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CONTENTS

This report is printed by authority of the State of Illinois, IRS Ch. 127, Par. 58.12. It is a contribution from the Section of Aquatic Biology of the Illinois Natural History Survey.

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The Effects of Supplemental Feeding and Fall Drawdowns on the Largemouth Bass and Bluegills at Ridge Lake, Illinois

George W. Bennett
H. Wickliffe Adkins
William F. Childers

IN 1963 WHEN THE PROGRAM described here was begun, studies of the fish population of Ridge Lake had been going on for 21 years (Bennett 1954*a* and 1954*b*; Bennett & Durham 1951; Durham & Bennett 1949 and 1951; Bennett, Adkins, & Childers 1969). These studies involved annual controlled public fishing during June, July, and August and draining censuses (usually in the spring) to gain estimates of the total population of fishes in the lake. Between these draining censuses we applied several types of primary or secondary population manipulation, or none at all, to explore the effects of these manipulations upon the fish populations and the yields of fishes. This period included 10 years of biennial draining of the lake and culling of small fishes; 5 years of fall drawdowns of the lake, with one draining census after 2 years and one after 3; 4 years of stable water levels and no manipulation of the fish population; and 3 years of testing the value of hybrid sunfishes for angling (Childers 1967:189). In the period 1941–1970, Ridge Lake has been completely drained and the fishes have been censused 10 times: in 1943, 1945, 1947, 1949, 1951, 1953, 1956, 1959 (in the fall), 1963, and 1970. On the basis of complete creel censuses in all years (except 1942, when the lake was closed to fishing) we were able to measure with some degree of certainty the type of fish population the lake would support and the effects of various management efforts on that population.

The fishes included in this investigation were largemouth bass, *Micropterus salmoides* (Lacépède); bluegills, *Lepomis macrochirus* Rafinesque; warmouths, *Lepomis gulosus* (Cuvier); lake chubsuckers, *Erimyzon sucetta* (Lacépède); and channel catfish, *Ictalurus punctatus* (Rafinesque). Any other fishes that gained entrance to the lake through fishermen's minnow buckets or from the drainage basin were removed during the draining censuses. All of the fishes in the Ridge Lake population descended from 435 largemouth bass stocked in 1941, 129 bluegills stocked in 1944, 138 warmouths stocked in 1949, 558 lake chubsuckers stocked in 1960, and several groups of 6- to 12-inch channel catfish stocked in 1951, 1952, 1957, and 1969. The several stockings of catfish were necessary because channel catfish usually cannot reproduce successfully in Ridge Lake. All of the other fishes (bass, bluegills, warmouths, and chubsuckers) have maintained adequate populations through natural reproduction and survival with no stocking but the original one.

Experimental drawdowns were begun at Ridge Lake in 1951. In the spring of that year the lake was drained; the fishes were censused; and selected numbers of largemouth bass, bluegills, and warmouths were returned to the partially filled basin. The lake refilled before June 1 and was opened to controlled public fishing during the summer until September 1. Fishing was then terminated and the lake level was lowered 4.6 meters (15 feet), reducing the surface area from 6.9 to 2.0 ha (17 to 5 acres) and the maximum depth from 7.6 meters to 3 meters (25 to 10

Frontispiece.—A 3-meter (10-foot) drawdown at Ridge Lake. About one-third of the lake bottom, mostly in the upper end of the impoundment, is exposed by such a drawdown.

feet) without allowing any fishes to escape with the water. Thus, the fish population that had developed through natural reproduction and growth to fill a volume of water represented by a surface area of 6.9 ha[1] (17 acres) became concentrated in a volume represented by 2 ha (5 acres), a minor fraction of the full lake.

In 1952, after the lake had been open to public fishing during the summer, the lake level was again drawn down 4.6 meters (15 feet) in early September. In late March of 1953 the lake was completely drained, the fish were censused, and selected individuals were returned to the lake. These studies were reported in several papers (Bennett 1954*a* and 1954*b*; Bennett et al. 1969). The effect of the 4.6-meter drawdowns in 1951 and 1952 upon the bluegills was severe, reducing their numbers to the point that fewer small bluegills survived than did large ones. To insure the survival of enough bluegills to maintain successive year classes for fishing, it was decided to limit drawdowns to 3 meters (10 feet), leaving a maximum lake depth of 4.6 meters (15 feet) near the dam and a lake surface area of about 4.5 ha (11 acres). This procedure was followed in early September of 1953, 1954, and 1955, and the lake was drained again in the spring of 1956 and a census was made of the fishes. The lesser drawdowns of 1953–1955, inclusive, allowed the survival of a greater number of bluegills (both larger and smaller than 150 mm, or 6 inches, the length at which this fish was considered useful) than the 4.6-meter drawdowns allowed.

Following the spring lake draining and fish census of 1956, selected bass, bluegills, warmouths, and a few channel catfish were returned to the lake; the basin refilled by May. From March 1956 until October 1959 the water level in Ridge Lake was allowed to fluctuate around the crest of the tower spillway, i.e., without any drawdowns and with only minor fluctuations caused by runoff from rains in the lake watershed. In October 1959, after four growing seasons for fishes, the lake was again drained completely and the fishes were censused. As in the years of the drawdowns, the lake was open to controlled public fishing during the summers of 1956–1959.

Thus, as a background for the experiment reported here, the authors had information on anglers' catches and total fish populations from 10 years of biennial draining of the lake and culling of the fishes, 5 years of drawdowns, and 4 years of stable water levels (including that part of 1959 important for fish reproduction and growth). From the lengths, weights, and scales of individual fishes taken by fishermen in 1951–1959 and from similar data gathered from fishes during the draining censuses of 1953, 1956, and 1959, it was possible to compare the growth rates of bluegills and their relative plumpness (condition) under a program of annual fall drawdowns and under another of stable water levels.

In the fish censuses of 1953 and 1956, many of the bluegills were of exceptional sizes but appeared to be comparatively thin. The supplemental feeding proposed at the beginning of the experiment reported on here was in part related to this observation.

Our laboratory production and culture of hybrid sunfishes (Childers 1967) had demonstrated that most species of sunfishes (Centrarchidae) quickly learn to feed upon commercial trout food if the pellets are small enough for them to swallow. Bluegills in laboratory aquaria became plump and grew rapidly on a trout pellet diet. If bluegills in Ridge Lake could be trained to eat fish food pellets to supplement their diet of natural foods, this additional food supply should be reflected in improved bluegill growth and condition. We wished to discover whether enough improvement in bluegill yield would occur to make artificial feeding practical. In 1963 following the spring fish census, we decided to combine September drawdowns of Ridge Lake (for the control of bluegill numbers) with supplemental feeding to increase the

[1] Ridge Lake originally had a surface area of 7.3 ha (18 acres); silt deposits in the upper lake had reduced the area to about 6.9 ha by 1953 and to 6.5 ha by 1963.

growth rate, condition, and yield of these fish. Results would determine whether such a program was practical.

ACKNOWLEDGMENTS

Mr. H. Wickliffe Adkins, stationed at the Ridge Lake Laboratory during the summer months, supervised the fishermen and recorded their catches, fed the fishes twice daily, made daily observations on schools of bass fry and on the nesting of bluegills, assisted in age and growth analyses from fish scales, and recorded many biological happenings of importance to this study. Dr. William F. Childers planned and supervised the draining censuses in 1963 and 1970. Many people assisted in the fish censuses; these included Mr. Robert O. Ellis, Mr. Howard Crum (deceased), Mr. Robert T. Crompton, Mr. Dennis Dooley, Dr. D. Homer Buck, Mr. Richard Baur, Mr. Russell Rose, Dr. R. Weldon Larimore, Mr. H. W. Adkins, Mr. Ronald Havelka, Mr. David Mower, Mr. Edward Doyle, and Dr. George Sprugel, Jr., of the Illinois Natural History Survey staff; Mr. Alvin C. Lopinot, Mr. Arnold Fritz, and Mr. Rudy Stinauer of the Illinois Department of Conservation; and Dr. Leonard Durham and Scott Buck and other students from Eastern Illinois University. The manuscript of this paper was read and criticized by Dr. Horace W. Norton, Professor of Statistical Design and Analysis, Department of Animal Science, University of Illinois, and it was edited by Mr. Robert M. Zewadski of the Natural History Survey.

THE 1963 RESTOCKING OF RIDGE LAKE

Following the draining census of April 8–13, 1963, Ridge Lake was restocked with 2,270 small bass and 116 large ones, 4,492 bluegills, 1,335 warmouths, 1,020 lake chubsuckers, and 11 large channel catfish, a total of 9,244 fishes weighing 510.6 kg (1,125.5 pounds) (Table 1). The weight of these fishes was 78.8 kg per hectare, or 70.3 pounds per acre. Before the restocking, the lake contained 287 kg per hectare (256 pounds per acre), almost four times the weight of fish returned to the lake.

A total of 1,000 channel catfish were stocked on May 21 and 29, 1969. These were Age III fish with an average total length of 259 mm (10.2 inches) and an average weight of 127 grams (0.28 pound); their total weight was 127 kg (280 pounds). On October 20 and 21, after the 1969 growing season was nearly over, an additional 1,000 channel catfish were released. These were also Age III fish, averaging 234 mm (9.2 inches) in total length and 113 grams (0.25 pound) and having a total weight of about 113.4 kg (250 pounds). All of these catfish originated in Arkansas in 1968 and were held in ponds on the Sam A. Parr Cooperative Fisheries Research Center in Marion County, Ill., until stocked in 1969.

After the spring draining and restocking of 1963, the fish population was fished by the public during the summers of 1963 and 1964 under the regular creel censusing system. Otherwise, the restocked fish population of Ridge Lake was allowed to expand for almost 2 years before any experimental management program was applied. During the summer of 1963 fishermen caught 299 largemouth bass, 358 bluegills, 49 warmouths, and 11 hybrid sunfishes, weighing a total of 113.4 kg (250 pounds) in 1,816 hours; the catch in 1964 was composed of 554 bass, 1,287 bluegills, 108 warmouths, and 65 miscellaneous hybrid sunfishes, weighing a total of 232.2 kg (512 pounds) in 2,346 hours of fishing. While the total yield per hectare in 1964 was twice that of 1963 (1963, 17.5 kg per hectare, or 15.6 pounds per acre; 1964, 35.9 kg per hectare, or 32 pounds per acre), both must be considered much below the average of the hook-and-line yields of fishes from Ridge Lake in the 1941-1963 period.

THE FEEDING PROGRAM

In May 1965, a supply of Splash Expanded Fish Food was purchased from the Ralph G. Wells Company of Monmouth, Ill. This food consisted of fish

Table 1.—Fishes returned to Ridge Lake following the draining census of April 8–13, 1963.

Species	*Number*	*Weight in Kilograms*	*Weight in Pounds*	*Average Weight in Kilograms*	*Average Weight in Pounds*	*Percent of Total Weight*	*Total Weight*	
							Kilograms Per Hectare	Pounds Per Acre
Largemouth bass								
1954-1955 year classes	8	24.1	53.1	3.01	6.64	....	....	....
1956-1960 year classes	51	79.9	176.2	1.57	3.45	....	....	....
Post-1960 year classes, large	57	57.0	125.6	1.00	2.20	....	....	....
Post-1960 year classes, small	2,270	42.3	93.2	0.02	0.04	....	....	....
Total	2,386	203.3	448.1	....	....	39.8	31.4	28.0
Bluegills								
146–216 mm	966	56.9	125.5	0.06	0.13	....	....	....
76–145 mm	3,526	65.6	144.7	0.02	0.04	....	....	....
Total	4,492	122.5	270.2	....	....	24.0	18.9	16.9
Warmouths								
146–216 mm	5	1.1	2.4	0.22	0.48	....	....	....
76–145 mm	1,330	28.3	62.5	0.02	0.05	....	....	....
Total	1,335	29.4	64.9	....	....	5.8	4.5	4.0
Channel catfish, large	11	44.8	98.8	4.07	8.98	8.8	7.0	6.2
Lake chubsuckers	1,020	110.5	243.5	0.11	0.24	21.6	17.0	15.2
Grand total	*9,244*	*510.5*	*1,125.5*	....	....	*100.0*	*78.8*	*70.3*

meal, corn distillers' dried solubles, meat and bone meal, soybean meal, cottonseed meal, wheat shorts, dehydrated alfalfa meal, brewers' dried yeast, yellow hominy feed, salt, vitamin A and D oils, vitamin A palmitate, D-activated plant sterol, d-alpha tocopherol acetate, thiamin hydrochloride, riboflavin supplement, calcium pantothenate, niacin, choline chloride, vitamin B-12, and trace amounts of nine additional compounds. The food was 32 percent protein and 4 percent fat. Total calories of energy per pound of finished feed were recorded as 1,884.

The original pellets were too large for most bluegills to swallow, but they soon learned to pick at the pellets until they could break off pieces small enough to swallow. After the first season, we purchased smaller pellets. About half of the pellets would float for several hours. The rest would become waterlogged and sink almost at once.

Feeding was begun in late May or early June, and bluegill spawning beds were selected as feeding areas along with the area around the boat dock, where bluegills were observed to congregate (Fig. 1). The fishes were fed twice each day at 10:30 AM and 6:30 PM; the dry fish food pellets were broadcast by hand from a boat. The authors assumed that food pellets that sank into bluegill nests would be picked up by the guarding males for removal from the nests, at which time these fish would discover that the pellets were edible. This was exactly what happened, and bluegills were actively foraging for pellets after less than a week of daily feeding. In less than 2

Fig. 1.—H. W. "Wick" Adkins scattering food for bluegills from the laboratory pier.

weeks it became possible to distinguish bluegills that were eating pelleted food from those that were not by their obviously plump condition. Bluegills were more interested in the pellets that floated and those in the process of sinking than those that had reached the bottom. Probably most of the latter were picked up by catfish after dusk.

The quantity of pelleted fish food purchased and fed each season amounted to 1,360.5 kg in a 6.48-ha lake (1.5 tons per 16 acres of lake). This represented 210 kg per hectare per season (187.5 pounds per acre per season) or a little more than 2.2 kg per hectare per day (2 pounds per acre per day). The cost of the pelleted food used in this experiment was 6 cents per pound when purchased in lots of 1,000 pounds or more. With the feeding rate given above, the cost was $11.25–$12.19 per acre per season or $27.80–$30.12 per hectare per season. As mentioned above, feeding was begun in late May or early June, and it was continued through August.

It became evident that not all of the bluegills were feeding on the pelleted food, either because they had not learned to eat it or because they had not ranged into areas where the food was available. These fish appeared to be quite thin. Some fish appeared to be feeding almost exclusively on "Splash," and when we dissected them, we found that their digestive tracts were gorged with this food. These fish rather quickly became very plump and developed fatty deposits in the mesentaries between the loops of the intestine. After bluegills had fed exclusively on Splash for a month or more, the livers of these fish lost their dark red color and became pink, suggesting fatty degeneration.

FALL DRAWDOWNS

The early fall drawdowns proposed for Ridge Lake were similar in extent and timing to those performed there in the period 1951–1956. The objectives were: (i) to concentrate the fishes that had developed in a 6.5-ha lake (16 acres) within a much smaller volume of water to cause selective mortality among the smaller fishes by stranding and by predation; (ii) to expose a significant portion of the lake bottom to oxidation and drying; (iii) to time the drawdown so that it would coincide with at least a month of warm weather during which water temperatures would remain at 18° C. (64° F.) or above. In the 1951–1956 period our draining censuses in 1953 and 1956 indicated that drawdowns within the range of 3.0–4.6 meters (10–15 feet) would reduce the number of bluegills in the Ridge Lake population by 80–90 percent.

Early fall drawdowns were conducted each year in early September, 1965–1969, inclusive. In 1965 the lake level was lowered 4.6 meters (15 feet) over a period of 15 days (August 30–September 13, inclusive). This slow drawdown was the result of some intermittent rains and our concern about the poor condition of the road beyond the boundary of the park, where the outlet channel from the lake became a ford for several farm families. By October 3, the water level was back up to within 3.4 meters (11 feet) of the full level.

In 1966 and 1967 the lake level was lowered 3 meters (10 feet) below the full level. In both years draining was started on August 28 and completed by August 31. The road ford was regraveled in 1966 so that automobiles could pass through a greater flow of water, and little or no fall precipitation occurred.

In the summer of 1968 there was visual evidence of an abundant supply of small bluegills. Consequently, in the fall of 1968 the lake level was again lowered by 4.6 meters (15 feet); in 1969 the drawdown lowered the lake level 4.3 meters (14 feet). The drawdown operation required 3 days in 1968 and 5 days in 1969.

In every year the lake had completely refilled by April. There was no evidence of loss of fish from winterkill, as even when the lake level was lowered by 4.6 meters (15 feet) there was always an area of water above the dam where the water was 3 meters or more in depth.

Table 2.—Total hook-and-line yield of fishes from Ridge Lake during 2 consecutive years following a draining census (with no supplemental feeding or drawdown), 1963–1964, and 5 consecutive years with summer feeding and early fall drawdowns, 1965–1969.

Year	*Largemouth Bass*		*Bluegills*		*Warmouths*		*Channel Catfish*		*All Fishes*	
	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre
1963	13.6	12.1	3.5	3.1	0.3	0.3	...	...	17.5[a]	15.6[a]
1964	12.6	11.2	20.4	18.2	2.0	1.8	...	...	35.9[a]	32.0[a]
Average of 2 years without feeding and drawdowns	*13.1*	*11.6*	*12.0*	*10.6*	*1.2*	*1.0*	*0.0*	*0.0*	*26.7*	*23.8*
1965	19.4	17.3	53.8	48.0	7.7	6.9	0.2	0.2	81.2[a]	72.4[a]
1966	18.6	16.6	83.9	74.8	3.1	2.8	2.4	2.1	108.0	96.3
1967	17.8	15.9	89.8	80.1	2.3	2.1	1.2	1.1	111.2[a]	99.2[a]
1968	20.3	18.1	64.2	57.3	3.4	3.0	0.4	0.4	88.3	78.8
1969	14.1	12.6	64.4	59.5	1.1	1.0	14.9	13.3	96.8	86.4
Average of 5 years of feeding and drawdowns	*18.0*	*16.1*	*71.2*	*63.9*	*3.5*	*3.2*	*3.8*	*3.4*	*97.1*	*86.6*

[a] Includes a few hybrid sunfishes and other miscellaneous fishes.

POPULATION DYNAMICS OF FISHES DURING THE FEEDING-DRAWDOWN PERIOD

Table 2 shows the yields of the four species of fishes taken by anglers in the fishing seasons 1963–1969, inclusive. This table also shows the averages of the yields for the 2 years when no supplemental feeding or drawdowns were conducted and for the 5 years of the feeding-drawdown program. From these averages it was obvious that a large difference occurred in the yield of bluegills, so large a difference that the average bluegill yield during the feeding-drawdown (f-d) period was about six times that for the pre-experimental 2 years. This difference occurred partly because the fish population was expanding in 1963–1964, and many of the bluegills were too small to interest anglers. This lack of interest in the small bluegills was further demonstrated by the light fishing pressure in those years (46 man-hours per hectare, or 114 man-hours per acre, in 1963; 56 man-hours per hectare, or 138 man-hours per acre, in 1964), as annual fishing pressures below 125 man-hours per hectare per season (309 man-hours per acre) indicated the poor quality of the fishing. However, the eight boats available for angling were seldom, if ever, used to the maximum during August in any year. Annual fishing effort, 1963–1969, is shown in Table 3.

Because the fish population was enumerated in total at the fish census and restocking in 1963 (at the beginning of the experiment) and in the fish census in 1970 (at the end of the experiment) and because the fishermen's total catch was recorded each year, it was possible to show the population dynamics of each individual species during the 7-year period.

Table 3.—Fishing effort, in man-hours per hectare and per acre, expended by fishermen during the seasons 1963–1969, inclusive, at Ridge Lake.

Year	*Man-Hours Per Hectare*	*Man-Hours Per Acre*
1963	46	114
1964	56	138
1965	98	242
1966	103	254
1967	107	265
1968	107	264
1969	102	252

Largemouth Bass

Table 4 shows that the lake was restocked in the spring of 1963 with 2,270 bass of less than 254 mm (10 inches) and 116 that averaged more than 1.36 kg (3 pounds) each. No bass were available in the 254–305-mm (10–12-inch) range, a situation that is inexplicable. In the following 7-year period, the catch consisted of 2,984 bass of less than 254 mm (10 inches), 962 bass of 254–305 mm (10–12 inches), and only 91 larger than 305 mm (12 inches). The record shows that 59 bass ranging in weight from 1.4 to 3.6 kg (3.0–8.0 pounds) were returned to the lake in 1963 and that 22 bass averaging 2.4 kg (5.35 pounds) and 47 averaging 1.2 kg (2.65 pounds) were exposed in the 1970 census, 7 years later. Therefore, one must assume that Ridge Lake contained at least 10 bass weighing more than 2.25 kg (5 pounds) each and 40 or more additional bass, each weighing 1.1 kg (2.5 pounds) or more, through this period of years. In spite of this valid assumption, fishermen caught only 49 bass as large as 1.1 kg (2.5 pounds) and only 2 larger bass, each weighing between 2.7 and 3.2 kg (6 and 7 pounds). At the same time, they were catching and removing 2,984 bass smaller than 255 mm (10 inches) at rates between 300 and 600 per season (fishermen were asked to bring in all bass regardless of size, but we know that some did not).

In general, Ridge Lake bass populations subjected to annual drawdowns over a period of years were composed of many small bass, a small number of very large ones, and relatively few of intermediate sizes. The thinning effect of the fall drawdown reduced the predation pressure on bass eggs and fry in the following

Table 4.—Population dynamics of largemouth bass in Ridge Lake, 1963–1970, including the feeding-drawdown period (1965–1969).

Year	*Smaller Than 254 mm (10 inches)*			*254–305 mm (10–12 inches)*			*Larger Than 305 mm*		
	Number	Weight in Kilograms	Average Weight in Grams	Number	Weight in Kilograms	Average Weight in Grams	Number	Weight in Kilograms	Average Weight in Grams
1963 restocking	2,270	42.3	18	...	....	...	116	161.0	1,388
Anglers' catch									
1963	91	3.9	43	...	....	...	70	76.9	1,098
1964	537	57.2	106	...	....	...	17	24.1	1,418
1965	466	52.6	113	235	73.2	311	..	....	.....
1966	605	68.9	114	128	51.5	402	..	....	.....
1967	307	41.0	134	260	69.2	266	3	4.8	1,600
1968	589	51.1	87	238	78.7	331	1	1.2	1,200
1969	389	40.8	105	101	50.4	499	..	....	.....
Total catch	*2,984*	*315.5*	...	*962*	*323.0*	...	*91*	*107.0*	.....
1970 census	2,146	69.2	32	167	43.3	259	107	132.1	1,234

spawning season, and successive strong year classes were produced, some of which were later reduced by predation from a preceding year class. This cycle of production created by the drawdown caused severe competition and slow growth among the small bass and rapid growth among the few that survived the food competition, stranding, and predation of their first season and the fishing pressure of their second season.

Severe predation upon small fishes other than bass was indicated by changes in the population of lake chubsuckers in the 7 years of this experiment. In 1963, 1,020 lake chubsuckers were restocked, totaling 110 kg (243 pounds) and averaging 108 grams (0.24 pound) each. Only 232 chubsuckers, weighing 44.7 kg (98.5 pounds) and averaging 193 grams (0.42 pound), appeared in the 1970 census. These fish were too large to be preyed upon by any but the very largest bass and catfish; none smaller had managed to survive.

Bluegills

A total of 4,492 bluegills, mostly within the 100- to 140-mm (4- to 5.5-inch) length range were returned to Ridge Lake after the spring census of 1963 (Table 5). These bluegills constituted a population of 693 per hectare (281 per acre). With such a small population, very few were caught in 1963, but by 1964 enough bluegills were present to increase food competition and improve the catch. Large catches of bluegills exceeding 150 mm (6 inches) in total length were made in each year from 1965 to 1969, inclusive, or throughout the f-d period (Table 5 and Fig. 2), and quite large numbers of small

Fig. 2.—Fishermen returning to the laboratory pier with large catches of bluegills.

Table 5.—Population dynamics of bluegills in Ridge Lake, 1963–1970, including the feeding-drawdown period (1965–1969).

Year	*Smaller Than 152 mm (6 inches)*			*152 mm or Larger*		
	Number	Weight in Kilograms	Average Weight in Grams	Number	Weight in Kilograms	Average Weight in Grams
1963 restocking	3,526	65.6	18	966	56.9	59
Anglers' catch						
1963	272	15.2	56	86	7.5	87
1964	141	4.6	33	1,146	127.6	111
1965	977	53.9	55	2,282	294.5	129
1966	1,670	93.9	56	3,916	448.7	114
1967	509	27.2	53	4,007	554.0	138
1968	1,880	79.8	42	2,285	336.0	147
1969	2,126	100.2	47	2,754	331.7	120
Total catch	*7,575*	*374.8*	..	*16,476*	*2,100.0*	...
1970 census	7,967	306.2	38	1,579	197.5	125

bluegills were caught by fishermen in 1966, 1968, and 1969. Bluegills of desirable sizes averaged 127 grams (0.28 pound) each.

Of some interest is the fact that the fishing pressure was nearly the same during each of the f-d years (1965–1969, inclusive) (Table 3), in part a reflection of the goodness of the fishing.

When the lake was drained in April 1970, it contained about 9,500 bluegills larger than 75 mm (3 inches). Most of these fish were within the 100- to 140-mm (4.0- to 5.5-inch) length range; however, about 1,600 were larger than 150 mm (6 inches), and many were more than 178 mm (7 inches).

In 7 years, fishermen had taken 16,476 large bluegills (Table 5) and 7,575 smaller ones. The large bluegills averaged 178 mm and 127 grams (7.0 inches and 0.28 pound) each; the small ones, 49 grams (0.11 pound).

Warmouths

More than 4,500 warmouths were taken in the 1963 draining, and most of them were less than 150 mm (6 inches) in

Table 6.—Population dynamics of warmouths in Ridge Lake, 1963–1970, including the feeding-drawdown period (1965–1969).

Year	*Smaller Than 152 mm (6 inches)*			*152 mm or Larger*		
	Number	Weight in Kilograms	Average Weight in Grams	Number	Weight in Kilograms	Average Weight in Grams
1963 restocking	1,330	28.3	21	5	1.1	220
Anglers' catch						
1963	49	2.4	49	...	....	...
1964	21	1.4	67	87	11.3	130
1965	211	15.8	75	279	34.0	122
1966	30	1.9	63	74	18.6	251
1967	8	0.4	50	110	14.9	135
1968	65	3.0	46	138	18.6	135
1969	34	1.8	53	44	5.7	130
Total catch	*418*	*26.7*	..	*732*	*103.1*	...
1970 census	422	21.9	52	134	17.5	130

length. Approximately 1,330 of the larger ones were restocked following the census (Table 6). The catch of both large and small warmouths was quite insignificant, 732 large warmouths and 418 small ones being brought in by fishermen in 7 years.

There were 556 warmouths in the census of April 1970, and only 134 of these were more than 150 mm (6 inches) in total length.

That the total number of warmouths was reduced during this period suggests that the drawdown was not obviously effective in stimulating an increase in the warmouth population. Warmouths have been observed to eat the pelleted food, and they presumably grow well on it. In 1966, for example, the 74 warmouths that comprised that part of the catch which exceeded 150 mm in total length averaged 251 grams (0.56 pound) each, or more than twice as much as the average weight of large bluegills caught in that year.

The warmouths, as is usually the case in Illinois (Larimore 1957:70), in competition with largemouth bass and bluegills in Ridge Lake, have contributed very little to the fish population and to the anglers' yield in every phase of experimental fish management that has been tested, including the f-d program.

Channel Catfish

Eleven large channel catfish appeared in the census of 1963 and were returned to Ridge Lake (Table 7). These were all very large fish, averaging 4 kg each (8.9 pounds). No catfish was caught by fishermen until 1965 when two small fish weighing 172 grams each (0.38 pound) were taken. These were believed to represent survivals from a spawn produced in the lake in 1963. Others of this year class probably survived because some catfish were taken each year, 1966–1969, inclusive (Table 7). These catches probably represented this same year class, because their average size moved progressively upward with each successive season: 1966, 1 kg; 1967, 2.3 kg; 1968, 3 kg; 1969, 3.4 kg (2.3, 5.1, 6.6, 7.5 pounds).

It appears improbable that any of the 11 catfish returned to the lake in 1963 were caught. However, it is likely that the 32 large catfish caught by fishermen, 1966–1969, and the 22 large fish taken in the census of 1970 were all survivors from a year class of fish produced in

Table 7.—Population dynamics of channel catfish in Ridge Lake, 1963–1970, including the feeding-drawdown period (1965–1969). The large catfish restocked in 1963 apparently produced a few young in 1963 or 1964.

Year	*Smaller Than 304 mm (12 inches)*			*304 mm or Larger*		
	Number	Weight in Kilograms	Average Weight in Kilograms	Number	Weight in Kilograms	Average Weight in Kilograms
1963 restocking	...	....	....	11	44.8	4.07
Anglers' catch						
1963	...	....	....	..	....	....
1964	...	....	....	..	....	....
1965	2	0.3	0.15	..	....	....
1966	...	....	....	15	15.4	1.03
1967	...	....	....	3	7.0	2.33
1968	...	....	....	1	3.0	3.00
1969	110[a]	52.1	0.47	13	44.2	3.40
Total catch	*112*	*52.4*	....	*32*	*69.6*	....
1970 census						
Offspring of 1963 restocking	...	....	....	22	86.3	3.92
1969 stocking	805	90.9	0.11	650	428.8	0.66
Total	*805*	*90.9*	*0.11*	*672*	*515.1*	....

[a] 1,000 channel catfish 203–330 mm (8–13 inches) long were stocked in Ridge Lake on May 1, 1969 from the Sam A. Parr Fisheries Research Center, Marion County, Ill., and 1,000 more of the same size range were stocked on October 21 and 22, 1969 after the fishing and feeding season.

Ridge Lake, probably in 1963. These channel catfish were able to survive in 1963 because the fish population was well below the carrying capacity of the lake in that year, and predation pressure was probably low.

THE EFFECTS OF EARLY FALL DRAWDOWNS IN REDUCING BLUEGILL NUMBERS IN RIDGE LAKE

With stable water levels, the bluegill population of Ridge Lake increases rapidly in total number with each successive spawning season and with apparently little regard for the number of largemouth bass present. In 1949 and 1950 the bass population of Ridge Lake was exceptionally large, and no bluegills other than those that remained in pockets of the old stream channel during the 1949 census were left in the lake. Yet the population found in the 1951 census amounted to 51,963 bluegills larger than 65 mm (Table 8). The 66,600 bluegills that appeared in the 1947 census originated from 61 large bluegills returned to the lake following the 1945 census. If the period between censuses is longer than 2 years, the numbers of bluegills become larger. For example, the 3-year period 1960–1962 started with zero bluegills and a dry lake basin over the winter of 1959–1960. A few bluegills appeared in 1960 from an unidentified source. These multiplied in competition with 4,500 hybrid sunfishes and a bass population that was building up to 6,000 small fishes. In 3 years the bluegills numbered 85,500.

Still larger numbers of bluegills were present after the four growing seasons with stable water levels, beginning in March 1956 and continuing until October 1959. After the 1956 census, 1,008 bluegills were restocked, and in the 1959 census the bluegill population was 92,700. It is impossible to suggest how much this population might increase numerically, but it seems apparent that in a relatively short period, say 7–10 years, the bluegills would become so dominant as to curtail the success of bass reproduction. Within the range of bluegill numbers (and time) shown in Table 8, there was no evidence of a reduction of bass numbers; in fact, the 6,200 bass exposed in the 1963 census, when 85,500 bluegills were present, was the largest population of small bass ever recorded for Ridge Lake.

The effects of the drawdowns on the

Table 8.—Total numbers and total weights in kilograms of fishes collected in several draining censuses at Ridge Lake when bluegills were present and when water levels were stable for two or more seasons prior to the census. Similar data are presented for censuses following 2–5 years of early fall drawdowns.

Year of Census	*All Fishes*		*Largemouth Bass*		*Bluegills*		*Other Fishes*	
	Number	Weight in Kilograms	Number	Weight in Kilograms	Number	Weight in Kilograms	Number	Weight in Kilograms
Stable water								
1947	69,801	2,092.5	2,509	257.0	66,629	1,577.8	663	257.7
1951	54,574	1,336.8	1,510	407.5	51,963	858.4	1,101	70.8
1959	97,312	1,906.0	2,354	240.0	92,669	1,246.5	2,289	419.4
1963	99,791	1,856.8	6,218	359.8	85,528	1,043.9	8,045	453.2
Average	*80,370*	*1,798.0*	*3,148*	*316.1*	*74,197*	*1,181.6*	*3,024*	*300.3*
Fall drawdowns								
1953[a]	10,377	901.0	1,964	204.8	7,476	449.9	937	247.1
1956[b]	20,308	1,538.7	2,242	289.3	17,180	924.6	886	324.8
1970[c]	14,234	1,440.0	2,420	244.6	9,546	503.8	2,268	691.7
Average	*14,973*	*1,293.2*	*2,209*	*246.2*	*11,401*	*626.1*	*1,364*	*421.2*

[a] Drawdowns of 4.6 meters (15 feet) in 1951 and 1952.
[b] Drawdowns of 3.0 meters (10 feet) in 1953, 1954, and 1955.
[c] Drawdowns varying between 3.0 and 4.6 meters (10 and 15 feet) in 1965, 1966, 1967, 1968, and 1969.

bluegill populations become evident when the bluegill numbers at the bottom of Table 8 are compared with those at the top. Also, a direct relationship apparently exists between the severity of the drawdown and the extent of bluegill population reduction, as indicated by the 1953 and 1956 census figures.

During a drawdown, small bluegills are more vulnerable to stranding and predation than are bluegills larger than a certain minimum size (25–100 mm). The larger fishes may live through several drawdowns, while relatively few of the small ones survive. The reduced population remaining in Ridge Lake after a drawdown (10,000–20,000 fishes instead of 50,000–100,000) becomes an expanding population in the refilled lake, with plenty of available food and space for reproduction and growth in the growing season following a fall drawdown.

Table 8 shows no large differences between the numbers of largemouth bass with and without drawdowns. Drawdowns are associated with successful reproduction of largemouth bass during the following spawning season, but when a drawdown is scheduled for every fall the young bass of each spawning season may be decimated by yearling bass from the previous year class. The discovery that drawdowns are almost always followed by successful bass fry production and the survival of these little fish beyond the size subject to predation by bluegills suggests a "surefire" method of producing a new year class of bass when a stunted bluegill population has been curtailing all bass reproduction. It is evident that annual drawdowns, with or without supplemental feeding, do not result in bass populations with superior potential for bass fishing although they probably should not be considered below average.

A COMPARISON OF THE EFFECTS OF VARIOUS MANAGEMENT TECHNIQUES ON ANGLING YIELDS

To make a comparison of management techniques, data from several fishing seasons directly affected by these techniques were selected and averaged (Tables 9 and 10). For example, several years in the biennial draining-and-culling period, 1941–1951, were characterized by large catches of largemouth bass. The year 1948 was selected because of the alternate years in which the lake was not drained, it was the year of the largest catch of bass.

In the first period of drawdown studies, 1951–1956, catches for the years 1951 and 1953 were omitted because they followed spring censusing operations in which the lake was completely drained and selected fish were returned. These operations also affected all other aquatic biota. While the fish returned to the lake after the 1953 census must have been influenced by the drawdowns of the fall seasons of 1951 and 1952, the fish population returned was probably more a reflection of the draining and censusing operation than of the drawdowns. The draining operation of 1956 again upset the replacement fish population. It marked the beginning of the "steady-state" period which lasted from May 1956 to October 1959. Only the years 1957, 1958, and 1959 were used to represent this period of stable water levels.

In the f-d period the years 1965–1969 were included because, as mentioned previously, feeding was begun during the summer of 1965 and the first drawdown was made in the fall of 1965.

In Table 9, statistics are shown for a comparison of the yields of the four major species of fishes in Ridge Lake for the several periods mentioned above. The average yield of bass of 18 kg per hectare (16.1 pounds per acre) for the f-d period is lower than that of any of the other periods shown and was exceeded by nearly twice this average in 1948, one of the best bass fishing seasons.

It seems safe to assume that annual fall drawdowns at Ridge Lake did not result in the production of large numbers of desirable-sized bass. Bass fishing was considerably better in the period when we drained the lake every 2 years and removed bass smaller than 200–255 mm (8–10 inches) along with large numbers of smaller bluegills. Under this culling

Table 9.—Total or average hook-and-line yields from fishing in Ridge Lake during the feeding-drawdown and other periods: 1948, when the bass catch was exceptionally large; the average of yields for 1952, 1954, and 1955 after a season or more of early fall drawdowns without feeding; and the average of yields for 1957, 1958, and 1959 during the period of stable water levels.

Year(s)	*Largemouth Bass*		*Bluegills*		*Warmouths*		*Channel Catfish*		*All Fishes*	
	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre	Kilograms Per Hectare	Pounds Per Acre
Good bass season, 1948	32.1	28.6	57.6	51.4	...	...	....	...	89.7	80.0
Drawdowns only; 1952, 1954, 1955 average	22.3	19.9	41.0	36.6	3.7	3.3	10.1	9.0	77.2	68.9
Stable water; 1957, 1958, 1959 average	20.5	18.3	58.7	52.4	5.6	5.0	7.8	7.0	92.7	82.7
Feeding and drawdowns; 1965–1969 average	18.0	16.1	71.6	63.9	3.6	3.2	3.8	3.4	97.1	86.6

Table 10.—Average number per unit of lake surface and average weight of largemouth bass and bluegills taken by anglers in 1948, a very successful year for bass fishing, and in years affected by drawdowns only, by stable water levels, and by supplemental feeding and drawdowns.

Year(s)	*Largemouth Bass*				*Bluegills*			
	Number Per Hectare	Average Weight in Grams	Number Per Acre	Average Weight in Pounds	Number Per Hectare	Average Weight in Grams	Number Per Acre	Average Weight in Pounds
Good bass season, 1948	89	361	36	0.79	801	72	324	0.16
Drawdowns only; 1952, 1954, 1955	163	137	66	0.30	416	98	168	0.22
Stable water; 1957, 1958, 1959	138	148	56	0.33	797	74	322	0.16
Feeding and drawdowns; 1965–1969	103	175	42	0.38	692	103	280	0.23

method, we selected for fast-growing bass and removed the slow-growing ones. This method also stimulated the production of large new year classes of bass at 2-year intervals.

It is also evident from the data in Table 9 that the f-d operation did not improve the catch of warmouths and channel catfish. This was due in part to the relatively small numbers of both species. We made no direct observations on whether warmouths were eating the pelleted food although they readily learned to eat it in the laboratory. Channel catfish fed well on "Splash," as was indicated in Table 7 by the large annual increases in the average weight of the catfish caught (except those stocked in 1969), 1966–1969, inclusive. However, so few were in the lake that their weight per hectare was small.

Table 10 shows average numbers of bass and bluegills caught per unit of lake surface and their average individual weight under the several methods of management. With both largemouth bass and bluegills, apparently a negative relationship exists between the average number of fish caught and their average size. If one may assume a positive relationship between the number of fishes available in any season and the number caught by anglers, one may also assume that, in years when the fish population is relatively small, each individual fish may have plenty of food available and therefore may grow rapidly and attain a large size. Thus, because the population is relatively small, each individual is subjected to little competition for food and space. If recruitment does not greatly increase the population, it is reasonable to assume that the average size of the individuals in this population will be large. Conversely, overproduction, the survival of new year classes, and the consequent competition for food and space will result in fishes of small average size. One can therefore assume a relationship between the catch of fishes and the average size of those fishes although so many variables are involved that the relationship may be quite obscured.

THE EFFECTS OF SUPPLEMENTAL FEEDING AND DRAWDOWNS ON THE CONDITION OF LARGEMOUTH BASS AND BLUEGILLS

We believed that the effects of supplemental feeding of the fishes of Ridge Lake would become evident through changes in the growth rate and in the relative plumpness of the fishes. The procedure of allowing two seasons to pass after the restocking of the lake before any experimental management or feeding was begun gave results from those 2 years that we could compare with results from 5 years of f-d operations. Also, results from the 5-year f-d period could be compared with results from previous Ridge Lake studies (Bennett 1954*a*; Bennett et al. 1969): 5 years of drawdowns without feeding, 10 years of biennial draining of the lake and culling of the fishes, and 4 years of stable water levels.

It is convenient to begin by comparing the condition of bass and bluegills collected in 1963 and 1964, when no supplemental feeding or drawdowns were conducted, with collections made in 1965–1969, inclusive, when the fish were fed daily during the summer and the lake level was dropped 3 or more meters each fall and held down as long as the weather was warm.

Fishermen's catches at Ridge Lake were measured as total lengths in tenths of inches and weights in hundredths of pounds. Therefore, it was convenient to use the *Index of Condition,* C, formulated by Thompson & Bennett (1939:16–17)

$$C = \frac{W\ 10{,}000}{L^3}$$

in which W is weight in pounds and L is length in inches.

To interpret results from this formula, one must know that bluegills showing an index of condition, C, of 6.0–7.0 are in poor flesh; those showing a condition of 7.1–8.0 are in the range of average plumpness; and those showing a condition of 8.1 or above are obese and usually show internal fat deposits.

The largemouth bass, having more elongated shapes than the shapes of bluegills, have a lower condition index range. In bass, condition indices of 3.5–4.5 are related to a thin body; bass in the range of 4.6–5.5 are about normal; and those within the range of 5.6 or higher are obese. Bluegills are known to have an annual cycle of condition (Bennett, Thompson, & Parr 1940:6), with condition being lowest during winter, gradually rising in March and April, and reaching a peak in late May or early June at the beginning of the spawning season. During the long spawning season extending throughout the summer, bluegill condition usually drops. Sometimes it rises in late August and early September, dropping again to the winter low. No annual condition cycle has been reported for largemouth bass.

Average indexes of condition are shown in Table 11. Data were taken from creel cards recorded for all fishes by the first junior author when fishermen returned to the laboratory pier with their catches. Length-weight data from fishes caught by anglers during early June, the first

Table 11.—Average index of condition, C, of monthly samples of largemouth bass and bluegills taken by fishermen from Ridge Lake during the summer fishing periods, 1963–1969.

Month and Year	*Largemouth Bass*		*Bluegills*	
	Number	Average C Value	Number	Average C Value
June 1963	32	4.82	96	6.17
July 1963	17	4.70	128	6.81
August 1963	26	4.08	118	6.37
June 1964	244	4.18	211	7.38
July 1964	134	4.53	245	7.37
August 1964	61	4.46	268	7.30
June 1965	84	4.60	147	7.54
July 1965	74	4.55	246	7.43
August 1965	114	4.44	237	7.44
June 1966	138	4.25	224	8.12
July 1966	93	4.44	270	7.84
August 1966	67	4.20	219	7.65
June 1967	174	4.49	287	8.43
July 1967	104	4.92	246	8.29
August 1967	144	4.77	282	8.11
June 1968	185	4.77	318	8.51
July 1968	92	4.58	337	7.57
August 1968	119	4.53	224	7.57
June 1969	183	4.09	273	7.51
July 1969	82	4.57	224	7.81
August 1969	81	4.71	275	7.96

part of July, and the first part of August were used, and the numbers of fish records ranged between 17 and 337, depending on the numbers available.

Indexes of condition were calculated for bass within the length range of 173–399 mm (6.8–15.7 inches) and for bluegills within the range of 147–246 mm (5.8–9.7 inches). Fishes were separated into 25-mm (1-inch) length groups (e.g., 147–172 mm, 173–198 mm, etc.) so that any great variations in the relative plumpness of these length groups would be exposed. Bluegills were fairly consistent in condition within the size groups recorded, but bass more than 12 inches long were heavier in proportion to their length than were shorter bass. Indices of condition for both bass and bluegills caught by anglers at any one time (within a period of a few days) were quite uniform for their species, although occasionally a few individuals varied widely. The bass condition data in Table 11 emphasizes the fact that in most months the bass averaged slightly *below* normal, or average, plumpness. In general, all bass were thin, but some were more so than others.

During the summer of 1963 the bluegills were thin (Fig. 3), but they improved to average plumpness in 1964 before any supplemental feeding was begun. Apparently, the feeding program in 1965 was not reflected in the condition of the bluegills in that year although they were, on the average, somewhat plumper than they were in 1964. The effects of supplemental feeding were evident in the collections for June in 1966, 1967, and 1968 (Fig. 3) when the average C values for bluegills were in the fat category. The condition cycle for this species was evident in most years. Bluegill plumpness in July and August was usually lower, on the average, than it was in June, with mid- and late-summer condition falling below the fat classification in all years except 1967. In 1968, bluegills were in fat condition in June, and large bluegills again reached that level in August. In that same year, a high survival rate occurred among the small bluegills of a very large year class. This high rate of survival became evident in 1969 when many bluegills were too small to interest anglers but were numerous enough to reduce the overall effect of the supplemental feeding.

Fig. 4 shows the average condition for

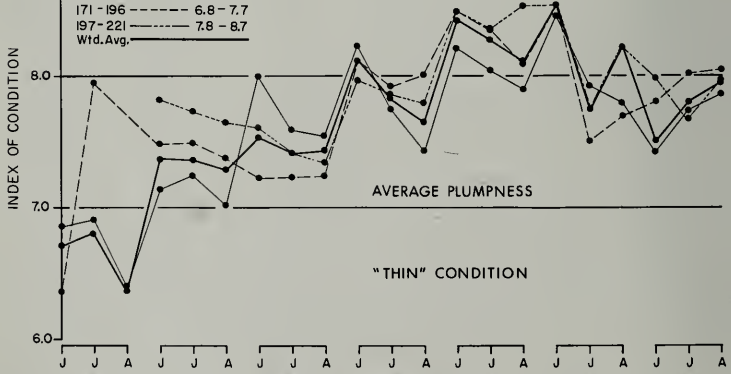

Fig. 3.—Indices of Condition of three length groupings of bluegills and the weighted average for all groupings in summers of the f-d experiment. Supplemental feeding was begun in 1965, and the first drawdown of this program was conducted in the fall of 1965.

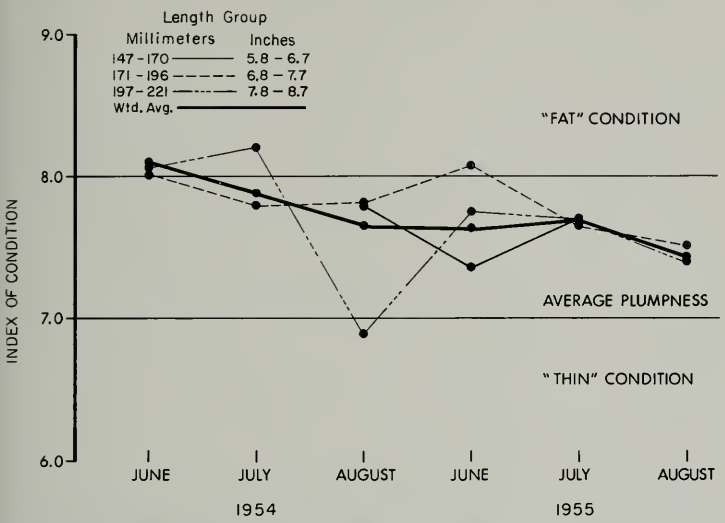

Fig. 4.—Indices of Condition of three length groupings of bluegills and the weighted average for all groupings taken in 1954 and 1955 during a period of annual fall drawdowns but with no supplemental feeding.

three length classes of bluegills taken from Ridge Lake in 1954 and 1955 when this fish population was being subjected to moderate annual fall drawdowns of about 3 meters (Bennett et al. 1969:16) but with no supplemental summer feeding. Bluegills showed an average condition in the fat zone only in June 1954; during the rest of the 2-year span these fish were generally in high average condition. As stated elsewhere, these fish did not appear to be plump.

THE GROWTH OF BASS AND BLUEGILLS IN A FEEDING-DRAWDOWN PROGRAM

Growth rates of largemouth bass and bluegills were estimated from scale analyses and from length, weight, and age data for fishes taken by anglers late in the summers of 1967 and 1968 when fish growth for the season was nearly complete. By averaging the total lengths of bass or bluegills separated into age classes on the basis of the number of annuli on selected scales, we were able to construct growth curves (Fig. 5, 6, and 7).

The growth of largemouth bass was slow during the f-d period, particularly when compared with that of the period of biennial culling, 1941–1951 (Table 12 and Fig. 5). In the 1941–1951 period the lake was completely drained five times at intervals of 2 years, and each time a census was made of the fish. The method of culling the population after the census has been described (Bennett 1954*a*:241). The data for the upper growth curve for bass (Fig. 5) were taken from Bennett (1954*a*:255). This curve shows that bass reached a useful size (254 mm) in less than two growing seasons in the biennial culling period; in contrast, three complete growing seasons were required to obtain 254-mm bass under the f-d program. Also, under this latter program there appeared to be a scarcity of 305- to 380-mm (12- to 15-inch) bass (Table 12). Quite obviously, from the standpoint of growth rate, the f-d program cannot be recommended for bass.

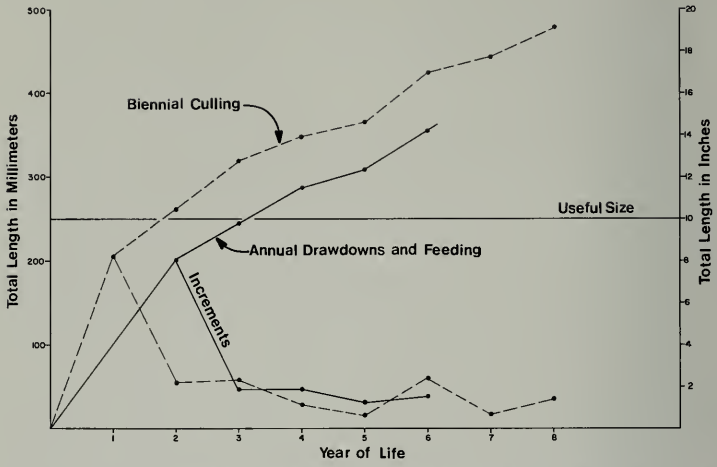

Fig. 5.—Growth rates and annual length increments of largemouth bass under a system of biennial lake draining and culling of small bass and bluegills and under the f-d program.

Table 13 and Fig. 6 and 7 show comparisons of the growth rates of bluegills under the f-d program and under a program of drawdowns without feeding and under conditions brought about by stable water levels.

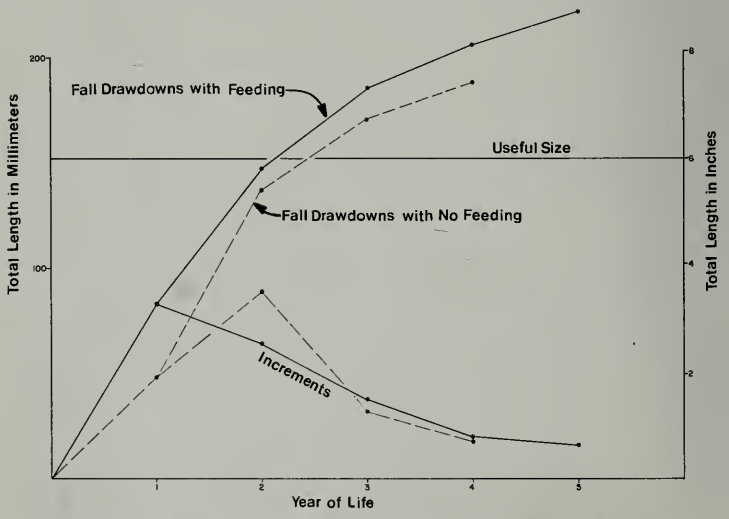

Fig. 6.—Growth rates and annual length increments of bluegills under a system of fall drawdowns without feeding and under a system combining feeding with fall drawdowns.

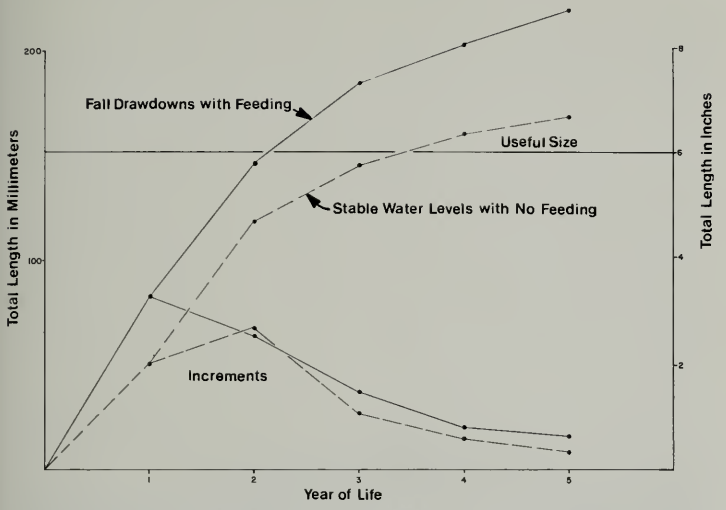

Fig. 7.—Growth rates and annual length increments of bluegills during the f-d program and under stable water levels (1956–1959, inclusive).

Bluegills grew almost as fast when subjected to annual fall drawdowns with no supplemental feeding as they did under the program of supplemental feeding and fall drawdowns (Fig. 6). In both programs useful sizes were attained early in the third summer of life. Under the f-d program, bluegills 4 and 5 years old averaged more than 200 mm (8 inches) in length; however, the average size of the 4-year-old bluegills subjected to drawdowns alone was less than 200 mm, and there were too few 5-year-olds to give a significant average. Whether supplemental feeding might have been a factor in slowing the mortality rate of the larger, older fish can only be conjecture at this time.

With stable water levels at Ridge Lake in 1956–1959, bluegill numbers increased rapidly, and more than three growing seasons were required for these fish to average 150 mm (Fig. 7). None was able to attain a length greater than about

Table 12.—Average total lengths in millimeters and inches of 405 largemouth bass taken at, or approximately at, the ends of the growing seasons in 1966, 1967, and 1968 during the feeding-drawdown period, and average total lengths of largemouth bass taken under similar circumstances in the 1941–1949 period of biennial draining and culling (from Bennett 1954a:255).

Unit of Measurement	*Average Total Length At or Near End of Indicated Growing Season*							
	1st	2nd	3rd	4th	5th	6th	7th	8th
				Feeding-Drawdown Period, 1965–1969				
Millimeters	...	201	244	287	318	358	....	....
Inches	...	7.9	9.6	11.3	12.5	14.1	....	....
				Biennial Culling Period, 1941–1949				
Millimeters	206	262	320	348	363	424	442	478
Inches	8.1	10.3	12.6	13.7	14.3	16.7	17.4	18.8

Table 13.—Average total lengths in millimeters of bluegills captured and aged near the ends of the growing seasons of 1967 and 1968 during the period of supplemental feeding and annual fall drawdowns, of 1958 and 1959 during the period of stable water levels, and of 1955 during the period of annual fall drawdowns without feeding. Annual length increments are also shown.

Period	Number	Year of Life				
		1st	2nd	3rd	4th	5th
Supplemental feeding and fall drawdowns (1967 & 1968 collections)	316	83	147	185	205	221
Length increment		83	64	38	20	16
Stable water levels (1958 & 1959 collections)	326	51	119	146	161	169
Length increment		51	68	27	15	8
Annual fall drawdowns and no feeding (1955 collection)	112	48	137	170	188	...
Length increment		48	89	33	18	...

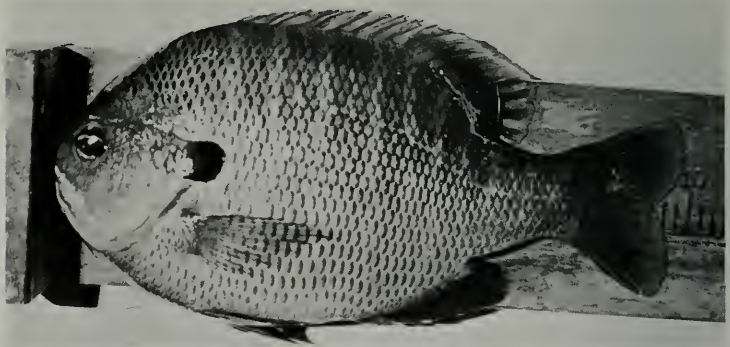

Fig. 8.—A 254-mm (10-inch) bluegill from Ridge Lake weighing 499 grams (1.1 pounds). This bluegill was very fat and had an Index of Condition of 12.

165 mm even though many reached the age of 5 years. Differences in the rates of growth of bluegills in Ridge Lake under differing systems of management apparently are related to the amount of available food and space per individual fish.

If abundant food and space are available, bluegill size must be limited by the length of life of this species and its maximum genetic growth potential. Few bluegills in central Illinois live longer than 5 years and genetically the bluegill is a relatively small fish. Thus, in combining a supplemental feeding program with drawdowns, we are, in theory, projecting a management technique for producing bluegills of exceptional sizes (Fig. 8).

DISCUSSION

The decision to give warmwater fishes a supplemental source of food in a management program to improve sport fishing depends, first of all, on cost as it is related to benefits. However, data about yield improvement may not be available to the individual fisherman, and he may judge the fishing quality by what he himself catches. Such judging was done by fishermen using Ridge Lake during our experiment.

In waters open to public fishing, usually no attempt is made to harvest more of the available crop of fishes than may be taken by angling; therefore, unless the benefits are readily observable through an improved rate of catch or improved sizes of the fishes caught, or both, fishermen may consider the program a waste of money. As has been mentioned, the cost of the pelleted fish food used in this experiment was about 6 cents per pound, and the feeding rate was 2 pounds of food per acre per day. Thus, the daily cost was 12 cents per acre, or $1.92 per day for 16-acre Ridge Lake. The feeding program required 1.5 tons of food per year at about $120–$130 per ton, representing a seasonal cost of $11.25–$12.19 per acre, or $27.80–$30.12 per hectare.

Schmittou (1969:312–313) used 2,896 pounds of food costing $159.28 in 1-acre Pond T_1 over two growing seasons and 8,766 pounds of food costing $482.13 in Pond T_2 (surface area, 3.5 acres) for five growing seasons. Thus, the food costs per acre per season were $79.64 for Pond T_1 and $27.55 for T_2. These costs may be compared with $11.25–$12.19 per acre per season for the food used at Ridge Lake.

The results of this f-d program were evident to most, if not all, bluegill fishermen in furnishing them with (i) larger bluegills, (ii) fatter bluegills, and (iii) a larger total poundage of bluegills because of the increased average weight of individuals. Greater numbers of bluegills were taken by anglers in the period of stable water levels, 1956–1959, than were caught in the f-d period, but the fishes taken in the earlier period were hardly more than 152 mm (6 inches) in average total length and their average weight was less than 82 grams (0.18 pound) each. Another benefit cited by fishermen was the improved flavor of the bluegills that fed on the prepared food.

Schmittou (1969:318) fed "balanced" bass-bluegill populations in two "treatment ponds" while following the population changes in a control pond. In his feeding program without drawdowns, there appeared to be a gradual increase in the number of bluegills and a reduction in the number of bass that eventually would have caused a severe slump in bass fishing. In the Ridge Lake experiment the annual fall drawdowns also upset the bass population dynamics by indirectly causing the production of excessive numbers of small bass, of which only a small percentage attained attractive sizes.

The fact that largemouth bass will not learn to eat pelleted food unless given special training when very small (Snow 1965:193 and 1968:145) reveals the uselessness of simply broadcasting pelleted food in the management of bass for sport fishing.

It is our opinion, after studying the movements of marked bluegills in various parts of the lake, that these fish are fairly sedentary, i.e., their normal range of movements would not insure that individuals from all parts of Ridge Lake would find a feeding area. Therefore, if pelleted food is to be made available to all of the Ridge Lake bluegills, it must be well distributed in shallow water in all parts of the lake.

Once the bluegills have learned to feed on the pelleted food, they will ingest the amount distributed in a relatively short time. There was no particular reason for setting the amount to be fed at 2 pounds per acre per day except that we wished to have the food used as a supplement to the bluegills' natural diet rather than as a substitute for it. However, the weight of bluegills in the 1970 census (78 kg per hectare, or 69 pounds per acre) was about one-third of the maximum standing crop found in any past census (223 kg per hectare, or 200 pounds per acre). Thus, the daily quota of pelleted food represents about 2.5 percent of the total weight of bluegills. The effect of the drawdown in thinning the bluegill population was to increase the amount of food available to each fish from about 1.0 to 3.0 percent of body weight per day.

Various companies in the business of preparing and marketing animal foods usually have one or more types of pelleted fish foods. Generally these preparations consist of one or two grades of "trout" food and at least one, and sometimes two,

grades of "catfish" food. The trout foods are usually more expensive than those for catfish and are more "complete" fish diets because trout have been fed on prepared diets for more years than have catfish and more research has been done on their specific food requirements.

During the development of techniques for the culture of channel catfish in cages, many fish were confined in relatively small spaces with little chance of obtaining a significant amount of natural food from the ponds in which the cages were floated. In this situation foods that were quite adequate for free-swimming channel catfish lacked certain food elements that the free catfish were able to forage from pond sources. Very little is known about the nutrition requirements of bluegills, but it seems reasonable to assume that the food requirements of caged and uncaged bluegills might be similar to those of catfish, i.e., caged bluegills would also require a more nearly complete diet than would free-swimming bluegills.

The drawdown, when combined with a feeding program, is a money-saving operation because it limits the survival of successive year classes of bluegills to the numbers that can be utilized in the fishing program. Thus, the bluegills that survived the drawdowns always had an adequate supply of food for rapid growth and were abundant enough to satisfy the needs of anglers.

Diminishing the aquatic habitat selects against the survival of smaller fishes in two ways. First, it forces the small fishes away from the shore shallows into open water with little or no protective cover in an environment that may be entirely strange to them. Here they become prey to larger fishes and other aquatic vertebrates and invertebrates such as crayfish. Second, it strands the smaller fishes in mats of settling rooted aquatic plants or in pockets of water in an uneven lake bottom which dry up in a few hours or days. The relative importance of these two phenomena in reducing the numbers of smaller fishes is conjectural, however, as much depends on the normal behavior patterns of the species involved. Those that tend to avoid very shallow water are decimated more by direct predation than by becoming stranded, and vice versa.

To some pond owners a fall drawdown may present a problem because many ponds are not equipped with controlled outlets; therefore, drawdowns are impossible except through pumping or siphoning. Often when a pond is being built, the owner is operating on a limited budget, and the elimination of the drain outlet appears to be one way to cut expenses. This view is unfortunate because the use of the drawdown as a fish management technique has become well established (Bennett 1971:209–219). In fact, it is considered the single most important operational procedure for eliminating overpopulation and stunting among the fishes in artificial ponds and reservoirs.

The procedure is simply to open the outlet valve in the dam and lower the water level until the surface area of the lake or pond is between one-fourth and three-fourths that of the full lake, depending on how severe an effect is desirable. It is usually unnecessary to build a weir in the outlet to prevent the larger fishes from leaving the lake because they will not go out of the outlet until the water level becomes much lower than the level which results in a 75-percent reduction in the lake surface area. Presumably, the larger fishes will not leave because they do not immediately recognize the danger of becoming stranded in the lake basin. If the outlet valve in the dam is at the lowest level of the lake basin and the lake is of the eutrophic type, a drawdown in summer or early fall will release oxygen-deficient water which also may contain methane, hydrogen sulfide, carbon dioxide, and other anaerobic decomposition products. This water may be toxic to fishes immediately below the outlet and is certainly uninhabitable for fishes attempting to enter or leave the lake through the outlet.

It is always advisable that those responsible for the operation of a drawdown inspect the surviving population of fishes to make certain that the expected results are occurring. In some instances it may be necessary to supplement a draw-

down with seining, as Hulsey (1957:286) arranged for in Nimrod Lake, to remove a large population of carp or buffalo or suckers that cannot be stranded and are too large to become prey to fishes or other aquatic animals. Even excessively large populations of stunted sunfishes may require supplemental cropping, particularly when they are living with relatively small numbers of large bass, of which there are too few to make impressive inroads on the hordes of sunfishes. In both cases boat-mounted electric shockers may be used effectively in thinning the stunted or undesirable fishes, because during a drawdown the fishes are concentrated in such small areas that large numbers may be stunned within a relatively short time. Where seine hauls have been planned for reservoir basins before the water has been impounded, small-meshed drag seines may be used to help reduce the numbers of undesirable fishes.

In managing a lake or pond for sport fishing, it is desirable to manage all important species that are present. This we were unable to do with our f-d program. The program was effective in producing superior bluegills, and probably superior catfish, but it was not so for largemouth bass. Perhaps a severe fall drawdown each year is unnecessary, and one in 2 or 3 years with annual summer feeding might improve the size of the bass caught without greatly reducing the average size of the bluegills. In another direction, the maintenance of a population of channel catfish of at least 100 per hectare might add a new interest for fishermen.

SUMMARY

1.—After a draining census in 1963, Ridge Lake was restocked with 2,386 largemouth bass, 4,492 bluegills, 1,335 warmouths, 11 channel catfish, and 1,020 lake chubsuckers, making a total of 9,244 fishes weighing 510.6 kg (1,125.5 pounds). This was 78.8 kg per hectare, or 70.3 pounds per acre. In the census preceding this restocking this lake was found to contain 287 kg per hectare, or 256 pounds per acre, almost four times the weight of fish returned to the lake. In 1969, 2,000 additional channel catfish were stocked.

2.—The population of fishes was allowed to expand for two growing seasons (1963 and 1964) without drawdowns or supplemental feeding but with the usual controlled public fishing during the summer months. The hook-and-line catch in 1963 and 1964 was below the average for the preceding 20 years.

3.—Beginning in late May 1965, and continuing each year during the 3 summer months, 1965 through 1969, the fish were fed daily on a commercial pelleted fish food (32 percent protein) at the rate of 2 pounds per acre per day. Food was spread in the shallows in all parts of the lake. The food cost was within the range of $27.80–$30.12 per hectare per season ($11.25–$12.19 per acre per season).

4.—Each year, beginning in September 1965, the lake level was lowered:

4.6 meters (15 feet) in 1965, leaving a surface area of 2.12 ha
3.0 meters (10 feet) in 1966, leaving a surface area of 4.5 ha
3.0 meters (10 feet) in 1967, leaving a surface area of 4.5 ha
4.6 meters (15 feet) in 1968, leaving a surface area of 2.12 ha
4.3 meters (14 feet) in 1969, leaving a surface area of 2.76 ha

The level was maintained until the water temperature in the lake was about 13° C. (57° F.) in October, when the lake was allowed to refill.

5.—In March 1970, the lake was drained to make a census of the fishes. The lake contained 2,420 bass, 9,546 bluegills, 556 warmouths, 1,477 channel catfish, 232 lake chubsuckers, and 3 fishes of other species, a total of 14,234 fishes weighing 1,440.0 kg (3,175.3 pounds).

6.—The catch of largemouth bass during the seasons 1965–1969, inclusive, was composed mostly of small fish. The f-d program resulted in the production of excessive numbers of small bass but generally did nothing to improve bass fishing.

7.—The fishermen's catch included more than twice as many large bluegills (152 mm or longer) as it did smaller ones during the 1965–1969 period. Blue-

gills of desirable sizes averaged 127 grams (0.28 pound) each.

8.—Neither warmouths nor channel catfish produced large hook-and-line yields because their numbers were always small. Channel catfish produced a small year class in 1963 or 1964, and this year class appeared in the catch in 1966–1969, inclusive. The catfish stocked in 1969 were too small to appear in the 1969 catch.

9.—During years when the water level in Ridge Lake remained fairly constant, bluegill numbers increased to 50,000 in one 2-year period and to 66,000 in another, to 86,000 in one 3-year period, and to 93,000 in a 4-year period. Annual fall drawdowns of 4.6 meters reduced the bluegill population to 7,500, those of 3.0 meters to 17,000 bluegills, and the 4.3-meter drawdown reduced the population to 9,500 bluegills. These drawdowns apparently had little effect on largemouth bass numbers.

10.—The average hook-and-line yield of bass in the 5 f-d years was only 18.0 kg per hectare (16.1 pounds per acre). This yield was below the average for 3 drawdown years (1952, 1954, and 1955) and 3 stable water level years (1957, 1958, and 1959). The average bluegill yield under the f-d program was 71.6 kg per hectare (63.9 pounds per acre), higher than the catch in any other period.

11.—The average index of condition of largemouth bass in the f-d period was slightly *below normal*. Average bluegill condition was "fat" in June of all f-d years except 1965 and 1969. Usually the average bluegill index of condition was lower in July and August, which followed a previously observed condition cycle for that species. The condition of bluegills in 1954–1955 with fall drawdowns, but without supplemental feeding, was "fat" in June of 1954 but only reached "high average" plumpness for July and August of 1954 and for all of the summer of 1955.

12.—Largemouth bass growth was slower during the f-d period than during the period of biennial lake draining and culling of the fish population. Bluegills grew somewhat faster during the f-d period than they did during the program of drawdowns without feeding. They appeared to live longer during the f-d period and therefore attained larger sizes. They grew much faster under the f-d program than they did when water levels were stable.

13.—The pelleted food for the f-d program cost about 12 cents per acre per day, or about $11.25—$12.19 per acre per season. Fishermen were enthusiastic about the program because they were able to catch larger and fatter bluegills, and they believed that the pelleted food improved the flavor of these fish. Feeding bluegills without fall drawdowns would probably be wasteful because the bluegill population would expand faster than the food supply.

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