Evaluation of a Protected Slot Regulation for Largemouth Bass on Lake Sutton, North Carolina

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Abstract: A 305–406 mm protective slot and 4 fish daily creel limit, allowing harvest of 2 fish <305 mm, was placed on largemouth bass (*Micropterus salmoides*) in Lake Sutton during July 1989. The purpose of the regulation was to protect slot length bass and increase the angler catch rate for bass >400 mm. The objective of this investigation was to evaluate the regulation's effectiveness by comparing size distributions, PSD and RSD_{40} of fish captured by electrofishing and anglers, as well as angler catch rates of bass >400 mm, before and after the regulation change. Daytime spring shoreline electrofishing was conducted annually between 1988 and 1992. An angler diary program spanned 1986 to 1992. Post-regulation PSD and RSD_{40} values of largemouth bass captured by electrofishing were significantly greater than 1988 and 1989 values. Length of angler caught bass also increased after the regulation change. PSD and RSD_{40} values from angler diaries were significantly greater after the slot limit in 1991 and 1992 than during 1986 and 1987. Slight increases in bass condition (relative weight) and mean length at capture for Age 1, 2, and 3 fish were observed in 1991 and 1992, suggesting forage had not become limiting 3 years after the regulation change. The regulation was considered successful.

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Lake Sutton is a popular fishing area and has received considerable angling pressure since its construction in 1972. From 1985 through 1988, cove rotenone estimates of largemouth bass standing crop declined steadily from 112.2 kg per ha to 17.3 kg per ha (Carolina Power and Light Company (CP&L), R. Garrett, pers. commun.). The number of angler complaints regarding smaller sizes of bass and lower catch rates also increased during this period. Bass regulations in place at the time were the statewide 355 mm size limit allowing harvest of 2 fish <355 mm and

an 8 fish per day creel limit. An angler diary program conducted on the lake during 1986–1987 reported a total of 133 bass caught at a rate of 0.32 fish per hour (CP&L, unpubl. data). Proportional Stock Density (PSD) and Relative Stock Density (RSD_{40}) (Anderson and Gutreuter 1983) were 77 and 5, respectively, for angler caught bass.

Conductivities >700 *u*mhos per cm precluded the use of electrofishing gear in Lake Sutton prior to 1987. Relocation of water intake pumps further upstream on the Cape Fear River and pumping during periods of reduced salinities lowered lake conductivities to between 200 and 500 *u*mhos per cm after 1987. Assisted by CP&L, Nelson and Little (1990) subsequently used electrofishing to obtain largemouth bass size distribution and age information in 1988. The 1988 data indicated good growth rates and a scarcity of bass >400 mm, suggesting fishing pressure may have reduced the abundance of larger bass. To protect mid-sized fish and increase angler catch rates for larger bass, a 305–406 mm protective slot limit and a 4 fish per day creel limit, allowing harvest of 2 bass <305 mm, was placed on Lake Sutton beginning 1 July 1989. Spring shoreline electrofishing was continued in 1989 to obtain additional pre-treatment data.

The effects of slot limits on bass population structure have been variable. Eder (1984) reported increases in PSD 5 years after a 300–375 mm protective slot limit was established. Chapman et al. (1991) found a 305–406 mm slot limit resulted in increased numbers of bass >400 mm in 2 Piedmont North Carolina reservoirs. Crawford et al. (1988), however, failed to detect significant changes in length frequency or abundance of bass using a 350–500 mm slot limit on 2 Florida lakes. The goals of the Lake Sutton regulation change were to increase the relative abundance of large bass in the population and to increase angler catch rates of large bass. An evaluation was required to determine whether desired changes in population size structure followed implementation of the slot limit. Specific objectives of this investigation were to measure changes in size distributions, to measure changes in PSD and RSD_{40}, and to measure changes in angler catch rates of bass >400 mm.

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Methods

Lake Sutton is a 445-ha cooling lake for the CP&L L.V. Sutton Steam Electric Plant located adjacent to the Cape Fear River near Wilmington, North Carolina. The lake was formed by impounding Catfish Creek, a tributary of the Cape Fear River. Lake Sutton is shallow (average depth approximately 2 m) except along the old creek channel and where excavated to create dikes. Growth of submersed aquatic vegetation sometimes becomes extensive, interfering with power plant operations and angling. Thermal and oxygen stratification have not been observed in the lake (CP&L 1987). Yearly water temperatures range from 7° to 33° C

and dissolved oxygen concentrations from 6 to 11 mg per liter. Decreased lake flushing in 1990 and 1991 was thought to have contributed to increased hardness, total alkalinity, and calcium concentrations noted for those years (CP&L 1992).

Shoreline electrofishing was conducted between 1 March and 30 June in 1990, 1991, and 1992 at 8 stations established in 1988. Efforts were made to collect a minimum of 300 bass annually. Repetitive sampling of the stations at approximately 1 month intervals was required for all years. Bass were weighed to the nearest gram and total length measured in millimeters.

Length frequency histograms were prepared annually from the electrofishing data using 25-mm groups and PSD and RSD_{40} values were calculated. A significance level of $P = 0.05$ was used for all hypothesis testing. Length frequency distributions before and after the regulation change were compared using Dunn's multiple comparison extension of the Kruskal-Wallis Rank Sum test (Hollander and Wolfe 1973). Comparative proportion statistics (Snedecor and Cochran 1978) were used to compare PSD and RSD_{40} values for the 2 pre-slot limit years of 1988 and 1989 to the final study year of 1992.

Bass condition and length at age were examined for responses to potential increases in the proportion of large bass and declines in forage availability. Relative weight (W_r) (Wege and Anderson 1978) was calculated for individual bass using the revised equation of Henson (1991). W_r ranges and means were plotted annually for each 25-mm group. Otoliths were taken from about 60 bass each year from CP&L rotenone and North Carolina Wildlife Resources Commission electrofishing samples. Otoliths were sectioned through the nucleus, imbedded in resin on a glass slide, and ground and polished with 220 and 320 grit sandpaper on a sanding wheel. Ageing was done through a layer of clove oil using a binocular dissecting microscope. Mean total length at time of capture for each age class was tabulated for all years.

Angler diary forms and measuring boards were distributed to 20 cooperators recruited from local bass clubs beginning in October 1989. Cooperators were briefed on study objectives and procedures for data collection. Anglers measured bass total length to the nearest inch. Each angler diary year ended in July. Diary forms were collected annually and catch rates, expressed as bass caught per hour, were determined. Results were reported to the bass clubs each year. Angler diary length frequency distributions and diary PSD and RSD_{40} values for 1986–87 and 1991–92 were tested in the same manner as the electrofishing data.

The following criteria were selected to evaluate the success of the regulation change on Lake Sutton: 1) maintain PSD between 40 and pre-slot limit values, 2) increase RSD_{40} by 10% and 3) increase angler catch rate of bass >400 mm by 10%. The regulation was to be considered successful if any 2 of the criteria were met.

Results

Size distributions of largemouth bass collected by spring electrofishing showed a trend toward proportionately larger fish between 1988 and 1992 (Fig. 1).

Length frequency distributions for the years 1988, 1989, and 1990 were not significantly different from each other, but were significantly different from 1991 and 1992 distributions. Electrofishing PSD values did not appear to vary appreciably between 1988 and 1991 (Fig. 1), but values for 1988 (PSD = 68) and 1989 (PSD = 70) were significantly different ($P < 0.01$) from 1992 (PSD = 90). An increase in electrofishing RSD_{40} was observed during 1991 and 1992 (Fig. 1).

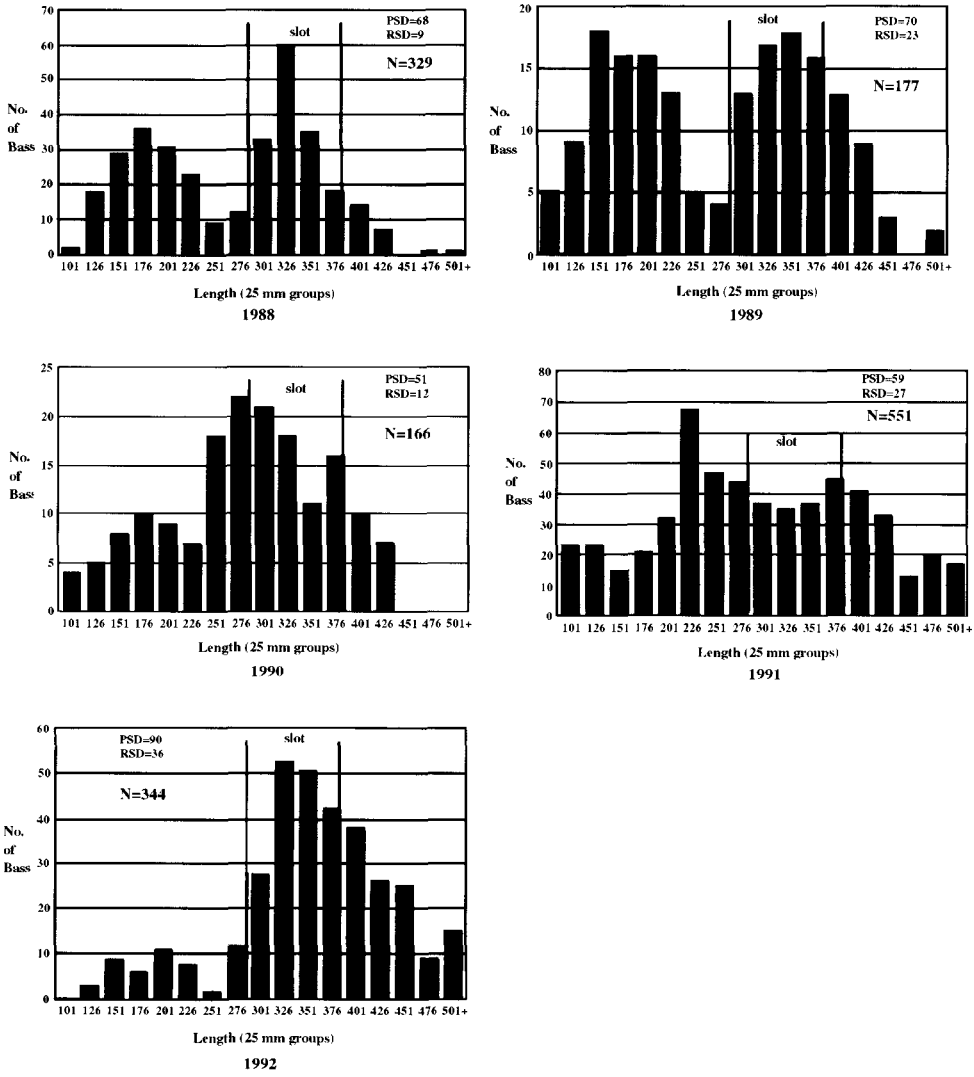

Figure 1. Lake Sutton largemouth bass size distributions from spring electrofishing samples before (1988, 1989) and after (1990, 1991, 1992) slot regulation.

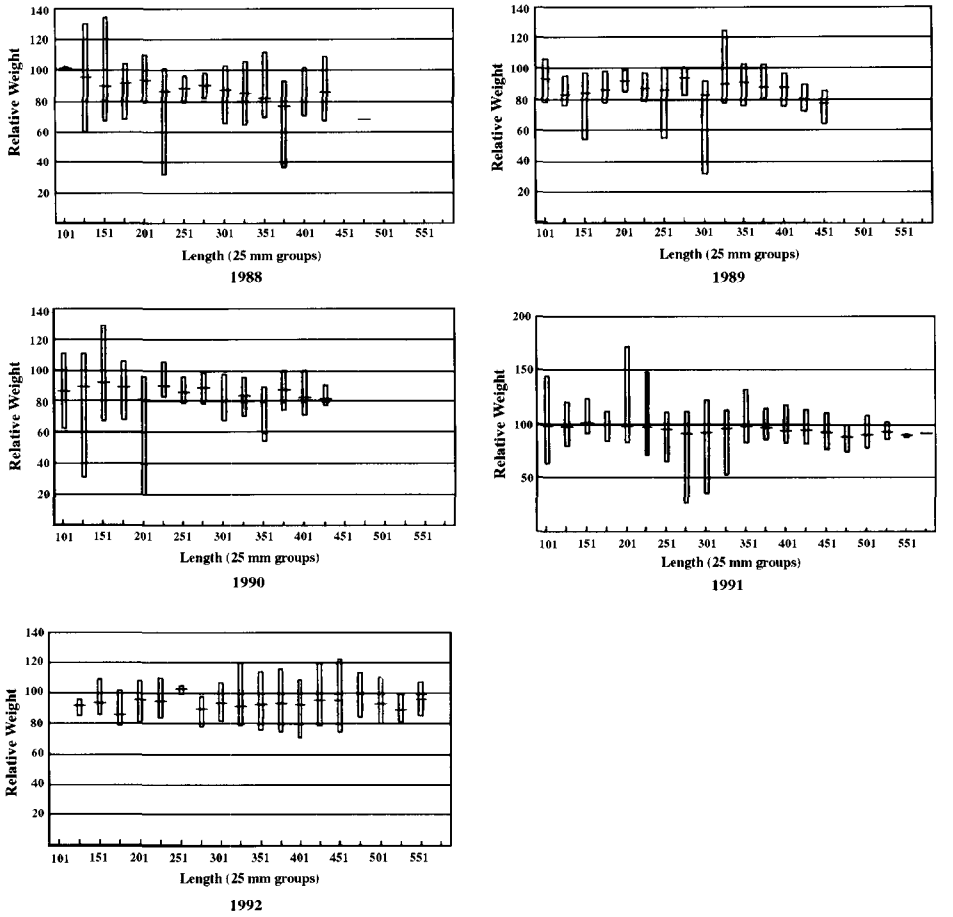

Figure 2. Range and mean W_r values per size group for Lake Sutton largemouth bass from spring electrofishing samples before (1988, 1989) and after (1990, 1991, 1992) slot regulation implementation.

RSD40 values in 1988 (RSD_{40} = 9) and 1989 (RSD_{40} = 23) were significantly different ($P < 0.01$) from 1992 (RSD_{40} = 36). Condition of electrofished bass increased slightly during 1991 and 1992, with W_r values approaching the optimum of 100 (Fig. 2). Likewise, mean length of bass at capture for Age 1, 2, and 3 fish increased during 1991 and 1992 (Table 1).

Size distributions of angler caught bass showed a pronounced shift toward proportionately larger fish after the slot limit went into effect (Fig. 3). Length frequency distributions were significantly different between all years. Angler diary PSD values between 1986–87 (PSD = 77) and 1991–92 (PSD = 95) were significantly different ($P = 0.01$) (Fig. 1). Differences between RSD_{40} values for 1986–87 (RSD_{40} = 5) and 1991–92 (RSD_{40} = 48) were also highly significant ($P < 0.01$).

Table 1. Mean length (mm) at time of capture by age class for Lake Sutton largemouth bass from electrofishing and rotenone samples before (1987–88) and after (1990, 1991, 1992) slot regulation.

		Age class					
Year	*N*	0	1	2	3	4	5
1987–88	61	198	309	362	407	411	364
1990	77	143	264	365	395	472	532
1991	60	233	327	400	448	415	
1992	66	185	329	417	465		524

The number of hours fished reported by angler diary cooperators increased from 415 in 1986–87 to 732 in 1991–92 (Table 2). Total bass caught per hour of angling increased from 0.32 bass per hour in 1986–1987 to 0.81 bass per hour in 1991–92. Number of fish caught per hour of angling between 330 and 380 mm (within slot) fell below the 1986–87 value of 0.21 bass per hour in 1989–90 and 1990–91, but increased to 0.33 bass per hour in 1991–92. Numbers of bass

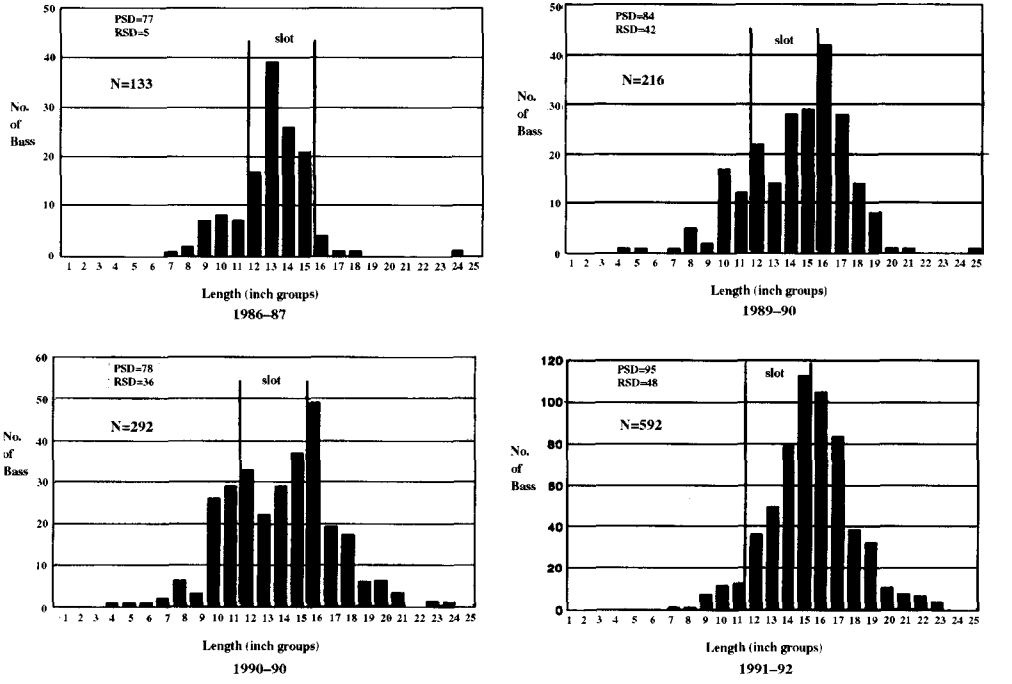

Figure 3. Lake Sutton largemouth bass size distributions from angler diaries before (1986–87) and after (1988–90, 1990–91, 1991–92) slot regulation.

Table 2. Number of hours fished and largemouth bass caught per hour of angling from angler diary co-operators fishing Lake Sutton before (1986–87) and after (1989–92) slot regulation.

		Size group		
Year	Hours fished	330–380 mm	>400 mm	Total
1986–87	415	0.21	0.02	0.32
1989–90	691	0.10	0.14	0.31
1990–91	714	0.15	0.10	0.41
1991–92	732	0.33	0.38	0.81

>400mm caught per hour increased from 0.02 bass per hour in 1986–87 to 0.38 bass per hour in 1991–92.

Discussion

Slot limits are typically used to influence the number and condition of fish within or above a selected size range and are most effective when applied to fisheries with high fishing mortality and good recruitment (Novinger 1984). Protection of fish within a given size range is designed to increase the numbers of desirable size fish. Limited harvest below the slot is allowed to control this increase and mitigate density related decreases in condition of larger fish.

Most of the changes sought by applying this concept to Lake Sutton's largemouth bass population were realized. Although RSD_{40} showed declines in 1990 electrofishing (Fig. 1) and 1990–91 angler diaries (Fig. 3), length frequencies and overall RSD_{40} of bass from both electrofishing and angler diaries showed significant increases in the proportion of fish >400 mm 3 years after the regulation change. Increases in RSD_{40} ranging from 56% (electrofishing between 1989 and 1992) to 860% (angler diary between 1986–87 and 1991–92) easily met the 10% increase success criterion. Cooperator attrition (approximately 40%) and gear bias may have influenced the strong trend toward larger fish observed in the angler diary data. The angler catch rate of bass >400 mm increased by a factor of 19 by 1991–92, greatly exceeding the 10% increase success criterion and comparing favorably to catch rates of bass >400 mm in piedmont North Carolina reservoirs (Chapman et al. 1991). A 57% increase in the catch rate of 330–380 mm bass by 1991–92 indicated an increase in the proportion of within-slot size bass as well. Chapman et al. (1991) did not observe increased abundance of slot size fish. No indication of a forage limitation was seen, as slight improvement in bass condition and growth accompanied the slot limit in 1991 and 1992. Prather (1990) attributed condition and growth increases following a slot regulation on a public fishing lake in Kentucky to increased density of small bluegill. Some bias in the length at time of capture data (Table 1) must be acknowledged, however, since time of capture for the rotenoned bass (approximately 7% of the total sample) lagged 2 to 3 months behind electrofished bass.

Several factors not directly related to the regulation change probably contributed to the observed results. The large proportion of slot size fish present in 1989 when the new regulation began (Fig. 1) may have facilitated the trend toward larger bass. High levels of submersed aquatic vegetation in 1990, subsequent chemical treatment (CP&L 1991), and consequent changes in fish habitat and water quality may have enhanced productivity and bass feeding efficiency in 1991 and 1992. A decline in densities of bluespotted sunfish, *Enneacanthus gloriosus*, and other small sunfishes in summer rotenone samples between 1990 and 1991 was attributed to reduced availability of vegetative cover following chemical treatment (CP&L 1992). Increased susceptibility to bass predation may have also contributed to lower sunfish densities. The dramatic change in lake conditions from high clarity water dominated by aquatic macrophytes to low clarity water dominated by algae between 1990 and 1991 affected electrofishing capture efficiencies. More sampling repetitions yielded fewer bass in the clear water year 1990. There was no indication, however, that habitat changes influenced the spatial distribution of different sized bass. A decline in the proportion of small bass observed in 1992 contributed to the high PSD and RSD_{40} values (Fig. 1) and was responsible for failure to meet the PSD success criterion. Cause of the reduction in small fish during 1992 is unknown, but could be related to loss of vegetative cover or increased harvest of subslot-size fish. Availability of Age 1 bass for recruitment into the slot may be limited in 1993.

In summary, significant increases in the proportion of largemouth bass >400 mm in Lake Sutton were indicated by both electrofishing and angler diary length frequencies and RSD_{40} three years after implementation of the slot limit. The angler catch rate of bass >400 mm increased substantially as well. Consequently, 2 of the 3 success criteria established at the onset of the evaluation were met, qualifying the regulation as successful.

Management Recommendations

We make the following management recommendations based on our data:

- Maintain the present largemouth bass slot regulation on Lake Sutton.
- Evaluate effects of poor recruitment in 1992 on length frequency distributions and associated indices by spring electrofishing.

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