Year Class Contribution of Genetically-marked Florida x Northern Largemouth Bass Stocked in Three Texas Reservoirs

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Abstract: Percent year class contribution was evaluated for genetically-marked Florida largemouth bass (*Micropterus salmoides floridanus*) × northern largemouth bass (*M. s. salmoides*) stocked in 3 Texas reservoirs. Electrofishing catch rate and size structure data were used to determine population characteristics of each study reservoir. Stocking rates of genetically-marked fingerlings ranged from 30 to 200 fish/ha. Post-stocking collections were made by electrofishing at permanent stations over a 4-year period. Town Reservoir, which had the highest largemouth densities and recruitment, had the lowest percent contribution by stocked fish (1%–7%). Conversely, Meredith and Braunig reservoirs, which had lower largemouth bass densities and historical recruitment and reproduction problems, respectively, had relatively high returns (41%–45%). Year class strength at the time of stocking influenced success at Town and Braunig reservoirs. The percent contribution of stocked fish was greatest during years with relatively week year classes. In Town Reservoir, offspring of stocked bass contributed significantly to subsequent year classes (5%–13%). These fish appeared to change the genetic structure of this population by increasing age-0 hybrid bass phenotypes (F_1 and F_x) and decreasing the northern bass phenotype. Results suggest supplemental largemouth bass stocking success may be influenced by the density and recruitment characteristics of the native population. However, due to sample size limitations a strict interpretation of these results would be inappropriate. Similar studies, with increased sampling effort, may better define the role of density and recruitment on stocking success.

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Fingerling largemouth bass (*Micropterus salmoides*) are commonly stocked to supplement natural recruitment (Boxrucker 1986). Evaluations of this management technique are limited; however, several studies point to some positive benefits. Largemouth bass stocked at Liberty and Wiley Post Lakes, Oklahoma comprised 70%–75% of a year class for 2 growing seasons (Boxrucker 1986). Fifteen months following stocking, densities of largemouth bass 150–200 mm tripled in Lake Coronado, Arkansas (Filipek and Gibson 1986). Stocked bass comprised nearly 33% of the fish in this length category. In Chatfield Reservoir, Colorado, largemouth bass (125 mm) stocked at rates of 4, 7, and 22/habitat hectare in 3 successive years comprised 12%, 59%, and 59% of age-2 bass in the following years (Krieger and Puttman 1986). Stocking 150–200 mm largemouth bass increased year class strength in an Alabama lake (Lawson and Davies 1979). Several investigators have suggested that stocked largemouth bass may contribute to the abundance of quality (300 mm) size fish (Boxrucker 1986, Fieldhouse 1971, Weaver 1979). While these studies substantiate the validity of this technique many fisheries managers remain pessimistic (Loska 1982). Given the wide geographical distribution of largemouth bass, reservoir specific conditions surely play a role in the success or failure of these stockings.

Texas contains a wide diversity of reservoir types (Dolman 1990). The quality of largemouth bass habitat can vary widely, affecting reproduction and recruitment, and ultimately the density of largemouth bass populations. The effects of these variables on supplemental stocking success have never been evaluated. In 1991 only 49% of the bass requested for supplemental stocking by the Texas Parks and Wildlife Department (TPWD) were produced and stocked (TPWD, unpubl. data). Because the demand for hatchery reared largemouth bass often exceeds supply, reservoirs receiving the greatest benefit from stockings need to be identified.

Discrimination between stocked and native fish is essential for measuring the benefits of supplemental stocking programs (Murphy and Kelso 1986). External marks or tags have been used for this purpose; however, cost and manpower constraints, mark or tag loss, and handling mortality limit their effectiveness (Ricker 1975). Survival of marked fish may be directly impacted by the marks themselves (Shetter 1967, McNeil and Crossman 1979). The Texas Parks and Wildlife Departments' (TPWD) Hatcheries Branch has selectively bred largemouth bass carrying unique alleles to produce genetically identifiable stocks. Electrophoretically detectible genetic markers have provided fisheries managers with an efficient mechanism to evaluate stocking success (Schweigert et al. 1977, Murphy et al. 1983, Seeb et al. 1986, Maceina et al. 1988, Jennings and Philipp 1992, Koppleman et al. 1992). Genetic tags are superior to artificially applied tags because they are permanent, can be passed to succeeding generations (Carmichael et al. 1986, Murphy et al. 1983), and large numbers of fish can be marked with virtually no cost.

Stocking genetically marked largemouth bass provides a good tool for evaluating stocking success under different conditions. Reservoirs best suited for supplemental stocking might then be identified, making the most efficient use of hatchery reared largemouth bass. The primary objectives of this study were to: a) determine and compare the contribution of supplementally-stocked, genetically-marked largemouth bass to their year class in three Texas reservoirs exhibiting different largemouth bass density and recruitment characteristics, b) evaluate the effects of varied stocking rates on year class contribution in Town Reservoir, a reservoir having high largemouth bass density and recruitment, and c) determine the contribution by offspring of supplementally stocked bass.

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Methods

Town Reservoir, located in Central Texas, is a 212-ha impoundment of the Colorado River. Town Reservoir supports a high-density largemouth bass population with good recruitment (Ryan 1987). A 356-mm minimum-length limit and 5-fish daily bag limit has been in effect since 1986.

Braunig Reservoir is a 547-ha heated impoundment located in South Texas. Braunig Reservoir has a history of largemouth bass reproduction problems (Dean and Baily 1977), which has resulted in wide variations in year class strength (V. M. Pitman, unpubl. data). A 533-mm minimum-length limit and 2-fish daily bag limit has been in effect since 1985.

Meredith Reservoir, an impoundment on the Canadian River located in Northwest Texas, covers 6,447 ha at conservation pool. Excessively low water levels (Kraai 1992) and lack of submerged vegetation (Durocher et al. 1984) have been identified as major factors limiting largemouth bass recruitment on this reservoir. A 356-mm minimum-length limit 5-fish daily bag limit has been in effect since 1988.

Northern strain largemouth bass broodstock carrying a unique *IDHP-1*51* allozyme were obtained from Texas A&M University in 1984. These fish were produced from stocks originating from 3 private Texas farm ponds near Caldwell, Texas (Bill Harvey, pers. commun.). The *IDHP-1*51* allozyme was not reported by Philipp et al. (1983) and has not been found in extensive public reservoir evaluations throughout the state of Texas (TPWD, unpubl. data). Florida strain broodstock, originating from Florida, were crossed with these unique northern strain fish to produce genetically marked F_1 (heterozygous) progeny, hereafter called Kemps bass. Broodstock were certified as "pure" using methods similar to those described by Harvey et al. (1984). Kemps bass were stocked as fingerlings (19–32 mm TL). Town Reservoir was stocked with 30 fish/ha (1987) and 100 fish/ha (1988). Braunig Reservoir was stocked with 200 fish/ha (1987) and Meredith Reservoir was stocked with 94 fish/ha (1988).

The largemouth bass population at each reservoir was sampled using pulsed-DC electrofishing boats at permanent stations. Catch rate (fish/hour) data were obtained from samples collected at four 0.25-hour stations in fall 1986, 1988, 1989, and 1990 at Town Reservoir and eight 0.25- to 0.50-hour stations in the fall from

1986 to 1990 at Meredith Reservoir. Catch rate data were obtained at Braunig Reservoir in the fall from 1986 to 1990. Electrofishing effort was not recorded by station at Braunig Reservoir; however, total annual effort ranged from 0.7 to 3.03 hours.

Data used to evaluate post-stocking success of marked fish were collected in the fall from 1988 to 1990 at Town Reservoir, in the fall of 1988 and 1990 at Meredith Reservoir, and in the spring of 1988 and 1991 at Braunig Reservoir. At Town Reservoir, three 0.25-hour electrofishing stations were added to increase sample size. Electrofishing effort during post-stocking collections at Braunig Reservoir ranged from 1.0 to 1.8 hours.

Total length (mm) was recorded for all largemouth bass collected. Liver and otolith samples were taken from all largemouth bass in post-stocking collections at Town and Meredith reservoirs and from a stratified random sample at Braunig Reservoir. Genetic markers from liver samples were identified using horizontal agarose gel electrophoresis and used to differentiate between Kemps and native largemouth bass. Whole otoliths were used for age and year class determinations.

Percent contributions of stocked Kemps bass to year classes were determined for each reservoir. Proportions of Kemps and native bass were compared between sampling years at each reservoir using a chi-square analysis of 2-way contingency tables. Data were then pooled by reservoir, and compared between reservoirs using the same analysis. Total catch rate was used as a measure of population density. Catch rate of fish ≥203 mm was used as a measure of recruitment to stock-size. Proportional stock density (PSD) was also calculated for each study reservoir and used to describe size structure (Anderson 1978).

Offspring resulting from crosses between stocked Kemps bass and native bass were identified to evaluate the spread of this unique allele through the population. Since Kemps bass were heterozygous, 50% of their progeny carried the genetic mark (assuming that Kemps bass only mated with native bass). Accordingly, numbers of marked offspring in samples were doubled to adjust for Kemps offspring which did not carry the mark and the estimated number of native offspring was determined by reducing the number of unmarked fish by the same amount. Proportions of Kemps bass offspring and native offspring collected were compared at each reservoir using a chi-square analysis of 2-way contingency tables. The level of significance for all statistical analyses was $P = 0.05$.

At Town Reservoir, electrophoretic phenotypes (FLMB = Florida largemouth bass; NLMB = northern largemouth bass; F_1 = first-generation hybrid between FLMB and NLMB; F_x = second- or higher-generation hybrid between FLMB and NLMB) were determined for largemouth bass at 3 diagnostic loci (*sAAT-1, IDHP-1* and *sSOD-1*) in liver tissue (Philipp et al. 1983). This was done to evaluate any genetic changes which occurred in the population following the stocking of Kemps bass.

Results and Discussion

Largemouth bass density and recruitment varied between study reservoirs. Based on total electrofishing catch rates, Town Reservoir had the highest large-

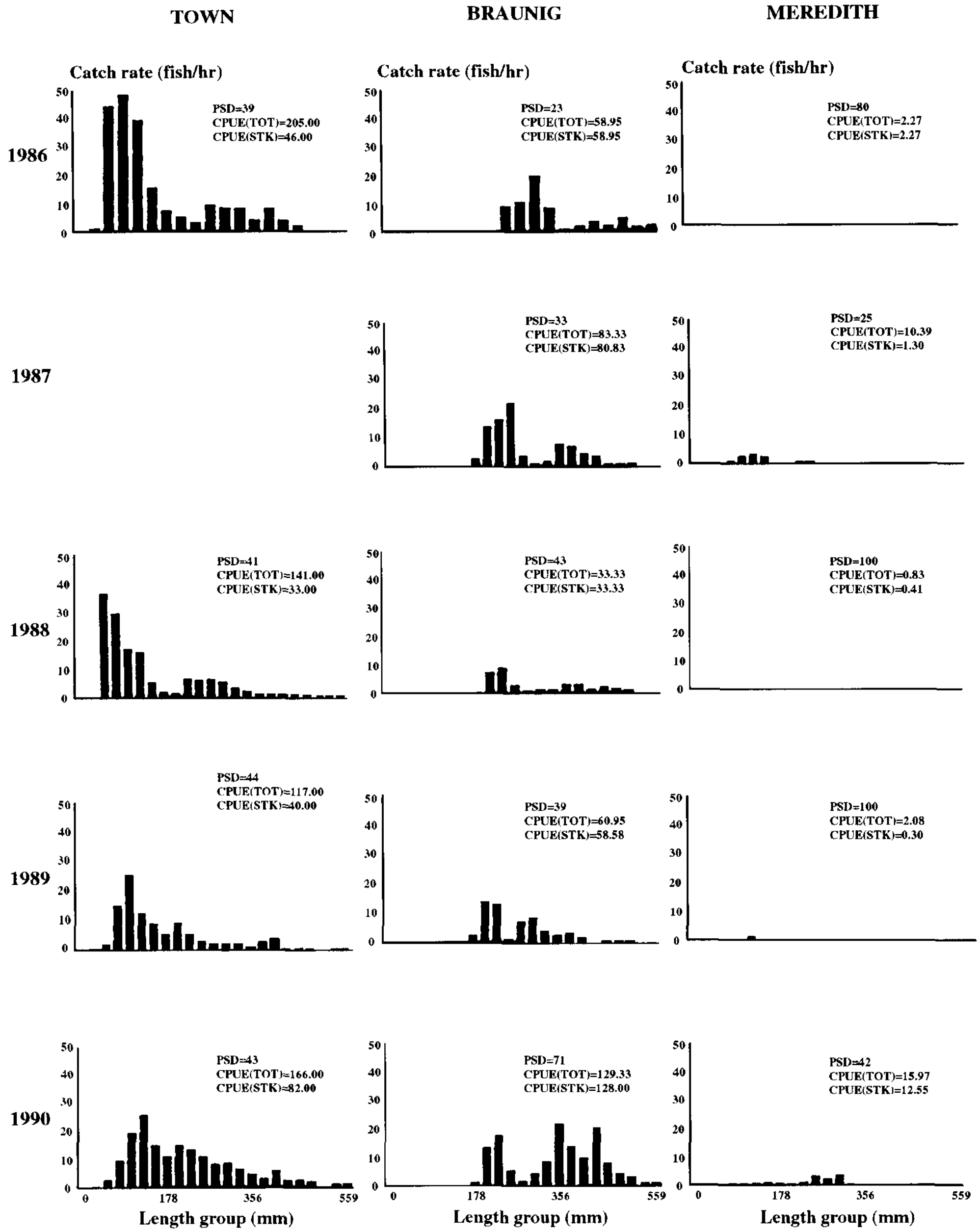

Figure 1. Length frequency distributions of largemouth bass captured by electrofishing at Town, Braunig, and Meredith reservoirs, Texas, during fall from 1986 to 1990. Electrofishing catch rates are presented for all largemouth bass (TOT) and those ≥203 mm TL (STK). Proportional Stock Density (PSD) was calculated and used as a measure of population size structure. Length data are presented in 25 mm length groups.

Table 1. Numbers of Kemps bass (K) and native bass (N) collected by electrofishing at Town, Braunig, and Meredith reservoirs, Texas, 1987–1991. Also included are results of chi-square analysis testing for differences in proportions of K and N between reservoirs. Probability values (P) exceeding 0.05 are not significant.

				Sample year					
Reservoir	Rate[a]	Year class	Type	88	89	90	91	N	Year class[b] contribution (%)
Town	30	1987	K	2	1	0		3	7A
			N	27	8	5		40	
Town	100	1988	K	1	0	1		2	1B
			N	185	52	22		259	
Braunig	200	1987	K	9			0	9	45C
			N	9			2	11	
Meredith	94	1988	K	3		8		11	41C
			N	3		13		16	
$X^2 = 105.45$	df = 3	$P < 0.000001$							

[a] Stocking rate (*N*/ha).
[b] Percentage of year class that is comprised of stocked fish. Percentages with the same letter are not significantly different ($P > 0.05$)

mouth bass density and supported the highest density of fish less than stock size (Fig. 1). Town Reservoir had recruitment characteristics similar to Braunig Reservoir; both supported large numbers of adult bass and exhibited similar size structure (Fig. 1). At Braunig Reservoir, the density of fish less than stock size was considerably less than at Town Reservoir (Fig. 1). Low densities of small bass in Braunig Reservoir may be due to exceptional largemouth bass growth rates. Largemouth bass recruit to 203 mm before the end of their first growing season. Largemouth bass density in Braunig Reservoir may also be limited by inherent reproduction problems (Dean and Bailey 1977). This is thought to be responsible for wide variations in year class strength (V. M. Pitman, unpubl. data), but the exact cause of these problems has not been determined. Meredith Reservoir had the lowest overall catch rates indicating lower density and recruitment (Fig. 1). Low water levels and lack of protective nursery cover are factors which prevent the development of year classes in this reservoir (Kraai 1992).

Unfortunately, small numbers of bass collected at Braunig and Meredith reservoirs limited the power of our statistical tests in evaluating stocking success at these reservoirs. However, despite the small number of bass collected, a high proportion of these fish were stocked Kemps bass (Table 1). Results seem to indicate that Kemps bass stockings at these reservoirs made proportionally a greater year class contribution than stockings at Town Reservoir (Table 1). Reasonable estimates of stocking survival could not be determined due to low numbers of Kemps bass recaptures. However, we suspect that stocking survival would have been higher in Town and Braunig reservoirs due to the better largemouth bass habitat and recruitment conditions in these 2 reservoirs.

Stocking contributions observed did not appear to be directly related to stocking rate. For example, an increased stocking rate at Town Reservoir resulted in a significantly smaller year class contribution (Table 1). Also similar stocking rates at Meredith and Town reservoirs in 1988 resulted in significantly different class contributions. Other factors, besides stocking rate, likely played a stronger role in determining success of our stocking activities.

The proportion which stocked fish make up of a year class may be limited by the density and recruitment characteristics of native populations. Town Reservoir, with high largemouth bass density and recruitment characteristics (Fig. 1), had the lowest percent contribution by stocked fish (Table 1). Conversely, Meredith Reservoir which had a lower largemouth bass density and historical recruitment problems, had higher returns. Differences here may be due to sampling probability. Stocking on top of strong native year classes, which are typical in high density and high recruitment reservoirs, may contribute proportionally less because native fish simply out number stocked fish. Therefore, year class strength at the time of stocking may be an important factor regulating the proportional contribution stocked fish make to a year class.

Within a reservoir, year class strength at the time of stocking also seemed to regulate stocking contributions. Again, the number of native fish present in a year class at the time of stocking may have been responsible for differences in the percent return. At Town Reservoir, stocking contributions were greater in 1987 than in 1988 (Table 1). Collections of bass from the 1988 year class at ages 1 and 2 were approximately twice as large as those from the 1987 year class at the same ages (Table 1). Therefore, it is reasonable to assume the 1988 year class was larger than the 1987 year class at the time of stocking. At Braunig Reservoir, cove rotenone data indicated Kemps bass may have been stocked during a year with relatively low reproductive success (Table 2). This stocking appeared to contribute greatly to the year class (Table 1). If Braunig Reservoir had been stocked in any other year during the study period, stocking success may have been reduced.

Supplemental stockings in reservoirs with high reproduction and recruitment characteristics may proportionally contribute little to a year class. However, these stockings may be important in altering a population's genetic composition through the reproduction of stocked fish. Offspring (Kemps × native) produced from the reproduction of stocked bass in Town Reservoir contributed significantly to the 1989 and 1990 year classes (Table 3). Kemps bass offspring observed in 1989 were probably the result of reproduction of fish stocked in 1987. The increase observed in 1990 was likely due to reproduction resulting from both stockings combined. Reproduction of stocked fish also occurred in Braunig Reservoir; 2 of 10 bass collected from the 1990 year were offspring from Kemps bass. Offspring of Kemps bass were not observed in Meredith Reservoir. Poor recruitment characteristics of this reservoir may have prevented the survival of these fish.

Introductions of Kemps bass into Town Reservoir appeared to alter the genetic structure of this population. Electrophoretic analyses of age-0 bass collected from 1988 to 1990 revealed a general increase in hybrid bass phenotypes (F_1 and F_x) and

Table 2. Number of y-o-y largemouth bass (25–127 mm) caught per hectare in summer cove rotenone samples, Braunig Reservoir, Texas (V. M. Pitman, unpubl. data).

Year	*N*
1986	1,934
1987	934
1988	2,675
1989	2,100
1990	3,633

a notable decrease in the northern strain phenotype (Table 4). Similar findings were reported by Maciena et al. (1988) following the introduction of Florida bass in a population comprised primarily of northern strain fish. They attributed phenotypic changes to hybridization of stocked fish with northern strain bass, higher survival rates of Florida bass and subspecific differences in spawning. In Town Reservoir, hybridization of stocked fish was documented (Table 3). This may at least partially explain shifts observed in age-0 bass phenotypes. Crosses between stocked bass and native phenotypes would have resulted in production of F_1, F_x and Florida bass phenotypes. Survival differences may have also existed between Florida and northern strain bass in Town Reservoir; however, these differences were not readily apparent (Table 4). Subspecific differences in spawning reported by Maceina et al. (1988) may also exist in Town Reservoir, but this was beyond the scope of our study.

Table 3. Numbers of Kemps bass offspring (K) and native offspring (N) collected by electrofishing at Town Reservoir, Texas, 1988–1990. Also included are results of chi-square analysis testing for differences in proportions of K and N between years. Probability values (*P*) exceeding 0.05 are not significant.

Year class	Type	*N*	Year class[a] contribution (%)
1988	K	0	0A
	N	259	
1989	K	12	5B
	N	226	
1990	K	18	13C
	N	116	

$X^2 = 35.26$ df = 2 $P < 0.00001$

[a] Percentage of a year class that is the result of reproduction of stocked Kemps bass. Percentages with the same letter are not significantly different ($P > 0.05$).

Table 4. Percent composition of largemouth bass phenotypes for 3 Town Reservoir year classes over time. FLMB = Florida largemouth bass; NLMB = northern largemouth bass; F_1 = first-generation hybrid between FLMB and NLMB; F_x = second- or higher-generation hybrid between FLMB and NLMB. *N* = sample size.

Year class	Phenotype and sample size	Percent composition in year		
		1988	1989	1990
1988	FLMB	2	4	0
	NLMB	37	40	30
	F_1	12	21	30
	F_x	49	35	40
	N	178	52	23
1989	FLMB		6	3
	NLMB		20	31
	F_1		25	17
	F_x		49	49
	N		119	117
1990	FLMB			2
	NLMB			17
	F_1			20
	F_x			61
	N			134

Management Implications

This study demonstrates the importance of obtaining reproduction and recruitment information prior to stocking. These factors in part determine largemouth bass population density, which ultimately may dictate the success or failure of supplemental stocking efforts. Supplemental stocking programs should be initiated where habitat is good but reproduction and recruitment are limiting. These programs could also be used to supplement known weak year classes. In these cases, stocking should result in a greater proportional contribution by stocked fish. While survival is an integral component of some stocking evaluations it may not be possible to estimate without large numbers of recaptures. Calculating proportional year class contribution, the proportion which stocked fish make up of a year class, may be a simpler means of estimating stocking success. Striking a balance between percent contribution to the fishery and stocking survival should give fisheries managers optimal use of stocked fish.

The genetic structure of bass populations should also be examined prior to stocking. Stockings could have serious genetic effects (positive or negative) on the existing population. In this study, genetic changes occurred 2–3 years following the introduction of Kemps bass. These changes appeared to be the result of reproduction of stocked fish. Maceina et al. (1988) also reported rapid genetic changes following introductions of Florida strain bass. Consequently, Florida strain bass and their hybrids should only be stocked in areas where they are best suited. Inherent differences, including catchability, growth, and survival, exist between largemouth bass strains (Maceina et al. 1988, Kliensasser et al. 1990). These factors can certainly affect the success of supplemental stocking programs.

Genetically marked Florida × northern F_1 largemouth bass seem to be an excellent tool for evaluating stocking success; however, genetic marks need to be developed for both pure Florida and northern strains. Developing additional markers for all strains of largemouth bass would facilitate the evaluation of future stocking programs.

A better understanding of the exact mechanisms involved in supplemental largemouth bass stockings is also needed. The trends we observed indicate that supplemental stocking success may be influenced by the density and recruitment characteristics of the native population. Future studies, focusing on increased sampling effort and estimates of stocking survival, may provide a more definitive explanation.

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