Manipulation of Fish Populations Through Reservoir Drawdown[1]

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ABSTRACT

A summer drawdown was implemented on Little Dixie Lake, an 83 ha (205-acre) Central Missouri impoundment, to improve growth rate of largemouth bass (*Micropterus salmoides*) and to re-establish populations of desirable size. Water level was lowered 2.4 m (8 ft) between 19–29 July, 1964. Surface area was reduced by 42% and the volume by approximately 58%.

As a result of draining water from the bottom of this lake the hypolimnial waters were removed. Temperature gradient in the remaining epilimnial waters was broken and the lake became homothermos at 30 C (86 F).

Stomach analysis of largemouth bass indicated an increase in feeding activity following drawdown. Grams of food found in the stomach per 0.454 kg (1 lb) of bass was used as an index to feeding. These values increased from 4.0 g of food per 0.454 kg (1 lb) of fish prior to drawdown to 10.7 following drawdown. Per cent of empty stomachs also decreased during the post-drawdown period.

Scales collected from largemouth bass indicated an acceleration of growth in the year of drawdown, 1964. The increase in this increment of growth for 1964 over the previous year for age groups I, II, and III was 4.0, 4.0, and 3.3 cm (1.6, 1.6, 1.3 inches) respectively.

Harvest of bluegill increased immediately following the drawdown and declined during the succeeding two-month period. Largemouth bass harvest was reduced during August but there were increases in the numbers and average size of fish caught through September and October.

Shoreline seining before and after the drawdown indicated the density of fry and intermediate bluegill (*Lepomis macrochirus*) was reduced. It was thought the drawdown was responsible for a portion of this reduction through stranding of small sunfish in weed beds and shallow pools, through increased predation by bass on these small sunfish, and through exposure of nests as the water was lowered.

INTRODUCTION

A major problem facing the fishery manager is the decline in fishing success with the aging of warmwater reservoirs (Bennett, 1962). This decline has followed a reasonably uniform pattern, so that one can almost predict the sequence of events which may occur. Removal of large numbers of fish by anglers at a rate that exceeds recruitment during the first year of fishing tends to hasten this decline (Pierce et al., 1963). With time bass tend to be replaced by forage or rough fish species (Thompson, 1954). Bennett (1950) states that dominant bluegill populations are very effective in controlling bass populations through predation on eggs, yolk-sac fry, and free swimming fry stages, resulting in the entire fish population becoming "out of balance."

Beneficial effects of fluctuating water levels on fish populations have been described by Eschmeyer (1947), Wood (1951), Shields (1957), and Grizzell (1960). Hulsey (1957, 1958) suggested that the ideal situation is to maintain a full lake during the spawning and summer growing season, then, after the production of small forage fish and insects, lower the lake to concentrate the fish. Predator species should reduce the number of forage fish and respond through accelerated growth. Reservoir refilling permits expansion of the residual fish population (Bennett, 1962).

Bennett concluded:

> "More experimental work must be done on drawdowns to allow biologists to predict the exact effects of these

[1] Contribution from the Missouri Cooperative Fishery Unit (Missouri Department of Conservation, U. S. Bureau of Sport Fisheries of Wildlife, and University of Missouri cooperating), and Missouri Department of Conservation (Financed in part by Dingell-Johnson series F-1-R, Missouri).

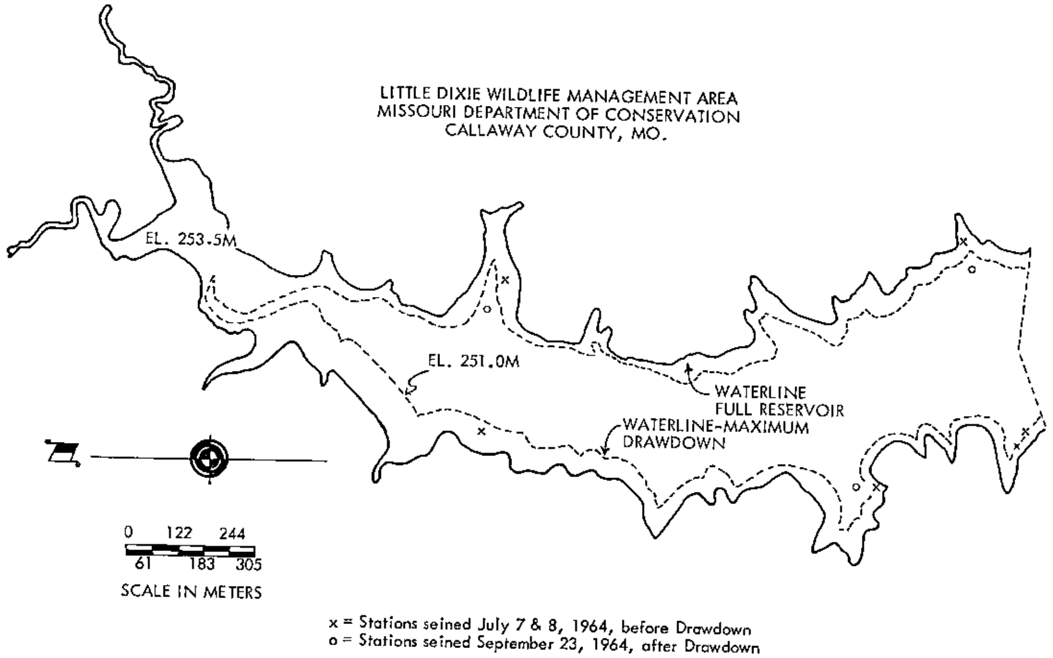

FIGURE 1.—Little Dixie Wildlife Management Area Missouri Department of Conservation Callaway County, Missouri.

> operations upon the fish populations. Nearly all of the experimental work has been done on drawdowns at the end of the fishing season. As yet, no one can say whether a drawdown made in midsummer would be more beneficial than one made in early September."

This study was based on the premise that small forage fish were too numerous and presumably unavailable to predaceous largemouth bass (*Micropterus salmoides*), because of extensive growth of vegetation in the shallows. Growth of bass had declined since 1959, resulting in a preponderance of small slow-growing bass. A progressive decline in the quality of fishing indicated that these conditions were becoming serious problems in Little Dixie Lake.

Purposes of this study conducted between 1962–1965 were to evaluate the effects of a mid-summer drawdown 19–29 July, 1964 on 1) growth of largemouth bass, 2) harvest of fish, and 3) numbers of bluegill of forage size in a warmwater impoundment.

DESCRIPTION OF STUDY AREA

Little Dixie Lake is an 83 ha (205-acre) Central Missouri impoundment (Figure 1), constructed in 1957. Water level can be regulated by a 58.8 cm (24-inch) drain pipe and gate valve in the dam. Dense beds of rooted aquatic macrophytes, primarily *Chara* sp., were present in waters less than 1.7 m (5.5 ft) deep, and occupied 22.3–24.3 ha (55–60 acres) of the littoral zone. Stands of dead timber occupied the shallow water in the upper end of the reservoir. Water deepened progressively from the upper end toward the dam where a maximum depth of 8.2 m (27 ft) was recorded.

Little Dixie is a second order temperate lake. Records from years other than drawdown show that thermal stratification persists from May through September. A thermocline was usually established in deeper water at 3.0 to 4.0 m (10 to 13 ft) depth and frequently extended to the bottom so that a classical hypolimnion did not develop.

Limnological records from March through October, 1964, provided the following: Alkalinity was entirely bicarbonate, with a range of 26 to 69 ppm. Specific conductance values in mmhos/cm at 25 C were: Surface, 140–172 (mean 152); bottom, 150–325 (mean 183). Measurements of pH ranged from 6.8 to 7.7. Dissolved oxygen values in ppm were: Surface, 6.6–10.3 (mean 7.7); bottom, 0.0–7.2 (mean 3.6). Fifty-one measurements by Secchi disc had a range of 22.9–157.5 cm, mean 68.6 cm (9–62 inches, mean 27 inches).

Initial stocking consisted of 40 largemouth bass per hectare (100 per acre) in 1958, 40 channel catfish (100 per acre) (*Ictalurus punctatus*), 200 bluegill (500 per acre) (*Lepomis macrochirus*), and 200 redear sunfish (500 per acre) (*Lepomis microlophus*) per hectare in 1959. Green sunfish (*Lepomis cyanellus*) were present in the lake basin prior to stocking. The lake was first opened to fishing on 28 May 1960.

MATERIALS AND METHODS

Shoreline Seining—Three 18.3 m (60 ft) seine hauls, with a 7.6 m, 6.4 mm (25 ft ¼ inch) mesh bag seine were made at each of six sampling stations (Figure 1) prior to drawdown 7–8 July and at three of these stations following drawdown 23 September. The same six stations were sampled each July 1962–1965. All fish over 2.5 cm (1 inch) were retained by the seine and sorted by species into 2.5 cm (1 inch) size groups.

Creel Survey—A complete creel survey was conducted May and June, 1960 (Turner, 1963), and an intensive partial creel survey July through October 15, 1960, and April through October 15, 1961, patterned after Kathrein (1953). Beginning 1 April 1962, a partial creel survey was conducted by the following method. Length of the census day was determined by the monthly average time of sunrise to the average time of sunset. A count of the fishermen was made daily. The period the count was to be made (morning versus afternoon) was predetermined by a flip of a coin and working vertically through the calendar month. This was sampled in couplets so that if the first day of the month (e.g. Monday) was a morning count, the following Monday would automatically be an afternoon count. Coin flipping again determined the next period of sampling. Weekend and holiday sampling periods were determined separately, but in the same manner. Actual hour of counting was determined by assigning each censusing hour an arbitrary number. A table of random numbers was used to determine the hour the count was to be made. No hour was repeated until all hours had been used once. These hours of sampling were assigned to the days by again progressing vertically through the calendar month. Morning hours were assigned first, afternoon hours last. Weekends and holidays again were figured separately.

The count of all fishermen was made daily by proceeding by boat up the center of the lake at the prescribed hour. On the return trip both boat and bank fishermen were interviewed. Information obtained from the interviews was: number and sex of the fishermen; residence; number of hours spent fishing; species, number, and length of fish creeled; method of fishing; and type of bait used. At the end of each month, this information was compiled and expanded to obtain the total creel for the month as follows:

Estimated total fishing hours = $(A \cdot B \cdot C)$
Estimated total catch = $(A \cdot B \cdot C \cdot D)$

- A = average number of fishermen per day.
- B = length of census day (hours).
- C = number of days in census period.
- D = rate of catch (fish per hour).

Total catch by species was determined by multiplying the total estimated catch by the per cent composition by species.

Stomach Analysis of Largemouth Bass

Bass stomachs were collected approximately biweekly throughout the summer of 1964. A total of 259 stomachs was obtained by using an AC boom shocker (Witt and Campbell, 1959) in the littoral zone in the early hours of darkness. Bass were placed in tubs of water and the stomachs were promptly removed. Regurgitation was not evident.

Age and Growth of Largemouth Bass

Scales were removed from the left side of live fish below the lateral line and beneath the origin of the dorsal fin. Impressions of four scales from each fish were made in clear plastic (Campbell and Witt, 1953), and read on a microprojector. Analysis of scale mea-

TABLE 1.—*Stomach analysis of largemouth bass, 15.2 to 27.9 cm (6 to 11 inches) total length, expressed as grams of food per 0.454 kg (1 lb) of bass, with selected environmental data, 1964*

Date of collection	Number of bass	Grams of food per 0.454 kg (1 lb.) of bass	Percent empty stomachs	Aquatic plants (depth in m)	Surface temperature °C	Secchi disk cm
29 May	13	5.6	7.1	trace	21.7	43
10 June	19	4.6	20.8	*Potamogeton* sp. 0.3–0.6	22.8	66
29 June	20	3.3	25.9	*Potamogeton* sp. 0.3–0.9; *Chara* sp. 0.0–0.2	27.8	122
17 July	28	4.0	30.0	*Potamogeton* sp. 0.3–0.9; *Chara* sp. 1.5–1.7	26.7	132
DRAWDOWN						
29 July	43	10.7	4.4	none	30.0	74
12 Aug.	34	4.9	2.9	none	23.3	74
24 Sept.	27	5.1	6.9	none	21.7	140

surements revealed a yearly linear body-scale relationship. Back calculated lengths were determined by a nomograph (Hile, 1950) and the corresponding intercept was used when back calculating each year's data.

RESULTS AND DISCUSSION

Summer Drawdown

During an initial test 25 June, 1964, the lake was lowered 23.9 cm (9.4 inches) during a 24-hour period. It was then estimated the 2.4 m (8 ft) drawdown would take from 8 to 10 days. Drawdown operations were begun 19 July and completed by 29 July.

Between 26 June and 19 July the water level dropped by evaporation an additional 7.9 cm (3.1 inches). Consequently, when the drawdown began, the surface was 48.7 cm (12.5 inches) below full pool or an elevation of approximately 253.2 m (830 ft). During the first day the rate of lowering was 23.9 cm (9.4 inches) during the last day 27.4 cm (10.8 inches). The average drawdown rate for the entire period was 26.2 cm (10.3 inches) per day. With the surface at 251 m (823 ft) the acreage was reduced by 42% from 83 to 44 ha (205 to 118 acres); the volume was reduced by 58% from 2,276,066 m^3 (1,845 acre-ft) to approximately 949,903 m^3 (770 acre-ft).

Both temperature and dissolved oxygen measurements suggested that the bottom waters (thermocline and hypolimnion) were withdrawn during drawdown. Figure 2 depicts the changes in water temperature at various depths throughout drawdown. Temporary stratification developed 3–7 August and by 11 August the lake exhibited a fall overturn pattern. Throughout the drawdown the Secchi disk readings gradually decreased from 182.9 cm (72 inches) on 19 July to 73.6 cm (29 inches) by 29 July when the lake entered overturn. Increased turbidity appeared to result from the resuspension of bottom organic matter and plankton bloom.

Feeding of Largemouth Bass

It has been assumed that as the summer progresses, the late developing vegetation provides protection for food organisms and thus, may cause a decrease in the available bass forage. Reduced food consumption was substantiated by analysis of bass stomach contents (Table 1). This table is restricted to fish 15.2–27.9 cm (6 to 11 inches) total length because this length group was well represented in each collection and fish of these lengths accounted for 71% of all the bass collected. Ratio of grams of food found in the stomach per 0.454 kg (1 lb) of fish clearly demonstrated the reduction in feeding before drawdown. This ratio was 5.6 on 29 May, and by 17 July, just prior to drawdown, was reduced to 4.0. The percentage of empty stomachs increased from 7.1% on 29 May to 30% by 17 July.

That this reduced feeding may have been related to increased growth of aquatic vegetation is suggested by these observations: There was little vegetation in the lake during

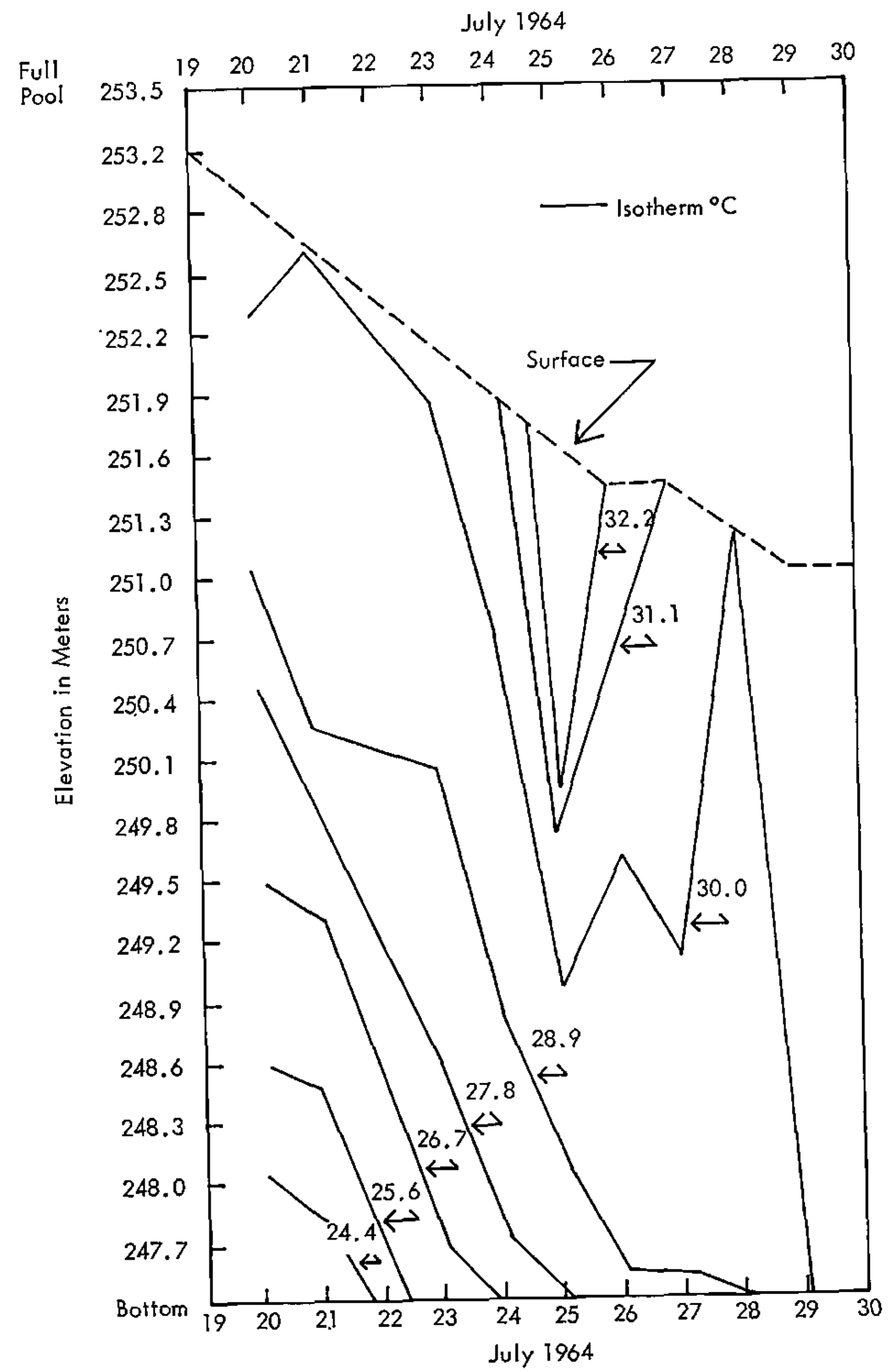

FIGURE 2.—Pattern of the thermal stratification of Little Dixie Lake, during the period of drawdown.

TABLE 2.—*Feeding habits of 123 largemouth bass 7.6–48.3 cm (3–19 inches) in total length during the pre-drawdown period 29 May–17 July, 1964*

Food item	29 May		10 June		29 June		17 July	
	Frequency of occurrence	Percent by weight	Frequency of occurrence	Percent by weight	Frequency of occurrence	Percent by weight	Frequency of occurrence	Percent by weight
I. Fish								
Bluegill	31.3	52.3	23.8	36.7	24.1	29.1	3.5	0.4
Redear sunfish	0.0	0.0	0.0	0.0	0.0	0.0	3.5	7.6
Largemouth bass	0.0	0.0	4.8	0.6	0.0	0.0	3.5	3.8
Unidentified	50.0	21.6	19.1	6.2	48.3	13.1	20.7	33.6
Total	75.0	73.9	47.6	43.6	72.4	42.2	27.6	45.4
II. Crayfish	50.0	25.1	38.1	48.0	37.9	34.0	34.5	41.6
III. Insects								
Ephemeroptera	0.0	0.0	19.1	2.0	0.0	0.0	27.6	6.8
Diptera	0.0	0.0	4.8	0.1	0.0	0.0	3.5	trace
Hemiptera	0.0	0.0	9.5	trace	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	14.3	4.1	0.0	0.0	0.0	0.0
Trichoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified	25.0	trace	0.0	0.0	0.0	0.0	3.5	0.1
IV. Annelida	0.0	0.0	4.8	trace	0.0	0.0	0.0	0.0
V. Tadpole	0.0	0.0	0.0	0.0	6.9	22.6	3.5	3.9
VI. Plant material	6.3	1.0	23.8	1.9	10.4	0.3	10.4	0.2
VII. Unidentified animal remains	0.0	0.0	4.8	0.3	0.0	0.0	13.8	2.0

May, but by 17 July the pondweed, *Potamogeton nodosus,* extended from the shore to depths of 0.9 m (3 ft) and *Chara* sp. to depths of 1.7 m (5.5 ft).

In the post-drawdown period the ratio of grams of food per 0.454 kg (1 lb) of fish increased to 10.7 from a pre-drawdown ratio of 4.0 (Table 1). This value for 29 July was almost double that of late May and early June when feeding would be at an expected high. Values for food intake from August and September were almost as high as those of late May and early June collections. Additional verification of an increased feeding rate was the marked decrease in the percentage of empty stomachs which were never in excess of 6.9% during the post-drawdown period. These changes in feeding were not related to water temperature or transparency (Table 1).

Major items comprising the bulk of the diet during the pre-drawdown period were fish and crayfish, both in frequency of occurrence and percentage of total weight (Table 2). Fish and crayfish remained the principal food items after drawdown (Table 3). There was a major increase in the consumption of crayfish immediately following the drawdown and then a gradual decline in the

TABLE 3.—*Feeding habits of 136 largemouth bass 5.1–33.0 cm (2–13 inches) in total length during the post-drawdown period 29 July–24 September, 1964*

Food item	29 July		12 August		24 September	
	Frequency of occurrence	Percent by weight	Frequency of occurrence	Percent by weight	Frequency of occurrence	Percent by weight
I. Fish						
Bluegill	56.6	18.9	47.5	32.8	41.2	48.7
Redear sunfish	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth bass	1.9	1.0	2.5	7.1	0.0	0.0
Unidentified	3.8	1.5	32.5	12.1	38.2	23.5
Total	64.2	21.4	75.0	52.0	82.4	72.2
II. Crayfish	56.6	77.7	22.5	36.5	17.7	12.7
III. Insects						
Ephemeroptera	11.3	0.7	0.0	0.0	5.9	0.3
Diptera	1.9	trace	0.0	0.0	14.7	0.3
Hemiptera	0.0	0.0	0.0	0.0	2.9	trace
Odonata	5.7	0.1	0.0	0.0	2.9	0.5
Trichoptera	0.0	0.0	0.0	0.0	2.9	0.1
Unidentified	1.9	trace	0.0	0.0	0.0	0.0
IV. Annelida	0.0	0.0	0.0	0.0	0.0	0.0
V. Tadpole	0.0	0.0	2.5	4.7	8.8	13.8
VI. Plant material	7.6	0.1	5.0	0.8	11.8	0.2
VII. Unidentified animal remains	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 4.—*Increment of growth for largemouth bass of age groups 0, I, II, and III, 1959–1964*

Age groups	Increment of growth in cm (inches in parentheses)					
	1959	1960	1961	1962	1963	1964
0	13.0 (5.1)	10.9 (4.3)	11.4 (4.5)	13.0 (5.1)	12.7 (5.0)	11.7 (4.6)*
I	13.0 (5.1)	9.4 (3.7)	8.4 (3.3)	9.1 (3.6)	6.9 (2.7)	10.9 (4.3)*
II	– –	6.4 (2.5)	7.9 (3.1)	7.1 (2.8)	4.8 (1.9)	8.9 (3.5)*
III	– –	– –	7.4 (2.9)	5.8 (2.3)	3.3 (1.3)	6.6 (2.6)*

* Year of summer drawdown.

succeeding two months. Consumption of fish continued to increase through August and September.

Growth of Largemouth Bass

The rate of growth of largemouth bass in Little Dixie Lake decreased steadily from 1959 to 1963 because 1) there had been a continual increase in the competition for food among individuals of this species, 2) the expanding population of other species had depressed the growth of bass by competing for food and living space, and 3) increased vegetation in the lake had provided additional cover and thus reduced the amount of available forage.

A total of 1,269 largemouth bass were aged to obtain growth increments of age groups 0, I, II, III (Table 4). There was a general decline in the increments of growth of age groups I, II, and III, from 1959 through 1963. There was no consistent trend in increments of growth of young-of-the-year bass. Growth of age groups I, II, and III in 1964, the year of drawdown, was greatly accelerated (Table 4).

This accelerated growth rate for the post drawdown period parallels the increased feeding rate of bass already described. (Further, it will be proposed that there was an increased availability of forage bluegill of the size most readily used by largemouth bass age groups

TABLE 5.—*Fish harvest and fishing pressure, 1960–1964*

	1960*	1961**	1962	1963	1964
Largemouth bass					
Total number	13,699	6,050	6,173	7,545	6,714
Total kg (lbs)	3,351 (7,381)	979 (2,157)	1,993 (4,390)	1,910 (4,208)	2,138 (4,709)
Kg/ha (lbs/A)	40.4 (36.0)	11.8 (10.5)	24.0 (21.4)	23.0 (20.5)	25.8 (23.0)
Bluegill					
Total number	4,319	19,786	19,552	25,191	40,156
Total kg (lbs)	299 (659)	1,424 (3,137)	1,344 (2,961)	1,485 (3,271)	1,870 (4,119)
Kg/ha (lbs/A)	3.6 (3.2)	17.2 (15.3)	16.2 (14.4)	17.9 (16.0)	22.5 (20.1)
Green sunfish					
Total number	33,599	10,968	2,939	1,122	625
Total kg (lbs)	2,053 (4,522)	742 (1,635)	260 (573)	88 (193)	30 (67)
Kg/ha (lbs/A)	24.7 (22.1)	8.9 (8.0)	3.1 (2.8)	1.1 (0.9)	0.4 (0.3)
Redear sunfish					
Total number	679	670	581	1,135	1,396
Total kg (lbs)	99 (219)	142 (313)	101 (222)	143 (316)	182 (400)
Kg/ha (lbs/A)	1.2 (1.1)	1.7 (1.5)	1.2 (1.1)	1.7 (1.5)	2.2 (2.0)
Channel catfish					
Total number	1,080	1,245	1,403	1,408	4,505
Total kg (lbs)	115 (253)	420 (925)	459 (1,010)	569 (1,253)	1,481 (3,263)
Kg/ha (lbs/A)	1.4 (1.2)	5.1 (4.5)	5.5 (4.9)	6.9 (6.1)	17.8 (15.9)
Yellow bullhead					
Total number	0	0	0	0	71
Total kg (lbs)	0 (0)	0 (0)	0 (0)	0 (0)	10 (23)
Kg/ha (lbs/A)	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (0.1)
Total number of all fish caught	53,376	38,719	30,648	36,401	53,538
Total kg (lbs) of all fish caught	5,917(13,034)	3,708 (8,167)	4,157 (9,156)	4,195 (9,241)	5,722(12,604)
Total kg/ha (lbs/A)	71.3 (63.6)	44.7 (39.8)	50.1 (44.6)	50.5 (45.0)	68.9 (61.4)
Total hours per ha (hrs/A)	162 (406)	118 (294)	105 (262)	113 (283)	159 (398)

* Turner, 1963.
** Turner's study was terminated September 4, 1961 at which time the senior author began the present study. These figures are the totals for the season.

TABLE 6.—*Fish harvest and fishing pressure by month, 1962–1964*

		April	May	June	July	August	September	October 15
Total fishing hours								
1962		6,029	9,331	9,403	11,171	8,868	6,977	2,005
1963		8,502	9,852	9,093	11,636	8,914	6,954	2,979
1964		9,867	18,054	14,647	13,714	13,978*	8,970*	2,277*
Catch per hour								
1962		.18	.72	.62	.66	.45	.58	.83
1963		.28	.82	.79	.57	.61	.58	.87
1964		.32	.55	.61	.83	.92*	.70*	.43*
Total catch								
1962	Largemouth bass	386	999	1,362	820	987	1,226	393
1963		707	1,555	2,039	1,226	1,079	700	239
1964		533	1,592	1,119	1,085	636*	1,287*	462*
1962	Bluegill	304	4,027	3,787	5,447	2,556	2,326	1,105
1963		1,419	5,811	4,571	4,438	3,857	2,957	2,138
1964		1,846	7,296	6,468	8,216	11,291*	4,633*	388*
1962	Green sunfish	329	1,520	409	307	70	219	85
1963		123	240	229	279	153	15	83
1964		126	126	123	48	86*	42*	74*
1962	Redear sunfish	0	70	58	147	140	121	45
1963		117	348	258	142	106	69	95
1964		119	311	191	346	259*	131*	39*
1962	Channel catfish	90	94	168	619	237	155	40
1963		41	124	69	547	277	313	37
1964		477	587	1,078	1,659	537*	142*	25*
1962	Yellow bullhead	0	0	0	0	0	0	0
1963		0	0	0	0	0	0	0
1964		0	18	0	16	37*	0*	0*

* Post-drawdown period.

I through III. Bennett (1962) found that bass growth was good during August and September if an abundance of food was available.)

Harvest of Fish

A progressive decline in quality of fishing in Little Dixie Lake, 1960 through 1963, dictated the need for intensive fishery management.

The lake was first opened to fishing on 28 May, 1960. Initial fishing pressure was heavy with 4,591 fishing trips during the first 4 days yielding 12,478 fish (Turner, 1963). Also in this initial period, 46% of the bass population over 22.9 cm (9 inches) were harvested. By the end of the first season (October 15), a total of 23,198 fishing trips were completed and 53,376 fish caught. During this time, the harvest of largemouth bass 22.9 cm (9 inches) and longer was 72% of the available stock of this size.

In the years following, 1961–1963, the quality of fishing declined (Table 5). Bass harvest for each year was approximately one-half that of the first year. Size of bass caught remained small with the percentage checked in the creel, 25.4 cm (10 inches) or shorter in total length, being 66.8, 82.0 and 67.8% for each year 1962 through 1964 respectively (Figure 3). Harvest of green sunfish decreased from 24.8 kg per ha (22.1 lb per acre) in 1960 to 0.3 kg per ha (0.3 lb per acre) in 1964 (Table 5). Bluegill catch expanded from 3.6 kg per ha (3.2 lb per acre) in 1960 to 22.5 kg per ha (20.1 lb per acre) in 1964. Golden shiners (*Notemigonus crysoleucas*) conversely had been introduced during 1960–1964, probably as bait minnows. Yellow bullheads (*Ictalurus natalis*), which were not stocked, were first checked in the creel in 1964.

Since the object of fishery management is to provide more and better quality fish for the angler, the possible effects of drawdown on the harvest received careful consideration.

Our evaluation of summer drawdown on fishing success is based on a comparison of the creel returns for 4 months (April, May, June, and July) prior to drawdown with the return for 2½ months (August, September, and 15 October immediately following drawdown (Table 6). Creel returns are provided for comparison from identical months in 1962 and 1963, years without a drawdown. The reader is reminded that the July values, 1964, are a composite of the pre-drawdown 1 through 18 July, drawdown 19 through 29 July, and post-drawdown 30 through 31 July periods.

The immediate effect was that bass harvest

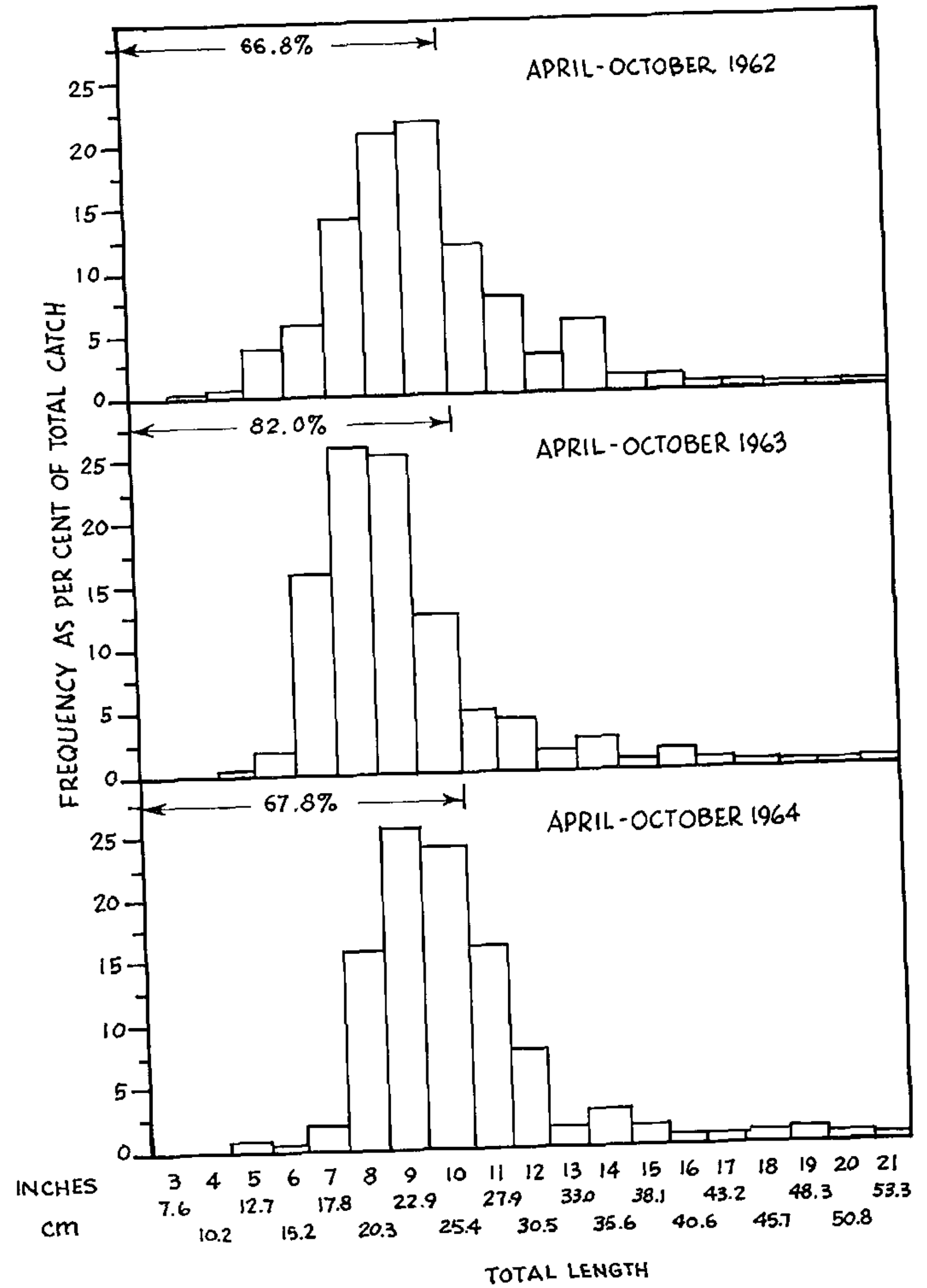

FIGURE 3.—Length frequency distribution of largemouth bass taken in the creel, with percentage 25.4 cm (10 inches) and under indicated.

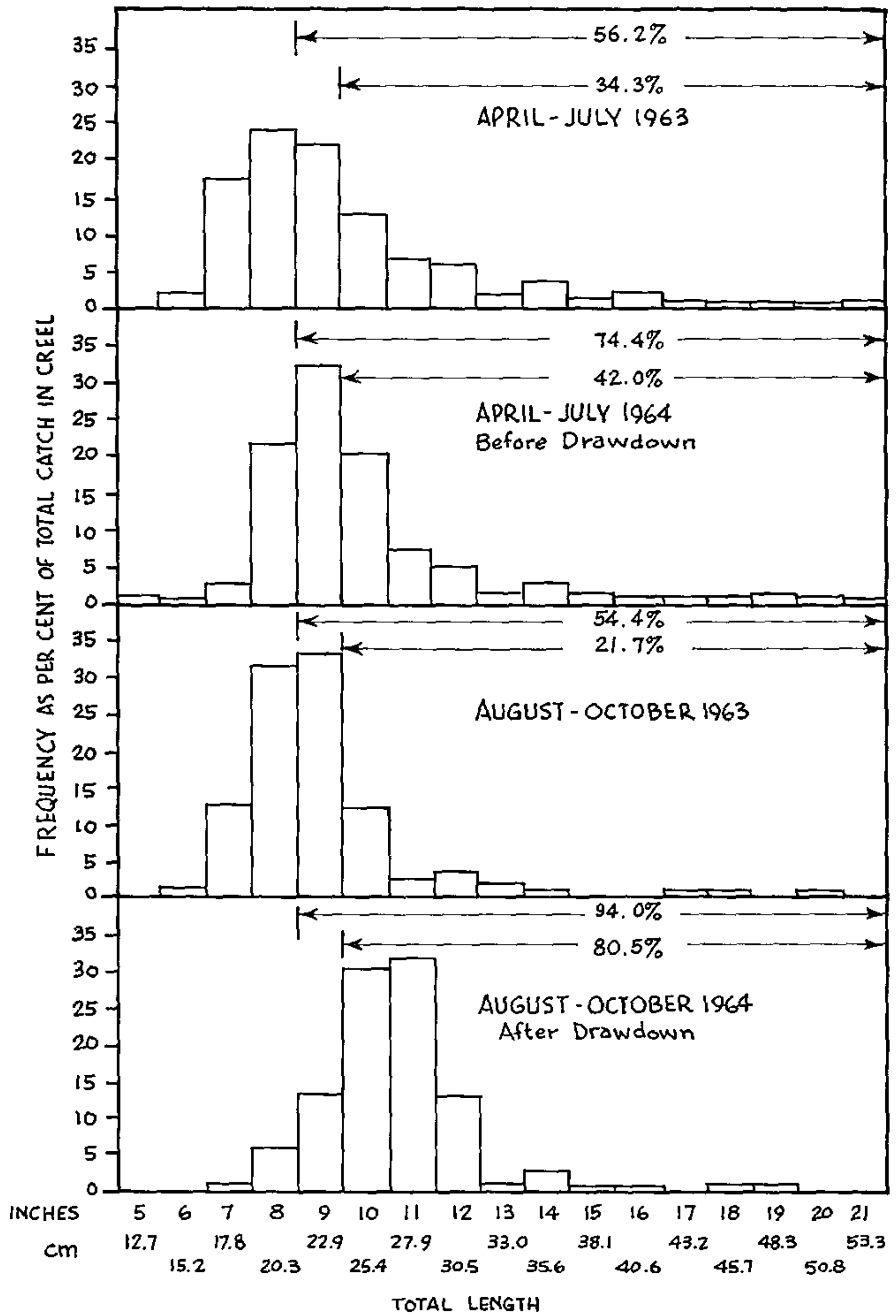

FIGURE 4.—Length frequency composition of the largemouth bass in the creel in 1963 (1,304 fish measured) and before and after drawdown in 1964, (1,124 fish measured). The percentage of the total take 22.9 cm (9 inches) and over as well as 25.4 cm (10 inches) and over is indicated.

decreased immediately following drawdown and then improved (Table 6). It appeared that the immediate effect of the drawdown was to reduce the bass harvest by providing a surplus of forage. As this surplus was reduced, as suggested by our seining data, then fishing success for bass improved.

When the pre- and post-drawdown length frequencies of creeled bass were compared (Figure 4), the percentage of bass caught 25.4 cm (10 inches) and longer was similar in both years, 1963 and 1964, from April through July. However, during the period August through October 15, after the lake was lowered, there was considerable difference in these percentages between the two years. Fish 25.4 cm (10 inches) and longer made up 80.5% of the bass catch after the drawdown in 1964; only 21.7% in the comparable period in 1963. As supporting evidence, in 1965, fish 25.4 cm (10 inches) and longer made up 58.3% of the catch of bass April through July and 74.8% August through October 15. The greater growth rate of bass in 1964 as opposed to that of 1963 has already been established (Table 4). Thus, although there was no appreciable increase in the number of bass in the creel in late summer, 1964, the size of bass caught was distinctly larger than in the previous year.

There was a conspicuous increase (35%) in total catch of bluegill in August, 1964 as opposed to July (Table 6). This is in contrast to the decrease in catch in August in 1962 and 1963, which was caused in part by decreased fishing pressure. In 1964 there was no change in fishing pressure. That the difference in July and August, 1964 was from drawdown was further shown by the change in the July catch rate (from pre-drawdown to drawdown period). While the catch rate of fish increased from 0.75 to 1.10 fish per hour, the percentage of bass caught decreased from 12 to 3 and the percentage of bluegill caught increased from 69 to 81. Fishing pressure during the drawdown period 20–31 July, was only 22% of the total for the month; catch was 30% of the total.

Numbers of Forage Bluegill

Seine hauls in July before drawdown and in September, 55 days after drawdown, differed as follows: In the July census 2.5–5.1 cm (1–2 inch) bluegill were captured at an average rate of 221 per seine haul, while in the September census this was reduced to 137 per seine haul. The catch rate of 5.1–7.6 cm (2–3 inch) bluegill also was reduced from 40 per seine haul in July to 17 per seine haul in September. Catch rate of 7.6–10.2 cm (3–4 inch) bluegill was 6 in July and 3 in September. Estimates of bluegill less than 2.5 cm (1 inch) which escaped through the seine also dropped from 238 per seine haul before drawdown to 25 in September of 1964. These reductions in numbers following drawdown were still evident in 1965 catch rates of 29, 9 and 5 for 2.5–5.1 cm, 5.1–7.6 cm, 7.6–10.2 cm (1–2 inch, 2–3 inch, 3–4 inch) bluegill respectively.

It is difficult to separate the specific effects of the different factors, each of which possibly contributed to this reduction in numbers of bluegill. It was evident through the analysis of bass stomachs during the post-drawdown period that the feeding intensity of bass increased and small fish were one of the major food items in the latter part of this period. Therefore, it is believed that increased predation by bass was a factor in this reduction of small bluegill. Small bluegill also were trapped in the weed beds and shallow pools as the water receded. This mechanical stranding appeared to be somewhat specific for the smaller forage fish. Further, the exposure of bluegill nests as the water was lowered probably reduced the number of young produced.

While the authors acknowledge the possibility of seasonal and environmental changes, and of sampling error effecting this decline, they do suggest that the decline in numbers of forage bluegill was real and was accentuated through drawdown.

CONCLUSIONS

The authors recognize the magnitude of variation appearing in biological collections due to seasonal differences and to sampling discrepancies. With due recognition of such variations—well documented by five years of creel census data, 1960–1964 (Tables 5, 6) —we are still impressed by observations that major changes have appeared in Little Dixie Lake which are best explained by the drawdown of 19–29 July, 1964. At least five different but related phenomena reinforce one another in their apparent response to drawdown. These phenomena are 1) increased increment in growth of largemouth bass, 2) increased food consumption by largemouth bass, 3) alteration in the size of the harvest of bass and bluegill, 4) increased size of bass comprising the harvest, and 5) an apparent decline in the relative abundance of forage bluegill.

Since these various phenomena reinforce one another, and are logical outgrowths of changes in conditions brought about by drawdown, we suggest that these are, at least in part, influenced by summer drawdown.

The observations presented in this paper tend to support the proposals by Bennett (1962) and others. Our best evaluation of the sequence of events in Little Dixie Lake follows. The initial heavy removal by angling of largemouth bass during the first open season (1960) prepared the way for the gradual increase in numbers of bluegill. Their increase and survival was encouraged by the development of macrophytes in 25 per cent of the area of the lake. Competition for food among predators due to unavailability of forage because of the excessive vegetation, resulted in a slow growing population of bass so that most bass harvested were less than 25.4 cm (10 inches) in length (Figure 3). Drawdown reduced the area of the lake so that plant beds were exposed and forage fish were made available to the predators. Forage was then readily available and was subsequently reduced through predation. Bass showed an increase in rate of growth and bass harvest improved.

This study suggests that mid-summer drawdown is an effective management tool. The length of time the technique remains effective is undetermined.

ACKNOWLEDGMENTS

We are indebted to John A. Coddard for providing most of the 1965 data, and to members of the Fisheries Division, Missouri Department of Conservation for their assistance.

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