Changes in Redbreast Sunfish Population Characteristics in the Black and Lumber Rivers, North Carolina

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Abstract: The objective of this study was to document changes in catch rates (fish/hour) and size structure of the redbreast sunfish (*Lepomis auritus*) populations in the Black and Lumber rivers, North Carolina, over a 4-year period following implementation of a 12-fish daily creel limit. Using boat-mounted electrofishing gear, 123, 122, 94, and 59 redbreast sunfish were collected from the Black River from 1994 through 1997. Numbers of redbreast sunfish collected from the Lumber River during the same years were 257, 252, 164, and 183. Mean CPUE for Black River redbreast sunfish was 18, 19, 16, and 7 fish/hour from 1994 through 1997. Lumber River redbreast sunfish were captured at rates of 35, 33, 27, and 23 fish/hour from 1994 through 1997. Proportional stock density (PSD) values for redbreast sunfish in the Black River exceeded 25 all 4 years of the study while PSD values for Lumber River redbreast sunfish exceeded 45. Based on these values, the redbreast sunfish populations in both systems would be categorized as supporting quality-size individuals. RSD200mm values for Lumber River redbreast sunfish of 13 (1994) and 28 (1995) would suggest an exceptional redbreast population in this system.

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The Black and Lumber rivers are large coastal plain streams located in southeastern North Carolina. These popular fishing streams have provided excellent fishing for largemouth bass (*Micropterus salmoides*), sunfish (*Lepomis* spp.), catfish (*Ictalurus* spp.), chain pickerel (*Esox niger*), and yellow perch (*Perca flavescens*) (Louder 1963, Nelson and Ashley 1989). The Black River has also been considered one of the premier redbreast sunfish fishing streams in the state.

Sunfish population size structure data (Nelson and Ashley 1989) were collected from 4 locations on the Black River between 1986 and 1988 to evaluate public concerns about declining sunfish catch rates and to support designation of a portion of the river as Outstanding Resource Waters by the North Carolina Division of Water Quality. Stock-size sunfish were captured at all sample sites. PSD (Anderson and Gutreuter 1983) for redbreast sunfish was 55 in 1989 (Nelson and Ashley 1989), indicating quality-size redbreast sunfish were present in the system at that time.

Sunfish population size structure data were also collected from the Lumber River during 1986 and 1987. Redbreast sunfish were the dominant game species in the river and stock-size sunfish were captured at all sample sites. However, PSD was 10 for Lumber River redbreast sunfish, indicating few quality-size fish were present in the population.

Routine sampling of the redbreast sunfish populations in both rivers during 1993 revealed electrofishing catch rates had declined from 1986–87 rates, suggesting redbreast sunfish abundance may have declined over the previous 7 years (K. W. Ashley, unpubl. data). Complaints from local anglers concerning declining redbreast sunfish catch rates also increased during this time. Speculated causes of these declines were increased predation from expanding predator populations such as flathead catfish (*Pylodictus olivaris*) and bowfin (*Amia calva*), increased angling pressure and resulting fishing mortality, or a combination of these and other factors.

In response to the perception that angling pressure may have been adversely affecting redbreast sunfish populations in the Black and Lumber rivers, the NCWRC imposed a 12-fish daily creel limit, effective 1 July 1994, hoping to reduce harvest and increase redbreast sunfish abundance. The objective of this study was to determine if abundance and size structure of redbreast sunfish in the Black and Lumber rivers changed following implementation of the restrictive creel limit.

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Methods

Redbreast sunfish were collected from the Black and Lumber rivers using boat-mounted electrofishing gear (Smith-Root Mark VI GPP). Standardized electrofishing samples were collected from 8 fixed stations on each river from 1 April through 30 September, 1944–1997. Electrofishing stations were each sampled for 15 minutes, 3–4 times per year (if possible). All redbreast sunfish collected were counted, weighed (g), and measured (total length in mm).

Abundance of redbreast sunfish was indexed with electrofishing CPUE, defined as the number of fish captured per hour of sampling effort. Redbreast sunfish population size structures were analyzed by examining length-frequency distributions in 10-mm length intervals (Anderson and Gutreuter 1983), proportional stock density (PSD) and relative stock density (RSD) (Anderson 1980), and the length-categorization system described by Gabelhouse (1984). Since stock-, quality-, and preferred-length categories have not been proposed for redbreast sunfish, these values were arbitrarily chosen based on the values for bluegill (*L. macrochirus*), pumpkinseed (*L. gibbosus*), and warmouth (*L. gulosus*). Stock size for redbreast sunfish was 80 mm, quality size was 150 mm, and preferred length was 200 mm.

Scale samples were taken from all redbreast sunfish collected. Scales were taken from the left side of the fish below the lateral line at the end of the depressed pectoral fin. Impressions of scale samples were made on 0.5-mm acetate slides and read at 42× magnification on a microfiche reader. Where >10 fish were present in an age group, growth and mean total length at age at time of capture were determined. Box and whisker plots were used to graphically depict the length characteristics of the different age groups (Tukey 1977).

A repeated-measure analysis of variance (ANOVA) and contrasts (Sokal and Rohlf 1981) was used to compare electrofishing CPUE data among years, by river. Length-frequency distributions were compared among years, by river, using Friedman's test (Sokal and Rohlf 1981). A repeated-measures ANOVA (Sokal and Rohlf 1981) was then used to compare captured mean fish lengths among years, by river. All hypothesis testing was done at $\alpha = 0.05$.

Results

Black River

A total of 398 redbreast sunfish were collected from the Black River from 1994 through 1997 (Table 1). Catch rates for Black River redbreast sunfish ranged from 7 (1997) to 19 (1995) fish/hour. Catch rates for Black River redbreast sunfish were significantly different among years ($P < 0.006$) and showed a significant linear decline ($P < 0.01$) between 1994 and 1997.

Table 1. Number, weight (kg), and CPUE (*N*/hour) of redbreast sunfish collected by electrofishing from the Black and Lumber rivers, North Carolina.

Location	Parameter	1994	1995	1996	1997
Black River	Total *N*	123	122	94	59
	Total weight (kg)	4.2	5.5	3.7	5.5
	CPUE	18	19	16	7
	PSD	31	30	25	71
	RSD_{200mm}	9	7	8	46
	Mean length (mm)	99	106	103	143
	Mean weight (g)	34	45	39	128
	Effort (hours)	7	6.5	6	8
Lumber River	Total *N*	257	252	164	183
	Total weight (kg)	15.9	25.9	18.6	16.1
	CPUE	35	33	27	23
	PSD	45	55	49	48
	RSD_{200mm}	13	28	61	19
	Mean length (mm)	125	148	149	137
	Mean weight (g)	62	103	114	92
	Effort (hours)	7.25	7.75	6	8

Percent composition of redbreast sunfish in the Black River centrarchid samples varied from a high in 1994 of 20% by number and 5% by weight to a low in 1997 of 10% by number and 5% by weight. They were the third most abundant sunfish collected from this system during the study, accounting on average for 16% by number of the centrarchid game fish population. However, they only accounted for 5%–7% by weight of the centrarchid game fish population collected.

The Black River redbreast sunfish population was characterized as having a polymodal size distribution, dominated by fish 50 to 125 mm (Fig. 1). Size distributions of Black River redbreast sunfish were significantly different ($P < 0.001$) among years with a shift toward larger fish occurring from 1994 to 1997. There was a significant increase in mean length of redbreast sunfish from 138 mm in 1994 to 174 mm in 1997. PSD values for redbreast sunfish met or exceeded 25 during all 4 years of data collection, with a high of 71 occurring in 1997. RSD_{200mm} values ranged from 7 to 46.

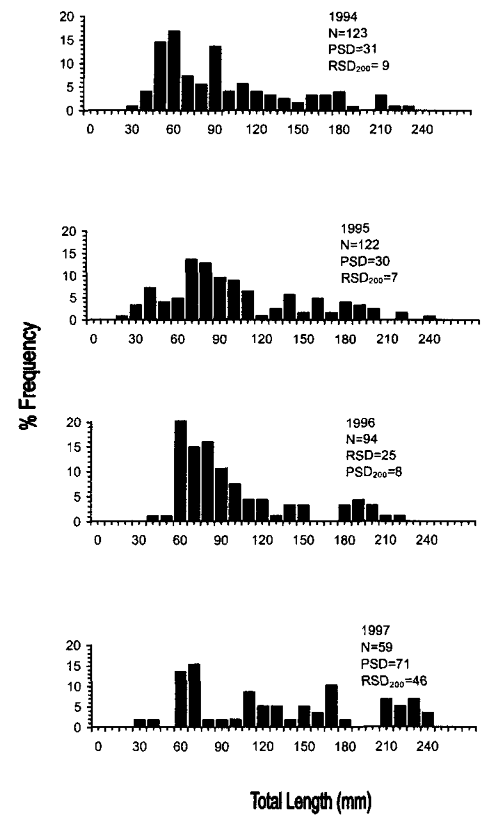

Figure 1. Length-frequency distribution (10-mm intervals) of redbreast sunfish collected from the Black River, North Carolina, 1994–1997.

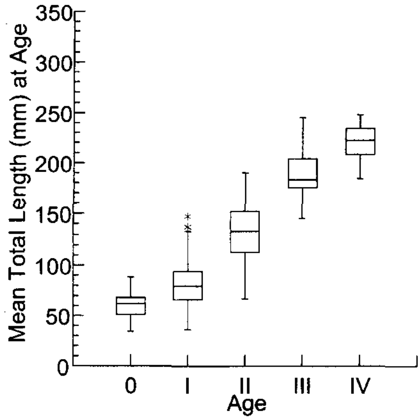

Figure 2. Mean total length (mm) at age at time of capture for redbreast sunfish collected from the Black River, North Carolina, 1994–1997. The horizontal line inside the box represents the median (50th percentile) and the horizontal ends of the box represent the 25th (lower) and 75th (upper) percentiles. The extreme horizontal lines represent the 10th (lower) and 90th (upper) percentiles. Stars represent outliers, values outside the range of plotted values.

Redbreast sunfish in the Black River grew an average of 81 mm during their first year (Fig. 2), generally requiring 3–4 years to reach the 200-mm preferred size (Gabelhouse 1984). Fish up to age 4 were collected from this system.

Lumber River

A total of 856 redbreast sunfish were collected from the Lumber River during the study period (Table 1). Catch rates ranged from 23 (1997) to 35 (1994) fish/hour. Catch rates for Lumber River redbreast sunfish were significantly higher ($P < 0.05$) than those for Black River redbreast sunfish, and like the Black River population, were significantly different among years ($P < 0.03$), showing a significant linear decline ($P < 0.02$) between 1994 and 1997.

Redbreast sunfish dominated the Lumber River centrarchid samples from 1994 to 1996, accounting for 30%–41% by number and 32%–36% by weight of all sunfish collected during this period. They were the third most abundant sunfish in 1997, below spotted sunfish (*L. punctatus*) and bluegill, and the second most dominant by weight, below largemouth bass.

The Lumber River redbreast sunfish population was also polymodal, revealing a wide distribution of sizes (Fig. 3), including y-o-y and multiple age classes. Lumber River redbreast sunfish size distributions were not significantly different ($P > 0.05$) among years. There was no significant change in mean length of Lumber River redbreast sunfish during the study period. In fact, Lumber River redbreast sunfish length-frequency distributions were fairly stable from 1995 through 1997.

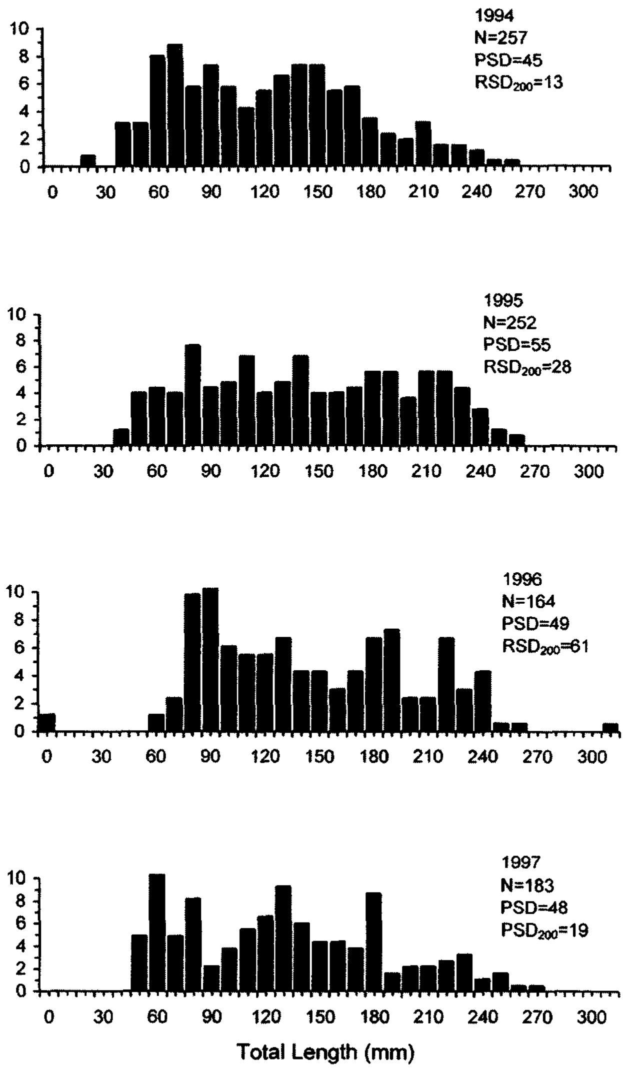

Figure 3. Length-frequency distribution (10-mm intervals) of redbreast sunfish collected from the Lumber River, North Carolina, 1994–1997.

PSD values for Lumber River redbreast sunfish varied from a low of 45 in 1994 to a high of 55 in 1995. RSD_{200mm} values ranged from 13 (1994) to 61 (1996).

Growth of Lumber River redbreast sunfish was similar to that of Black River redbreast sunfish, with fish growing to 85 mm during their first year and requiring about 3–4 years to reach the 200-mm preferred size (Fig. 4). Older fish, up to age 6, were collected.

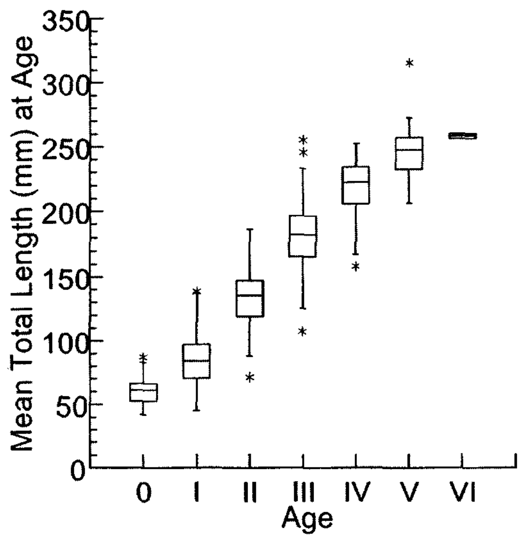

Figure 4. Mean total length (mm) at age at time of capture for redbreast sunfish collected from the Lumber River, North Carolina, 1994–1997. The horizontal line inside the box represents the median (50th percentile) and the horizontal ends of the box represent the 25th (lower) and 75th (upper) percentiles. The extreme horizontal lines represent the 10th (lower) and 90th (upper) percentiles. Stars represent outliers, values outside the range of plotted values.

Discussion

Creel limits are employed by fisheries managers in an attempt to increase the size of harvested fish and to more evenly distribute the potential harvest of game fish among the angling public (Fox 1975, Everhart et al. 1975). However, creel limits are seldom set low enough to affect the total harvest of the desired species and may result in adverse impacts to the population by creating a maximum limit or "target" for anglers to achieve (Fox 1975). In addition, most anglers do not catch a daily limit of the targeted species. Redmond (1974) demonstrated this when he reported that only 0.2% of bass anglers fishing Little Dixie Lake, Missouri, caught a 10-bass limit in 4 days of fishing. In this study, there was no enhancement of desirable stock characteristics (i.e., increase in abundance and shift in size toward larger fish) of redbreast sunfish populations in the Black or Lumber rivers during the 4 years following implementation of the 12-fish daily creel limit. For creel limits to be effective in altering stock composition, harvest must be a significant component of mortality. Examination of the length-frequency distributions for the first year of the study, which could be considered analagous to a control, does not suggest high levels of harvest on redbreast sunfish, especially in the Lumber River. PSD and RSD_{200mm} values similarly do not indicate depressed size structures in either population. Fishing pressure, therefore, did not appear to be significantly affecting abundance of larger-sized redbreast sunfish prior to regulation change. Creel survey data are necessary to determine angler effort and harvest rates of sunfish in these rivers.

Study results indicate a trend of declining redbreast sunfish catch rates in both systems, however, factors that could account for the observed declines have not been quantified. Water quality changes and predation by flathead catfish, or other species, may account for population declines. Flooding associated with hurricanes Bertha and Fran in September 1996 caused hypoxia and fish kills in the Black and other coastal rivers and may have affected abundance during the final year of the study. CPUE of redbreast sunfish in 1997 in both study rivers was lower than in any of the 3 previous years. Another possible factor for the declining catch rates could be competition and/or predation by other species. Flathead catfish have expanded into the lower portions of both river systems. Flathead catfish have been collected in the Black River for several years and were first captured in the lower Lumber River in the summer of 1998. Flathead catfish are a dominant predator in the Cape Fear River (Guier et al. 1980, Ashley and Buff 1987), of which the Black River is a tributary, and previous studies have indicated sunfish are an important component of the flathead catfish diet (Hackney 1965, Edmundson 1974, Guier et al. 1980, Davis 1985, Ashley and Buff 1987). Flathead catfish are thought to be responsible for significant declines in redbreast sunfish abundance in several South Carolina rivers (C. Thomason, pers. commun.). In this study, catch rates for redbreast sunfish appear to be somewhat lower in downriver areas where flathead catfish were collected than in upriver areas where they were not. An evaluation of this species distribution and food habits will clarify its role in the decline of redbreast sunfish in the Black and Lumber rivers.

Concurrent with declines in electrofishing CPUE in both systems was a significant ($P < 0.0001$) increase in mean length at capture from 138 mm in 1994 to 174 mm in 1997 (excluding fish <90 mm) of Black River redbreast sunfish. Lumber River redbreast sunfish increased slightly in mean length, from 154 mm to 166 mm between 1994 and 1997 (excluding fish <90 mm). And while the average length of redbreast sunfish in the Lumber River was significantly higher ($P < 0.05$) in 1994, the 1997 average length was not ($P > 0.66$). Growth rates for both populations was

Table 2. Mean total length (mm) at age at time of capture and sample size (N) for redbreast sunfish collected by electrofishing from 6 coastal North Carolina streams.

	Age					
Stream (year)	0	1	2	3	4	5
Black River (1994–97)	61 (37)	81 (214)	133 (79)	190 (49)	220 (16)	
Cape Fear River (1988)	54 (2)	88 (12)	121 (5)	160 (3)		
Contentnea Creek (1993)		117 (54)	166 (43)	202 (28)	226 (3)	
Lumber River (1994–97)	60 (35)	85 (237)	133 (243)	181 (179)	218 (95)	245 (24)
South River (1971)			140 ([a])	152 ([a])	178 ([a])	201 ([a])
Trent River (1986)	81 (7)	99 (10)	145 (42)	160 (27)	199 (3)	191 (1)

a. Sample size unknown.

greater in comparison to rates reported from the South River during 1971 (Davis 1971) and for fish ≥age 3 when compared to growth rates reported for redbreast sunfish collected from the Trent River during 1986 (Nelson and Little 1988) (Table 2). Additionally, growth exceeded that of redbreast sunfish in the Cape Fear River, while falling below that of redbreast sunfish in Contentnea Creek (Kornegay et al. 1994) (Table 2).

Management Implications

Study results indicate the desirability of collecting creel survey data when evaluating regulation changes. Creel data would have provided pre-regulation change data on angler harvest and fishing effort and may have provided insight as to whether the regulation change would have resulted in changes in population abundance or size structures of the targeted species. Since there was no enhancement of desirable stock characteristics (i.e., increase in abundance and shift in size toward larger fish) in this study, one obvious management reaction might be to repeal the creel regulation. However, since the study was conducted during the 4 years immediately following implementation of the regulation change, the sampling time frame may have been too short to detect potential changes in the study criteria (i.e., benefits may not become evident for several additional years). To address this issue one could continue collecting population abundance and size structure data for several additional years to determine if changes in these population characteristics are eventually realized. Finally, as mentioned previously, since creel limits are seldom set low enough to affect the total harvest of the desired species, another possible management alternative would be to make the creel limit more restrictive by reducing it from 12 to 6 or 8 fish per day. However, determining the number to reduce the creel limit to would be a "best guess" estimate and would require the collection of population abundance and size structure data over several additional years to determine if and when changes in these population characteristics occur.

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