EVALUATION OF LIBERALIZED REGULATIONS ON LARGEMOUTH BASS BROWNS LAKE, WISCONSIN

TECHNICAL BULLETIN NUMBER 31

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Madison, Wisconsin 53701

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Edited by Ruth L. Hine

ABSTRACT

The effects of liberalized angling regulations (no size limit and an earlier opening) on a largemouth bass *(Micropterus salmoides)* population were evaluated over a six-year period (1952-57) at Browns Lake, Racine County, Wisconsin.

Partial creel censuses produced catches of 2,671 bass in 1953 and 1,252 in 1955. Fishing pressure amounted to 75 and 63 hours per acre for the respective years. In 1953, 60 percent of the bass caught were over 10 inches long and in 1955, 75 percent were 10 inches or longer. Angler rejection of small fish after the no-size-limit novelty had worn off is given as the reason for this variation in the anglers' catch. Age-groups II, III, and IV combined accounted for 68 to 83 percent of all fish sampled, whether caught by anglers or seine hauls. Changes in the age composition of the population occurred from year to year because of uneven recruitment of year classes.

Growth rates were slightly better in 1955 and 1957 than when the study was initiated in 1953, for years of life 3 through 6. No steady and progressive increase was apparent, however. Browns Lake bass reached 10 inches during the fourth growing season, averaged 15.6 inches at the end of seven, and few fish were found to be older than eight years.

The total population of largemouth bass was estimated by the mark and recapture technique to include 21,980 fish over 6 inches long in 1953, 14,698 in 1955, and 14,115 in 1957. Data are presented which indicate that largemouth bass are caught somewhat more easily just prior to spawning, while on the nests, or guarding young fish. However, reproduction and recruitment did not appear to be adversely affected during the study period.

The liberalization of bass regulations afforded increased opportunity for anglers to pursue their sport, without harm to the bass population during the study period.

CONTENTS

Introduction 5

Description of the Study Area 5

Anglers' Harvest 7

Age and Growth 8

Population Estimates 15

Discussion 19

Literature Cited 23

INTRODUCTION

The past 15 years have seen the trend in largemouth bass *(Micropterus salmoides)* mangement change from extreme protection to liberalization – to the point of no size, bag, or season restrictions in some states. Wisconsin approached these changes rather cautiously. In 1952, liberalized bass regulations were established on two southern Wisconsin lakes: Browns Lake in Racine County and Turtle Lake in Walworth County.

Browns Lake was chosen as the site to evaluate the effects of the changed regulations. Minor efforts were made in 1952 by Kmiotek and Cline[1], and with the establishment of a federally financed Dingell-Johnson project in 1953 the evaluation effort was greatly expanded.

"Liberalized," as used in this study, is defined as advancing the season from a former opening of June 20 to May 16 in 1953, to April 30 in 1955, and to May 1 in 1957; and removing the minimum size limit of 10 inches but retaining a daily bag limit of 5 fish.

The ultimate evaluation of a regulation change should reveal whether the bass population is harmed or benefited by the new regulations and if so, how and to what degree, and also if the angler is provided with more fishing pleasure. To evaluate the results of liberalized bass regulations it was necessary to determine: (1) the standing crop of largemouth bass, (2) the rate of exploitation by anglers, (3) age composition of the population, and (4) rate of growth of various year classes. This was done by fall population estimates, a creel census, and extensive age and growth studies.

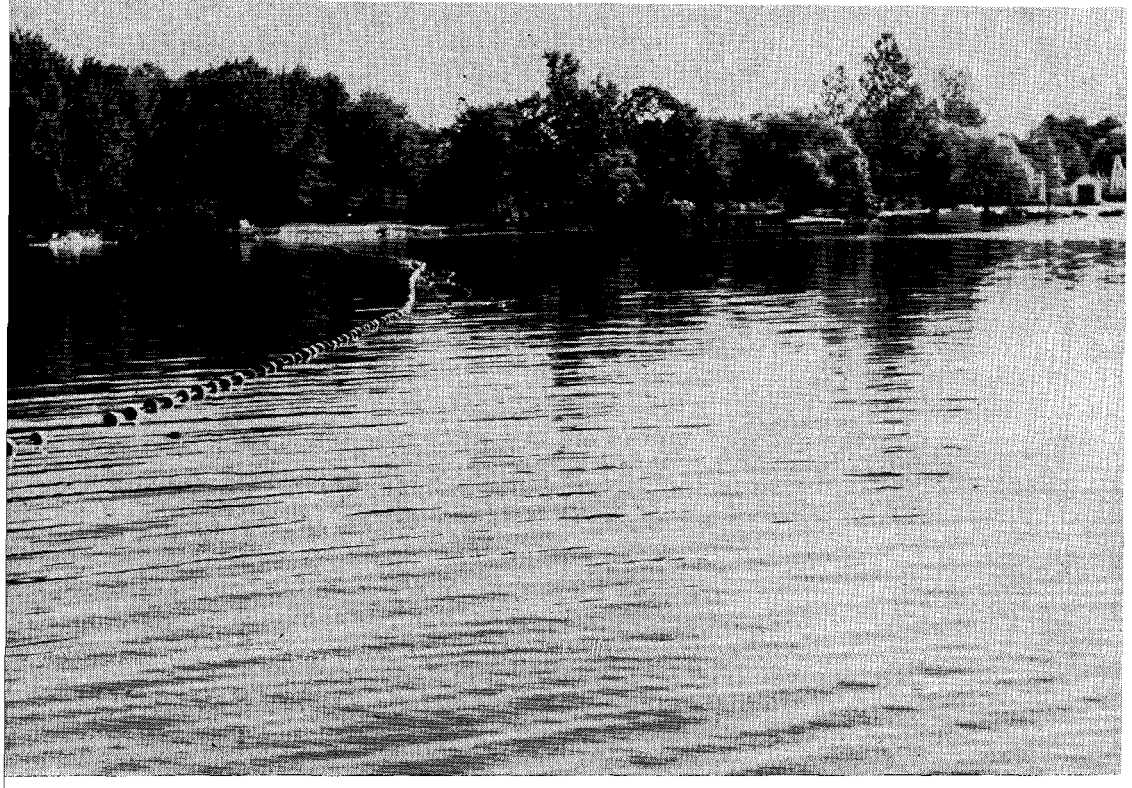
A previous report on Browns Lake by Mraz and Threinen (1957) presented preliminary data collected in 1953. Data from that report are also presented here to provide continuity and to show the effects of liberalization after six years (the angling seasons from 1952 through 1957) of fishing under the new regulations.

DESCRIPTION OF THE STUDY AREA

Browns Lake was chosen for the experimental liberalization and subsequent evaluation because it had a good largemouth bass population, was heavily fished, and could be readily seined, making the sampling of the population practical.

It is located in southeastern Wisconsin, near the city of Burlington

[1] Kmiotek, Stanley and Clarence L. Cline (1952). Growth of southern Wisconsin largemouth bass with creel census results from lakes with liberalized regulations. Wis. Conserv. Dept., 11 p. (mimeo.).



Browns Lake was chosen to test the effects of liberalized regulations for it had a good largemouth bass population, was heavily fished and could be readily seined.

in Racine County, covers 396 surface acres and has a maximum depth of 44 feet, and an average depth of 12 feet. Contours are gradual and regular with the exception of one small depression. The lake is surrounded by wooded hills except for the flat south shore. The bottom is sand, gravel, and marl. The entire shoreline is developed with both summer and year-around homes, several large resorts and boat liveries, and a public beach and boat access point.

Summer stratification is confined to the one deep depression, and dissolved oxygen is present at all levels in quantity adequate to support fish life.

Summer water temperatures range from 80° F. at the surface to the mid-70's at depths of 15 feet. Maximum secchi disc readings are 8 feet in the summer. The water has a methyl-orange alkalinity of 186 ppm, which is considered hard.

Rooted vegetation is very abundant with wild celery *(Valisneria americana)*, and sago pondweed *(Potamogeton pectinatus)*, most common. Muskgrass *(Chara* sp.*)* is also abundant. Vegetation control by chemical means has been attempted but the lake is still densely vegetated. Past history shows that extensive beds of bulrush *(Scirpus* sp.*)* existed, but are now extinct.

The fish population is the common bass-panfish combination. The largemouth bass is the dominant game fish with the bluegill *(Lepomis macrochirus)* and black crappie *(Pomoxis nigro-maculatus)* the most important in the catch of a wide variety of panfish. Northern pike *(Esox lucius)* are also present in small numbers as predators. Carp *(Cyprinus carpio)* are present in Browns Lake, but are not abundant (60 - 75 lbs. per acre).

ANGLERS' HARVEST

To obtain information on the anglers' harvest of largemouth bass from Browns Lake, a creel census was conducted in 1953 and 1955. The census schedule, which was arranged to cover peak periods of bass harvest on each day, was from 6 a.m. to 10 a.m. and 3 p.m. to dark. In addition, on two days a week a census was taken between the hours of 10 a.m. and 3 p.m. These two long days were changed each week so that individual days received a complete check twice each seven-week period. Census was conducted approximately 80 hours a week.

The census clerk made boat counts every two hours during his tour of duty, contacted as many fishermen as possible, tallied hours fished and fish caught, and took scale samples and lengths of all largemouth bass. Because of the several resorts and boat liveries, it was not possible to establish a central point to check fishermen leaving the lake, but instead all fishermen were contacted on the lake itself. This work was facilitated by a local ordinance requiring all boats to be registered and to display a license number. The clerk on first contact with a fishing party wrote the boat license number on a creel card and collected preliminary data as to hours fished and numbers caught. Upon contacting the boat a second time, he sorted through his cards, located the one for the specific boat and brought his data up to date.

The creel census was conducted from May 16, opening day in 1953, to October 9, and from opening day April 30, 1955, through September 30. In 1955 Browns Lake was one of several "duck resting lakes" in the state, and no fishing was allowed from boats during the migratory waterfowl season, October 1 through December 9. Normally the lake freezes over early in December and checks during winter months showed very little ice fishing pressure. The season for largemouth bass closed on February 15. The period covered by the creel census accounted for nearly all of the significant largemouth bass harvest.

Census methods actually tended to overestimate harvest because clerks were advised to concentrate on boats known to be fishing for bass, but all boats present were used in projecting the estimates for total hours fished and bass caught. On the other hand, the census was only conducted until dark and catches after dark were not tallied. As

few boats were still on the lake at the time of darkness this number is estimated to be small.

Browns Lake received an estimated 30,091 hours of fishing pressure in 1953 and 24, 974 hours in 1955 (Tables 1 and 2). Fishing pressure was 75 hours per acre in 1953, and 63 hours per acre in 1955 despite a season which opened two weeks earlier. Some of the reasons for this drop in fishing pressure were: (1) during the latter part of May and early June, 1955, heavy daily rains kept fishermen off the lake; (2) the summer of 1955 was the hottest on record with 90° F. weather occurring on 37 days (average for the area is about 7 days); (3) in 1953, Browns Lake was one of two lakes which had an experimental early opening, but in 1955 the southern tier of 12 Wisconsin counties all opened on the same early date; and (4) the bass population had declined by about 30 percent in 1955 from the 1953 level.

Anglers caught an estimated 2,671 largemouth bass in 1953 and 1,252 in 1955 (Tables 1 and 2). Primarily contributing to the decline were the lowered fishing pressure (from 75 to 63 hours per acre) and possibly the rejection of the smaller bass by the angler after the novelty of the "no size limit" had worn off. In 1953, 60 percent of the bass caught were over 10 inches long (the former legal size limit) and in 1955, 75 percent were 10 inches or longer. Further support of angler rejection of small fish will be found in the following section on age and growth.

The 30 percent drop in numbers for the entire population would certainly result in a reduced catch. Lagler and DeRoth (1953), in their expression of a theoretical relationship between standing crop of legal-sized largemouth bass and yield of such bass in small ponds with mixed fish population, found that the numbers of catchable fish present in a body of water influenced both angling success and angler attitude.

With nearly equal hours fished during the morning and evening census periods, 55 percent of all bass caught in 1955 were taken in the morning (Table 2). The morning period also produced a greater percentage of larger fish than the evening period. Of the 695 fish caught in the morning, 566 (82 percent) were 10 inches or longer while only 369 of the 557 (66 percent) evening-caught fish were of this size. The angler had slightly better success numberwise and decidedly better success sizewise fishing the morning hours rather than the evening hours.

AGE AND GROWTH

Part of the evaluation of liberalized regulations on largemouth bass in Browns Lake was concerned with the changes in age composition and rate of growth of the population.

Scales were taken from all bass examined by census clerks in 1953

TABLE 1

Estimated Total Hours Fished and Number of Largemouth Bass Caught (Browns Lake Creel Census, 1953)

Census Period	Estimated Total Hours Fished	Estimated Number Largemouth Bass Caught			
		Shorter Than 10 Inches	10 Inches or Longer	All Lengths	Cumulative Percentage Caught
May 16-22	1,144	16	60	76	2.9
May 23-29	1,136	57	148	205	10.6
May 30-June 5	2,100	111	179	290	21.3
June 6-12	1,900	58	123	181	28.1
June 13-19	1,820	47	159	206	35.9
June 20-26	1,652	96	101	197	43.3
June 27-July 3	1,564	182	76	258	52.9
July 4-10	1,646	56	49	105	56.8
July 11-17	2,332	43	41	84	59.9
July 18-24	1,588	30	59	89	63.3
July 25-31	1,828	39	52	91	66.7
Aug. 1-7	1,228	43	41	84	70.0
Aug. 8-14	2,184	69	105	174	76.3
Aug. 15-21	1,596	24	68	92	80.0
Aug. 22-28	1,884	87	117	204	87.4
Aug. 29-Sept. 4	1,268	49	90	139	92.7
Sept. 5-11	1,392	34	60	94	96.2
Sept. 12-18	436	13	19	32	97.3
Sept. 19-25	524	12	10	22	98.2
Sept. 26-Oct. 2	592	11	27	38	99.7
Oct. 3-9	277	0	10	10	100.0
Total	30,091	1,077	1,594	2,671	
Percent		40.3	59.7		

and 1955 and a similar number of fish sampled from fall seine hauls. No creel census was conducted in 1957 and samples for that year came entirely from fall seine hauls. All fish caught by the seine on a selected day were sampled to avoid bias on the part of the collectors. Differences in growth of bass caught by anglers or seine were insignificant and all fish were combined to determine growth rates.

The detailed methods of scale-collecting, processing, and calculating growth for the Browns Lake largemouth bass given by Mraz and Threinen (1957) remained the same. Briefly, they were removing scales from the area midway between the lateral line and the anterior insertion of the dorsal fin, making plastic impressions and reading at a magnification x44.

A nomograph similar to the one described by Hile (1950), based on the body-scale relationship: $S = 0.1813\ L^{1.3613}$, where $S =$ the

TABLE 2

Estimated Total Hours Fished and Number of Largemouth Bass Caught (Browns Lake Creel Census, 1955)

Census Period	Estimated Total Hours Fished		Estimated Number Largemouth Bass Caught							
			Shorter Than 10 Inches		10 Inches or Longer		All Lengths			Cumulative Percentage
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Total	Caught
Apr. 30-May 6	868	449	25	15	96	16	121	31	152	12.2
May 7-13	492	340	6	11	39	24	45	35	80	18.5
May 14-20	563	698	12	33	61	36	73	69	142	29.8
May 21-27	389	451	5	7	39	25	44	32	76	35.9
May 28-June 3	709	968	0	14	38	43	38	57	95	43.5
June 4-10	572	529	4	7	44	24	48	31	79	50.0
June 11-17	288	638	3	8	7	21	10	29	39	52.9
June 18-24	1,050	861	12	17	43	27	55	44	99	60.9
June 25-July 1	797	926	5	9	32	20	37	29	66	66.1
July 2-8	781	814	6	10	13	19	19	29	48	69.9
July 9-15	766	1,179	7	9	8	10	15	19	34	72.7
July 16-22	978	934	5	0	20	3	25	3	28	75.0
July 23-29	662	890	4	7	30	18	34	25	59	79.6
July 30-Aug. 5	658	550	2	8	15	12	17	20	37	82.6
Aug. 6-12	535	712	3	15	29	23	32	38	70	88.1
Aug. 13-19	518	498	3	2	6	18	9	20	29	90.4
Aug. 20-26	440	405	4	6	10	8	14	14	28	92.7
Aug. 27-Sept. 2	410	383	13	5	19	8	32	13	45	96.3
Sept. 3-9	530	344	9	3	10	5	19	8	27	98.5
Sept. 10-16	215	90	1	1	7	8	8	9	17	99.9
Sept. 17-30	72	22	—	1	—	1	—	2	2	100.0
Subtotal	12,293	12,681	129	188	566	369	695	557	1,252	
Percent	49.2	50.8	40.9	59.1	60.5	39.5	55.5	44.5		
Total	24,974		317		935		1,252			
Percent			25.3		74.7					

anterior scale radius (inches x 44) and L the total fish length in inches, was employed for all calculations of growth.

In the earlier report on Browns Lake, fish were aged to 13 years, and the largest was 21.6 inches. Because of the difficulty of accurately aging fish beyond 7 years and also the poor representation in the various samples, resulting in extremely erratic growth comparisons, it was deemed advisable to use only fish through age-group VII. (This does result in minor differences in the comparison of the 1953 data published earlier and presented here, as some recalculations were made with the older fish eliminated.) The number of fish discarded was only about 1 percent of those collected.

Age-groups II, III, and IV combined accounted for 68 to 83 percent of all the fish caught, whether by anglers or seine, in the five samples shown in Table 3. The age composition of the Browns Lake bass population changed from year to year because of uneven recruitment of the various year classes. Age-group III in the 1953 sample was a very poor year class (18.1 percent of the angler-caught and 11.7 percent of the seine-caught fish), while age-group IV in 1953 (VI in 1955), was a strong year class (11.4 percent of the angler-caught and 10.0 of the seine-caught fish in 1955.).

Although about 24 percent of the seine-caught fish were 2 years old in both 1953 and 1955, the percentage of 2-year-olds in the anglers' catch varied markedly (28 percent in 1953 and only 9 percent in 1955). This large difference supports the contention that anglers began to reject the smaller fish in hopes of catching a limit of larger ones, after the initial novelty of the "no size limit" had worn off. If there were no bag limit, the angler might have kept all the fish caught.

The common problem encountered in growth studies of determining what is an annual fluctuation in growth and what can be attributed to other factors existed in the analysis of growth data for the Browns Lake largemouth bass.

TABLE 3

The Number and Percentage of Various Age Groups of Largemouth Bass From Browns Lake

Age Group	Caught by Anglers				Caught by Seine					
	1953		1955		1953		1955		1957	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
I	40	4.6	9	1.1	125	14.5	69	7.6	13	1.2
II	246	28.0	78	9.2	215	24.9	220	24.4	160	15.9
III	159	18.1	344	40.7	101	11.7	298	33.0	412	40.8
IV	283	32.2	159	18.8	273	31.5	106	11.7	270	26.8
V	98	11.2	131	15.5	102	11.8	103	11.4	110	10.9
VI	45	5.1	96	11.4	35	4.0	90	10.0	25	2.5
VII	7	0.8	28	3.3	14	1.6	16	1.9	19	1.9
Total	878	100.0	845	100.0	865	100.0	902	100.0	1,009	100.0

The calculated growth of the fish was determined for each year of life for each collection year and compared to see if a definite trend in change of growth rate could be determined. These comparisons do tend towards a better growth rate in 1955 and 1957 than was present in 1953, for years of life 3 through 6 (Table 4) – for example, 8.9 inches in 1953, 9.3 inches in 1955 and 9.2 inches in 1957 for year 3; and 13.1

inches in 1953, 13.9 inches in 1955 and 14.7 inches in 1957 for year 6. The small maximum difference of 0.2 inch for years 1 and 2 indicate nearly identical but slower growth in 1957 than in 1953. The maximum differences between the years ranged from a low of 0.2 inch to 1.6 inches.

Calculation of growth of various year classes from 1946 through 1956 gave a maximum age of 5 years for fish born under the liberal regulations and 6 and 7 years for those born prior to the liberal seasons.

TABLE 4

Calculated Growth in Length of Largemouth Bass Collected at Browns Lake

Year of Collection	Calculated Total Length (Inches) at End of Year of Life						
	1	2	3	4	5	6	7
1953	3.5	6.7	8.9	10.7	11.8	13.1	15.5
1955	3.4	6.7	9.3	11.3	13.0	13.9	15.4
1957	3.3	6.5	9.2	11.2	12.8	14.7	16.0
Maximum Difference	0.2	0.2	0.4	0.6	1.2	1.6	0.6

The calculated growth histories of the various year classes are shown in Table 5. The graphic presentation of growth of year classes, shown in Figure 1, was used by Hile (1941) and best displays the extent to which growth histories of year classes may differ.

The broken lines connecting the calculated lengths for corresponding years of life show the first-year growth to be very erratic, but generally poorer for fish born in 1952 and later, than for fish born prior to that year. Second-year growth tended to minimize the erratic first-year growth, so nearly all year classes were equal at the end of two years. If the two extremes in range (6.3 inches for 1954 and 7.2 inches for 1946) are eliminated, the maximum difference for the nine remaining year classes was only 0.2 inch.

Bass from the 1952, 1953, and 1954 year classes which grew up entirely under the liberal regulations all showed better growth at the end of three years than did fish from the 1947, 1948, and 1949 year classes for the period they grew prior to 1952. The 1946 year class which had a good growth rate (in all cases the calculated length of the following year tended downward) were faster growing than any of the six following groups. Fish from the 1952 and 1953 year classes were also larger than those from the 1947 and 1948 year classes at the end of four years; the 1952 fish were larger than the 1947 fish at the end of

TABLE 5

Calculated Growth in Length of the Year Classes of Largemouth Bass From Browns Lake

Year Class	Number of Fish	Calculated Total Length (Inches) at End of Year of Life						
		1	2	3	4	5	6	7
1946	21	3.9	7.2	9.8	11.4	12.8	14.0	15.5
1947	80	3.2	6.6	8.9	10.4	11.6	12.9	—
1948	244	3.6	6.6	8.8	10.5	12.0	14.2	15.4
1949	742	3.9	6.7	8.9	10.9	12.9	13.8	—
1950	513	3.7	6.7	9.3	11.5	13.0	14.7	16.0
1951	751	3.2	6.8	9.5	11.3	13.2	14.7	—
1952	917	3.2	6.6	9.2	11.0	12.6	—	—
1953	568	3.1	6.7	9.1	11.2	—	—	—
1954	490	3.4	6.3	9.3	—	—	—	—
1955	160	2.8	6.6	—	—	—	—	—
1956	13	3.8	—	—	—	—	—	—
Maximum difference		1.1	0.9	0.9	1.1	1.6	1.8	0.6

five years but again the 1946 year class was the fastest growing in both instances.

The 1950 and 1951 year classes are difficult to compare. As was pointed out, nearly all variance in first-year growth was minimized at the end of the second year. This being the case, the growth of the 1950 and 1951 year classes in 1952 and 1953, the first two years of the liberal regulation period, would have to be considered excellent, compared to all but the 1946 year class.

The years 1952 and 1953 appear to have been years of excellent growth for bass over 2 years old, followed by a decline in 1954 and 1955. A very slight increase is again shown in 1956.

In general, growth records for 1952 through 1957 do indicate better growth during this period than was experienced prior to 1952.

It was pointed out earlier that the 1949 year class (age-group IV fish collected in 1953 and age-group VI in 1955) represented a strong year class. These fish grew very fast the first year of life, slowed down the next two years, then grew at an erratic increased rate the last two years.

Fish from the following year class (1950), which was noted to be a poor one, grew at about the same rate as the 1949 group the first two years, but then grew at a more rapid rate and were 0.9 inches longer at the end of six years.

All samples were combined to produce an average growth curve through the first seven years of life (Table 6). The Browns Lake largemouth bass reached the former legal size limit of 10 inches during

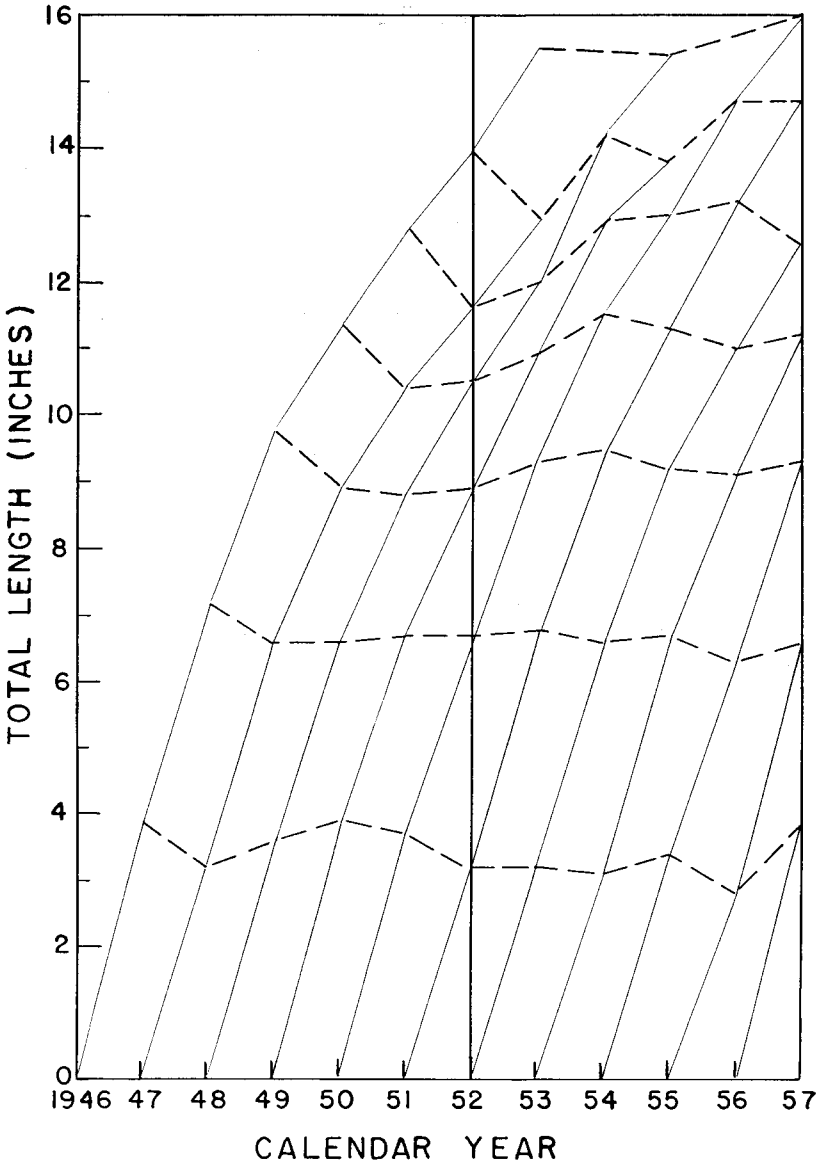


FIGURE 1. Calculated growth histories of year classes of largemouth bass from Browns Lake. The calculated lengths for corresponding years of life in different calendar years have been connected by the broken lines. The heavy solid line at 1952 shows when liberal regulations went into effect.

TABLE 6

Calculated Growth in Length of Largemouth Bass From Browns Lake

Age Group	Number of Fish	Calculated Total Length (Inches) at End of Year of Life						
		1	2	3	4	5	6	7
I	256	3.7	—	—	—	—	—	—
II	919	3.0	6.7	—	—	—	—	—
III	1,314	3.4	6.5	9.2	—	—	—	—
IV	1,091	3.5	6.6	9.1	11.1	—	—	—
V	544	3.7	6.8	9.0	10.9	12.4	—	—
VI	291	3.7	6.8	9.1	10.9	12.6	13.7	—
VII	84	3.7	7.1	9.4	11.3	12.9	14.3	15.6
Grand average calculated length		3.4	6.6	9.1	11.0	12.5	13.8	15.6
Increment of average		3.4	3.2	2.5	1.9	1.5	1.3	1.8

the fourth growing season and averaged 15.6 inches at the end of seven.

The average annual increment of growth declined from the first through the sixth year, but in the seventh increased. While the fewest number of fish (84) were represented at 7 years and sample size may have biased these growth data, it is still felt that this increase was a true one. The extreme variability of growth of the 5-, 6-, and 7-year-old fish could have been influenced by their feeding habits once they reached this size range and the larger food items, in this case an abundance of bluegills, available to them.

POPULATION ESTIMATES

In this study it was imperative to determine the size of the bass population. Since the use of the seine for making population estimates of the bass was considered superior to other netting methods, the lake presented a nearly ideal situation. As the greater part of the basin is less than 15 feet deep, seine hauls could be made almost at random. The gear used for the estimates was 2,000 to 2,500 feet of seine, 15 feet deep, and with 2- and 3-inch (stretched) mesh.

The requirements necessary to carry out a successful population estimate as expressed by Ricker (1948) are as follows: There should be no recruitment during the time of the estimate or corrections made for recruitment; there should be no loss of marks or mortality due to marking; there should be no difference in vulnerability of marked or unmarked fish to the sampling gear; there must be a random distribution of marked or unmarked fish; various sizes of fish must be equally vulnerable to the gear used.

To meet these requirements the estimates were made in September when growth was about complete for the year. The seining was done over a relatively short period of three weeks or less and at a time when fishing pressure had dropped markedly. Water temperatures were in the mid-50's to low 60's and handling was easier on the fish than during the very warm water period. Also, most forms of submerged aquatic plants and filamentous algae were not as abundant. This latter factor was a major difficulty in the operation, particularly in 1957.

Fish caught were impounded in a bag and a few handled at a time. Fish were measured, marked by clipping a portion of the caudal, or soft dorsal fin, placed in a large tank and transported to a central release point. The three-week period was short enough to prevent fin regeneration, a dead fish due to handling was rare, and as angling was at a minimum, mortality and loss of marked fish was insignificant. The use of the seine all but eliminated the factor of "net-shy" and "net-happy" fish.

The problems of nonrandom distribution of marked fish and nonrandom location of seine hauls was met by releasing fish at a central point making each of the three lobes of the lake equally accessible to the fish (Fig. 2). Also, the seining effort was distributed about the lake to cover a large portion of the surface area. The seine hauls were so made as to permit only a small overlap. One haul was made a day, alternating among the basins. Each haul was made as factors of wind, weather, and vegetation demanded and there was no effort to duplicate previous hauls. Fish captured in each of the three basins of the lake were differently marked but all releases were made at a central point.

Chi-square tests of the assumption that random mixing was taking place produced values indicating that random mixing was not fully attained. Mixing was considerable, however, and the seine hauls were sufficiently well distributed about the basins to avoid any serious bias toward any one group of homing fish. It is not felt that the lack of complete random mixing of marked fish casts serious doubt upon the estimates.

The Peterson (1896), Schumacher and Eschmeyer (1943), and Schnabel (1938) methods are most commonly used for calculating a fish population by marking and recapturing. DeLury's (1947) method, involving a time series of catch-effort statistics, was also applied to attempt to confirm the mark and recapture methods. Because of dense aquatic plant growth and other seining obstacles, fewer fish were caught in 1957 and the DeLury estimates showed poor agreement. A summary of estimates of the bass population made using all four methods is presented in Table 7.

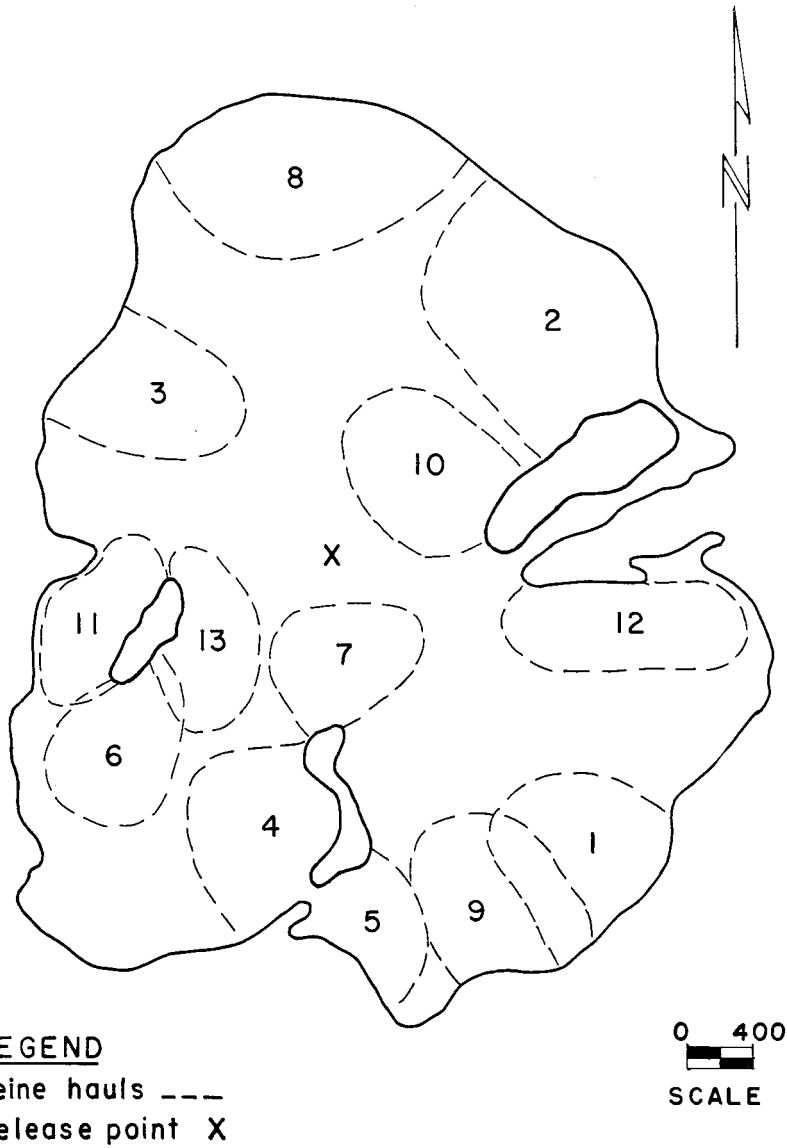


FIGURE 2. Outline map of 396-acre Browns Lake showing location of seine hauls and release point of marked fish in 1955.

Comparisons of the estimated populations of largemouth bass 6 inches and longer by the various methods showed quite good agreement. The last Peterson estimate in 1953 (14,038) was considerably lower than the other three methods (21,980, 19,780, and 18,400) but the Peterson estimates based on 3 of the 4 preceding hauls were in the 20,000 to 21,000 range.

TABLE 7

Summary of Estimates of
the Largemouth Bass Population in Browns Lake

Year and Haul Number	Estimate Method			
	Schnabel	Peterson	Schumacher Eschmeyer	DeLury
1953				
7	31,393	—	—	—
8	32,753	—	—	—
9	27,693	20,882	—	—
10	31,732	107,666	—	—
11	28,282	20,338	—	—
12	26,899	21,124	—	—
13	21,980	14,038	19,780	18,400
1955				
7	11,656	—	—	—
8	16,867	—	—	—
9	12,091	7,198	—	—
10	12,587	14,836	—	—
11	13,387	20,898	—	—
12	15,063	37,311	—	—
13	14,698	12,963	14,780	15,880
1957				
7	17,671	—	—	—
8	19,257	30,751	—	—
9	14,533	7,754	—	—
10	16,690	26,758	—	—
11	15,424	6,811	—	—
12	14,115	10,926	13,000	3,615

The estimates made in 1955 showed the best agreement with the lowest 12,963 and the highest 15,880. The last five Schnabel estimates ranged from a low of 12,091 to the high of 15,063.

The 1957 estimates which involved the fewest number of fish sampled, ranged from a low of 10,926 to a high of 14,115. (This excludes the DeLury method which did not work out well with the fewer fish involved.) The last four Schnabel estimates had the tight range of 14,115 to 16,690 fish.

The Schnabel method of estimating the population was accepted as probably the most dependable and the estimate made for the last seine haul is considered the population of largemouth bass for each of the years. The population of largemouth bass over 6 inches long was 21,980 fish in 1953; 14,698 in 1955 and 14,115 in 1957.

Based on a length-weight relationship determined by measuring a

number of fish in each one-half-inch interval, and projecting the distribution of seine-caught fish to equal the estimated population, Browns Lake was carrying 33.3 pounds of largemouth bass per acre in 1953; 27.5 pounds per acre in 1955; and 33.8 pounds per acre in 1957.

DISCUSSION

The main objective in evaluating the liberalized bass regulations was to determine whether the bass population was harmed or benefited by the regulations and if so, how and to what degree, and also if better fishing was provided.

The liberalized regulations under study provided an earlier opening which lengthened the season, and removed the former size limit of 10 inches. Angling records for the period prior to the former June 20 opening and the catch of fish less than 10 inches long were therefore of particular concern.

The 5-week liberal period (May 16 to June 19) in 1953 was 24 percent of the 21-week census season but produced 36 percent of the total number of bass caught that year. The 7-week liberal period, April 30 to June 17 (nearest complete week to June 20) in 1955 was 32 percent of the 22-week census season and produced 53 percent of the total catch (Tables 1 and 2).

These data are similar to those of Maloney, Schupp, and Scidmore (1962) which indicated about 35 percent of the bass harvest on Gladstone Lake in north central Minnesota occurred during the first two weeks of the season and then gradually declined through October. This occurred with a June 20 opening and also when their season was advanced by two weeks.

There appears to be little question that the peak period of bass harvest occurs the first few weeks of the season despite the opening date. (There would of course be limitations due to an extremely early opening prior to the time bass start to feed.) There is apparently little effect on the total bass harvest by the earlier openings.

The increased catch because of removal of the size limit of 10 inches was 40 percent in 1953 and 25 percent in 1955. The total effect of the liberal regulations as regards exploitation by anglers is best demonstrated by the fact that the number of fish of all sizes caught through the nearest census period before June 20, plus all fish less than 10 inches long caught during the remainder of the season, accounted for 82 percent of the bass catch in 1953 and 81 percent in 1955.

However, the anglers' harvest of 2,671 bass in 1953 was about 12 percent of the fall estimated population of 21,980 bass, and in 1955 the harvest of 1,252 bass was 8.5 percent of the fall estimate of 14,698

bass. These figures are slightly lower than the average harvest rate of 15 percent for the seven years 1952-58 reported for Gladstone Lake, Minnesota by Maloney *et al.* (1962).

A common concern when bass seasons are opened early enough to permit fishing during the spawning period is that large numbers of adults are removed from nests or while guarding young fish, and that reproduction is affected.

Largemouth bass nests were observed in Browns Lake as early as May 3 and as late as May 25. Bass nests were numerous on the opening day of the fishing season, May 16, 1953. Assuming that adult bass are extremely susceptible to fishing effort during the spawning period, the percentage of fish over 10 inches in the creel should be greater in the early part of the season than later. Since June 20 was formerly the opening date for bass fishing, it has been used as a base line for comparative data. In 1953, 70 percent of the estimated total number of bass caught during the period May 16 to June 19 were over 10 inches and for the remainder of the season 54 percent were over 10 inches. In 1955, 75 percent were over 10 inches long from April 30 to June 17 (nearest full census week to June 20), and for the remainder of the season 72 percent were over 10 inches. These data tend to bear out only slightly the concern that largemouth bass are caught more easily just prior to spawning, while on the nests or guarding the young fish.

Fish hatched in 1952, the first year of liberal regulations on Browns Lake, were one-year-old at the time of the population estimate in 1953, 3 years old in 1955 and 5 years old in 1957. Three-year-old fish dominated the population in 1955 (33 percent of the seine-caught fish and 40 percent of angler-caught fish), and were still well represented as 5-year-olds in 1957 (10.9 percent of the seine-caught fish) (Table 3). Similar comparisons can be made of the other year classes hatched since 1952.

Examination of the percentages in Table 3 of age-group I fish caught by seine might lead to the argument that there was a steady decline in numbers of these fish from 1953 (14.5 percent) to 1957 (1.2 percent), and that reproduction was vitally affected. This, it is felt, is not the case but rather the seine haul sampling in 1957 was not as effective as in the two prior efforts. More difficulty was experienced seining in 1957 because of dense vegetation, more boat piers still in the lake, and bottom obstacles tearing the webbing, than in the other years. As the smaller fish are still commonly in schools, the escape of several at one time was noticed. Also, small tears in the webbing or bag allowed small fish to escape while the large ones were still retained. Had more smaller fish been caught, the percentage for each of the older age groups would of course have been lessened, but trends al-

ready established would not be affected. For example, if 100 age-group I fish were added to the 1957 sample (only 8 per seine haul) age-group I fish would then make up 10.2 percent of the total, but age-group III fish would still dominate at 37.1 percent, followed by age-group IV with 24.3 percent. The other groups with lesser numbers of fish represented would be less affected.

Rather than indicating declining reproduction over the period from 1952 to 1957, it probably indicates that the 1957 estimate of the bass population was low by not including a large segment of the age-group I fish.

The first records of the Browns Lake bass population are lake survey reports by Mackenthun[2] and Cline[3]. A comparison of length-frequency histograms of bass captured in these survey seine hauls with those made in 1953, 1955, and 1957 showed that no dominant year class could be traced from 1947 to 1951 but that year classes could be traced from 1951 through 1957 to the point they nearly disappeared from the population. Two examples were the poorly represented 1950 year class and the very strong 1949 year class. These comparisons show that the bass population in Browns Lake is subject to extremely uneven recruitment, and since a year class of desirable size is only present for about four years, the age-group composition of the population can change very rapidly. The earlier samplings did show that bass over 15 inches long were relatively scarce even with the protection of size and season restrictions. The samplings in 1953 after two years of liberal regulations showed 6- and 7-year-old fish present in low numbers. The samplings in 1955 showed 6-year-old fish to be much more abundant than previously or in 1957. This was because of the relative strength of the 1949 year class and not the new regulations.

What the actual natural reproduction was over the years is not known, but stocking records show annual plants of about 18,000 fingerling largemouth bass for the years 1938 through 1942; 13,500 for 1943; 10,000 for 1944; 9,500 for 1945; 5,000 for 1946; 2,499 for 1947; and 1,000 for 1948. No bass have been stocked since then. It is interesting to note that the year class which contributed more older fish to this lake's population in 1955 than at any other time the lake has been surveyed developed from the 1949 year class — the first year since 1938 there was no bass stocking.

The 1955 and 1957 population estimates of 14,698 and 14,115 bass were very similar and both about 30 percent less than the 1953 estimates

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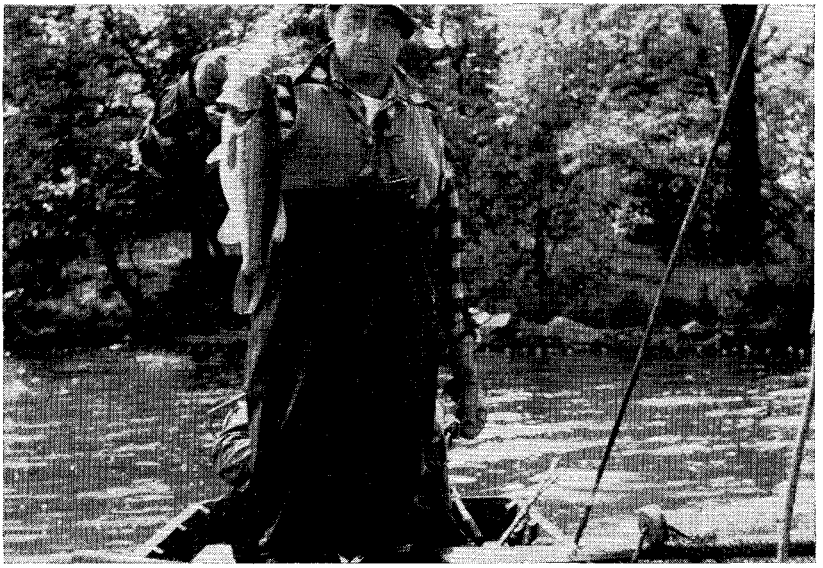
[2] Mackenthun, Kenneth M. (1947). A biological survey of Browns and Eagle Lakes, Racine County, Wisconsin. Wis. Conserv. Dept., 11 p. (mimeo.).
[3] Cline, C. L. (1951). Browns Lake, Racine County. Lake Survey Report 657. Wis. Conserv. Dept., 8 p. (mimeo.).



The angler benefited from the liberalized regulations for he could fish earlier in the season and harvest bass as soon as they reached desirable size.

of 21,980 bass. As was pointed out, the 1957 estimate could be somewhat low by not including many smaller fish. The estimates made at the two-year intervals do not indicate a steady progressive decline in numbers of fish which can be attributed to the regulation changes.

The standing crops of 33.3, 27.5 and 33.8 pounds per acre also indicate that the population did not decline during the study period.

From this study it is concluded that over the six-season period (1952-57) of liberalized regulations, the bass population did not suffer any ill effects nor did the regulations do much to improve it. Slight evidence was found to show that larger fish were more susceptible to the angler during the spawning period. No evidence was found, however, to indicate that the anglers' harvest changed the structure of the population or affected reproduction.

Growth data for the 11 year classes (1946-56) showed that growth of fish 3 years and older was generally better after the liberalized regulations went into effect. As this increase was so immediate and did not continue in a progressive manner, it is difficult to say the regulation change caused this effect.

On the other hand, the angler did reap benefits from the liberalization. He was given an opportunity to fish for bass earlier in the season before peak summer activities of boating and swimming, and before fishing pressure increased. He was able to harvest smaller bass if he wished as soon as they reached desirable size and take a portion of

what would otherwise have been natural mortality. He was, in fact, given an extra year to fish for these bass. Under the former size limit the fish were 3 to 4 years old before they reached 10 inches. After 8 growing seasons, they were about gone from the population.

The liberalization of bass regulations in Browns Lake afforded increased opportunity for anglers to pursue their sport, without harm to the bass population during the study period.

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