CONTRIBUTION OF STOCKED FINGERLING WALLEYES IN LAKE JAMES

Final Report

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Douglas A. Besler
Regional Research Coordinator

North Carolina Wildlife Resources Commission
Division of Inland Fisheries
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Abstract.—Approximately 30,000 walleye *Sander vitreus* fingerlings were marked with oxytetracycline hydrochloride (OTC) and stocked in Lake James in May 2000–2002 to measure the contribution of stocked fingerlings to the sport fishery. Gillnetting was conducted during October–November in 2001–2003. Total catch of age-1 walleyes varied between years (range, 51–94). The percent of marked age-1 walleyes was consistently low and ranged from 2.1–3.7%. The proportionate contribution reported for all years was substantially below the criteria used to determine stocking success. It is recommended that fingerling walleye should not be stocked in Lake James.

In 1949, the North Carolina Wildlife Resources Commission (NCWRC) introduced 10,000 walleye *Sander vitreus* fry into Lake James. By 1954, over 1 million fry had been stocked (Table 1). As a result of these stockings, walleyes became established and have provided a popular sport fishery in Lake James.

Walleye stockings in Lake James were halted by 1955 and the population was maintained by natural reproduction. Walleye spawning has been documented in two tributaries of Lake James, the Linville and Catawba rivers (Brown and Kearson 1986). The NCWRC currently obtains walleyes for spawning from the Catawba River near its confluence with Lake James. In addition, a section of the Linville River from the mouth at Lake James upstream to the NC 126 bridge is seasonally closed to angling from 15 February through 15 April to protect spawning walleyes. Walleye reproduction may also occur within the reservoir, but spawning activity has not been documented (Brown and Kearson 1986).

Angling interest for walleyes has increased in the past 25 years. Increased demand for walleye angling opportunities, coupled with a lack of knowledge about the species, led many state resource agencies to develop supplemental stocking programs. A total of 29 state agencies operated walleye stocking programs by 1991 (Fenton et al. 1994). As a result of public concern over a perceived decline in the Lake James walleye fishery, the NCWRC resumed walleye fry stockings in 1977 to supplement natural reproduction (Table 1). Fry stockings were phased out after 1986 as production efforts switched to rearing walleye fingerlings. Fingerling stockings in Lake James began in 1988 at a recommended rate of 11/ha, or approximately 30,000 fingerlings annually. The actual number of walleye fingerlings stocked from 1988–1998 was highly variable and ranged from 16,128–313,857 (mean, 112,010) per year, with additional periodic stocking of excess fry (Table 1). Walleye fingerlings stocked in excess of the recommended rate was largely the result of public pressure to return all walleye progeny produced from Lake James spawning stock back into the reservoir. Stocking rates since 1999 have remained at 30,000 fingerlings per year.

Supplemental stocking of walleye is a common management practice in the U.S., although its effectiveness has not been widely investigated (Li et al. 1996a). Walleye stocking programmatic goals are usually designed to establish, supplement, or maintain populations (Laarman 1978). To be successful, supplementally stocked walleyes must contribute to the abundance of the fishable population. Li et al. (1996a) concluded after reviewing data on 200 Minnesota lakes that stocking walleye fingerlings in lakes with natural reproduction did not improve age-1 recruitment and recommended such lakes should not be stocked. It was also found that although the abundance of a naturally reproduced year class increased with supplemental stocking on some lakes, the abundance of year classes one year younger and one year older decreased (Li et al. 1996b). Similarly, Laarman (1978) reviewed walleye introductions on 125 separate water bodies and concluded that only 5% of those programs that utilized supplemental stocking as a management tool were considered successful. Nate et al. (2000) found that total walleye abundance was higher in Wisconsin lakes with natural reproduction compared to those sustained through stocking. They concluded that poor first-year survival of stocked walleyes may be a factor contributing to the consistently lower recruitment.

In contrast to supplemental stockings in the presence of naturally producing populations, maintenance stocking of walleye fry or fingerlings has been successful in systems where natural reproduction or recruitment was a limiting factor. Recruitment of walleyes and formation of year-class size is often highly variable and can be affected by both density-independent and density-dependent mechanisms (Fielder 1992; Kayle 1992). Madenjian et al. (1996) found that 98% of the variation in western Lake Erie walleye recruitment was a function of spawning stock size, water temperature, and the density of gizzard shad *Dorosoma cepedianum*. McWilliams and Larscheid (1992) found that 50–150 mm walleye fingerlings stocked at a rate of 30–68/ha into West Okoboji Lake, Iowa, comprised from 70–99% of the age-0 population. First year mortality of stocked walleyes in this system, however, was 2–16 times greater than naturally reproduced fish. Cannibalism was listed as a major factor regulating recruitment of walleyes in Oneida Lake, New York, and was found to be inversely related to walleye growth rates (Forney 1976). Hansen et al. (1998) found the number of age-0 walleyes produced and surviving through the first summer was regulated largely by early mortality associated with cannibalism, intraspecific competition, and water temperatures.

The supplemental stocking of walleye fingerlings in Lake James costs the NCWRC an estimated US$5,000 annually, or $0.17 per fingerling (C. J. Kittel, NCWRC, personal communication). However, because walleye stockings have not been evaluated, the cost of a stocked walleye contributing to the sport fishery on Lake James is unknown. A study of supplemental stocking in Virginia estimated that a stocked walleye harvested by an angler costs an average of $27.00 per fish (Murphy et al. 1983). In order to allow better use of limited NCWRC resources and manpower, the contribution of supplementally stocked walleyes in Lake James needs to be determined. The objective of this study was to measure the contribution of stocked fingerling walleyes to the age-1 population in Lake James over a three year period. Results of this study will be used to develop appropriate walleye management strategies for Lake James.

Methods

In March 2000–2002, walleye brood stock were collected via electrofishing from the Catawba River immediately upstream of Lake James and transported to the NCWRC Table Rock State Fish Hatchery, Morganton, North Carolina. Walleyes were strip-spawned at the hatchery and the fertilized eggs were transferred to hatching jars. After hatching and swim-up, fry were transferred to outdoor ponds and reared to approximately 50 mm total length.

In May 2000–2002, approximately 30,000 walleye fingerlings were collected from the ponds and transferred to 1.8-m diameter round fiberglass tanks. Walleye fingerlings were immersed in a solution of 500 mg/L oxytetracycline hydrochloride (OTC) and 1000 mg/L sodium chloride, buffered with tris to a pH of 6.5–6.9, for six hours. A subsample of 400 walleye fingerlings were held for 30 days at the hatchery and fed a diet of fathead minnow *Pimephales promelas* fry. Walleye fingerlings were stocked 24 h post-marking at a rate of approximately 11 fish/ha by boat in main channel areas throughout Lake James. Twenty-four hour survival was estimated by placing a random subsample of 100 walleye fingerlings into in a 0.9-m^3 net pen set on the bottom of the lake at a depth of approximately 10 m. Numbers of walleye fingerlings alive after 24 h were enumerated.

After 30 days post-marking in 2000–2002, sagittal otoliths were removed from a random subsample of 100 walleyes held at the Table Rock State Fish Hatchery. One whole otolith from each walleye was bonded to a microscope slide using ethyl cyanoacrylate (super glue) and viewed whole under a Nikon Eclipse E400 compound microscope under transmitted epiflourescent light. If an OTC mark was not found, the otolith was then lightly sanded (4–5 strokes) using 400 grit wet-dry sandpaper and re-viewed. This process was repeated until the OTC mark was identified or the focus had been reached. Mark efficacy was determined as the visibility of fluorescent OTC marks; qualitatively rated as absent, fair, good, or bright (Lorson and Mudrak 1987).

Twelve fixed gill net locations were established by the NCWRC on Lake James in 1999 to standardize walleye sampling (Figure 1). These sites were located on lake points with a moderate slope of 25–45^{o} using a stratified non-random design to represent all areas of the lake. One experimental gill net was set at each site on 6-9 November 2001, 5-8 November 2002, and 21-24 October 2003. Gill net dimensions were 2.4 x 76.3 m and consisted of five 2.4 x 15.3-m panels with 25-, 32-, 38-, 44- and 51-mm bar mesh. All nets were bottom-set perpendicular to shore for 24 h. The mesh size towards shore was randomly selected for each net set. Gill nets were run in the same order they were set. All walleyes captured were separated by site and mesh size, bagged with an identifying site label, measured for total length (mm), and given a unique identification number. Saggittal otoliths were removed and placed in plastic otolith vials with a unique identification number, stored in the dark, and allowed to air-dry for 14 d. Otoliths were then immersed in water and viewed under reflected light using a 10x dissecting microscope (Hammers and Miranda 1991). Otoliths were read twice to verify age.

Age-1 walleye otoliths were mounted in epoxy resin and the otolith kernels were sectioned using an Isomet low-speed saw. Thin sections were mounted to a glass side with ethyl cyanoacrylate, and viewed under the epiflourescent microscope using the same methods as the mark efficacy portion of the study. The presence, absence, and quality of the OTC marks were recorded for each age-1 walleye.

One gill net night was used as the unit of effort. The mean number of marked and unmarked age-1 walleyes captured per net night was used as a measure of relative abundance. Relative abundance of stocked (OTC marked) and naturally reproduced age-1 walleyes were compared using a Mann-Whitney nonparametric test. All statistical tests declared significance at α=0.10 and utilized the SYSTAT computer software package (SYSTAT 2000).

The proportionate contribution of stocked walleyes to their corresponding year-classes was estimated by dividing the number of marked age-1 walleyes, adjusted for OTC mark loss, by the total number of age-1 walleyes captured. Mark loss was accounted for by multiplying the number of marked fish by 1.x, where x equals the percent rate of mark loss. Walleye fingerling stocking will be considered successful if the proportionate contribution at age-1 is 25% or greater. This relatively low success criterion was arbitrarily selected because there are no standard evaluation criteria in other documented studies to evaluate walleye stocking success and in an effort to be conservative.

Results and Discussion

Twenty-four hour post-stocking survival of age-1 walleyes in Lake James was relatively high, except for 2002 (Table 2). Hot weather conditions and handling stress during harvest from the rearing pond in 2002 may have led to relatively low 24-h survival. Additional walleyes were OTC marked and stocked in Lake James within one week of the original stockings in 2002 to compensate for the observed mortalities (Table 2). The 24-h survival rate of the second stocking of walleyes in 2002 was similar to the 2000 and 2001 stockings. Other studies have reported that tetracycline marking did not influence short-term survival of stocked walleyes (Peterson and Carline 1996).

Oxytetracycline mark retention of walleyes held at the hatchery for 30 d was 100% in all years. Mean mark quality, however, varied considerably between years (Table 3). The higher incidence of "fair" marks in 2001 may have been the result of variable water quality in the marking tank. In 2001, pH levels in the marking tank were near the low end of the optimal range (6.5–6.9) for a longer period of time than in 2000 or 2002. Because mark retention was 100%, despite the variability in mark quality in 2001, adjustments were not made in any year for tag loss. Other studies evaluating the contribution of stocked walleyes with concentrations of OTC and immersion times used in this study reported high marking success (Brooks et al. 1994; Lucchesi 2002).

Total catch of age-1 walleyes ranged from 53–94 each year (Table 4). Overall, age-1 walleyes were captured at a rate of 4.4 fish/net night in 2001, 7.8 fish/net night in 2002, and 6.9 fish/net night in 2003 (Table 4). Naturally reproduced age-1 walleyes were captured at significantly ($P = 0.001$) higher rates than OTC-marked age-1 walleyes in all years (Table 4). Dispersal of walleyes post-stocking has been a confounding factor in other walleye stocking evaluations because stocked walleyes were not given enough time to disperse to all locations in the water body prior to sampling (Parsons and Pereira 1997). Post-stocking dispersal should not have been a factor in this study since walleyes were stocked in all lake regions by boat and approximately 18 months passed between stocking and gill netting for each year class.

Age-1 walleyes captured in gill nets were similar in length between years, ranging from 265–406 mm (Figure 2). Differences were found each year in the lengths of age-1 walleyes between the two major regions in Lake James (Linville and Catawba). Overall, mean lengths of age-1 walleyes captured from the Catawba region of Lake James were 20 mm larger than age-1 walleyes captured from the Linville region (Figure 3). The length differential observed among regions in Lake James has been previously documented for age-0 (Besler 2002) and adult walleyes (Besler 2000, Besler 2001). The Catawba region of Lake James is considerably more eutrophic than the Linville region (NCDENR 1998) and might be a factor contributing to the size variations. Although age-1 walleye lengths varied among lake regions, 88% of age-1 walleyes were captured in the mid gill net panels (32-mm & 38-mm); this suggests that age-1 walleyes were fully recruited and vulnerable to the gill nets used in this study, regardless of reservoir sampling location.

Stocked walleyes contributed to the age-1 walleye population in Lake James at a low rate. The proportionate contribution of OTC-marked age-1 walleyes ranged from 2.1–3.7% in all three years and was far below the arbitrary criteria (25%) used to establish stocking success (Table 5). In a 1990 walleye symposium, ten studies documented 96 walleye stocking attempts to create or enhance walleye fisheries in North America (Ellison and Franzin 1992). Of those, Only 37 stocking attempts reported in the symposium were successful to some degree (Ellison and Franzin 1992). Most studies that have documented failures of individual walleye stockings were in systems with established walleye populations with natural reproduction (Ellison and Franzin 1992; Li et al.1996a; Nate et al. 2000). Most walleye stocking evaluations, including this study, were designed to determine success or failure of individual stockings and were not designed to determine the mechanisms responsible for that success or failure. It is likely, however, that high levels of consistent walleye natural reproduction in Lake James is the reason for the low proportionate contribution of stocked fish. The current walleye supplemental stocking program does not substantially contribute to the abundance of the fishable population in Lake James.

Conclusions

Based on the high level of natural reproduction relative to stocked fish, the fingerling walleye stocking program in Lake James has had minimal success in supplementing the sport fishery and is unnecessary for maintaining a walleye population. It is also likely that few stocked walleyes are harvested by anglers, making the stocking of walleyes expensive in terms of direct agency costs and manpower. Oxytetracycline mass-marking walleyes was a valuable tool to effectively determine stocking success in this study and should be used in future walleye stocking evaluations.

Demands on the NCWRC for supplementing walleye populations in other reservoirs in western North Carolina are increasing. The NCWRC recently initiated an experimental walleye stocking program in Hiwassee Reservoir, Cherokee County, in 2004 after documenting consistent failures in walleye reproduction (D. L. Yow, NCWRC, personal communication). The resources of the NCWRC hatchery system currently used to supplement the Lake James walleye fishery would be better allocated providing hatchery-reared walleyes for those reservoirs with documented needs for stocking.

Recommendations

1) Discontinue stocking fingerling walleyes in Lake James.

2) Monitor Lake James walleye population to verify sustained natural reproduction and walleye abundance.

3) Evaluate future stocking of walleyes in North Carolina with oxytetracycline.

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TABLE 1.–Summary information for walleyes stocked into Lake James by the NCWRC from 1949–2004. Size of walleyes stocked are categorically listed as fry (<25 mm TL or listed as fry on stocking records), fingerling (>25 mm TL), or adult (listed as adult on stocking records).

Year	Number stocked	Size	Number/ha
1949	10,000	Fry	3.8
1950	30	Adult	0.1
1952	15,000	Fry	379.6
1954	1,000,000	Fry	5.7
1977	200,000	Fry	75.9
1978	1,000	Fry	0.4
1981	1,082,694	Fry	410.9
1982	1,627,980	Fry	617.8
1983	1,000,311	Fry	379.6
1984	1,411,107	Fry	535.5
1985	1,860	Fry	0.7
1986	31,297	Fry	11.9
1988	16,128	Fingerling	6.1
1989	150,158	Fingerling	56.9
1990	313,857	Fingerling	119.1
1991	162,985	Fingerling	61.9
1992	55,000	Fry	20.9
1992	48,735	Fingerling	18.5
1993	121,659	Fingerling	46.2
1994	183,603	Fingerling	69.7
1995	62,943	Fingerling	23.9
1996	71,529	Fingerling	27.1
1997	359,528	Fry	136.4
1997	70,515	Fingerling	26.8
1998	500,000	Fry	189.8
1998	30,000	Fingerling	11.4
1999	30,000	Fingerling	11.4
2000	30,000	Fingerling	11.4
2001	30,000	Fingerling	11.4
2002[A]	41,400	Fingerling	15.7
2003	30,000	Fingerling	11.4
2004	30,000	Fingerling	11.4

[A] 11,400 additional walleyes were stocked in 2002 to compensate for stocking mortality.

TABLE 2.–Summary stocking and 24-h survival data for walleyes stocked into Lake James during May in 2000–2002. ND = no data.

Year	Walleyes stocked	Mean length (mm) (SE)	Number of survival cages	Walleyes per cage	Percent 24-h survival
2000	30,000	45.3 (0.6)	1	100	96
2001	30,000	50.0 (0.5)	1	100	98
2002	30,000	51.7 (0.3)	1	100	62
2002	11,400	ND[1]	1	100	96

[1]Walleyes stocked from same batch as previous 2002 stocking.

TABLE 3.–Visibility of fluorescent oxytetracycline marks (as measured by the percent assigned to each mark-visibility category) on otoliths from age-0 walleyes treated at Table Rock State Fish Hatchery.

		Percent by mark-visibility category			
Year	N	Absent	Fair	Good	Bright
2000	100	0	1	43	56
2001	100	0	58	22	20
2002	100	0	0	1	99

TABLE 4.–Sample data, CPUE (number of age-1 walleyes/net night), and associated standard errors (SE) for age-1 walleyes captured in gill nets from Lake James during October–November in 2001–2003. Summary statistics also listed for Oxytetracycline marked and unmarked age-1 walleyes.

	Year		
Summary statistic	2001	2002	2003
Gill net sets	12	12	12
Number of age-1 walleyes collected	53	94	83
Mean total length (mm) (SE)	363 (2.9)	364 (4.4)	339 (1.4)
Mean overall age-1 walleye CPUE (SE)	4.4 (1.4)	7.8 (2.0)	6.9 (1.3)
Mean marked age-1 walleye CPUE (SE)	0.2 (0.2)	0.2 (0.2)	0.3 (0.1)
Mean unmarked age-1 walleye CPUE (SE)	4.2 (1.4)	7.6 (1.9)	6.6 (1.2)

TABLE 5.–Percent contribution and visibility of fluorescent oxytetracycline marks (as measured by the percent assigned to each mark-visibility category) on otoliths from age-1 walleyes collected from Lake James during October–November in 2001–2003.

		Percent contribution	Percent by mark-visibility category			
Year	N	to age-1 year class	Absent	Fair	Good	Bright
2001	53	3.7	96	0	4	0
2002	94	2.1	98	1	1	0
2003	83	3.1	97	1	2	0

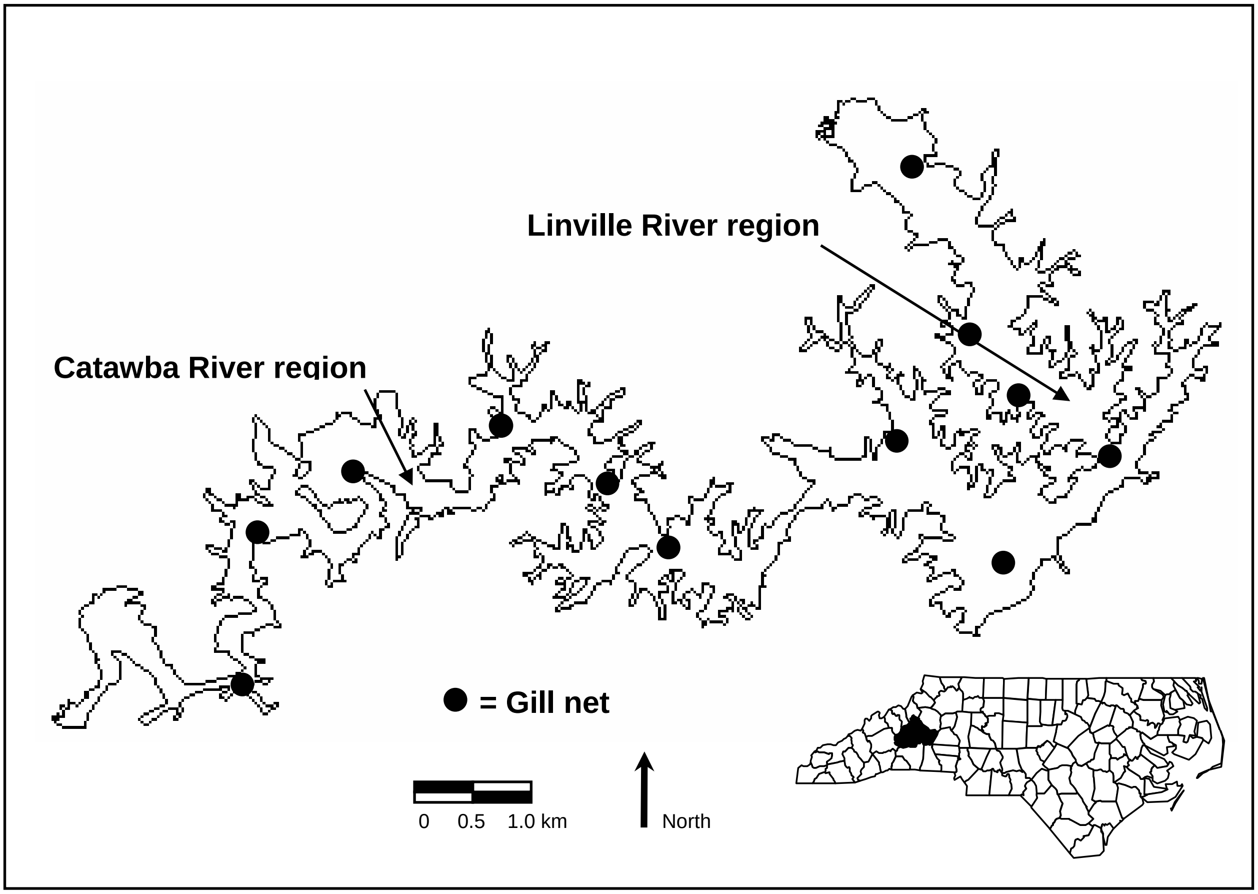

FIGURE 1.–Map of Lake James, Burke and McDowell counties, North Carolina. Identified areas are the major regions of the reservoir. Dark circles indicate walleye gill net sampling locations used on 6–9 November 2001, 5–8 November 2002, and 21–24 October 2003.

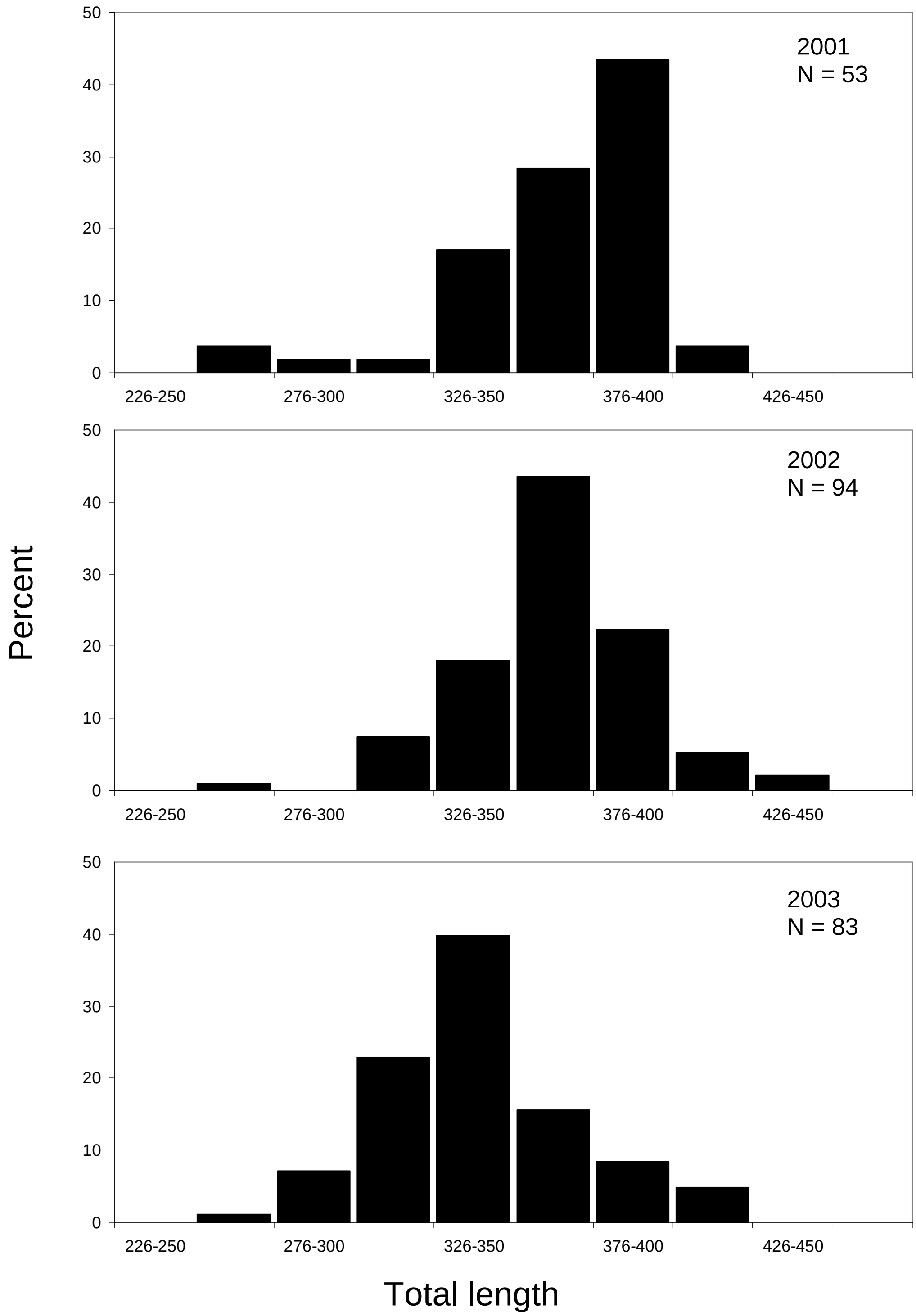

FIGURE 2.–Length frequency histograms of age-1 walleyes captured in gill nets from Lake James, 6–9 November 2001, 5–8 November 2002, and 21–24 October 2003.

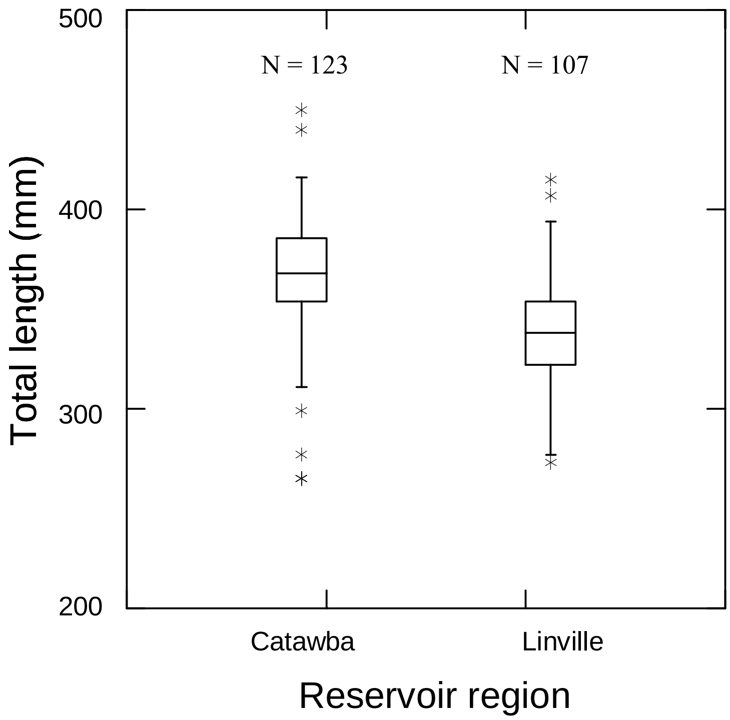

FIGURE 3.–Box plots depicting total length values of age-1 walleyes captured from Lake James in 2001–2003, by lake region. Age-1 walleyes were captured with gill nets in the Catawba and Linville regions of Lake James 6–9 November 2001, 5–8 November 2002, and 21–24 October 2003. Center horizontal lines within each box represent the median value, while the box itself represents the range within which the central 50% of the values fall. Vertical lines and asterisks outside the box represent outliers to the central 50% of the values.