Effects of Expanded Stocking Locations on Striped Bass Survival

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Abstract: Smith Mountain Lake is a 8,337-ha reservoir formed by the Roanoke and Blackwater Rivers in Virginia. This lake maintains suitable habitat for striped bass *(Morone saxatilis)* but does not contain adequate spawning habitat for natural reproduction. Consequently, it requires annual stockings of this species to maintain the fishery. We examined how recruitment of striped bass to age-1 was affected by increasing the number of stocking locations at Smith Mountain Lake. Prior to 1996, striped bass were stocked at 2 sites. Four sites were stocked in 1996–1997 and 10 to 14 sites were stocked from 1998–2000. Approximately 118,000–170,000 striped bass were stocked at each site prior to 1996 but the number of striped bass stocked at each site in 1996–2000 was reduced to 17,000–78,000. Some of the new stocking sites were in areas of the lake that had greater nutrient concentrations and prey densities. Reduced stocking densities at each site increased recruitment to age-1. Reservoir managers may need to consider reservoir dynamics and density dependent relationships of stocked fish when choosing the number and location of stocking sites.

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Most inland bodies of water typically lack suitable spawning habitat for striped bass and require annual stockings to maintain populations that will contribute to the pelagic fishery (Axon and Whitehurst 1985, Sutton et al. 2000). Smith Mountain Lake maintains suitable habitat for all ages of striped bass but does not contain adequate spawning habitat for natural reproduction. Consequently, Smith Mountain Lake requires annual stockings of striped bass to maintain the fishery. Stocking began in 1969 and an outstanding fishery developed prior to 1980.

Striped bass angling pressure has steadily increased since the 1980s. During 1998, striped bass anglers accounted for 37% of the total angler pressure on Smith Mountain Lake resulting in an estimated 28.4 hours/ha of directed striped bass fishing effort (Va. Dep. Game and Inland Fish., unpubl. data). Angler concern arose as increased angling pressure coincided with reduced catch rates, especially for larger fish. Declining angler success was similar to what Van Horn et al. (1999) noted at Lake Norman, North Carolina. Smith Mountain Lake anglers believed that increasing the number of striped bass stocked would negate increased angler pressure by sustaining catch rates and increasing the number of larger fish that they had become accustomed to catching.

The Smith Mountain Lake striped bass fishery has also become an important economical component of the local communities. Trip expenditures estimates in 1998 of Smith Mountain Lake anglers totaled $3.1 million (Va. Dep. Game and Inland Fish, unpubl. data). Striped bass angler concerns about a declining fishery spread to the local business community. Both groups began to pressure the Virginia Department of Game and Inland Fisheries (VDGIF) to stock additional striped bass to compensate for the declining fishery.

Increased pressure on VDGIF to improve the striped bass fishery resulted in an effort to increase public input for the development of future management goals. The Smith Mountain Striper Club (SMSC) has over 500 members, which includes many facets of the angling community such as lake residents, local businessmen, striped bass guides, and avid striped bass anglers. Consequently, VDGIF worked in cooperation with the SMSC to develop a striped bass management plan. The management plan specified specific goals and objectives to address angler concerns. One of the major goals of the plan was to increase survival of stocked fish and later to increase stocking rates from 300,000 to 450,000 fish annually. In order to distribute stocked fish more evenly throughout the reservoir, VDGIF and SMSC worked closely to identify and gain access to numerous private access areas for future stocking.

Adequate survival of stocked fish is essential to maintain a fishery in a reservoir that is not sustained by natural reproduction. Improved survival of stocked fish could contribute not only to an increase in the sport fish population but may also reduce future production needs for department hatcheries. A reduction in hatchery allocation for Smith Mountain Lake could decrease hatchery-operating costs or expand stocking opportunities for other bodies of water.

The objective of this study was to evaluate the impact of stocking strategies (concentrated vs. dispersed) on recruitment of striped bass to age-1. Results from the study were utilized to determine if the additional stocking sites for striped bass at Smith Mountain Lake were necessary to enhance recruitment to age-1.

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Methods

Smith Mountain Lake is a 8,337-ha pump back storage reservoir formed by the Roanoke and Blackwater Rivers (Fig. 1). The reservoir has mean and maximum depths of 16.8 m and of 63.7 m, respectively, and a retention time of 1.35 years. The shoreline is highly dendritic and typically steep sided. Pump back operations recycle significant amounts of water from the lower lake throughout the year. A substantial nutrient gradient is produced from headwaters to the dam. Largemouth bass *(Micropterus salmoides),* smallmouth bass *(M. dolomieu),* and striped bass are the primary species sought by anglers. Gizzard shad *(Dorosoma cepedianum),* threadfin shad *(D. petenense),* and alewife *(Alosa pseudoharengus)* are the principal pelagic

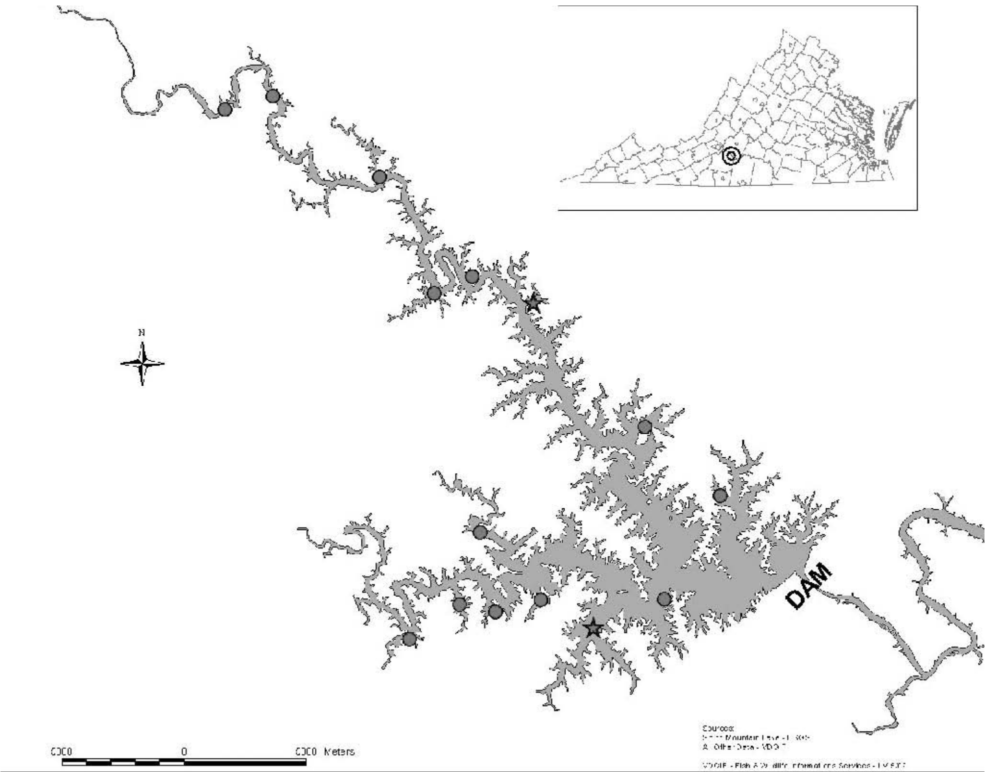

Figure 1. Distribution of striped bass stocking sites in Smith Mountain Lake, Virginia. Stocking sites marked by a star represent the 2 historical stocking sites utilized from 1990–1995. Additional stocking sites utilized after 1995 are marked by circles

forage species. Striped bass are regulated with a 520-mm minimum size limit and a 2 fish per day creel limit.

All parental stock for striped bass fingerlings stocked in this study were collected from the Staunton River, Virginia. Fingerlings stocked into Smith Mountain Lake averaged 25–50 mm in all years. An average of 291,147 fingerling striped bass were stocked in 1990–1995 and an average of 418,782 fingerlings were stocked in 1997–2000. Only 66,857 striped bass were stocked in 1996 due to new hatchery construction and production constraints. Fish were stocked at the same 2 locations each year from 1990–1995. The number of stocking sites were expanded to 4 sites in 1996–1997 and to 10–14 sites in 1998–2000. The additional stocking sites were chosen based on distance from other stocking sites and accessibility.

Striped bass were collected with gill nets during the fall of each year from 1991–2001. Sampling was conducted at 4 sample areas during the first 2 weeks of

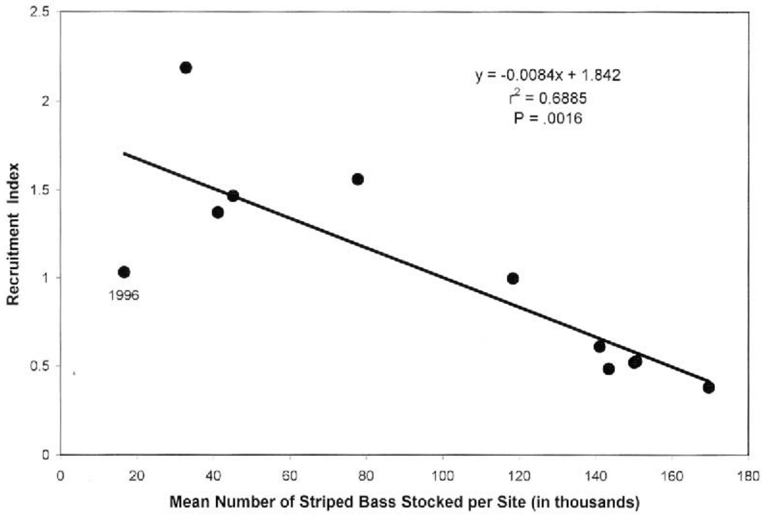

Figure 2. Linear regression describing the relationship between the mean number of striped bass stocked per site and recruitment index of striped bass from Smith Mountain Lake, Virginia.

October, November, and December each year. Each of the 4 sample areas contained 3 fixed gill net sites, 1 for each mesh size. Total annual effort was 36 net nights. All gill nets contained only 1 mesh size; however, 3 different mesh sizes were utilized (19-, 32-, and 51-cm bar mesh). Gill nets utilized in this study were 60 m long and 2.4 m deep.

Length, weight, and collection date were recorded for each striped bass captured in gill nets. Otoliths were removed from all fish. Age-1 striped bass were the most abundant age group collected each year. Although age-1 striped bass were collected in all mesh sizes, the 19-cm mesh nets collected primarily age-0 striped bass, the 32-cm mesh nets collected primarily age-1 striped bass, and the 51-cm mesh nets collected primarily large age-1 and small age-2 striped bass. Since all gill nets were not equally efficient at collecting age-1 striped bass, statistical analyses of catch per unit of effort of age-1 striped bass were not performed.

A recruitment index was developed to incorporate annual gill net catch of age-1 striped bass and changes in annual stocking rates. The annual recruitment index was defined by the following equation: (*N* of age-1 striped bass per net/*N* of striped bass stocked) $\times$ 100,000. This recruitment index was utilized to measure the success of additional stocking sites.

Results

An average of 145,574 striped bass were stocked at 2 sites through 1995. Beginning in 1996, an average of only 42,732 striped bass were stocked per site. This represented a 67% reduction in the number of fish stocked per site. Four sites were stocked in 1996–1997, and 10 to 14 sites were stocked from 1998–2000.

Annual recruitment index values for age-1 striped bass increased from an average of 0.59 (1990–1995) to 1.52 (1996–2000) after the additional stocking sites were added (Fig. 2). A significant negative relationship between stocking density and recruitment index was observed ($r^2 = 0.6885$, $P = 0.0016$). The range of these values was 0.38 to 1.00 with 2 stocking sites and from 1.03 to 2.19 with additional stocking sites (Table 1).

Discussion

Two factors likely contributed to the improvement of striped bass recruitment by expanding stocking locations. First, stocking fewer fish at each site may have reduced predator densities due to limited dispersal immediately after stocking. Second, more fish were stocked in areas with greater nutrient levels and higher forage densities. The combination of these 2 factors may have provided a reduction in predator density and increased prey availability at each stocking site. Ney and Orth (1986) emphasized the importance of prey availability and consumption during early life stages to eliminate the negative affects of increased predator densities and limited available prey near stocking sites. More prey encounters increases prey capture and promotes fatty acid storage, which has been shown to be critical to winter survival for

Table 1. Numbers of fingerling striped bass stocked, gill net catch per unit of effort of age-1 striped bass (CPUE), recruitment index of age-1 striped bass (CPUE adjusted for varying stocking rates), and mean number of fingerling striped bass stocked per site in Smith Mountain Lake, Virginia, 1990–2000.

Year stocked	Fingerling striped bass stocked	*N* stocking sites	Gill net CPUE	Recruitment index	Stocking density per site
1990	300,131	2	1.56	0.52	150,066
1991	301,346	2	1.59	0.53	150,673
1992	282,281	2	1.72	0.61	141,141
1993	287,054	2	1.39	0.48	143,527
1994	339,337	2	1.29	0.38	169,669
1995	236,734	2	2.36	1.00	118,367
1996	66,857	4	0.69	1.03	16,714
1997	311,300	4	4.86	1.56	77,825
1998	453,063	11	6.22	1.37	41,188
1999	450,769	10	6.61	1.47	45,077
2000	459,996	14	10.06	2.19	32,857

juvenile striped bass (Ploskey and Jenkins 1982, Moore et al. 1991, Michaelson 1996, Cyterski 1999). When stockings were concentrated at 2 sites, fingerling striped bass at Smith Mountain Lake would consume fish prey when available and then convert to less preferred invertebrate prey (Sutton et al. 2000). This scenario would limit fatty acid storage and maturation throughout the summer and fall months and reduce first year survival.

Adequate prey availability, especially for fingerling fish, was a concern when an increased stocking rate of 450,000 fish was discussed. Availability of preferred prey for stocked piscivores may have previously been a limiting factor for first-year survival (Ney and Orth 1986). Density and first-year survival of stocked striped bass were inversely related in Watts Barr Reservoir, Tennessee, according to Van Den Avyle and Higginbotham (1979). A model developed by Sutton et al. (2000) predicted recruitment to increase progressively with increased stocking rates, up to 300,000 stocked fingerlings, but leveling off for higher stocking densities. However, the development of this model was based on data collected when all the striped bass stockings were at 2 Smith Mountain Lake sites.

Smith Mountain Lake fertility declines in a downstream direction from eutrophic upstream to mesotrophic in the lower lake (Yurk and Ney 1989) and prey abundance followed a similar trend (VDGIF, unpubl. data). One of the historical stocking sites was located in a mesotrophic area while the second site was located in a transitional area between the 2 trophic zones. Most of the additional stocking sites were located in an upstream direction from the 2 traditional sites (Fig. 1). Stocking striped bass in areas with greater prey densities may be more beneficial to stocked fish recruitment.

Sutton and Ney (2001) suggested improvements in first year growth and survival of striped bass at Smith Mountain Lake may be achieved by modifying historical stocking strategies to improve predator-prey size relationships. In Smith Mountain Lake, striped bass remained in the outer reaches of stocking coves for a month following stocking (Michaelson 2001). Similarly, Van Den Avyle and Higginbotham (1979) found that fingerling striped bass tended to remain near the stocking area for 5 months after stocking. Since emigration from stocking sites is limited for at least 1 month and possibly much longer after stocking, more stocking sites with fewer fish stocked at each site likely improved fingerling distribution and predator-prey size relations throughout the reservoir.

A very reduced number of fingerling striped bass stocked in 1996 resulted in low gill net catches the following year. Gill net sampling at Smith Mountain Lake was designed to monitor a population with a much higher stocking rate. Additional gill net sampling may have sampled the 1996 year class more effectively and possibly resulted in improved survival index value for 1996. When the 1996 data were excluded from the analysis, a much better relationship was found between recruitment index and the mean number of fish stocked per site ($r^2 = 0.8839$, $P = 0.0001$).

Although a greater distribution of stocked fish is not always possible, this study found distributing fingerling striped bass more evenly in Smith Mountain Lake resulted in greater first-year survival and greater recruitment to age-1. Predator and prey densities should be considered when stocking strategies are established for predator species in reservoirs.

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