Journal of the Arkansas Academy of Science

Volume 51 Article 14

1997

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Abstract

The population size structure, length at age and condition of 140 largemouth bass, *Micropterus salmoides*, were studied for Lake Ashbaugh, Arkansas. Scales and otoliths were used for age and length at age determination of individual bass. Length at age was determined by back-calculation and relative weight was used to measure condition. The Lake Ashbaugh population is dominated by young, slow growing bass in poor condition. Ninety-one percent of the largemouth bass in Lake Ashbaugh were less than four years of age, with age 3+ bass serving as the dominant year class. Proportional and relative stock density values were 25 and 3 %, respectively, significantly less than those of other surveyed Arkansas reservoirs. The mean relative weight for this population was 84, significantly less than that projected for healthy populations. Mean back-calculated lengths for largemouth bass ages I through age III were 141 mm, 190 mm, and 257 mm, respectively. Mean lengths at each age were significantly less than those obtained from a 1987 study of Lake Ashbaugh bass and for bass in other Arkansas reservoirs. Several factors may have contributed to the steady decline in the bass population of Lake Ashbaugh. Winterkills occurred in 1989-1991, which seemed to affect mostly mature largemouth bass. A 380 mm length limit imposed in 1987 may have resulted in a stockpiling of bass less than 380 mm, increasing the competition for available prey for those size classes. These hypotheses are supported by consistent yearly declines over the past five years in the available prey/predator ratios and relative weights, particularly for the size classes between 226 mm-350 mm.

Introduction

The largemouth bass, *Micropterus salmoides* (Lacepede), is the best known and most widespread of the six species of Micropterid black basses. The native range of the largemouth bass (LMB) occurs in southeastern Canada, northeastern Mexico, and the eastern half of the United States, except for the region east of the Appalachian mountains (Robbins and MacCrimmon, 1974). Numerous reservoirs have been constructed throughout the United States, including Arkansas, and, due to its adaptability and growth characteristics, the range of the largemouth bass has been dramatically extended.

Lake Ashbaugh is a 243 hectare lake constructed in 1981 and located in Greene County (long. 90°45' and lat. 36°15') in northeast Arkansas. It has a maximum depth of 3.8 with a mean depth of 2.0. The major bass habitat types of Lake Ashbaugh include stumps, cypress trees, floating logs and emergent weeds, which are ideal bass habitats. Initial growth rates were quite good, as is typical for new reservoirs. However, there has been a progressive deterioration in the LMB fishery in Lake Ashbaugh over the past several years despite changes in length limits to improve recruitment and growth (Barkley and Henry, 1992a).

The Arkansas Game and Fish Commission annually estimates population structure and condition of fishes on managed reservoirs. The objectives of the present study were to provide a more in-depth analysis on population size structure, length at age, and condition of the LMB of Lake Ashbaugh, to investigate parameters contributing to this declining fishery, and to compare these results with other reservoirs within Arkansas and adjoining states.

Materials and Methods

Largemouth bass (n = 140) were collected by electrofishing from Lake Ashbaugh in May of 1992 with the assistance of Arkansas Game and Fish Commission. Length and mass of each bass were measured to the nearest mm and gm. Largemouth bass were separated into distinct 25 mm length groups ranging from 126 mm to 600 mm, and the frequency for each length class was determined. Proportional and relative stock densities were calculated for the sample. The stock population is defined as those LMB in the population which are greater than 200 mm in length. The proportional stock density (PSD) is an index which expresses the percentage of bass in the stock population which are 300 mm or greater in length. The relative stock density (RSD) is a variation of the PSD and is an index which expresses the number of bass in the stock population which are 380 mm or greater in length (Anderson and Gutreuter, 1983).

Scales and otoliths were removed from LMB collected. No differences were observed when using scales or otoliths for age determination, which is consistent with findings by Doerzbacher and Schramm (1982). Scales were mounted in acetate, projected onto a screen, and annuli identified to determine age. Bass were categorized as young of year (YOY), age 1+, age 2+, etc. Otoliths of young bass (< age 3+) were cleared in glycerin, mounted on a microscope slide, and projected onto a screen using a microprojector. Otoliths of older LMB were cross-sectioned to a thickness of 0.5 mm, polished and measured as discussed above.

The length of the bass at each growing season was determined by using the Fraser-Lee method for back-calculation (Fraser, 1916; Lee, 1920), with an α intercept of 20 (Carlander, 1982). To reduce the effects of Lee's phenomenon, mean back-calculated lengths were calculated for only the two most recent growing seasons for bass older than three years of age (Carlander, 1982).

Condition was measured using relative weight for each individual LMB (Wege and Anderson, 1978). Relative weight is defined as the actual weight of a fish divided by a standard weight for the same length for that species times 100 (Anderson and Gutreuter, 1983). Both Wege and Anderson (1978) and Henson (1991) constants were utilized, as traditionally the Wege and Anderson (1978) constants have been used in condition studies, while Henson (1991) constants were recently recommended by Murphy et al. (1991), as reducing size bias.

The following statistical applications were utilized to compare the 1992 data obtained with that of previous work performed on Lake Ashbaugh and other reservoirs in Arkansas (Beaver Lake, DeGray Lake, Lake Catherine, Lake Chicot, Lake Erling, Lake Norfork, and Lake Ouachita). Contingency tables were prepared with chi square analysis performed for the parameters of proportional stock density and relative stock density to compare values obtained for Lake Ashbaugh versus the Arkansas reservoirs listed above. This analysis provided a comparison of quality bass size structure for Lake Ashbaugh versus other Arkansas reservoirs, with Lake Ashbaugh's bass size structure frequencies serving as the standard (expected) for comparison with other reservoirs. A two sample *t*-test compared the mean back-calculated length at age for the present study versus a previous study in 1987, and versus other reservoirs in Arkansas. A two-tailed *t*-test determined the significance of differences between Wr of the present study as compared to optimal values recommended by Wege and Anderson (1978). Pearson-Product correlation coefficients were determined for relative weight versus back-calculated length at age for reservoirs in Arkansas, for relative weight versus the number of individuals per cohort and available prey to predator ratios obtained for Lake Ashbaugh.

Results and Discussion

Length Frequency.--Length frequency was determined for the largemouth bass of Lake Ashbaugh, with bass categorized in 25 mm size groups (Table 1). The most frequent size groups were 176-200 mm and 201-225 mm. A vast majority (97%) of the bass were below the 380 mm length limit established by the Arkansas Game and Fish Commission in April 1987, giving a RSD of three percent. The PSD for the Lake Ashbaugh 1992 bass population was 25%.

Table 1. Comparison of relative and proportional stock densities of LMB by way of Chi square analysis for Lake Ashbaugh for years 1986-1991 to the 1992 sample[1].

YEAR	RSD	PSD
1986	26***	36*
1987	31**	50***
1988	14**	56***
1989	16**	49***
1990	12**	39**
1991	5	14*
1992	3	25

[1]Armstrong et al., (18 = 986; 1987; 1988); Roberg and Henry (1989); Armstrong et al. (1990); and Barkley and Henry (1991).

* indicates significance difference at $P<0.05$.
** indicates significance difference at $P<0.01$.
*** indicates significance difference at $P<0.001$.

There has been a consistent decrease in the size structure of the LMB of Lake Ashbaugh over the past six years. The RSD value peaked in 1987 at 31, and the PSD value peaked in 1988 at 56 but both have rapidly and significantly declined thereafter (Table 2). These decreasing harvestable numbers are due in part to winterkills in 1989, 1990 and 1991 that affected thousands of adult LMB within the population. This factor, along with poor recruitment of young bass into the population, has contributed to the reduction in size structure of largemouth bass in Lake Ashbaugh (Barkley and Henry, 1991). A 300 mm length limit was in effect on Lake Ashbaugh from its impoundment in 1981 to April of 1987, when a 380 mm length limit was established. The largemouth bass population was in its boom period at the time of the length limit change; however, many adult bass were harvested soon after reaching the legal size limit (Armstrong et al., 1990). The purpose of establishing length limits is to protect bass stocks from

impending overharvest, increase catch rates of sub-legal sized bass, and to affect changes in the forage population through predator and prey relationships (Ming and McDannold, 1975). However, four years after the change, the 1992 RSD was approximately three percent. This may be in part the result of the 380 mm length limit not having served its purpose. Contradictory results have been obtained by game and fish agencies using minimum length limits to control stock composition (Timmons, 1985; Mitchell and Sellers, 1989), although slot limits have improved stock composition through the harvesting of smaller bass (Summers, 1988).

Table 2. A comparison of relative and proportional stock densities of LMB by way of Chi square analysis of Lake Ashbaugh with other reservoir populations in Arkansas.

Lake Name	Location (county)	Sample Year	Stock Densities	
			Relative	Proportional
Ashbaugh	Green	1992	3	25
Beaver[1]	Benton	1991	23***	57***
Catherine[1]	Hot Springs	1991	36***	87***
Charles[2]	Lawrence	1992	7	13**
Chicot1	Chicto	1991	23***	64***
DeGray[1]	Clark	1991	45***	73***
Erling[1]	Lafayette	1991	40***	90***
Hogue[3]	Poinsett	1992	21***	46***
Norfolk[1]	Baxter	1991	33***	73***
Ouachita[1]	Garland	1991	47***	75***
Poinsett[4]	Poinsett	1992	18***	68***

[1]Fishery Management Information Systems (1991).
[2]Barkley and Henry (1992b)
[3]Barkley and Henry (1992c)
[4]Barkley and Henry (1992d)

* indicates significance difference at $P<0.05$.
** indicates significance difference at $P<0.01$.
*** indicates significance difference at $P<0.001$.

A comparison of the size structure of Lake Ashbaugh bass versus those of other Arkansas reservoirs sampled by the Arkansas Game and Fish Commission demonstrated that the 1992 RSD value from Lake Ashbaugh was significantly lower than for all of the lakes compared (Table 3). The PSD of Lake Ashbaugh was also determined to be significantly lower than for all other reservoirs except for Lake Charles, which had a significantly lower PSD value than did Lake Ashbaugh.

Table 3. Comparison of 1987 and 1992 age structure and length at capture of largemouth bass of Lake Ashbaugh (Standard deviations in parenthesis) {*t*-test}.

Age	1987[1] Length (mm) at Capture	1987[1] Number	1992 Length (mm) at Capture	1992 Number
1+	219 (43)***	27	173 (19)	42
2+	305 (33)***	23	219 (13)	26
3+	388 (29)***	10	290 (29)	60
4+	438 (38)***	13	375 (46)	8
5+	464 (28)	13	450 (N/A)	1
6+	530 (N/A)	3	500 (N/A)	1
7+	562 (N/A)	1	510 (N/A)	1
8+	N/D (N/A)	0	N/D (N/A)	0
9+	N/D (N/A)	0	N/D (N/A)	1

[1]Armstrong et al. (1987).

*** indicates significance at $P<0.001$.

Age Structure.--Eight age groups were identified for the 140 largemouth bass sampled. No largemouth bass older than nine years of age were identified, and no young of the year bass were represented in this study due to the nature of the sampling methods.

Few LMB (8.6%) were age four years old and older, with the age 3+ bass (43%) representing the greatest proportion of bass identified. All age groups greater than age 4+ LMB were represented by at most a single individual; therefore, all statistical comparisons for length at age and relative weight will not include bass older than 4+ (Table 4). The winterkills discussed previously explains in part the dominance of age classes from the years of 1990 through 1992 and the poor representation of earlier age classes. These events have drastically affected the population dynamics by decreasing the number of mature LMB.

The 1992 age structure of Lake Ashbaugh bass was compared to a 1987 study conducted by the Arkansas Game and Fish Commission. The age structure of the 1987 population was significantly different from the present sample population $\{\chi^2 = 299.851, df = 6; P < 0.001\}$ (Table 4). In the 1987 sample, all age groups were well represented and recruitment was present for all age groups.

Age structure was also compared by way of chi square analysis with other Arkansas reservoirs studied in 1991 (Table 5). Lake Ashbaugh bass possessed a significantly different age structure than all other reservoir populations ($P<$ 0.001).

Length at Age.--Mean length at age was determined for

Table 4. Comparison of age structure of Lake Ashbaugh LMB with other reservoir populations in Arkansas[1].

Lake Name	Age Groups														
	1+		2+		3+		4+		5+		6+		7+		
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Ashbaugh	42	30.2	26	18.6	60	42.9	8	5.71	1	0.71	1	0.71	1	0.71	140
Beaver	56	41.2	42	30.9	20	14.7	11	8.1	4	2.9	1	0.74	1	0.74	136
Catherine	79	27.7	78	27.4	60	21.1	28	9.8	23	8.1	12	4.2	4	1.4	285
Chicot	159	41.4	153	39.5	43	11.2	17	4.3	9	2.3	3	.78	N/D		384
DeGray	235	32.5	212	29.3	123	17.0	88	12.2	50	7.0	15	2.1	1	0.14	724
Erling	128	32.9	128	32.9	84	21.6	29	7.5	14	3.6	4	1.0	2	0.51	389
Norfork	84	39.8	65	30.8	27	12.8	18	8.5	8	3.8	5	2.4	2	0.95	211
Ouachita	221	29.2	218	28.8	143	18.9	88	11.6	59	7.8	20	2.6	6	0.79	758

[1]Fishery Management Information Systems (1991).

Table 5. Comparison of 1987 and 1992 mean back-calculated length values for each age class of LMB for Lake Ashbaugh (*t*-test).

	1987[1]			1992		
Age Class	N	Back-calculated Length (mm)	Standard Deviation	N	Back-calculated Length (mm)	Standard Deviation
I	90	162***	50	140	141	20
II	63	248***	49	98	190	16
III	40	303***	52	72	257	26
IV	30	385***	51	12	331	6
V	17	444	41	4	425	N/A
VI	4	509	46	3	447	N/A
VII	1	562	N/A	2	496	N/A
VIII	0	N/D	N/D	1	N/D	N/D
IX	0	N/D	N/D	1	564	N/A

[1]Armstrong et al. (1987).

*** indicates significance at $P<0.001$.

each age group of LMB (Table 4). Largemouth bass in Lake Ashbaugh reach 300 mm by their third or fourth summer, and a legal size of 380 mm by the fourth or fifth summer (Table 4). The length at capture was demonstrated to be significantly higher for each age class from the 1987 survey of Lake Ashbaugh bass {*t*-test, $P<0.001$} (Table 4). These same significances were observed when back-calculated lengths were compared for age groups I - IV of the 1987 and 1992 populations {*t*-test, $P<0.001$} (Table 6).

The back-calculated lengths for largemouth bass, ages I to IV, of Lake Ashbaugh were significantly lower than for bass of other reservoirs studied with the exception of age I bass of Lake Ouachita {*t*-test, $P<0.001$} (Table 7).

Length and Weight Relationships.--Relative weights were calculated for individuals, age groups, and total population. The largemouth bass of the 1992 sample population were in poor condition as indicated by low relative weights (Figure 1). Mean relative weights for this sample population were significantly lower than the optimum values of 100 ($t=18.93$; $P<0.001$), as set forth by Anderson and Gutreuter (1983). Relative weight values were greatest for immature bass (age 1+). Conversely, age 3+ bass were the most frequent age group and possessed the lowest relative weight, with 43.3% having relative weight values falling between 62-79. However, there was no significant correlation identified for cohort size versus relative weight ($r=-0.32$).

Murphy et al. (1991), stated that the Wege and Anderson (1978) formula artificially inflates the relative weight of larger LMB at the expense of smaller LMB. This phenomenon was observed in the present study (Figure 1). Although Henson' s formula is the more accurate of the two, Wege and Anderson's formula has been so widely utilized that we used it for comparison purposes.

Historically, the condition of largemouth bass of Lake Ashbaugh was excellent and relative weights often exceeded the optimum 100 standard for all bass length groups (Roberg and Henry, 1989). However, condition has consistently decreased since the 1989 growing season (Figure 2). Relative weights obtained for LMB sized 200-400

Table 6. Comparison of back-calculated lengths at age in mm of largemouth bass of Lake Ashbaugh with other reservoirs in Arkansas (Standard deviations in parentheses)[1].

Lake Name	Age Groups						
	I	II	III	IV	V	VI	VII
Ashbaugh	141 (20)	190 (16)	257 (26)	331 (6)	425 (N/A)	447 (N/A)	496 (N/A)
Beaver	156 (4)***	274 (5)***	340 (7)***	368 (9)***	385 (17)	367 (N/A)	380 (N/A)
Catherine	162 (3)***	273 (4)***	348 (4)***	411 (6)***	449 (4)	473 (5)	504 (12)
Chicot	162 (2)***	295 (3)***	390 (6)***	444 (5)***	474 (5)	505 (14)	0 (ND)
DeGray	147 (2)***	265 (3)***	355 (3)***	419 (3)***	468 (4)	500 (8)	533 (N/A)
Erling	155 (3)***	283 (4)***	369 (3)***	427 (4)***	461 (5)	486 (6)	505 (10)
Norfork	165 (3)***	294 (6)***	370 (4)***	413 (4)***	439 (7)	481 (10)	522 (5)
Ouachita	133 (2)***	251 (3)***	348 (3)***	411 (3)***	459 (3)	496 (6)	506 (17)

[1]Fishery Management Information Systems (1991).

*** Indicates significance at $P < 0.001$.

Table 7. Relationship of available prey/predator ratio to relative weight (Wr) of largemouth bass in Lake Ashbaugh.

Length Class (mm)	1989[1] AP/P	1989[1] Wr	1991[2] AP/P	1991[2] Wr	1992[3] AP/P	1992[3] Wr
201-225	7.82	93	3.50	83	1.20	81
226-250	7.49	93	1.15	85	0.56	82
251-275	6.15	89	1.25	87	0.70	80
276-300	6.53	93	0.46	88	0.58	78
301-325	7.17	95	0.69	90	0.78	80
326-350	6.63	93	0.88	84	0.98	82
351-375	6.32	98	1.16	95	1.26	84
376-400	5.63	95	1.60	89	1.86	ND
401-425	6.32	100	2.10	88	2.48	ND
426-450	5.88	96	2.06	78	2.73	81
451-475	6.04	112	2.09	ND	2.84	ND
476-500	6.24	106	2.13	83	2.93	83
501-525	6.52	105	2.18	ND	2.95	93
526-550	6.78	137	2.31	ND	2.99	ND
551-575	6.97	115	2.30	98	3.05	ND
576-600	7.41	127	2.58	ND	3.37	95
Corr. Coef. (r):	(-0.16, $P < 0.60$)		(0.20, $P < 0.55$)		(0.74, $P < 0.01$)	

[1]Roberg and Henry (1989).
[2]Barkley and Henry (1991).
[3]Barkley and Henry (1992a).

mm studied in Oklahoma and Texas were significantly greater than those of the present study {$P < 0.01$} (Wright and Wigtail, 1980; Maceina and Murphy, 1988).

Prey Availability.--An adequate forage base along with a balanced population is essential to condition, recruitment and overall growth of a LMB population (Heidinger, 1975). There were numerous younger LMB, with 81 % of the total population measuring between 200 mm and 380 mm. There was poor recruitment of LMB into size classes larger than 380 mm and slow overall growth for the entire sample population of Lake Ashbaugh, resulting in very low potential harvest rates by fisherman on Lake Ashbaugh.

The major prey species for largemouth bass of Lake Ashbaugh are gizzard shad {51.5%} (*Dorosoma cepedianum*) and bluegill {25.9%} (*Lepomis macrochirus*) (Barkley and Henry, 1992a). Gizzard shad have the ability to quickly grow through the size range where they are vulnerable to largemouth bass in the population (Kirk and Davies, 1985). If the largemouth bass cannot adequately control the numbers of shad within a reservoir, the shad can reduce the carrying capacity of the lake for LMB through competition for available food. This lack of population control is evident as 99.7% of the shad population biomass was adult-sized, rendering them unavailable as prey (Barkley and Henry, 1992a). Recruitment of bluegill has also been poor for the past several years due in part to the high numbers of young LMB feeding on young of the year bluegill (Barkley and Henry, 1991; Barkley and Henry, 1992a). Gizzard shad feeding on bluegill eggs and juveniles compounds this problem (Kirk and Davies, 1985).

Food availability can be estimated by available

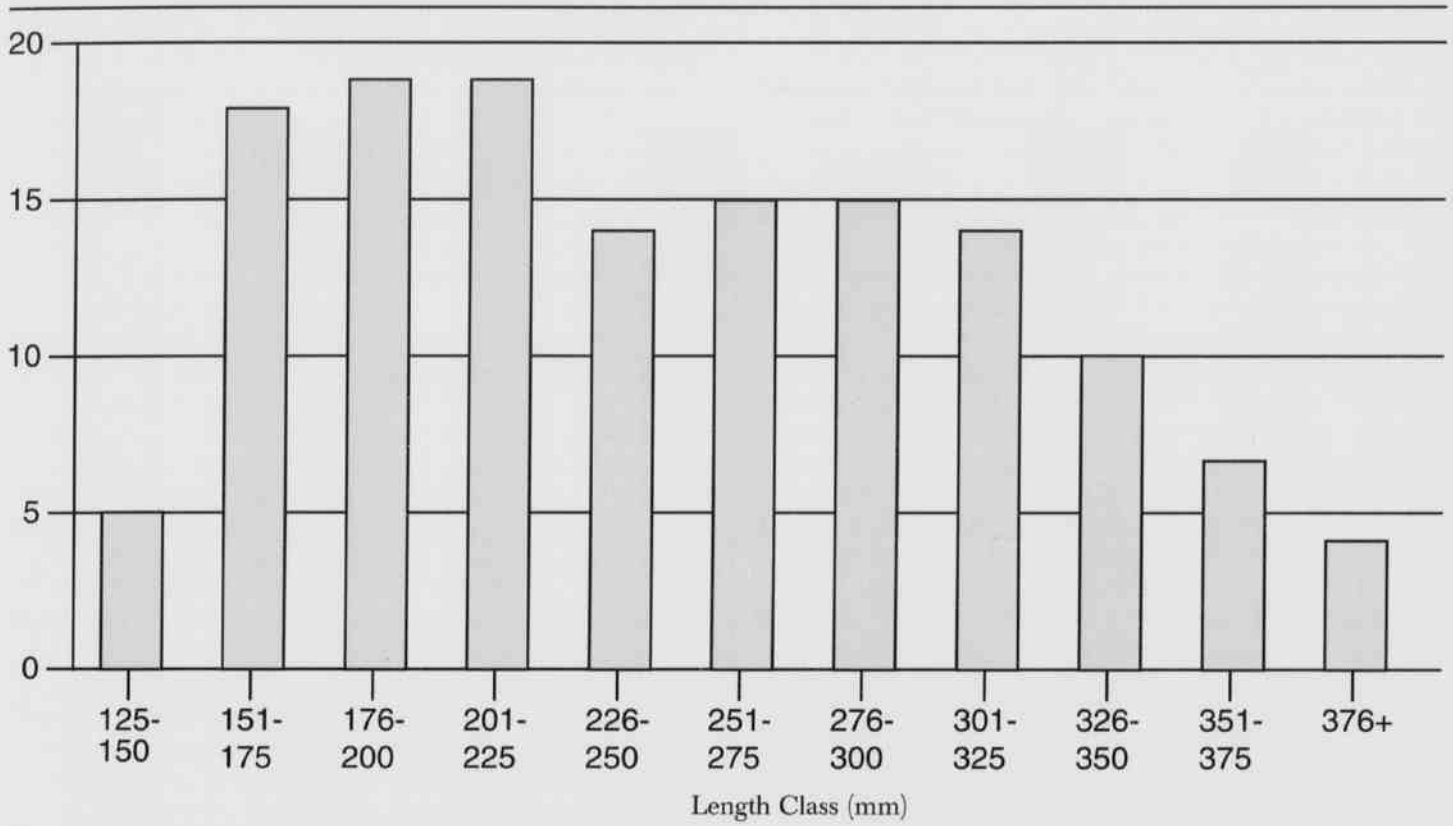

Fig. 1. Length frequencies for LMB of Lake Ashbaugh for 1992.

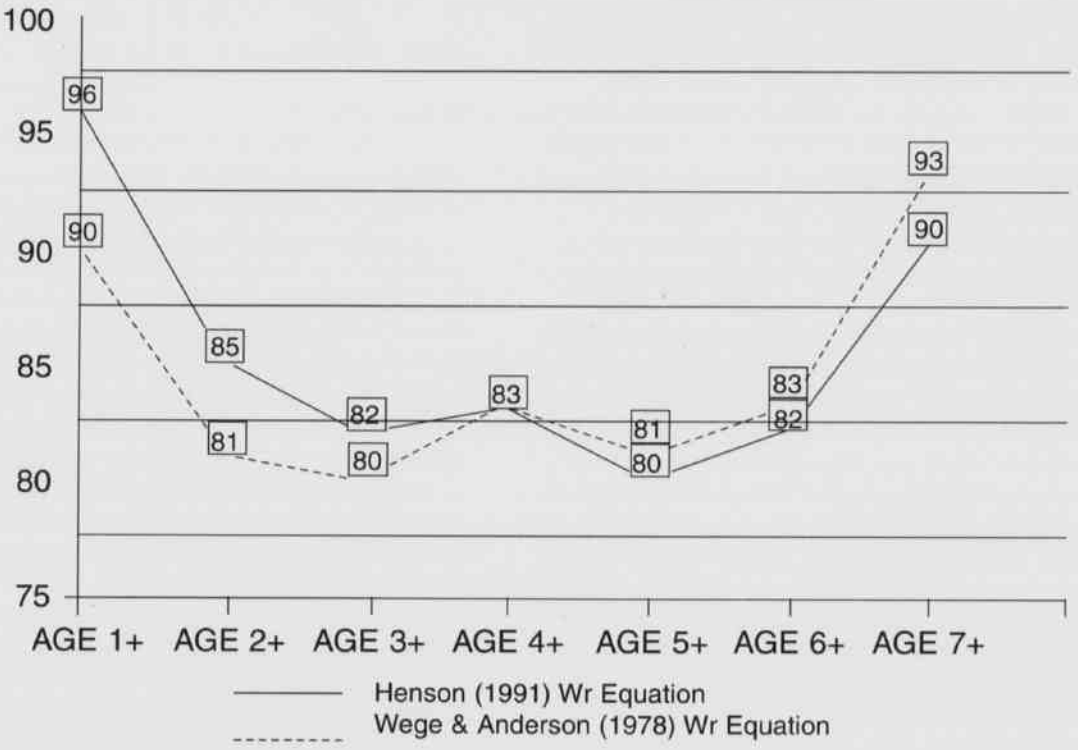

Fig. 2. Mean relative weight for different age groups of LMB in Lake Ashbaugh.

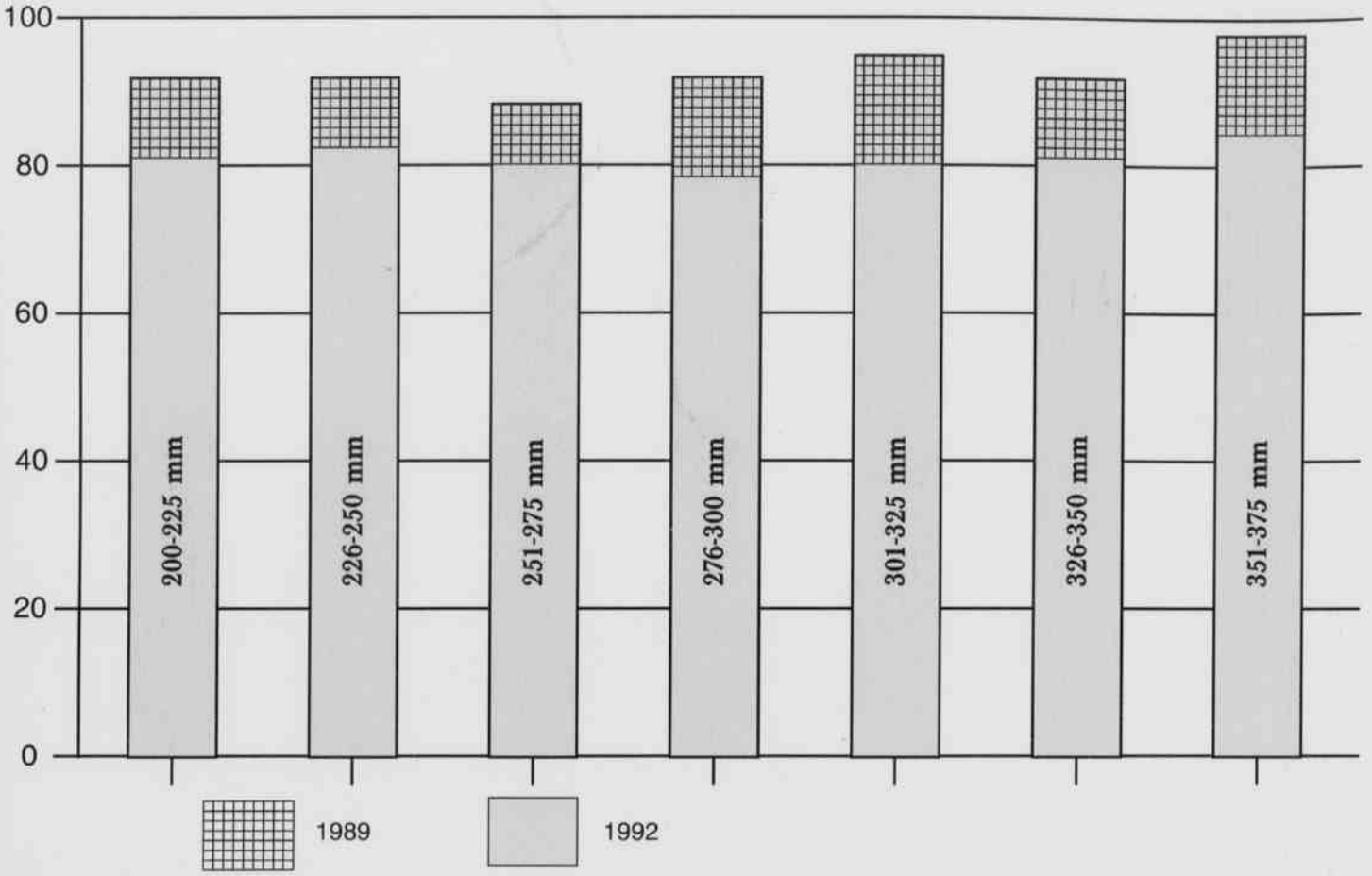

Fig. 3. Mean relative weights for LMB size classes for the years 1989 and 1992.

prey/predator (AP/P) ratios calculated from rotenone sampling. The optimal AP/P ratio is generally considered to be 1.0 (Jenkins and Morais, 1978). The AP/P ratios for all size classes of Lake Ashbaugh LMB have continually decreased since 1989 (Table 9). In 1989 there was abundant forage for all size classes, which is reflected by higher relative weight values for each length class (Roberg and Henry, 1989). The AP/P ratio was well below 1.0 for several size classes (226-325 mm) in the present study, indicating an inadequate forage base for bass of those size classes (Barkley and Henry, 1991). The high number of younger LMB and the low availability of prey have contributed to the poor condition of largemouth bass in the 1992 sample. Condition was significantly correlated to the AP/P ratio in the 1992 population, yet not for the years 1989 and 1991 (Table 9). This low availability of prey may be due to the prey being quickly consumed prior to their growing large enough to sustain a quality largemouth bass population.

ACKNOWLEDGMENTS.—We thank S. Barkley and S. Henry of the Arkansas Game and Fish Commission for their assistance with collection. Helpful insight was provided by M. Huss, R. Grippo, S. Henry, V.R. McDaniel, and anonymous reviewers, to whom we are most grateful.

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