Comparison of Plastic Pipe and Juniper Tree Fish Attractors in a Central Texas Reservoir

Stephan J. Magnelia, *Texas Parks and Wildlife Department, Inland Fisheries Division, 505 Staples Rd., San Marcos, TX 78666*

Marcos J. De Jesus, *Texas Parks and Wildlife Department, Inland Fisheries Division, 505 Staples Rd., San Marcos, TX 78666*

J. Warren Schlechte, *Texas Parks and Wildlife Department, Inland Fisheries Division, 5103 Junction Highway, Ingram, TX 78025*

Greg C. Cummings, *Texas Parks and Wildlife Department, Inland Fisheries Division, 505 Staples Rd., San Marcos, TX 78666*

Joshua L. Duty,[1] *Texas Parks and Wildlife Department, Inland Fisheries Division, 505 Staples Rd., San Marcos, TX 78666*

Abstract: Fish attractors are commonly used by fisheries agencies to concentrate cover-seeking species. The objective of this study was to determine if an attractor fabricated with polyethylene pipe (plastic) attracted and concentrated as many largemouth bass (*Micropterus salmoides*) and sunfish (*Lepomis* sp.) as juniper tree (*Juniperus ashei*) attractors. Fish counts at each attractor type were made by scuba divers at five study sites in Canyon Reservoir, Texas. Overall, few fish were observed in the plastic attractors (mean = 3.4) compared to juniper tree attractors (mean = 30.3) ($P < 0.05$). Significantly greater numbers ($P < 0.05$) of adult and juvenile largemouth bass and bluegill (juvenile and adult) were concentrated in juniper attractors compared to plastic attractors. While 81% of the attractors deployed at the test sites were plastic, there was strong evidence ($P < 0.05$) that bluegill (adults and juveniles) and adult largemouth bass selected juniper attractors. Juvenile bluegill were the most abundant species and life stage observed (71% of the fish observed), which may have attracted foraging adult largemouth bass. Although fabricated plastic fish attractor designs are desirable because of their longevity, their effectiveness for attracting and concentrating target species should be evaluated prior to being used in large scale projects.

Key words: attractors, plastic, largemouth bass, underwater observation

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 62:183–188

Fish attractors are commonly used by fisheries agencies to concentrate fish and increase angler catch rates for cover-seeking species such as largemouth bass (*Micropterus salmoides*) (Brown 1986, Tugend et al. 2002, Bolding et al. 2004). Attractors are often used in reservoirs when little natural cover (aquatic vegetation, standing timber, brush etc.) is available. Cut brush, bundled tires, evergreen trees, rocks, boulders, and plastic (e.g., polyethylene and polyvinyl chloride) materials have all been commonly used when constructing attractors (Rogers and Bergersen 1999, Bolding et al. 2004). Brushpiles and evergreen trees are time-tested attractor materials in freshwater, but often degrade quickly and must be regularly replenished (Wilbur 1974). Structures made of plastic are advantageous because they have increased longevity, but often have several disadvantages. Four issues which have been identified are: 1) they lack complex structure and small interstitial spaces which small sunfish (*Lepomis* sp.) seem to favor (Johnson et al. 1988, Walters et al. 1991, Bolding et al. 2004), 2) they can be expensive when compared to brush (Mosher 1985), 3) they have been found to attract fewer fish (Rold et al. 1996), and 4) they have had low satisfaction rates among state fisheries agencies when the objective is to increase angler catch rates (Tugend et al. 2002).

Canyon Reservoir, located in Comal County, Texas, is generally devoid of cover and has historically had few aquatic macrophytes (Magnelia and Bonds 2004). Angler catch rates for largemouth bass have historically been poor (<0.5 bass/hour), although this species was the reservoir's most sought after (46% of directed effort) sport fish (Magnelia and Bonds 2000). Bluegill (*Lepomis macrochirus*), redbreast sunfish (*Lepomis auritus*), and redear sunfish (*Lepomis microlophus*) were also present and serve as forage species for largemouth and smallmouth bass (*Micropterus dolomieu*) (Magnelia and Bonds 2004). White crappie (*Pomoxis annularis*), which are often a target species of fish attractor projects (Petit 1973, Johnson and Lynch 1992), were also present in low density (Magnelia and Bonds 2004).

In 2004 a cooperative effort between the Texas Parks and Wildlife Department Inland Fisheries Division, the Comal County Water Oriented Recreation District, the U. S. Army Corps of Engineers, the Texas Association of Bass Clubs, local bass clubs, and other volunteers was initiated to improve angler catch rates for largemouth bass through the use of fish attractors. Two fish attractor types were proposed: (1) a plastic attractor designed to emulate a small bush made with high density polyethylene pipe and (2) har-

1. Texas Department of State Health Services, Seafood and Aquatic Life Group, Mail Code 2829, P.O. Box 149347, Austin, TX 78714-9347

vested juniper trees (*Juniperus ashei*), which grow in abundance along the reservoir's shoreline. Commercially-made plastic attractors have been found to concentrate largemouth bass (Rogers and Bergersen 1999), but the high per-unit-cost of these (Bolding 2004) made their use unattractive to Canyon Reservoir cooperators. The primary objective of this study was to determine if the attractors fabricated with polyethylene pipe attracted and concentrated as many largemouth bass and small sunfish as the juniper tree attractors. Because both juniper and polyethylene attractors were placed at each site we were able to conduct a side-by-side comparison of the different attractor types' effectiveness.

Methods

Canyon Reservoir is a 3335-ha flood-control reservoir located in Comal County, Texas, and was created in 1964 when the Guadalupe River was impounded. It is classified as an oligo-mesotrophic, hard water, deep storage, bottom draining reservoir (Hannan et al. 1979). Thermal stratification is normally present from May through November with anoxic conditions existing in the hypolimnion from July through November (Hannan and Young 1974). The reservoir's only cover for fish is standing timber, which is available along only 4% of the reservoir's shoreline. No significant stands of aquatic vegetation have ever been documented in the reservoir (Magnelia and Bonds 2004).

Fish attractors were installed in January 2005 and 2006 at 18 sites at a depth of approximately 7–8 m, which is above the depth of the summer metalimnion (S. Magnelia, TPWD, unpublished data). Attractor locations were recorded with a global positioning system (GPS). A map marked with attractor locations along with their GPS coordinates was made available to cooperators and the public. Two fish attractor types were used: a fabricated plastic attractor and juniper trees. The plastic attractor was constructed of 15–20 cut pieces (1–2 m in length) of 19 mm (outside diameter) high-density polyethylene pipe (plastic) cemented into a 10.2 by 20.3-cm concrete construction block (Figure 1). The pipe was drilled along its length with 5-mm holes to allow air to escape from the pipe as the attractor sank. The plastic attractor was designed to emulate a 1- to 1.5-m diameter bush. The polyethylene pipe had a projected life of 20 to 25 years. We could not find any literature describing a similar plastic attractor design. Cooperators thought the design might be effective at attracting target species, be easy to deploy, economical to construct, and have a long life span. Volunteers expended approximately 250 man-hours and US$8,336 ($3,336 of this total was donated materials) on materials constructing 378 plastic pipe attractors. The cost per plastic attractor was $22.05 (materials only), which was inexpensive in comparison to commercially made plastic attractor prices quoted in the literature (Mosher 1985, Rogers and Bergerson 1999). Juniper trees (n = 58) (mean height of approximately 1.5 to 2 m) were cut at the base from private property near the shore line, where they are considered to be a nuisance by landowners. A concrete construction block was attached near the middle of the tree with a 0.9-m heavy duty nylon cable tie. The cost per juniper tree for the concrete block and nylon cable tie was $1.60.

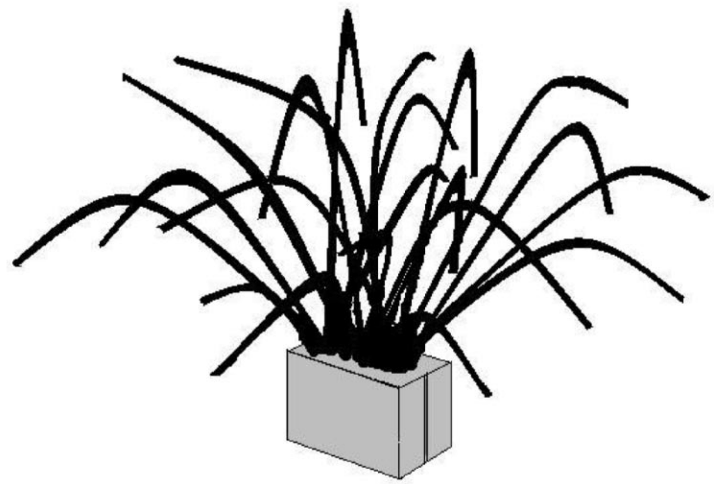

Figure 1. Drawing of one plastic pipe fish attractor deployed in Canyon Reservoir, Comal County, Texas, January 2005. The attractor was constructed of 15–20 cut pieces (1–2 m in length) of 19 mm (outside diameter) high-density polyethylene pipe cemented into a 10.2 by 20.3-cm concrete construction block.

Attractor sites were selected that had little or no natural cover, but already had what we thought might be other good attracting qualities for largemouth bass. Examples of selected sites included: the end of underwater points, featureless bottoms near sharp bottom contour breaks (i.e., drop offs), and the edge of creek or river channels. A bottom contour map was used to locate these areas and a liquid crystal type depth finder was then used on the water to pinpoint precise locations for attractor placement. Once locations were identified, small marker buoys defining the target area (50–70 m^2) were placed at each site and attractors were dropped within that area by boat. Attractors at each site were placed within a small area (70 m^2) which was well within the home range of largemouth bass and bluegills (Fish and Savitz 1983, Paukert et al. 2004). This allowed them to select between plastic attractors and the two juniper attractor types (juniper trees and mixed).

Five attractor sites were selected for evaluation. These sites were selected because water clarity was sufficient for scuba divers to observe fish associated with each attractor type and both types of attractors were present. Four of the sites were in the lower portion of the reservoir and one was in the middle portion. Diver visibility at attractor depth was approximately 1.8 m and 0.9 m, at the lower and middle reservoir sites, respectively. One hundred and forty-three plastic and 34 juniper tree attractors were placed at the five sites. The number of attractors placed at each site were: Site one—27 plastic attractors and 6 juniper trees; site two—30 plastic attractors and 8 juniper trees; site three—32 plastic attractors and 7 juniper trees; site four—31 plastic attractors and 6 juniper trees; site five—23 plastic attractors and 7 juniper trees.

On two days in September 2006 attractor types at the five sites were evaluated simultaneously, but independently by two scuba divers. Bohnsack and Bannerot (1986) described a stationary visual census technique that could be used to quantify fish by scuba divers on coral reefs where visibility was good. Modifications of this technique have been used to count fish at freshwater fish attractors, and we used a technique similar to that described by Graham (1992). Once a diver encountered an attractor type he remained stationary on the bottom for approximately five minutes facing the attractor. During this time period the diver scanned left to right 0–180° within an imaginary hemisphere. The area observed was limited to the maximum visibility at each attractor site. The species identified within this initial time period were recorded on an underwater writing slate.

At the end of the five-minute period the number of individuals of each species was counted. Each diver recorded the number and life stage (juvenile or adult) of bluegill, redbreast sunfish, and largemouth bass associated with each attractor type. Adult bluegill and redbreast sunfish were those individuals >76 mm, while adult largemouth bass were classified as those >200 mm. A ruler was initially used by each diver to help gauge lengths of fish observed. Other species encountered were not classified as to life stage, but were counted. Because juniper and plastic attractors were placed at each site we also encountered attractors that were intertwined (mixed). Observations at these attractors were recorded separately from the other two attractor types. Each attractor type encountered, within a site, was evaluated once by each observer. Temperature and dissolved oxygen profiles were taken at each attractor site to confirm that the sites were above the metalimnion.

To test for differences in the attractors' ability to concentrate target species, mean counts of total fish observed and total fish by species and life stage observed at each attractor type were compared using a randomized block design two-way ANOVA. Treatments (fish attractor type) were blocked by site. Pairwise comparisons between attractor types were made using a Tukey's studentized range test. To confirm that observations were similar between the two divers, mean count of total fish observed and total fish by species and life stage observed were compared between divers using a *t*-test. Two additional study sites located in the lower end of the reservoir, which just had juniper tree attractors (25 juniper trees per site), were added to the diver counts to increase the sample size for this comparison. All fish count data were square-root transformed prior to analysis (Zar 1984).

To test for attraction (i.e., selection) we compared the estimated proportion of fish using each attractor type to the proportion of fish we would have expected if the fish had no preference. We examined attractor preference for juvenile and adult largemouth bass and bluegill, as well as all fish combined. The number of plastic attractors intertwined with juniper was calculated for each site so they could be deleted from the plastic attractor category total (site 1 = 2, site 2 = 3, site 3 = 4, site 4 = 5, site 5 = 3). This was calculated by using the mean number of plastic attractors intertwined in juniper (as observed by the divers) multiplied by the maximum number of mixed attractors observed by the divers. Our expected proportion under the null hypothesis of "no preference" was the proportion of attractors of each type. We subtracted the expected proportion from the observed proportion and used that result as the test statistic. Under the null hypothesis, we expected our test statistic would have a mean of zero. We tested the hull hypothesis using a weighted *t*-test on the difference in proportions (Zar 1984). We used the number of fish observed as our weights; hence, sites with more fish received greater weights in the analysis. Statistical Analysis Software (SAS) was used for all tests (alpha = 0.05) (SAS 2007).

Results

Bluegill and largemouth bass made up 96% of the fish observed. Few largemouth bass were observed (n = 91) compared to bluegill (n = 985). Other species observed included: redear sunfish, redbreast sunfish, green sunfish (*Lepomis cyanellus*), longear sunfish (*Lepomis megalotis*), smallmouth bass, Guadalupe bass (*Micropterus treculi*), flathead catfish (*Pylodictis olivaris*), and Rio Grande cichlid (*Cichlasoma cyanoguttatum*). A total of 63 counts (n = 1112 fish counted) were made by the two divers at the five attractor sites which had all three attractor types present. This included counts at 30 plastic pipe, 22 juniper tree, and 11 mixed attractors. The number of counts by each diver was almost equal (30 and 33, respectively). An additional 23 diver counts (12 and 11 counts by each diver, respectively) were made at the two additional sites which just had juniper attractors. These counts were added to the other counts (n = 86 total counts by divers) and only used in the comparison of fish counts between divers. There was no significant difference observed in counts for mean total fish (t = 1.41, DF = 84, P = 0.16), bluegill adults (t = 1.05, DF = 84, P = 0.29), juvenile bluegill (t = 1.92, DF = 84, P = 0.06) and largemouth bass adults (t = –0.29, DF = 84, P = 0.77) between the divers. There was a significant difference in mean total counts of juvenile largemouth bass between divers (t = 2.41, DF = 78, P = 0.02). Few (n= 28) juvenile largemouth bass were observed and the difference in means between divers may have been due to the low sample size or difficulty observing them among the juniper tree branches and/or plastic pipes.

There was no evidence of spatial correlation of fish counts among treatments by site. The influence of site was non-significant ($P > 0.05$) and was removed from the final analysis to improve the power to detect differences among the treatments and improve estimates of error. Because site was non-significant, a Welch's one-way analysis of variance was used to detect differences in fish counts between attractor types. Fish attractor type had a significant effect on mean total fish (F = 41.9, DF = 2, $P < 0.0001$), juvenile (F = 3.9, DF = 2, $P = 0.03$), and adult largemouth bass (F = 6.2, DF = 2, $P = 0.007$), and juvenile (F = 34.4, DF = 2, $P < 0.0001$) and adult bluegill (F = 10.6, DF = 2, $P < 0.001$). All the plastic pipe attractors were covered in periphyton and most (99%) had deployed as intended, with the plastic pipe radiating up from the substrate to provide cover, yet we observed few fish (9% of the total fish observed) utilizing them. The mean total number of fish observed in the plastic pipe attractors was small ($x = 3.4$, SE = 1.0) compared to juniper tree attractors ($x = 30.3$, SE = 4.4) and mixed attractors ($x = 31.3$, SE = 5.4). Bluegill was the most abundant species observed, with juveniles and adults accounting for 71% and 17% of all fish observed, respectively. Significantly higher ($P < 0.05$) total fish counts and counts of juvenile and adult largemouth bass and bluegill were observed in juniper tree than the plastic pipe attractors (Table 1). No differences ($P > 0.05$) were observed in these categories for juniper tree versus mixed attractors (Table 1). Juvenile and adult largemouth bass counts at mixed sites were no different ($P > 0.05$) from plastic pipe attractors. However, the percentage of time we observed (presence at an attractor) an adult or juvenile largemouth bass at a mixed attractor (54% or 45%, respectively) was much higher than at plastic pipe attractors (30% or 13%, respectively).

When totals by attractor type were estimated for the five sites it appeared there was little difference in the number of fish attracted, except for juvenile bluegill (Table 2). It appeared that about four times as many plastic attractors could be used to concentrate the same number of fish. When we tested for attraction we found there was strong evidence that bluegill (adults and juveniles) and largemouth bass adults selected the juniper attractors (Table 3). Although juvenile largemouth bass always appeared in higher proportion than expected, missing data (zero counts at two sites) reduced the number of sites available for testing from five to three, reducing the power of the test.

Table 1. Mean number of largemouth bass adults (LMBA), largemouth bass juveniles (LMBJ), bluegill adults (BLGA), bluegill juveniles (BLGJ) and total fish (TOT) observed at plastic pipe (n = 30), juniper tree (n = 22) and mixed attractor (n = 11) types by scuba divers, Canyon Reservoir, Texas, September 2006. Standard error is included in parentheses. Means with a letter (A, B, or C) in common at each attractor type are not significantly different ($P > 0.05$).

	Mean number observed				
Attractor type	LMBA	LMBJ	BLGA	BLGJ	TOT
Plastic pipe	0.33^{A} (0.10)	0.16^{A} (0.84)	0.73^{A} (0.39)	1.83^{A} (0.84)	3.36^{A} (0.10)
Juniper tree	1.64^{B} (0.36)	0.68^{B} (0.20)	2.86^{B} (0.56)	23.72^{B} (4.04)	30.31^{B} (4.37)
Mixed	$1.27^{A,B}$ (0.52)	$0.72^{A,B}$ (0.30)	9.27^{B} (4.59)	19.73^{B} (4.28)	31.27^{B} (5.39)

Table 2. Estimated total largemouth bass adults (LMBA), largemouth bass juveniles (LMBJ), bluegill adults (BLGA), and bluegill juveniles (BLGJ) calculated using means observed at plastic pipe and juniper tree fish attractors from five sites, Canyon Reservoir, Texas, September 2006.

		Total calculated			
Attractor type	*n* attractors	LMBA	LMBJ	BLGA	BLGJ
Plastic pipe	143	47.19	22.88	104.39	261.69
Juniper tree	34	55.76	23.12	97.24	806.48

Table 3. Mean preference (%) of attractors containing juniper for total fish, bluegill adults (BLGA), bluegill juveniles (BLGJ), largemouth adults (LMBA), and largemouth juveniles (LMBJ). Under the null hypothesis of "no attraction" we would expect the mean attraction to equal zero.

Category	Sites	Mean preference (%)	Preference lower confidence limit	Preference upper confidence limit	*t*-value	$P > t$
Total fish	5	53.8	19.2	88.3	4.3	0.01
BLGA	5	50.7	7.9	93.5	3.3	0.03
BLGJ	5	62.5	23.5	101.0	4.4	0.01
LMBA	5	40.3	9.3	71.2	3.6	0.02
LMBJ	3	37.8	–36.0	111.0	2.2	0.15

Discussion

The plastic pipe design used in this study was much less effective at attracting and concentrating bluegill and adult largemouth bass than juniper trees. The difference in the percentage of total fish observed at plastic versus juniper attractor types based on the means was similar to that of Rold et al. (1996), who also used direct observation by scuba divers to compare fabricated polypropylene and cedar tree attractors. In that study, many more fish were observed in cedar tree attractors (78%) than polypropylene attractors (17%) and control areas (5%). They attributed this difference to the small interstitial spaces (denseness) the brush attractors provided. Manufactured attractors in general seem to lack the structural complexity and small interstitial spaces (Bolding et al. 2004) which attract bluegills (Johnson et al. 1988, Walters et al. 1991). Yearling bluegill prefer structures with small interstices especially in clear water where largemouth bass are present (Johnson et al. 1988). Juvenile bluegill use dense cover as protection from largemouth bass (Gotceitas and Colgan 1987). The lack of small interstitial spaces in our plastic pipe design may be responsible for its ineffectiveness at concentrating juvenile bluegill. The presence of these small forage fish, rather than the cover provided by attractors, may be an important part of the success of any attractor specifically designed to concentrate largemouth bass. However, because small juniper limbs may quickly degrade, their ability to attract and concentrate juvenile bluegill over several years may decrease.

Interestingly, there was no difference between plastic and mixed attractors for juvenile and adult largemouth bass. Mixed attractors had the fewest diver observations among the attractor types (17% of the total observations) and few largemouth bass (compared to bluegill), especially juveniles, were observed at any of the attractors. The failure to detect a statistical difference between mixed and plastic attractors for largemouth bass may be due to the small number of observations rather than a difference in the attractors' ability to concentrate this species. Adult largemouth bass were often observed moving along the periphery of juniper and mixed attractors or hovering near the attractors, but were rarely observed among the branches. The dense cover provided by the juniper and mixed attractors may be less important to adult largemouth bass for protection and simply serve as areas that concentrate forage. Their affinity to the attractors may be decreased when they are not foraging. While the mean number of largemouth bass observed was not statistically higher at the mixed attractors they were certainly more readily observed (presence versus absence) at these structures when compared to the plastic attractors.

Plastic attractors have been successfully used to concentrate largemouth bass and can be used when natural materials are not readily available (e.g., in desert reservoirs), with some designs having better attracting qualities than others (Rogers and Bergersen 1999). In this study cooperators agreed to use an unproven plastic attractor design hoping it would concentrate largemouth bass, provide lower maintenance costs, and be economical compared to commercially manufactured attractors. Given the large number of natural and synthetic attractor materials and designs, as well as commercially made attractors available (Brown 1986, Tugend et al. 2002, Bolding et al. 2004), one might easily make the assumption that almost any attractor design would bring desirable results. Fisheries managers should first try small pilot projects to see if the attractor design selected for their project will attract target species. Failure to conduct evaluations of new designs and materials could lead to costly mistakes if used later on a large scale. In addition, if increased angler catch rates are an objective, anglers may lose confidence in agency expertise if this objective is not met.

Additional evaluations should give fisheries managers a better understanding of the specific attractor materials and designs which could be used for achieving specific objectives. While plastic attractor materials are often desirable because of their longevity, the effectiveness of the design for attracting target species should be evaluated prior to being used for large scale projects, when more proven materials and/or designs are readily available. Side-by-side comparisons of attractor types through direct observation are not always possible because underwater visibility is poor in many reservoirs, but other techniques such as monitoring angler catch rates, telemetry, and pop-net catches at attractor sites have been successfully used to evaluate attractor designs and materials (Petit 1973, Walters et al. 1991, Johnson and Lynch 1992, Rogers and Bergersen 1999). The ideal attractor, whether made from plastic or natural materials, would be inexpensive, have a long lifespan, be acceptable to anglers (easy to fish without snagging), be easily deployed, and attract large numbers of target species.

Acknowledgments

The authors acknowledge Texas Parks and Wildlife Department (TPWD) Inland Fisheries employees Ken Saunders for assistance collecting data at the attractor sites and Michael Baird, Bruce Hysmith, and Brian VanZee for providing editorial comments. We also acknowledge the Comal County Water Oriented Recreation District for providing funding for materials used in fabricating the plastic attractors and the Texas Association of Bass Clubs, Comal Bass Anglers, The Canyon Bass Club of San Marcos, Austin Bass Club, and ATX Bassmasters for providing volunteer labor used in constructing the plastic pipe attractors. We also thank Sylvan DeJardo who allowed us to use his property for constructing and staging the plastic attractors. This research was funded by the Federal Aid in Sport Fish Restoration Act, Grant F-30-R to the TPWD.

Literature Cited

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report. National Marine Fisheries Service 41:1–15.

Bolding, B., S. Bonar, and M. Divens. 2004. Use of artificial structure to enhance angler benefits in lakes, ponds, and reservoirs: A literature review. Reviews in Fisheries Science 12:75–96.

Brown, A.M. 1986. Modifying reservoir fish habitat with artificial structures. Pages 98–102 *in* G.E. Hall and M.J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Maryland.

Fish, P.A. and J. Savitz. 1983. Variations in home ranges of largemouth bass, yellow perch, bluegills, and pumkinseeds in an Illinois lake. Transactions of the American Fisheries Society 112:147–153.

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.

Graham, R.J. 1992. Visually estimating fish density at artificial structures in Lake Anna, Virginia. North American Journal of Fisheries Management 12:204–212.

Hannan, H.H., I.R. Fuchs, and D.C. Whitenberg. 1979. Spatial and temporal patterns of temperature, alkalinity, dissolved oxygen and conductivity in an oligo-mesotrophic, deep-storage reservoir in Central Texas. Hydrobiologia 66:209–221.

——— and W.J. Young. 1974. The influence of a deep-storage reservoir on the physicochemical limnology of a Central Texas river. Hydrobiologia 44:177–207.

Johnson, D.L., R.A. Beaumier, and W.E. Lynch, Jr. 1988. Selection of habitat structure interstice size by bluegills and largemouth bass in ponds. Transactions of the American Fisheries Society 117:171–179.

——— and W.E. Lynch, Jr. 1992. Panfish use of and angler success at evergreen tree, brush, and stake-bed structures. 12:222–229.

Magnelia, S.J. and C.C. Bonds. 2000. Survey report for Canyon Reservoir, 1999. Texas Parks and Wildlife Department, Federal Aid in Sportfish Restoration Project F-30-R-25, Austin.

——— and ———. 2004. Survey report for Canyon Reservoir, 2003. Texas Parks and Wildlife Department, Federal Aid in Sportfish Restoration Project F-30-R-29, Austin.

Mosher, T.D. 1985. An evaluation of synthetic fish attractors and brushpiles at a small prairie lake. Kansas Fish and Game Commission, Technical Report, Project FW-9-P-2, Emporia.

Paukert, C.P., D.W.Willis, and M.A. Bouchard. 2004. Movement, home range, and site fidelity of bluegills in a great plains lake. North American Journal of Fisheries Management 24:154–161.

Petit, G.D. 1973. Stake beds as crappie concentrators. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners. 26:401–406.

Rogers, K.B. and E.P. Bergersen. 1999. Utility of synthetic structures for concentrating adult northern pike and largemouth bass. North American Journal of Fisheries Management. 19:1054–1065.

Rold, E.R., T.S. McComish, and D.E. Van Meter. 1996. A comparison of cedar trees and fabricated polypropylene modules as fish attractors in a strip mine impoundment. North American Journal of Fisheries Management. 16:223–227.

SAS Institute, Inc. 2007. SAS add-in 2.1 for Microsoft Office. SAS Institute, Inc. Cary, North Carolina.

Tugend, K.I., M.S. Allen, and M. Webb. 2002. Use of artificial habitat structures in U.S. lakes and reservoirs: A survey from the Southern Division American Fisheries Society reservoir committee. Fisheries 27(5): 22–27.

Walters, D.A., W.E. Lynch, Jr., and D.L. Johnson. 1991. How depth and interstice size of artificial structures influence fish attraction. North American Journal of Fisheries Management 11:319–329.

Wilbur, R.L. 1974. Florida's fresh water fish attractors. Florida Game and Fresh Water Fish Commission, Bulletin 6, Tallahassee.

Zar, J.H. 1984. Biostatistical analysis, 2nd edition. Prentice Hall, Englewood Cliffs, New Jersey.