Experimental Stocking of Florida Largemouth Bass into Small Oklahoma Reservoirs[1]

Eugene R. Gilliland, *Oklahoma Fishery Research Laboratory, 500 E. Constellation, Norman, OK 73072*

Abstract: Thirteen Oklahoma reservoirs (<120 ha) containing northern largemouth bass (*Micropterus salmoides salmoides*) populations were stocked with Florida largemouth bass (*M. s. floridanus*) for 3 years. Stocked and native fish were identified phenotypically by electrophoresis. Stocked fish made up an average of 15% of each year class in the fall at age 0, but the mean proportion declined to 5% by the following spring. Relative overwinter survival to age 1 averaged 25%. Florida largemouth bass were significantly longer at age 0 and age 1 than the northern subspecies but had significantly lower mean relative weights. Survival, mean length, and mean relative weight of Florida phenotypes were lowest in study lakes in the northern and western portions of Oklahoma, indicating that climatic factors were very influential. A recommendation was made to discontinue Florida largemouth bass stockings in Oklahoma north of a diagonal boundary from southwest to northeast. This would limit stockings of hatchery production to areas of the state that show the greatest potential for producing trophy bass.

Proc. Annu. Conf. Southeast. Assoc. Fish & Wildl. Agencies 46:487–494

The Oklahoma Department of Wildlife Conservation (ODWC) began widespread stocking of Florida largemouth bass (FLMB) in the mid 1970s. The intent was to introduce genes into northern largemouth bass (NLMB) populations that would increase growth rates and produce larger bass. In a statewide electrophoretic survey, Gilliland and Whitaker (1989) found Florida-subspecific alleles in 47 of 55 Oklahoma reservoir populations that had been stocked between 1973 and 1985. High degrees of introgression (>50% of the bass carrying FLMB alleles) were seen in 14 populations but few contained any pure FLMB (Gilliland and Whitaker 1989). By 1985, additional indications of the impacts of the stockings were seen as numbers of trophy bass (>3.6 kg) and the number of lakes producing them began to increase (Gilliland 1992). It could not be determined whether high FLMB allele frequencies were the result of introduced fish surviving and mating with native bass,

[1]Contribution No. 218 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma Biological Survey.

or if intergrade fingerlings produced from "contaminated" brood fish were stocked. No information was available on the genetic purity of fingerlings used for stocking prior to 1985; however, ODWC hatchery broodstocks were found to contain high frequencies of NLMB alleles (Gilliland and Whitaker 1989).

Given the uncertainty about the genetic integrity of fingerlings stocked in previous years, further assessment of FLMB stocking as a management tool to increase numbers of trophy bass was needed. Beginning in 1987, fingerlings produced from electropohoretically verified broodstock were introduced into populations of known genetic makeup to determine what physical and biological conditions influence growth and survival of FLMB to age 1. Results from this study would be useful in refining the ODWC criteria used to select reservoirs for future FLMB introductions.

I thank ODWC fishery management, hatchery, and research personnel including Rick Horton and Ken Cunningham for field and laboratory assistance, data analyses, and manuscript review. This research was funded through Oklahoma Federal Aid to Sport Fish Restoration Project F-39-R, Job 12.

Methods

Thirteen lakes were selected that had no history of FLMB stockings (lack or low frequencies of FLMB alleles), were small in size (<120 ha) so that high stocking rates could be used, and were located in 1 of 4 quadrants of the state so that geographic (climatic) influences could be examined (Fig. 1). Some of the lakes that

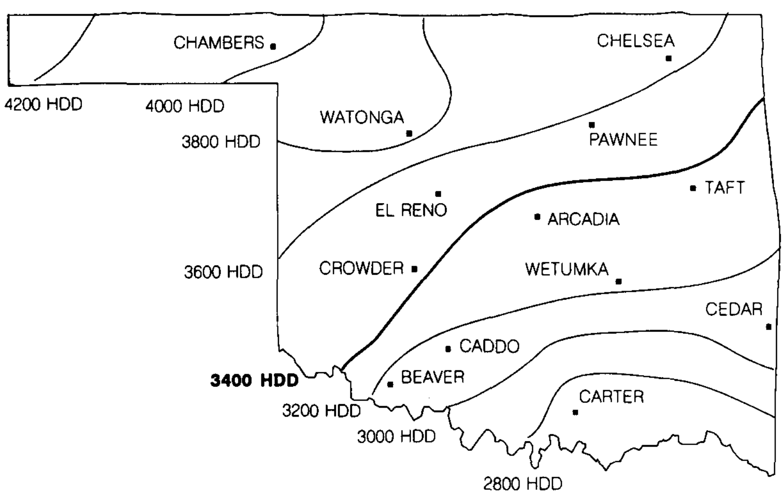

Figure 1. Locations of 13 Oklahoma reservoirs experimentally stocked with Florida largemouth bass from 1987 through 1991, and heating degree day (HDD) clines across Oklahoma, including the 3400 HDD cline which delineates the recommended northern boundary for Florida bass introductions.

fit these criteria had limited bass habitat, but overall they represented a wide range of biotic and abiotic characteristics.

Electrophoretically verified FLMB fingerlings were obtained in 1986, 1987, and 1988 from the U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD). These fish were reared to brood size in ODWC hatcheries. Each lake was stocked with 30- to 50-mm long fingerlings at a rate of 250/ha for 3 consecutive years. Three lakes were stocked from 1987 through 1989, 9 more lakes were stocked from 1988 through 1990, and 4 additional lakes received FLMB from 1989 through 1991.

Samples of 30 age-0 bass were collected from each lake for 3 years beginning the fall following the first stocking. Electrofishing was conducted at several locations on each lake to insure representative samples. Bass were measured for total length (TL in mm) and weighed (g), placed on ice, and returned to the lab for analysis by electrophoresis (Phillip et al. 1982, Harvey 1983, Kulzer et al. 1985). Otoliths were removed from each fish to verify age. The percentage of each year class made up of stocked FLMB was estimated. Similarly, age-1 bass were collected each subsequent spring to estimate overwinter survival of FLMB relative to proportions the previous fall. Only samples with ≥20 bass were included in statistical testing.

Estimates of FLMB survival to age 1 were compared among quadrants and between 2 groups of lakes formed by dividing the state diagonally from southwest to northeast (ANOVA; SAS 1987). Survival estimates were compared to annual cumulative heating degree days (HDD; the sum over all days fall to spring of the difference between 18.3° C and the average daily temperature), deviations in HDD from a 10-year "normal," reservoir age, mean water level fluctuation, secchi disc transparency, electrofishing catch-per-unit-effort (c/f) of largemouth bass and forage species, and presence or absence of aquatic vegetation (linear correlations; SAS 1987). Phenotypic differences in mean lengths and mean relative weights (Wr) were compared by lake, year, and among geographic regions (*t*-test and ANOVA procedures; SAS 1987).

Results

Thirty-nine samples provided 1,268 age-0 bass for electrophoretic analysis. The overall mean proportion of age-0 FLMB in fall samples was 15% with 3-year means for each lake ranging from 0% to 38% (Table 1). Stocked FLMB made up an average of 32% of their respective year classes in fall 1987 but the average declined to 23%, 13%, 11%, and 5% from 1988 to 1991. Collecting sufficient age-1 bass in spring samples for statistical analysis was not feasible in all lakes; however, 841 fish were obtained in 38 samples. Age-1 FLMB made up an average of 5% of each year class (9% using all samples; Table 1). Mean proportions of age-1 FLMB in spring samples were 11%, 4%, 11%, 7%, and 2% from 1988 through 1982.

Substantial numbers of F_x intergrade phenotypes were found in each lake that was stocked in 1988 (INTLMB: Table 1). These fish were the result of stocking

Table 1. Proportions of northern (NLMB), Florida (FLMB), and intergrade (INTLMB) largemouth bass collected from 13 Oklahoma lakes stocked with Florida bass 1987–1991; grouped by geographic region (years stocked), mean sample size of age-0 bass collected in fall and age-1 bass collected in spring (*N*), mean proportion of each phenotype (%), mean survival of FLMB to age 1 (%), mean cumulative heating degree days (HDD), and mean HDD deviation from a 10-year normal.

Region/Lake (years stocked)	Age	Mean *N*[a]	NLMB (%)[a]	FLMB (%)[a]	INTLMB (%)[a]	Mean FLMB Surv. (%)[a]	Mean HDD[ab]	HDD Dev.[c]
NW Region	0	35	80	4	16			
	1	15	99	0	1	0	3,966	− 12
Chambers	0	55	79	6	15			
(88–90)	1	29	97	0	3	0	4,651	+ 52
El Reno	0	31	81	2	17			
(89–91)	1	2	100	0	0	0	3,440	−182
Watonga	0	18	80	4	16			
(89–91)	1	15	100	0	0	0	3,808	+124
NE Region	0	38	55	26	19			
	1	20	49	15	36	38	3,467	−206
Arcadia	0	32	38	38	24			
(88–90)	1	9	16	41	43	67	3,217	−518
Chelsea	0	31	86	14	0			
(89–91)	1	31	97	3	0	33	3,856	− 91
Pawnee	0	24	52	23	25			
(88–90)	1	12	90	2	8	6	3,471	− 91
Taft	0	65	44	29	27			
(87–89)	1	28	72	15	13	47	3,324	− 85
SW Region	0	44	79	7	14			
	1	21	82	1	17	3	2,986	+ 75
Caddo	0	40	86	9	5			
(88–90)	1	24	99	1	0	10	2,874	+175
Crowder	0	50	75	5	20			
(88–90)	1	29	79	0	21	0	3,274	+108
J. Beaver	0	42	75	6	19			
(87–89)	1	9	67	0	33	0	2,810	− 58
SE Region	0	38	75	19	6			
	1	27	92	8	0	55	2,858	− 44
Carter	0	38	66	29	5			
(89–91)	1	32	97	3	0	36	2,377	−331
Cedar	0	38	76	19	5			
(87–89)	1	23	87	11	2	61	3,060	+276
Wetumka	0	38	84	14	2			
(88–90)	1	27	91	9	0	68	3,136	− 77
SE Diagonal	0	42	67	21	12			
	1	22	76	11	13	39	2,971	− 88
NW Diagonal	0	35	76	9	15			
	1	20	94	1	5	8	3,750	− 13
All lakes	0	33	71	15	14			
	1	22	84	9	7	25	3,330	− 52

[a] Means calculated using data from each lake over 3 years.
[b] Shafer 1992.
[c] Positive deviations indicate mean was colder than 10-year normal, negative deviations indicate mean was warmer than normal.

"contaminated" fingerlings supplied by the USFWS that year (7% non-FLMB phenotypes; Gilliland 1992). Due to the low proportions of FLMB in most lakes, the likelihood of FLMB x FLMB matings was small enough that any pure FLMB offspring produced were considered an insignificant addition to proportions of age-0 fish collected during sampling the third year. However, some FLMB did survive to maturity and mated with NLMB to produce F_1 intergrade offspring (Table 1). No age-0 FLMB were collected from lakes that were sampled for 2 to 3 years after the last stocking (Gilliland 1992).

Estimates of FLMB overwinter survival to age 1 for each population ranged from 0% to 68% with an overall mean of 25% (Table 1). Survival was significantly different among lakes grouped by quadrant with means of 0% for the northwest, 3% for the southwest, 38% for the northeast, and 55% for the southeast (P = 0.0236; Table 1). When the state was divided diagonally, FLMB in southeastern lakes had a significantly higher mean survival (39%) than in northwestern lakes (8%; P = 0.0197; Table 1).

Overall, age-0 FLMB were significantly longer than NLMB (mean TL of 127 mm vs. 119 mm; P = 0.0001) but had significantly poorer body condition (mean Wr of 94 vs. 97; P = 0.0059). Age-1 FLMB were longer than NLMB (mean TL of 139 mm vs. 128 mm; P = 0.0001) and had lower Wr values (88 vs. 93; P = 0.0007).

Significant differences in mean TL and mean Wr were found among FLMB by region. Age-0 FLMB were significantly longer in lakes of the southeast quadrant (TL of 135 mm; P = 0.0015) and in lakes of the southeastern half of the state (mean TL of 130; P = 0.0125). Age-1 FLMB were longest in lakes of the northeast and southeast quadrants (mean TL of 134 mm and 147 mm; P = 0.0015 and P = 0.0108). Relative weights of age-0 FLMB were also highest in lakes in the southeastern half of the state (Wr of 94; P = 0.0034).

Comparing mean survival of FLMB to age 1 with cumulative HDD, deviations in HDD from a 10-year normal, reservoir age, and mean water level fluctuation showed slightly negative trends. Weak positive relationships were seen with secchi disc transparency, electrofishing catch-per-unit-effort (C/f) of largemouth bass and forage species, and presence or absence of aquatic vegetation. None of the relationships were statistically significant.

Discussion

This study has shown that first year growth of electrophoretically verified FLMB in Oklahoma reservoirs generally exceeded that of NLMB but generally had poorer body condition (Wr) in the same environments. Perhaps the Florida subspecies does not store fat to the extent that NLMB do because in Florida the winters are seldom severe enough to need such reserves (Phillip and Whitt 1991). Although neither phenotype exhibited Wr values that were considered low, Maceina and Murphy (1988) suggested that if FLMB were experiencing physiological stress during winter, the differences in condition between the subspecies should be greater. Where environmental conditions are already marginal for FLMB growth and survival, slight reductions in condition may trigger increased overwinter mortality. This "condition" dependent mortality may be affecting FLMB in Oklahoma.

This study was conducted in small reservoirs (22–115 ha) rather than hatchery ponds and this may explain why the results conflict with those from Texas of Williamson and Carmichael (1990) and from Illinois of Phillip and Whitt (1991) who found NLMB had faster first-year growth than FLMB. Perhaps the larger volume of water in these reservoirs helped to buffer water temperature changes affecting survival and growth. Phillip and Whitt (1991) reported a range of mean HDD from 2,553 to 3,172 in an Illinois study. Maceina and Murphy (1988) reported the mean annual HDD value during a Texas study was 2,189. Mean HDD during our study were from 2,377 to 4,651 (Shafer 1992; Table 1). If HDD accurately represented the influences of climate on growth of FLMB, the results of our study should have been poorer than those from Illinois and Texas since the mean HDD values from Oklahoma were greater, indicating colder winters.

Survival of supplementally stocked largemouth bass has been shown to be very poor in most cases (Loska 1982). Previous stockings of fingerling NLMB in Oklahoma reservoirs were not successful in increasing bass density, angler catch, or harvest, and is not generally recommended as a mangement tool by the ODWC (Boxrucker 1982). However, the survival of supplementally stocked FLMB fingerlings has been shown to influence the genetic makeup of populations (Kulzer et al. 1895, Gilliland and Whitaker 1989) and produce increases in the production of trophy bass (Forshage et al. 1989, Gilliland 1992).

To attribute the low survival of stocked bass in this study to genetic causes alone would be premature, but the significant changes in phenotypic proportions within year classes between fall and spring indicated weather had a strong influence on survival of FLMB. Mean survival of FLMB to age 1 was significantly higher in study lakes in the southern and eastern parts of Oklahoma which follows the general pattern of decreasingly cold climate across the state from northwest to southeast (Fig. 1). Since no statistically significant relationship existed between survival and cumulative HDD, it appears that this index is not a precise enough measure of winter severity to predict FLMB survival. Brief, intensely cold periods during a winter that may strongly affect FLMB survival (Cichra et al. 1982, Guest 1982) are masked in a cumulative HDD total. In each of the winters of 1989–90, 1990–91, and 1991–92, single week-long periods with high temperatures below $-15°$ C were seen across much of Oklahoma. During these years, statewide mean HDD indicated progressively warmer winters (Shafer 1992), yet the mean proportions of FLMB surviving to age 1 declined each subsequent spring.

Significantly lower survival of FLMB to age 1 in northern and western study lakes supports the idea that a climatic boundary, north of which the Florida subspecies probably will not survive or contribute to a population lies across Oklahoma (Gilliland and Whitaker 1989). Significant differences in growth and survival among populations of FLMB appears to have modified the boundary from an east-west latitudinal line to a southwest to northeast diagonal. To maximize the benefits of FLMB stockings, it is recommended that until further research can more accurately define the role of climate in FLMB survival, the criteria the ODWC uses in selecting lakes for FLMB introductions should include a northern boundary approximately equal to the 3,400 HDD cline (Fig. 1). The selection of this cline takes into account that northeast quadrant lakes experienced a series of milder than normal winters during this study (Table 1) and are likely to be poorer candidates for FLMB stocking in the long term. Because the production of trophy bass is necessarily a long term process (FLMB growth of 0.5 to 1.0 kg/year in Oklahoma; Gilliland 1992), several years of observation will be needed to determine if the levels of FLMB survival reported here make a significant contribution to their respective populations.

Agencies that are considering stocking FLMB bass should strongly consider the climatic variation across their state when choosing recipient lakes. Relying on latitude or cumulative HDD alone to define suitable locations may result in reduced survival of stocked fish because neither account for weather extremes that may significantly influence survival.

Literature Cited

Boxrucker, J. 1986. Evaluation of supplemental stocking of largemouth bass as a management tool in small impoundments. North Am. J. Fish. Manage. 6:391–396.

Cichra, C. E., W. H. Neil, and R. L. Noble. 1980. Differential resistance of northern and Florida largemouth bass to cold shock. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 34:19–24.

Forshage, A. A., P. P. Durocher, M. A. Webb, and D. G. Lewis. 1989. Management application of angler recognition program data. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 43:36–40.

Gilliland, E. R. 1992. Evaluation of genetic status of largemouth bass populations. Okla. Dep. Wildl. Conserv., Perf. Rep., Fed. Aid Proj. F-39-R-14, Job 12. Oklahoma City. 11pp.

——— and J. Whitaker. 1989. Introgression of Florida largemouth bass introduced into northern largemouth bass populations in Oklahoma reservoirs. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 43:182–190.

Guest, W. C. 1982. Survival of adult Florida and northern largemouth bass subjected to cold temperature regimes. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:332–339.

Harvey, W. D. 1983. An electrophoretic evaluation of bi-specific populations of largemouth bass in small Texas impoundments. Ph.D Diss., Texas A&M Univ., College Station. 98pp.

Kulzer, K. E., R. L. Noble, and A. A. Forshage. 1985. Genetic effects of Florida largemouth bass introductions into selected Texas reservoirs. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:56–64.

Loska, P. M. 1982. A literature review on the stocking of black bass (*Micropterus* spp.) in reservoir and streams. Ga. Dep. Nat. Resour., Atlanta. 27pp.

Maceina, M. J. and B. R. Murphy. 1988. Variation in the weight-to-length relationship among Florida and northern largemouth bass and their intraspecific F_1 hybrid. Trans. Am. Fish. Soc. 117:232–237.

Phillip, D. P., W. F. Childers, and G. S. Whitt. 1982. Electrophoretic analysis of largemouth

bass, *Micropterus salmoides*. Pages 1–156 *in* D. P. Phillip, W. F. Childers, and G. S. Whitt, eds. Biochemical genetics of largemouth bass, *Micropterus salmoides*. Electric Power Inst., Palo Alto, Calif.
——— and G. S. Whitt. 1991. Survival and growth of northern, Florida, and reciprocal F_1 hybrid largemouth bass in central Illinois. Trans. Amer. Fish. Soc. 120:58–64.
SAS Institute, Inc. 1987. SAS/STAT Guide: For personal computers; Version 6 edition. SAS Inst., Inc., Cary, N.C. 378pp.
Shafer, M. A. 1992. Oklahoma annual summary. Okla. Climatological Survey, Univ. Okla., Norman. 27pp.
Williamson, J. H. and G. J. Carmichael. 1990. An aquacultural evaluation of Florida, northern, and hybrid largemouth bass, *Micropterus salmoides*. Aquaculture 85:247–258.