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Response of Largemouth Bass and Bluegill to Length Limits in Lake of Egypt

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ABSTRACT

Changes in proportional stock density, relative weight, age and growth, and survival rates of largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis machrochirus*) were evaluated in relation to various length limits placed on largemouth bass in a southern Illinois reservoir. Improvements of largemouth bass and bluegill populations occurred initially after a 356 mm (14-inch) minimum limit was placed on bass in 1983. A 406 mm (16-inch) minimum-length limit placed on bass in 1987 produced slow-growing bass in poor condition and a decrease in the condition of the bluegill. A slot limit on the largemouth bass would probably improve the growth rate and size structure of the bass and bluegill.

INTRODUCTION

Length limits are among the most widely used and valuable tools available to fishery managers for the protection and manipulation of freshwater game fishes (Wilde, 1997). In an attempt to produce or maintain quality largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) populations, fisheries managers have frequently used minimum-length and slot-length limits. The purpose of this study was to document the effects of largemouth bass length limits on the largemouth bass and bluegill populations in Lake of Egypt, Illinois.

In theory, minimum size limits lower angling and total mortality and reduce the exploitation of fish before they are sexually mature (Noble and Jones, 1993). Angler exploitation of a largemouth bass population can be quite high. Redmond (1974) reported 74% of largemouth bass larger than 229 mm were harvested from Pony Express Lake, Missouri, in the first nine months after the lake was opened to public fishing. Based upon his extensive review, Wilde (1997) concluded that length limits on largemouth bass populations resulted in mixed success. A bass population with high recruitment can be negatively affected by a minimum-size limit, while a bass population with high fishing pressure and low recruitment can be improved by a minimum-length limit (Van Horn et al., 1981). Lindgren and Willis (1990) attributed the success of a 380 mm minimum length limit placed on largemouth bass in Lake Alvin, South Dakota, to naturally low recruitment and density of the largemouth bass population. Poor growth and size structure of largemouth bass under minimum-length limits have been frequently reported, and a change in the regulation to a slot-length limit improved the largemouth bass population (Dean, Jr. et al., 1991; Eder, 1984; Neumann et al., 1994). A slot limit has a protected length range where no fish may be harvested, but allows for the harvest of fish on either side of the protected range. Angler harvest below the lower limit of the slot reduces the surplus of recruits and allows the mid-size fish to grow out of the slot. For the slot limit to work, the surplus young fish must be harvested, and satisfactory growth rates must be sustained to allow fish to grow out of the slot (Noble and Jones, 1993).

LAKE DESCRIPTION AND METHODS

Lake of Egypt is a 931 ha man-made lake located in Williamson and Johnson counties, Illinois. The lake has a maximum depth of 15.8 m and was impounded in 1962 by Southern Illinois Power Cooperative to supply cooling water for a 300 megawatt fossil fuel electric power plant. In 1983, a 6 fish/day, 356 mm (14-inch) minimum length limit was placed on largemouth bass. In an attempt to produce more largemouth bass over 381 mm (15-inch) in 1987, the length limit was increased to a 406 mm (16-inch) minimum length limit with a 6 fish/day limit. Using AC electrofishing, largemouth bass were collected from Lake of Egypt in the fall of 1984 and 1985 and the spring of 1988, 1990, and 1994. In order to compare growth rates among years, fall collected fish were aged one year older, which assumes that they would not significantly increase their length from fall to January. Bluegill were also sampled in the spring or 1988, 1990, and 1994. All largemouth bass and bluegill were measured for total length to the nearest millimeter and weighed to the nearest gram. In addition, saggitae otoliths were removed for age and growth analysis.

The distance from the nucleus to the annuli was measured on a whole mount of one otolith, and the cross section of the other otolith was used to verify age of the whole mount. A straight line relationship with a zero intercept was used to back calculate the length of the fish at age from the otolith (Heidinger and Clodfelter, 1987).

Population size structure was assessed using proportional stock density (PSD) (Anderson, 1978), relative stock density (RSD) (Wege and Anderson, 1978), and length-frequency distributions. Approximate 95% confidence interval estimates for PSD and RSD were taken from tables calculated by Gustafson (1986).

Standard length-weight equations developed by Henson (1991) and Hillman (1982) were used to determine relative weight (Wt) of largemouth bass and bluegill. For largemouth bass, the minimum applicable total length is 150 mm, and for bluegill it is 80 mm. Incremental relative weight was calculated for four of the five categories developed by Gablehouse (1984). Gablehouse defined five progressively increasing length ranges as stock, quality, preferred, memorable, and trophy. We did not collect fish in the trophy category. Incremental relative weight is the mean relative weight between stock and quality size (S-Q), quality and preferred size (Q-P), preferred and memorable size (P-M), and memorable and trophy size (M-T). Each size category has a specific length for each species. The corresponding sizes of largemouth bass for stock size is 200 mm, for quality size 300 mm, for preferred size 380 mm, for memorable size 510 mm, and for trophy size 630 mm. The stock size for bluegill is 80 mm, quality size is 150 mm, preferred size is 200 mm, memorable size is 250 mm, and trophy size is 300 mm (Gablehouse, 1984).

Confidence interval estimates were calculated by using the equation: confidence interval = mean relative weight times (1.96) (standard error) and are reported with all relative weight values. Survival was calculated using the method developed by Robson and Chapman (Ricker, 1975). All mean values calculated were compared with analysis of variance and Duncan's multiple range test (Zar, 1984).

RESULTS

Largemouth Bass

Gablehouse (1984) considered bass populations to be in balance when the PSD ranges from 40-70 and the RDS-380 range from 10-40. From 1984 to 1994, both PSD and RSD-380 values remained within these ranges (Table 1). The PSD (43) and RSD-380 (5) were both lowest in 1984, under the 356 mm (14-inch) minimum length limit implemented in 1983. Based on a mean relative weight of 95 and a growth rate at or above the average for bass from Illinois, forage appeared to be adequate (Tables 1 and 2).

By 1985, while still under the 356 mm (14-inch) length limit, the PSD value increased to a high of 64 and the RDS-380 value to a high of 20. Mean relative weights remained good at 97, and length at age continued to be above the state average (Tables 1 and 2). In 1987, a 406 mm (16-inch) minimum length limit was placed on the largemouth bass. In 1988, both the PSD (51) and the RSD-380 (14) were lower than the study high obtained in 1985 (Table 1). Mean relative weight fell to 90, but growth rates were still about the average for Illinois (Tables 1 and 2). Little change occurred in the PSD and RSD-380 from 1988 to 1990, but relative weights were lower (Table 1). By 1994, seven years after the 406 mm (16-inch) length limit was placed on the largemouth bass, the PSD (49) and RSD-380 (6) were very similar to those obtained in 1984 and lower than those obtained in 1985, 1988, and 1990. Mean relative weight (86) was the same as obtained in 1990 and significantly lower than in 1984, 1985 and 1986 (Table 1). Growth rates of largemouth bass were similar to the Illinois average from 1984 to 1990, but by 1994, except for age 2, the total length at age was less than the Illinois average (Table 2). By age 8, the largemouth bass were 120 mm less in total length than the Illinois average (Table 2). There was no evidence of stacking just below the length limit during any of the five sampling years (Figure 1).

Using the age-frequency method developed by Robson and Chapman, estimated survival was computed for largemouth bass in 1984, 1985, 1988, 1990, and 1994 (Ricker 1975). Estimated survival in 1984 for ages 2-5 was 54%. In 1985, the estimated survival increased slightly to 57% for ages 2-6. In 1988, the year after the implementation of the 16-inch minimum-length limit, estimated survival declined to 43% for ages 2-6. Estimated survival increased to 75% for ages 2-6 in 1990. In 1994, there was a decline to 64% for ages 2-6, while survival for ages 2-9 was 65%.

Bluegill

In 1988, the bluegill PSD of 22 was at the low end of the desired range of 20-40. In 1994 it had declined below the desired range to 16. RSD-200 was always low (Table 3). Mean relative weights of bluegill were lowest (87) in 1988, increased to a high of 99 in 1990, and then declined to 90 in 1994 (Table 3). In general, incremental relative weight of bluegill followed the same trend. Mean total length at age three and older bluegill were shorter in 1988 than in 1990 or 1994. The 1988 data were not available to statistically test the differences in age and growth among the three years. Bluegill lengths were significantly longer at ages 1-5 in 1990 than in 1994, the same at age 6, and shorter at age 7 (Table 3).

DISCUSSION

In general desirable population structure and condition of largemouth bass increased to their highest levels in 1985 under the 356 mm (14-inch) length limit and then declined. In 1990, under the 406 mm (16-inch) length limit, growth rates of bass had started to decline, and in 1994 there was a reduction in the number of larger bass and in overall bass plumpness. The lower growth rates in 1990 and 1994 correspond with higher survival in 1990 and 1994 than in 1984, 1985 and 1988.

The reduction in condition and growth rate is presumed to be the result of smaller size bass increasing their numbers and thus their demand for food. In 1988 survival of smaller size fish remained high and their condition continued to decrease which indicates vulnerable forage was limiting. Survival continued to remain high in 1990 and 1994 with few bass reaching the legal length limit. The bluegill population structure shifted toward smaller individuals from 1988 to 1994. The relative weight of bluegill increased from 1988 to 1990 and then decreased in 1994. Likewise, growth rates increased dramatically from 1988 to 1990 and then decreased from 1990 to 1994.

In his review of length limits Wilde (1997) concluded that minimum-length limits increased angler catch rates but did not usually increase proportional stock densities or relative weights of largemouth bass populations. Slot limits tend to restructure the bass population but neither tend to do both. Minimum-size limits are recommended for bass populations with good growth rates, high fishing, mortality, and low rates of recruitment (Anderson, 1980). A reduction in the quality of largemouth bass populations can be expected in eutrophic waters with minimum-length limits placed on largemouth bass. The high recruitment and low mortality of the bluegill and largemouth bass populations in Lake of Egypt resulted in low condition, slow growth, and poor population structure in less than four years.

The reduction in the quality of bluegill population corresponds to the reduction in the quality of the largemouth bass population. Evidently, not enough large bass were present to reduce the numbers of intermediate size bluegill so that the remaining bluegill would have sufficient food to grow rapidly.

When the size limit was changed in 1987 to a 406-mm minimum-length limit, the bass were just at the lower range of condition for a balanced bass population. By the early 1990's, the length limit needed to be altered to reduce the number of small bass and increase the amount of prey available to the bass. In 1996, the limit was changed to a 2 bass less than 356 mm and 4 bass larger than 406 mm slot-length limit. The slot-length limit is designed to increase growth rates, condition, and population structure of the bass population by reducing the number of small bass below 356 mm while protecting the limited number of bass between 356 and 406 mm. The protected range allows those bass an opportunity to grow to a larger size. If anglers do not harvest bass below the slot, the slot-length limit will function as a 406-mm minimum-length limit and compound the problem. When length limits are used to manage largemouth bass and bluegill populations, the objective of the length limit needs to be clearly stated. The effect of the length limit should be monitored at least every two years. The classical stacking of bass just below the minimun-size limit did not occur in Lake of Egypt. Thus in some lakes it is necessary to supplement length-frequency data with relative weight and age and growth information in order to make the best management decisions.

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Table 1. Summary for population structure and condition for largemouth bass from 1984, 1985, 1988, 1990 and 1994 for Lake of Egypt, Illinois. Confidence intervals (95%) are included. Analysis of variance was used to test for significant differences among years with different letters denoting significant differences among years.

	1984	1985	1988	1990	1994
Length Limit (mm)	356	356	406	406	406
Population Structure					
PSD	43 (16)	64 (10)	51 (10)	52 (10)	49 (9)
RSD-380	5 (7)	20 (8)	14 (7)	15)7)	6 (4)
Condition					
Mean Wr[a]	95 (2) y	97 (2) z	90 (2) x	86 (2) w	86 (1) w
S-Q Wr[a]	93 (3) z	98 (2) z	89 (2) y	87 (4) x	87 (1) x
Q-P Wr[a]	96 (3) z	97 (2) z	88 (3) y	84 (3) y	84 (1) y
P-M Wr[b]	95 (7) zy	96 (2) z	93 (5) zy	85 (4) y	90 (4) zy
	94 (2) y	98 (2) z	90 (2) x	97 (3) w	86 (1) w
<406mm Wr[a]					
>406mm Wr	97 (3)	97 (3)	89 (5)	86 (3)	93 (4)

[a]p=0.0001
[b]p=0.0081

Table 2. Age and total length (mm) of largemouth bass collected from Lake of Egypt, Illinois, in 1984, 1985, 1988, 1990 and 1994.

Age	1984[b]	1985[b]	1988[a]	1990[a]	1994[a]	IL Average IDNR 19884
1	170	173	160	175	143	160
2	264	257	263	262	239	228
3	312	333	321	309	287	295
4	343	366	371	340	315	345
5	402	373	402	390	337	401
6		488	459	430	348	442
7				469	362	480
8				512	383	503

[a] Back-calculated age and growth from spring sample.
[b] Actual length at capture. These fish were collected in the fall; therefore, in order to make the data comparable, 1+, 2+, etc., fish in 1984 and 1985 were assigned an age of 2, 3, etc., respectively.

Table 3. Summary of population structure, condition, and mean back-calculated lengths for bluegill from 1988, 1990 and 1994 from Lake of Egypt, Illinois. Confidence intervals (95%) are included for PSD, RSD-200, and Wr values. Analysis of variance was used to test for significant differences among years for condition and mean back-calculated total length with different letters denoting significant differences among years. 1988 was not included in the statistical analysis for back-calculated total length.

	1988	1990	1994
Population Structure			
PSD	22 (7)		16 (6)
RSD-200	1 (4)		
Condition			
Mean Wr[a]	87 (2) x	99 (2) z	90 (1) y
S-Q Wr[a]	86 (2) x	97 (4) z	91 (1) y
Q-P Wr[a]	89 (2) y	100 (2) z	88 (2) y
P-M Wr	96	100 (7)	
Age	Back-Calculated Total Length (mm)		
1[a]	67	81 z	64 y
2[a]	96	113 z	93 y
3[a]	117	140 z	120 y
4[a]	128	160 z	146 y
5[b]	138	172 z	163 y
6	147	174 z	173 z
7[c]	145	164 z	180 z

[a] p=0.0001
[b] p=0.0148
[c] p=0.0270

Figure 1. Length-frequency distribution, proportional stock density (PSD-95% Cl), and relative stock density (RSD-380-95% Cl) of largemouth bass from Lake of Egypt, Illinois, in 1984, 1985, 1988, 1990, and 1994. Arrow indicates size limit.