North American Journal of Fisheries Management 22:1340–1348, 2002

Rescinding a 254-mm Minimum Length Limit on White Crappies at Ft. Supply Reservoir, Oklahoma: The Influence of Variable Recruitment, Compensatory Mortality, and Angler Dissatisfaction

JEFF BOXRUCKER*

Oklahoma Fishery Research Laboratory,
Oklahoma Department of Wildlife Conservation,
500 East Constellation,
Norman, Oklahoma 73072, USA

Abstract.—[redacted]

Management practices for crappies *Pomoxis* spp. have historically 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 has not generally been considered a management problem. However, due to increased fishing pressure and efficiency of sport anglers, minimum length limits on crappie populations have become necessary to prevent overharvest during the past decade (Quinn 1996). I surveyed the 2002 fishing regulations on the internet web pages of fish and wildlife management agencies in the Southern and North-central Divisions of the American Fisheries Society and found that 10 states in the southern and five states in the Midwestern United States manage some crappie fisheries using minimum length limits.

Results of minimum length limits used to improve crappie fisheries have been variable. Colvin (1991) found that crappie yield was maximized in Missouri reservoirs when crappie were harvested at age 3, therefore a regulation that shifted harvest to age-3 and older fish should increase yield. Size structure of crappie in two Texas reservoirs improved following implementation of a 254-mm length limit (Webb and Ott 1991); size and age structure of the crappie population on Arbuckle Reservoir, Oklahoma, also improved with a 254-mm length limit (Boxrucker 2001). However, a 254-mm length limit in Delaware Reservoir, Ohio, was reduced to 229 mm after a dramatic reduction in yield and an increase in release rates by anglers of up to 84–97% of the total catch (Hale et al. 1999). Larson et al. (1991) and Reed and Davies (1991) recommended against the use of minimum length limits due to high rates of natural mortality in the populations that they studied.

* E-mail: jboxrucker@aol.com

Received December 1, 2000; accepted April 29, 2002

Simulation models have demonstrated that crappie yield is unlikely to increase via minimum length limits unless a population is characterized by fast growth and low natural mortality. Allen and Miranda (1995) reported that increasing yield by decreasing exploitation was the exception rather than the rule in their review of published literature and modeling. Among crappie populations, conditional natural mortality averaged 49%, but ranged from 8 to 92% (Allen and Miranda 1995). Maceina et al. (1998), predicted that a 254-mm minimum length limit would increase yield of crappie on Weiss Lake, Alabama, only if conditional natural mortality rates were <35%, and then anglers would have to accept fewer crappies in the creel in exchange for increased average weight.

The objective of this case study was to provide a history and recommendations from my experience with the Ft. Supply Reservoir crappie fishery so that other managers of crappie fisheries can evaluate regulation changes. I examined data spanning 7 years before a length limit was enacted, 6 years during the regulation, and 3 years after the regulation was rescinded. A minimum length limit of 254 mm and a creel limit of 15 crappies/d were implemented on January 1, 1990. Anglers requested the reduction in the creel limit from 37 crappies/d to 15 crappies/d, although data indicated that a 15-fish limit would not reduce harvest. The objectives of the regulation were to improve population size and age structure, and increase angler catch rates of white crappie. Due to a large number of angler complaints, the regulation was rescinded on January 1, 1996. Additionally, I examined whether a yield model would have predicted the outcome of the regulation.

Methods

Study area.—Ft. Supply Reservoir (i.e., Ft. Supply) is a shallow (mean depth <2 m), windswept impoundment on Wolf Creek, a tributary of the Beaver River in northwest Oklahoma. The reservoir covers 748 ha, has sandy substratum, and cattails *Typha* spp., on the shoreline are the only aquatic vegetation. Gizzard shad *Dorosoma cepedianum* are the primary forage species and are abundant compared with other Oklahoma impoundments (Oklahoma Department of Wildlife Conservation, unpublished survey data). The predator populations are composed primarily of white crappies, white bass *Morone chrysops*, and stocked walleye *Stizostedion vitreum* and a hybrid serranid (white bass *M. chrysops* × striped bass *M. saxatilis*).

The Ft. Supply white crappie fishery is typified by relatively low fishing pressure (<10 h/ha of directed effort), most occurring during spring. However, white crappies are extremely vulnerable to harvest during spring because their inshore spawning habitat is limited and readily accessible to bank anglers.

A nonuniform, random, access-point creel survey was conducted during daylight from September–May of 1986–1988. Twenty 10-h days (13 weekend; 7 weekday) were surveyed per season. Previous information indicated that little angling effort occurred during summer at Ft. Supply Reservoir. These surveys indicated that the majority (about 75%) of the white crappie effort, angler catch, and harvest occurred during spring (Boxrucker 1994). To reduce monitoring costs, the creel period was limited to spring (March through May) from 1989 to 1998; no survey was conducted in 1993 due to budget constraints. Angler effort, catch and harvest, and harvest rates were estimated.

Trap nets were used to sample white crappies in the fall from 1983 to 1998. 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. Each net had a 19.8-m lead that was 91.5 cm in depth constructed of 12.7-mm square-mesh, knotless nylon netting. Nets were fished at six to eight fixed stations, usually for 4 consecutive days and were lifted to retrieve fish approximately every 24 h. The number of annual sets ranged from 8 to 75 over the course of the study. Catch per unit effort (CPUE) were calculated as number/net. Relative precision of the untransformed CPUE estimates was expressed using the coefficient of variation of the mean (Cyr et al. 1992). Total lengths (mm) and weights (g) were measured on all white crappies collected.

Catch rates from the trap-net samples for quality-size (200–249 mm) and preferred-size (≥250 mm; Gabelhouse 1984a) crappies were $\log_e$-transformed and compared for years before (1983–1989, hereafter referred to as ‘‘pre-length-limit years’’) and after the length limit went into effect (1990–1995, hereafter referred to as ‘‘length-limit years’’) using a repeated-measures, split-plot analysis of variance (ANOVA; Maceina et al. 1994). Significance was set at $\alpha = 0.10$ for all statistical tests. Survival (S) for ages 1–4 was estimated by dividing age-specific CPUE from year $t + 1$ by the CPUE of the same year-class in year t (Ricker 1975). Conditional natural mortality rates (n, expected natural mortality in the absence of angling mortality) were estimated after Ricker (1975), as:

$$n = -[(A - m)/(m - 1)];$$

m is conditional fishing mortality rate (expected fishing mortality in the absence of natural mortality), or $m = 1 - \exp\{\mu[\log_e(1 - A)]/A\}$, where μ = actual annual exploitation rate, and A is annual total mortality rate or $A = 1 - e^{-Z}$, where Z = the instantaneous total mortality rate.

Instantaneous mortality rates (Z) were estimated by regressing age (1–5) by $\log_e$-transformed age-specific CPUE (Ricker 1975). Conditional natural mortality rates were estimated for pre-length-limit years only because exploitation was not estimated for length-limit years nor for the years after the length limit was rescinded (hereafter referred to as ''post-length-limit years''; 1996–1998). Survival rates from pre-length-limit years were compared with those calculated for length-limit years using a one-way ANOVA.

Colvin (1991) stated that age-0 crappie were not fully vulnerable to capture with trap nets. Log_e-transformed catch of age-0 white crappie in year t was not well correlated to $\log_e$-transformed catch of age-1 white crappie in year $t + 1$ (R^2 = 0.20; P = 0.10); therefore, recruitment was expressed as catch of age-1 white crappie. Recruitment between pre- and length-limit years was compared using a repeated-measures split-plot ANOVA. Mean lengths-at-age for prelength-limit and length-limit years were compared using a one-way ANOVA.

Size structure was described by relative stock density of preferred-length fish (RSD-P; Gabelhouse 1984a). Oklahoma biologists consider an RSD-P of 20% or more to be satisfactory for crappie management (Boxrucker 1989). Age structure was defined as the proportion of the age-1-and-older white crappie population that were age 3 or older. From each 20-mm length-group, otoliths (sagittae) were removed from up to 20 individuals, if available, for age analysis. Age structure was determined using methods described by Ketchen (1950). Age structure of 10% or greater is considered satisfactory by Oklahoma standards (Boxrucker 1989).

Angling exploitation was estimated in 1986 and 1987. Floy spaghetti tags were placed in the dorsal musculature of 987 white crappies (≥200 mm total length) in October 1986 and 650 crappies in October 1987. The tags were labeled, ''REWARD.'' Signs were posted at prominent angler access points around the lake, and posters were placed in local tackle and sporting goods stores notifying anglers of the tagging study. Prizes from area merchants (primarily of fishing tackle) were solicited to be used as rewards for returned tags. Annual exploitation rate (μ) represented the percentage of returned tags. Tag returns were adjusted for a nonreporting rate of 33%, as assumed by Zale and Bain (1994). Tag loss reported from previous crappie tagging studies has varied: 4% (Zale and Stubbs 1991), 5–30% (Larson et al. 1991), and 46% (Miranda et al. 1997). No adjustments for tag loss were made in this study, thereby making exploitation estimates conservative.

TABLE 1.—Population parameters and variables used to estimate yield for the crappie fishery from Ft. Supply Reservoir, Oklahoma.

Variable or parameter	Definition
Recruitment	Constant recruitment of 100 fish/year (N_0) into the population at time t_0
Growth	Coefficients for the von Bertalanffy equation: L_∞ = 400, k = 0.0303, t_0 = −0.475
	Regression equation of weight (WT; g) on total length (TL; mm): WT = 0.00000035(TL$^{3.679}$)
Natural mortality	Conditional rates of annual natural mortality were 25, 35, and 45% and started at age t_0
Exploitation	Conditional rates of annual fishing mortality ranged from 10% to 60% at 10% intervals and started at age recruited to the fishery

Fishery Analysis Simulation Tools (FAST; Slipke and Maceina 2000), which employs the Jones modification of the Beverton–Holt equilibrium yield model (Ricker 1975, as cited by Maceina et al. 1998), was used to predict yield of the fishery under the length limit. Pre-length-limit empirical population data were used as model inputs. Model parameters are listed in Table 1. Ranges of μ and n were used to compare predicted yield resulting from a 203-mm length limit (crappies smaller than this length are seldom found in angler creels where length limits are absent) and a 254-mm length limit.

A series of public meetings were held in 1988 and 1989, before implementing the length limit, to inform local anglers of the results of netting surveys and to educate them on the potential benefits of minimum length limits. Additional meetings were held after the regulation went into effect to detail the results of the field studies and to get angler feed-back on the regulation. Numerous

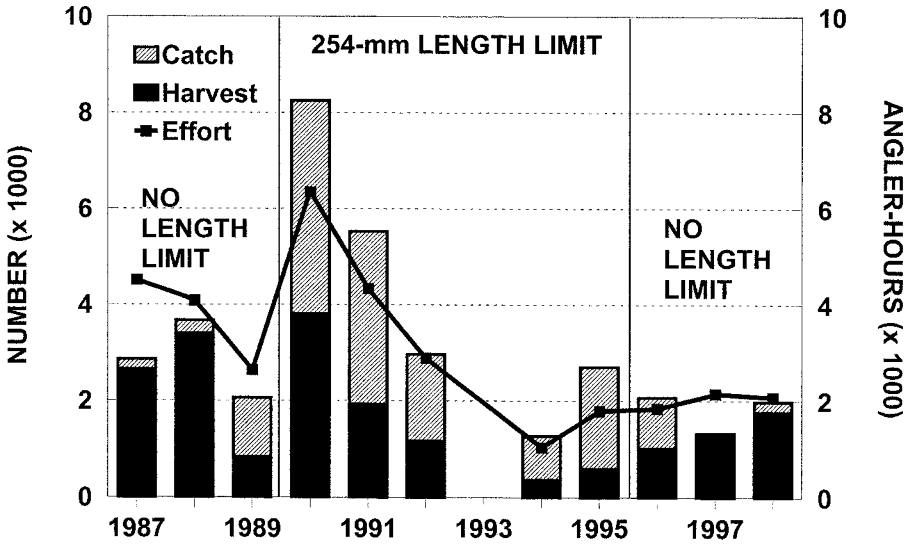

FIGURE 1.—Spring angling effort, catch, and harvest of white crappies at Ft. Supply Reservoir, Oklahoma, before the imposition of a 254-mm length limit, while the limit was in effect, and after it was removed.

press releases were issued both before and after the regulation. No formal angler opinion surveys were conducted.

Results

Angler effort (6,344 h), catch (8,251), and harvest (3,805) of white crappies were the highest recorded during the spring after the length limit went into effect in 1990 (Figure 1) but declined steadily thereafter, reaching lows of 1,025 h, 1,268 fish, and 368 fish, respectively, in 1994. The ratio of harvest to catch declined during the length-limit years, leading to numerous angler complaints. Harvest increased in each of the 3 years following removal of the regulation (Figure 1). Angler catch rates increased in length-limit years, but harvest rates were comparatively stable, declining only slightly (Figure 2). Harvest rates increased following removal of the regulation, the 1998 level matching the highest recorded (0.86 fish/h; Figure 2). Yield (kg) declined during the length-limit years and increased following removal of the regulation (Figure 3).

Catch of quality-size white crappies in the trap-net samples in length-limit years (31 fish/net) increased about 50% from pre-length-limit years (21 fish/net; $F_{1,5}$ = 36.7, P = 0.0001; Table 2). The catch of preferred-size white crappies increased from 7 fish/net in pre-length-limit years to 11 fish/net in length-limit years ($F_{1,5}$ = 13.3, P = 0.0009). Trap-net catches of both quality- and preferred-size crappies declined following removal of the length limit.

Recruitment (i.e., CPUE of age-1 white crap-

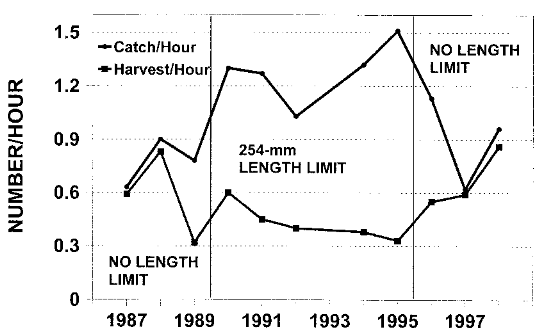

FIGURE 2.—Spring angling catch and harvest rates of white crappies at Ft. Supply Reservoir, Oklahoma, during the three regulatory periods (see Figure 1).

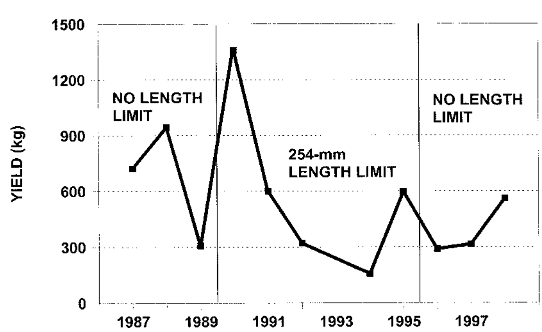

FIGURE 3.—Yield (kg/ha) of white crappies at Ft. Supply Reservoir, Oklahoma, during the three regulatory periods, as estimated from the spring creel survey.

TABLE 2.—Catch per unit effort (CPUE; number/net) and coefficient of variation of the mean ($CV_{\bar{x}}$ of age-1, quality-size (200–249 mm) and preferred size (≥250 mm) white crappies in fall trap-net samples in Ft. Supply Reservoir, Oklahoma, 1983–1998.

Year	CPUE mean ($CV_{\bar{x}}$) Age 1	200–249 mm	≥250 mm
Pre-length-limit years			
1983	34 (0.11)	32 (0.11)	3 (0.12)
1984	99 (0.30)	11 (0.21)	8 (0.24)
1985	16 (0.25)	31 (0.27)	12 (0.31)
1986	28 (0.14)	25 (0.16)	7 (0.17)
1987	7 (0.09)	10 (0.09)	4 (0.19)
1988	51 (0.22)	3 (0.19)	2 (0.19)
1989	7 (0.20)	34 (0.18)	16 (0.18)
Mean	35 (0.34)	21 (0.24)	7 (0.29)
Length-limit years			
1990	17 (0.11)	22 (0.13)	7 (0.15)
1991	47 (0.29)	41 (0.20)	20 (0.22)
1992	15 (0.21)	24 (0.36)	9 (0.42)
1993	19 (0.18)	22 (0.20)	6 (0.26)
1994	25 (0.11)	34 (0.13)	12 (0.16)
1995	48 (0.13)	42 (0.15)	9 (0.22)
Mean	29 (0.21)	31 (0.13)	11 (0.18)
Post-length-limit years			
1996	1 (0.32)	14 (0.27)	9 (0.27)
1997	1 (0.36)	13 (0.16)	7 (0.16)
1998	106 (0.20)	3 (0.25)	2 (0.26)
Mean	36 (0.97)	10 (0.35)	6 (0.33)

pies) in pre-length-limit years was not significantly different compared with length-limit years (P = 0.97; Table 2). Recruitment fluctuated widely over the course of the study, ranging from 1/net to more than 100/net. Strong year-classes were produced every 3–4 years.

The Ft. Supply white crappie population was considered fast-growing, age 1 typically averaging greater than 200 mm and age 2 greater than 250 mm (Figure 4). Growth rates remained relatively

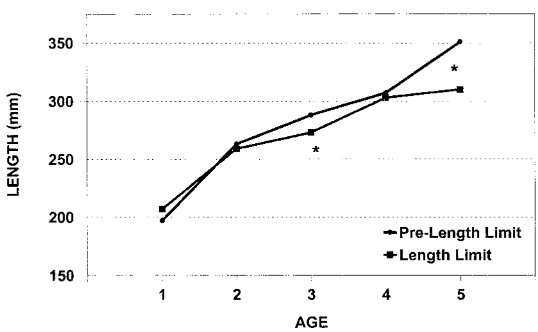

FIGURE 4.—Mean length at age for white crappies from pre-length-limit (1983–1989) and length limit years (1990–1995), Ft. Supply Reservoir, Oklahoma. Asterisks denote significant differences.

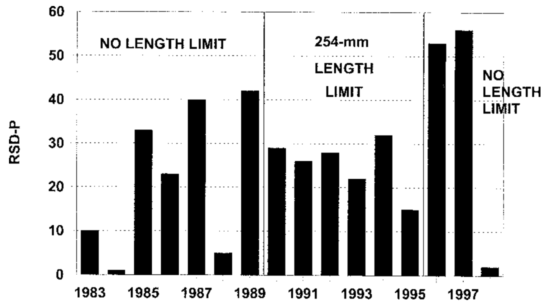

FIGURE 5.—Relative stock density of preferred-length (RSD-P) white crappies in fall trap-net samples during three regulatory periods, Ft. Supply Reservoir, Oklahoma.

unaffected by the regulation. Mean lengths at age 3 declined slightly during post-length-limit years (P = 0.002), as they did for age 5 (P = 0.036).

The RSD-P for white crappies fluctuated in the pre-length-limit years, ranging from 1% to 40% but during length-limit years stabilized, exceeding 20% in 5 of 6 years (Figure 5). For the first 2 years following removal of the regulation (1996–1997), RSD-P exceeded 50% but then decreased to 2% in 1998.

The age structure (i.e., proportion age 3 and older) of the white crappie population never exceeded 10% during the pre-length-limit years, exceeded 10% for the first 4 years following implementation of the regulation, but declined to less than 10% in the last 2 length-limit years (Figure 6). Age structure increased markedly following removal of the regulation (15% in 1996 and 52% in 1997), although the 1998 sample was 2%.

The length limit shifted spring harvests from age-2 to age-3 fish. Therefore, survival from age 1 to age 2 should have been substantially increased following the length limit. Survival from age 1 to age 2 averaged 29% for pre-length-limit versus

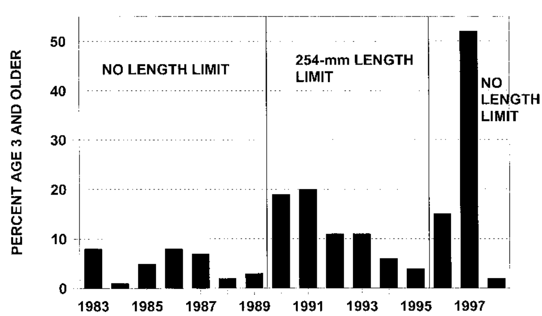

FIGURE 6.—Percent age 3 and older white crappies (age 0 not sampled) in fall trap-net samples during three regulatory periods, Ft. Supply Reservoir, Oklahoma, 1983–1998.

TABLE 3.—Catch per unit effort (CPUE; number/net) of white crappies by age-class and associated survival (*S*) and conditional mortality (ages 1–4) (CM) estimates, Ft. Supply Reservoir, Oklahoma, 1983–1998. Survival estimates can be read on a diagonal between successive age-classes. Blank spaces in the survival estimates represent either missing data or unrealistic survival estimates (i.e., CPUE in year $x + 1$ was higher than CPUE in year x).

Year	$CPUE_{Age\ 1}$	*S*	$CPUE_{Age\ 2}$	*S*	$CPUE_{Age\ 3}$	*S*	$CPUE_{Age\ 4}$	CM
Pre-length-limit years								
1983	35.2		0.2				1.9	
		18.8			1.2	25.0		46
1984	80.8		6.6				0.3	
		25.2		28.8				64
1985	17.8		20.4					
		16.3		10.3	1.9			36
1986	25.6		2.9					
		9.4		6.9	2.1	19.0		38
1987	6.3		2.4				0.4	
		36.5		25.0	0.2			32
1988	50.6		2.3				0.2	
		57.5		39.1	0.6	33.3		60
1989	7.3		29.1				0.2	
		37.0		13.4	0.9	11.1		47
Length-limit years								
1990	15.3		2.7		3.9			
		90.8					0.1	
1991	47.4		13.9		7.6			
		23.4		18.7			7.4	
1992	13.6		11.1		2.6			
		27.2		16.2		11.5		
1993	17.9		3.7		1.8			
		59.8		24.3		38.9	0.3	
1994	25.0		10.7		0.9			
		41.6		8.4		77.7	0.7	
1995	47.4		10.4		0.9			
		28.1		20.2		33.3	0.7	
Post-length-limit years								
1996	0.7		13.3		2.1		0.3	
				36.1		66.6		
1997	0.6		5.6		4.8		1.4	
				12.5		16.7		
1998	106.1		0.8		0.7		0.8	

45% for length-limit years (Table 3). However, because of the wide range in survival estimates, these means were not significantly different ($P = 0.15$). Survival estimates for 1997 and 1998 were inaccurate because more white crappies were caught at age 2 than at age 1. Conditional natural mortality rates averaged 46% (ranged 32–63%) in pre-length-limit years (Table 3). Exploitation was estimated at 40% in 1987 and 1988, based on a 30% return of tags and adjusting for nonreporting rate.

Results of the Beverton–Holt equilibrium yield models indicated that at low levels of natural mortality ($n = 25\%$) the length-limit would have increased yield, even at low levels of exploitation (20%; Figure 7A). With moderate natural mortality (35%), yield would have increased slightly to the levels of exploitation measured in this study (40%; Figure 7B). However, at higher natural mortality levels (45%), as estimated for the pre-length-limit years, yield would have declined under a 254-mm minimum length limit, irrespective of exploitation rates (Figure 7C).

Discussion

The Ft. Supply Reservoir evaluation of white crappies indicated that abundance of both quality and preferred sizes, population size and age structure, and angler catch rates may be improved by using minimum length limits; however, this management strategy failed, overall, to meet angler expectations. Length limits have reduced total mortality in populations of largemouth bass *Micropterus salmoides* (Ming and McDannold 1975; Gabelhouse 1984b; Van Horn et al. 1984; Summers 1989) and improved some crappie fisheries (Colvin 1991; Webb and Ott 1991; Maceina et al. 1998). However, because of high rates of natural mortality inherent in some populations, the use of length limits as a crappie management tool has been questioned (Larson et al. 1991; Reed and Davies 1991; Allen and Miranda 1995; Allen et al. 1998).

Estimating natural mortality and exploitation rates before implementing restrictive harvest regulations appears to be vital to making informed management decisions. Exploitation studies are expensive, but the negative angler response resulting from the length limit at Ft. Supply may be more expensive in less tangible ways. The length limit should have eliminated most, if not all, of the exploitation of age-2 white crappies, yet survival from age 1 to age 2, as estimated from the previous fall trap-net data, increased only slightly from 29% to 45% and was not detected statistically. Given pre-length-limit rates of conditional natural mortality of 45% and exploitation of 40%, a larger increase in survival would be expected if natural and fishing mortality were additive. Larson et al. (1991) and Allen et al. (1998) argue that compensatory mortality may occur in crappie pop-

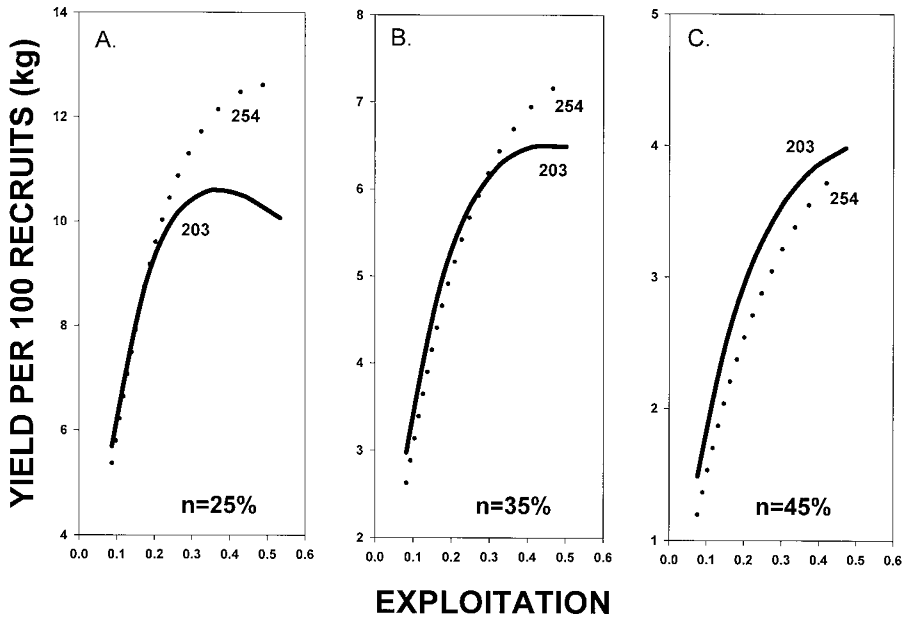

FIGURE 7.—White crappie yield per recruit at varying exploitation rates plotted against three levels of conditional natural mortality (n = 25, 35, 45%). Numeric values (203 and 254) refer to minimum length limits.

ulations. The compensatory mortality model suggests that total mortality remains unchanged at low to intermediate levels of harvest but increases as fishing mortality surpasses a compensatory point (Anderson and Burnham 1976). Natural mortality rates may increase if harvest is reduced causing total mortality to remain unchanged. Previous studies have also indicated that total mortality in populations of northern pike *Esox lucius* was unaffected by harvest (Snow and Beard 1972; Kempinger and Carline 1978; Snow 1978).

Traditional yield models, including the Beverton–Holt model used in this study, assume that n and μ are additive. As such, these models may overestimate the attainable yield through harvest reductions if mortality is actually compensatory (Allen et al. 1998). However, the Beverton–Holt model accurately predicted a decline in yield at the levels of n (45%) and μ (40%) in the pre-length-limit samples. If the Beverton–Holt model had been used before implementing the regulation, the recommendation would not have been made.

Erratic recruitment of crappie fisheries (Goodson 1966; Swingle and Swingle 1967; Hooe 1991) may confound management strategies and evaluations (Allen and Miranda 1998). Erratic recruitment influenced trap-net catch rates, as did reduced growth of particularly strong year-classes. Mean length below 150 mm at age 1 was considered poor growth (Boxrucker 1989). Three year-classes (1983, 1987, 1997) experienced poor growth during the course of this study, but none of these were produced during the length-limit years. Reduced growth to age 1 in 2 of the 7 pre-length-limit years had a negative effect on the catch of quality-size crappie, thereby making the differences in the pre-length-limit and length-limit catch somewhat misleading. Webb and Ott (1991) suggested that minimum length limits might lessen the effects of variable recruitment on crappie population structure by protecting the smaller fish of each year-class, thereby supplementing the fishery during periods of low recruitment. Our data show more consistent catch rates ($CV_{\bar{x}}$ of quality-size crappies averaged 0.24 in pre-length-limit years and 0.13 during the length-limit years) and size structure in length-limit years. However, it is difficult to separate the effects of the length limit from those of poor growth, as discussed previously.

Erratic recruitment also affected size structure and age structure. The 1991–1993 year-classes were relatively weak and resulted in less than satisfactory size structure (<20%) in 1995 and poor age structure in 1994 and 1995 (<10%). Weak year-classes in 1995 and 1996 accounted for the high RSD-P of the 1996 and 1997 samples. However, catch of preferred-size crappies in the trap-net samples was stable from 1995 to 1997. Rather than an improvement in the fishery following removal of the regulation, the high RSD-P resulted from few white crappie larger than 250 mm in the sample.

Lake-specific human-dimensions data to determine angler expectations from particular fisheries and whether or not a proposed management strategy has the potential to meet these expectations may be as important as fishery population data when harvest restrictions are being considered. The regulation was designed to provide the opportunity to harvest fewer, larger crappies on perhaps a more consistent basis. Ft. Supply crappie anglers appeared to prefer targeting age-2 fish that averaged 120 g and tolerate an occasional year in which few quality-size crappies are available. Even though angler catch rates increased in length-limit years, anglers remained unsatisfied and many stopped fishing or went elsewhere during the latter years of the length limit. This low fishing effort was a major contributor to the decrease in yield and continued after the regulation was removed. The effects of reduced fishing effort at Ft. Supply on license revenues was unknown, but it certainly was not positive. Biologists strive for credibility with their constituents, and implementing ill-advised management programs certainly reduces their credibility. Furthermore, the lost trust of these constituents may negatively affect future management efforts, not just in fisheries, but for other programs of the Oklahoma Department of Wildlife Conservation. Crappie anglers do not seem to practice the voluntary catch-and-release ethic practiced by largemouth bass anglers. Catching fish to eat is a prime motivator, second only to relaxation, for crappie anglers in Mississippi (Allen and Miranda 1996). Crappie anglers are consumptive users of the resource, and increasing angler catch rates may not be an appropriate objective of crappie management programs. Given the fast growth rates and high exploitation rates measured before the length limit, I saw an opportunity to make a satisfactory fishery better. My approach was to try and sell the anglers on the idea, rather than to determine what qualities of the fishery they expected. The old adage, ''if it's not broken, don't fix it,'' was certainly true in this instance.

Acknowledgments

Funding for this study was provided by the Oklahoma Department of Wildlife Conservation under Federal Aid in Sport Fish Restoration funds, Projects F-37-R, Jobs 10, 13, and 20, and Grant F-50-R, Project 4. This manuscript was substantially improved by reviews from Gene Gilliland, Scott Hale, Elise Irwin, Mike Maceina, Steve Miranda, and Scott Van Horn. This is Contribution number 232 of the Oklahoma Fishery Research Laboratory.

References

Allen, M. S., and L. E. Miranda. 1995. An evaluation of the value of harvest restrictions in managing crappie fisheries. North American Journal of Fisheries Management 15:766–772.

Allen, M. S., and L. E. Miranda. 1996. A qualitative evaluation of specialization among crappie anglers. Pages 145–151 *in* L. E. Miranda and D. R. DeVries, editors. Multidimentional approaches to reservoir fisheries management. American Fisheries Society, Symposium 16, Bethesda, Maryland.

Allen, M. S., and L. E. Miranda. 1998. An age-structured model for erratic crappie fisheries. Ecological Modelling 107:289–303.

Allen, M. S., L. E. Miranda, and R. E. Brock. 1998. Implications of compensatory and additive mortality to the management of selected sportfish populations. Lakes and Reservoirs: Research and Management 3:67–98.

Anderson, D. R., and K. P. Burnham. 1976. Population ecology of the mallard: VI. The effect of exploitation on survival. U. S. Fish and Wildlife Service Resource Publication 128.

Boxrucker, J. 1989. Development of a population index useful in characterizing crappie population dynamics in large Oklahoma impoundments. Oklahoma Department of Wildlife Conservation, Federal Aid in Sport Fish Restoration, Project F-37-R-10, Job 13, Performance Report, Oklahoma City.

Boxrucker, J. 1994. Effects of a minimum length limit and daily creel reduction on the white crappie population structure and angler creel on Ft. Supply Reservoir. Oklahoma Department of Wildlife Conservation, Federal Aid in Sport Fish Restoration, Project F-37-R, Job 20, Final Report, Oklahoma City.

Boxrucker, J. 2001. Changes in crappie population structure following restrictive harvest regulations. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 53(1999): 80–90.

Colvin, M. A. 1991. Evaluation of minimum-size limits and reduced daily limits on the crappie populations and fisheries in five large Missouri reservoirs. North American Journal of Fisheries Management 11: 585–597.

Cyr, H., J. A. Downing, S. Lalonde, S. B. Baines, and M. L. Pace. 1992. Sampling larval fish populations: choice of sample number and size. Transactions of the American Fisheries Society 121:356–368.

Gabelhouse, D. W., Jr. 1984a. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Gabelhouse, D. W., Jr. 1984b. An assessment of largemouth bass slot length limits in five Kansas lakes.

Kansas Fish and Game Commission, Federal Aid in Sport Fish Restoration, Project F-9-P-3, Final Report, Emporia.

Goodson, L. F. 1966. Crappie. Pages 312–322 *in* A. Calhoun, editor. Inland fisheries management. California Department of Fish and Game, Sacramento.

Hale, R. S., M. E. Lundquist, R. L. Miller, and R. W. Petering. 1999. Evaluation of a 254-minimum length limit on crappies in Delaware Reservoir, Ohio. North American Journal of Fisheries Management 19:804–814.

Hanson, D. A., B. J. Belonger, and D. L. Schoenike. 1983. Evaluation of a mechanical population reduction of black crappie and black bullheads in a small Wisconsin lake. North American Journal of Fisheries Management 3:41–47.

Hooe, M. L. 1991. Crappie biology and management. North American Journal of Fisheries Management 11:483–484.

Kempinger, J. J., and R. F. Carline. 1978. Dynamics of the northern pike population and changes that occurred with a minimum size limit in Escanaba Lake, Wisconsin. Pages 382–389 *in* R. L. Kendall, editor. Selected coolwater fishes of North America. American Fisheries Society, Special Publication 11, Bethesda, Maryland.

Ketchen, K. S. 1950. Stratified subsampling for determining age distribution. Transactions of the American Fisheries Society 79:205–212.

Larson, S. C., B. Saul, and S. Schleiger. 1991. Exploitation and survival of black crappies in three Georgia reservoirs. North American Journal of Fisheries Management 11:604–613.

Maceina, M. J., P. W. Bettoli, and D. R. DeVries. 1994. Use of a split-plot ANOVA design for repeated-measures fishery data. Fisheries 19(3):14–20.

Maceina, M. J., O. Ozen, and M. S. Allen. 1998. Use of equilibrium yield models to assess different size limits for crappie in Weiss Lake, Alabama. North American Journal of Fisheries Management 18: 854–863.

Ming, A., and W. E. McDannold. 1975. Effect of length limit on an overharvested largemouth bass population. Pages 416–424 *in* H. G. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Miranda, L. E., M. S. Allen, R. E. Brock, K. M. Cash, B. S. Dorr, L. C. Issak, and M. S. Shorr. 1997. Evaluation of regulations restrictive of crappie harvest. Mississippi Department of Wildlife, Fisheries, and Parks, Federal Aid in Sport Fish Restoration, Grant F-105, Report 163, Final Report, Jackson.

Quinn, S. 1996. Trends in regulatory and voluntary catch-and-release fishing. Pages 152–162 *in* L. E. Miranda and D. R. DeVries, editors. Multidimensional approaches to reservoir fishery management. American Fisheries Society, Symposium 16, Bethesda, Maryland.

Reed, J. R., and W. D. Davies. 1991. Population dynamics of black crappies and white crappies in Weiss Reservoir, Alabama: implications for the implementation of harvest restrictions. North American Journal of Fisheries Management 11:598–603.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Schneberger, E. 1982. The black crappie, its life history, ecology and management, 2nd edition. Wisconsin Department of Natural Resources, Publication 243-72, Madison.

Schramm, H. L., J. V. Shireman, D. E. Hammond, and D. M. Powell. 1985. Effect of commercial harvest of sportfish on the black crappie population of Lake Okeechobee, Florida. North American Journal of Fisheries Management 5:217–226.

Slipke, J. W., and M. J. Maceina. 2000. Fishery analyses and simulation tools (FAST). Auburn University, Auburn, Alabama.

Snow, H. E. 1978. A 15-year study of the harvest, exploitation, and mortality of fishes in Murphy Flowage, Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 103.

Snow, H. E., and T. D. Beard. 1972. A ten-year study of native northern pike in Bucks Lake, Wisconsin: including evaluation of an 18.0-inch size limit. Wisconsin Department of Natural Resources Technical Bulletin 56.

Summers, G. L. 1989. Largemouth bass population changes following implementation of a slot length limit. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 42(1988):209–217.

Swingle, H. S., and W. E. Swingle. 1967. Problems in dynamics of fish populations in reservoirs. Pages 229–243 *in* Reservoir Committee. Reservoir fishery resources symposium. American Fisheries Society, Southern Division, Reservoir Committee, Bethesda, Maryland.

Van Horn, S. L., W. R. Chapman, and F. A. Harris. 1984. Results of a 45 cm (18 in) minimum size regulation on largemouth bass populations. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 35(1981):424–429.

Webb, M. A., and R. A. Ott, Jr. 1991. Effects of length and bag limits on population structure and harvest of white crappies in three Texas reservoirs. North American Journal of Fisheries Management 11: 614–622.

Zale, A. V., and M. B. Bain. 1994. Estimating tag-reporting rates with postcards as tag surrogates. North American Journal of Fisheries Management 14: 208–211.

Zale, A. V., and K. C. Stubbs. 1991. Development of a white crappie fishery in a stage-filled impoundment in Oklahoma. Oklahoma Department of Wildlife Conservation, Federal Aid in Sport Fish Restoration, Project F-41-R-13, Final Report, Oklahoma City.