Smallmouth Bass Management in the New River, Virginia: A Case Study of Population Trends with Lessons Learned

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Abstract: Smallmouth bass (*Micropterus dolomieu*) have been the preferred species of New River anglers since the early 1960s. Since the early 1960s, shifts in New River smallmouth bass population conditions have occurred. Some of these shifts are due to changed size limits which altered angler behavior. However, a number of unexplained changes prevent definitive analysis of causative factors. The New River smallmouth bass fishery of 1982 and 1983 was characterized by high numbers of sublegal fish (< 305 mm), slow growth, poor survival, and low relative weights. These characteristics shifted to conditions indicative of a more healthy population subsequent to the implementation of a 279- to 356-mm protected slot limit in 1987. The New River smallmouth bass fishery is currently managed with a 356- to 508-mm protected slot limit, reflecting current management emphases on producing trophy bass, while continuing harvest of numerous bass < 356 mm. Future management of the New River smallmouth bass fishery will incorporate population monitoring, attention to changing angler behavior, and keeping a close watch on environmental factors affecting the fishery.

Key words: Micropterus dolomieu, smallmouth bass, size structure, relative weight, slot limits

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Smallmouth bass (*Micropterus dolomieu*) are not native to the New River of Virginia (Jenkins and Burkhead 1993). They are a relatively new addition to the upper New River fish fauna (Hallerman et al. 2005). The historic native fish fauna consisted of few traditional game fishes, with the exception of channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*) (Jenkins and Burkhead 1993). Smallmouth bass have been the primary species sought by anglers since the first angler survey was conducted on the New River in 1963 (Wollitz 1968, Austen and Orth 1988, Copeland 2005). Wollitz' (1968) New River fishery survey indicated a dominance of smallmouth bass in the fish community and among the species sought by anglers. The Virginia Department of Game and Inland Fisheries (VDGIF) managed the New River fishery with no size or creel limits until 1965 (Austen and Orth 1984 and 1988, Smith and Kauffman 1991, Wollitz 1968). In 1965, the VDGIF implemented a 305-mm minimum size limit and an eight per day creel limit for smallmouth bass on all Virginia rivers, including the New River (Smith and Kauffman 1991).

The New River smallmouth bass fishery of 1982 and 1983 was characterized by high numbers of sublegal fish (< 305 mm), slow growth, poor survival, and low relative weights (Austen and Orth 1988). These characteristics indicated a population with good recruitment, inadequate thinning of small fish, and overharvest of legal fish (Austen and Orth 1988). Based on the 1982 and 1983 New River study (Austen and Orth 1988) and a similar one on the Shenandoah River in Virginia (Kauffman 1983), the 305-mm minimum length limit on all major Virginia rivers was changed in 1987 to a 279- to 356-mm protected slot limit with a five per day creel limit (Smith and Kauffman 1991). In January 2003, the 279- to 356-mm slot limit on the New River was increased to a 356- to 508-mm protected slot limit with a five per day creel limit with only one bass > 508 mm allowed per day. This regulation was passed to encourage the development of a trophy smallmouth bass fishery in the New River in response to changing attitudes and interests among Virginia's smallmouth bass anglers (O'Neill 2001).

The New River produces more citation size smallmouth bass (> 508 mm or 2.27 kg) than any other water body in Virginia. Between 1995 and 2005, the New River led all other Virginia rivers in the production of citation size smallmouth bass with a total of 1,679. The next closest river in Virginia, the James River, produced 1,301 citation size smallmouth bass during that same timeframe (J. R. Copeland, VDGIF, unpublished data). The 2002 creel survey demonstrates the economic value of the New River fishery, with anglers on the New River below Claytor Lake (an 88.5-km reach), spending nearly US$1 million in direct expenditures and expending 298,083 hours of effort during the course of the nine-month survey (Copeland 2005).

Over the 50-year timeframe of this case study, changes in smallmouth bass size structure in the New River are partially explained by changes in harvest regulations. However, changes in river management during the past 50 years confound interpretation.

Methods

Study Area

The New River originates in North Carolina and flows northward through Virginia. The first of two major dams on the New River is Claytor Dam near Radford, Virginia. Immediately after leaving Virginia, the New River is impounded by Bluestone Dam and reservoir, with its headwaters reaching the town of Narrows, Virginia. The U.S. Army Corps of Engineers built Bluestone Dam and reservoir in West Virginia to re-regulate flow fluctuations from Claytor Dam. These two dams isolate the population of smallmouth bass in the 100 km reach from Claytor Dam to the Virginia/West Virginia state line.

Claytor Dam is a hydroelectric power generation dam constructed by Appalachian Power in 1939. Because Claytor Lake has little flood storage capacity and a short retention time (Rosebery 1951), flow characteristics in the New River downstream change little on a seasonal basis. Daily flow changes related to hydropower generation do occur. During the early years of its operation, Claytor Dam was used for daily peak power production (Wollitz 1968, Austen and Orth 1984 and 1988). Beginning in 1991, peak power production was suspended during the highest recreational use period on the New River from 15 April to 15 October each year (T.P. Rogers, Appalachian Power, personal communication). The 279- to 356-mm protected slot limit for New River smallmouth bass was implemented four years prior to this power production change. Turbine releases from Claytor Dam draw from depths of 6.4 to 20.4 m in Claytor Lake (Kilpatrick 2003), resulting in a cooler than ambient downstream temperature regime (J.R. Copeland, VDGIF, unpublished data).

Our case study area is the 22-km section of the New River in Virginia described in Austen (1984) and Austen and Orth (1988). Austen and Orth's (1988) study area stretched from the State Highway 114 crossing to an access point approximately 3 km upstream from McCoy Falls. We reference this study area as the Whitethorne section (Fig. 1).

Electrofishing Data Collection

Single-pass electrofishing.—During fall 1996 and between summer 1998 and fall 2001, single-pass electrofishing data was collected using pulsed DC from a Type VIA Smith-Root electrofisher and two drop-wire boom-mounted anodes on a 5 m aluminum jonboat. During spring 2002, the Type VIA electrofisher was replaced with a 5.0 GPP Smith-Root electrofishing system.

Single-pass electrofishing collections were done in the same areas described in Austen and Orth (1988) within the Whitethorne section of the New River. In addition, single-pass electrofishing

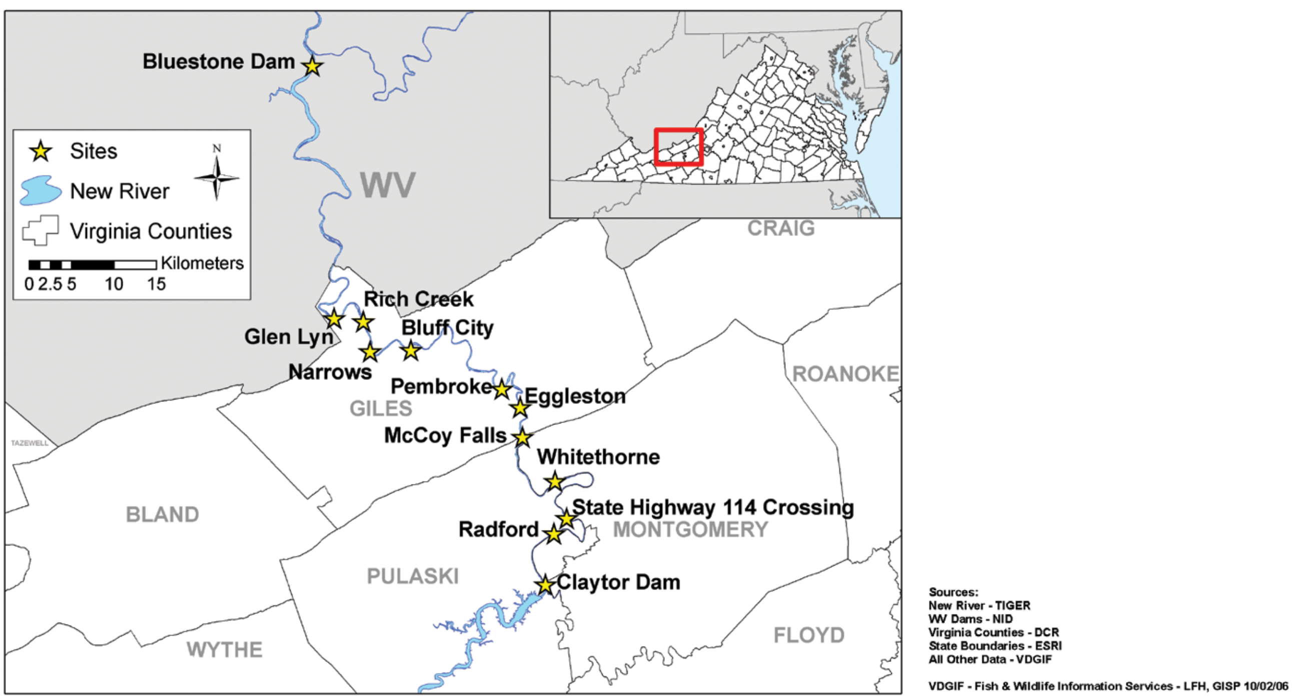

Figure 1. Map of the New River in southwest Virginia, showing the location of Claytor Dam and Bluestone Dam, the location of the Whitethorne section studied by Austen and Orth (1988), and the sampling sites used in this study.

collections were done at Claytor Dam, Radford, Pembroke, Bluff City, and Rich Creek (Glen Lyn in 1996), and Eggleston in 2005 (Fig. 1). The primary electrofishing data comparisons made in this case study are between Austen and Orth's (1988) Whitethorne section collections and current Whitethorne section collections, except where a broader dataset was needed, as noted in the methods.

Austen and Orth's (1988) electrofishing collections were conducted at night. During our study, electrofishing collections were done during daylight hours, with the exception of summer 1999 sampling, when 2.05 hours of the total electrofishing collection time of 4.36 hours was conducted at night. Proportional stock density and relative weights were not influenced by time of capture, so comparison of Austen and Orth's (1988) night collections and our daylight collections are valid (J.R. Copeland, VDGIF, unpublished data). Summer electrofishing collections in 1998 and 1999 were done during June and July. Fall electrofishing collections in 1996, 1998 to 2001, and 2003 to 2005 were primarily done during October, although collections in three years included sampling in late September and early November. Length and weight data was recorded for all captured smallmouth bass during single-pass electrofishing collections in summer 1999, and fall 1996 and 1998 to 2001. Only length data was recorded for captured smallmouth bass during single-pass electrofishing collections in summer 1998 and fall 2003 to 2005.

Multiple-pass electrofishing.—For purposes of comparing fall collected smallmouth bass relative weights, we included smallmouth bass relative weight data from a mid-September 2005 multiple-pass electrofishing collection at a main channel site in the vicinity of Austen and Orth's (1988) downstream most electrofishing run areas. The multiple-pass electrofishing collection site, located along the river right of two adjacent main channel islands, was 479 m long with an average width of 113 m, a total surface area of 5.1 ha, and a maximum depth of 3 m. This site was located 1.4 km upstream from the Whitethorne boat access area (Fig. 1). Electrofishing during the multiple-pass collection used methods described by Odenkirk and Smith (2005).

Comparisons of catch per unit effort from Austen and Orth's (1988) July 1982 and 1983 electrofishing collections were made to summer 1998 and 1999 single-pass electrofishing collections and fall 1996, 1998 to 2001, and 2003 to 2005 single-pass electrofishing collections. Catches of age-0 smallmouth bass in fall 1996, 1998 to 2001, and 2003 to 2005 were delineated by examining length-frequencies and otoliths to determine a cutoff size for age-0 smallmouth bass in each year.

Mean flow rates for the Glen Lyn gauge were calculated based on daily flow data for the month of July obtained from the U. S. Geological Survey (USGS). July mean flow was selected as an indicator of age-0 abundance for the New River, unlike other Virginia rivers where June mean flows provided the best model (Smith et al. 2005). Age-0 smallmouth bass abundance between fall 1996 and 2005 was linked to July mean flow, using the same model Smith et al. (2005) used for other Virginia rivers ($r^2 = 0.68$, $P = 0.06$) (S. Smith, personal communication).

Proportional stock density indices from Austen's (1984) July 1982 and 1983 electrofishing collections were compared to summer 1998 and 1999 electrofishing collections as well as fall 1996, 1998 to 2001, and 2003 to 2005 electrofishing collections. Confidence intervals for the summer 1982 and 1983 collections were reported in Austen (1984). Confidence intervals for the fall 1996 to fall 2005 collections were based on Gustafson (1988).

Smallmouth bass mean relative weight from Austen and Orth's (1988) July 1982 and 1983 electrofishing collections and the summer 1999 single-pass electrofishing collection were compared. Comparisons were not made to the electrofishing collection in summer 1998 since smallmouth bass were not weighed. Smallmouth bass mean relative weights and sample sizes from the July 1982 and 1983 electrofishing collections were obtained from Austen and Orth (1988: Table 2) and standard deviations were estimated from Austen and Orth (1988: Figure 2). Smallmouth bass mean relative weights from the November 1982 electrofishing collection were estimated from Austen and Orth (1988: Figure 2) and sample sizes for this collection were obtained from Austen (1984). The November 1982 mean relative weights were compared to smallmouth bass mean relative weights from fall single-pass electrofishing collections in 1996 and 1998 to 2001 and the September 2005 multiple-pass electrofishing collection.

Mean relative weights were compared based primarily on the 152–228 mm and 229–304 mm size groups used by Austen and Orth (1988) since these were the size groups exhibiting a size-related bottleneck in Austen and Orth's study (1988). Comparisons were not made between our summer 1999 electrofishing collection and Austen and Orth's (1988) July 1982 and 1983 electrofishing collections for smallmouth bass > 304 mm due to low sample sizes for smallmouth bass > 304 mm in Austen and Orth's (1988) data. The only mean relative weight data available for smallmouth bass > 304 mm from Austen and Orth (1988) was their November 1982 smallmouth bass collections for a food habits study. We compared their November 1982 smallmouth bass mean relative weight for bass > 304 mm with mean relative weights of smallmouth bass > 304 mm in our fall single-pass electrofishing collections in 1996 and 1998 to 2001 and our September 2005 multiple-pass electrofishing collection. Relative weights calculated from our data were derived from the standard weight formula used by Austen and Orth (1988).

Ages of smallmouth bass from the fall 1998 electrofishing sample were determined using scales. The Fraser-Lee formula was used for back-calculation of length at age, using the same intercept of body-scale regression (42 mm) used by Austen and Orth (1988). Austen and Orth's July 1982 and 1983 smallmouth bass age samples were from the Whitethorne section. Smallmouth bass age data from our fall 1998 single-pass electrofishing collections were combined from three sites, Claytor Dam, Radford, and Whitethorne (Fig. 1), since sample size from the Whitethorne section was too low for comparison. Scale age data from Wollitz (1968) are from a total of 50 smallmouth bass collected from an unknown section of the New River (previously reported in Austen and Orth [1988]). The intercept used for this data is unknown.

Survival estimates for age 2–4 smallmouth bass collected in July 1982 and 1983, generated using Robson-Chapman and cohort analysis (Austen and Orth [1988]), were compared to catch-curve survival estimates for age 2–4 and age 2–6 smallmouth bass collected during fall 1998. Fall 1998 age and catch data were from combined single-pass electrofishing samples at Claytor Dam, Radford, and Whitethorne (Fig. 1), since sample size from the Whitethorne section alone was too low for comparison.

Creel Data Collection.—Comparisons of angler survey results from Wollitz (1968) and Austen and Orth (1984) were made with 2002 angler survey results from Copeland (2005), although study areas varied. Wollitz reported estimates for a 100 km reach of the New River from Claytor Dam to the Virginia/West Virginia state line near the town of Glen Lyn. Austen and Orth (1984) reported estimates for their 22-km Whitethorne study section. Copeland (2005) reported estimates for a 39-km New River reach from Claytor Dam to McCoy which includes Austen and Orth's (1984) 22 km Whitethorne section (Fig. 1). Wollitz (1968) conducted a roving angler survey by accessing the New River at popular angling areas between March and October. Austen and Orth (1984) conducted a roving angler survey from July through October 1982 and May and June 1983. Copeland (2005) conducted an access point survey, with a roving survey component when the Radford site was selected, from mid-March to early November 2002.

Since Austen and Orth (1984) did not generate angling pressure estimates, comparisons between the surveys are limited to smallmouth bass catch and harvest rates, mean length of smallmouth bass harvested, percent of smallmouth bass in the harvest, and relative stock density preferred (RSD-P) of harvested smallmouth bass.

No statistical treatment of sampling or creel data was performed in this case study. Some tables include standard error or standard deviation of the estimates when available.

Results

Population Characteristics

Electrofishing.—Mean relative abundance of smallmouth bass (CPUE in number per hour) (Table 1) varied from 41 to 132 smallmouth bass per hour between July 1982 and fall 2005. The two lowest relative abundance values (1999, 2000) coincided with drought years in southwest Virginia. Age-0 smallmouth bass relative abundance accounted for much of the variation observed in fall single-pass electrofishing collections since 1996 (Table 1). The years with lowest age-0 smallmouth bass abundance coincided with low flow and high flow years in the New River and the years with high age-0 abundance occurred in moderate flow years (Table 1).

Proportional stock density (PSD) demonstrated a noticeable shift in the size structure of the smallmouth bass population between 1982 and 1999. PSD increased from extremely low levels, an average of 3.5% in July 1982 and 1983, to an average of 44% in summer 1998 and 1999 (Table 2). Fall values mirrored summer values, with an average PSD of 49 (Table 2).

Mean relative weights in summer 1999 reflected excellent body condition in both intermediate size groups of smallmouth bass (Table 3). These values represent a definite increase from July 1982 and 1983. The size-related bottleneck, evident in 1982 and 1983, low mean relative weights for smallmouth bass < 304 mm, appeared to have been eliminated by 1999 (Table 3). Mean relative weight of 152–228 mm smallmouth bass increased from 70.5 in November 1982 to 89 in combined fall collections in 1996, 1998 to 2001, and 2005. Mean relative weight of 229–304 mm smallmouth

Table 1. Mean catch per unit effort of smallmouth bass (CPUE), expressed as number per hour of electrofishing (standard deviation, sample size), for smallmouth bass captured during single-pass electrofishing collections in the Whitethorne section of the New River, Virginia, between July 1982 and fall 2005, and mean July flow on the Glen Lyn gauge in cubic meters per second (m^3/s).

Month/Season	Year	Total SMB CPUE	YOY SMB CPUE	Mean July flow (m^3/s)
July	1982[a]	94.5 (92.8, 315)		
July	1983[a]	50.1 (33.6, 159)		
Fall	1996[b]	59.4 (25.3, 170)	22.0 (21.2, 65)	73
Summer	1998[b]	111.7 (21.5, 240)		
Fall	1998[b]	61.4 (30.8, 196)	16.0 (11.6, 51)	75
Summer	1999[b]	53.7 (34.0, 233)		
Fall	1999[b]	40.8 (14.2, 118)	3.4 (3.1, 10)	54
Fall	2000[b]	44.2 (26.7, 142)	4.3 (4.2, 14)	69
Fall	2001[b]	70.4 (21.1, 177)	18.7 (8.5, 44)	121
Fall	2003[b]	131.5 (26.0, 133)	8.9 (5.9, 9)	239
Fall	2004[b]	89.9 (58.8, 184)	50.3 (40.6, 103)	90
Fall	2005[b]	125.5 (65.9, 256)	62.5 (63.3, 127)	107

a. Electrofishing effort in both of these collections was 3.33 hours.
b. Electrofishing effort in all of these collections was >1 hour (mean = 2.57 hours, SE = 0.26).

Table 2. Proportional stock density (PSD), with 95% confidence interval and number ≥ stock size, for smallmouth bass collected during single-pass electrofishing collections in the Whitethorne section of the New River, Virginia, during July 1982 and 1983, summer 1998 and 1999, and fall 1996, 1998 to 2001, and 2003 to 2005.

Month/Season	Year	PSD	95% Confidence interval	Number ≥ stock size
July	1982	5.1	2.4–7.8	70
July	1983	1.8	0.2–3.9	70
Summer	1998	45	35–45	117
Summer	1999	42	32–52	132
Fall	1996	45	34–56	99
Fall	1998	45	30–60	62
Fall	1999	47	34–60	73
Fall	2000	46	35–57	100
Fall	2001	37	27–47	112
Fall	2003	60	49–71	94
Fall	2004	39	26–52	69
Fall	2005	69	60–78	116

Table 3. Relative weights (Wr) (standard deviation, sample size) for smallmouth bass in three size groups collected during single-pass electrofishing collections in the Whitethorne section of the New River, Virginia during July 1982 and 1983, summer 1999, and fall 1996, 1998 to 2001, and a multiple-pass electrofishing collection in September 2005.

Month/Season	Year	Wr 152–228 mm	Wr 229–304 mm	Wr > 304 mm
July	1982	79.5 (12, 210)	78.1 (8, 18)	
July	1983	81.4 (15, 153)	80.4 (15, 37)	
Summer	1999	111.0 (11.9, 33)	108.0 (14.4, 38)	
November	1982	70.5 (12, 47)	69.5 (11, 38)	87 (10, 50)
Fall	1996	80.2 (7.1, 19)	80 (5.7, 34)	80.5 (8.8, 34)
Fall	1998	91.5 (5.4, 19)	89.9 (5.2, 14)	88.7 (6.6, 18)
Fall	1999	89.0 (4.7, 47)	90.0 (6.8, 28)	96.0 (12.9, 22)
Fall	2000	102.0 (7.8, 48)	102.0 (8.7, 24)	106.0 (9.1, 40)
Fall	2001	80.0 (9.1, 62)	78.0 (8.7, 36)	79.0 (8.4, 34)
September	2005	89.0 (6.8, 89)	90.6 (6.6, 55)	97.0 (8.6, 76)

Table 4. Mean back-calculated total length-at-age (with standard deviation (SD) and sample size (*N*) for smallmouth bass in the New River, Virginia, based on collections by Wollitz (1968), Austen and Orth (1988), and Copeland (1998).

Collector(s)	1	2	3	4	5	6	7	8	9
Wollitz (1968)	74	155	213	300	373	411			
Austen and Orth (1988)	107	176	236	281	312	344	365	410	440
SD	5.8	5.6	10.6	9.3	9.7	16.5	29.0		
N	33	545	42	49	31	11	5	0	1
Copeland (1998)	91	156	215	257	301	352	415	433	486
SD	12.1	22.3	26.1	30.6	36.7	44.7	40.9	51.7	
N	146	107	52	37	24	6	3	2	1

bass increased from 69.5 in November 1982 to 88 in combined fall collections in 1996, 1998 to 2001, and 2005. Relative to smallmouth bass collected in November 1982, improvement in body condition of smallmouth bass > 304 mm was evident in three years (1999, 2000, and 2005). Body condition of smallmouth bass > 304 mm was similar to or less than November 1982 values in three years (1996, 1998, and 2001).

Comparison of mean total length-at-age was mixed. Time required for a smallmouth bass to reach quality size (>280 mm) did not change over the timeframe of this case study (Table 4).

By 1998, the New River smallmouth bass population showed evidence of substantially increased survival from age 2 to 4 and age 2 to 6 (Table 5). Scale ages from Austen and Orth (1988) and 1998 data were too limited to estimate survival of older fish (> age 6), which constitute the trophy portion of the population.

Angler surveys since 1963 indicate that smallmouth bass have been a consistent portion of the angler harvest, with the percent of smallmouth bass in the harvest hovering around 30% (Table 6). Mean total length of smallmouth bass harvested increased by 100 mm between 1963 and 1982/1983 (Table 6). Smallmouth bass catch rates were consistently high in the 1982/1983 angler survey and the 2002 angler survey, with 1.4 and 1.2 smallmouth bass caught per hour, respectively (Table 6). The smallmouth bass harvest rate in the 2002 angler survey (0.02 per hour) was 66% less than the harvest rate in the 1982/1983 angler survey (0.06 per hour) (Table 6).

The opportunity to catch a preferred size smallmouth bass (> 350 mm) improved since the earliest New River angler survey was conducted in 1963, when RSD-P was one (Table 6). Angler harvested RSD-P for smallmouth bass vastly improved by 1982/1983 (16), then increased to 24 in the 2002 New River angler survey. Further evidence of the improved quality of New River smallmouth bass fishing is provided by an examination of the largest smallmouth bass harvested in angler surveys since 1963. In 1963, the largest measured smallmouth bass harvested in the angler survey were two 510-mm fish (Wollitz 1968). During the 1982/1983 New River angler survey, the largest measured smallmouth bass harvested were two 460-mm fish (Austen and Orth 1984). During the 2002 angler survey, the largest measured smallmouth bass harvested were two fish > 550 mm, including one that was 563 mm (Copeland 2005).

Discussion

Improvements in the New River smallmouth bass fishery are partially explained by changes in angler behavior relative to smallmouth bass size limits. Between 1963 and 1983, anglers changed their harvest behavior relative to the 305-mm minimum length limit by increasing the mean size smallmouth bass harvested from

Table 5. Survival rates for smallmouth bass in the New River, Virginia, from Austen and Orth (1988) using cohort and Robson-Chapman analysis, and by Copeland, using catch curve analysis.

Investigator	Method	Ages	Estimated survival (%)
Austen and Orth (1988)	Cohort	2–3	1.8
Austen and Orth (1988)	Cohort	3–4	7.7
Austen and Orth (1988)	Robson-Chapman	2–4	9.8
Copeland (1998)	Catch-Curve	2–4	42
Copeland (1998)	Catch-Curve	2–6	46

Table 6. Catch and harvest rates (number per hour) for smallmouth bass (SMB), mean length SMB harvested (mm total length), percent of SMB in the harvest, and relative stock density preferred (RSD-P) of harvested SMB based on New River, Virginia, angler surveys by Wollitz (1968), Austen and Orth (1984), and Copeland (2005). NA = data not available

Investigator(s)	Year (s)	SMB catch rate	SMB harvest rate	$\bar{x}$ length SMB harvested	% SMB in harvest	RSD-P harvested SMB
Wollitz	1963	NA	NA	222	32	1
Austen and Orth	1982/1983	1.35	0.06	322	28	16
Copeland	2002	1.24	0.02	304	33	24

222 mm to 322 mm. This change in behavior resulted in a stockpiled smallmouth bass population, characterized by high numbers of sublegal fish (< 305 mm), slow growth, poor survival, and low relative weights (Austen and Orth 1988).

The 2002 angler survey provided evidence of changed angler behavior relative to the protected slot length limit in place at the time of the survey. While the mean size smallmouth bass anglers harvested in 2002 was similar to the mean size harvested during Austen and Orth's (1984) survey (304 mm in 2002 versus 322 mm in 1982/1983), the composition of the harvest changed. Austen and Orth (1984) reported an estimated illegal harvest of 33% relative to the 305 mm minimum size limit in place during their survey. During 2002, in the Claytor Dam to McCoy section of the New River, 59% of the smallmouth bass harvested ($N = 579$) were below the protected slot limit, 23% of the smallmouth bass harvested were illegal (i.e., within the protected slot limit), and the remaining 18% were over 356 mm, with harvest above 356 mm spread broadly (Copeland 2005).

The opportunity to catch quality and preferred size fish has increased in the Whitethorne section of the New River as evidenced by the improvement in the PSD of electrofishing catches, the increase in RSD-P for smallmouth bass harvested, and the largest fish harvested in angler surveys.

During the 1980s and 1990s, catch and release bass angling practices grew. This case study documents a 66% decline in smallmouth bass harvest rates between the 1982/1983 and 2002 angler surveys (Table 6). Recent Virginia river angler studies confirm that 98% to 99% of smallmouth bass caught are released (S. Smith, VDGIF, personal communication). Angler behavior on the New River is consistent with these studies (Copeland 2005). In the period before 1982, there was substantial harvest (legal and illegal). Although most sport anglers did not harvest their daily limit, some anglers greatly exceeded this limit (Wagner and Orth 1991). Simulation studies have quantified the effect voluntary release of legal fishes has on the efficacy of size limit regulations (Creamer 1993). Angler self regulation is, in part, driving the improvement in the smallmouth bass size structure in the New River.

Improvement in survival of fully recruited smallmouth bass is most likely the result of reduction in smallmouth bass harvest due to changing angler preferences and attitudes as well as size limit regulation changes. Large relative weight changes occurred in smallmouth bass ≦ 304 mm and it appears that body condition in smallmouth bass ≧ 304 mm improved. Smallmouth bass may have a better food supply during the growing season to put on weight although condition improvement varied from year to year. Smallmouth bass growth has not changed appreciably since the 1960s. However, older age smallmouth bass appear to be more readily available in the New River. Smallmouth bass in this system currently survive up to age 15 (based on otoliths collected from taxidermist specimens) (J.R. Copeland, unpublished data). In summary, although current angler catch rates are similar to historical catch rates, as of 2002 anglers catch more preferred, memorable, and trophy smallmouth bass.

Lessons Learned

Changes that occurred on the New River between the 1960s and 2000s likely influenced the smallmouth bass population, yet few have been systematically studied. Therefore, we are not certain that size limit changes are entirely responsible for New River fishery improvements.

The 279- to 356-mm protected slot limit helped eliminate the size-related bottleneck of low survival and poor relative weight of subadult smallmouth bass that developed under the 305 mm minimum length limit. That protected slot limit, implemented in 1987, was applied to multiple rivers in Virginia without detailed studies of angler preferences on those rivers. As of 2001, regulation changes are based on angler preferences and population metrics. We expect the results from the 356- to 508-mm protected slot limit, implemented in January 2003, to be more favorable, given the current combination of population conditions and angler characteristics on the New River.

Age-0 smallmouth bass abundance in the New River was linked to flow regime; however, flow explained only 68% of the variation.

Altered temperature regime and daily flow fluctuations in the New River likely contribute to variation in smallmouth bass recruitment (Lukas and Orth 1995). Flow alone was more directly linked to age-0 smallmouth bass abundance in unregulated Virginia rivers (Smith et al. 2005).

The improvement in abundance of older age smallmouth bass in the New River suggested by this case study is coincident with changes in peak power production at Claytor Dam. Since 1996, smallmouth bass size structure, relative weight, and survival improvements may have been influenced by the elimination of peak power production.

The Future

Virginia's leading trophy smallmouth bass fishery is the New River. The future of trophy smallmouth bass fishing in Virginia depends on enlightened ecosystem management of this river. Perceptions of fishing quality on the New River may be affected by recent fish consumption advisories published for this river. Rising fuel prices, recent increases in Virginia fishing license fees, and increased costs of goods and services will likely affect angler use. In spite of these environmental and economic changes, public awareness of fishery improvements on the New River may increase angling pressure. Fisheries managers need to conduct frequent monitoring to assess the effects of shifts in angler behavior on the New River. Angler compliance may limit the effectiveness of the current 356- to 508-mm trophy slot length limit.

Virile crayfish (*Orconectes vinlis*) were introduced in the New River in Virginia (Pinder and Garriock 1998) in the late 1990s. Previous New River studies document the importance of crayfish to the diets of smallmouth bass (Austen and Orth 1985, Roell and Orth 1993, Benson and Newcomb 2000), particularly for bass > 304 mm (Austen and Orth 1985). However no current studies document whether the introduction of a large-bodied exotic crayfish species to the New River is causing a shift in smallmouth bass diets with associated effects on the health of the New River fishery.

A recent New River study indicated that muskellunge predation on smallmouth bass is not having a significant effect on survival of bass (Brenden et al. 2004). In July 2006, the muskellunge size and creel limit on the New River increased from a 762-mm minimum size limit with two-per-day creel to a 1,067-mm minimum size limit with a one-per-day creel. The expected shift to a muskellunge fishery with more large individuals may affect smallmouth bass survival through direct predation and interspecific competition, so its effects should be monitored (Brenden et al. 2006).

In 2006, the Federal Energy Regulatory Commission initiated review of Appalachian Power's hydropower operating license at Claytor Dam, a process that will culminate in license renewal in July 2011. Modifications of the current New River flow and temperature regime as a result of negotiations during this license renewal may provide further fishery enhancements, but the effects of flow and temperature changes on the smallmouth bass fishery need to be monitored.

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