Growth and Spawning Characteristics of Southern Riverine and Northern Strain Walleyes in Texas

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Abstract: Genetically-marked strains of walleye (*Stizostedion vitreum vitreum*) from Arkansas (ARS) and Iowa (IAS) were stocked simultaneously into a Texas reservoir in 1985 to evaluate strain-related performance differences associated with spawning and growth. Post-stocking collections made during the spring spawning season (1988–1990) resulted in the capture of 132 walleyes from this year class. ARS walleyes comprised 35% of 1985 year-class samples which was significantly higher than the stocking proportion (26%). Differences were attributed to ARS females being more abundant than IAS females in samples. This unexpectedly high abundance of ARS walleye was not considered an indication of higher survival but merely evidence of temporal differences in movement of females of each strain to spawning grounds. This hypothesis was supported by strain-related sex ratio differences identified in samples; ARS ratios favored females whereas IAS ratios favored males. Survival was deemed similar between strains throughout the duration of the 5-year study. Natural year classes were produced following the introductions, but they could not be specifically traced to ARS walleye spawning. ARS walleyes attained larger sizes than IAS walleyes. ARS females were significantly longer and heavier than IAS females by age 3. ARS males were significantly longer and heavier than IAS males by age 4. Future stockings of ARS walleyes in Texas may provide anglers with larger walleyes than have typically been available with IAS walleye but they do not hold promise for increasing natural reproduction.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 49:118–128

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Northern strains of walleye have been stocked into Texas reservoirs since the 1950s to supplement existing sport fisheries and to control prey fish populations. The success of these stockings has been mixed, especially in climatically mild regions of the state (Prentice and Clark 1978). One factor that has limited the development of these fisheries is poor reproductive success due to above-optimum spring water temperatures that limit egg production, fertilization, incubation, and hatch rate (Prentice and Clark 1978, Palma 1986). Poor reproduction has resulted in low population densities, thus facilitating the need for supplemental stocking (Prentice 1985). Highly successful fisheries have been established in northwest Texas where water temperatures during the spawning season are optimum and natural reproduction sustains high-density populations (Prentice 1985).

Poor growth also may be limiting the development of walleye fisheries in Texas. Although young walleyes stocked in Texas grow more rapidly than in more northern states, growth declines rapidly in older age groups (Prentice 1977, Prentice and Clark 1978), which limits the trophy aspects of these fisheries. The current Texas state record is 5.4 kg, while walleyes elsewhere in the country reach 9.0 kg or larger.

In an effort to increase walleye reproduction and improve growth, a program was initiated to introduce a strain of walleye that may be more adapted to southern climates. Northern strains of walleye previously stocked into Texas originated from states such as Iowa, New York, New Mexico, Oklahoma, and Kansas (Terre 1985). Three native southern strains also are thought to exist in some southeastern states (Hackney and Holbrook 1978). Some of these strains grow to exceptionally large sizes (Hackney and Holbrook 1978) and may be better adapted to spawn at warmer water temperatures (Colby et al. 1979). Other reproductive differences are thought to exist between northern and southern strains (Hackney and Holbrook 1978). Southern strain fish may be obligate river spawners whereas northern strain fish spawn in both lakes and rivers. Genetic differences also have been found between northern and southern walleye strains (Murphy 1981, 1990; Wingo 1982). These differences provide opportunities to genetically mark fish to evaluate stocking success.

The objectives of this study were to: 1) determine year class contributions made by southern (Arkansas-originated strain hereafter referred to as ARS) and northern (Iowa-originated strain hereafter referred to as IAS) walleyes stocked into a central Texas reservoir and assess post-stocking survival differences between strains; 2) determine if the stocking of ARS walleyes would increase natural reproduction in a reservoir where reproduction of IAS walleyes was limited; and, 3) determine if ARS walleyes would attain larger body sizes than IAS walleyes.

We thank the Arkansas Game and Fish Commission (AGFC), especially C. Perrin, for assistance with broodfish collections at Greers Ferry Reservoir. Thanks also go to J. Acrey, J. Contreras, J. Kraai, C. Munger, M. Ryan, T. Schlagenhaft, and A. Temple for assistance in field collections and walleye procurement activities in Arkansas and Texas. Thanks also go to L. Fries and A. Temple for electrophoretic work and W. Guest, R. Luebke, S. Magnelia, R. McCabe, and M. Webb for editorial comments on the manuscript. Funding was provided by the Federal Aid in Sport Fish Restoration Act, Project F-30-R of the Texas Parks and Wildlife Department (TPWD). Additional funding was provided by Texas Tech University, Fairfield Communities, Inc, and Texas Agricultural Experimental Station Project 6843-H.

Methods

Canyon Reservoir, located in central Texas, was selected as a test site for the introduction of ARS walleyes. This 3,335-ha reservoir is generally steep sided, has clear water, and has been classified as oligotrophic (Barrows 1978). Rocky structure is abundant and provides 16.6 ha of suitable walleye spawning habitat (Prentice and Clark 1978). The Guadalupe River, which flows into the reservoir, also contains significant riverine habitat suitable for walleye spawning. Above-optimum spring water temperatures have been thought to limit walleye reproductive success at this reservoir (Prentice and Clark 1978, Palma 1986). Northern strain walleyes have been stocked here since 1965; most of these fish originated from Iowa (TPWD stocking records).

ARS walleyes for stocking were produced through on-site procurement activities at Greers Ferry Reservoir, Arkansas. Greers Ferry Reservoir contains a nationally-renowned walleye fishery which has produced exceptionally large fish, including the current Arkansas state record of 10.3 kg. Water in this reservoir is supplied by several unobstructed rivers which support river-spawning populations of walleyes presumed to be southern natives. These fish may have originally been a part of a Mississippi River drainage stock described by Hackney and Holbrook (1978). Northern strain walleyes have been introduced into the reservoir (AGFC stocking records); however, the extent of hybridization between native and northern strains is unknown. Broodfish from Greers Ferry Reservoir were collected on the North Fork of the Little Red River where a river spawning population was known to exist.

Meredith Reservoir, located in the Texas Panhandle, was used as the source for IAS walleyes. Walleyes from Spirit Lake, Iowa, were introduced into Meredith Reservoir in the early 1960s (Terre 1985) and a reproducing population was established (Kraai and Prentice 1974). The reservoir maintains a high density walleye population through natural reproduction. Brood fish used were collected from rip-rap areas along the dam. All walleye procurement activities at both Greers Ferry and Meredith reservoirs took place during the 1985 spawning season (February-March).

Allele frequency differences in muscle myogen (*MYO*) proteins (Uthe and Ryder 1970) were used to create genetically marked progeny by selective breeding. The Greers Ferry Reservoir walleye population is known to possess a high frequency of the *MYO*125* allele (B. R. Murphy, unpubl. data) whereas the

Meredith Reservoir walleye population is nearly fixed for the *MYO*100* allele (Terre 1985). At Greers Ferry Reservoir, broodfish possessing the *MYO*100*125* or *MYO*125*125* phenotypes were bred to produce progeny possessing the *MYO*125* allele. At Meredith Reservoir, broodfish possessing only the *MYO*100*100* phenotype were bred to fix progeny for the *MYO*100* allele. Electrophoretic phenotypes of parents were determined through vertical acrylamide gel electrophoresis of white muscle tissue (Terre 1985). Fertilized eggs from each site were transported by air to the Dundee State Fish Hatchery in Texas where they were hatched and raised to fingerling size (25–44 mm). Fingerlings of each strain were stocked into Canyon Reservoir in May 1985 at a combined stocking rate of 20/ha (26% ARS and 74% IAS, based upon availability).

Post-stocking collections at Canyon Reservoir were made with gill nets fished at 15 standardized sites. Sampling was conducted overnight during the spring spawning period (February through March), 1988 through 1990. All sample sites were located on or adjacent to potential spawning grounds. Sample sites were located throughout the entire length of the reservoir to assess spawning segregation differences between strains. Five sites were located in each of 3 reservoir sections (upper, middle, and lower). Three of the 5 sites in upper section were located in the Guadalupe River. Some additional sampling was also necessary at the dam (a known spawning site) to increase sample sizes for year class contribution, growth, temporal spawning migration, and sex ratio comparisons. Nets used were 61.5 m long and consisted of 8, 7.7-m panels of the following bar mesh sizes: 13, 25, 38, 51, 64, 76, and 89 mm. Catch rate data were expressed as the number of walleyes caught in 1 net set over night (fish/net night) and were used to measure trends in walleye abundance during the sampling period. Surface water temperature data (C) were recorded for each net set and were used to assess strain-related differences in peak spawning activity. Annual sampling effort ranged from 18 to 31 net nights.

Sex, total length (mm), weight (g), otoliths, and a white muscle sample were obtained from each walleye collected. Walleye age was determined by microscopic examination of whole otoliths. Age data were used to differentiate between walleye year classes. Genetic marks were identified through acrylamide gel electrophoresis of white muscle tissue (Terre 1985) and were used to distinguish between IAS and ARS walleyes stocked in 1985.

Observed proportions of ARS and IAS walleyes collected during sampling years were compared to original stocking proportions with *G*-tests for heterogeneity (Sokal and Rohlf 1981). Independent tests were conducted for males, females, and sexes combined. Results were used to evaluate year-class contribution and survival differences between strains.

Allele frequencies (*MYO*125*) were determined for stocked and native walleye year classes at Canyon Reservoir. Allele frequency data were analyzed with *G*-tests for heterogeneity and used to trace the parental origin of naturally-produced walleyes following the stockings in 1985.

Using Mann-Whitney *U*-tests for independent samples (Seigel 1956), lengths and weights of ARS males and females were compared to those of IAS males and females. Results were used to assess growth differences between strains.

Results and Discussion

Of the walleyes collected during this study, 54% (132 of 243) were from the 1985 year class. ARS walleyes comprised 35% of the 1985 year class sample between 1988 and 1990 which was significantly higher than expected (Fig. 1). Abundance of ARS walleyes was highest in 1988 (Fig. 2) when they comprised 56% of the 1985 year class sample (Fig. 1); however, abundance of ARS fish declined throughout the study and by 1989 both strains were captured in their original stocking proportions. This unexpectedly high abundance of ARS walleye may not be an indication of higher survival but merely evidence of temporal differences in movement of females of each strain to spawning grounds.

Year class contribution differences observed were attributed to strain-related differences in the abundance of female walleyes in our samples. ARS females were more abundant than IAS females in 1988 and 1989 (Fig. 2) and

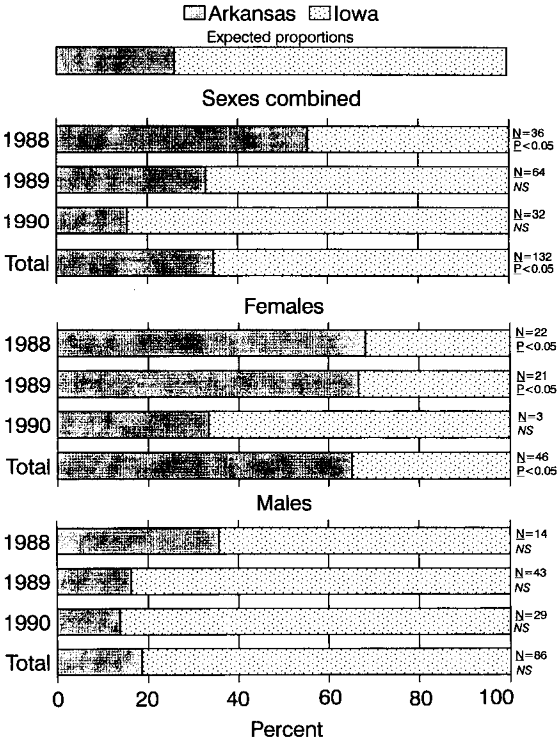

Figure 1. Proportions of 1985 year class Arkansas (ARS) and Iowa strain (IAS) walleyes captured during post-stocking collections at Canyon Reservoir, Texas, February and March (total indicates combined sampling year data). Proportions in post-stocking collections were compared to the expected original stocking proportion (26% ARS and 74% IAS) with *G*-tests for heterogeneity. Probability levels (P) < 0.05 are significant. NS denotes no significant difference.

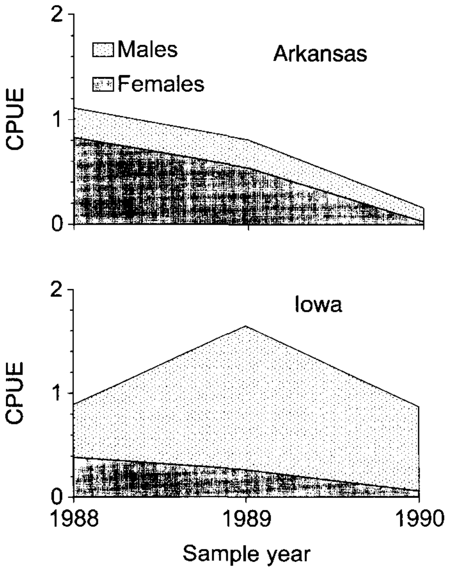

Figure 2. Gill net catch rates (CPUE) of 1985 year class Arkansas and Iowa strain walleyes captured in Canyon Reservoir, Texas, February and March. Data are expressed as the average number of walleyes captured in 1 net set overnight. Total sampling effort was 18, 26, and 31 net nights in 1988, 1989, and 1990, respectively.

were captured in proportions that differed significantly from original stocking proportions (Fig. 1). Male walleyes of both strains were caught in their original stocking proportions throughout the entire study period (Figs. 1, 2). Female walleye abundance is known to change at spawning grounds in response to peak spawning activity (Colby et al. 1979). All walleyes captured during this study were on or very near potential spawning areas with surface water temperatures ranging from 11 to 15 C. It is possible these strains may have been acting independently by attempting to spawn at different times or water temperatures. Evidence of this was observed in 1989 when ARS females seemed to occupy spawning grounds at the dam earlier and at colder water temperatures than IAS females (Fig. 3). We had anticipated ARS walleyes would prefer warmer water temperatures than IAS walleyes for spawning; however, a strict interpretation of these results may be inappropriate due low sample size. Differences in spawning behavior could explain differences in the abundance of female walleyes and therefore differences between observed and expected contributions to year class strength of each strain.

Sex ratios varied considerably between ARS and IAS walleye which further suggests temporal spawning migration differences may have existed between strains (Table 1). Sex ratios of ARS walleyes favored females, whereas those of IAS walleyes favored males. These differences were evident during all sample years except 1990 when only a small number ($N = 5$) of ARS walleyes were collected (Fig. 1). Sex ratios of IAS walleyes stocked in 1985 were similar to other northern-originated year classes (1981 and 1984) (Table 1) and to earlier year classes reported by Palma (1986). Colby et al. (1979) reported that during the spawning period walleye sex ratios on spawning grounds typically favor

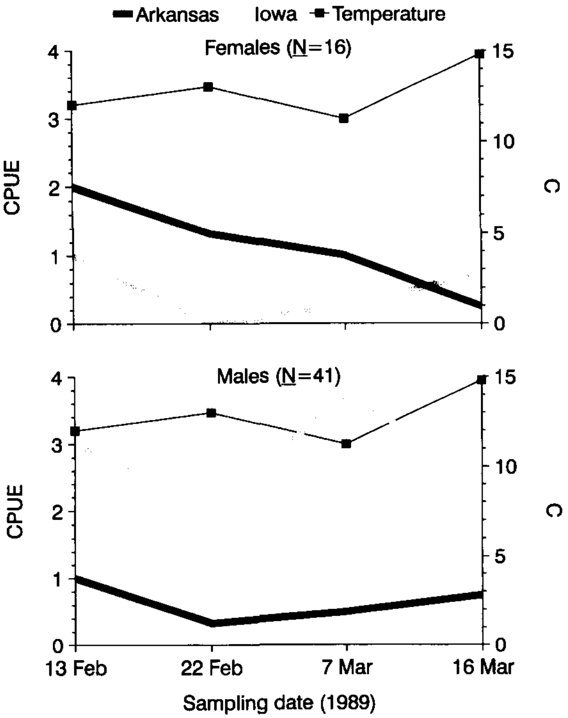

Figure 3. Gill net catch rates (CPUE) of 1985 year class Arkansas and Iowa strain walleyes captured at a major spawning site in Canyon Reservoir, Texas. Data are expressed as the average number of walleyes captured in 1 net set overnight. Total sampling effort was 11 net nights. Surface water temperatures (C) are presented for each date.

Table 1. Allele frequencies and male sex ratios in walleye year classes (YC) collected at Canyon Reservoir, Texas, February and March 1988 through 1990. Walleye in Group 1 are year classes that could be considered parental stocks of walleyes in group 2. Walleyes from the 1985 year class were split into 2 groups, 1985-A denoting Arkansas strain and 1985-I denoting Iowa strain. Walleyes from 1982–1983 and 1987–1989 year classes were the result of natural reproduction. Allele frequency data were compared between year classes and groups with *G*-tests for heterogeneity, Frequencies contained within the same table column that have different letters are significantly different ($P < 0.05$).

			*MYO*125* frequencies		
Group	YC	*N*	YC	Group	Male sex ratio (%)
1	1981	17	0.21AB	0.24A	77
	1982	1			
	1983	1			
	1984	65	0.17A		86
	1985	132	0.28B		65
	1985-A	46	0.82C		35
	1985-I	86	0.00D		81
2	1987	19	0.18AB	0.19A	68
	1988	6	0.25AB		83
	1989	2			

males, but sex ratios often change, with increased numbers of females near the onset of peak spawning activity. He cited considerable variability in observed spawning temperatures of walleyes, ranging from 5.6 to 17.2 C, and noted differences in preferred spawning temperature might be attributed to thermal and maturation histories of local stocks or vary regionally depending on walleye strain.

Sex ratios were not examined during non-reproductive periods, but we suspect sex ratios would have been nearly 1:1 based on a review of previous studies on this subject (e.g., Colby et al. 1979). Some studies have reported walleye sex-ratio changes related to age (Carlander 1945, Smith and Pycha 1961), but in these studies significant changes were reported to occur at age groups much older than those examined in this study. It is unlikely ARS and IAS walleyes originally possessed different sex ratios at the time of stocking, as these strains were selectively bred, handled, and procured in the same manner. We found no evidence to suggest the artificial breeding practices used, which are commonly used to propagate walleyes in Texas, resulted in skewed sex ratios of progeny. Muscle myogen proteins have been found to be independent of sex (Terre 1985), so our selective breeding process for the MYO alleles also would not be expected to skew sex ratios.

Male abundance differences observed in this study could be used to assess strain-related differences in survival. Male walleyes of both strains were caught in their original stocking proportions throughout the entire study period (Figs. 1, 2) and, unlike female walleyes, their catch rates may not have been as strongly influenced by strain-related differences in spawning (Fig. 3). These results suggest survival of ARS walleyes was similar to IAS walleyes, at least until age 5. We suggest future comparisons should be made during non-reproductive periods when both sexes can be included. Such data may provide a more definitive explanation of these results.

ARS and IAS walleyes did not seem to occupy different areas of the reservoir during the spawning period. Based upon standardized gill net samples, 70% (14 of 20) of ARS walleyes and 85% (22 of 26) of IAS walleyes were captured in the lower section of the reservoir while 15% of each strain were captured in middle section. Only 15% of ARS walleyes and no IAS walleyes were captured in the upper section, an area which included the Guadalupe River. Results suggest the greatest portion of the spawning activity for both strains took place in the same reservoir areas. Results also suggest, although ARS walleyes may have used the river for spawning, they did not seem to use it in an obligatory manner as suspected (Hackney and Holbrook 1978).

Three natural year classes were produced following the introduction of ARS walleyes (Table 1). Most of these fish were from the 1987 year class, 2 years after the introduction of ARS walleyes (Table 1). Walleyes in southern reservoirs of the United States, including Canyon Reservoir, have been shown to mature as early as age 1 (Colby et al. 1979, Palma 1986), but most walleyes in Texas and Canyon Reservoir become mature between ages 2 and 4 (Kraai and Prentice

1974, Colby and Nepszy 1981, Palma 1986). It is therefore reasonable to assume most walleyes stocked in 1985 were reproductively mature before the end of our sampling period. Age-at-maturity differences between ARS and IAS walleyes were not addressed as part of this study; however, many researchers believe walleyes which grow faster tend to mature earlier (Kraai and Prentice 1974, Colby et al. 1979). If that is true, because ARS walleyes grew faster in Canyon Reservoir (Fig. 4), we could assume these fish matured earlier than IAS fish.

Based on allele frequency data, it is unlikely the 1987–1989 natural year classes were solely the result of reproduction of ARS walleyes. Allele frequencies of ARS walleyes collected during this study were significantly different from allele frequencies of fish from these naturally-reproduced year classes (Table 1). Allele frequencies of these naturally-reproduced fish were more similar to northern-originated strains stocked in 1981, 1984 and to the entire 1985 year class (strains combined) (Table 1). Palma (1986) also identified some naturally-reproduced walleyes (1975–1980) following large stockings that occurred in 1973 and 1974. It appears the increase in reproductive success we observed was

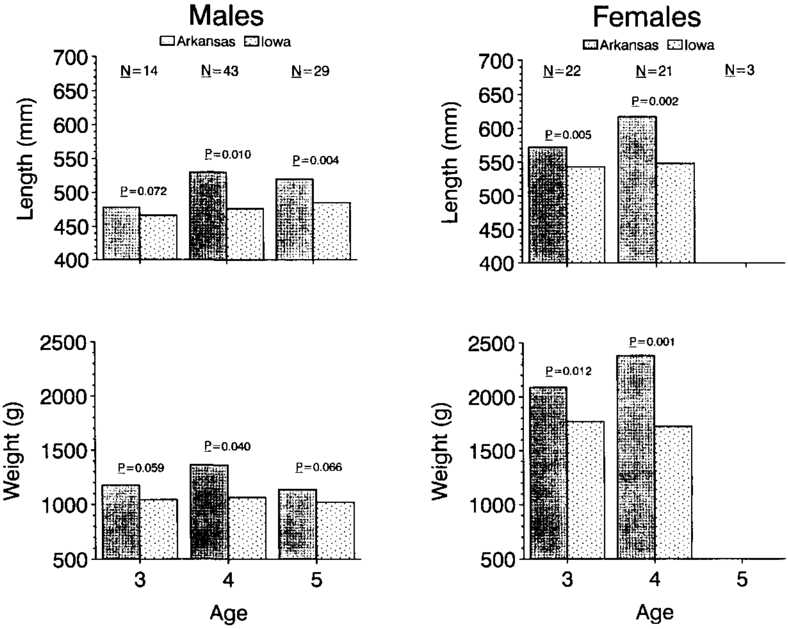

Figure 4. Median total length and weight comparisons between Arkansas and Iowa strain walleyes collected from Canyon Reservoir, Texas, February and March 1988 through 1990. Comparisons of males were made at 3 age groups; comparisons of females were made at only 2 age groups due to sample size limitations. Lengths and weights were compared with Mann-Whitney *U*-tests for independent samples. Probability levels (P) < 0.05 are significant.

more likely due to increased numbers of mature adults in the population from all stockings combined rather than the specific introduction of ARS walleyes.

Body size and growth differences were observed between the ARS and IAS walleyes stocked in Canyon Reservoir (Fig. 4). ARS females were significantly longer and heavier than IAS females by age 3. ARS males were significantly longer and heavier than IAS males by age 4. Body sizes remained significantly different between strains throughout the study, except for male walleye weights, which were not significantly different at age 5. ARS walleyes also appeared to grow more rapidly than IAS walleyes between ages 3 and 4. During this time period, ARS females increased their total length and body weight by 8% and 15%, respectively, whereas total length of IAS females increased by only 1% and weight decreased by 2%. It is not known if body size and growth differences persisted past age 5, but the stocking of ARS walleyes at least provided anglers with larger walleyes available for harvest. This may be especially true for ARS female fish, which by age 4 were 38% heavier and 13% longer than IAS females.

Management Implications

Results suggest survival of ARS and IAS walleyes would be similar following stocking; however, future ARS walleye stockings in climatically mild regions of Texas would not be expected to establish reproducing populations. There was no evidence to suggest natural reproduction in Canyon Reservoir was improved by stocking ARS walleyes. Supplemental or maintenance stocking efforts will be needed to sustain this population and fishery.

ARS walleyes attained larger sizes than IAS walleyes in Canyon Reservoir. These walleyes reach catchable and harvestable sizes sooner and would provide a quicker angler return on stocking investment dollars. If growth differences between the 2 strains persist with increasing age and there is no strain-related difference in longevity, trophy aspects of Texas walleye fisheries also may improve. To maximize growth benefits of ARS walleyes,future introductions should be done in areas where hybridization with northern strains would not occur. This would minimize dilution of their superior growth characteristics. In cases where hybridization of northern strain walleyes would be expected, regular stockings of ARS walleyes may be needed to maintain good growth.

This study provides evidence for the continued existence of southern strain walleyes in Greers Ferry Reservoir, Arkansas. If these walleyes represent a unique stock of fish with superior growth and spawning characteristics, genetic conservation measures should be taken to preserve them. Further efforts should be directed towards the genetic characterization and protection of this potentially valuable strain. These efforts would be facilitated by the establishment of a genetic sanctuary prohibiting stocking of northern strain walleyes into Greers Ferry Reservoir. Alternatively, southern strain walleyes from Greers Ferry Reservoir could be introduced into other reservoirs which also could serve as sanctuary areas.

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