Fish Population and Angler Responses to a 406-mm Minimum Length Limit for Largemouth Bass on Lake Eufaula, Alabama-Georgia

Kenneth C. Weathers, *Alabama Wildlife and Freshwater Fisheries, P. O. Box 310292, Enterprise, AL 36331*

Michael J. Newman, *Alabama Wildlife and Freshwater Fisheries, P. O. Box 310292, Enterprise, AL 36331*

David Partridge, *Georgia Department of Natural Resources, Fisheries Management Section, 109 Hatchery Access Road, Dawson, GA 31742*

Russell Wright, *Department of Fisheries and Allied Aquaculture, Swingle Hall, Auburn University, AL 36849*

Abstract: Due to a history of cyclic adult largemouth bass population trends, a 406-mm minimum length limit was imposed on largemouth bass on Lake Eufaula in July 1992. Two main objectives for the harvest restriction were to increase the abundance of adult largemouth bass in the fishery and to maintain an abundant bass population so that the cyclic nature of this fishery would not be as severe. We examined the effects of the harvest restriction by comparing several population variables from sampling data collected 6 years before the length limit (1987–1992) and 6 years after the length limit (1994–1999). A large database was available due to consistent standardized sampling by Alabama and Georgia fisheries personnel. Spring proportional stock density estimates did not change significantly, with an average of 63 before and 65 after the length limit. Fish conditions declined for every relative stock density (RSD) group, with significantly lower mean relative weights for fish in the RSD-Stock and RSD-memorable groups, as well as for annual averages for all fish >200 mm. Growth was significantly slower for Age-2 through Age-5 fish, with fish requiring almost 10 additional months to reach 406 mm in length. Bass abundance increased after the length limit, with significant increases in RSD-P fish. After the length limit was imposed, young-of-year (YOY) shad, YOY bass, and spring adult bass densities continued to fluctuate. Spring electrofishing was low in 1998 following a chronic bass die-off during spring and summer 1997. Virology examinations confirmed the presence of largemouth bass virus in the population in 1997 and 1998. Creel survey data from 1984, 1987–1992, and 1999 indicated that angler effort for bass changed very little after the length limit, but harvest rates declined 85% to 95% while release of "keeper" fish increased to over 92%. The majority of anglers interviewed in 1999 (64%) indicated they did not wish to see the length limit changed. However, many negative comments from anglers, tournament

organizers, and local business owners with an opposing view lead Alabama and Georgia fisheries personnel to re-examine possible changes to the 406-mm minimum length limit.

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Freshwater fisheries managers often use minimum length and protected length range (slot) limits to manage largemouth bass *(Micropterus salmoides)* (Anderson 1976, Summers 1988, Ager 1989, Dean et al. 1991). However, analyses of many largemouth bass populations from which both pre- and post-size restriction data were available revealed that initial objectives were either not achieved or had mixed results. (Wilde 1997, Parks and Seidensticker 1998). The successes of regulations could not be evaluated without predefined objectives (Dent 1986), and these objectives often did not encompass angler expectations and motivations that were associated with a particular fishery (Fedler and Ditton 1994). This case history report evaluates a 406-mm minimum length limit on largemouth bass by comparing pre- and post-length restriction data to see if predefined objectives for the largemouth bass population were met. Angler attitudes and expectations encountered before and after the regulation change are also discussed.

Lake Eufaula (a.k.a. Walter F. George Reservoir, Alabama and Georgia), a 18,285-ha U.S. Army Corps of Engineers reservoir impounded in 1962, has been recognized as a premier largemouth bass fishery. In the late 1960s and early 1970s, literally tons of bass were harvested. The lake was new, very fertile, and several year classes of bass had not been heavily exploited. However, since that time, the fertility has decreased, fishing effort has increased, and bass fishing success has been cyclic. In some years, bass fishing has been considered excellent, while other years have produced only fair to poor bass fishing. Throughout the 1980s and early 1990s, dominant bass year classes were produced approximately every 4 to 6 years. As these fish reached harvestable size, bass angling catch rates would improve. As fishing and natural mortality reduced the dominant year class, bass abundance would consistently decline until another strong year class was produced (Newman et al. 1992).

In large southeastern reservoirs, black bass and shad densities have been found to be higher in eutrophic systems (Bayne et al. 1994, Maceina et al. 1996, Hoxmeier and DeVries 1998). Lake Eufaula typically falls within the eutrophic classification (Harman et al. 1995, Maceina et al. 1996), and contains large populations of gizzard *(Dorosoma cepedianum)* and threadfin shad *(D. pentenense).* Stadardized sampling has documented that years of abundant shad young-of-year (YOY) are often followed by years of very few YOY shad, while adult shad increased in length and biomass each year. In 4 or 5 years, the larger shad eventually die off, and as shad numbers decrease, surviving shad spawn prolifically (Newman et al. 1994). Abundant YOY shad resulted in high growth and survival rates for YOY bass, producing strong year classes (Timmons et al. 1980).

During the 1980s the cyclic nature of the largemouth bass fishery at Lake Eufaula caused considerable controversy. Many anglers felt that the 406-mm minimum length limit imposed on West Point Reservoir, a 10,481-ha Chattahoochee River impoundment upstream from Lake Eufaula (Ager 1989), was beneficial to that reservoir and should be applied to Lake Eufaula. These request were directed to the Alabama Department of Conservation and Natural Resources and the Georgia Department of Natural Resources. At that time, Alabama and Georgia fisheries biologists agreed that a 406-mm bass minimum length limit would be ineffective, and that bass numbers would increase in the near future. These state agencies conducted a joint 5-year study to address cyclic bass fishing success. Based on the results of the study, the lack of shad spawn in 1991, and the downward trend observed in the bass cycle, a 406-mm minimum length limit on largemouth bass was initiated in July 1992, following a strong bass year class. The purpose of the length limit was to conserve bass numbers and to protect young bass until they grew out of the protected size range. The objectives were to increase the abundance of adult largemouth bass, and to maintain a relatively abundant and consistent bass population. Prior to this regulation, Alabama did not have a minimum length limit for largemouth bass, while Georgia enforced a 305-mm minimum length limit. These regulation differences caused problems for enforcement officers.

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Methods

Fisheries personnel from Alabama and Georgia have routinely sampled Lake Eufaula with electrofishing since the early 1980s. Each state has conducted separate, annual, standardized spring electrofishing collections of largemouth bass using Smith-Root Type VI-A pulsators (600–1,000 volts, 4–6 amps). Both states conducted shoreline sampling during the daylight hours, usually in the month of March.

During spring standardized electrofishing, Alabama biologists collected a minimum of 100 stock size bass along with all sub-stock (<200 mm TL) bass observed. Prior to sampling, a minimum of 3 sample sites was chosen by random selection from a pre-outline map grid of the Alabama side of the reservoir. Each site was sampled using 30 minutes of pedal time. Alabama biologists also collected annual fall electrofishing samples following this same protocol. All bass collected during the spring samples were measured, weighed, and aged with otoliths magnified under direct light illumination. Bass <330 mm were also aged with otoliths from the fall collection (Newman et al. 1994). Beginning in 1996, shad were sampled annually with a trawl net in late August near the middle portion of the reservoir. Trawl net samples were conducted after dark using a 1.2 by 2.4 by 6.1 m framed surface trawl. The net was towed 4 to 6 times (2 to 5 minutes each) during each annual collection. A 6.1-m pontoon boat with a 70

horsepower outboard motor powered at approximately 2,800 rpm was used to pull the net. A Kahl Model 005WB138 digital flow meter was attached to the net opening to measure the volume of water sampled so that catch rates could be calculated.

Georgia's spring sampling design consisted of shoreline electrofishing at 10 fixed locations of the reservoir. All bass observed during 30 minutes of pedal time were collected, measured (TL, mm), and weighed (g). A non-uniform roving access creel survey, developed by North Carolina State University, was conducted by Georgia fisheries personnel in 1984, 1987–1991, and March–May 1999. In order to compare total effort and total harvest for all creel surveys, these 2 parameters of the 1999 creel survey were expanded over the entire year based on the percentage of effort and harvest that occurred during the same time period of the 1987–1991 surveys. Anglers were questioned about their attitudes regarding the 406-mm minimum length limit during the 1999 creel survey.

Because both states collected their spring electrofishing samples in the same manner with similar equipment and techniques, the collections were combined into annual spring largemouth bass collections for statistical analysis. Annual spring electrofishing samples were categorized into relative stock density (RSD) groups as described by Gabelhouse (1984). Prpoertional stock densities (PSD) (Anderson 1980) for annual spring samples and the annual means for relative weights (Wr) (Wege and Anderson 1978) of each RSD group also were compared for spring collections. Significant differences ($P < 0.05$) in PSD, Wr, and catch per unit of effort (CPUE) for each RSD group, and predicted lengths at age for the 6 years pre- and 6 years post-406-mm minimum length limit were compared using a rerandomization test of mean differences (Manly 1991). The 1993 data were not included because 1993 was considered a transition year for the fish population.

Results and Discussion

The PSD for spring bass samples ranged from 50 to 83 and did not significantly change between the 6 years before (average 63) and the 6 years after (average 65) the minimum length limit was imposed. However, the condition of the fish declined following the initiation of the harvest restriction. Relative weights declined for every RSD group when annual mean Wrs from 1987–1992 were compared with the 1994–1999 mean Wr values. (Table 1). These declines were significant ($P < 0.05$) for RSD-stock

Table 1. Mean relative weights (Wr) for largemouth bass divided into relative stock density (RSD) size categories for 6 years pre- (1987–1992) and 6 years post- (1994–1999) 406-mm minimum length limit on largemouth bass in Lake Eufaula, Alabama-Georgia.

	RSD-stock	RSD-quality	RSD-preferred	RSD-memorable	All fish >200 mm	All fish >406-mm
Pre-limit average	86.7	90.8	97.0	103.7	91.8	99.7
Post-limit average	83.0	86.8	93.8	99.2	87.5	95.5
Change	-3.7	-4.0	-3.2	-4.5	-4.3	-4.2
P value	0.048	0.065	0.121	0.045	0.016	0.056

Table 2. Predicted length at age using the von Bertalanffy growth equation for largemouth bass collected from Lake Eufaula aged by otoliths, 1989–1999.

Year	*N*	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Time to reach 406 mm TL (years)
1989	117	172	293	380	442	486	517	540	556	3.4
1990	100	182	298	383	444	488		544		3.4
1991	120	202	281	345	397	439	472	499		4.2
1992	113	130	277	359	405	430	445	453		4.0
1993	111	197	303	381	438	480	510		548	3.4
1994	111	182	280	354	409	451	482	505	523	3.9
1995	112	143	235	306	361	403	437	462	482	5.1
1996	143	204	277	338	388	430	465	494	518	4.4
1997	123	161	263	341	400	445	479	505		4.5
1998	111	140	227	300	363	416	461	500	532	4.8
1999	138	231	284	329	369	403	432	457	479	5.1
Pre-size limit average		172	287	367	422	461	478	509	556	3.8
Post-size limit average		177	261	328	382	425	459	487	507	4.6
P value		0.421	0.023	0.005	0.020	0.032	0.160	0.193	0.013	

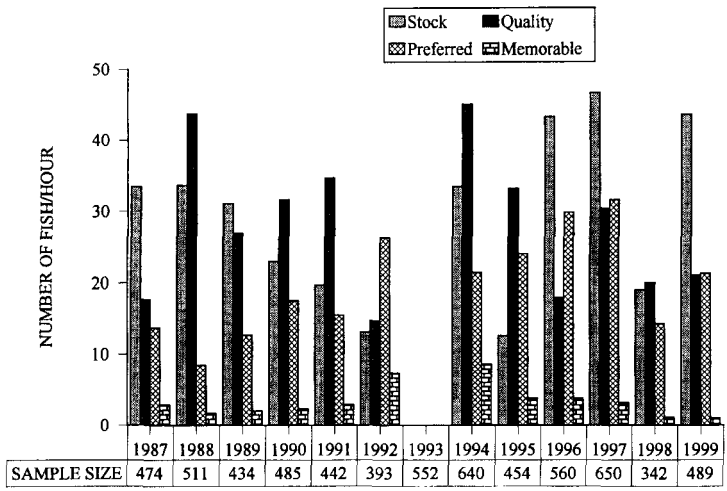
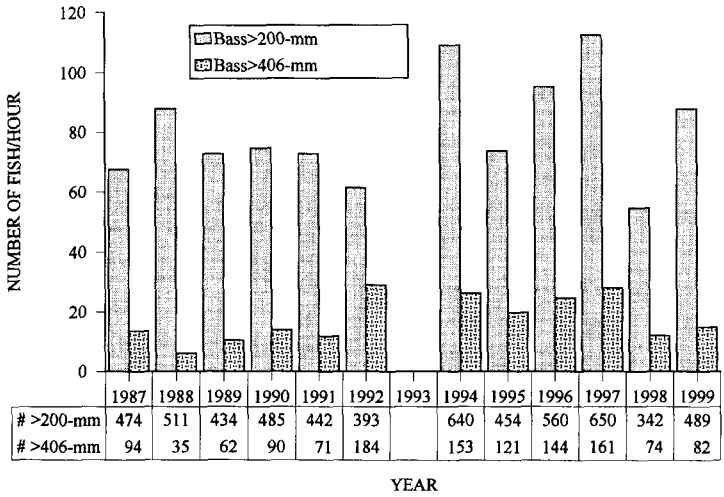


Figure 1. Electrofishing catch rates (CPUE) for largemouth bass in the RSD categoires of stock, quality, preferred, and memorable collected during spring electrofishing in Lake Eufaula, 1987-1999.

and RSD-memorable and also when the mean Wr's for all bass >200 mm were compared. This decline in condition was also reflected in the slower growth of the bass following the length limit. From the fish that were aged, all ages groups grew slower following the harvest restriction, except for Age-1 fish (Table 2). Age-2 through Age-5 fish grew significantly slower ($P < 0.05$) following implementation of the length limit. It also took the bass significantly longer ($P < 0.05$) to reach 406 mm, with an average of 3.8 years before the length limit compared to 4.6 years after the regulation.

The catch per unit of effort (CPUE) suggested that the relative abundance of bass in all RSD groups, except RSD-quality, increased after the length limit (Fig. 1). However, the only significant increase ($P < 0.05$) was observed in the RSD-preferred fish. The increase in CPUE for bass over 406 mm was biologically significant ($P < 0.07$) (Fig. 2). Fall sampling indicated that bass year-class strength still fluctuated a great deal after implementation of the length limit (Fig. 3). Standardized summer trawl netting indicated that YOY shad densities (Table 3) compared favorably to the fall bass year class strengths for each year except 1999 (Fig. 3). This was probably due to the lake being unusually low during the fall electrofishing in 1999, resulting in low CPUE for the bass YOY sample.

The angler creel surveys indicated that angler effort did not change, but total number of bass harvested declined by approximately 85% to 95% (Table 4). Another interesting observation is the steady increase in the percent of "keeper" bass which anglers report they have released, starting with a 12.5% release rate in 1984 and increasing to 92% in 1999. Angler catch rates for all sizes of bass were lower than expected in the 1999 creel survey (0.39 fish/hour).



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
# >200-mm	474	511	434	485	442	393		640	454	560	650	342	489
# >406-mm	94	35	62	90	71	184		153	121	144	161	74	82

Figure 2. Electrofishing catch rates (CPUE) and relative weights (Wr) for all largemouth bass ≥ 200-mm TL and largemouth bass ≥406-mm TL collected during spring electrofishing in Lake Eufaula, 1987–1999.

The objectives of the 406-mm minimum length limit for largemouth bass were to increase the abundance of adult bass and alleviate the cyclic nature of adult bass abundance trends. Comparison of the pre- and post- length limit years revealed the abundance of adult bass did increase, especially for larger fish. However, bass recruitment and year class strength continued to vary, presumably due to fluctuations in YOY shad numbers. The adult bass population also continued to fluctuate in abundance. Growth rates decreased, with fish taking approximately 10 months longer to reach 406mm. These results agree with an evaluation of a 381-mm minimum length limit for largemouth bass at Table Rock Lake, Missouri (Novinger 1987).

Several factors other than the bass harvest reduction can be assumed to have contributed to these results. First, the adult bass population in Lake Eufaula suffered a fish kill in 1997. The bass population was near record highs during the spring sampling, while condition factors were near all time lows. The shad population was composed mainly of old gizzard shad that were too large to serve as prey (TL>250 mm) and in too poor condition to spawn heavily. Following the bass spawn in 1997, anglers began reporting observations of dead adult bass throughout the lake. Large numbers of dead fish were never reported from any one particular place, but the chronic die off continued the spring and into the early fall. Field investigations revealed several dead bass and gizzard shad scattered over a wide portion of the lake, with lesions characteristic of *Aeromonas* and *Saprolegnia* infections. Virology analysis at Auburn University Fish Parasite and Disease Lab confirmed the presence of largemouth bass (LMB) virus in the samples from Lake Eufaula in 1997 and 1998. Dead bass, crappie *(Pomoxis sp.)* and shad were also reported following the spawning season in 1998, but very few fish were observed at that time. A chronic fish kill

Table 3. Total number of young-of-year shad (<8cm TL) per cubic meters of water filtered (CPUE), and total cubic meters of water filtered (total effort) during trawlnet sampling on Lake Eufaula, 1996–1999.

Year	*N* Trawl samples	Species	Total *N*	CPUE	+/-SE	Total effort
1996	6	Threadfin shad	796	0.266	0.087	2,997
	6	Gizzard shad	49	0.016	0.013	2,997
1997	5	Threadfin shad	38	0.013	0.004	3,000
	5	Gizzard shad	0	0.000		3,000
1998	4	Threadfin shad	3,158	0.477	0.204	6,619
	4	Gizzard shad	24	0.004	0.014	6,619
1999	6	Threadfin shad	2,621	0.386	0.258	6,791
	6	Gizzard shad	22	0.003	0.005	6,791

such as documented in 1997 cannot be quantified, but the effects are evident in the reduced electrofishing spring catch rates for largemouth bass in 1998.

Other factors that are probably impacting the largemouth bass population in Lake Eufaula are competition from other predators and a reduction in fertility. Even though Lake Eufaula still meets the criteria for a eutrophic reservoir, the fertility has apparently decreased as the reservoir ages (Harman et al. 1995). Declines in fertility have been shown to favor young spotted bass *(Micropterus punctulatus)* growth and survival (Greene and Maceina 2000). While spotted bass have been present in the Chattahoochee River drainage for years, anglers have reported much

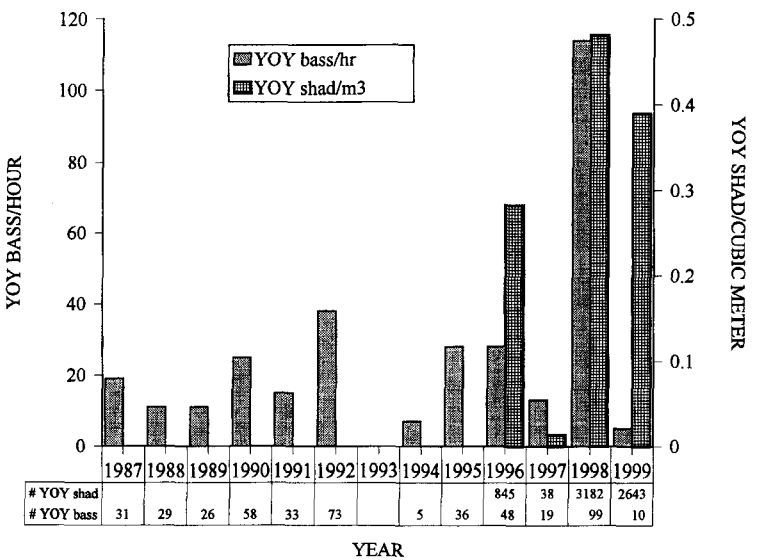


Figure 3. Electrofishing catch rates (*N*/hour) for YOY largemouth bass collected during fall electrofishing in Lake Eufaula, 1987–1999, and catch rates (N/m^3) of shad YOY collected during summer trawl net sampling 1996–1999.

Table 4. Creel survey summaries for largemouth bass from Lake Eufaula, 1984–1999.

Parameter	1984	1987	1988	1989	1990	1991	1999[a]
Angler effort (hours × 1,000)	194	266	258	259	221	271	267
% total effort	50	58	45	57	51	57	47
Angler catch (all bass/hour)	0.24	0.51	0.49	0.42	0.42	0.40	0.39
Total bass harvest	11,060	45,021	39,643	30,665	25,101	29,818	1,866
% legal-sized bass released	12.5	39.3	63.2	63.3	55.2	65.6	92.0

a. The 1999 creel survey was conducted 1 March through 31 May 2000 and expanded for the year in order to compare with earlier creel surveys.

higher catch rates for these fish over the last 5 years. Spotted bass began showing up in Alabama and Georgia's standardized electrofishing samples in the late 1990s. Environmental changes also often impact largemouth bass abundance (Buynak et al. 1999).

One question that becomes evident after analyzing 13 years of bass population data is: Are Lake Eufaula anglers willing to sacrifice lower growth rates, lower harvest rates, and higher natural mortality in order to have more abundant bass populations, especially of larger fish? The comments received by anglers from the 1999 spring creel survey seem to indicate that most anglers were satisfied with the current size restrictions (Table 5). However, the poor angler catch rates of "keeper" bass in 1998 and 1999 resulted in many contacts to both Alabama and Georgia fishery managers regarding lower or removing the length limit. Many anglers expressed that even if they were practicing catch and release, they considered their fishing trip unsatisfactory if they did not catch any legal-sized fish. Bass tournament anglers were especially vocal due to low numbers of bass weighed in following major tournaments. Local business owners voiced concerns over the perceived loss in revenue due to reduced angler activity. These concerns lead to a Lake Eufaula Symposium and several public meetings that are still currently in progress. The dramatic increase in voluntary catch and release documented over the last 15 years has also cast doubt over the need for a high minimum length limit. The Georgia Fisheries Management Section is currently engaged in an angler exploitation study to determine if voluntary release rates are actually as high as anglers indicated in the 1999 creel survey. Decisions re-

Table 5. Responses by anglers interviewed regarding their preference for the 406-mm minimum size limit for largemouth bass on Lake Eufaula, 1999.

	Increase		Decrease		Stay the Same	
Angler group	*N*	%	*N*	%	*N*	%
All anglers	9	1	378	35	680	64
Bass anglers	3	<1	215	34	412	65
Bass tournament anglers	2	<1	160	38	257	61
Non-tournament angler	1	<1	55	26	155	73
Crappie anglers	4	1	109	34	203	64
Other anglers	2	2	54	45	65	54

garding the future of minimum length limits for largemouth bass at Lake Eufaula will be made following completion of these studies.

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