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FINAL REPORT

RESEARCH AND SURVEYS

FEDERAL AID GRANT NO. F-50-R

FISH RESEARCH FOR OKLAHOMA WATERS

PROJECT NO. 3

EFFECTS OF A MINIMUM LENGTH LIMIT AND DAILY CREEL REDUCTION ON THE WHITE CRAPPIE POPULATION STRUCTURE AND ANGLER CREEL ON ARBUCKLE RESERVOIR

MARCH 1, 1994 through FEBRUARY 28, 1998

FINAL REPORT

State: Oklahoma Grant Number: F-50-R

Grant Title: Fish Research for Oklahoma Waters

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Project Title: Effects of a minimum length limit and daily creel reduction on the white crappie population structure and angler creel on Arbuckle Reservoir.

Period Covered: From: March 1, 1994 To: February 28, 1998

ABSTRACT

Crappie *Pomoxis* spp. population structure on Arbuckle Reservoir was monitored using fall trap-net samples from 1984-1997. A creel survey was conducted from 1985-1995. A 254-mm length limit/15-fish daily creel regulation was placed on the lake January 1, 1993. Prior to the length limit, the population was characterized as fast-growing and short-lived. Angler harvest steadily improved after the length limit and in the final year of the creel survey, harvest (kg/ha) was higher than in 5 of the 8 years data were collected prior to the length limit. Angler acceptance of the length limit regulation was high. Growth rates remained unchanged following implementation of the length limit. Although no differences in mortality rates could be demonstrated using the trap-net data, size and age structure of the crappie population improved. Based on the data collected, the length limit regulation was deemed a success.

I. Problem or Need:

Annual crappie *Pomoxis* spp. population survey data have been collected with fall trap-net samples since 1984. A 9-month creel survey was conducted annually from 1985-1995. The data indicated that the Arbuckle crappie population was fast-growing and short-lived. Age-2 and age-3 crappie in fall trap-net samples typically averaged >200 mm and >250 mm, respectively. Age-4 and older crappie comprised <10% of the population sample in 7 of 9 years prior to the length limit (1984-1992). It appeared that angler harvest was influential in shaping crappie population structure. In an effort to increase the number of age-4 and older crappie in the population and restructure the fishery to spread angler harvest over more age classes, a restrictive harvest regulation (254-mm minumum length limit and 15-fish daily creel) was enacted on January 1, 1993. Simulation models, based on creel data collected prior to the length limit, indicated that a daily creel of 15 fish would not reduce total harvest. However, it was felt that a creel reduction in conjunction with the size restriction would make it easier to "sell" the length limit to the anglers.

II. Background:

Historical crappie management practices focused on liberal harvest limits, mechanical removal, and commercial harvest to compensate for what managers perceived to be the tendency of crappie to overpopulate (Schneberger 1982; Hanson et al. 1983; Schramm et al. 1985). Overexploitation was generally not considered to be a

management problem. However, with the increased focus on crappie in angling publications and the proliferation of angling techniques to capture crappie year round, the potential for higher exploitation rates has led to the adoption of restrictive size limits on crappie populations in the southeastern and midwestern USA over the past decade.

The ability of restrictive size limits to meet the stated management objectives has been mixed (Colvin 1991b; Webb and Ott 1991; Mitzner 1995; Boxrucker 1997). Colvin (1991b) found that peak yield of crappie occurred in Missouri reservoirs when crappie were harvested at age 3 and that a higher proportion of the harvest shifted to age-3 and older crappie following implementation of restrictive harvest regulations. RSD-P (Gabelhouse 1984) of crappie in two Texas reservoirs increased following implementation of a 254-mm length limit (Webb and Ott 1991). However, a 254-mm minimum length limit/15-fish daily creel limit regulation on Ft. Supply Reservoir, Oklahoma was rescinded after 5 years because angler harvest rates failed to improve (Boxrucker 1997).

The success of restrictive harvest regulations is dependent on fast growth rates and low rates of natural mortality, as well as on angler satisfaction and compliance. We felt that the crappie population on Arbuckle Reservoir fit these criteria. Growth rates are considered to be excellent by Oklahoma standards, with age-2 and age-3 crappie averaging 216 mm and 274 mm, respectively in fall trap-net samples (Table 1). Although angling mortality rates were not estimated (no tagging studies were done to estimate exploitation

rates) there was evidence from the creel surveys conducted prior to the length limit that anglers were influential in shaping crappie population structure. The bulk of angler harvest prior to implementation of the length limit was comprised of age-2 crappie. Anglers experienced good crappie fishing in 1986 and 1987, harvesting over 30,000 crappie each year (Figure 1). A sharp decline in harvest was seen in 1988 and continued into 1989. This was largely due to a complete failure of the 1986 year class to recruit to the fishery. An increase was observed in 1990, however 80% of the harvest occurred in the fall and was largely supported by the 1989 year class (mean length of crappie harvested in fall 1990 was 235 mm; mean length of age-2 crappie in 1990 fall trap-net samples was 237 mm).

Data prior to 1994 presented in this report were collected under Federal Aid Projects F-37-R, Job 13 and Job 19.

III. Project Objective:

To determine if implementing a 10-inch minimum length limit and 15-fish daily creel limit on Arbuckle Reservoir will improve the size structure (% of crappie > 250 mm total length) and age structure (% of crappie age 3 and older) of crappie caught in fall trap-net samples. The effects of the regulation on angler catch and harvest of crappie will also be evaluated to determine if angler catch rates (no./hr) are increased and if harvest (no./hr and kg/ha) are improved.

IV. Approach:

Arbuckle Reservoir is a 951 ha impoundment of Guy Sandy, Buckhorn, and Rock Creeks located in southcentral Oklahoma. Construction was completed in 1967 and the reservoir is operated by the Bureau of Reclamation. Arbuckle Reservoir has a mean depth of 9.4 m and a maximum depth of 24.3 m, a shoreline development ratio of 5.4, and a secchi disk visibility of approximately 120 cm in the main pool in August. Fish habitat consists primarily of aquatic vegetation, rock, and some flooded timber in the upper ends of the creek channels. The shorelines are typically steep and consist largely of rock bluffs. The largemouth bass *Micropterus salmoides* population is characterized as dense and below average growth rates and is currently managed with a 330-406 mm slot length limit. White bass *Morone chrysops* is the other major predator in the lake. Gizzard shad *Dorosoma cepedianum* and threadfin shad *D. petenense* are the principal forage species.

Annual fall (October) trap-net samples were collected on Arbuckle Reservoir (1984-1997). Trap nets were constructed from two 183-cm wide by 91.5-cm high steel frames with four 76-cm diameter hoops covered with 12.7-mm square mesh knotless nylon netting material. Each net had a 19.8-m long lead, 91.5 cm in depth constructed of 12.7-mm square mesh knotless nylon netting material. Nets were located at ten standard sampling stations and fished for four consecutive days for a total effort of 40 net-nights. Nets were run at approximately 48-hr intervals giving 20 replicate

samples. A mean catch/hr was calculated based on these 20 replicates. This mean was multiplied by 24 and expressed at catch/net-night (CPUE).

White crappie *Pomoxis annularis* comprise approximately 80% of the crappie collected in the trap-net samples, with black crappie *P. nigromaculatus* comprising the remainder. The data presented in this report are for both species combined. Total lengths (mm) and weights (g) were taken on all crappie collected. Otoliths (sagittae) were removed from 20 crappie per available 20-mm length group for age analysis. Because our data were collected in the fall, ages referred to in this report reflect the number of growing seasons the fish have survived. Hence, the 1997 year class is referred to as age 1 in the fall 1997 samples.

Age-1 crappie are not fully recruited to our sampling gear (Colvin 1991a). Therefore, we estimated recruitment using CPUE of age-2 crappie collected using fall trap nets. Recruitment prior to the length limit (1984-1992) was compared to recruitment in years after the length limit (1993-1997) by testing the the log-transformed CPUE+1 using a two sample t-test, $\alpha \leq 0.05$. Catch curves were used to calculate total annual mortality rates (A) after Ricker (1975). Prior to the length limit, crappie entered the creel at age 2 and were generally harvested prior to reaching age 3 (see growth rates in Table 1 and mean lengths at harvest in Figure 2). Since a 254-mm minimum length limit would preclude harvest of most age-2 crappie, comparing survival of a year class from age-2 to age-3,

before and after the length limit, should reflect the changes in total mortality brought about by the restrictive harvest regulation. Survival estimates were calculated by comparing catch rates in the trap-net samples of age-2 crappie to the catch rates of age-3 crappie in the succeeding year's sample after Ricker (1975):

$$S = \text{CPUE Age } 3_{t+1} \div \text{CPUE Age } 2_t \times 100$$

where: S=Survival

CPUE=Number crappie/net-night in fall trap-net samples

t=Year

Age and size structure of the crappie population were estimated from the fall trap-net samples. Age structure is defined as the percentage of crappie age-2 and older that are age-4 and older. An age structure of 10% is considered satisfactory (Boxrucker 1989). Size structure is defined as the percentage of fish age-2 and older that exceed 250 mm total length. We consider 20% to be a satisfactory size structure (Boxrucker 1989).

A non-uniform, daylight 9-month (March through November, 1985-1995) creel survey was conducted to determine angler catch and harvest. Twenty 10-hour days (13 weekend/7 weekday) were randomly selected per season. Pressure, catch, and harvest rates were calculated. The creel survey was discontinued in 1996 due to personnel and equipment limitations.

A 10-inch (254-mm) minimum length limit with a 15-fish daily creel went into effect January 1, 1993. The statewide limit for crappie in Oklahoma is a 37-fish daily creel with no minimum length

limit.

V. Results and Discussion

Angler harvest of crappie at Arbuckle in 1993 was the lowest recorded since creel survey inception in 1985 (Figure 1). Angler harvest suffered during the first year of a length limit due to restricting harvest of age-2 crappie without the benefit of protection of previous year classes. The reduction in harvest was also due to fishing pressure directed at crappie being the lowest recorded since 1985 (approximately 10,000 angler-hours; Figure 1). The low level of pressure in 1993 was part of a declining trend in fishing pressure beginning in the late 1980's. Directed crappie fishing pressure increased slightly in 1994, but was still the second lowest recorded since the creel survey began. Fishing pressure continued to increase in 1995, surpassing the 1992 estimate (the year prior to the length limit going into effect). The angler catch rates (number/h) of crappie in 1993, 1994, and 1995, 1.4/h, 1.6/h, and 1.5/h, respectively, were among the highest recorded (Figure 4). Harvest rate increased steadily following the length limit with the 1995 harvest rate (0.8 fish/h) being comparable to the harvest rate in 1991 and 1992 (the two years prior to the length limit going into effect; Figure 4). The average length of the crappie harvested in 1995 (280 mm) exceeded the average length harvested in 1991 and 1992 by more than 30 mm (247 mm and 241 mm in 1991 and 1992, respectively; Figure 2). Harvest by weight (kg/ha) increased steadily after the length limit went into effect (Figure

4). The harvest by weight (1.9 kg/ha) in 1995 was higher than 5 of the 8 years prior to the length limit regulation. Creel data were not collected the final two years of the study to see if improvements in angler success continued due to budget and man-power limitations.

Although formal angler opinion surveys relative to acceptance of the length limit regulation were not conducted, creel clerk contacts with anglers were overwhelmingly favorable. Few reports of dissatisfied anglers were received by game wardens and fisheries staff.

Increased abundance of the sizes of crappie protected by a length limit has the potential to decrease growth rates associated with that size fish. A decrease in growth rates can be counterproductive to the objectives of a length limit regulation by delaying the age at which crappie enter the creel and increasing potential losses due to natural mortality. Crappie growth rates (ages 2-5) at Arbuckle Reservoir remained unchanged following the implementation of the restrictive harvest regulation (Table 1; One-Way ANOVA; $\alpha \leq 0.05$).

Crappie age structure in the fall trap-net samples has steadily improved since the length limit went into effect, exceeding the recommended level of 10% (Boxrucker 1989) in the 1995 (12%), 1996 (22%), and 1997 (18%) samples; only the fifth time in 14 years of sampling (Figure 5). Size structure has exceeded 30% each year since the length limit has been in effect and approached 50% in the 1995, 1996, and 1997 samples (Figure 6). Webb and Ott (1991) found

an increase in RSD-P of crappie in two Texas Reservoirs following implementation of a 254-mm length limit.

Improvements in the size and age structure, as evidenced in Figures 5 and 6 could not be explained by decreases in mortality rates resulting from the length limit. Survival estimates between age 2 and age 3 prior to the length limit (1985-1992) averaged 32.0% (Table 2). The respective estimates for the years that the length limit was in effect (1993-1997) averaged 39.4% (Table 2). Total annual mortality, estimated from catch curves, averaged 35.3% prior to the length limit and 34.2% after enactment of the length limit regulation (Table 2). The annual mortality rates found in this study were lower than those reported by Allen and Miranda (1995) for 14 reservoirs across the midwest and southeast United States.

The apparent contradiction between the data presented in Figures 5 and 6 and the mortality estimates presented in Table 2 could be explained if crappie recruitment was higher in years following the length limit. Even if mortality rates remained unchanged following enactment of the length limit, higher recruitment could result in a higher percentage of older and hence larger crappie in the population. No differences in recruitment between the pre- and post-length limit years were indicated from the trap-net data (Figure 3; two-sample t-test; $\underline{P}=0.60$). The trap-net data did indicate that the recruitment in pre-length limit years was more variable [variance (s^2)=10.27] than in the years following the length limit (s^2=4.30). This may help explain the variable nature of the age and size structure data prior to the length limit

(Figures 5 and 6).

Most discussions of mortality in fish populations assume that angling mortality and natural mortality are additive. Consequently, any decrease in exploitation (μ), as the result of a length limit, would result in a decrease in total mortality. Alternatively, mortality could be compensatory (Anderson and Burnham 1976). Under this model, a decrease in μ would result in an increase in natural mortality and annual mortality could remain unchanged. Compensatory mortality mechanisms may be operating in some crappie populations (Larson et al. 1991; Allen and Miranda 1995). Our mortality data from Arbuckle Reservoir also suggest a possibility of compensatory mortality.

The mortality estimates generated from the catch curves should be viewed with caution because they were based on only three (ages 2-4) and occasionally four (ages 2-5) age classes. The mortality estimates may also be suspect due to the quality of the catch rate data used to generate them. It is difficult to obtain reliable abundance estimates of the crappie population at Arbuckle Reservoir through annual trap-net surveys due to lake morphometry. The lake is typical of Ozark-type impoundments found in eastern Oklahoma with clear water and steep rocky shorelines. This type of shoreline structure makes it difficult to set nets in areas of prime crappie habitat. Typical catch rates at Arbuckle Reservoir are < 5 crappie/net-night (Table 3). These low catch rates may not be a true reflection of crappie abundance. The precision estimates of the catch rate data are also higher than recommended levels. Robson

and Regier (1964) suggested than a 25% confidence interval around the mean would be an appropriate target for management studies. A $CV_{\bar{x}}$=0.125 corresponds to this standard. The $CV_{\bar{x}}$'s associated with the catch rates in this study were generally around 0.30 (Table 3). The lack of precision of our catch rate estimates makes the mortality data presented in Table 2 suspect.

In spite of our inability to show decreases in total annual mortality rates as a result of the length limit, based on creel results and size and age structure improvements in the trap-net data, we conclude that the objectives of the study were met. The crappie population currently consists of older, larger fish than prior to the length limit. Angler harvest by weight in 1995 surpassed 5 of the 8 years prior to the length limit. When our survey data are coupled with what appears to be angler acceptance of the length limit, the length limit regulation should be deemed a success.

VI. Recommendations:

We recommend to continue managing the crappie population of Arbuckle Reservoir with a 254-mm length limit/15-fish daily creel regulation.

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VIII. Date: March 1, 1998

IX. Approved by: Harold Namminga

Dr. Harold Namminga

Federal Aid/Research Coordinator

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Table 1. Mean lengths (mm) at the end of the growing season for crappie from fall trap-net samples at Arbuckle Reservoir, Oklahoma, 1984-97.

	Mean Length (mm) at end of growing season					
YEAR	**1**	**2**	**3**	**4**	**5**	**6**
1984	101	201	254			
1985	132	210	268	300		370
1986	110	179	279		355	
1987	101	218	256	275	250	
1988	106	204	275	274	370	
1989	165	237	276		297	370
1990	130	237	289	310	230	240
1991	128	224	287	279	310	
1992	160	236	276	330		
	254-mm Length Limit					
1993	-	217	269	290	310	
1994	155	225	278	290	305	
1995	145	224	282	301	290	370
1996	87	223	275	301	307	313
1997	103	193	268	296	310	340

Table 2. Catch rates (number/net-night) of age-2 and age-3 crappie in fall trap-net samples with with associated survival estimates (S) and total annual mortality rates (A) calculated from catch curves from Arbuckle Reservoir, Oklahoma, 1984-1997.

YEAR	CPUE Age 2	S	CPUE Age 3	A
1984	0.0		0.72	
1985	8.64		0.96	50
		8.3		
1986	8.64		0.72	49
		80.5		
1987	0.48		6.96	20
		0.0		
1988	2.64		0.0	29
		18.2		
1989	0.96		0.48	21
		50.0		
1990	2.64		0.48	33
		27.3		
1991	3.60		0.72	39
		40.0		
1992	3.60		1.44	41
		254-mm Length Limit		
		20.0		
1993	3.12		0.72	37
		38.5		
1994	2.88		1.20	31
		41.7		
1995	2.40		1.20	33
		70.0		
1996	7.20		1.68	41
		26.7		
1997	2.16		1.92	29

Table 3. Catch rates (number/net-night) and Coefficient of Variation of the Mean ($CV_{\bar{x}}$; in parentheses) of crappie from fall trap-net samples from Arbuckle Reservoir, Oklahoma, 1984-1997.

YEAR	$CPUE_{total}$	$CPUE_{\geq 200\ mm}$	$CPUE_{\geq 250\ mm}$
1984	2.16 (0.29)	0.96 (0.33)	0.72 (0.50)
1985	11.04 (0.31)	6.96 (0.27)	1.92 (0.25)
1986	9.36 (0.39)	7.20 (0.22)	0.72 (0.33)
1987	8.16 (0.32)	7.44 (0.34)	5.04 (0.32)
1988	4.56 (0.29)	2.40 (0.30)	0.96 (0.25)
1989	1.68 (0.20)	1.44 (0.20)	0.48 (0.00)
1990	7.68 (0.45)	4.56 (0.38)	1.68 (0.50)
1991	5.04 (0.24)	4.32 (0.22)	1.44 (0.17)
1992	5.52 (0.35)	5.52 (0.35)	2.64 (0.36)
		254-mm Length Limit	
1993	4.32 (0.28)	3.60 (0.27)	1.44 (0.33)
1994	4.56 (0.32)	4.32 (0.28)	1.68 (0.29)
1995	4.32 (0.67)	4.08 (0.65)	2.16 (0.67)
1996	12.00 (0.26)	10.32 (0.30)	5.28 (0.32)
1997	5.04 (0.38)	3.60 (0.40)	2.40 (0.50)

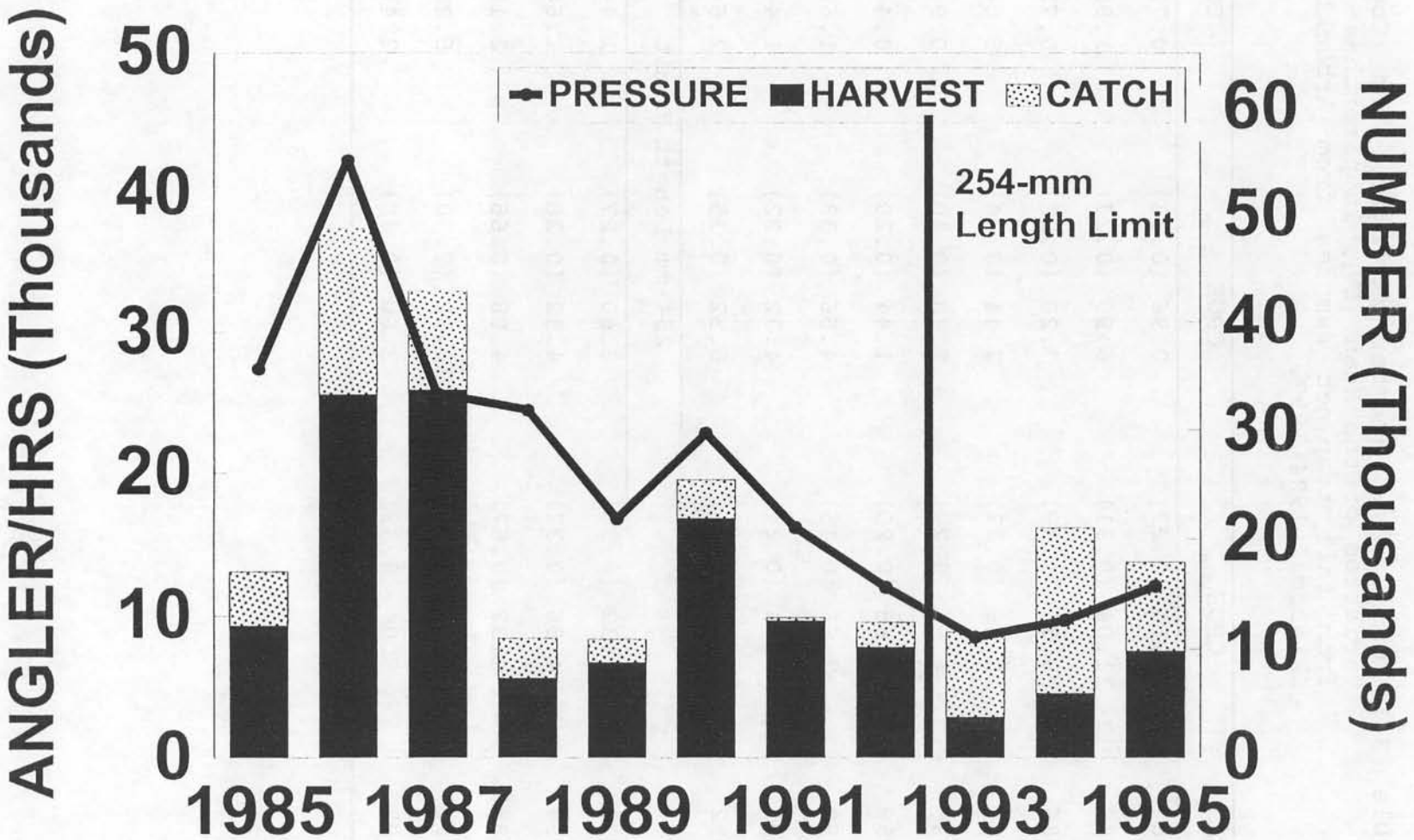

Figure 1. Pressure, catch, and harvest of crappie from Arbuckle Reservoir, Oklahoma, 1985-1995.

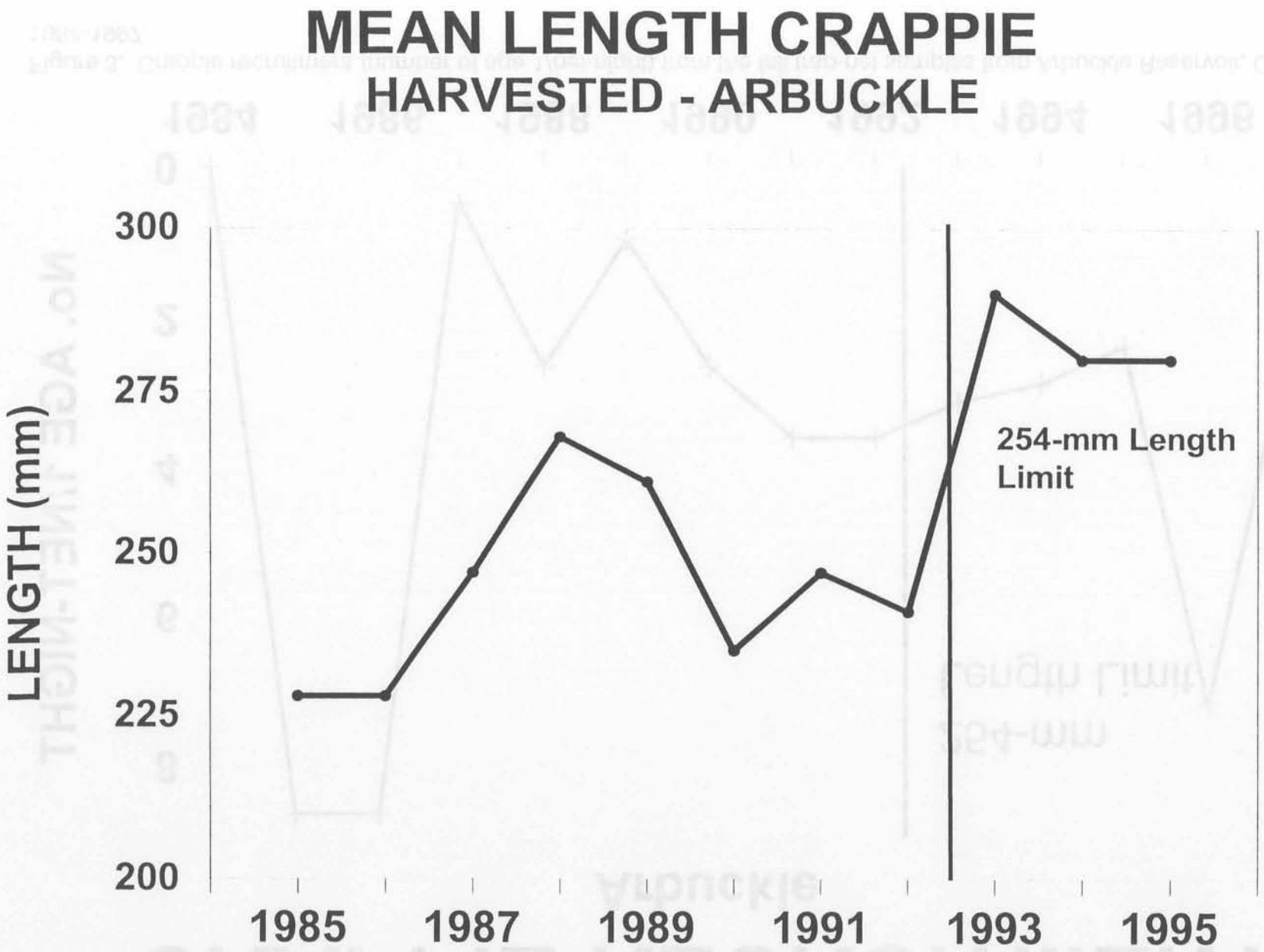

Figure 2. Mean length of crappie in the creel from Arbuckle Reservoir, Oklahoma, 1985-1995.

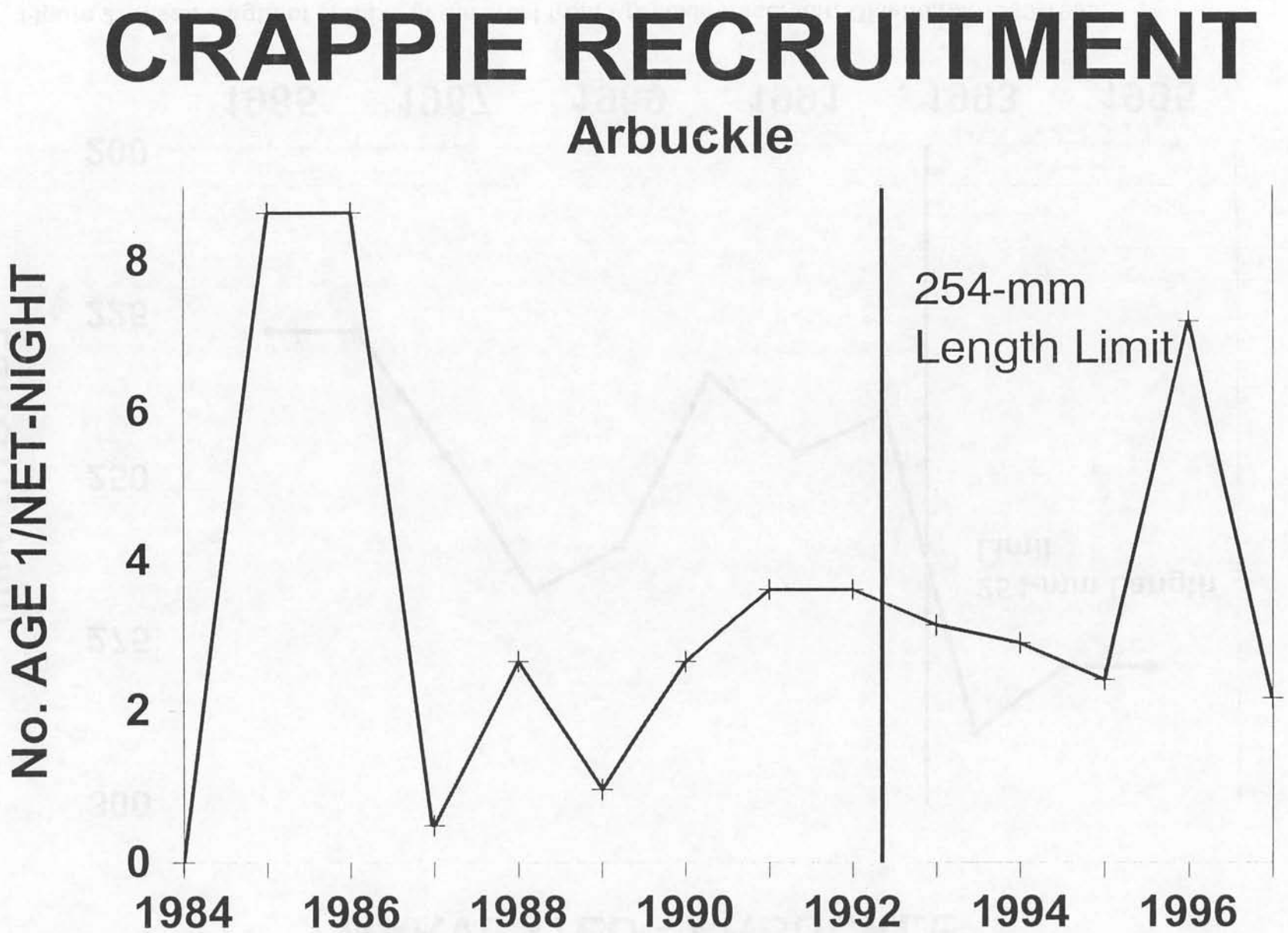

Figure 3. Crappie recruitment (number of age 1/net-night) from the fall trap-net samples from Arbuckle Reservoir, Oklahoma, 1984-1997.

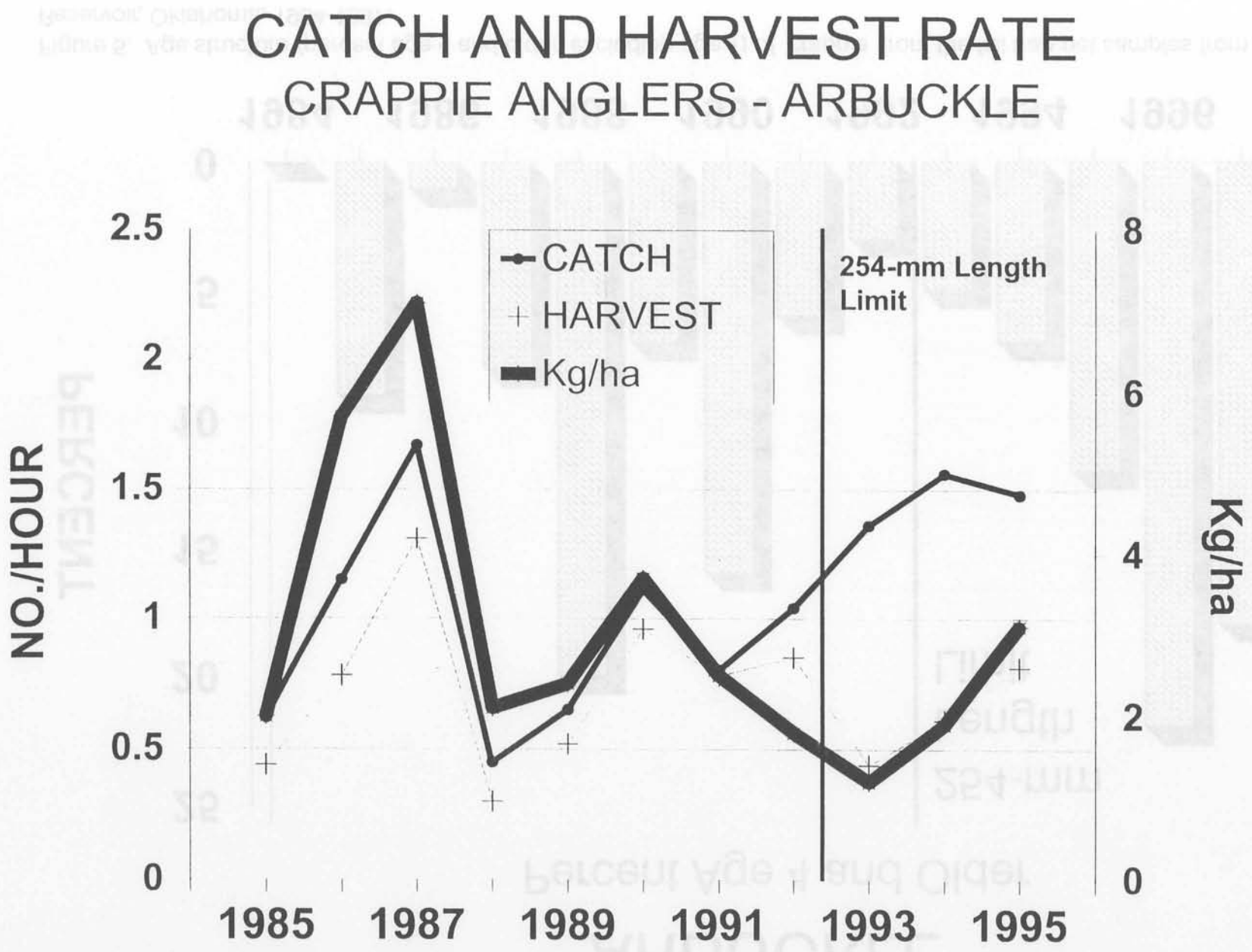

Figure 4. Catch and harvest rates (no./hour) and harvest by weight (kg/ha) of crappie anglers from Arbuckle Reservoir, 1985-1995.

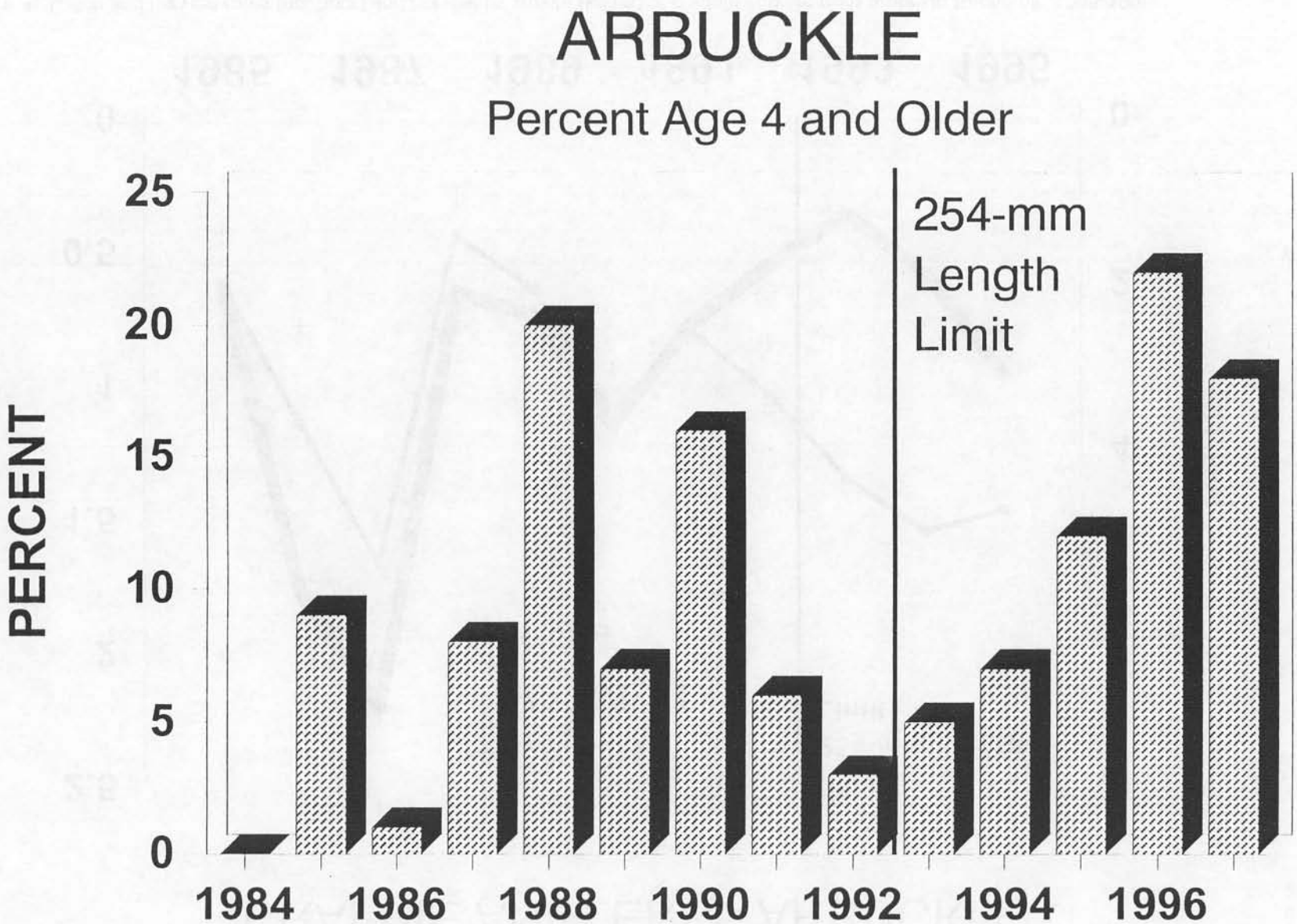

Figure 5. Age structure (percent age 4 and older, excluding age 1) of crappie from the fall trap-net samples from Arbuckle Reservoir, Oklahoma, 1984-1997.

ARBUCKLE

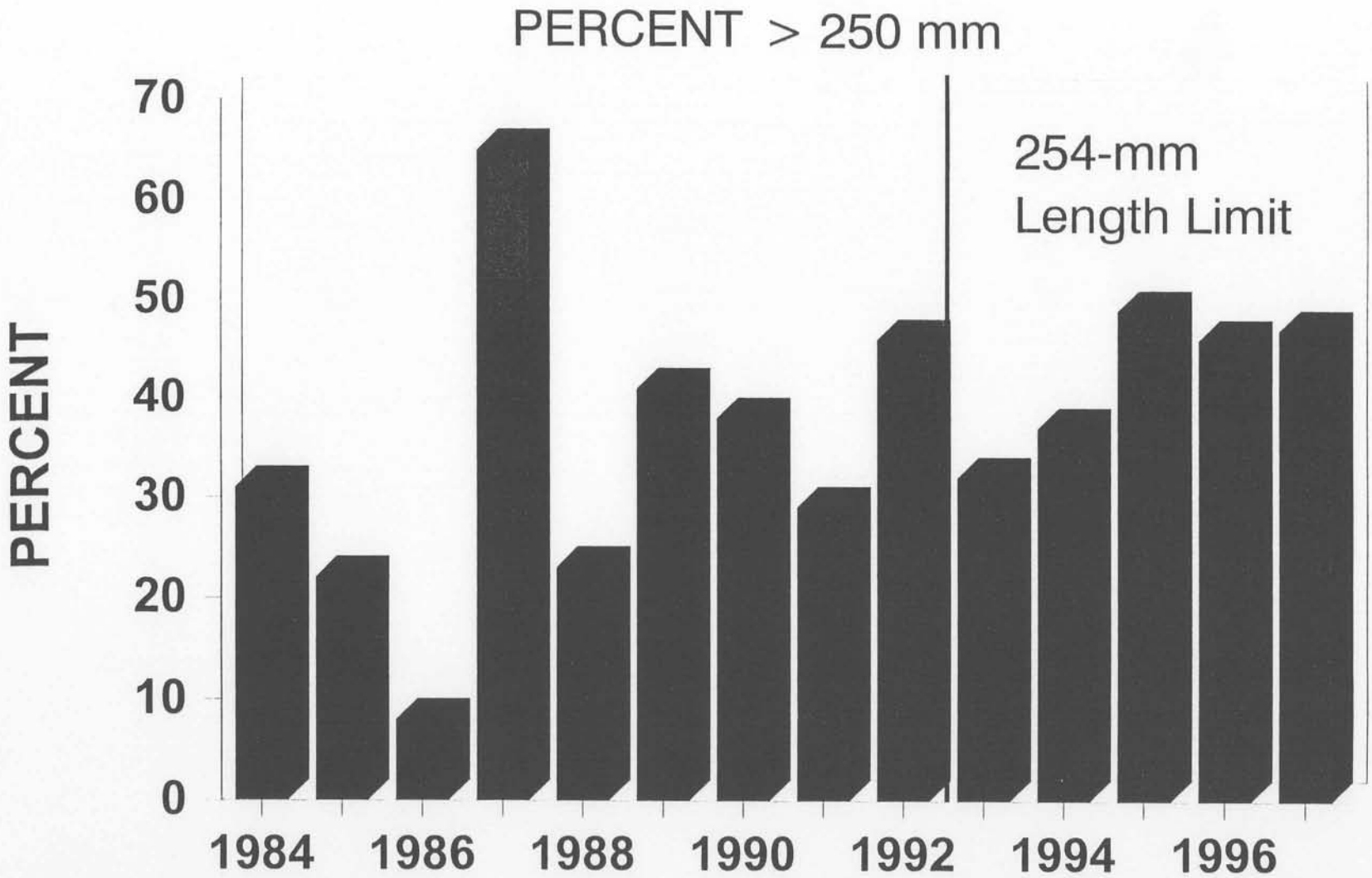

Figure 6. Size structure (% >250 mm, excluding age 1) of crappie from the fall trap-net samples from Arbuckle Reservoir, Oklahoma, 1984-1997.

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