Growth and Condition Response of Lake Norman Striped Bass to Increased Stocking Rates and More Restrictive Harvest Regulations

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Abstract: Striped bass *(Morone saxatilis)* stocking rates were increased in 1988 and more restrictive harvest regulations were initiated in 1992 to increase striped bass abundance in Lake Normal, North Carolina. The objective of this study was to make inferences about current forage sufficiency for striped bass from length at age of capture and body condition of striped bass collected since 1994. Fish were obtained from November–January fishing tournaments and gillnet sets in 1994–1998. Late season samples were designed to collect fish after they had several months to recover from any reduced condition caused by summer temperature and dissolved oxygen related habitat stress. Striped bass were also collected with gill nets in late June or early July 1996–1998 to gather pre-summer habitat stress body condition information. Growth for fish older than age 2 had declined from pre-study data collected by Duke Power Company. Relative weight (Wr) indices for striped bass were poor (means ~80%) in all years for both winter and the June samples. Poor growth and condition, especially in the absence of summer habitat stress, suggest that forage is insufficient for the current number of striped bass in Lake Norman.

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Lake Norman is a 13,516-ha cooling reservoir for 2 Duke Power Company (DPC) electric generating facilities. Striped bass do not reproduce in the reservoir and are stocked annually. The fish were first introduced into the reservoir in the late 1960s or early 1970s at approximately 100,000 phase I fingerlings/year (Fig. 1). The forage base for striped bass in Lake Norman is primarily threadfin shad *(Dorosoma petenense).* Gizzard shad *(Dorosoma cepedianum)* are present in the lake but young-of-the-year gizzard shad have been virtually absent from push trawl and purse seine samples collected by DPC since the early 1980s (unpubl.).

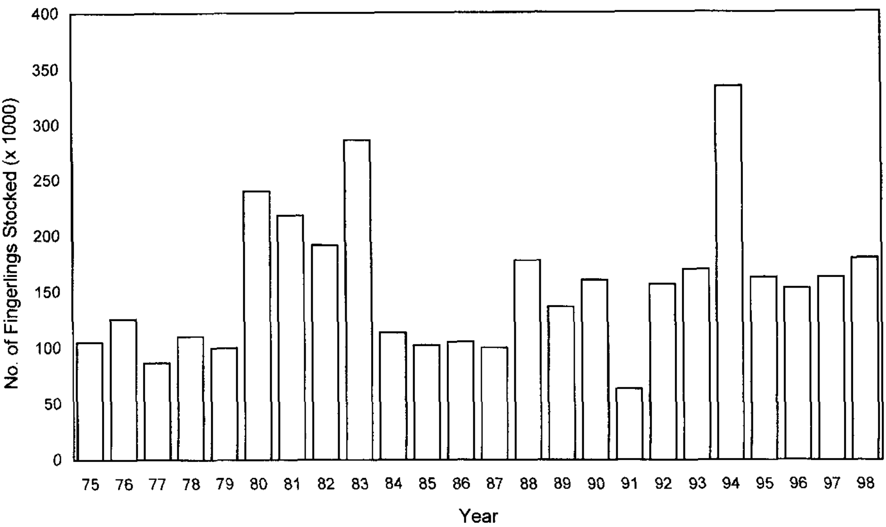

Figure 1. Striped bass stocking history for Lake Norman, North Carolina.

Creel surveys conducted by DPC estimated 7.6 hours/ha of striped bass fishing in 1978 (Siler et al. 1981) and 13.4 hours/ha in 1982 (Baker 1983). The average size of a harvested striped bass in the 1978 creel survey was 1.9 kg under a 406 mm size limit and 8 fish daily creel limit. Seven percent of the estimated striped bass harvest in 1978 was <406 mm. Harvest regulations were modified in 1982 to include a 2 fish size limit. The result was 48% of the striped bass harvest in 1982 was below the minimum size limit. The high representation of "exemption" fish in the creel produced an average harvest weight of 1.0 kg per striped bass. Baker (1983) stated there was little change in the number of harvested striped bass >406 mm in 1982.

The striped bass stocking rate more than doubled from 1980–1983 as surplus fingerlings from federal hatcheries were stocked into Lake Norman (Fig. 1). DPC staff aging a small number of striped bass during this period suggested that growth rates decreased (Cloutman, pers. commun.) and raised the possibility that striped bass growth was limited by forage availability. When the federal hatcheries changed their priorities to anadramous fish stock recovery efforts in 1984, fewer striped bass were available for put-grow-and-take reservoir fisheries and stocking rates returned to 100,000 per year. Growth of striped bass returned to levels comparable to other southeastern reservoirs (Clawson et al. 1989).

Angler concern about declining numbers of striped bass, particularly larger fish (>5kg), in Lake Norman was growing during the mid-1980s. Anglers felt that growing fishing pressure and corresponding harvest were depressing their catch rates and reducing the average size of fish caught. Part of the striped bass angling community saw the low minimum size limit and particularly the 2 fish exemption as impediments to producing higher numbers of larger striped bass.

In the late 1980s NCWRC biologists accepted the hypothesis that higher fishing pressure and harvest might permit heavier stocking rates without associated undesirable decreases in striped bass growth and condition. They re-established the policy of stocking excess striped bass hatchery production into Lake Norman. Striped bass stocking rates rose to approximately 150,000 annually in 1988 with the objective of increasing striped bass fishing success. The 1988 rate was adopted as the target stocking rate in 1992. Acquisition of the Watha Warmwater Hatchery gave the NCWRC the consistent production capacity needed to meet the new stocking rate each year.

Anglers approached the NCWRC in 1992 and requested an increase in the striped bass minimum size limit to 560 mm, a reduction in the daily creel to 4 fish, and removal of the 2 fish exemption. Concern over forage availability prompted the NCWRC to modify the request by reducing the size limit to 508 mm, and the proposal became rule that summer. Subsequent to the regulation change, a third creel survey was completed at Lake Norman indicating directed effort for striped bass had dropped to 8.0 hours/ha (DPC unpubl.). The average size of a harvested striped bass was near the 508-mm limit and 1.2 kg. Lower directed effort implied lower striped bass harvest, reinforcing the agency's forage sufficiency concerns.

The new size and creel limits and the higher stocking rate were designed to increase striped bass catch rates and the average size of harvested fish. The success of this policy change is heavily dependent upon the available striped bass forage in Lake Norman. The purpose of this study was to examine striped bass growth and condition since the regulation change and make inferences about forage sufficiency in Lake Norman.

Methods

Striped bass were obtained from November–January (late season) gill nets and fishing tournaments in 1994–1998. Gill nets also were fished in late June or early July 1996–1998 (early season). The gill nets were a collection of mesh sizes and lengths. Most of the effort expended was in 2 net configurations. Both nets were 2.4×76 m with 2 panels each. One net configuration used 76 and 102 mm stretch mesh, the other used 127 and 152 mm stretch mesh. Nets were deployed near striped bass located using electronic fish finders. Length and weight were recorded for each striped bass captured. Additionally, at least 1 striped bass tournament was attended each fall. Lengths and weights were recorded for every striped bass entered in each tournament.

Otoliths were removed from all of the fish collected in gill nets and from tournament fish when anglers consented to the process in 1994, 1996, 1997, and 1998. Otoliths were sectioned and aged. In all years, the fish had not laid down the annulus for the growing season nearly completed and otolith margins were treated as the most recent annulus.

Sample data were combined when multiple collecting dates or gears were used within a single sample season. No fish <400 mm were included in the condition analysis. A relative weight (Wr) (Murphy et al. 1991) was calculated for each fish collected. Mean Wr's were calculated and plotted by 50-mm size groups for all striped bass collected in the late season samples from 1994–1998. Wr's were averaged over all early season samples and years, and again over all late season samples and years. The 2 seasonal means and a mean of Wr's calculated from striped bass samples collected between the months of May–November between 1985–1987 by DPC (unpubl.) were plotted and compared using analysis of variance and LSD post hoc comparisons (SYSTAT 1996).

Mean lengths at age of capture and standard deviations are calculated for the 4 years age information was collected. Our post regulation change length at age of capture was compared in tabular form to back calculated striped bass length at annulus data from Lake Norman collected from 1986–1988 by DPC (Clawson et al. 1989). The comparison of pre- and post-study information was used to evaluate striped bass growth. No statistical tests were conducted because there was only mean length at age (no measure of variance) was available for the 1986–1988 data.

Results and Discussion

A total of 577 striped bass was collected in the 5 late season samples and 308 fish were collected in the 4 early season samples. Seasonal sample sizes within years ranged from 69–164 fish. We report ages from 320 striped bass.

Clawson et al. (1989) reported Lake Norman striped bass growth was historically within the range of growth observed for striped bass populations in other southeastern reservoirs (Table 1). However, growth during the present study generally was lower than reported by Clawson et al. (1989). It is important to note that striped bass do feed actively in the winter and it is likely some of the difference in growth

Table 1. Striped bass age and size (mm) information from Lake Norman. The 1986–1988 data are back-calculated length at annulus and the 1990s data are length at capture assuming the margin is an annulus.

		Age					
Year		2	3	4	5	6	7
1986–1988[a]	$\bar{x}$	542	612	659	715	764	755
	N	206	165	87	39	20	10
1994	$\bar{x}$	533	569	588	641	690	
	SD	21	19	24	43	45	
	N	34	23	16	2	3	
1996	$\bar{x}$	430	487	536	541		
	SD	35	29	35	72		
	N	20	18	19	4		
1997	$\bar{x}$	413	552	567	607	604	634
	SD	37	23	25	57	56	70
	N	18	20	19	27	19	4
1998	$\bar{x}$	444	496	533	572	613	
	SD	35	20	54	19	95	
	N	34	25	6	6	3	

a. Clawson et al. 1989

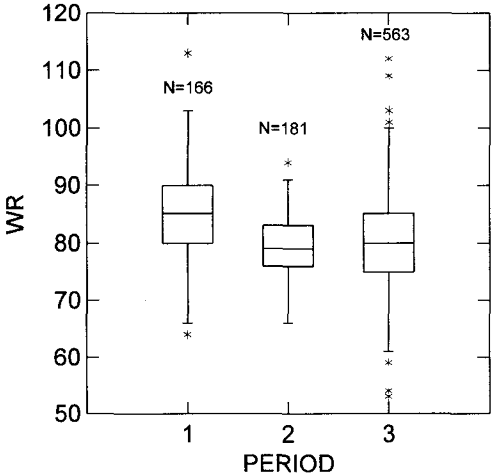

Figure 2. Box plot, including median (centerline), range, and quartiles (box edges), of Lake Norman striped bass relative weights (Wr) computed for fish collected by gill netting and fishing tournaments from Period 1 (1985–1988, May–Nov), Period 2 (1994–1998, Jun–Jul) and Period 3 (1994–1998, Nov–Jan).

between Clawson et al.'s data and ours can be attributed to methodology. Clawson's data was back calculated length at annulus thus incorporating a full year's growth. We report length at capture and miss that increment of growth occurring between about mid-December and actual annulus formation.

Striped bass Wr's differed among pre-1992 ($\bar{x}$=85%), post-1992 early season ($\bar{x}$=79%), and post-1992 late season ($\bar{x}$=80% samples (P<0.001) (Fig. 2). The

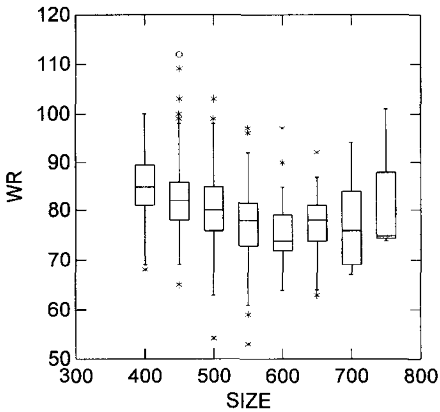

Figure 3. Box plot, including median (centerline), range, and quartiles (box edges), of relative weights (Wr) by length (mm) for striped bass collected by gill netting and fishing tournaments at Lake Norman.

pre-1992 samples differed from the early season samples ($P<0.001$) and the late season samples ($P<0.001$). The 2 most recent Wr means also differed ($P=0.015$). Striped bass Wr's were generally lower for larger fish in Lake Norman (Fig. 3). We observed many fish >500 mm. with Wr's ≤75%.

The sources of poor body condition of striped bass in Lake Norman likely are high summer temperatures and poor forage availability. Coutant (1985) argued warm water temperatures (>25 C) cause striped bass mortalities in many southeastern reservoirs, especially among fish >5 kg. Poor summer habitat conditions (water temperatures >26 C) in Lake Norman typically occur somewhere between mid-July and mid-September (Van Horn et al. 1996). During the more severe episodes, striped bass may be physically isolated from their usual prey base and may cease feeding even though prey are available (Lewis 1983, Coutant 1985, and Zale et al. 1990). Lewis (1983) found striped bass in Lake Norman concentrated in cooler water and were less able to exploit the available shad forage base as reservoir temperatures reached their maximum in Lake Norman.

However, early season Wr's demonstrate that poor striped bass body condition in Lake Norman is not exclusively a response to poor summer habitat quality. Siler et al. (1986) observed that clupeid biomass, especially the threadfin shad, in Lake Norman may reach its maximum in late fall and then collapse as dropping water temperatures depress shad survival. Winter kill of clupeids may deplete striped bass forage early in the growing season. Clawson et al. (1989) found distended gall bladders in nearly half the striped bass examined in Lake Norman in April 1987 and again in 1988. Distended gall bladders indicated the fish had not fed for a prolonged time (Coutant 1985).

Early season 1996 (mean Wr <80%) was followed by an unseasonably cool and wet summer. Cool (<26 C), oxygenated (dissolved oxygen >2 mg/liter) water was continuously present throughout the reservoir (DPC unpubl. data). However, mean Wr remained low in the late season sample (<80%). Poor striped bass body condition in both early and late season samples in a year with little adverse warm water temperature stress suggests an inadequate prey base.

In a worst case scenario at Lake Norman, a cold winter severely depresses the clupeid forage available in mid-winter and spring. A dry, hot summer then creates temperature/dissolved oxygen stress that can delay the striped bass' ability to exploit more effectively an expanding clupeid biomass. As fall temperatures begin to alleviate the thermal stress in late September, the striped bass may have only several months to feed heavily on clupeids before cold weather again depresses the shad population.

The relationship between striped bass growth and condition, and changing stocking rates and harvest regulations is confounded by a number of factors in Lake Norman. There has been a rapid increase in blue catfish *(Ictalurus furcatus)* and flathead catfish *(Ictalurus pylodictis)* in the lake since the mid-1980s. Both species will readily eat clupeids. Lake Norman was stocked with nearly twice the prescribed number of striped bass in 1994. This big "year class" of fish may have exacerbated growth and condition problems. Finally, DPC rotenone and purse seine samples hint at a decrease in the presence of gizzard shad in the lake (DPC unpubl.) since the mid-1980s. Fewer of the larger (>100 mm) overwintering gizzard shad would make striped bass more dependent upon small (<100 mm) seasonally abundant threadfin shad.

Our results indicate forage is insufficient to provide good growth and condition for striped bass above the existing size limit (508 mm) in Lake Norman. We conclude the strategy of using higher stocking rates and more restrictive harvest regulations to increase the number of large (>5 kg) striped bass is hampered by an insufficient prey base and cannot succeed in Lake Norman.

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