Stocking Contribution of Fingerling Largemouth Bass in Three Aquatic Vegetation Types in Toledo Bend Reservoir, Texas-Louisiana

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Abstract: Texas Parks and Wildlife Department stocks Toledo Bend Reservoir annually with fingerling Florida largemouth bass (*Micropterus salmoides floridanus*). Studies suggest that largemouth bass stockings often result in variable and low contributions to cohort abundance. We explored effects of aquatic vegetation on stocking success of fingerling Florida largemouth bass marked with a pelvic fin clip in three species of aquatic vegetation (hydrilla *Hydrilla verticillata*, coontail *Ceratophyllum demersum*, and Eurasian watermilfoil *Myriophyllum spicatum*) in Toledo Bend Reservoir. Stocking sites received 10,000 fingerlings (mean total length = 35 mm) and consisted of 2 km of contiguous habitat. Study sites were stocked in May–June 2010 ($n = 6$) and May–June 2013 ($n = 5$) and sampled with electrofishing at 3 weeks and 20 weeks post-stocking. At 3 weeks post-stocking, contribution of stocked fish ranged from 0–10% across all sites (mean = 3.7%) and no significant differences were detected among the three aquatic vegetation types. We detected no significant differences between total length of stocked and wild fish among the different vegetation types. No stocked fish were collected at 20 weeks post-stocking. Stocking fingerling largemouth bass resulted in low contribution rates that were not affected by vegetation type.

Florida largemouth bass (FLMB) *Micropterus salmoides floridanus* have been stocked by Texas Parks and Wildlife Department (TPWD) since 1972. Historically, FLMB were primarily stocked in Texas to increase Florida allele frequency of the existing population, supplement limited recruitment, or to mitigate losses after catastrophic events. These stockings have been successful in altering the genetic composition of largemouth bass populations (Forshage and Fries 1995). Currently, TPWD primarily stocks fingerling FLMB (target size 38 mm total length [TL]) into waterbodies with the demonstrated ability to produce relatively high numbers of largemouth bass >3.6 kg, with the goal of enhancing production of large fish. However, largemouth bass stockings often result in variable and low contributions to cohort abundance (Ryan et al. 1998, Buckmeier and Betsill 2002, Hoffman and Bettoli 2005).

Predation on stocked largemouth bass fingerlings is likely one of the most significant sources of mortality. Miranda and Hubbard (1994) found that stocked largemouth bass fingerling survival was positively correlated to fish length and the amount of shelter in the presence of predators in a pond-controlled study. Buckmeier et al. (2005) estimated that nearly 25% of all stocked FLMB were preyed upon within 24 h post-stocking in O. H. Ivie Reservoir, Texas, primarily by other largemouth bass. Similarly, Hoffman (2003) found that 63% of potential predators that had recently consumed a meal contained age-0 largemouth bass in Lake Chickamauga, Tennessee.

Currently, TPWD procedures suggest stocking FLMB into best available inshore habitat (vegetative areas are preferred). Numerous studies have shown that vegetative cover can provide refuge from predation (Savino and Stein 1982, Schramm and Zale 1985, Ostrand et al. 2004). Olson et al. (2003) concluded that age-0 largemouth bass survival was higher in vegetative habitats than in cobble habitats. Schlechte et al. (2005) and Schlechte and Buckmeier (2006) documented that dense habitat improved survival of stocked fingerling largemouth bass in both pond and lab settings.

Aquatic vegetation type, density, and complexity have been shown to affect foraging efficiency (Savino and Stein 1982, Schramm and Zale 1985, Gotceitas and Colgan 1987, Schlechte et al. 2015) and thus may influence contribution of stocked fingerling largemouth bass. However, stocked largemouth bass can also have difficulty foraging, which may result in reduced growth and survival when compared to wild fish (Porak et al. 2002). We could find no studies in reservoirs that examined contribution or growth of stocked largemouth bass in different vegetation types. This information would enable fisheries managers to select stocking sites that maximize the impact of stocked fish. Therefore, our objectives in this study were to estimate contribution and compare sizes of fingerling FLMB stocked into habitats dominated by three species of submersed aquatic vegetation in a Texas reservoir.

Study Area

Toledo Bend Reservoir is an impoundment of the Sabine River in southeast Texas/west Louisiana. The Sabine River Authority constructed the reservoir in 1966 for municipal, industrial, and agricultural water supply, generation of hydroelectric power, and recreational use. At conservation pool (52 m above mean sea level), Toledo Bend Reservoir is 65,780 surface ha (28,745 ha in Texas), has a shoreline length of 1930 km, and a mean depth of 6 m (Driscoll and Ashe 2014). Water level fluctuations average 2.5 m annually. The reservoir is eutrophic with a mean Carlson's Trophic State Index chl-a of 46.7 (Texas Commission on Environmental Quality 2011). Habitat consists of standing timber and aquatic vegetation, primarily hydrilla *Hydrilla verticillata*, Eurasian watermilfoil *Myriophyllum spicatum*, coontail *Ceratophyllum demersum*, and torpedograss *Panicum repens*. These aquatic vegetation species vary in water depth (hydrilla and Eurasian watermilfoil 1.5–4.0 m, coontail 1.5–3.0 m, torpedograss 0–1.5 m) and complexity. Toledo Bend Reservoir is highly prioritized relative to statewide FLMB stockings due to historical production of large bass, total fishing effort, and economic impact of the fishery (Driscoll and Ashe 2014). The reservoir is stocked annually with 500,000–1.6 million FLMB fingerlings (up to 10% of total TPWD production), depending on statewide requests and available surplus.

Methods

In 2010, six study sites were selected consisting of coontail ($n=3$) and Eurasian watermilfoil ($n=3$), followed by five sites selected in 2013 consisting of coontail ($n=2$) and hydrilla ($n=3$). Low water levels due to drought in late 2010 through early 2012 prevented sampling at study sites as most aquatic vegetation was eliminated. Sampling continued in 2013 due to regrowth of aquatic vegetation. Torpedograss was ubiquitous throughout all sites from the shoreline to 1.5-m depths. To minimize potential effects of stocked fish dispersal out of study sites, each site consisted of 2 km of contiguous habitat, as Buckmeier and Betsill (2002) and Jackson et al. (2002) found that most age-0 stocked largemouth bass stayed within 1 km of their stocking site in a Texas and North Carolina reservoir, respectively. Mean stem density was estimated for each study site with methods described by Smart et al. (1994). Ten 1-m² grid counts for stem density were sampled at each site (five at 1-m and five at 2-m depths). Grid counts were evenly spaced throughout the 2-km habitat reach (0, 0.5, 1.0, 1.5, and 2.0 km). All 1-m depth grid counts consisted of torpedograss, and all 2-m depth grid counts consisted of either hydrilla, coontail, or Eurasian watermilfoil. All vegetation was removed at the base within each sampled grid, and for torpedograss did not include biomass emerged from the water surface.

Study sites were stocked at their midpoint with 10,000 FLMB fingerlings (mean TL = 35 mm). Previous work at Toledo Bend Reservoir by Buckmeier et al. (2003) determined that stocking 10,000 FLMB fingerlings per site was most efficient relative to contribution and cost. Stocked FLMB were individually marked with a pelvic fin clip. Fish were anaesthetized using tricane methanesulfonate to facilitate handling and marking, then placed in a holding trough with 2.0 g L⁻¹ un-iodized salt for 24-h before transport and stocking. Mortality 24-h after handling and marking was < 1%.

Sampling for age-0 largemouth bass occurred at 3 weeks (2010 and 2013) and 20 weeks post-stocking (2013 only, as low water prevented sampling in 2010), using day boom-mounted electrofishing. Sampling at each site continued until 80 age-0 largemouth bass had been collected or for one hour, whichever occurred first. Sampling began mid-point with the direction being determined by a simple coin toss. If the end of the site was reached before the required number of fish was sampled or the allotted time expired, then sampling continued at the mid-point of the site in the opposite direction. This sampling protocol was based on simulations indicating that sampling either 80 fish or sampling for one hour should ensure that at least one stocked fish would be collected, assuming a 5% contribution rate.

The percent contribution of stocked FLMB for each sample date and vegetation type was defined as the ratio of stocked age-0 fish to all age-0 largemouth bass collected. Percent contribution of stocked fish per treatment was estimated using Poisson analysis of variance (ANOVA) with habitat type and year as independent variables. We used the log₁₀ transform of the total number of fish caught as an offset, and accounted for over-dispersion by using the scaled deviance. To test if there were differences in total length between stocked and wild fish, both overall and by vegetation type, we used a mixed model ANOVA (Proc MIXED) with location as a random effect to account for subsampling (SAS Institute 2008). All statistical analyses were considered significant at $P < 0.05$.

Results

At three weeks post-stocking, the overall mean stocking contribution rate among all sites ($n=11$) was 3.7% (range = 0–10.8%), and did not vary among the vegetation types ($F=0.48$; df = 2, 7; $P=0.64$). Percent stocking contribution was 3.4%, 3.8%, and 4.8% for Eurasian watermilfoil, coontail, and hydrilla sites, respectively (Table 1). Estimated stem densities were relatively high and similar among vegetation types ($F=2.36$; df = 2, 6; $P=0.18$; range = 449 – 92 stems m⁻²) (Table 1). Total lengths of stocked and wild fish were similar overall ($F=2.51$; df = 1, 15; $P=0.13$) and by vegetation type ($F=0.99$, df = 2, 13; $P=0.40$) (Table 1).

Table 1. Mean stem density[a] of aquatic vegetation type (Relative Standard Errors [RSE] in parentheses), percent contribution, and mean total length (TL, mm) of stocked and wild largemouth bass collected by aquatic vegetation type, Toledo Bend Reservoir, Texas, in 2010 and 2013. Fish were collected at 3 weeks post-stocking.

Type	Percent contribution	Stem density[a] (stems m^{-2})	Stocked TL (*n*; RSE)	Wild TL (*n*; RSE)
Coontail	3.8	449 (17.8)	51 (14; 9.9)	55 (363; 2.2)
Eurasian watermilfoil	3.4	692 (11.5)	37 (7; 8.8)	51 (206; 3.3)
Hydrilla	4.8	597 (13.4)	38 (3; 3.1)	63 (58; 6.2)

a. Torpedograss was ubiquitous from shoreline to 1.5-m depths.

Discussion

Previous studies consistently indicated that vegetation stem densities are inversely correlated with predation rates (Savino and Stein 1982, Schramm and Zale 1985, Gotceitas and Colgan 1987). Juvenile largemouth bass survival has been positively correlated to vegetative coverage (Durocher et al. 1984, Wiley et al. 1984, Miranda and Hubbard 1994, Miranda and Pugh 1997), likely due to refuge from predation (Savino and Stein 1982, Schramm and Zale 1985, Ostrand et al. 2004). However, despite high stem densities in our study sites, estimated stocking contributions were low.

Given the lack of vegetation type and stem density effects we observed on stocked fish contribution, these same factors may have reduced foraging efficiency or altered prey consumed (Bailey 1974, Morris and Follis 1978). Aquatic vegetation has been found to reduce largemouth bass foraging efficiency at an approximate density of 250 stems m^{-2} (Savino and Stein 1982, Gotceitas and Colgan 1987), which was considerably lower than estimated densities in our study sites. Wild and stocked fish may have had had similar diets and foraging success given the similar total lengths between wild and stocked fish. Hoffman and Bettoli (2005) also found no differences in foraging efficiency between stocked and wild largemouth bass fingerlings.

In 2013, no stocked fish were collected at 20 weeks post-stocking in any site, further suggesting that mortality rate of stocked fish remained high between 3 weeks and 20 weeks post-stocking. Marked fish should have still been easily detectable, as other studies have demonstrated that fin clips are nearly 100% discernable for more than one year (Buynak and Mitchell 1999, Diana and Wahl 2009). Furthermore, catch rates of age-0 largemouth bass were similar at 3 weeks and 20 weeks post-stocking (59.2 and 64.0 age-0 fish h^{-1}, respectively). Hoffman and Bettoli (2005) documented decreasing contributions of stocked largemouth bass in Lake Chickamauga, Tennessee, at similar periods (13% –29% and 9% at approximately 2 weeks and 18 weeks post-stocking, respectively).

Certainly, our contribution rate estimates were low. However, contribution may not be a reliable gauge of actual survival and stocking success at waters with high wild fish abundance, simply due to dilution. For example, our study reservoir had an average electrofishing catch rate of 184 fish h^{-1} during the study period. In contrast, Hoffman and Bettoli (2005) and Colvin et al. (2008) calculated higher contribution rates (approximately 15% to 25%) from Lake Chickamauga, Tennessee, and the Arkansas River, respectively, but wild fish abundance was considerably lower (< 50 fish h^{-1}) (Tennessee Valley Authority, unpublished data, Eggleton et al. 2010). Estimates of stocked fish survival would better reflect stocking success, but increased sampling frequency and sample sizes would be required.

Our findings suggested little success of FLMB fingerling stockings in Toledo Bend Reservoir regardless of habitat used. However, survival of stocked, fingerling FLMB has been sufficient to genetically alter largemouth bass populations throughout Texas (Forshage and Fries 1995) as well as Toledo Bend Reservoir (Driscoll and Ashe 2014). Also, there can be little doubt that these stockings have been generally successful relative to the goal of enhancing production of largemouth bass > 3.6 kg. Prior to FLMB stockings in Texas, the state record largemouth bass weighed 6.1 kg. Currently, it now takes a fish > 7.0 kg to make the list of the largest 50 largemouth bass caught in Texas, and all of these fish were either FLMB or intergrades. To improve stocked fingerling survival, future research should explore relationships between habitat complexity and rates of stocked fish predation, prey availability, and foraging efficiency. Additional studies of stocking success should be designed to provide estimates of stocked fish survival, not contribution.

Acknowledgments

Literature Cited

Bailey, W. M. 1974. An evaluation of striped bass introductions in the southeastern United States. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 28:54–68.

Buckmeier, D. L. and R. K. Betsill. 2002. Mortality and dispersal of stocked fingerling largemouth bass and effects on cohort abundance. American Fisheries Society Symposium 31:667–676.

———, J. W. Schlechte, and R. K. Betsill. 2003. Stocking fingerling largemouth bass to alter genetic composition: efficacy and efficiency of three stocking rates. North American Journal of Fisheries Management 23:523–529.

———, R. K. Betsill, and J. W. Schlechte. 2005. Initial predation of stocked fingerling largemouth bass in a Texas reservoir and implications for improvingstocking efficiency. North American Journal of Fisheries Management 25:652–659.

Buynak, G. L. and B. Mitchell. 1999. Contribution of stocked advanced-fingerling largemouth bass to the population and fishery at Taylorsville Lake, Kentucky. North American Journal of Fisheries Management 19:494–503.

Colvin, N. E., C. L. Racey, and S. E. Lochmann. 2008. Stocking contribution and growth of largemouth bass stocked at 50 and 100 mm into backwaters of the Arkansas River. North American Journal of Fisheries Management 28:434–441.

Diana, M. J. and D. H. Wahl. 2009. Growth and survival of four sizes of stocked largemouth bass. North American Journal of Fisheries Management 29:1653–1663.

Driscoll, M. T. and D. E. Ashe. 2014. Inland fisheries division monitoring and management program survey report for Toledo Bend Reservoir, 2013. Texas Parks and Wildlife Department, Federal Aid Report F-30-R, Austin.

Durocher, P. P., W. C. Provine, and J. E. Kraii. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. North American Journal of Fisheries Management 4:84–89.

Eggleton, M. A., B. G. Batten, and S. E. Lochmann. 2010. Largemouth bass fishery characteristics in the Arkansas River, Arkansas. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 64:160–167.

Forshage, A. A. and L. T. Fries. 1995. Evaluation of the Florida largemouth bass in Texas, 1972–1993. American Fisheries Society Symposium 15:484–491.

Gotceitas, V. and P. Colgan. 1987. Selection between densities of artificial vegetation by young bluegills avoiding predation. Transactions of the American Fisheries Society 116:40–49.

Hoffman, K. J. 2003. Recruitment variability of largemouth bass and stocking efficacy in Tennessee River impoundments. Master's thesis. Tennessee Technological University, Cookeville.

——— and P. W. Bettoli. 2005. Growth, dispersal, mortality, and contribution of largemouth bass stocked into Chickamauga Lake, Tennessee. North American Journal of Fisheries Management 25:1518–1527.

Jackson, J. R., R. L. Noble, and J. R. Copeland. 2002. Movements, growth, and survival of individually marked fingerling largemouth bass supplementally stocked into a North Carolina reservoir. Pages 677–689 *in* D. P. Philipp and M. S. Ridgeway, editors. Black bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Miranda, L. E. and W. D. Hubbard. 1994. Winter survival of age-0 largemouth bass relative to size, predators, and shelter. North American Journal of Fisheries Management 14:790–796.

——— and L. L. Pugh. 1997. Relationship between vegetation coverage and abundance, size, and diet of juvenile largemouth bass during winter. North American Journal of Fisheries Management 17:601–610.

Morris, D. J. and B. J. Follis. 1978. Effects of striped bass predation upon shad in Lake E. V. Spence, Texas. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 32: 697–702.

Ostrand, K. G., B. J. Braeutigam, D. H. Wahl. 2004. Consequences of vegetation density prey species on spotted gar foraging. Transactions of the American Fisheries Society 133:794–800.

Olson, M. H., B. P. Young, and K. D. Blinkoff. 2003. Mechanisms underlying habitat use of juvenile largemouth bass and smallmouth bass. Transactions of the American Fisheries Society 132:398–405.

Porak, W. F., W. E. Johnson, S. Crawford, D. J. Renfro, T. R. Schoeb, R. B. Stout, R. A. Krause, and R. A. DeMauro. 2002. Factors affecting survival of largemouth bass raised on artificial diets and stocked into Florida Lakes. Pages 649–665 *in* D. P. Phillipp and M. S. Ridgeway, editors. Black bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Ryan, M. J., M. A. Webb, and L. T. Fries. 1996. Contribution of largemouth bass reared in nursery ponds to year classes in two Texas reservoirs. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 50:131–138

SAS Institute. 2008. SAS user's guide: statistics, version 9.1. SAS Institute, Cary, North Carolina.

Savino, J. F. and R. A. Stein. 1982. Predator-prey interaction between largemouth bass and bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society 111:255–266.

Schlechte, J. W., R. K. Betsill, and D. L. Buckmeier. 2005. A laboratory evaluation of poststocking predatory losses for cultured largemouth bass. Transactions of the American Fisheries Society 134:141–148.

——— and D. L. Buckmeier. 2006. A pond evaluation of habituation as a means to reduce initial mortality associated with poststocking predation of hatchery-reared largemouth bass. North American Journal of Fisheries Management 26:119–123.

———, B. P. Fleming, and K. S. Reeves. 2015. Predation on largemouth bass fingerlings in artificial habitat of varying hydrilla stem density and architecture. The Texas Journal of Science. 64:173–193.

Schramm, H. L., Jr. and A. V. Zale. 1985. Effects of cover and prey size on preferences of juvenile largemouth bass for blue tilapias and bluegills in tanks. Transactions of the American Fisheries Society 114:725–731.

Smart, R. M., J. W. Barko, and D. G. McFarland. 1994. Competition between *Hydrilla verticillata* and *Vallisneria americana* under different environmental conditions. Technical Report A-94-1, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Texas Commission on Environmental Quality. 2011. Trophic classification of Texas reservoirs: 2010 Texas water quality inventory and 303 (d) list.

Wiley, M. J. R., W. Gorden, S. W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois ponds: a simple model. North American Journal of Fisheries Management 4:111–119.