Effects of a Smallmouth Bass Minimum Size Limit on the Shenandoah River Sport Fishery[1]

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Abstract: A minimum size limit of 305 mm for smallmouth bass (*Micropterus dolomieui*) in the Shenandoah River was evaluated by creel surveys to determine the limit's effect on the sport fishery. Smallmouth bass harvest decreased from 24/ha prior to the limit to an average of 6/ha after the limit. The catch and release fishery increased from 19/ha to 111/ha. Despite the restricted harvest, the number of legal bass (≥305 mm) harvested remained unchanged and average size decreased from 348 mm to 330 mm. Channel catfish (*Ictalurus punctatus*) harvest decreased 91%, but sunfish harvest increased more than 57%. Smallmouth bass growth rates were unchanged by the size limit, but annual mortality for ages III-V bass increased from 0.51 to 0.65. Increased mortality rate is thought to be the reason that bass harvest (≥305 mm) did not increase.

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Size limit restrictions are among the most frequently evaluated regulations in Centrarchid bass management. However, most of the size limit studies have been conducted on lakes containing largemouth bass (*Micropterus salmoides*). Few size limit studies have been conducted on smallmouth bass in river systems (Fleener 1974*a*, 1974*b*, Jones 1968, Sanderson 1958, Surber 1969*a*).

The Virginia portion of the Shenandoah River (a tributary of the Potomac River) has long been noted for its smallmouth bass fishery. In 1965, a 305 mm minimum size limit was adopted for black bass to increase the stock of large bass. This paper examines the effects of that restriction on the sport fishery. Growth and mortality rates of the smallmouth bass were also examined as factors influencing harvest results.

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Methods

To evaluate the effect of the minimum size limit on the sport fishery, creel surveys were conducted on the South Fork of the Shenandoah River from 1964 through 1968 (Surber 1969*b*) and in 1974 and 1975 (Kauffman and Smith 1977).

Creel surveys were conducted on that segment of the Shenandoah River located between Compton and Front Royal. Total area in the 40.2 km section was 315.7 ha.

Surber (1969*b*) estimated annual fishing pressure from 1964 through 1968 by aerial flights scheduled by stratified, nonuniform probabilities. The surveyed area was divided into 2 sections in the earlier studies to facilitate the aerial pressure counts. Discrete harvest and pressure estimates were made for each section.

Two sections (105.7 ha and 210.0 ha) were resurveyed in 1974 and 1975. This later survey was an access point survey with access points and sample times scheduled by stratified nonuniform probabilities (Kauffman and Smith 1977). To enhance comparability with the earlier 1964–1968 studies, an independent pressure estimate was obtained by aerial flights conducted during a portion of the 1975 access point survey. The access point pressure estimates were increased approximately 65% (Kauffman 1976). This allowed comparison with Surber (1969*b*) who averaged pre- and post-estimates to account for flights missed due to inclement weather.

Both surveys obtained trip length and catch rate data from completed angler trip interviews. The 1964–1968 study used 1 permanent interview site in each study section. The 1974 and 1975 surveys incorporated all major access sites in the 2 study sections. Anglers were also questioned as to the number and size of bass caught and released. In later discussions the terms used and their definitions are:

1. catch — includes harvested fish and those caught and released (including voluntary release of legal size fish).

2. harvest — all fish removed by anglers including fish under the legal size limit.

3. released — the difference of the catch minus the harvest, includes release of legal size fish.

Total catch and harvest estimates were obtained by multiplying the catch rate by the expanded pressure estimate for each section. Pumpkinseed (*Lepomis gibosus*), bluegill (*L. macrochirus*), and redbreast sunfish (*L. auritus*)

were combined into a single sunfish category. No catch information was collected from Section C in 1964. Therefore, catch rates from Section B were used to estimate harvest for Section C in 1964. Catch rates between Section B and Section C varied from year to year, but use of paired *t*-tests (95% level) revealed no significant differences between mean catch/hour between Section B and Section C for the catch rates of panfish, channel catfish, all smallmouth bass, and smallmouth bass greater than 305 mm. Therefore, expanded pressure and harvest estimates are reported for the 2 sections combined, and B data were substituted for C in 1964.

Smallmouth bass mortality rates were estimated from the 1964, 1974, and 1975 angler catch data. Bass were placed in their appropriate age class based upon size. Changes in year class catch rates provided estimates of mortality rates. The formula

$$S = \frac{C/f_{t+1}}{Cf_t}$$

$$A = 1 - S$$

was used to estimate annual mortality where S = annual survival rate, C/f_t – catch per effort at age t, C/f_{t+1} = catch per effort of age t = 1 fish, and A = annual mortality rate. Computed mortality estimated from young age classes may be conservative because of incomplete recruitment (Ricker 1975).

Scales were taken from bass collected by electrofishing and growth rates were determined using the method described by Miller (1966).

Catch and harvest statistics were evaluated using the students *t*-distribution test. The 2-sample *t*-test was used to evaluate the mortality rates. In both tests, the hypothesis was that pre-size limit estimates did not differ from post-size limit estimates.

Results

Fishing pressure estimates fluctuated annually but no trend was evident (Table 1). Pressure averaged 219 hours/ha during the 2 studies. The highest (289.6 hours/ha) and lowest (181.6 hours/ha) estimates occurred during the earlier 1964–68 survey.

Total smallmouth bass catch increased after the size limit was adopted (Table 1). Even the low catch (63.2/ha) reported in the 1974 survey was 47% higher than the pre-size limit catch observed in 1964 (43.0/ha).

The catch and release fishery increased substantially and was significantly higher at the 95% level than in 1964. Fish smaller than the size limit were the predominant contributor to the increase. Catch and release of smallmouth bass larger than the size limit was minimal except in 1967 and 1968 when approximately 14% and 6%, respectively, of bass greater than 305 mm were released.

Table 1. Pressure (hours/ha) and catch estimates (number/ha) from the Shenandoah River.

Year	Pressure	Sunfish	Channel catfish	Smallmouth bass				
				Catch	Release	Harvest		
						Total	≥ 305 mm	≥ 381 mm
1964[a]	227.3	16.0	59.3	43.2	18.9	24.3	6.6	2.0
1965	217.9	35.0	44.4	151.2	144.5	6.7	6.7	1.9
1966	206.5	53.3	28.6	133.9	128.9	4.9	4.9	.9
1967	181.6	57.0	18.5	128.2	124.2	3.9	3.4	.6
1968	289.6	95.1	27.1	156.9	146.5	10.3	9.6	1.0
1974	223.3	32.1	6.4	63.2	57.8	5.4	4.9	.4
1975	195.9	25.2	6.6	70.4	64.7	5.6	4.6	.5
Average	219.1	49.6	21.9	117.3	111.1	6.1	5.7	.9

[a] No size limit in effect and harvest based on measured rates from Section B.

Total bass harvest (Table 1) declined after imposition of the size limit as would be expected. The size limit did not result in a demonstrable increase in the harvest of bass 305 mm long or longer. The highest and lowest harvest occurred in the 1964–68 study. Numbers of bass harvested (≥305 mm) were positively correlated with fishing pressure ($r = 0.95$, $P < 0.01$). Some sub-legal fish were harvested but the 1974–1975 survey indicated that 50% of the sub-legal harvests were within 6 mm of legal size.

While the harvest of bass greater than 305 mm in length remained relatively unchanged, the average size of these fish decreased (Table 2) and was significantly less ($P \geq .95$) after the size limit was adopted. The sample size is small in some years but the trend is apparent. The harvest/ha of smallmouth bass ≥381 mm decreased by 50% (Table 1).

Sunfish catch increased from 16.0/ha prior to the size limit to a minimum of 25.2/ha in 1975 (Table 1). Harvest levels were lower in 1974 and

Table 2. Average length (mm) of smallmouth bass (305 mm or larger), sunfish and channel catfish harvested from the Shenandoah River (1964–1968, 1974–1975). Sample size in parenthesis.

Year	Smallmouth	Sunfish	Channel catfish
1964[a]	348 (29)	180 (119)	351 (132)
1965	345 (107)	168 (812)	348 (895)
1966	323 (37)	178 (758)	371 (508)
1967	333 (79)	173 (1,306)	348 (397)
1968	328 (177)	193 (1,767)	373 (693)
1974	327 (82)	177 (488)	424 (109)
1975	330 (103)	169 (578)	413 (148)

[a] No size limit in effect and sample based on measured rates from Section B.

Table 3. Smallmouth bass total mortality rate in 1964 from harvest data only and in 1974 and 1975 from harvest and catch and release data.

	Year					
	1964		1974		1975	
Age class	Catch/hour	A[a]	Catch/hour	A	Catch/hour	A
II	.042		.137		.155	
		.17		.36		.34
III	.035		.088		.102	
		.60		.64		.63
IV	.014		.032		.038	
		.43		.66		.68
V	.008		.011		.012	
Geometric mean of A						
II–V		.35		.53		.53
III–V		.51		.65		.65

[a] Annual mortality rate.

1975 than from 1965 to 1968, but were still significantly ($P > .95$) above the 1964 pre-size limit harvest. There was no significant difference in the sunfish average size.

Harvest of channel catfish steadily declined (Table 1) and was significantly less ($P \geq .95$) after the size limit implementation. Harvest appeared to have stabilized in the 1974–1975 surveys but at a much lower level than ob-

Table 4. Smallmouth bass, total length (mm) at ages III and IV. Sample size in parenthesis.

	Size at age			
	III		IV	
Year class	Length mm		Length mm	
1961	259	(3)[a]	307	(3)[a]
1962	208	(6)[a]		
Weighted means	225	(9)	307	(3)[a]
1963	251	(15)		
1964	249	(43)		
1968	246	(9)	304	(4)
1969	236	(28)	272	(28)
1970	239	(73)	295	(38)
1971	251	(50)	300	(38)
1972	266	(21)		
1973	231	(81)		
Weighted mean	242	(320)	291	(108)

[a] Growth before size limit was adopted.

served in the earlier surveys. The average size increase from 351 mm to more than 400 mm in 1974–1975 (Table 2) was not statistically significant.

Mortality rates for smallmouth bass appeared to increase sharply after age II (Table 3). Incomplete recruitment to the sport fishery at age II may have contributed to the apparently lower mortality for age II fish. According to field data from 1964, a minimum of 44% of the bass caught that year were released. Most of those releases were probably of the age II fish (between 160–221 mm). Total annual mortality rate of smallmouth between ages III and IV has significantly increased ($P \geqq .90$) from .51 prior to the size limit to .65 after the limit.

Mean lengths for smallmouth bass were computed only for ages III and IV (Table 4) as there were insufficient samples collected from older fish prior to imposition of the size limit. Size at age III and IV varied considerably between years but no trend was apparent.

Discussion

The lack of several years of pre size-limit creel and catch data is a study deficiency. Reproductive success can account for harvest fluctuations (Coble 1975) and may be adversely affected by stream level fluctuations exceeding 1.2 m or stream temperatures below 10° C (Pflieger 1975). Therefore, spawning period (1 May–15 June) stream flow and water temperature data were examined for the years 1958–1967. Stream temperatures did not drop below 10° C and stream level fluctuations did not exceed 1.3 m during the spawning period. Therefore, for this study it was assumed reproductive fluctuations were typical prior to 1964 and that the 1964 harvest was within the normal range.

Several black bass size limit studies have suggested "increases" in total bass catch (harvest plus releases) resulting from size limits. Total bass catch increased in both Fleener (1974*a*, 1974*b*) studies but it was assumed that no bass were released prior to the introduction of the size limit. Surber (1969*b*) made the same assumption for the Shenandoah River fishery in 1964. However, in reviewing the 1964 raw data, it was noted that the creel clerk had recorded a minimum estimate of bass returned in 1964. Additional fishing parties were recorded as having returned "several" to "many" bass. Even if the total catch underestimate is considered, it is apparent that the Shenandoah River catch and release bass fishery increased after the size limit.

The 1974–1975 catch and release bass fishery was above the level observed in 1964 but below the 1965–1968 catch levels. The reduced 1974–1975 catch may have been a reflection of spring flooding in 1971 and 1972 which may have adversely affected survival of those year classes. Water level rose approximately 4.6 m on 31 May 1971 and 6.4 m on 22 June 1972 (due to Hurricane Agnes) on the South Fork of the Shenandoah River at the Front Royal gaging station.

Studies have shown variable smallmouth bass harvest results following implementation of size limits. Jones (1968) did not show increased bass harvests during a size limit restriction in spite of increased bass standing crops. Harvests of 305 mm or longer bass increased about 18% at Big Piney Creek in Missouri after a size limit (Fleener 1974*b*). Sanderson (1958) observed increased harvests and surprisingly increased average weights when the size limit for the Potomac River bass was reduced from 254 to 229 mm. The current study reflected no significant change in the number of 305 mm or larger smallmouth bass harvested from the Shenandoah River after imposition of the 305 mm length limit. Average size of harvested Shenandoah River smallmouth bass exceeding 305 mm declined (Table 2).

Increased numbers of smaller bass caught with no corresponding increase in the number of larger bass harvested suggested a restructuring of the age/size frequency within the Shenandoah smallmouth bass population. Changes in growth and/or mortality rates could explain the apparent restructuring. Although growth rates were quite variable with sizes at ages III and IV, varying as much as 58 mm between years, no apparent trend to reduced growth was documented. Annual variations in growth probably reflected either errors in estimating the mean or density dependent factors.

Mortality estimates are subject to question if based upon angler estimates and recall of released fish. Mortality rates were determined by electrofishing in 1974 and 1975 (Kauffman and Smith 1977). A *t*-test analysis indicated no significant differences (95% level) between the estimates computed from electrofishing and angler catch rates. For this study it appears that mortality rates as determined by angler catch is a satisfactory method.

Mortality rates can best be described by following the catch rates for an individual year class for a period of several years. However, this option was not available with only 1 year's pre-size limit data available. As the highest rise in the May–June water level in the Shenandoah River was 1.2 meters (1959) from 1958 through 1967, an assumption was made that calamity-related losses of young were minimal during the period and that recruitment fluctuations were not significant. Poor recruitment caused by flooding in 1971 and 1972 should have resulted in a lower estimated mortality rate. However, in spite of 2 potentially poor year classes the mortality rate appears to have increased between the 1964 and 1974–1975 estimates. Mortality for ages III–V as estimated in 1974 and 1975 was high when compared to other studies. Only 1 out of 12 studies Coble (1975) summarized had a higher smallmouth bass annual mortality rate than observed from the angler estimate (Age III–V) in 1974 and 1975, in the South Fork Shenandoah River, whereas only 2 studies had a lower annual mortality rate than observed for the 1964 estimate of ages III–V.

Sunfish harvest increased a minimum of 60% (16.0/ha versus 25.2/ha) after the size limit was adopted on the Shenandoah River (Table 1). In-

creased sunfish harvests have been observed by others following application of restrictive size limits on bass, but not to the extent observed in the South Fork of the Shenandoah River. Fleener (1974*a*) observed an increase in the average sunfish weight and harvest after adoption of the Big Piney River bass size limit. In Huzzah Creek (Fleener 1974*b*), average sunfish weight increased only slightly after the size limit on bass was adopted. The increase observed in the Shenandoah River catch of sunfish may have been influenced by factors other than the size limit. The increased fertility which has been reported by Surber (1972) for the Shenandoah River may have been an important factor.

Channel catfish harvests in the Shenandoah declined steadily after the size limit was adopted. Decreased harvest may be indicative of reduced recruitment. By contrast, Jones (1968) reported increased catfish harvests after a bass size limit was adopted.

A possible explanation for the catfish decline involves bass food habits. Surber (1940) and Miner (1978) found that Ictalurids occurred more frequently than *Lepomis* spp. in food habit studies of Shenandoah River smallmouth bass. Ictalurids present are the channel catfish, yellow bullhead (*Ictalurus natalis*), and margined madtom (*Noturus insignis*). Miner's study reported that sub-legal (150 to 305 mm) smallmouth bass were 11 times more likely to feed on ictalurids than a *Lepomis* spp. (frequency of occurrence 5.4% vs. 0.5%). An increase in the number of smallmouth bass (less than 305 mm) would increase the predatory pressure on ictalurids.

The regulation did not improve the stock of large bass as anticipated. Therefore, the regulation on the South Fork of the Shenandoah River was repealed in 1981 and a slot limit adopted for a portion of the South Fork.

Conclusion

The 305 mm size limit has modified angler harvests from the Shenandoah River. The size limit resulted in increased catches of smaller bass and a greater sunfish harvest. Implementation of the size limit was accompanied by decreased channel catfish harvest, no demonstrable increase in the number of larger bass harvested, and a decrease in the contribution of bass over 382 mm. Mortality rate increased and is thought to account for the decline in average size.

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