	0	0	.9	3.6	0	1.4	.5	0	.8
4	A	1.4	0	0	1.4	.9	.5	0	6.4	1.3
	B	1.4	0	.5	1.8	0	0	0	.9	.6
9	A	6.9	16.1	21.5	42.3	1.9	1.9	.5	5.5	12.1
10	A	1.4	0	0	.9	.9	0	.5	1.9	.7
Mean		1.5	2.5	3.6	7.4	.7	.8	.3	2.1	2.4

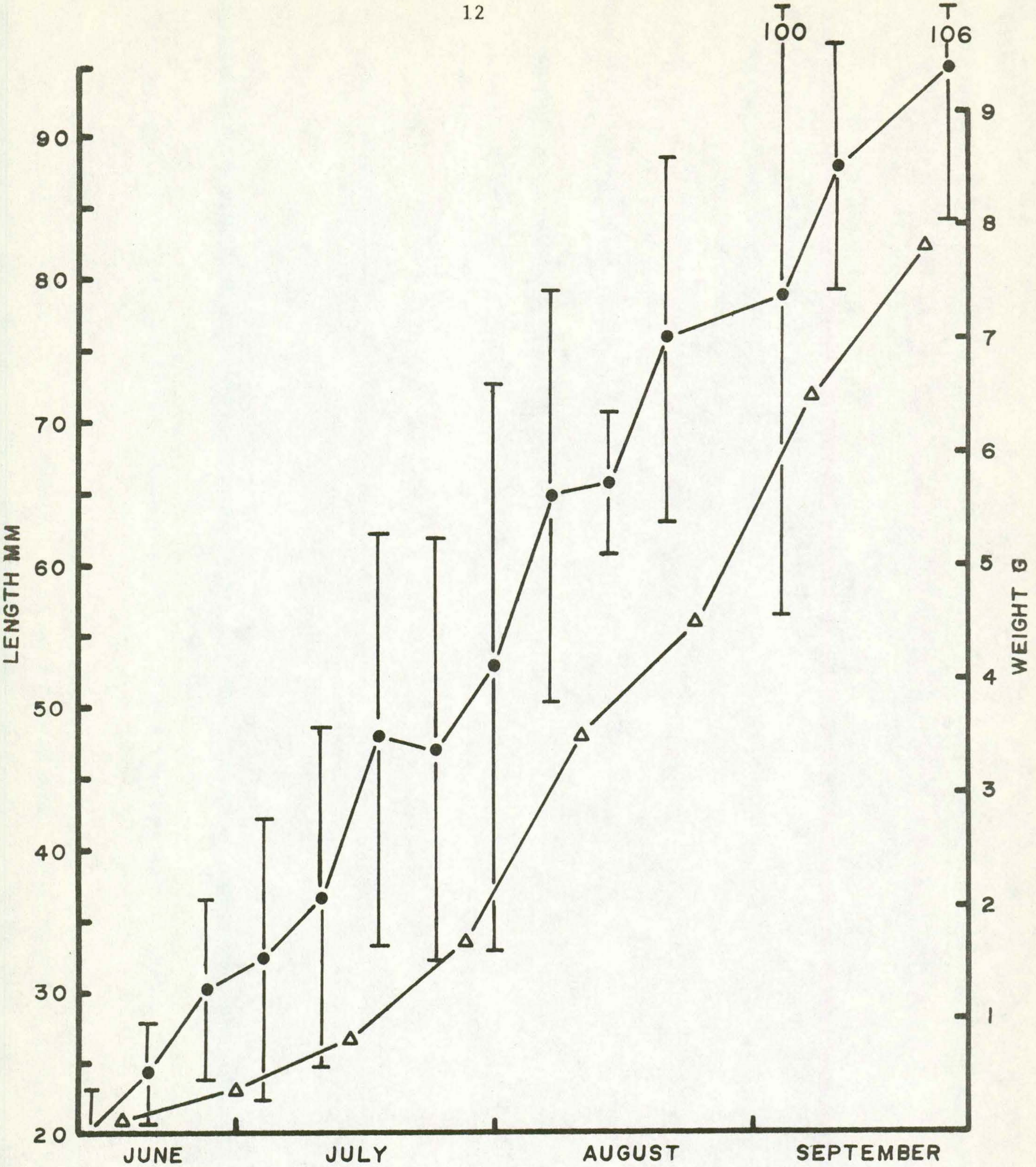

Figure 4. Mean length (solid circles) and weight (open triangles) of juvenile crappie from trawl samples in 1977 at Rathbun Lake. Vertical lines show ± one standard deviation from the sample mean.

Two discrete estimates of crappie mortality were necessary because the descending right limb of the catch curve was concave even after transformation to natural logarithms. Either there was irregularity in sampling or mortality was disproportionately greater when crappie were small. The first estimate was made during the period 25 July-15 August, and the latter during 22 August-12 September. The difference in mortality between the periods was greater than expected by a normal geometric function. Mortality during the first segment was 91%. Mortality within the latter segment (22 August-12 September) was estimated at approximately 62%.

Freshwater Drum Freshwater drum were taken at all sample locations except at 3A and 4A. Highest catches occurred at station 4B with an average catch of 16.8 F/H (Table 3). Mean catch at the remaining locations was .7 F/H. In all cases drum were most prevalent within the lower strata where catch-effort at stations 2B, 3B and 4B was 6.8 F/H. The upper strata at these stations produced fewer drum and the mean catch was .2 F/H. There was no particular trend of increasing or decreasing drum abundance away from the dam. Catch at station 4 was greatest, station 2 near the dam ranked second in catch-effort, and station 3 ranked third.

Analysis of variance showed a significant difference in mean drum catch between location and depth strata. Mean catch at station 4 was significantly greater ($p < .05$) than the other stations, while there was a similarity in catch success at stations 2, 3, 9 and 10. The comparison between upper and lower strata showed significantly greater ($p < .05$) catches occurring within the lower strata.

Drum were taken in all periods at station 4B, but were not collected at the other stations until mid-August. Catch-effort gradually increased from .1 F/H in mid-June to 7.5 F/H in late August and was mainly a reflection of the catches at station 4B. Greatest success at station 4B was 55.8 F/H attained in late August. During the remainder of the periods there was a systematic decline in catch-effort.

Population estimates of drum ranged from 1,484 (± 3,017) when sampling commenced in June to 152,121 (± 300,717) in late August when vulnerability to the gear was at a maximum. Thereafter, the abundance of drum decreased to 88,798 (± 45,503) in late September.

Mean length of drum in mid-June was 34 mm (1.3 in) which increased to about 65 mm (2.6 in) by mid-August (Figure 5). During the final sampling interval mean length was 87 mm (3.4 in). Mean weight of drum in early July was .46 g. During the next sample period there was a slight increase to .59 g. Thereafter, mean weight increased rapidly and by mid-September average weight in the sample was 6.1 g. Mean weight of drum when sampling ceased in late September was 9.5 g.

Instantaneous mortality of drum was computed from 22 August when maximum catch in the trawl was attained until 28 September. The mortality for August-September was 39% within each biweekly period.

Walleye Walleye juveniles ranked fourth in abundance, but comprised only 2% of the sample. Of the 44 captured, 63% were taken near the dam at station 2. The remainder of the catch was distributed uniformly at the other stations. There was a greater tendency for walleye to be captured within deeper strata; 64% were taken in deeper tows.

Table 3. Catch of juvenile freshwater drum in 10 minute standardized trawl hauls at Rathbun Lake, 1977.

Station	Depth	13 June-20 June	27 June-6 July	11 July-19 July	25 July-1 Aug	8 Aug-15 Aug	22 Aug-30 Aug	6 Sept-12 Sept	21 Sept-28 Sept	Mean
2	A	0	0	0	0	2.3	.9	0	.5	.5
	B	0	0	0	0	2.2	2.2	.9	14.5	2.5
3	A	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	3.2	.9	3.2	.5	1.0
4	A	0	0	0	0	0	0	0	0	0
	B	.5	4.5	5.4	19.8	22.5	55.8	19.2	6.8	16.8
9	A	0	0	0	0	.5	0	1.4	0	.2
10	A	0	0	0	0	0	0	4.2	0	.5
Mean		.1	.6	.7	2.5	3.8	7.5	3.6	2.8	2.7

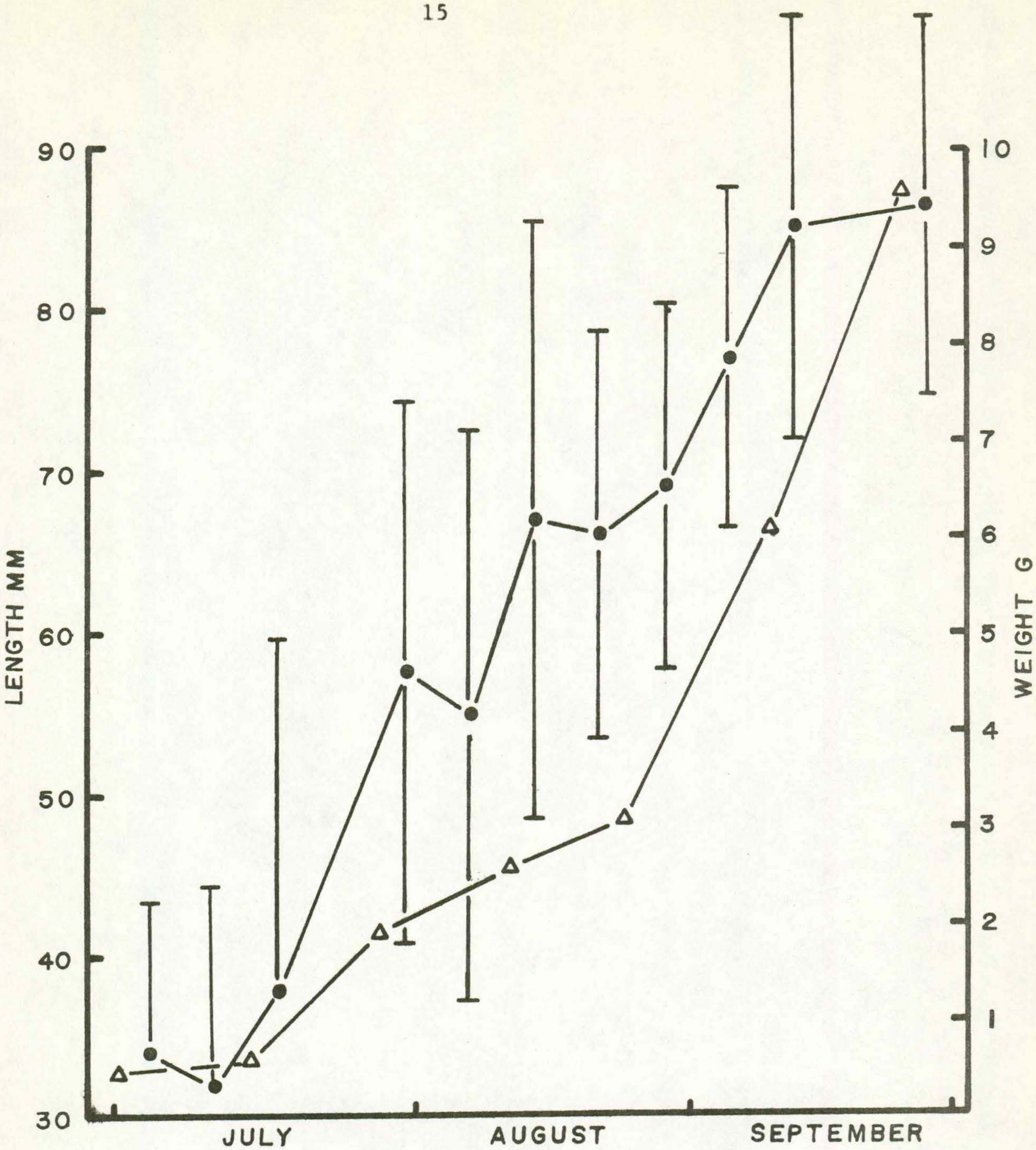

Figure 5. Mean length (solid circles) and weight (open triangles) of juvenile freshwater drum in 1977 at Rathbun Lake. Vertical lines show ± one standard deviation from the sample mean.

Walleye grew from a mean length of 50 mm (2.0 in) in June to 95 mm (3.8 in) by early August. Sample size was too small to compute population estimates, mortality or tests for differences in horizontal or vertical distribution.

COVE SAMPLING

Six coves were sampled with rotenone in August yielding 84,251 fish weighing 1,630 kg (3,590 lbs). The sample included fish ranging in size from juvenile minnows to walleye as large as 670 mm (26 in). The forage fish population consisted of all juvenile fish species in addition to age 1 bullhead, bluegill, green sunfish and orangespotted sunfish. Larger fish such as age 1 shad and age 2 centrarchids contributed to the forage population, but overall were of minor importance. The forage population in the cove samples comprised 89% of the fish my number and 21% by weight.

Juvenile gizzard shad were, by far, the most abundant prey comprising 80% of the numerical prey population and 71% of the biomass. Standing crop was 5,617/ha (2,273/ac) and 25.87 kg/ha (23.09 lbs/ac) (Table 4). Young crappie were second in abundance at 391/ha (158/ac) with a biomass of .60 kg/ha (.54 lbs/ac). Freshwater drum were nearly as abundant as crappie with an estimate of 366/ha (148/ac), however mean size of juvenile drum was larger yielding a biomass estimate of 2.07 kg/ha (1.85 lbs/ac). Age 0 and age 1 bluegill contributed 206/ha (83/ac) to the forage fish population with a biomass of 3.73 kg/ha (3.33 lbs/ac).

Table 4. Estimated abundance and biomass of juvenile fish in the forage population from cove samples in August at Lake Rathbun.

	N/ha	kg/ha
Gizzard shad	5,617	25.87
Crappie	391	.60
Freshwater drum	366	2.07
Bluegill	206	3.73
Bullhead	68	1.41
Channel catfish	67	.60
Largemouth bass	65	.34
White bass	53	.72
Carpsucker	45	.43
Walleye	33	.41
Carp	22	.33
Other[a]	94	.16
Total	7,027	36.67

[a]Green sunfish, orangespotted sunfish, madtom and *Notropis*.

The remaining species were quite sparse contributing no more than 1% to the forage population. Bullhead, channel catfish, largemouth bass, white bass, carpsucker, walleye, carp, green sunfish, orangespotted sunfish, madtom and cyprinids combined comprised the remaining 447 fish/ha (181/ac) to the forage population with an estimated biomass of 4.40 kg/ha (3.93 lbs/ac).

Length distribution of juvenile gizzard shad in the cove samples showed a range of 40-110 mm (1.6-4.3 in) with a mode at 60 mm (2.4 in) (Figure 6). Juvenile crappie had a range of 30-90 mm (1.2-3.5 in); the mode was 70 mm (2.8 in). Range in size of freshwater drum was identical to crappie, but the greatest frequency in the distribution occurred at 80 mm (3.1 in).

Juvenile bluegill were the smallest fish taken in the cove samples ranging from 10-40 mm (.4-1.6 in). The distribution of age 1 bluegill was quite similar to juvenile gizzard shad. The remaining prey species ranged in length between young bullhead which had a distribution of 20-90 mm (.8-3.5 in) and juvenile walleye which ranged between 70 mm (2.8 in) and 150 mm (5.9 in).

Modes in the length-frequency distributions were ranked for each prey group from smallest to largest starting with juvenile bluegill, 30 mm (1.2 in); bullhead and minnows, 40 mm (1.6 in); largemouth bass and carpsucker, 50 mm (2.0 in); gizzard shad, 60 mm (2.4 in); crappie, 70 mm (2.8 in); freshwater drum and channel catfish, 80 mm (3.1 in); carp, white bass and age 1 bluegill, 90 mm (3.5 in); and walleye, 110 mm (4.3 in).

DISCUSSION OF FINDINGS

The forage fish population at Rathbun Lake was sampled with midwater trawl and rotenone. Comparison of the findings between sampling methods showed each was valuable in describing unique population statistics. Results from trawling provided statistics on midwater distribution within the reservoir; whereas, rotenone sampling represented the forage abundance in a small, localized area on the day of sampling. Trawl samples provided information on the abundance of prey during the production period in June-September. Additional statistics obtained from trawl samples included growth and mortality which could only be determined by multiple sampling.

Rotenone sampling augmented findings from the trawl sampling regime by providing population estimates of fish which are, by habitat preference, confined to the littoral zone. Bluegill and minnows were rarely taken with the trawl, but were common in cove samples. Length-frequency distributions of juvenile fish in rotenone sample differed for some species since sample size was larger and gear avoidance was nearly non-existent. Also, sampling provided length-frequency distributions and population estimates of species not taken in the trawl sample.

Comparison of species composition, numerical abundance and size distribution was made between trawl samples in August and cove rotenone samples. The cove sample had a greater taxonomic list containing 15 groups, while nine taxa were sampled with the trawl. The difference was due mostly to habitat preference of the various fish species. Juvenile species not common to both sampling methods were bullhead, largemouth bass, carpsucker, orangespotted sunfish, green sunfish, madtom, *Notropis spp.* and bigmouth buffalo.

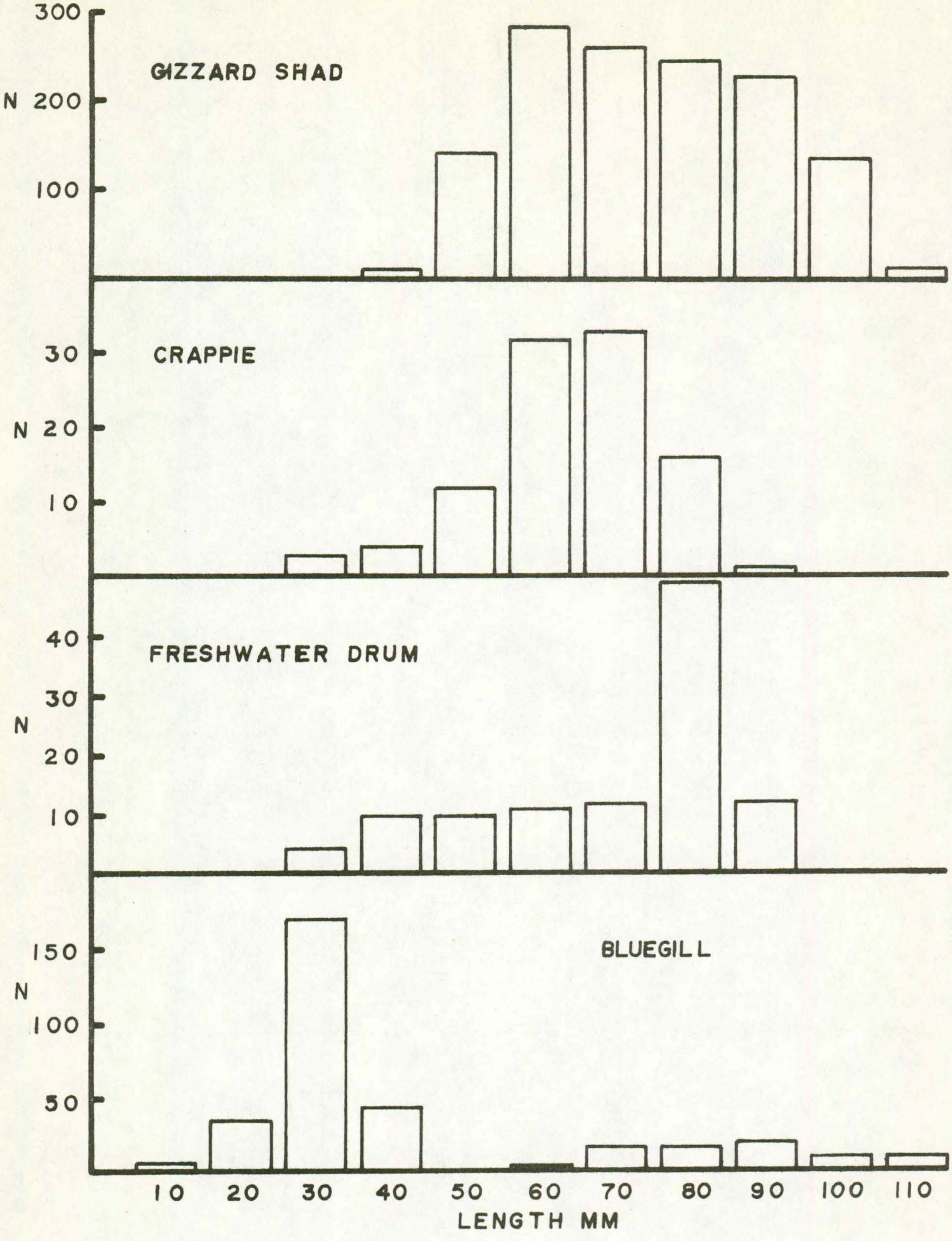

Figure 6. Length-frequency distribution of the four most numerous prey species in rotenone samples at Rathbun Lake, 1977.

Juvenile buffalo were taken only in the trawl, while the others were taken exclusively in cove samples. Habitat preference of the species not found with both sampling methods accounted for much of the difference. Juvenile centrarchids, although at times found in midwater, were associated more with shallow water. Likewise, many *Notropis* species and madtom are found in shoal areas or streams. Conversely, bigmouth buffalo are more pelagic and therefore are more apt to trawl capture.

Differences in length-frequency distributions of fish captured between the sample methods was most apparent for gizzard shad where the range in length for the rotenone sample was 40-110 mm (1.6-4.3 in) compared to 55-100 mm (2.2-3.9 in) for the trawl sample. Modes for the shad length-frequency were 60 mm (2.3 in) for the rotenone samples and 70 mm (2.8 in) for the trawl samples in August. Trawl avoidance was obviously not a factor until shad reached about 80 mm (3.1 in). Contrarily, smaller shad were more prevalent in the coves. Mayhew (1977) found a similar trend and showed gizzard shad moved from shallow water to midwater at about 11-20 mm (.4-.8 in).

Range in size for juvenile freshwater drum was nearly identical between sample methods, yet the mode in the length-frequency distribution was 55 mm (2.2 in) for trawl samples and 80 mm (3.1 in) for rotenone samples. The opposite was found for crappie where the modes in the length distribution were identical in trawl and rotenone samples, but the size ranges were quite different. The smallest crappies in the trawl were 19 mm (.17 in) compared to 30 mm (1.2 in) in the cove sample.

There was a large disparity in population estimates for gizzard shad, crappie and freshwater drum using the two sampling methods independently. Estimates from rotenone samples were consistently greater. For example, the cove rotenone estimate yielded 5,617 juvenile shad/ha (2,273/ac) compared to the estimate using the trawl which was < 100/ha (< 40/ac). Previous investigations at Rathbun (Mayhew, 1977) showed gizzard shad populations in August were much greater than 100/ha (40/ac) ranging as high as 9,268/ha (3,751/ac).

Similarly there was about a 100-fold difference in the population estimates for crappie. Again, August population estimates by Mayhew (1977) were in much closer agreement with the cove rotenone estimates than the August trawl estimates.

These comparisons show a single type of sampling would be inadequate to describe forage population density in reference to the objectives of this investigation. Both methods were selective, to a degree, for species and fish size. Population and biomass estimates from cove sampling were more reliable than estimates computed from the trawl, however based on the present sampling regime, computation of growth and mortality were wholly dependent upon trawl catches. Likewise, sampling with the trawl showed temporal and spatial distribution of forage species within the reservoir that was unavailable by cove sampling.

RECOMMENDATIONS

There is some doubt that the trawl adequately sampled the forage fish population; therefore, the numerical population estimates for gizzard shad, crappie and freshwater drum are questionable. The sampling regime should be altered for inclusion of a more effective trawl. In the next sampling segment the otter board trawl should be used concurrently with a tucker trawl (Houser, 1976).

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ANNUAL PERFORMANCE REPORT
RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-91-R-1

STUDY NO.: 507.1

JOB NO.: 2

NAME: Inter-Relationships of Forage Fish Species and Predator Populations in Lake Rathbun

TITLE: Predator population abundance in Lake Rathbun

Period Covered: 1 July, 1977 through 30 June, 1978

ABSTRACT: Abundance of the predator population at Rathbun Lake was estimated at about 500/ha (200/ac) based upon mark and recapture in April-May. Estimated abundance for cove rotenone sampling in August was 260/ha (106/ac) at 63 kg/ha (57 lbs/ac). Crappie were most abundant at 137/ha (56/ac) with biomass estimates of 21 kg/ha (19 lbs/ac). White bass were estimated at 76/ha (31/ac) with a biomass of 16 kg/ha (15 lbs/ac). The remaining predators included channel catfish at 15/ha (6/ac); estimated biomass was 11 kg/ha (9 lbs/ac). Walleye density was 14/ha (6/ac) with a biomass of 8 kg/ha (7 lbs/ac). Estimates for largemouth bass were 20/ha (8/ac) at 9 kg/ha (8 lbs/ac). Length-frequency distributions and proportional stock density of the predator populations were compared.

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Date prepared: 30 June, 1978

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STUDY OBJECTIVE

To increase utilization of forage fish by predator fish populations in Lake Rathbun by using floodwater control regimes to alter the abundance, size structures and diversity of forage fish populations.

JOB 2 OBJECTIVE

To determine population abundance and size structure of predatory fish in Lake Rathbun.

INTRODUCTION

Channel catfish, walleye, white bass and largemouth bass were stocked at Lake Rathbun to create a sport fishery from the initial plant and at the same time provide a self-perpetuating predator population. Crappie remained in the watershed after renovation, hence stocking was not necessary. Likewise, forage species were not introduced consequently the forage population developed from indigenous species.

Growth and development of the predator species was documented by Paragamian (1977) where he found dominant year classes of walleye, largemouth bass and channel catfish were due to early plantings; later stockings were not as successful and channel catfish stocking was discontinued after the second year of impoundment. Largemouth bass stocking ceased after three years, but experimental stocking of larger fingerling was resumed in 1977. Walleye were stocked annually since initial impoundment.

Predator population abundance fluctuated quite widely, particularly for white bass where there was a 75-fold increase during 1972-1975. The magnitude of change for walleye and largemouth bass was much less with the population decreasing by about six times. Crappie and channel catfish populations fluctuated even less, changing no more than three-fold.

Relative abundance and trends in the predator population were well documented, but the absolute numerical abundance remains unknown. The objective of this segment was to determine the numerical abundance and size structure of the major predatory fish species populations at Rathbun Lake.

METHODS

Population abundance for predators was estimated by two methods. For walleye, crappie, white bass, largemouth bass and channel catfish the populations were estimated by mark-recapture technique in the spring at Buck Creek embayment and by cove rotenone sampling in August.

Spring population estimates commenced on 23 March and continued through 19 May where predators were marked by excision of left pectoral or pelvic fins depending upon the area in Buck Creek they were captured. The pectoral fin was removed from fish captured above the boat ramp whereas the pelvic fin was removed from fish located below the ramp. These marks were later used to estimate intra-bay and inter-reservoir movement. Population estimates were computed from a multiple census Schnabel procedure where marking and recapture occurred simultaneously.

Fish were captured with gill nets, fyke nets and electrofishing. Largemouth bass were sampled almost exclusively with electrofishing, while the remaining species were taken with fyke and gill nets. Nearly 60% of the walleye and channel catfish were marked during walleye spawning in March, while the number of crappie, white bass and largemouth bass marked was fairly uniform from 23 March-19 May. Crappie ≥ 140 mm (5.5 in) were marked while the size restriction for white bass was ≥ 150 mm (6 in). Walleye and largemouth bass ≥ 220 mm (9 in) were marked. The population estimate of channel catfish was based upon fish ≥ 305 mm (12 in).

Methods for population estimates of predators based upon cove rotenone samples were identical to methods for prey populations. Numerical counts in the cove samples were expanded to the whole reservoir by adjusting the data to account for lack of homogeniety in spatial distribution of species and size groups between cove and open water habitat (Hayne, 1967).

FINDINGS

SPRING ESTIMATES

Population estimates of walleye were based upon 362 marked fish, examination of 380 fish, and recapture of 7. The estimate commenced at about 3,000 and then gradually increased to 8,726 in May (Table 5). The estimate never stabilized but continued to rise until marking ceased indicating at least one assumption for a valid estimate was violated.

Table 5. The final cummulative population estimates ($\hat{N}$) of the major predatory fish species in Buck Creek Embayment with lower and upper 95% confidence intervals.

	$\hat{N}$	95% C.I.	
		Lower	Upper
Walleye	8,726	5,013	33,667
Largemouth bass	184	116	451
White crappie	20,716	18,143	24,143
Black crappie	6,883	5,645	8,814
Channel catfish	2,808	2,245	3,749
White bass	21,064	12,740	60,762

Walleye movement during spawning undoubtedly influenced the accuracy of the estimate. A marked walleye was netted by a brood fish collection crew approximately eight miles from Buck Creek five days after marking. During the remainder of the segment 40 walleye marked in Buck Creek Bay were recaptured outside the embayment. Such extensive movement, particularly during spawning, precluded an estimate of the walleye population within Buck Creek Bay.

The final cummulative population estimate of crappie was 20,716 for white and 6,883 for black crappie. The estimate for the former was based upon a sample of 3,090 fish of which 2,660 were marked and released. Recaptured crappie totalled 191. The estimate started at about 11,000 increasing gradually to 20,000 by 21 April where it remained fairly constant until the end of the estimate. The confidence interval at the 95% level on the last estimate was 18,143-24,143. Population abundance of black crappie was determined from 1,013 marked fish, 1,142 examined and 80 recaptured. Black crappie population estimate reached stability by 27 April at about 6,500. Fiducial limits for the final cummulative estimate at the 95% level were 5,645-8,814.

Movement of crappie from Buck Creek Bay into the pool was minimal. Netting within a three mile radius of the mouth of Buck Creek Bay yielded 2,634 crappie of which 36 were marked (1.4%) compared to 13.3% marked within the study area.

Numerical abundance of white bass in Buck Creek Bay was estimated at 21,064 with 95% confidence on the final cummulative estimate of 12,740-60,762. Sample size was 572 marked, 722 examined and 9 recaptured. There was no detected movement of white bass from the study area. The estimate started at about 10,000 in early April, then it gradually increased and stabilized at 20,000 by late April.

Sample size for the largemouth bass population estimate was 52 largemouth bass marked, 75 examined and 11 recaptured. An estimated 28% of the population was marked. The initial estimate in early April was 118 which gradually increased to 184 when sampling ceased. The confidence interval at the 95% level was 116-451. Movement of largemouth bass out of the study area was nonexistent.

The cummulative population estimates of channel catfish ranged from 1,660 on 1 April to 2,808 on 19 May when sampling ceased. The final estimate was based upon 571 marked fish and 649 examined of which 61 were recaptured. Confidence interval at the 95% level on the final cummulative estimate was 2,245-3,749. Considerable interchange of channel catfish between Buck Creek Bay and the pool was revealed. During the segment the population estimate continued to increase and even after seven weeks the estimate continued to fluctuate. Netting within a three mile radius from the mouth of Buck Creek yielded 201 channel catfish of which 13 (6.5%) were marked. Estimated percentage of catfish with fin clips in Buck Creek Bay was no greater than 6.5%. Thus, there was a high degree of catfish movement between the pool and embayment causing an upward bias from the true estimate. A more realistic estimate based upon the frequency and distribution of marked fish out of the study area would be within 1,600-1,800.

Size structure of the predator populations fell into two groups including crappie and white bass in the smaller spectrum and walleye, largemouth bass and channel catfish in the larger size group. Proportional stock density (PSD) was computed for the populations to more quantitatively describe the size structure. The PSD standard for largemouth bass is: 45-65% of the population sample over

203 mm (8 in) should be larger than 305 mm (12 in). Largemouth bass at Rathbun yielded a PSD of 71% well above the standard indicating poor reproductive success. Size structure in the population ranged from 190 mm (7.5 in) to 520 mm (20.5 in) with the mode at 340 mm (13.3 in) (Figure 7).

PSD criteria for walleye and channel catfish were arbitrarily chosen as: 40-55% of the population sample over 254 mm (10 in) should be larger than 381 mm (15 in). This standard showed walleye PSD was 75%. Sampling was mainly during spawning, therefore immature fish were not well represented. The walleye distribution was bimodal with the first mode at 460 mm (18.1 in) and dominated by mature males. The second mode occurred at 570 mm (22.4 in) and was dominated by females. Range in size was 210-660 mm (8.3-26.0 in).

Channel catfish PSD was 73% which was well above the standard. The large PSD indicated good survival of catfish during the first years of impoundment. Size structure in the catfish population had a range of 190-640 mm (7.5-25.2 in) with a mode occurring at 470 mm (18.5 in).

PSD standards for crappie and white bass were: 40-60% of the population sample over 127 mm (5 in) should be larger than 203 mm (8 in). Crappie PSD was 43% and the size range was 130-300 mm (5.1-11.8 in) with a mode at 180 mm (7.1 in) (Figure 8). Black and white crappie were nearly identical in size with white crappie slightly larger than black crappie.

White bass PSD was 67%. Size structure of white bass was more restricted than crappie with a 150-280 mm (5.9-11.0 in) size range. The mode was centrally located occurring at 210 mm (8.3 in).

Biomass estimates for the five major predators based upon the population estimates and mean weight in the population ranged from 1.0 kg/ha (0.9 lbs/ac) for largemouth bass to 101 kg/ha (90 lbs/ac) for walleye. Crappie had an estimated biomass of 25 kg/ha (22 lbs/ac), while white bass and channel catfish biomass was identical at 22 kg/ha (20 lbs/ac). Population estimates of walleye and channel catfish were biased upwards; therefore, the biomass estimates were inflated.

COVE ROTENONE ESTIMATES

The predator population estimate based upon cove rotenone samples was 261 fish/ha (106/ac) at 53 kg/ha (57 lbs/ac). Crappie comprised approximately 50% of the sample by number contributing 137/ha (56/ac) at a biomass of 21 kg/ha (19 lbs/ac).

White bass were second most numerous at 76 fish/ha (31/ac) with an estimated biomass of 16 kg/ha (15 lbs/ac). The remaining predators were far less dense with channel catfish at 15/ha (6/ac); estimated biomass was 11 kg/ha (9 lbs/ac). The estimated abundance of walleye was 14/ha (5.5/ac) with a biomass of 7.6 kg/ha (6.8 lbs/ac). Density and biomass of largemouth bass was slightly greater at 20 fish/ha (8/ac) and 8.5 kg/ha (7.6 lbs/ac).

Length-frequency from the cove samples showed crappie had the smallest size structure in the predator population ranging from 130 mm (5 in) to 270 mm (11 in) (Figure 9). Median size and the mode in the distribution were identical at 200 mm (7.9 in).

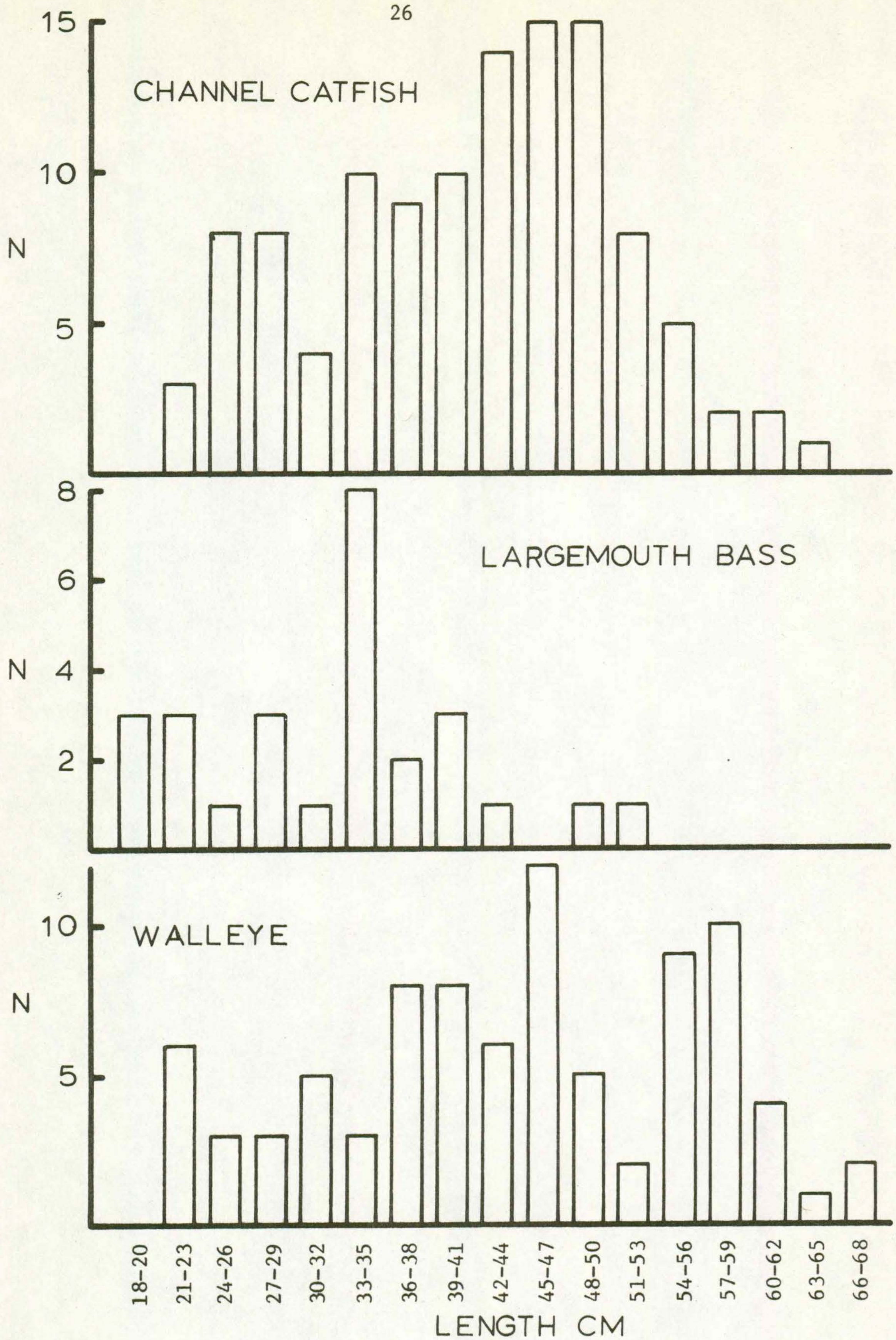

Figure 7. Length-frequency distribution of three predatory fish from spring samples at Lake Rathbun, 1977.

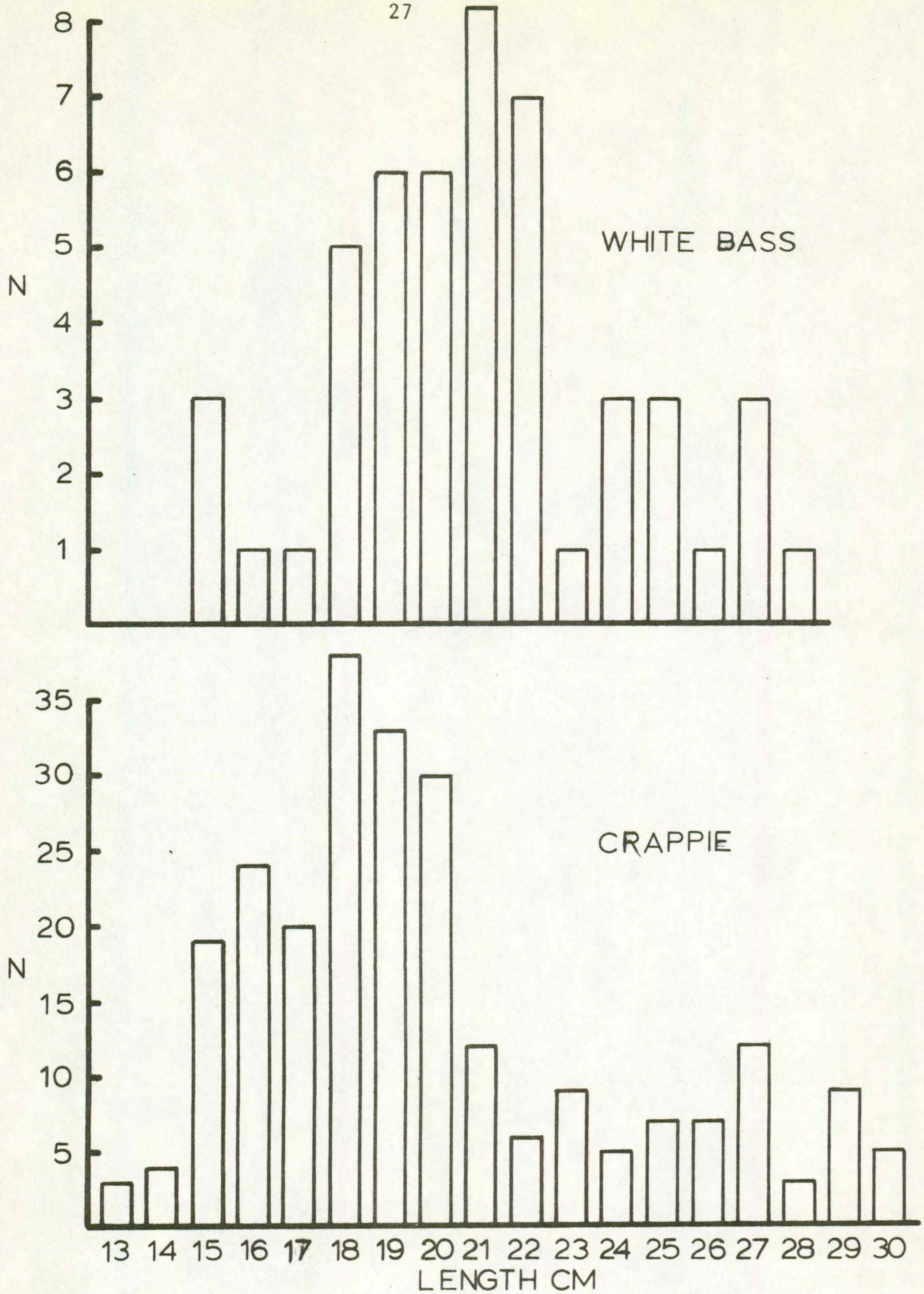

Figure 8. Length-frequency distribution of white bass and crappie from spring samples at Lake Rathbun, 1977.

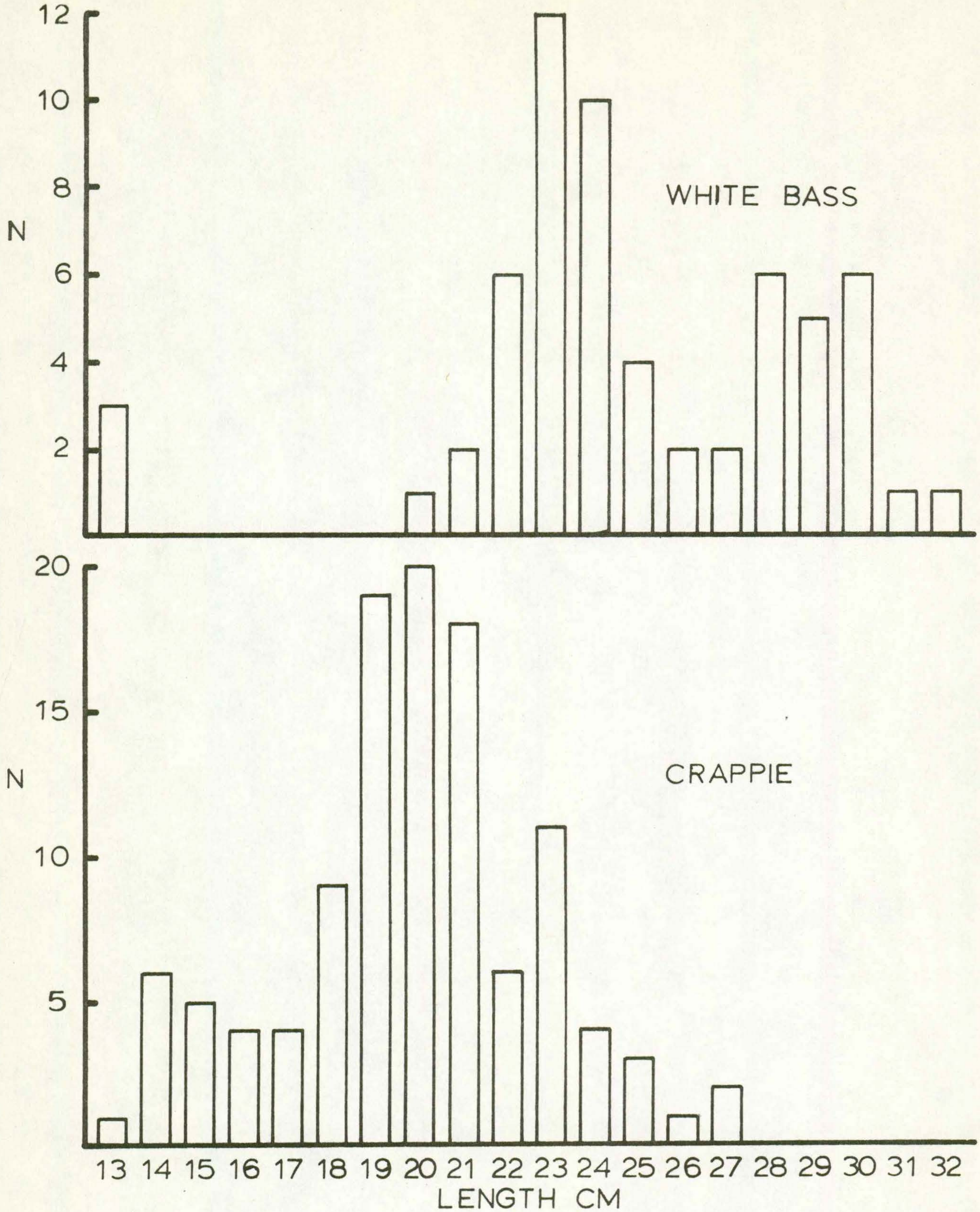

Figure 9. Length-frequency distribution of white bass and crappie from cove samples at Lake Rathbun, 1977.

White bass were considerably larger ranging from 130-320 mm (5.1-12.6 in) with no fish taken in the 140-190 mm (5.5-7.5 in) size group. The median in the sample was 225 mm (8.9 in), but the distribution was multimodal with peaks occurring at 130, 230 and approximately 290 mm (5.1, 9.0 and 11.4 in).

Sample size for walleye, channel catfish and largemouth bass was much smaller, but a wide range in size was found. Walleye ranged from 220 mm (8.7 in) to 670 mm (26.4 in) with distinctive modes at 240 mm (9.4 in), 370 mm (14.6 in) and 470 in (18.5 in). The first mode was represented by yearling walleye, while the latter were adults.

Largemouth bass ranged from 130-430 mm (5.0-16.9 in) with no particular modes. Channel catfish showed a similar pattern except the overall size distribution was greater with a range of 250-530 mm (10.0-20.9 in). Again, the sample size was small (N = 19) with rarely more than two fish representing a 10 mm (.4 in) size class. Thus, the distribution was uniform or in many classes void.

DISCUSSION OF FINDINGS

Estimates of population abundance, biomass and size structure were vastly different between sampling methods. This was particularly true for walleye and largemouth bass. Mark-recapture estimtes showed walleye abundance was approximately 5 times greater than the cove sampling method and the biomass estimate was 13 times greater. Likewise, the size structures by the two methods were considerably different; the mean weights were 543 g and 1,396 g for cove and mark-recapture methods, respectively. Much of the difference in estimated density was due to the inaccuracy of the mark-recapture estimate, caused by movement of marked fish from the confines of Buck Creek Embayment during spawning. The difference in sample size structure was also related to spawning activity where a preponderence of fish sampled were large, mature females.

Population statistics for largemouth bass showed the opposite. Cove estimates were about 13 times numerically greater and 9 times greater in biomass. Average size in the cove sample was slightly smaller.

Comparison of population statistics between the sampling methods showed there was much closer agreement in biomass estimates for crappie, white bass and channel catfish. The biomass estimate for crappie based upon mark and recapture was 25 kg/ha (23 lbs/ac) compared to 21 kg/ha (19 lbs/ac) for the cove sample. The greatest difference in population statistics for crappie occurred in size structure where crappie in the cove sample were about 25% larger by weight.

White bass biomass estimates were 16 kg/ha (14 lbs/ac) and 22 kg/ha (19 lbs/ac) for cove and Buck Creek samples, respectively. As with crappie, the mean weight of white bass in the cove sample was greater; in this case approximately 40% greater.

Estimated biomass of channel catfish was 51% greater for the mark-recapture sample. Much of this difference was explained by the movement of marked fish from the study area. Size structure of the catfish population was similar where weight in the mark-recapture sample was about 20% greater.

RECOMMENDATIONS

Both methods of sampling the predator population were valuable in describing abundance, biomass and size structure, but the mark-recapture method for walleye was inaccurate due to movement. In 1978, the mark-recapture method should continue for walleye only, but it should be modified to reduce the error. Walleye should be marked during March and April when they are spawning and include those fish used by the hatchery for stripping. Marked and released fish will be allowed to mix with the unmarked population for approximately one month before the second sample commences. Sampling for marked walleye will continue with replacement until 95% precision at 80% accuracy is attained.

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-91-R-1

STUDY NO.: 507.1

JOB NO.: 3

NAME: Inter-Relationships of Forage Fish Species and Predator Populations in Lake Rathbun

TITLE: Utilization of the forage fish population by predators in Lake Rathbun

Period Covered: 1 July, 1977 through 30 June, 1978

ABSTRACT: Food habits of crappie, white bass, walleye, largemouth bass and channel catfish were determined in April-October to estimate the total consumption of each forage population. These predators consumed an estimated 240 kg/ha (210 lbs/ac) of forage, most of which were fish accounting for 203 kg/ha (178 lbs/ac) of the predator intake. Shad were the most important prey species contributing about 80% to the ration by weight. Daily food consumption ranged from 162 g/ha/day (.14 lbs/ac/day) for walleye to 322 g/ha/day (.29 lbs/ac/day) for crappie. White bass were most piscivorous; 99% of the food items were fish remains. Channel catfish were second most piscivorous, but less selective. They fed on shad, walleye, crappie, bluegill, carp and white bass. Channel catfish also depended upon dead shad during April-May. Largemouth bass were less dependent upon shad consuming 11 kg/ha (10 lbs/ac) and were more dependent upon crayfish which made up 10 kg/ha (9 lbs/ac) of the total intake. Crappie were less piscivorous than the other predators with 76% of the diet consisting of fish. Because of their greater abundance crappie consumed 46 kg/ha (41 lbs/ac) of the annual shad production. Crappie were more dependent upon invertebrates consuming 13 kg/ha (12 lbs/ac). Walleye consumed three prey species including gizzard shad at 20 kg/ha (18 lbs/ac), crappie at 2 kg/ha (1 lbs/ac) and young walleye at .2 kg/ha (.1 lbs/ac). Predatory fish consumed the same food items, primarily gizzard shad, most of which were eaten during the same time period and in the same habitat component, however, because shad growth was slow and there was a great abundance of forage, competition was not severe. Recommendations were presented to improve the forage populations by introductions of threadfin shad and spottail shiner.

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Date prepared: 30 June, 1978

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Fishery Research Supervisor

STUDY OBJECTIVE

To increase utilization of forage fish by predator fish populations in Lake Rathbun by using floodwater control regimes to alter the abundance, size structure and diversity of forage fish populations.

JOB 3 OBJECTIVE

To determine the quantity and size of forage fish species consumed by predatory fish in Lake Rathbun.

INTRODUCTION

Fish populations in large reservoirs when considered at the species level are fairly well understood, but knowledge of the inter-relationships between these populations is lacking. Life history and population characteristics for single species within the predator population at Rathbun Lake were presented by Paragamian (1977). Mayhew (1977) investigated larval fish populations at Rathbun Lake where he described the populations of gizzard shad, crappie and bluegill. Mayhew's investigation, however, included a community-type approach with concise descriptions of larval fish population statistics and the relationships to major physical factors, flood control regimes, and fish-food organisms. The latter included the food habits of fish larvae and their trophic interaction with zooplankton populations. The investigation quantified important physical and biological factors involved in production of larval and juvenile fish, however, the relationship between predator and prey remains unknown.

Numerous investigations have adequately described the food habits of nearly every fish species, but few studies have dealt with the community concept and fewer investigations such as Forney (1977) and Seaburg (1964) have dealt with the concept of competition and trophic overlap within the predator population.

The objective of this segment is to proceed upwards in the trophic structure by determining the quantity and size of forage consumed by predators in Lake Rathbun.

METHODS

Prey consumed was computed for walleye, largemouth bass, white bass, crappie and channel catfish and each species was further divided into three size categories. Thus, predators were represented by 15 components. Qualitative food habits were determined monthly during April-September for each component. Within each period 10 stomachs from each species were preserved for analysis. Care was taken to select fish representing the entire size range of the species. Size categories for predator species are given in Table 6.

Table 6. Major predators and size categories in mm used for food habit sampling at Lake Rathbun. Values in parenthesis are inches.

	Small	Intermediate	Large
Walleye	200-349 (7.9-13.7)	350-499 (13.8-19.6)	> 500 (> 19.7)
Largemouth bass	200-309 (7.9-12.2)	310-419 (12.3-16.5)	> 420 (> 16.6)
White bass	140-219 (5.5- 8.6)	220-299 (8.7-11.8)	> 300 (> 11.9)
Crappie	130-189 (5.1- 7.4)	190-249 (7.5- 9.8)	> 250 (> 9.9)
Channel catfish	300-409 (11.8-16.1)	410-519 (16.2-20.4)	> 520 (> 20.5)

Fish were captured with electrofishing gear and gill nets. The latter were used when electrofishing failed. Gill nets were fished at two hour intervals to assure food items in the stomachs were not digested beyond recognition. Sampling occurred primarily at night because fish were more easily attained, a greater frequency of stomachs contained food and the food items were more easily identifiable.

Food items in the stomach were identified, weighed and measured. When possible fish were identified to species, while invertebrates were identified at least to Order. Fish remains were further analyzed to estimate length and weight. Forage fish taken during the sampling period and undigested fish within the stomachs were used as a reference series. Measurements from hard structures in the stomach contents such as vertebrae, scales and spine dimensions were compared with reference to estimate size and weight of the prey before digestion.

Forage weight in the diet was expressed as a decimal equivalent, by weight, of the whole ration. Total composition for each predator and size group was based upon information from previous investigations where the daily ration was expressed as percent of body weight. Biomass of each species in the predator population was multiplied by the appropriate percent body weight factor giving the ration required on a particular day. For example, estimated daily consumption for crappie was 1.55% of the body weight and the estimated biomass of crappie was 20.8 kg/ha (18.6 lbs/ac). Thus, the necessary daily consumption for body maintenance and growth was 322 g/ha/day (.29 lbs/ac/day). The percent ration per body weight and biomass estimates used for prey consumption estimates are given in Table 7.

Total consumption of each prey species was computed as the product of estimated daily consumption (kg/ha/day) and the decimal equivalent of that particular prey species. And last, consumption of the prey species for each predator species was summed.

Table 7. Biomass, daily ration and estimated daily consumption by predator populations at Lake Rathbun.

	Biomass		Ration	Daily consumption	
	kg/ha	lbs/ac	% body wt	g/ha/day	lbs/ac/day
Walleye	7.6	6.8	2.00[a]	162	.14
Largemouth bass	8.5	7.6	2.82[b]	240	.21
White bass	16.3	14.6	1.55[c]	253	.23
Crappie	20.8	18.6	1.55[d]	322	.29
Channel catfish	10.6	9.5	3.00[e]	318	.28

[a]Swenson (1973).

[b]Lewis (1974).

[c]Wissing (1974).

[d]Seaburg (1964).

[e]Andrews (1972).

FINDINGS

Walleye, largemouth bass, white bass, crappie and channel catfish consumed an estimated 240 kg/ha (210 lbs/ac) of prey during April-October, 1978. The most important food, by far, was fish accounting for 203 kg/ha (178 lbs/ac) of the predator intake (Table 8). Fish accounted for 85% of the biomass consumed, insects were second most important contributing 8% to the diet by weight followed in order of importance by crayfish, filamentous algae, rodents and unidentified food. The latter items contributed no more than 3% to the weight of prey consumed by predators.

White bass were most piscivourous where 99% of the food items examined were fish remains. They consumed 43 kg/ha (38 lbs/ac) of shad, while 10 kg/ha (9 lbs/ac) were unidentified fish. Insects comprised the remaining 1% of the white bass diet accounting for .1 kg/ha (.09 lbs/ac) of prey. Channel catfish were second most piscivorous but less selective. Prey identified in catfish stomachs were shad, walleye, crappie, bluegill, carp and white bass. Estimated consumption of fish during April-October accounted for 51 kg/ha (45 lbs/ac) of prey production. Most important in the diet was shad comprising 28 kg/ha (25 lbs/ac) of the catfish ration. Small walleye were second most important comprising 13% of the catfish diet by weight accounting for 8 kg/ha (7 lbs/ac) of the walleye production. Bluegill and white bass juveniles and yearlings were consumed in nearly the same proportion contributing about 5 kg/ha (4 lbs/ac) to the catfish ration. Crappie and carp each contributed about 2 kg/ha (2 lbs/ac) to the total consumption by channel catfish in April-October. The remainder of the catfish ration included insects, crayfish, filamentous algae and unidentified food with crayfish most important.

Table 8. Estimated total consumption (kg/ha) of food items by five major predators at Rathbun Lake, April-October, 1977.

	Crappie		W bass		Walleye		LM bass		C catfish		Total	
	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac	kg/ha	lbs/ac
Shad	46	41	43	38	20	18	11	10	28	25	148	132
Walleye	2	1			< 1	< 1			8	7	10	8
Crappie					2	1			2	2	4	3
Bluegill									5	4	5	4
Bullhead							6	5			6	5
C catfish							< 1	< 1			< 1	< 1
Carp							7	6	2	2	9	8
W bass									6	5	6	5
Unidentified fish	4	3	10	9	1	1	< 1	< 1	< 1	< 1	15	13
Total fish	52	45	53	47	23	20	24	21	51	45	203	178
Insects	13	12	< 1	< 1	4	4	< 1	< 1	< 1	< 1	17	16
Crayfish							10	9	1	1	11	10
Filamentous algae									3	2	3	2
Rodent									< 1	< 1	< 1	< 1
Unidentified	4	3			< 1	< 1			2	1	6	4
Total	69	60	53	47	27	24	34	30	57	49	240	210

Largemouth bass also had a wide range of food selection consuming five fish species, insects and crayfish. Shad dominated the diet accounting for 11 kg/ha (10 lbs/ac) of shad production, while consumption of carp and bullhead was 7 and 6 kg/ha (6 and 5 lbs/ac), respectively. Crayfish were third in importance contributing 10 kg/ha (9 lbs/ac) to the total consumption of largemouth bass. Young crappie, channel catfish, unidentified fish and insects provided the remainder of the ration accounting for 3 kg/ha (2 lbs/ac) of the forage population.

Crappie were less piscivorous than other predators with 76% of the diet made up of fish. Because of their greater abundance crappie consumed more shad than any of the other predators with 46 kg/ha (41 lbs/ac) of the food from shad population. Young walleye comprised 2 kg/ha (1 lbs/ac) of the total crappie ration, while unidentified fish accounted for 4 kg/ha (3 lbs/ac) of the forage production. Crappie were far more dependent upon insects than other predators where approximately 20% of the diet, by weight, were insects. This portion of the diet accounted for 13 kg/ha (12 lbs/ac) of the prey consumed.

Walleye were nearly as selective as white bass consuming three prey species: gizzard shad, crappie and walleye. Shad were most important comprising 20 kg/ha (18 lbs/ac) of the forage population consumed by walleye. Juvenile crappie made up 2 kg/ha (1 lbs/ac) of the prey and young walleye comprised .2 kg/ha (.2 lbs/ac) of the forage population. Insects provided the remaining 4 kg/ha (4 lbs/ac) food biomass.

Food selection between sample periods was mainly dependent upon what was available. For example, in April and May shad were nearly non-existent in predator stomachs with the exception of large channel catfish which consumed yearling gizzard shad. Undoubtedly most of these shad were dead when consumed. Dead shad were common on the bottom and along the shoreline during the spring. Gizzard shad didn't become important to the predator until June and from then on shad dominated as a major food item through October. Crappie and walleye consumed insects in April and May comprising about 96% of the biomass in the diet. During June gizzard shad increased in importance and by July approximately 80% of the diet, by weight, was shad. White bass switched to shad sooner; in May 100% of the diet was shad.

In April-June largemouth bass fed primarily on yearling bullhead and crayfish and only in July were shad found as the dominate food item. The primary food items of channel catfish in April and May were small white bass and bluegill. In July 99% of the food biomass was shad.

From June to the end of the sampling period in October the five major predators fed primarily on gizzard shad, however, each segment of the predator population consumed shad of different sizes. For example, in June, walleye consumed shad $\geq$ 30 mm (1.2 in), while crappie and white bass consumed few shad in that size category, rarely consuming shad greater than 20 mm (.8 in). Likewise, in July walleye tended to consume larger shad [50-90 mm (2.0-3.5 in)], while crappie and white bass fed upon smaller shad [30-60 mm (1.2-2.4 in)]. By September, walleye, crappie and white bass were consuming shad of the same size ranging from 50-100 mm (2.0-4.0 in). Largemouth bass and channel catfish consistently selected large shad regardless of the month sampled.

Diversity of indexes used to measure habitat stability and fitness were computed both for the predator and prey populations using a modification model by Hilsenhoff (1971). A large index number showed greater diversity. Forage diversity was computed for cove samples and trawl samples. The former yielded an index of .91, while the trawl sample had a diversity of 1.05. Diversity in the predator population was 1.22.

DISCUSSION OF FINDINGS

Gizzard shad were abundant in Rathbun Lake in 1977, growth was slow, and forage population diversity was low. The slow growth in the shad population allowed predatory fish to feed upon the entire size range of juvenile shad, even into October. At first, crappie and white bass fed mainly upon smaller shad, while walleye and channel catfish consumed larger individuals. By late summer mean length of shad was fairly low and in September and October predators fed on shad of all sizes. Size selection of prey species by predators was negligible from mid-August to the end of the sampling period.

Production of juvenile shad based upon mortality and growth in the trawl samples and numerical abundance of shad in the cove samples yielded an annual production of 46 kg/ha (41 lbs/ac). This was about three times less than the estimated biomass of shad consumed. Most of the discrepency was due to the exclusion of age 1 and larger shad from the production estimates. Walleye and channel catfish consumed a few yearling and age 2 shad. Although few in number the biomass of one large shad was at least 10 times greater than a juvenile shad. Channel catfish, in particular, consumed large quantities of gizzard shad in the spring. Thus, they were feeding on the previous years shad production. Crappie and small walleye fed almost entirely on insects before small shad were available.

Regardless of the difference in estimated shad production and the biomass of shad consumed, predators undoubtedly were responsible for a major portion of mortality in the prey population. Shad were removed at an estimated rate of 30% per week and the estimated consumption of shad by predators was about 5 kg/ha/week (4 lbs/ac/week). By August the juvenile shad population biomass was reduced to 26 kg/ha (23 lbs/ac). Undoubtedly much of the shad production previous to the August estimate was used as food by predators.

Predatory fish at Rathbun Lake consumed the same food items, most of which were eaten during the same time period and, in most cases, in the same habitat component, however, competition was not severe. The low diversity index of prey and the large quantity of food consumed by predators showed a potential for competition, but the forage population, particularly shad, remained at high levels into October. Competition at low levels was also shown by the selection of the same food item (shad) by all predator species. Channel catfish and large-mouth bass are more facultative in their feeding habits, but even in October they were consuming large quantities of shad. Also, juvenile crappie and drum were not readily used as food even though they were fairly abundant. Either they were less vulnerable or shad were more preferred or more easily sought by predators.

RECOMMENDATIONS

Competition for forage fish between predatory fish species at Rathbun Lake was nearly non-existent when the gizzard shad population was abundant and growth was slow. However, during years of lower shad density and more normal growth small walleye, crappie and white bass would have to rely upon another food source. Findings of the investigation also showed forage fish were lacking in the predator diet in April through mid-June.

Management of forage species at Rathbun Lake should include 1) introductions of more favorable forage species and 2) alteration of water management regimens to allow maximum reproductive success and slow growth rates in the forage populations.

Introductions should include threadfin shad and spottail shiner. Threadfin shad has a slower growth rate than gizzard shad and will be vulnerable as prey during a longer time. Concomitantly threadfin will compete directly for food with gizzard shad, thus providing a growth limiting control within the gizzard shad population. Threadfin shad would have to be stocked annually and would not be available as prey during the spring when forage is scarce. Stocking should occur in early April at no less than 10,000 mature fish.

Spottail shiner should be introduced to provide forage in the spring and also exert a biological control on gizzard shad growth. Spottails grow slower than threadfin shad and in some years spawn twice; once in May-June and again in August. Spottail shiner are an open-water species feeding mainly upon zooplankton. Introduction and establishment of spottail shiner would be ideal for small walleye, crappie and white bass particularly early in the growing season. Stocking should occur previous to spawning at no less than 20,000 mature fish.

Water management should be implemented to help control gizzard shad density. Although the primary management goal is flood control at Rathbun input into the comprehensive operational plan should be provided. Implementation of recreational fishery oriented management within the framework of flood control would help assure the success of forage species introductions and ultimately the well-being of the predator fish populations.

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