Comparison of Growth, Abundance, and Emigration of Two *Morone* Hybrids in a High Flow-through Oklahoma Reservoir

Kurt E. Kuklinski, *Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, 500 E. Constellation Norman, OK 73072*

Abstract: Hybrid striped bass (*Morone saxatilis* × *Morone chrysops*) are commonly introduced in southeastern U.S. reservoirs to create a sport fishery and as a means of utilizing abundant shad (*Dorosoma* spp.) populations. The Oklahoma Department of Wildlife Conservation (ODWC) has historically stocked the common-cross hybrid (*M. saxatilis* female × *M. chrysops* male; hereafter, common HSB) rather than the reciprocal-cross hybrid (*M. saxatilis* male × *M. chrysops* female; hereafter, reciprocal HSB). Due to concerns over downstream emigration of stocked fish from reservoirs, common HSB have mostly been stocked in reservoirs with low water exchange rates; whereas stockings in high flow-through reservoirs have been limited. Some evidence exists that reciprocal HSB have less tendency to emigrate from the reservoirs they are stocked in; however, a direct comparison of the two *Morone* hybrid crosses in Oklahoma reservoirs had never been done. Therefore, the objective of this study was to compare growth, abundance, and emigration of common HSB and reciprocal HSB in a high flow-through reservoir. Kaw Lake was stocked annually with equal numbers (85,000) of each hybrid cross from 2005–2008; lesser, but approximately equal, numbers of each hybrid cross were stocked in 2009. Relative abundance of both hybrid crosses was similar in Kaw Lake and in the basin below Kaw Lake over the course of this study. Thus, emigration of both hybrid crosses appeared to be similar. However, growth of common HSB was greater than that of reciprocal HSB. Based upon the results of this study, ODWC modified its hybrid striped bass stocking protocol to allow for more stocking of common HSB into reservoirs with high water-exchange rates.

Key words: hybrid striped bass, stocking, management, reciprocal

Journal of the Southeastern Association of Fish and Wildlife Agencies 1:20–25

Hybrid striped bass (HSB, *Morone saxatilis* × *Morone chrysops*) have been stocked throughout the southeastern United States to create sport fisheries and to control and utilize abundant shad (*Dorosoma spp.*) populations (Kinman 1987, Mesing et al. 1997). Most states, including Oklahoma, exclusively stock the common-hybrid cross striped bass (*M. saxatilis*) female × white bass (*M. chrysops*) male (hereafter, common HSB). Outside the southeastern region of the United States, access to female striped bass broodstock can limit hatchery production of common HSB and leave the reciprocal-hybrid cross (striped bass male × white bass female; hereafter reciprocal HSB) as the only viable hybrid to produce (Wamboldt 2013). Florida and Georgia were the first states to stock reciprocal HSB in the late 1980s (Mesing et al. 1997). Other southeastern states have produced and stocked reciprocal HSB since then, but most have discontinued work with reciprocal hybrids due to unfavorable cultivation issues when compared to common HSB. Reciprocal HSB require more intensive incubation techniques to prevent eggs from clustering during cultivation, are smaller than common HSB at the fry stage, and are less hardy in aquaculture production ponds when being grown to fingerling size (Wynne and Webster 2000). In addition, female striped bass broodstock are often more difficult to obtain than female white bass (Mesing et al. 1997, Wynne and Webster 2000).

Hybrid striped bass have been shown to rapidly leave the reservoir when water is released from the dam via normal water release operations or during flooding events. Emigration of HSB out of a reservoir poses several problems to fishery managers. First, a reduced population of HSB remaining in the reservoir can weaken the potential of the fishery to utilize abundant forage. A smaller population may also negatively impact anglers' experiences on the reservoir due to potentially lower catch and harvest rates. Another impact of HSB emigration from a reservoir is the ecological effect of an introduced predator species on downstream waters, with potential issues such as competition with native species, predation on threatened or listed species, or negative effects on the genetic integrity of other *Morone* populations. Significant emigration of HSB during two consecutive years was documented in a central Kentucky impoundment when flood gates on the dam were opened (Kinman 1987). The loss of an entire year class of HSB in an Illinois reservoir was attributed in part to extensive emigration (Jahn et al. 1987). In both cases, the emigrating fish were the common HSB. For this reason, few HSB have been stocked in Oklahoma reservoirs with high water-exchange rates. However, few comparative movement studies of both common and reciprocal HSB have been conducted to date. One study reported that reciprocal HSB were more likely to remain in reservoirs during high-flow events, and emigrated from reservoirs less often, than common HSB (Mesing et al. 1997).

Resource management agencies have been placing increased importance on measurable stocking objectives and on specific criteria used to justify stocking public waters since the 1990s (Jackson et al. 2004). The Oklahoma Department of Wildlife Conservation (ODWC) Fisheries Division has used a system of stocking criteria since 1989 to determine which reservoirs will receive hatchery-reared hybrid striped bass, among other species (Gilliland and Boxrucker 1995). These stocking criteria assign points in several biological, social, and environmental categories to determine which reservoirs are best suited to receive portions of a limited hatchery supply of fish. From 1989 to 2009, the ODWC hybrid striped bass stocking criteria assigned the most points (40% of the total available) to the category of water-exchange rate (inflow / storage capacity, Gilliland and Boxrucker 1995). This meant that reservoirs with a lower water-exchange rate were much more likely to score high in the stocking criteria and receive hybrid striped bass regularly.

The purpose of this study was to directly compare the relative abundance and growth of two hybrid striped bass crosses within a high flow-through Oklahoma reservoir between 2005 and 2009. In addition to directly comparing the hybrid crosses within the reservoir, tailwater sampling was conducted to determine relative emigration of each *Morone* hybrid leaving the reservoir.

Methods

This study was conducted on Kaw Lake, a 6,779-ha mainstem impoundment of the Arkansas River in northcentral Oklahoma. The 74,883 km^2 watershed draining into Kaw Lake produces a mean (data from 2000–2009) annual inflow of 3,523 ha m^3 of water. The reservoir is operated by the US Army Corps of Engineers as a water supply and recreational lake, and when at full conservation pool has a storage capacity of 173,448 ha-m. Based on the volume of Kaw Lake at normal pool (173,448 ha-m), the 10-year average water exchange rate is 6.67, meaning in an average year Kaw Lake will exchange its conservation pool volume almost seven times, or once every 54.7 days. Kaw Dam is operated on a 24-hour run of the river release/generation schedule. Not all water entering Kaw in any given year is released as flood water through dam gates; rather, a portion of it (depending upon flood control requirements) is released through electricity generation gates.

Kaw Lake historically has had outstanding fisheries for white bass, white crappie (*Pomoxis annularis*), and blue catfish (*Ictalurus furcatus*). In addition, the tailwater fishery below Kaw Lake is a well-known striped bass, blue catfish, and paddlefish (*Polyodon spathula*) fishery which is strongly influenced by water releases from the dam.

Table 1. Number and mean total length (SE) of hybrid striped bass stocked into Kaw Lake between 2005 and 2009. Initial mean length was different between hybrid crosses in all years (ANOVA, $\alpha < 0.05$). A sample was not taken in 2005.

Year	Hybrid cross	Number stocked	Mean TL (SE)
2005	Common HSB	85,000	
	Reciprocal HSB	85,000	
2006	Common HSB	85,000	40.1 (0.4)
	Reciprocal HSB	85,000	45.0 (0.6)
2007	Common HSB	85,000	45.5 (1.2)
	Reciprocal HSB	85,000	51.6 (1.1)
2008	Common HSB	85,000	45.9 (0.7)
	Reciprocal HSB	85,000	40.9 (0.7)
2009	Common HSB	22,000	47.0 (0.8)
	Reciprocal HSB	25,000	42.3 (0.8)

OTC Marking and Stocking

Common HSB fingerlings were treated with oxytetracycline (OTC), which produces a glowing yellow to orange mark when saggital otoliths are viewed under ultraviolet light (Brothers 1990, Guy et al. 1996). During transportation from the Oklahoma Department of Wildlife Conservation's Byron Fish Hatchery to the reservoir, common HSB fingerlings were soaked for 6 h in a solution of 700 mg L^{-1} OTC and 434 mg L^{-1} sodium phosphate (dibasic) buffer. Reciprocal HSB fingerlings were not marked with OTC. From 2005 to 2007, reciprocal hybrid fingerlings were purchased from Keo Fish Farm (Keo, Arkansas), but beginning in 2008, these fish were produced by ODWC hatcheries. *Morone* hybrid fingerlings were stocked at a rate of 4 fish per surface ha, evenly split between the two hybrid crosses (i.e., 85,000 per year; Table 1). These fish were stocked once annually within a two-week period as fish were available near mid-reservoir at one of two boat ramp areas depending upon water levels. A small sample of fingerlings ($n < 100$) were taken from each stocking tank to record total length (mm) for annual comparisons between hybrid crosses.

To test for OTC mark efficacy, a small subsample (100–200 individuals) of common HSB was removed from the hauling truck immediately prior to stocking in 2006 and 2008. These fingerlings were removed from the OTC marking solution after 6 h and taken to outdoor holding tanks at the Oklahoma Fishery Research Laboratory and allowed to grow for 4–5 weeks before being harvested to check for the OTC mark on saggital otoliths (US Food and Drug Administration 2002).

Fish Collection and Data Analyses

Fall gillnet collections were conducted at 20 sites using two arrays of sinking nets. The ODWC standard experimental nets were composed of seven 7.6-m by 1.6-m panels of 12.7-mm, 19.1-mm, 25.4-mm 38.1-mm, 50.8-mm, 63.5-mm and 76.2-mm mesh. Smaller mesh experimental nets composed of five 15.2-m by 1.6-m panels of 12.7-mm, 15.9-mm, 19.1-mm, 22.2-mm, and 25.4-mm mesh were also employed beginning fall 2006 to target age-0 hybrid striped bass. All gillnets were set in the afternoon and fished overnight. Effort was recorded as total number of hours of soak time, and mean catch rates were calculated as the number of fish per net-night (number of fish per h × 24 h) averaged among all samples. Hybrid striped bass were also collected in the tailwaters (within the first kilometer of river) below Kaw dam to calculate relative emigration proportion between the hybrid crosses from 2005–2009. Tailwater samples were collected by angling and using a boat-mounted electrofisher (5.0 GPP, Smith Root) producing an electrical field using pulsed DC between 30 and 120 pulses per second. Catch per unit effort was not recorded in tailwater sampling as the goal was to calculate only the proportion of common to reciprocal HSB.

All hybrid striped bass were measured to the nearest millimeter (TL), weighed to the nearest gram, and held for subsequent otolith removal. Saggital otoliths were dissected, assigned an age based upon the number of annuli present, and prepared for OTC mark presence/absence analysis by adhesion to a glass microscope slide. To differentiate between the two hybrid crosses, saggital otoliths were viewed under magnification (12–25 ×) using an ultraviolet light source. Otoliths were transversely sectioned at the kernel and mounted to a glass slide using high temperature epoxy. The otolith was then polished with wetted fine grit sandpaper to produce a clear view for the reader. If a glowing orange mark was present between the kernel and first annulus, the fish was recorded as an OTC-marked common HSB. Otoliths lacking a glowing mark were classified as reciprocal HSB. OTC mark classification was done by two experienced readers viewing otoliths independently, then reviewing any differences jointly to produce a consensus.

Length analysis of stocked common and reciprocal HSB was performed using ANOVA to compare initial length at stocking from 2005–2009. Catch rates between hybrid crosses within the reservoir were compared using log-transformed data analyzed by a two-way ANOVA with an interaction variable of year × hybrid cross. Growth comparisons between hybrid crosses at each age class were completed using an ANCOVA with an interaction variable of year × hybrid cross. The program Fishery Analysis and Simulation Tools (FAST, Slipke and Maceina 2000) was used to calculate a von Bertalanffy growth equation for each hybrid cross based on growth parameters from length and age data. A Chi-squared test was conducted to determine differences in proportion of hybrid crosses within the reservoir and in the tailwaters. All statistical tests were considered significant at $P \leq 0.05$.

Results

Stocking and OTC Mark Efficacy

A total of 727,000 HSB fingerlings were stocked into Kaw Lake in June 2005–2009. Equal numbers (85,000) of both hybrid crosses were stocked in all years but 2009, when high mortality occurred en route to the lake (Table 1). Initial mean length of reciprocal HSB was greater than common HSB in 2006 ($F = 45.4$; $P = 0.0000$) and 2007 ($F = 13.8$; $P = 0.0004$) when reciprocal HSB were obtained from the Keo Fish Farm (Table 1). In contrast, initial mean length of common HSB was greater than reciprocal HSB in 2008 ($F = 25.7$; $P = 0.0000$) and 2009 ($F = 17.0$; $P = 0.0002$), when reciprocal HSB were produced by ODWC hatcheries (Table 1). In both years, OTC mark efficacy was 100% (43 of 43 fish in 2006 and 35 of 35 fish in 2008).

Abundance and Growth

A total of 217 HSB (101 common cross and 116 reciprocal cross) were collected in Kaw Lake from fall 2005 – fall 2009. Common HSB catch per net night ranged from 0.10 in fall 2005 to 1.98 in fall 2007, while reciprocal HSB catch per net night ranged from 0.24 in fall 2005 to 1.91 in fall 2007. Although catch rate of HSB differed among years ($F = 6.29$, df = 4, $P = 0.0251$), catch rate between hybrid crosses was similar each year ($F = 0.18$, df = 1, $P = 0.6800$), and the interaction term between year and hybrid cross was not significant ($F = 1.80$, df = 4, $P = 0.1797$). Chi square analysis of pooled data by age revealed equal proportions of hybrid crosses in the reservoir ($X^2 = 1.2937$, df = 4, $P = 0.8624$).

Growth of common HSB was significantly greater than reciprocal HSB for fish ages 0–2 (ANCOVA; $P \leq 0.05$, Table 2). The interaction of the variables year and hybrid cross was not significant (ANCOVA: $F = 0.37$, $P = 0.8282$). Predicted TL at all ages was greater for common HSB than reciprocal HSB when the data were modeled in von Bertalanffy growth equations (Figure 1). The von Bertalanffy coefficients from the growth equation calculated for

Table 2. Fall (September–November) mean length (mm) comparison between hybrid crosses by age class. Age class data was pooled (ie. age-0 data from 2005–2009 samples) and compared using ANCOVA (α = 0.05).

Hybrid cross	Age	Mean TL	SE	F	P
Common	0	190	13	4.25	0.0001
Reciprocal		176			
Common	1	368	21	13.25	0.0000
Reciprocal		342			
Common	2	488	26	6.42	0.0016
Reciprocal		444			
Common	3	562	31	5.04	0.0634
Reciprocal		508			
Common	4	639	19	3.86	0.1884
Reciprocal		588			

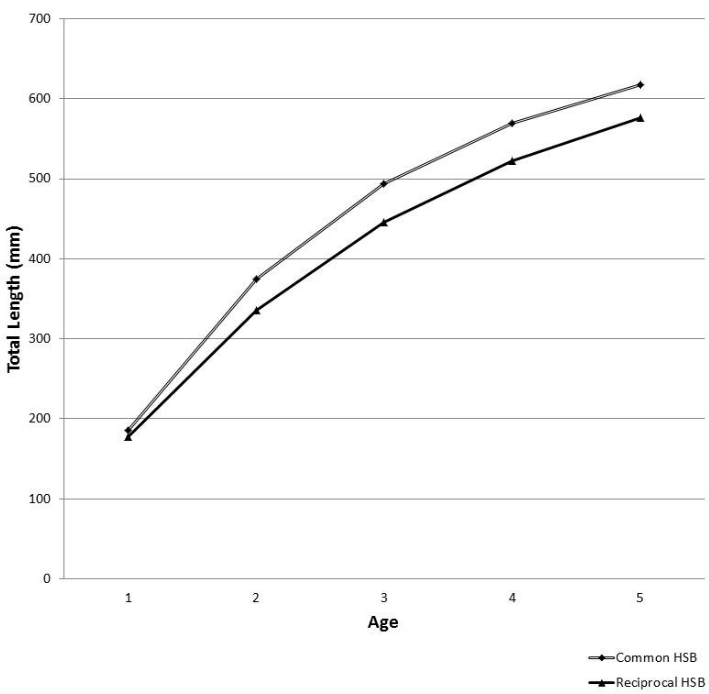

Figure 1. Von Bertalanffy growth model of predicted length at age for Kaw Lake common and reciprocal HSB from 2005 to 2009.

common HSB were 700 mm for L_∞, 0.456 for K, and 0.676 for t_0, with an excellent fit to the model ($r^2 = 0.9947$). The growth equation coefficients for reciprocal HSB were 700 mm for L_∞, 0.359 for K, and 0.817 for t_0, with a similar excellent fit to the model ($r^2 = 0.9962$).

Emigration

Nineteen HSB were collected below Kaw dam in 2007 (12 common and 7 reciprocal HSB), 29 HSB in 2008 (12 common and 16 reciprocal HSB), and 21 hybrids in 2009 (15 common and 7 reciprocal HSB). No HSB were collected during 2005 and 2006 tailwater sampling. Over all years, a slightly greater percentage of common HSB (56.5%, $n = 39$) than reciprocal HSB (43.5%, $n = 30$) were collected in tailwater sampling, though the difference was not significant ($X^2 = 2.5071$, df $= 4$, $P = 0.6434$).

Discussion

In-lake and tailwater sampling revealed relatively equal abundances of both hybrid striped bass crosses throughout this study. Extensive sampling yielded low combined HSB catch rates (0.34 to 3.89 fish per net night) within Kaw Lake, which would be expected given that this reservoir had never been stocked with hybrid striped bass prior to this study. Several consecutive years of successful stockings are required to establish a hybrid striped bass fishery, and fall gillnet catch rates of hybrid striped bass are often low (2–5 fish/net night) in Oklahoma reservoirs within the first 5 yr after the initial stocking event (Hicks 1992, 1997).

Although the total sample sizes in this study were not large, the proportion of common (46.5%) to reciprocal HSB (53.5%) in Kaw Lake was statistically equal. In addition, tailwater samples revealed similar proportions of each hybrid cross. Mesing et al. (1997) reported that common HSB comprised only 47% of hybrid striped bass collected in Lake Seminole, Florida-Georgia over a 4-yr period, but 83% of the hybrid striped bass collected in the Apalachicola River below Lake Seminole. Thus, my results within the reservoir closely resembled those of Mesing et al. (1997), but fewer common HSB appeared to emigrate from Kaw Lake compared to Lake Seminole. This difference may be attributed to the water inflow and subsequent water releases during each study or to the differences in water release operational procedures between reservoirs.

Neither hybrid cross exhibited a greater propensity to emigrate from Kaw Lake based on the in-reservoir and tailwater relative abundance proportions, which becomes especially meaningful when the water releases during the study period are considered. During the study period, Kaw Lake had above average inflows three consecutive years (2007, 2008, and 2009), average inflows one year (2005), and below average inflows one year (2006). Thus, this study was conducted under a wide range of inflow/water release scenarios. The succession of water flow from 2005–2006 (average to below average inflows) to 2007–2009 (all high inflow years) may have provided optimal conditions for HSB to emigrate from Kaw Lake. Young HSB (age-0 and age-1) would be less likely to emigrate from the lake than adults because of their orientation to shore for feeding and refuge from predators. Adult HSB are more pelagic than younger fish, making them much more susceptible to be influenced by current and flow in the reservoir. The 2005 and 2006 year classes of HSB had little reason to emigrate from Kaw Lake during their first year because they were juvenile fish and inflows (and therefore water releases) were low. However, beginning in 2007 and continuing through 2009, these year classes (now adult fish) were presented with inflow and dam release conditions favorable to emigration. The tailwater sampling data reflect this water flow pattern as zero hybrid striped bass were collected below Kaw dam in 2005 and 2006 when reservoir inflows and releases were below normal, while 69 hybrids were collected between 2007 and 2009 during normal or above normal conditions.

Differential growth between the hybrid crosses has reaffirmed the decision of ODWC hatcheries to produce only common HSB. Given that differential emigration was not observed between hybrid crosses, it would best serve anglers for ODWC to stock the common HSB because it exhibited faster growth than the reciprocal HSB (Figure 1). Fall mean length of age-0 hybrid striped bass in this study (common HSB = 190 mm TL, reciprocal HSB = 176 mm TL) was lower than reported in Cherokee Reservoir, Tennessee (215 mm TL, Saul and Wilson 1981) and in Ross Barnett Reservoir, Mississippi (227 mm TL and 241 mm TL, DeMauro and Miranda 1990). However, Kaw hybrid striped bass fall mean length at ages 1 through 3 in this study exceeded the statewide average used in ODWC stocking criteria (356 mm TL at age-1, 432 mm TL at age-2, and 483 mm TL at age-3) in all cases except the age-1 reciprocal cross mean length (342.2 mm TL, Bill Wentroth, ODWC Hybrid Striped Bass Stocking Committee Chair, personal communication). In addition to common HSB growth exceeding reciprocal HSB growth, ODWC hatchery personnel are proficient in producing common HSB in jar culture, and striped bass female broodstock is readily available in the Arkansas River system.

OTC mark efficacy for this study was high (100%), which is not unusual in fish marked and held for a relatively short period of time prior to otolith examination (Unkenholz et al. 1997, U.S. Food and Drug Administration 2002). The long-term retention of OTC marks on fish otoliths has been investigated in other studies. Reinert et al. (1998) reported less than 100% OTC mark retention in striped bass at 3 years of age. Mauk (2008) reported 95% mark efficacy in common HSB at 344 days post immersion in 700 mg/L OTC. In addition to less than 100% mark efficacy, otolith preparation and reader error can also contribute to inaccurate interpretation of OTC mark data (Reinert et al. 1998). Results from this study are based on the assumption that all common HSB could be identified by the OTC mark, regardless of age. If any misidentification of common HSB occurred (ie. labeling a common HSB as a reciprocal HSB because the OTC mark was not detected) due to problems preparing or reading OTC-marked otoliths, it is possible that the proportional abundances of common HSB in the reservoir and tailwaters could have been over-estimated.

Based on results from this study, ODWC has modified hybrid striped bass stocking criteria to place less emphasis on the water-exchange rate of the reservoir. Water-exchange rate is still the highest point value criteria, but a high water-exchange rate is no longer a prohibitive factor in whether or not a reservoir receives hybrid striped bass stockings. In addition, some value has been given to reservoirs with an accessible tailwater fishery where anglers will have an opportunity to catch hybrid striped bass that do emigrate from the reservoir.

The continued stocking of common HSB in Kaw Lake was recommended since growth potential of the new hybrid striped bass fishery is a priority. Local ODWC staff has also engaged in active promotion of the hybrid striped bass fishery in the tailwaters below Kaw dam as a result of this study. A corresponding OTC mark efficacy study in conjunction with this study's objectives would strengthen future studies by allowing the investigator to calculate or estimate actual OTC mark retention.

Acknowledgments

The author would like to recognize the assistance of S. O'Donnell, C. Porter, B. Wentroth, and T. Wolf in all field sampling during this project. Thanks to Keo Fish Farm, Keo, Arkansas, for providing the reciprocal hybrid striped bass used in this study in 2005, 2006, and 2007. This study was funded by ODWC and Sportfish Restoration funds via grant F-50-R-(21).

Literature Cited

Brothers, E. B. 1990. Otolith marking. Pages 183–202 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester Jr., E. D. Prince, and G. A. Winas, editors. Fish Marking Techniques. American Fisheries Society, Symposium 7, American Fisheries Society, Bethesda, Maryland.

DeMauro, R. A. and L. E. Miranda. 1990. Food and growth of age-0 hybrid striped bass in Ross Barnett Reservoir, Mississippi. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 44:105–113.

Gilliland, E. R. and J. C. Boxrucker. 1995. Species-specific guidelines for stocking reservoirs in Oklahoma. American Fisheries Society Symposium 15:144–151. American Fisheries Society, Bethesda, Maryland.

Guy, C. S., H. L. Blankenship, and L. A. Nielsen. 1996. Tagging and Marking. Pages 353–383 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques Second Edition. American Fisheries Society, Bethesda, Maryland.

Hicks, D. 1992. Oklahoma Fisheries Management Program Survey Report for Skiatook Lake. Federal Aid Report F-44-D-7. Oklahoma Department of Wildlife Conservation, Oklahoma City.

_____. 1997. Oklahoma Fisheries Management Program Survey Report for Birch Lake. Federal Aid Report F-44-D-12. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Jackson, J. R. , J. C. Boxrucker, and D. W. Willis. 2004. Trends in agency use of propogated fishes as a management tool in inland fisheries. Pages 121–138 *in* M. J. Nickum, P. M. Mazik, J. G. Nickum, and D. D. MacKinlay, editors. Propogated fish in resource management. American Fisheries Society, Symposium 44, American Fisheries Society, Bethesda, Maryland.

Jahn, L. A., D. R. Douglas, M. J. Terhaar, and G. W. Kruse. 1987. Effects of hybrid striped bass in Spring Lake, Illinois. North American Journal of Fisheries Management 7:522–530.

Kinman, B. T. 1987. Evaluation of hybrid striped bass introductions in Herrington Lake. Kentucky Department of Fish and Wildlife Resources publication, Frankfort.

Mauk, R. 2008. Efficacy of oxytetracycline marking of fingerling palmetto bass in hard water. North American Journal of Fisheries Management 28:258–262.

Mesing, C. L., E. A. Long, I. I. Wirgin, L. Maceda. 1997. Age, growth, and movement of 2 *Morone* hybrids in the Apalachicola River system, Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:123–134.

Reinert, T. R., J. Wallin, M. C. Griffin, M. J. Conroy, and M. J. Van Den Avyle. 1998. Long-term retention and detection of oxytetracycline marks applied to hatchery-reared larval striped bass, *Morone saxatilis*. Canadian Journal of Fisheries and Aquatic Sciences 55:539–543.

Saul, B. M. and J. L. Wilson. 1981. Food habits and growth of young-of-year white bass x striped bass hybrids in Cherokee Reservoir, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:311–316.

Slipke, J. W. and M. J. Maceina. 2000. Fishery analysis and simulation tools (FAST) user's guide. Auburn University, Auburn, Alabama.

Unkenholz, E. G., M. L. Brown, and K. L. Pope. 1997. Oxytetracycline marking efficacy for yellow perch fingerlings and temporal assays of tissue residues. The Progressive Fish Culturist 59:280–284.

U.S. Food and Drug Administration. 2002. Oxytetracycline hydrochloride for skeletal marking of fish fry (larvae) and fingerlings. USFDA Public Master File 5667. Washington, D. C.

Wamboldt, J. 2013. Hybrid striped bass: culture and use in Midwestern waters. Masters Thesis, Iowa State University, Ames.

Wynne, F. and C. Webster. 2000. Hybrid striped bass production in Kentucky. Kentucky State University Aquaculture Research Center, Frankfort.