A Comparison of Lead Lengths for Mini-Fyke Nets to Sample Age-0 Gar Species in Lake Texoma

Richard A. Snow
Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, Norman, OK 73072

James M. Long
U.S. Geological Survey Oklahoma Cooperative Fish and Wildlife Research Unit, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078

Chas P. Patterson
Oklahoma Department of Wildlife Conservation, Bryon State Fish Hatchery, Burlington, OK 73722

Abstract: Mini-fyke nets are often used to sample small-bodied fishes in shallow (<1 m depth) water, especially in vegetated shoreline habitats where seines are ineffective. Recent interest in gar (Lepisosteidae) ecology and conservation led us to explore the use of mini-fyke nets to capture age-0 gar and specifically how capture is affected by lead length of the fyke net. In the summers of 2012, 2013, and 2015, mini-fyke nets with two different lead lengths (4.57 m and 9.14 m) were set at random sites in backwaters and coves of the Red River arm of Lake Texoma, Oklahoma. Mean CPUE (catch-per-unit-effort; number per net night) was significantly lower for mini-fyke nets with short leads (0.52) compared to those with long leads (1.51). Additionally, Spotted Gar (*Lepisosteus oculatus)* were captured at a higher rate than the other three gar species present in Lake Texoma, although this could have been an artifact of sampling location. We found that differences in length-frequency of captured gar between gear types were nearly significant, with total length ranging from 47mm to 590mm. Mini-fyke nets with longer leads increased the efficiency of sampling for age-0 gar by increasing catch rate without affecting estimates of other population parameters and appear to be useful for this purpose.

Introduction

Gar are found in North America, Central America and Cuba, have a long-standing history of being considered a "trash" fish, and are often perceived by anglers and management biologists as a potential predator or competitor (Helfman et al. 1999, Pflieger 1997, Robertson et al. 2008, Scarnecchia 1992). As a result, many gar species have been the target of eradication efforts in lakes and rivers (Binion 2015, Scarnecchia 1992). Recently, however, there has been an increased interest in conservation of these species (O'Connell et al. 2007), resulting in a greater need to understand the ecological role of these predators in their native ecosystems and a greater need for research on sampling protocols.

With declining populations and changes in public perception, most conservation has been directed towards alligator gar (*Atractosteus spatula*), which grows large (up to 2.4 m) and has garnered a relatively high popularity among anglers (Buckmeier 2008). Spotted gar (*Lepisosteus oculatus*) has received renewed conservation interest in Canada since it was listed as threatened (COSEWIC 2005) and Florida gar (*L. platyrhincus*) has gained attention in that state due to habitat loss within their limited distribution (Glass et al. 2011, Gray et al. 2012, Murie et al. 2009). Because many gar species have been sampled as by-catch with gear types intended to target sportfish, little is known about gar densities, especially gear types useful to capture them. Additionally, most of the sampling information on gar has been collected for adults using: multifilament gillnets (Binion 2015, Robertson et al. 2008), monofilament gillnets (Howland et al. 2004, O'Connell et al. 2007), electrofishing (Glass et al. 2011, Murie et al. 2009), trawls (O'Connell et al. 2007), trammel-nets (Brinkman 2008), seines (O'Connell et al. 2007), jug lines (Buckmeier et al 2013, Dibenedetto 2009), and rod and reel (Buckmeier et al 2013). There is a paucity of information regarding the collection of age-0 gar, which is needed to better understand the early life-history of these species.

Most sampling methodologies that have been used to collect young-of–the-year (YOY) gar are limited to active gear (electrofishing; Echelle 1968 and seining; Inebnit 2009), which can be ineffective in shallow, vegetated habitats where this life stage occurs (Snow and Long 2015). Age-0 gar have been found floating at the surface along with twig fragments and leaf debris (Moore et al. 1973), which clogs net sampling gear or reduces detectability by the netter, reducing sampling effectiveness. Alternatively, passive gear types may be more effective in these habitats, but variation in their construction and deployment may affect capture efficiency (Kubecka et al.2012). Brinkman (2008) deployed mini-fyke nets with 4.57 m leads to successfully capture juvenile Alligator gar in Lake Texoma, Oklahoma, although catch was minimal. In a subsequent study, Snow and Long (2015) reported that mini fyke-nets with a long lead (9.14 m) caught more YOY alligator gar than nets with the 4.57 m lead, although this was not specifically tested. The ability to consistently sample age-0 gar species will give management biologists a better understanding of early life history requirements of these species (e.g., recruitment, growth, food habits). The purpose of this study was to compare catch per unit effort (CPUE) and length-frequencies of YOY gar species captured with mini-fyke-nets of differing lead lengths (4.57 m and 9.14 m).

Methods

Sampling Site – The area for this study was the river-reservoir interface section of the Red River arm of Lake Texoma, which is composed largely of backwater habitat and encompasses 33.56 km² (Figure 1). The typical sample site was less 1m in depth and surrounded by aquatic or terrestrial vegetation and woody debris.

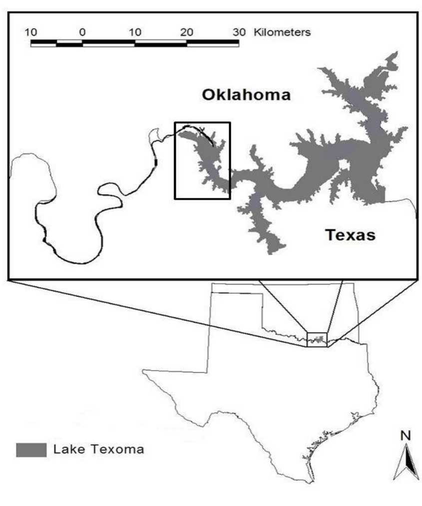

Figure 1. Location of Lake Texoma in south central Oklahoma where age-0 gar were sampled with mini fyke nets during the summer months of 2012, 2013, and 2015. The black outlined box represents the sampling area which encompasses 33.56 km² of Lake Texoma.

Lake Texoma is a 36,000-ha reservoir on the Oklahoma-Texas border. During normal flow, the Red River is constrained within a river channel, cut off from adjacent flood plains where terrestrial vegetation colonizes (Patton and Lyday 2008), creating suitable substrate for the adhesive eggs and developing larvae of gar (Moore et al. 1973). However, these sites are not accessible to adult spawning gar until flooding from the Red River reconnects adjacent floodplain environments.

In the summer of 2012, 2013, and 2015 mini-fyke nets (0.6 m x 6.35 m; with 3.18 mm mesh, 0.6 m x 1.92 m rectangular cab, and 510 mm metal throat) with two different lead lengths (4.57 m and 9.14 m) were set perpendicular towards the shoreline. In 2012 and 2013, sampling sites were chosen with an adaptive random cluster sampling design (Tompson 1990) to maximize detection of alligator gar. In 2015, sites were chosen at random in backwater areas and coves where herbaceous vegetation and woody debris were abundant (Brinkman 2008). All gar collected were identified using preserved specimens, dichotomous keys (Pflieger 1997; Miller and Robison 2004), and a guide to identification from cleithra (Traynor et al. 2010). Gar were measured to the nearest mm, and verified as young-of-year by examining the sagittae and lapilli otoliths for annual rings (Buckmeier et al. 2012, Long and Snow 2016).

Lepisosteus spp. less than 125 mm total length (TL) (Echelle and Riggs 1972) were problematic to identify in the field, so fish were frozen until they could be identified in the laboratory. We based our identifications of these individuals mostly from morphology of cleithra (Traynor et al. 2010), which are the paired bones of the pectoral girdle that form the frame of the body wall directly posterior to the opercular cavity (Scharf et al. 1998). For reference, we compared cleithra of wild fish to those from known-age, hatchery reared specimens of spotted gar (15-185 mm TL [Snow et al. *In Press*]), shortnose

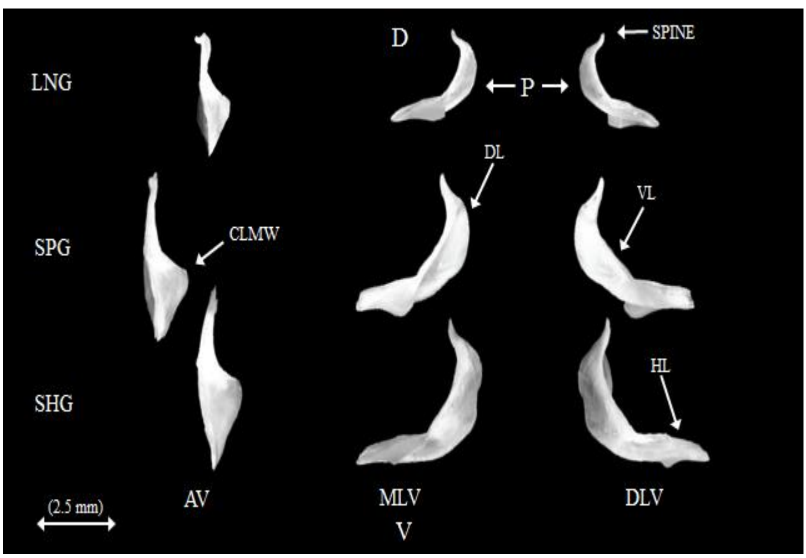

Figure 2. Cleithra morphology of three *Lepisosteus* spp (longnose gar [LNG; 109 mm TL], spotted gar [SPG; 103 mm TL], and shortnose gar [SHG; 117 mm TL]) according to 3 viewpoints: anterior view (AV), mesial lateral view (MLV), and distal lateral view (DLV). Shown here are the structure of the cleithra are cleithrum medial wing (CLMW), dorso-posterior lobe (DL), horizontal limb (HL), vertical limb (VL), and spine. Ventral (V), dorsal (D) and posterior (P) labels note orientation of the structure.

gar (57-192 mm TL [Snow and Long *In Review*]), and wild longnose gar >150 mm TL (this study). From 13 individuals ranging from 103 - 125 mm TL, cleithra were soaked in a 3:1 dilute bleach solution for 2 minutes, picked clean of flesh under a dissecting microscope, and rinsed with water until the cleithrum was clean. Based on shape from multiple viewpoints, the morphology of cleithra was used to distinguish among species (Figure 2). In anterior view (AV), the spine of cleithra from longnose gar protrudes farther from the midline and the cleithrum medial wing (CLMW) is less pronounced than shortnose gar and spotted gar. From the mesial lateral view (MLV), the dorso-posterior lobes of cleithra from shortnose gar and spotted gar were more robust than from longnose gar. In distal lateral view (DLV), the spines on the cleithra from longnose gar and shortnose gar had a more pronounced curve than from spotted gar. Shortnose gar and spotted gar cleithra were very similar when viewed in DLV and AV, but the horizontal limb extended over the dorso-posterior lobe and combined to form the spine when viewed in MLV. The horizontal limb of cleithra from shortnose gar folds and runs vertically, forming the spine at a much shallower depth compared to spotted gar. Also, the vertical and horizontal limbs of cleithra from spotted gar were disproportionate to each compared to longnose gar and shortnose gar whose limbs were more equal in proportion.

Two-way analysis of variance (ANOVA) was used to determine differences in CPUE (number of gar caught per net night) between lead length and gar species. All data were $\log_{10}+0.01$ transformed to conform to the assumptions of normality and tests were performed at a significance level of $P \leq 0.05$. Post-hoc tests of significant ANOVA results were conducted with the lsmeans pdiff option in SAS. The coefficient of variation (CV) was calculated as a measure of precision for CPUE estimates (Cyr et al. 1992, Patterson 2014). A Kolmogorov-Smirnov Test was used to determine differences in length frequency of gar collected between lead lengths. A length frequency histogram was added for visual interpretation. All statistical analyses were conducted with SAS 9.4 software (SAS Institute, Cary, North Carolina).

Results

Over the entire study period, 76 nights of netting captured 86 gar in nets with long leads compared to 61 nights of netting and 24 gar caught in nets with short leads (Table 1). Fyke nets with long leads caught 1.5 fish per net night on average, which were approximately 3X the number caught by fyke nets with short leads (0.5). Mean CPUE of gar was affected by species ($F_{3,540}$ = 3.89, P < 0.01) and lead length ($F_{1,540}$ = 21.15, P < 0.01), but no interaction was evident between the two ($F_{3,540}$ = 0.40, P = 0.75). Furthermore, nets with long leads produced more precise estimates of mean CPUE (i.e., lower CV estimates; 0.14) than nets with short leads (CV = 0.25). Post hoc test reveal that among species, spotted gar were captured at a higher rate than the other three species (Figure 3).

Lead length did appear to affect sizes of gar captured somewhat, producing nearly similar length frequency histograms (Kolmogorov-Smirnov, P = 0.058, Figure 4). Mean total length of gar captured in nets with long leads was 237 (11.1) mm compared to 220 (17.4) mm in nets with short leads. Both net types captured gar ranged in size from 47 mm TL to 590 mm TL.

Table 1. Summary of age-0 gar capture (n) for each year, net nights, CPUE with standard error (S.E.) and coefficient of variation (CV$\bar{x}$) for each lead type (long = L and short = S) from the river-reservoir interface section of the Red River arm of Lake Texoma.

Year	Lead Type	Net Nights	*n*	CPUE (S.E)	CV$\bar{x}$
2012	L	9	12	2.11 (.97)	0.46
	S	21	5	0.32 (.21)	0.66
2013	L	27	23	0.96 (.14)	0.15
	S	13	6	0.56 (.24)	0.43
2015	L	41	51	1.74 (.33)	0.19
	S	27	13	0.66 (.22)	0.34
All year combined	L	77	86	1.51 (.21)	0.14
	S	61	24	0.52 (.13)	0.25

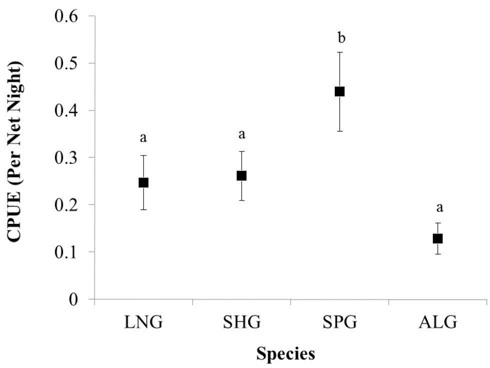

Figure 3. Post-hoc test results comparing mean CPUE among species of gar (LNG = longnose gar, SHG = shortnose gar, SPG = spotted gar, and ALG = alligator gar) sampled with mini fyke nets during the summer months of Lake Texoma in south central Oklahoma in 2012, 2013, and 2015. Different letters indicate significant differences of the post-hoc test (a being significantly different than b). Error bars represent ±1 SD.

Discussion

Doubling the lead length from 4.57 m to 9.14 m tripled the catch rates and improved precision, demonstrating the utility mini fyke nets with long leads to catch YOY gar. Also, lead length appeared to exert an influence on total length (mm) of fish captured, although a greater sampling effort would be needed to confirm this nearly-significant result. Additionally, we found differences in catch among species, which we attribute to the habitats sampled. The sampling area consisted of backwater and littoral zones of the river reservoir interface, which are used by all four species for spawning and nursery cover, but differences among relative abundance of species still likely existed. Longnose gar is the most widely distributed of the four gar species in Oklahoma (Miller and Robison 2004), so the lack of their predominance in our study area was intriguing. However, longnose gar often spawn over rocky habitat (Echelle 1968, Echelle and Riggs 1972), which was rare in our study area and would offer a partial explanation of our findings. We speculate that sampling in habitats with a greater preponderance of rocky substrate, such as the dam face, would result in a greater catch of longnose gar. Spotted gar, in contrast, was the most commonly captured species in our study, and this species seems to remain in backwater and littoral habits throughout life, moving in and across the floodplain depending on water level (Sneddan et al. 1999). Such backwater and littoral habitats were abundant in our study area.

The ability to efficiently capture YOY gar has many implications. For example, it has been suggested that juvenile alligator gar exhibit site fidelity, making them more prone to recapture (Sakaris et al. 2003). In Lake Texoma, alligator gar are relatively rare, reducing the probability of their capture, thus hindering studies that could investigate their site fidelity. Sampling of rare YOY alligator gar could be improved by deploying long-lead mini-fyke nets. Furthermore, this gear could help investigators better determine differences in habitat use or preference. Regardless of the species, having more efficient gear would improve sample sizes, leading to better estimates of numerous population-level metrics (e.g., age, growth, mortality; Snow and Long 2015).

For studies where sampling mortality is critical, it should be noted that access to surface air could be important. During our study, we sometimes observed dead individuals during retrieval. During periods of high temperature and low dissolved oxygen gar break the surface of the water to use their large vascularized swim-bladder to breathe air (Moyle and Cech 1982, De Roth 1973, Saksena 1975). These conditions are prevalent in shallow, backwater coves of southern reservoirs thru the summer months. To alleviate trap mortality, nets could be checked more often, or set such that captured gar would always have access to surface air for respiration (e.g., set shallower, or elevated in the water column with floats or a platform).

The use of cleithra to identify *Lepisosteus* gar < 125 mm may prove beneficial to biologist investigating early life history of gar (YOY

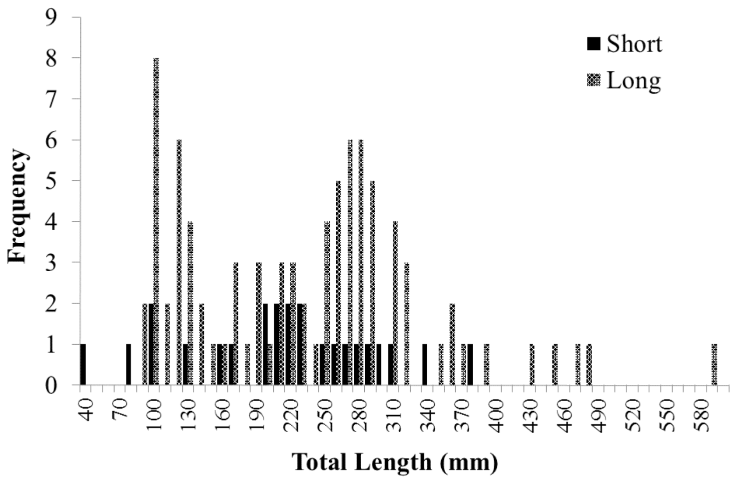

Figure 4. Length frequency histogram for all gar species sampled with mini fyke nets during the summer months of Lake Texoma in south central Oklahoma in 2012, 2013, and 2015 combined for both lead types.

alligator gar are easily identifiable from their dorsal stripe). While we used reference specimens to aid our identification and place high confidence on our results, a more formal examination of cleithra as an identification aid (e.g., shape analysis *sensu* Lombarte et al. 2006) would be beneficial. The cleithrum is the first structure to appear in the pectoral girdle, around 17-20 mm (Jollie 1984) making it potentially very useful for identifying and studying very early life stages of *Lepisosteus* gar. Although validation of cleithra is a need for further research, the differences noted in this manuscript make a compelling case for using this structure.

While we found that mini-fyke nets were efficient at capturing YOY gar, but may be biased toward catching fish >100 mm TL. Using active gear, approximately one-half of gar captured were < 100 mm TL (Echelle 1968: 53% and Echelle and Riggs 1972: 46%). In contrast, only 5% of the gar we captured were < 100 mm TL, suggesting that age-0 gar are not recruiting to the type of mini fkye nets we used in this study until after 100 mm TL. Speculatively, active gear may be better at capturing gar <100 mm because their body movement is limited to the use of their notochord appendage (Carpenter 1975). The notochord appendage is in the process of being absorbed as the gar grows beyond 150 mm TL, and is generally absent by 300 mm TL (Carpenter 1975). With limited movement capability, YOY gar < 100 mm TL may not encounter passive sampling gears very often, limiting catch, whereas these fish would also not easily be able to escape an active gear, resulting in increased catch rates. However, sampling large areas of backwater and flooded coves of reservoirs is not conducive to most active gears that could collect small fishes (e.g., backpack electrofishing and seining). In these cases, mini-fyke nets with long leads seem to be an efficient option.

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References

Binion, G. R., D. J. Daugherty, and K. A. Bodine. 2015. Population dynamics of alligator gar in Choke Canyon Reservoir, Texas: implications for management. SEAFWA 2:57-63.

Brinkman, E. L. 2008, Contributions to the life history of alligator gar, *Atractosteus spatula* (Lacepede), in Oklahoma. Master's Thesis. Oklahoma State University, Stillwater, Oklahoma.

Buckmeier, D. L. 2008. Life history and status of alligator gar *Atractosteus spatula*, with recommendations for management. TPWD Inland Fisheries Report, Heart Hills Fish Sci Cen (2008).

Buckmeier D. L., N. G. Smith, and K. S. Reeves. 2012. Utility of alligator gar age estimates from otoliths, pectoral fin rays, and scales. Tran Am Fish Soc 141:1510-1519.

Buckmeier D. L., N. G. Smith, and D. J. Daughterty. 2013. Alligator gar movements and macrohabitat use in the lower Trinity River, Texas. Tran Am Fish Soc 42:1025-1035.

Carpenter, C. C. 1975. Functional aspects of the notochordal appendage of young-of-the-year gar (*Lepisosteus*). Proc Okla Acad Sci 55:57-64.

COSEWIC. 2005. COSEWIC assessment and update status report on the spotted gar *Lepisosteus oculatus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vi + 17 pp. Available online at www.sararegistry.gc.ca/status/status_e.cfm.

Cyr, H., J. A. Downing, S. Lalonda, S. B. Baines, and M. L. Pace. 1992. Sampling larval fish population: choice of sample number and size. Tran Am Fish Soc 121:356-368.

De Roth, G. C. 1973. Effects of temperature and light on aerial breathing behavior of the spotted gar, *Lepisosteus oculatus*. The Ohio Journal of Science. 73:34-41.

DiBenedetto K. C. 2009. Life history characteristics of alligator gar *Atractosteus spatula* in the Bayou Dularge area of southcentral Louisiana. Master's Thesis. Louisiana State University, Baton Rouge, Louisiana.

Echelle, A. A. 1968. Food habits of young-of-year longnose gar in Lake Texoma, Oklahoma. Southwestern Nat 13:45-50.

Echelle, A. A. and C. D. Riggs. 1972. Aspects of the early life history of gar (*Lepisosteus*) in Lake Texoma. Tran Am Fish Soc 101:106-112.

Glass, W. R., L. D. Corkum, and N. E. Mandrak. 2011. Pectoral fin ray aging: an evaluation of a non-lethal method for aging gar and its application to a population of the threatened spotted gar. Envir Biol Fish 90:235-242.

Gray, S. M., L. J. Chapman, and N. E. Mandrak. 2012. Turbidity reduces hatching success in threatened spotted gar (*Lepisosteus oculatus*). Envir Biol Fish 94:689-694.

Helfman, G. S., B. B. Collette, and D. E. Facey. 1999. The Diversity of Fishes. Malden, MA: Blackwell Science.

Howland, K. L., M. Gendron, W. M. Tonn, and R. F. Tallman. 2004. Age determination of a long-lived coregonid from the Canadian North: comparison of otoliths, fin rays and scales in inconnu (*Stenodus leucichthys*). Annales Zoologici Fennici 41:205-214.

Inebnit III, T. E. 2009, Aspects of the reproductive and juvenile ecology of Alligator Gar in the Fourche LaFave River, Arkansas Master's Thesis. University of Central Arkansas, Conway, Arkansas.

Jollie, M. 1984. Development of cranial and pectoral girdle bones of *Lepisosteus* with a note on scales. Am Soc Ich Herp 2:476-502.

Kubecka, J., O. R. Godø, P. Hikley, M. Prchalova, M. Riha, L. Rudstam, and R. Welcomme. 2012. Fish sampling with active methods. Fish Res 124:1-3.

Lombarte, A., O. Chic, V. Parisi-Baradad, R. Olivella, J. Piera and E. Garcia-Ladona. 2006. A web-based environment from shape analysis of the otoliths. The AFORO database. Scientia Marina 70:147-152

Long, J. M. and R. A. Snow. 2016. Ontogenetic development of otoliths in alligator gar (*Atractosteus spatula*). Tran Am Fish Soc 145:537-544.

Miller, R. J. and H. W. Robison. 2004. Fishes of Oklahoma, Norman: University of Oklahoma Press. 52-57 pp

Moore, G. A., M. B. Trautman, and M. R. Curd. 1973. A description of post larval gar (*Lepisosteus spatula* Lacepede, Lepisosteidae), with a list of with a list of associated species for the Red River, Choctaw County, Oklahoma. Southwestern Nat 18:343-344.

Moyle, P. B. and J. J. Cech, JR. 1982. Fishes: An Introduction to Ichthyology, Department of Wildlife Biology, University of California 224-225pp.

Murie, D. J., D. C. Parkyn, L. G. Nico, J. J. Herod, and W. F. Loftus. 2009. Age, differential growth and mortality rates in unexploited populations of Florida gar, an apex predator in the Florida Everglades. Fish Mgmt Ecol. 16:315-322.

O'Connell M. T., T. D. Shepherd, A. M. U. O'Connell, and R. A. Myers. 2007. Long-term declines in two apex predators, bull shark (*Carcharinus leucas*) and alligator gar (*Atractosteus spatula*), in Lake Pontchartrain, an oligohaline estuary in southeastern Louisiana. Estuaries and Coasts 30:567-574.

Patterson, C. P. 2014. A comparison of a fixed vs. stratified random sampling design for electrofishing largemouth bass in Oklahoma. SEAFWA 1:70-74.

Patton, T. and C. Lyday. 2008. Ecological succession and fragmentation in a reservoir: effects of sedimentation and habitats on fish communities. Pg 147-167. *In* M.S. Allen, S. Sammons, and M.J. Maceina [ed.] Balancing fisheries management and water uses for impounded river systems. Am Fish Soc, Sym 62, Bethesda, Maryland.

Pflieger, W. L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City, Missouri. 55-60 pp.

Robertson C. R., S. C. Zeug, and K. O. Winemiller. 2008. Associations between hydrological connectivity and resource partitioning among sympatric gar species (Lepisosteidae) in a Texas river and associated oxbows. Ecol Freshwater Fish 17:119-129.

Sakaris, P. C., A. M. Ferrara, K. J. Kleiner, and E. R. Irwin. 2003. Movements and home ranges of alligator gar in the Mobile-Tensaw Delta, Alabama. Proc An Con Southeastern Assn Fish and Wildlife Ag 57:102-111.

Saksena, V. P. 1975. Effects of temperature and light on aerial breathing of the longnose gar, *Lepisosteus osseus*. The Ohio Journal of Science. 75:58-62.

Saksena, V. P. 1975. Effects of temperature and light on aerial breathing of the shortnose gar, *Lepisosteus platostomus*. The Ohio Journal of Science. 75:178-181.

SAS Institue. 1988. SAS/STAT user's guide. SAS Institute, Cary, North Carolina.

Scarnecchia, D. L. 1992. A reappraisal of gars and bowfins in fishery management. Fisheries 17:6-12.

Scharf F. S., R. M. Yetter, A. P. Summer, and F. Juanes. 1998. Enhancing diet analyses of piscivorous fishes in the northwest Atlantic through identification and reconstruction of prey sizes from ingested remain. Fish Bull 96: 575-588.

Snow R. A. and J. M. Long. *In Review*. Otolith marking of shortnose gar by immersion in oxytetracycline. N Am J Fish Manage.

Snow R. A. and J. M. Long. 2015. Estimating spawning times of alligator gar (*Atractosteus spatula*) in Lake Texoma, Oklahoma. Proc Okla Acad Sci 95:7-8.

Snow R. A., J. M. Long, and B. D. Frenette. *In Press*. Daily age validation in Spotted Gar. Proc An Con Southeastern Assn Fish and Wildlife Ag

Tompson, S. K. 1990. Adaptive cluster sampling. J Am Stat Assn 85:1050-1059.

Traynor, D., A.Moerke, , and R.Greil, 2010. Identification of Michigan fishes using cleithra. Great Lakes Fishery Commission, Miscellaneous Publications. 2010-02.

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Comparison of Long Lead Versus Short Lead Mini-Fyke Net for Sampling Shallow Backwater Habitats

Clayton P. Porter
Oklahoma Department of Wildlife Conservation, J. A. Manning Hatchery, Lawton, OK 73507

Richard A. Snow
Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, Norman, OK 73072

Abstract: We evaluated catch of mini-fyke nets of two lead lengths (long lead =9.14 m vs. short lead= 4.57 m) for comparing species richness and abundance estimates of fish captured using both approaches. The sampling area consisted of shallow backwater coves in the river-reservoir interface of Lake Texoma in Oklahoma. During high water events, the Red River reconnects to adjacent flood plains and isolated oxbow lakes, and inundates terrestrial vegetation. These dynamic habitats are colonized by a host of fish for spawning, nursery cover, foraging, and movement purposes. Fish were collected from 28 long lead nets and 20 short lead nets. A total of 38 species were captured, representing 13 families, and totaling 3,893 individuals. The mean species diversity represented in long lead was 17.4 (± 9.45) compared to 15.7 (± 9.21) for short lead nets, but the difference was not statistically significant. There was no significant difference in species richness between lead lengths, however there was a difference detected in abundance between lead lengths (long 99.6 and short 55.2).

Introduction

Sampling fishes in riverine and lentic systems has been a common activity among managers, and identifying the most appropriate methodology estimating abundance and other community is always a goal (Guy et al. 2009, Miranda and Boxrucker 2009). Some sampling gears select for certain species or sizes, and the relative number caught may not reflect true proportions of fishes in the assemblage (Weaver et al. 1993), making gear selection a vital component to managers.

A single sampling gear usually provides only a limited representation of a fish assemblage and cannot capture all species and size classes (Ruetz III et al. 2007, Murphy and Willis 1996). A multiple gear approach is almost always necessary to gain reliable estimates of community aspects and size structure (Fisher and Quist 2014, Ruetz III et al. 2007). Additionally, sampling gears are dependent upon habitats present and different gears to target specific species. When sampling in the river-reservoir interface water depth, rocks, macrophytes, logs, tree branches, and dead terrestrial vegetation accrue, which could interfere or prevent an accurate representation of densities and relative abundance when sampling with seines, gillnets, and electrofishing boats.

Sedimentation within the river-reservoir interface creates an artificial marsh or floodplain habitat (Patton and Lyday 2008), which can provide nursery refuge habitats for juvenile and small body fishes (Buckmeier et al. 2014). Clark et al. (2007) showed that in areas of inundated vegetation, fyke netting was the most effective means of collection for overall species richness and abundance. The use of mini-fyke nets for sampling fishes has been shown to be an effective passive collection method for small bodied fishes (Krueger et al. 1998, Hubert 1996, Fargo 1998).

For this project, we compared mini-fyke nets with two different lead lengths (long lead and short lead) for differences in species richness and abundance. It has been shown that fyke nets are preferred when collecting fishes in shallow areas less than 1m in depth in heavy vegetative and large amounts of woody debris (Clark et al. 2007, Bonvechio et al. 2014). We use fyke nets for these reasons: 1) Electrofishing can be biased by shocking select fish (size and species) along with netter bias, 2) Fyke nets are a smaller versions of traps nets and have been shown to collect broader size ranges and more species of fish, and 3) Gill netting accounts for high mortality rates.

Study Area

Our study area was located on the southern border of Oklahoma on the Red River arm of Lake Texoma (Figure 1), a 36,000-ha reservoir on the Oklahoma-Texas border, impounding the Red and Washita Rivers. The Red River drainage encompasses 81,199km^2. Sampling occurred in the Red River and Lake Texoma interface where siltation and fragmentation caused by sediment loading has created habit in the river-reservoir interface that function as a floodplain (Buckmeier et al. 2014; Patton and Lyday 2008). This functional floodplain creates spawning habitat and cover for a multitude of species (Buckmeier et al. 2014).

Methods

We deployed mini-fyke nets (0.6 m x 6.35 m; with 3.18 mm mesh, 4.57 m lead, 0.6 m x 1.92 m rectangular cab, and 510 mm metal throat, and 0.6 m x 6.35 m; with 3.18 mm mesh, 9.14 m lead, 0.6 m x 1.92 m rectangular cab, and 510 mm metal throat) in the river-reservoir interface of Lake Texoma in the Red River arm during August and September of 2015. Due to historical flooding and inflows, nets were not deployed between May and July 2015. A 100-m gridded map of all backwaters and shallow-water coves in the river-reservoir interface was used to randomly select initial sample sites. Nets were anchored with a T-Post on the lead end and pulled tight by a 9.1 kg kedge style anchor on the cod end. Nets were set perpendicular to the shore in water less than 1m in depth and run the next morning. All fish collected were identified and measured to the nearest (mm). Any individuals that could not be identified in the field were preserved on ice and brought back to the laboratory for further identification using a dichotomous key (Miller and Robison 2004), clethra guide (Traynor et al. 2010), and pharyngeal teeth key (Miller and Robison 2004).

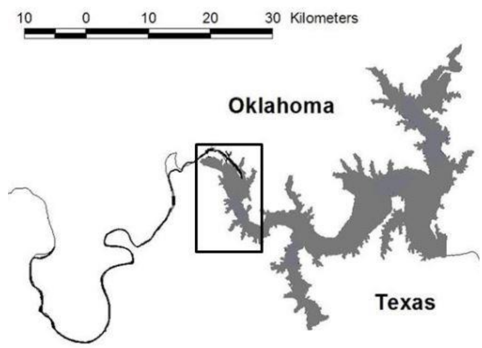

Figure 1. Location of Lake Texoma in south central Oklahoma where sampling occurred. The black outlined box represents the sampling area used in the Red River arm of Lake Texoma.

Data were analyzed using R and tests were performed at a significance level of $P \leq 0.05$ (R Core Team 2015). A Shapio-Wilk test was used to test for normality (P = 0.08). A T-Test was used to compare the number of species captured between the lead types, and to test differences in total individual captured by each lead type.

Results

A total of 3,893 fish were collected 48

combined net nights which consisted of 28 long lead net nights (N = 2,846) and 20 short lead net nights (N =1,047) of sampling. The mean species diversity represented per net night in long lead nets was 17.4 (± 9.45) compared to 15.7 (± 9.21) for short lead. There was no significant difference between lead type (T_{42} = 0.62, P = 0.27), however there was a difference detected with the abundance of individuals sampled in each net (long = 99.6 and short = 55.2) (T_{44} = 2.77, P = 0.01). The combined total of Bluegill (*Lepomis macrochirus*), White Crappie (*Pomoxis annularis*), and Silverside species (*Menidia ssp.*) made up 75.9% of the catch in long lead nets and 70.5% of the catch in short lead nets, respectively (Table 1).

Discussion

We found that both long and short lead mini fykes were able to collect a large number of fish from the littoral zone of the river-reservoir interface of Lake Texoma. Samples exhibited high species richness, yielding a total of 38 species with no difference detected between lead length. Clark et al. (2007) reported in fourty-six net nights in the White River system, Arkansas they collected 46 species and Ruetz III et al. (2007) reported similar results from sampling Muskegon Lake, Michigan (collecting 33 species).

Mini Fyke nets tend to collect smaller more mobile fish (Fago 1998, Bonvechio et al. 2014). We found that longer leads collected a significantly larger number of fish. This is a result of the lead being in more fishable water allowing for more of the littoral zone to be sampled. However, both lead lengths seemed to collect some species at a higher rate than others. For example, in the long lead net Bluegill represented 21% of the total catch, while in short lead bluegill comprised 37% of species sampled (Table 1). Similar results were presented in Clark (2007) where nearly 40% of fish captured were Bluegill. It has been speculated that age-0 fish seek cover or protection in or around the net, a behavioral occurrence that was documented (Gritters 1994).

The ability to sample Menidia ssp. in long lead mini fyke nets at such a high abundance may benefit management biologist when assessing the importance of Menidia species as a forge fish. An alternative gear to collect Menidia species in large numbers (1,015 individuals representing 36% of fish collected in 28 net nights of sampling), long lead mini fyke nets could act as a valuable gear for managers (Hubert 1996, and Ruetz et al. 2007). In a lake where physical sampling obstacles exist which may snag or hinder one from seining, mini fyke net would give managers the option to collect abundance data on Menidia species using a passive gear.

Mini-fyke net design includes a 5.2 cm excluder ring placed before the cod portion of the net to prevent predatory species from entering net. These excluder rings are problematic when catch data are compromised by an adult gar blocking the funnel. On average this occurred in 8.3% of net sets in our study. Bonvechio et al. (2014) described Florida gar being caught in 6.7 % of nets set, causing entanglement in the excluder ring which prevented the gear from fishing properly. Further research should be done on a small excluder ring which may prevent the cod portion from being obstructed, but also could have a negative impact on species and individuals sampled.

Mini-fyke nets could be a viable alternative to electrofishing or seining should shallow areas and obstacles (e.g. woody debris, vegetation or jagged rocks) exist when sampling. Mini-fyke nets also have the potential to reduce man-hours and effort required to collect sufficient quantities of fish compared to active gears (electrofishing and seining). Bonvechio et al. (2014) recommended that min fyke nets be used to monitor long term collection of fish communities because this gear type was able to detect 80% of species represented in a lake, and Eggleton et al. (2010) reported that mini fyke nets captured the largest number of unique species. We recommend the use of mini-fyke nets in a sampling protocol targeting small bodied fishes in river-reservoir interface or back water areas. Specifically, the use of long lead

Table 1. Total catch was measured to the near (mm) TL (± SD) and individuals counted (N) from 28 long-lead nets (L) and 20 short-lead net (S) net nights from the RRI of the Red River.

	N		% Catch		Mean TL mm (SD)	
Species	L	S	L	S	L	S
Largemouth Bass (*Micropterus salmoides*)	5	3	0.18	0.29	105 (55)	122 (10)
Spotted Bass (*Micropterus punctulatus*)	1	1	0.04	0.10	118	114
White Crappie (*Pomoxis annularis*)	504	138	17.71	13.18	107 (40)	99 (24)
Black Crappie (*Pomoxis nigromaculatus*)	96	15	3.37	1.43	98 (27)	116 (43)
White Bass (*Morone chrysops*)	18	20	0.63	1.91	107 (16)	101 (13)
Striped Bass (*Morone saxatilis*)	2	1	0.07	0.10	97 (2)	89
Saugeye (*Stizostedion vitreum X Stizostedion canadense*)	2	-	0.07	-	125 (2)	-
Channel Catfish (*Ictalurus punctatus*)	-	1	-	0.10	-	93
Blue Catfish (*Ictalurus furcatus*)	-	1	-	0.10	-	546
Bluegill Sunfish (*Lepomis macrochirus*)	600	387	21.08	36.96	59 (37)	51 (26)
Longear Sunfish (*Lepomis megalotis*)	14	6	0.49	0.57	65 (17)	61 (5)
Orangespot Sunfish (*Lepomis humilis*)	8	7	0.28	0.67	74 (3)	83 (2)
Redear Sunfish (*Lepomis microlophus*)	-	1	-	0.10	-	148
Green Sunfish (*Lepomis cyanellus*)	5	16	0.18	1.53	51 (16)	51 (20)
Warmouth Sunfish (*Lepomis gulosus*)	91	2	3.20	0.19	66 (24)	74 (9)
Hybrid Sunfish (*Lepomis hybrid*)	-	1	-	0.10	-	77
Yellow Bullhead (*Ameiurus natalis*)	-	1	-	0.10	-	31
Common Carp (*Cyprinus carpio*)	1	1	0.04	0.10	378	756
Freshwater Drum (*Aplodinotus grunniens*)	22	8	0.77	0.76	147 (77)	188 (88)
Smallmouth Buffalo (*Ictiobus bubalus*)	11	12	0.39	1.15	119 (27)	147 (30)
Bigmouth Buffalo (*Ictiobus cyprinellus*)	2	2	0.07	0.19	154 (11)	158 (2)
Black Buffalo (*Ictiobus niger*)	1	3	0.04	0.29	428	126 (18)
River Carpsucker (*Carpiodes carpio*)	2	4	0.07	0.38	110 (4)	172 (80)
Highfin Carpsucker (*Carpiodes velifer*)	13	-	0.46	-	182 (131)	-
Flathead Catfish (*Pylodictis olivaris*)	2	-	0.07	-	305 (202)	-
Alligator Gar (*Atractosteus spatula*)	6	1	0.21	0.10	294 (141)	347
Longnose Gar (*Lepisosteus osseus*)	14	4	0.49	0.38	367 (154)	279 (101)
Shortnose Gar (*Lepisosteus platostomus*)	23	12	0.81	1.15	316 (128)	307 (105)
Spotted Gar (*Lepisosteus oculatus*)	32	10	1.12	0.96	304 (109)	284 (117)
Gizzard Shad (*Dorosoma cepedianum*)	198	63	6.96	6.02	113 (33)	121 (127)
Threadfin Shad (*Dorosoma petenense*)	55	4	1.93	0.38	44 (17)	61 (32)
Golden Shiner (*Notemigonus crysoleucas*)	1	-	0.04	-	98	-
Bluntnose Minnow (*Pimephales notatus*)	2	-	0.07	-	48 (9)	-
Mosquito Fish (*Gambusia affinis*)	86	66	3.02	6.30	30 (4)	35 (6)
Red River Shiner (*Notropis bairdi*)	3	-	0.11	-	48 (21)	-
Logperch (*Percina caprodes*)	1	-	0.04	-	74	-
Red Shiner (*Cyprinella lutrensis*)	5	3	0.18	0.29	57 (16)	61 (16)
Silverside species (Atherinidae)*	1015	253	35.66	24.16	72 (14)	69 (16)
Totals	2846	1047	100%	100%		

*Inland Silversides and Brook inland Silverside combined mini-fyke nets for sampling Pomixis, Menidia, and some Lepomis species is recommended.

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References

Bonvechio, K. I., R. E. Sawyers, E. Leone, and S. Crawford. 2014. Increasing the efficiency of Florida's freshwater fisheries long term monitoring program. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 1:7-13.

Bonvechio, K. I., R. E. Sawyers, R. Bitz, and S. Crawford. 2014. Use of mini-fyke nets for sampling shallow-water fish communities in Florida. North American Journal of Fisheries Management 34:693-701.

Buckmeier. D.L., N.G. Smith, B. P. Fleming and K. A. Bodine. 2014. Intra-annual variation in river-reservoir interface fish assemblages: implications for fish conservation and management in regulated rivers. River Res Applic 30:780-790.

Clark, S. J., J. R. Jackson, S. E. Lochmann. 2007. A comparison of shoreline with fyke nets for sampling littoral fish communities in floodplain lakes. North American Journal of Fisheries Management 27:676-680.

Eggleton, M. A., J. R. Jackson, B. J. Lubinski. 2010. Comparison of gears for sampling littoral zone fishes in floodplain lakes of the lower White River, Arkansas. North American Journal of Fisheries Management 30:928-939.

Fago, D. 1998. Comparison of littoral fish assemblages sampled with a mini-fyke net or with a combination of electrofishing and small-mesh seine in Wisconsin Lakes. North American Journal of Fisheries Management 18:731-738.

Fisher, J. R., and M. C. Quist. 2014. Characterizing lentic freshwater fish assemblages using multiple sampling methods. Environmental Monitoring and Assessment 186:4461-4474

Gritters, S. A. 1994. Comparison of fish catch between mini fyke nets and 10.7 meter bag seine in the upper Mississippi River. National Biological Survey, 94-S008, Onalaska, Wisconsin.

Guy, C.S., P.J. Braaten, D.P.Herzog, J. Pitlo, and R. Scott Rogers. 2009. Warmwater fish in rivers. Pages 59-82 *in* S.A. Bonar, W.A. Hubert, and D.W. Willis, editors. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

Hubert, W. A. 1996. Passive capture techniques. P 157-192. In B. R. Murphy and D. W. Willis (eds.) Fisheries Techniques, 2nd ed. American Fisheries Society, Bethesda, MD, USA.

Krueger, K. L., Hubert, W. A., and Price, R. M. 1998. Tandem-set fyke nets for sampling benthic fishes in lakes. North American Journal of Fisheries Management 18:154-160.

Miller, R. J., and Robison, H. W. 2004. Fishes of Oklahoma. University of Oklahoma Press, Norman.

Miranda, L.E. and J. Boxrucker. 2009. Warmwater fish in large standing waters. Pages 29-40 *in* S.A. Bonar, W.A. Hubert, and D.W. Willis, editors. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

Murphy, B. R. and W. Willis. 1996. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Patton, T. and C. Lyday. 2008. Ecological succession and fragmentation in a reservoir: effects of sedimentation and habitats on fish communities. Pg 147-167. *In* M.S. Allen, S. Sammons, and M.J. Maceina [ed.] Balancing fisheries management and water uses for impounded river systems. Am Fish Soc, Sym 62, Bethesda, Maryland.

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, www.R-project.org.

Ruetz III, C. R., D. C. Uzarski, D. M. Krueger, and E. S. Rutherford. 2007. Sampling a littoral fish assemblage: comparison of small mesh mini fyke netting and boat electrofishing. North American Journal of Fisheries Management 27:825-831.

Traynor, D., Moerke, A., and Greil, R. 2010. Identification of Michigan fishes using cleithra. Great Lakes Fishery Commission, Miscellaneous Publications. 2010-02.

Weaver, M. J., J. J. Magnuson, and M. K. Clayton. 1993. Analysis for differentiating littoral fish assemblages with catch data from multiple sampling gears. Transactions of the North American Fisheries Society 122:1111-1119.

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