Growth Rates of Stocked Walleye in Several Georgia Reservoirs

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Abstract: The walleye (*Sander vitreus*) is a large predatory fish distributed throughout Canada and the United States, ranging from Central Canada southward to the Tennessee and Mississippi River drainages. Because of its importance as a recreational sportfish, walleye growth has been studied extensively in the northern portion of its distribution. However, little information is available regarding growth of this species in the southeast, particularly in Georgia. The objectives of this study were to quantify growth of walleye in several north Georgia reservoirs and to compare the growth rates of walleye in north Georgia to the growth rates of walleye throughout North America. Anchored gill nets and boat electrofishing were used to collect walleye on five different impoundments from April 2009 to September 2010. Age estimates for each of 115 walleyes were obtained by counting growth annuli from transverse sections of sagittal otoliths. Length-at-age data from each population were then fit to the von Bertalanffy growth model to estimate growth rates of each population. Growth rates of north Georgia populations were then compared to growth rates of populations from other parts of North America. Our results suggest that growth rates of walleye in north Georgia are among the fastest documented in North America. We suggest that further studies are needed to better understand survival and harvest rates of stocked walleye in north Georgia reservoirs.

Key words: walleye, age, growth, Georgia, reservoirs

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The walleye (*Sander vitreus*) is a large predatory fish distributed throughout the United States and Canada, ranging from central Canada southward to the Tennessee and Mississippi River drainages (Carlander 1997). The walleye has been extensively studied throughout its range, and presently, its life history, population dynamics, foraging habits and environmental tolerances are well understood. Walleye are relatively long lived, with individuals in northern populations reaching a maximum age of 24 years (Mathias et al. 1985). Depending on sex, walleye mature between 2 and 6 years of age and at sizes between 270 and 432 mm TL, with females maturing at later ages and at larger sizes than males (Carlander 1997). Walleye spawn in the early spring months of the year, depositing eggs over hard substrates at temperatures between 1.1 and 11.1 C (Scott and Crossman 1973). As larvae, walleye forage primarily on zooplankton and are particularly sensitive to food availability; during this period, low zooplankton availability is linked to poor year class strength (Peterson et al. 2006). After transitioning to the juvenile stage, walleye begin to forage on benthic invertebrates, and as adults, they are primarily piscivorous (Scott and Crossman 1973, Colby et al. 1979). Walleye are particularly sensitive to high temperatures (>31 C) and low dissolved oxygen levels (<1.5 mg/L), and as such, their distribution is restricted to cool water systems with high dissolved oxygen levels (Hokanson 1977, McMahon et al. 1984).

Because of their popularity among recreational anglers, walleye have been widely introduced into lakes, rivers, and reservoirs outside their native range (Colby et al. 1979, Quinn 1992, Quist et al. 2003). In Georgia, walleye are native to the Tennessee River drainage which extends into the extreme northern portions of the state (Lee et al. 1980). Beginning in the early 1960s, the Georgia Department of Natural Resources (GADNR) began stocking walleye fry and fingerlings into several north Georgia reservoirs with the objective of expanding cool water fishing opportunities for recreational anglers (Rabern 1989). Of the 12 reservoirs initially stocked, three developed self-sustaining walleye populations. Despite these initial successes, walleye abundance slowly declined in subsequent years, and by 1985, the fish were so rare that few anglers continued to target them. Declines in abundance were attributed to unfavorable spring flow regulation that limited spawning habitat and resulted in persistent recruitment failure (Rabern 1989). In the early 1990s, renewed interest in recreational walleye fishing led to the resumption of walleye stocking in several north Georgia impoundments. In 1990, walleye fry stocking was initiated in Lake Seed and reinitiated in Lake Burton (Rabern 1998). The stocking program was subsequently expanded to include lakes Tugalo, Yonah, and Rabun in 2001; Carter's Lake in 2003; and Tallulah Falls Reservoir, Lake Hartwell, and Lake Lanier in 2005. Because annual assessments by the GADNR suggest that natural reproduction is too low to maintain populations in these impoundments, walleye fingerlings (20–45 mm TL) of Pennsylvania and Tennessee origin are stocked annually to maintain populations at fishable levels. As such, walleye in north Georgia are essentially managed as a put, grow, and take fisheries (A. Rabern, GADNR, personal communication).

To properly manage a fish population using a put, grow, and take management strategy, quantified information on growth of stocked individuals is critical to understanding factors affecting survival and, ultimately, yield to the fishery. Unfortunately, information regarding walleye growth in north Georgia is limited to a single study of the Lake Burton population (Rabern 1989). Though this study provided important information about walleye growth in Georgia, further studies are necessary to provide managers with a better understanding of the potential for expanding recreational walleye fisheries within the state. By synthesizing information regarding walleye growth in relation to stocking rates, fisheries managers can maximize effectiveness of stocking programs to meet specific management objectives. Furthermore, comparisons of growth between north Georgia walleye populations and populations in other areas may also provide new insights into the factors that influence walleye growth throughout their range, particularly in the Southeastern United States. The objectives of this study were to (1) quantify growth of walleyes in north Georgia reservoirs and (2) compare growth of walleye in north Georgia Reservoirs to other walleye populations nationwide.

Study Area

Walleyes were collected from four reservoirs in north Georgia from November 2009 to March 2010: lakes Seed (97 ha), Yonah (131 ha), Tugalo (241 ha), and Lanier (15,597 ha). Located within the Blue Ridge Mountain region in north Georgia, all four impoundments are operated for hydropower generation and to provide municipal water supplies. Primary forage fish species within lakes Seed, Yonah, and Tugalo consist of yellow perch (*Perca flavescens*), blueback herring (*Alosa aestivalis)*, gizzard shad (*Dorosoma cepedianum*), golden shiner (*Notegomigonus crysoleucas*), and whitefin shiner (*Cyprinella nivea*) (Rabern 1998). In Lake Lanier, the forage base consists of blueback herring, gizzard shad, threadfin shad (*Dorosoma petenense*), spottail shiner (*Notropis hudsonius*), and brook silverside (*Labidesthes sicculus*) (U.S. Army Corps of Engineers 2009). All four reservoirs support popular recreational fisheries for black bass (*Micropterus sp.*); however, Lake Lanier also supports a popular recreational fishery for landlocked striped bass (*Morone saxatilis*).

Methods

In each impoundment, walleye were collected using monofilament, bottom-set gill nets comprised of multiple mesh sizes from 2.5–10.2 cm (stretch). All nets were 3-m deep and 30.5- or 91.4-m long, depending on channel width. Nets were deployed at sunset on 6, 18, 20, and 23 November 2009, and fished overnight. To increase sample size from Lake Lanier, an additional 19 fish ($n = 19$) were captured on 4 and 16 March 2010, using a pulsed DC boat electrofisher equipped with a Wisconsin style electrode. All captured fish were immediately killed and stored on ice for later processing. In the laboratory, TL of each fish was measured to the nearest mm and sagittal otoliths were extracted via the method of Schlueter (1989). Otoliths were prepared for aging by initially breaking them in half perpendicular to their longitudinal axis. The larger portion of each otolith was then mounted to a glass slide using epoxy, exposing the transverse section. The fractured surface was then sanded until opaque and hyaline zones were easily discernable with fiber optic illumination. Opaque zones were then counted as annuli using 10x magnification (Heidinger and Clodfelter 1987). Counts were verified by the consensus of two independent readers, with disagreements resolved by a third independent reader. Length-at-age for each walleye was then estimated based on the number of annuli present. Age assignments of each individual were based on the convention of DeVries and Frie (1996). Finally, growth was calculated using the von Bertalanffy growth model (von Bertalanffy 1938), which has the form:

$$L = L_{\infty} + (1 - e^{(-K\,(age - Tzero))})$$

where: L = Predicted total length (mm), $L\infty$ = Maximum total length (mm), K = Growth rate, and Tzero = Time at length zero.

Von Bertalanffy model parameters were calculated using non linear regression (PROC NLIN) in the Statistical Analysis System (SAS; Freund and Littell 1991).

Reservoirs were classified according to their location in either the Chattahoochee River chain (Lake Lanier) or the Tallulah River chain (lakes Seed, Yonah, and Tugalo) of reservoirs. To assess potential differences in growth between reservoir chains, a separate von Bertalanffy growth model for each reservoir chain was constructed. Because we did not determine the sex of walleye sampled in north Georgia, sex specific models were not constructed.

Growth curves for each reservoir chain were then compared to the North American average calculated by Quist et al. (2003) to assess potential differences in growth. Because the national average calculated by Quist et al. was based on studies that used back calculation to determine length-at-age, we adjusted length-at-age in our samples by adding 1 yr to the age assignments of each fish in our samples to account for growth beyond the last annulus. Esti-

Table 1. Sample size (*n*), mean total length (mm, sample size within age-class in parenthesis), and 95% confidence interval for walleye in four north Georgia reservoirs.

		Age						
Reservoir	***n***	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Lanier	32	385 (8)	424 (15)	491 (6)	–	522 (3)	–	–
CI 95%		312 – 458	368 – 479	405 – 577	–	471 – 572	–	–
Seed	36	356 (2)	426 (4)	435 (24)	494 (5)	–	–	549 (1)
CI 95%		353 – 358	313 – 538	329 – 540	408 – 580	–	–	–
Tugalo	22	337 (13)	428 (2)	458 (6)	598 (1)	–	–	–
CI 95%		285 – 389	310 – 545	382 – 534	–	–	–	–
Yonah	25	333 (9)	442 (4)	450 (4)	465 (1)	572 (2)	–	–
CI 95%		285 – 381	378 – 506	361 – 540	–	530 – 614	–	–
Tallulah River Chain Total	83	337 (24)	433 (10)	442 (34)	505 (7)	572 (2)	–	579 (1)
CI 95%		288 – 386	346 – 519	344 – 540	395 – 614	530 – 614	–	–

mated age at stock (>250 mm TL), quality (>380 mm TL), and preferred size (>535 mm TL; Gabelhouse 1984) were then calculated for walleye populations in each reservoir chain for subsequent comparisons with other North American population.

Results

During the study, a total of 115 walleye were collected from the four reservoirs (Table 1). Total length of sampled fish varied from 297–598 mm. Annuli counts showed that captured fish ranged from age 1–7 and that initial agreement of age estimates between the two independent readers was 93%. Parameter estimates of the von Bertalanffy growth curve for populations in each reservoir chain indicated that growth was similar between reservoir chains (Table 2). Growth curves suggested that young walleye grew fastest in Lake Lanier, but by age-4, walleye in the Tallulah River chain were predicted to be larger than those in Lake Lanier (Figure 1). Maximum predicted size (800 mm TL) also was larger in the Tallulah River chain than in Lake Lanier (622 mm TL).

Comparisons of growth indicated that size-at-age of walleye is greater in north Georgia than the North American average (Figure 1). In the Tallulah chain, walleye reached stock size during their first year, quality size during their third year, and preferred size during their fifth year. In Lake Lanier, walleye reached stock size during their first year, quality size during their second year, and preferred size during their fifth year. Based on the North American average, walleye are predicted to reach stock size during their second year, quality size during their third year, and preferred size during their sixth year.

Discussion

The results of this study suggest that growth rates of walleye in north Georgia are among the fastest documented for any population in North America. Rapid growth of walleye has been observed in other southern systems; growth rates in Arkansas, Kansas, Texas, and Tennessee exceed the range wide average (Carlander 1997, Quist et al 2003). Walleye are often managed as a "cool water" species; however, the combination of mild winter temperatures, prolonged growing season, and abundant forage in southern systems may provide walleye with optimal growing conditions. Rapid growth of walleye in southern systems has important implications for the management of these fisheries. Managers can take advantage of the relatively early ages that walleye reach stock, quality and preferred sizes in southern systems when managing and promoting recreational walleye fisheries. Our findings show that walleye fingerlings stocked in north Georgia impoundments recruit to stock size during their first year. Quality size walleye become

Table 2. Von Bertalanffy growth curve parameters for walleye in North Georgia reservoirs and the North American average calculated by Quist et al. 2003.

	L_∞	K	T_{zero}
Tallulah River reservoirs	800	0.137	–2.072
Lake Lanier	622	0.241	–1.913
North American average	610	0.300	0.148

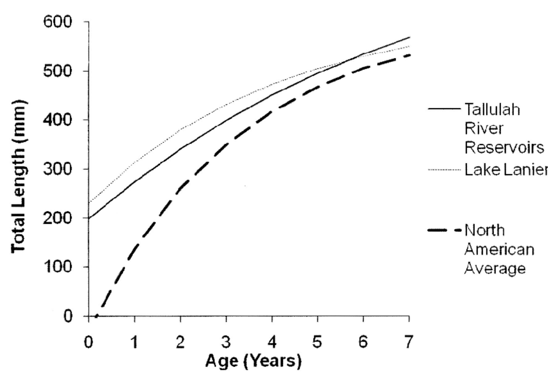

Figure 1. Von Bertalanffy growth curves for walleye in north Georgia reservoirs and the North American average calculated by Quist et al. 2003.

available during their second or third year, depending on reservoir chain, and by the end of their fifth year, walleye in both reservoir chains are predicted to reach preferred size. Because angler satisfaction is positively related to sportfish size, significant economic and social benefits may be realized shortly after the initiation of a walleye stocking program in southern impoundments (Anderson 1980, Gabelhouse 1984).

Despite the excellent growth rates documented in this study, the data used to calculate these growth rates had several important limitations. First, several previous studies have shown that gill nets tend to select larger (i.e., faster growing) individuals, possibly inflating estimated growth rates (Hamley and Regier 1973, Anderson 1998). Secondly, our sample included no individuals over age-7 and few ($n = 1$) individuals older than age-5, suggesting that our predicted size-at-age for older individuals may not be truly representative of the populations we sampled. Lastly, the low Tzero values represented in our models indicated that for young walleye, our model lacked predictive ability. Although these potential biases should be considered in any interstate comparison of walleye growth, our results provide important new information regarding the growth rates of Georgia walleye in relation to the key recreational metrics of stock, quality, and preferred sizes.

The results of our study focused on the "grow" portion of the put, grow, and take management strategy employed for walleye in north Georgia impoundments. The growth models presented in this study provide an important new tool for quantifying production dynamics of Georgia's walleye populations. Because fish growth is ultimately influenced by the interactions of habitat quality and fish genetics, growth rates also may provide fisheries managers with a general indication of population health in response to different management strategies (DeVries and Frie 1996). Despite some potential biases associated with gear selectivity, the rapid growth rates observed in this study suggest that habitat conditions in the impoundments studied may be capable of supporting expanded walleye fisheries. Consequently, we suggest that future studies of walleye in north Georgia focus on integrating the results of this study with those of previous studies on walleye population dynamics, particularly those focusing on factors affecting post-stocking survival and recruitment. Because walleye populations in north Georgia are apparently sustained by stocking, fisheries managers may be able to manipulate annual recruitment to meet specific management objectives. Through the careful manipulation of stocking rates, managers may be better able to balance walleye growth with stock density to ultimately establish recreational fisheries with broad appeal to recreational anglers. Furthermore, by assessing the effects of stocking density on walleye growth, managers can determine ideal stocking rates for maximizing abundance and growth.

Walleye stocking in north Georgia reservoirs may ultimately yield significant social and economic benefits; however, more information is needed to maximize the benefit of the walleye fishery to anglers. Presently, data regarding survival rates of stocked walleye in Georgia reservoirs is limited. Future studies are needed to quantify post-stocking survival and to better understand how environmental factors affect annual recruitment. By combining reservoir specific information on growth, survival, and stocking rate, fisheries managers can evaluate different stocking strategies with regard walleye production and harvest in the recreational fishery. Human dimension studies also are needed to evaluate angler values and preferences with regard to different walleye management objectives. By understanding angler preferences and integrating information on walleye population dynamics in north Georgia impoundments, fisheries managers should be better able to establish, maintain, and promote recreation walleye fisheries to maximize both their social and economic benefits.

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