NORTHERN LEON CREEK GREENWAY FISH COMMUNITY SURVEYS TO ENHANCE URBAN FISHING

by

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Leon Creek is a 92 km ephemeral stream in San Antonio, Texas, that contains numerous permanent and semi-permanent pools. A 32 km reach of Leon Creek is encompassed by the Leon Creek Greenway (LCG) which contains a paved trail utilized by outdoor enthusiasts. Fish community assessments were conducted in spring and fall in five Leon Creek pools (0.07 to 0.89 hectares in size) existing within a 5.1 km reach of the LCG in 2019 to determine the potential of Leon Creek as an urban fishery. A total of 2,651 fish were collected representing 11 species. Six sunfish species (*Lepomis* spp.) and largemouth bass (*Micropterus salmoides*) were the primary recreationally important fishes present and accounted for 14% and 43% of the total catch, respectively. In Earl Scott, Fox Park, and Oxbow, the three largest pools, sunfish comprised 50-68% of all fish collected, whereas in Bridge and UTSA pools, sunfish accounted for 5-9% of the total catch. Mean length of sunfish was also greater in the three larger pools (118-149 mm) compared to the smaller pools (66-89 mm). Largemouth bass catch frequency was greatest in the UTSA Pool (94%); however, all of these fish were collected during spring and ≤ 80 mm in length. Largemouth bass catch frequency was similar among the three largest pools (28-33% of total catch) and mean length was greatest in Earl Scott (215 mm) and Oxbow (188 mm) pools. This study recommends fisheries management and public awareness efforts to enhance Leon Creek as an urban fishery.

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CHAPTER ONE: INTRODUCTION

Angling is a staple outdoor recreation activity and has increased in recent years both in the U.S. and Texas. In 2015, 16% of the population aged six and older participated in angling at least once (The Outdoor Foundation 2016). The number of individuals participating in angling has increased from 33.1 million in 2011 to 35.8 million in 2016 (USFWS 2016). In Texas, the number of fishing licenses purchased was slightly higher in 2015 (1,229,393) than 2012 which ended a decreasing trend since 1993 (1,195,387; Kyle et al. 2016). Nationally, 79% of anglers in the U.S. preferred freshwater fishing, making it the most popular type of fishing (RBFF 2019). Based on a survey of Texas licensed anglers, 78% participated in freshwater fishing with 77% targeting black bass (*Micropterus* spp.; Kyle et al. 2016). Males made up the majority of anglers in the U.S. (73%), and of all age brackets, individuals age 45-54 represented the greatest percentage of anglers at 20% (USFWS 2016). In Texas, the majority of licensed anglers were white (91%), male (80%), and over 40 years old (Kyle et al. 2016).

Urbanization of the U.S. has occurred over its existence; 81% of the population resided in urban areas in 2010 (U.S. Census Bureau 2010). Texas experienced the largest annual population growth of any state in the U.S. between 2010 and 2016 with increases occurring in major metropolitan areas of Houston, Dallas-Fort Worth, San Antonio, and Austin (U.S. Census Bureau 2019). Texas anglers are now more urban-based than ever before. In 2015, 53% of all licensed Texas anglers resided in these Texas urban centers (Kyle et al. 2016). Fishing location proximity is an important determinant in whether or not an individual participates in angling (Patterson and Sullivan 2013). Most Texas freshwater anglers travel less than 80 km to fishing sites (Kyle et al. 2016), with travel cost, catch-related fishing quality, and environmental quality influencing choice of fishing sites (Hunt et al. 2019).

The Texas Parks and Wildlife Department (TPWD), who manages the fisheries resources in about 800 public impoundments and 307,384 km of rivers and streams in Texas (TPWD 2019[a]), has recognized the potential ramifications of increased urbanization on angling participation and placed priority on developing angling opportunities in major metropolitan areas (personal communication, Randy Myers, TPWD). Fish stocking, regulation of fish harvest, and fisheries habitat management are the three primary tools used by TPWD to enhance existing and develop new fisheries (personal communication, Randy Myers, TPWD). Current TPWD initiatives to improve urban angling opportunities include the Neighborhood Fishin' program, which involves bi-weekly stocking of catfish (*Ictalurus spp.*) during warm months and rainbow trout (*Oncorhynchus mykiss*) during cooler months in 18 small waterbodies located in major metropolitan areas (TPWD 2020[a]), and the Community Fishing Lakes program, which typically entails annual stocking of catchable-size channel catfish (*Ictalurus punctatus*) (TPWD 2020[b]). These programs use a more restrictive daily bag limit (5 fish/angler/day) and less restrictive minimum length limit (no size limit) for catfish compared to the statewide standard catfish harvest regulation (25 fish/angler/day and 305 mm minimum length limit; TPWD 2019[b]).

The TPWD currently manages the fisheries in 18 waterbodies in San Antonio (personal communication, Randy Myers, TPWD), which is the seventh most-populated U.S. city and the second fastest growing urban area in the southwest U.S. (U.S. Census Bureau 2017). The drier climate of south Texas (Larkin and Bomar 1983) limits the availability of urban waterbodies in San Antonio. Water level or flow in the majority of San Antonio urban waterbodies is not regulated and thus is governed by precipitation. Daily rainfall > 2.5 cm occurs at the San Antonio International Airport about every 43 days on average (Asquith and Roussel 2003). Although San Antonio receives low total rainfall, it is one of the most flash-flood prone areas in the U.S.

(Bomar 1995) because of limestone bedrock and urban development. Flooding can reduce the effectiveness of fisheries management activities causing stocked fish to emigrate downstream and alter or destroy fish habitat enhancements. Geography, dry climate, and flooding pose challenges in maintaining populations of recreationally important fishes in San Antonio waterbodies.

Development of an urban angling location requires knowledge about the existing fish community. This study focused on a 5.1 km reach of northern Leon Creek which is located within the Leon Creek Greenway (LCG). Leon Creek provides a unique opportunity as an urban angling location as it contains numerous permanent and semi-permanent pools adjacent to the 32 km LCG trail, which is popular among outdoor recreation enthusiasts (Keith 2016). The primary objectives were to determine and compare species composition and fish length among five pools existing along the study reach and formulate recommendations to enhance Leon Creek as an urban angling destination. Taking steps to enhance angling may not only increase angling participation, but may also encourage more people to utilize the greenway and become motivated to protect and manage the natural environment.

CHAPTER TWO: STUDY SITE

Leon Creek

Leon Creek is a 92 km stream that originates near Leon Springs, Texas, in northwest Bexar County (Figure 1). It flows from north to south for 58 km through San Antonio and then into the Medina River. Leon Creek is classified as an urban watershed, surrounded by 9,926 ha of expanding urbanization (Yi et al. 2018) and is very prone to flash floods (Bomar 1995). It is characterized as ephemeral with connectivity reliant on rainfall events (Ockerman and Roussel 2009). Continuous flow over the entire course of Leon Creek occurs twice annually, on average (Ockerman and Roussel 2009). Permanent and semi-permanent pools are scattered along its length. These resulted from either earthen dams, presumed constructed historically when adjacent property was under private ownership, or flood scour. A fish consumption ban is currently in effect for a 20 km reach of southern Leon Creek due to elevated polychlorinated biphenyls (TPWD 2020[c]).

The LCG is a corridor along northern Leon Creek occupying naturally forested riparian floodplains. It contains a 32-km paved trail extending from the intersection of Interstate Highway 10 and Loop 1604 (29.589290, -98.601478) to O. P. Schnabel Park (29.535107, -98.640724). The trail is managed by the San Antonio Parks and Recreation Department (San Antonio Parks and Recreation Department 2019). The mean population density for zip codes within 0.8 km of the trail is 7,469 people/km^2 (Keith et al. 2018). Numerous public trailheads with vehicle parking and restroom facilities exist along the LCG trail. Additionally, the LCG trail can be accessed via spur trails, many of which are paved, connecting neighborhoods, apartment complexes, and other locations. Keith et al. (2018) found that the LCG is used primarily for exercise and physical activity and that most users access the trail via car travel to public trailheads.

Study reach

This study focused on a 5.1 km reach of Leon Creek located within the LCG between UTSA Boulevard crossing (29.579092°, -98.607209°) and Oxbow Park Trailhead (29.551763°, -98.630193°). Five pools exist within this study reach, two of which are permanent (Earl Scott and Oxbow). These were formed by earthen dams, whereas the other three pools (Bridge, Fox Park, and UTSA) resulted from flood scour (Figure 2, Table 1.). All five pools are easily accessible from the LCG trail, with distance from the trail ranging from 9 to 140 m. Minimal canopy cover exists at each pool, except scattered trees and brush around the edges. Substrate in Earl Scott and Oxbow pools is mostly mud and silt, whereas substrate in Bridge, Fox Park, and UTSA pools is mostly gravel, rock, and clay. These five pools account for 8% of all pools occurring along Leon Creek based on examination of Google Earth® aerial images taken in 2018. Earl Scott Pool is actively managed by TPWD and receives channel catfish and rainbow trout stocking, whereas fish management activities have not occurred in the other four pools. However, field observations indicate fishing occurs at these pools evidenced by the presence of discarded fishing line and supplies.

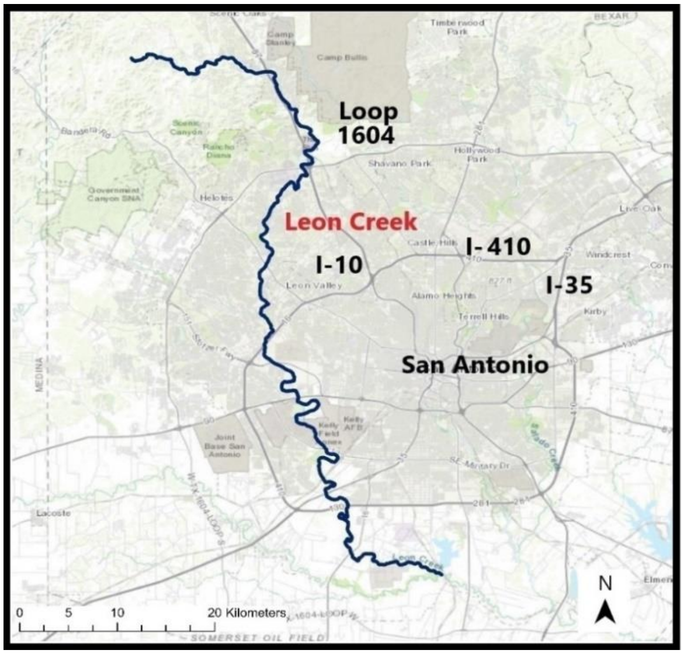

Figure 1. The location of Leon Creek on the western side of San Antonio, Texas as indicated by the blue line (image on the left). The location of San Antonio in Texas is indicated in the image on the right.

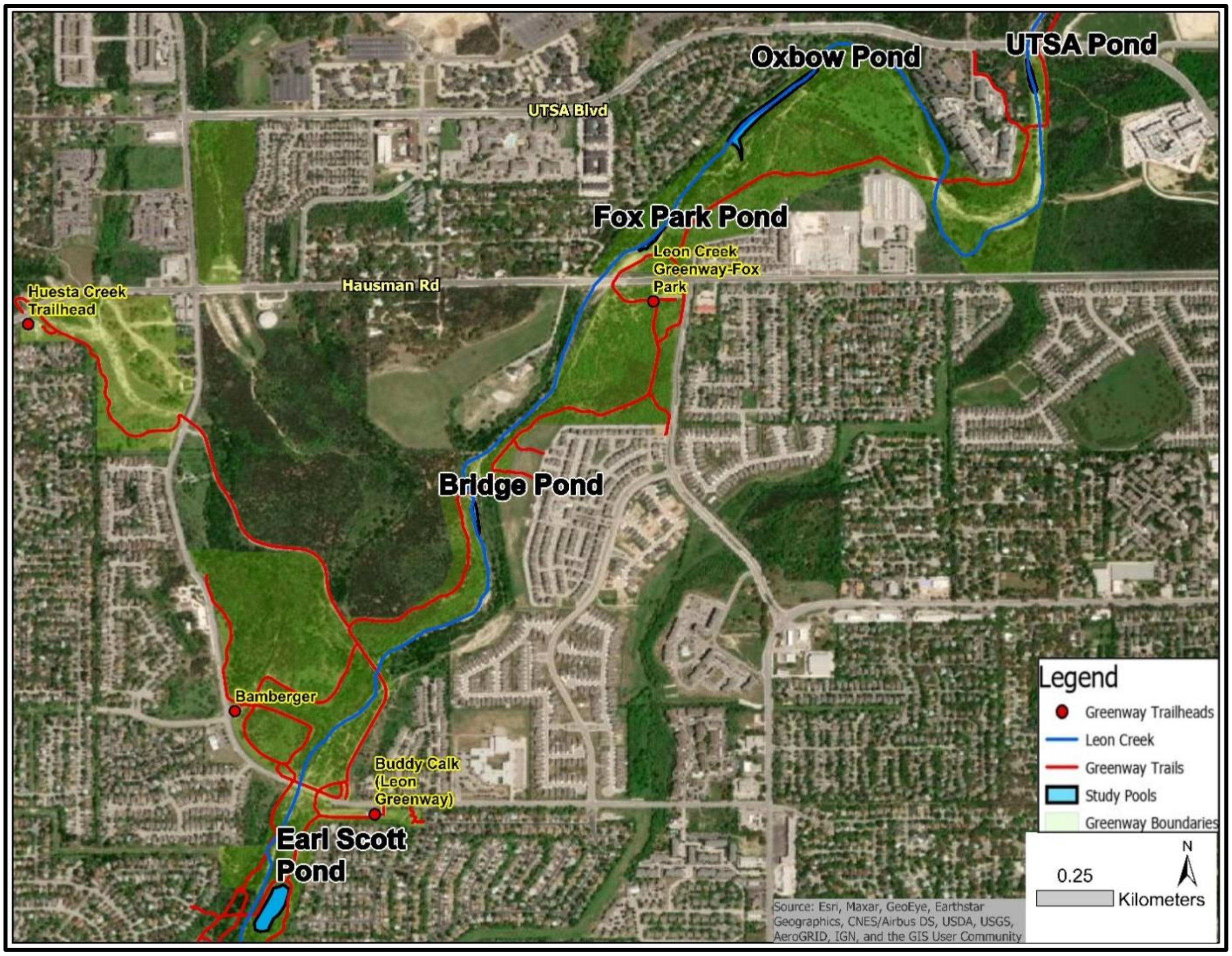

Figure 2. Locations of the five study pools (UTSA Pool, Oxbow Pool, Fox Park Pool, Bridge Pool, and Earl Scott Pool), paved trail (red line), and primary trailheads within the 5.1 km study reach in the northern section of Leon Creek Greenway. Leon Creek is delineated by the blue line.

Table 1. Study pool GPS coordinates (World Geodetic System 1984) and distances from the Leon Creek Greenway paved trail.

	Oxbow	Fox Park	Earl Scott	UTSA	Bridge
Latitude	29.577400	29.573325	29.554171	29.580476	29.565635
Longitude	-98.614994	-98.618458	-98.629351	-98.606763	-98.623511
Distance from trail (m)	140	30	9	40	50

CHAPTER THREE: SURVEY AND ANALYSIS METHODS

Habitat

Water quality parameters were recorded and size (ha) was estimated for each of the five pools located within the study reach concurrent with all fish community surveys (described below). Dissolved oxygen (mg/l) and water temperature (°C) were determined using a hand-held meter (Yellow Springs Instruments, Model 2030, Yellow Springs, Ohio). Pool length (m) was measured and then multiplied by the average of three pool width measurements (m) to obtain size in m^2 of Bridge, Fox Park, and UTSA pools and converted to ha. For Oxbow and Earl Scott pools which were larger, pool size was determined using historic Google Earth® images corresponding to season of fish sampling. Pool size for spring 2019 was calculated as the average of digitized pool size depicted in images taken April 25, 2020 and April 21, 2012, and for fall 2019, pool size was calculated as the average of digitized pool size shown in images taken October 20, 2016 and November 30, 2004.

The National Water Information database (U.S. Geological Survey 2020) was queried to obtain gauge height records for Leon Creek. Three recording stations were available for Leon Creek: at IH 35 (station ID: 08181480); at IH 10 and Loop 1604 intersection (station ID: 08180990); and at 410 (station ID: 08180990). The nearest station to the study reach is the IH 10 and Loop 1604 intersection, which is 2.6 km upstream of the study reach. Field observations of Leon Creek connectivity throughout the study reach were made following large precipitation events. Gauge height records at the IH 10 and Loop 1604 intersection station corresponding to these connectivity observations were examined to determine minimum gauge height necessary for connectivity. Complete connectivity of Leon Creek within the study reach resulted when gauge height was at least 1.4 m.

Fish community survey

Fish community sampling was conducted between the hours of 1000 and 1500 in spring (May 29 and June 12) and fall (October 17-18) of 2019. Each pool was sampled once in spring and fall. Fishes were collected using backpack electrofishing, boat electrofishing, and seining following standard methods described in Hayes et al. (1996) and Bonar et al. (2009). Sampling gear used in pools was contingent on accessibility and pool depth at time of fish community sampling. See Chapter 4 (Results) for gear types used in of the pools.

Backpack electrofishing was used in pools where shallow depth precluded use of boat electrofishing. The backpack electrofishing unit was a Smith-Root® Model 12-A (Smith-Root Inc., Vancouver, Washington) set at 60 hertz (pulsed-direct current with 10-15% duty cycle) and capable of producing up to 600 volts. These settings resulted in a maximum of 12 amps. Sampling was conducted around the entire circumference of the pool. Pulsator settings for the backpack electroshock equipment were held constant throughout the circumnavigation. Stunned fish were collected using long-handle dip nets having 0.64 mm bar mesh and temporarily held in water-filled containers for later processing. A backpack-electrofishing crew consisted of at least two members with each wearing a personal floatation device, waders, and 1,000-volt lineman gloves.

Boat-electrofishing was conducted when pool depth permitted boat launching and navigation throughout the majority of the pool. The boat was 4.9 m long, constructed of aluminum, and had a flat-bottom. The boat-mounted electrofishing unit was a Smith Root® Model GPP 5.0 (Smith-Root Inc., Vancouver, Washington) which produced direct current at a variable pulse rate of 600-800 volts with amperage held between 8 and 12. The boat was fitted with a pair of Smith Root® UAR-4 anode arrays (Smith-Root Inc., Vancouver, Washington) mounted ahead of the bow on fiberglass booms extending 2.4 m from the corners of the bow. There was one driver and two people stationed on the bow responsible for collecting stunned fish using long-handle dip nets with 1.27 bar mesh bags. Fish were collected from a 0° to 180° angle from the bow as the boat slowly circumnavigated pools. Collected fish were temporarily placed into a water-filled holding tank located within the boat for later processing. Safety equipment included a bow rail of approximately waist height extending to the rear of the bow deck. Bow deck, boat floor decking, and other walkways had a non-skid surface. The boat was equipped with dual, foot-operated safety switches (Smith Root® DDS-18-P) to stop the application of direct current in the event a worker fell overboard. An automatic external defibrillation unit was onboard the boat at all times. All staff netting fish wore waterproof rubber boots and lineman gloves (1,000-volt minimum rated).

Seining was conducted in shallow pools where depth prevented efficient use of backpack electrofishing, or in combination with backpack electrofishing when advantageous. The seine was 4.6 m long, 1.8 m deep, and constructed of nylon mesh having 4.8 mm bar size. With the seine stretched along the shore, it was pulled one brail upright through the water with the lead line in contact with bottom, in a 180-degree arc, while using the other brail as an onshore pivot point (Tibbs and Galat 1997; Kubisiak 1997). Multiple seine pulls were used and after each pull, captured fish were temporarily held in water-filled containers for later processing.

All collected fish were identified to species and measured to the nearest mm in total length. Black bullhead (*Ameiurus melas*), largemouth bass (*Micropterus salmoides*), and sunfish (*Lepomis spp.*) > 100 mm collected in spring were marked using fin clips. This involved removing approximately half of either the left or right pectoral or pelvic fin, or a small portion of the dorsal fin using scissors. Different fins were clipped on fish from each pool to distinguish the pool in which fish were marked to determine if any marked fish moved into another pool during the second sampling period. Fish were held no more than 10 minutes in water-filled containers and the boat-mounted holding tank before being released alive back into pools.

Fish community analyses

The number and percent of fish collected was compiled by species, pool, and season (spring and fall). Variable pool size and depth necessitated the use of different gear types to maximize fish catch. This study assumed that each of the gear types, when matched to habitat conditions, provided accurate representations of fish composition and size in each of the pools. Fish species richness and diversity was computed for each pool and for all pools combined using the Simpson Index of Diversity (Simpson 1949). Data were combined for spring and fall sampling periods for comparisons of species composition and fish length among pools. These comparisons involved recreationally important fishes, which were largemouth bass, bluegill *(Lepomis macrochirus)*, redear sunfish (*Lepomis microlophus)*, green sunfish *(Lepomis cyanellus)*, warmouth *(Lepomis gulosus)*, redbreast sunfish *(Lepomis auratus)*, and longear sunfish *(Lepomis megalotis)*. Additionally, all the above specified sunfish species were pooled for analysis because growth rates and maximum size are generally similar among these species (Robison and Buchanan 1988) and due to the low capture rate of some species. Percent of total fish catch that were sunfish and percent of total fish catch that were largemouth bass and associated standard errors (SE) was computed for each pool [Wallis 2013, SAS Institute 2011 (PROC FREQ, OPTION = binomial)].

Five by two contingency tables and chi-square tests (PROC FREQ, OPTION = chisq; SAS Institute 2011) were used to evaluate the relationship between pools (Bridge, Earl Scott, Fox Park, Oxbow, and UTSA) and catch frequencies of sunfish and largemouth bass. The null hypothesis was that catch frequency of sunfish or largemouth bass was independent of pool. When the null hypothesis was rejected [probability (P) < 0.05] signifying catch frequency was dependent on pool, chi-square tests were performed for each of the 10 possible pool combinations using two by two contingency tables to identify pairwise significant differences in catch frequency. Bonferroni-corrected significance [($P < 0.005$) 0.05/10 total pairwise comparisons] was used to maintain an experiment-wise error rate of alpha = 0.05.

Sunfish and largemouth bass length data were assessed for normality using the Shapiro-Wilk test (PROC UNIVARIATE, OPTION = normal; SAS Institute 2011). Sunfish ($W = 0.974$, $P < 0.001$) largemouth bass ($W = 0.356$, $P < 0.001$) length data were not normally distributed. Therefore, these data were $\log_{10}$ transformed to correct for non-normality for subsequent analyses. Analysis of variance coupled with least-squares means and Tukey's multiple comparison procedure (PROC GLM; SAS Institute 2011) was used to evaluate for among-pool differences in mean length of sunfish and largemouth bass. Standard error of the mean (SE) was computed for mean sunfish and largemouth bass lengths (PROC MEANS, OPTION = stderr; SAS Institute 2011).

CHAPTER FOUR: RESULTS

Habitat and fish community sampling

Leon Creek gauge height expectantly varied during 2019 ranging from a low of 0.4 m to a high of 3.0 m (Figure 3). Gauge height exceeded 1.4 m on 12 days during 2019 resulting in connectivity of pools within the study reach. Connectivity occurred on seven days in May prior to when spring fisheries sampling was conducted, on 3 days between spring and fall fisheries sampling, and on two days following fall fisheries sampling.

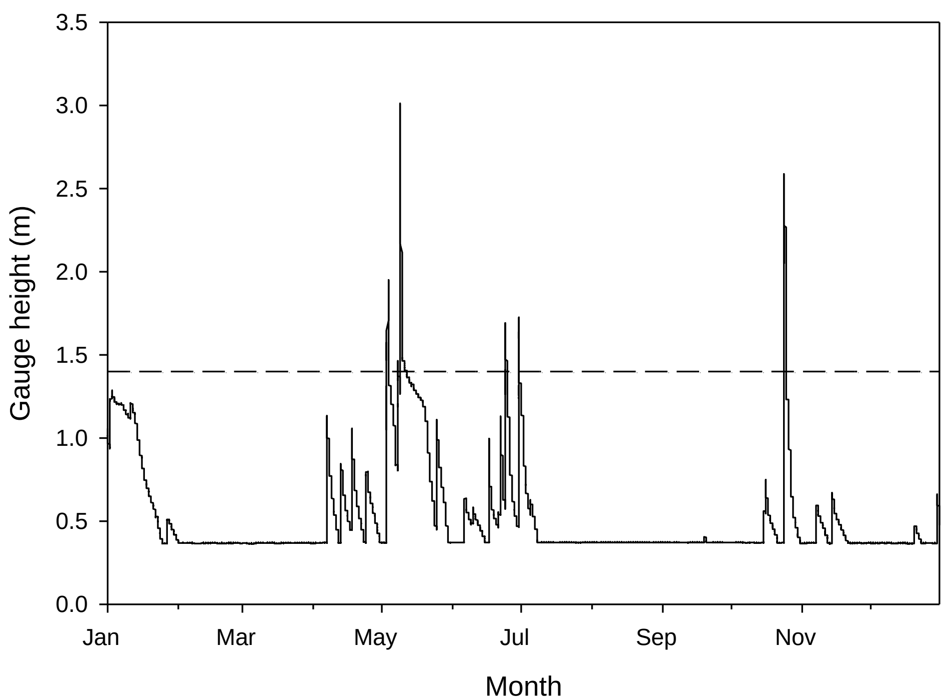

Figure 3. Leon Creek gauge height during 2019 at the U.S. Geological Survey gauge 08180990, which is 2.6 km upstream of the study reach. Gauge height measurements were recorded at 15 minute intervals. The horizontal dashed line denotes stage at which stream connectivity occurs (1.4 m) within in the study reach.

Boat electrofishing was used during spring and fall in Oxbow and Earl Scott pools, and seining was used in both spring and fall in UTSA Pool. Sampling gears used in Fox Park and Bridge pools differed between spring and fall due to decreased water depth (Table 2). Pool size was similar in spring and fall for Oxbow (0.89 ha), Fox Park (0.18 and 0.22 ha, respectively), and Earl Scott pools (0.77 ha), but differed between spring and fall for UTSA and Bridge pools, with both being about 50% smaller during fall sampling. Water temperature in pools ranged from 26.7 to 27.8 C when sampling occurred during spring and from 11.2 to 13.7 C when sampling occurred during fall. Dissolved oxygen varied more among pools when spring sampling occurred (6.5-11.7 mg/l) than when fall sampling occurred (11.2-13.7 mg/l).

Table 2. Sampling dates, gear used, and water quality measures in five pools located within the study reach of northern Leon Creek during the spring and fall of 2019. Boat electrofishing is designated as BOEF and backpack electrofishing as BPEF. Seines were 4.6 m by 1.8 m and constructed of 4.8 mm mesh.

Detail	Oxbow	Fox Park	Earl Scott	UTSA	Bridge
			Spring		
Date	06/12	05/29	06/12	05/29	06/12
Gear	BOEF	BPEF/Seine	BOEF	Seine	BOEF
Pool area (ha)	0.89	0.18	0.77	0.27	0.16
Water temperature (°C)	27.4	26.7	27	NA	27.8
Dissolved oxygen (mg/l)	9.3	11.7	6.5	NA	10.3
			Fall		
Date	10/18		10/18	10/17	10/17
Gear	BOEF	BOEF	BOEF	Seine	BPEF
Pool area (ha)	0.89	0.22	0.77	0.16	0.07
Water Temperature (c)	19.8	20.1	22.9	20.2	18.2
Dissolved Oxygen (mg/l)	12.3	11.2	13.1	13.5	13.7

Fish community composition

In total, 2,651 fish were collected from the five pools in Leon Creek representing 11 species (Table 3). Recreationally important species were largemouth bass, bluegill, green sunfish, longear sunfish, red breast sunfish, redear sunfish, and warmouth. Other species collected were black bullhead, mosquitofish (*Gambusia affinis*), gizzard shad (*Dorosoma cepedianum*), and mexican tetra (*Astyanax mexicanus*). Only one species, redbreast sunfish, was a non-native to Texas (TPWD 2020[d]). Largemouth bass and black bullhead accounted for 43% and 42%, respectively, of all collected fish. Six different sunfish species were collected and together comprised 14% of all collected fish. A total of 63 sunfish, 23 largemouth bass, and three black bullhead were marked using fin clips during spring sampling. Approximately five months later during fall sampling, only one marked fish was recaptured, a 169 mm bluegill which was recaptured in the same pool (Oxbow) in which it was marked.

Table 3. Total number and percentage of fish by species collected in five pools located within the study reach of northern Leon Creek during the spring and fall of 2019. Data are pooled for spring and fall surveys.

Species	Number	Percent
Black Bullhead	1,108	42
Bluegill	270	10
Mosquitofish	21	1
Gizzard Shad	7	<1
Green Sunfish	33	1
Largemouth Bass	1,131	43
Longear Sunfish	5	<1
Mexican Tetra	3	<1
Redbreast Sunfish	48	2
Redear Sunfish	13	<1
Unknown Sunfish	2	<1
Warmouth	10	<1

Species of fish collected varied among Leon Creek pools and between seasons within pools (Table 4). Total number of species collected was nine in Oxbow Pool, eight in Earl Scott, Fox Park, and Bridge pools, and seven in UTSA Pool. In all pools except UTSA, the number of species collected differed by 0-2 species between spring and fall. In the UTSA Pool, seven species were collected during spring and only one species during fall. Total number of fish collected in Bridge (1,268) and UTSA (1,062) pools greatly exceeded the total number of fish collected in Earl Scott (109), Fox Park (48), and Oxbow (164) pools. However, the vast majority of fish collected from Bridge and UTSA pools were fingerling-sized (< 80 mm) black bullhead (87%) and largemouth bass (94%), respectively. Between spring and fall, the total number of fish collected differed by 18% in Earl Scott Pool, 53% in Fox Park Pool, and 122% in Oxbow Pool. The difference in catch between spring and fall was much greater in UTSA and Bridge pools. A total of 1,152 fish were collected in the Bridge Pool and 1,060 in the UTSA Pool during spring, whereas during fall, total catch was 116 and 2 fish in these pools, respectively. The Simpson Index of Diversity ranged from a low of 0.77 (Bridge Pool) to a high of 0.99 (both Earl Scott and Oxbow pools) and was 0.99 when data were combined for all pools.

Table 4. Number and percentage of fish collected by species and season from five pools located within the study reach of northern Leon Creek in 2019. Cells containing dashes indicate no fish were collected during sampling period.

	Spring		Fall		Combined	
Species	Number	Percent	Number	Percent	Number	Percent
			Earl Scott			
Black Bullhead	3	5	-	-	3	3
Bluegill	30	51	31	62	61	56
Gizzard Shad	1	2	1	2	2	2
Green Sunfish	1	2	-	-	1	1
Largemouth Bass	17	29	13	26	30	28
Redbreast Sunfish	-	-	2	4	2	2

Table 4 continued.

Redear Sunfish	2	3	2	4	4	4
Warmouth	5	8	1	2	6	6
			Fox Park			
Black Bullhead	-	-	1	3	1	2
Bluegill	6	32	4	14	10	21
Mosquitofish	-	-	9	31	9	18
Green Sunfish	-	-	1	3	1	2
Largemouth Bass	10	53	4	14	14	29
Redbreast Sunfish	1	5	8	28	9	19
Redear Sunfish	1	5	2	7	3	6
Warmouth	1	5	-	-	1	2
			Oxbow			
Black Bullhead	1	2	-	-	1	1
Bluegill	9	18	52	46	61	37
Gizzard Shad	2	4	-	-	2	1
Green Sunfish	1	2	1	<1	2	1
Largemouth Bass	16	31	38	34	54	33
Longear Sunfish	1	2	-	-	1	<1
Redbreast Sunfish	17	33	18	16	35	21
Redear Sunfish	4	8	2	2	6	4
Warmouth	-	-	2	2	2	1
			Bridge			
Black Bullhead	1,101	96	2	2	1,103	87
Bluegill	15	1	74	64	89	7
Mosquitofish	-	-	4	3	4	<1
Gizzard Shad	2	<1	1	1	3	<1
Green Sunfish	6	<1	23	20	29	2
Largemouth Bass	25	2	11	9	36	3
Mexican Tetra	2	<1	-	-	2	<1
Redbreast Sunfish	1	<1	1	1	2	<1
			UTSA			
Bluegill	49	5	-	-	49	5
Mosquitofish	6	<1	2	100	8	1
Largemouth Bass	997	94	-	-	997	94
Longear Sunfish	4	<1	-	-	4	<1
Mexican Tetra	1	<1	-	-	1	<1
Unknown Sunfish	2	<1	-	-	2	<1
Warmouth	1	<1	-	-	1	<1

A total of six different sunfish species were collected with bluegill comprising 42-91% of total sunfish catch in the five pools (Figure 4). Redbreast sunfish was the second-most collected sunfish in Fox Park (38%) and Oxbow pools (33%). The second-most collected sunfish was warmouth in Earl Scott Pool (8%), green sunfish in Bridge Pool (24%), and redear sunfish in Fox Park Pool (13%). Six different sunfish species were collected in Oxbow Pool, while five different sunfish species were found in Earl Scott and Fox Park pools. In Bridge and UTSA pools, three different sunfish species were collected.

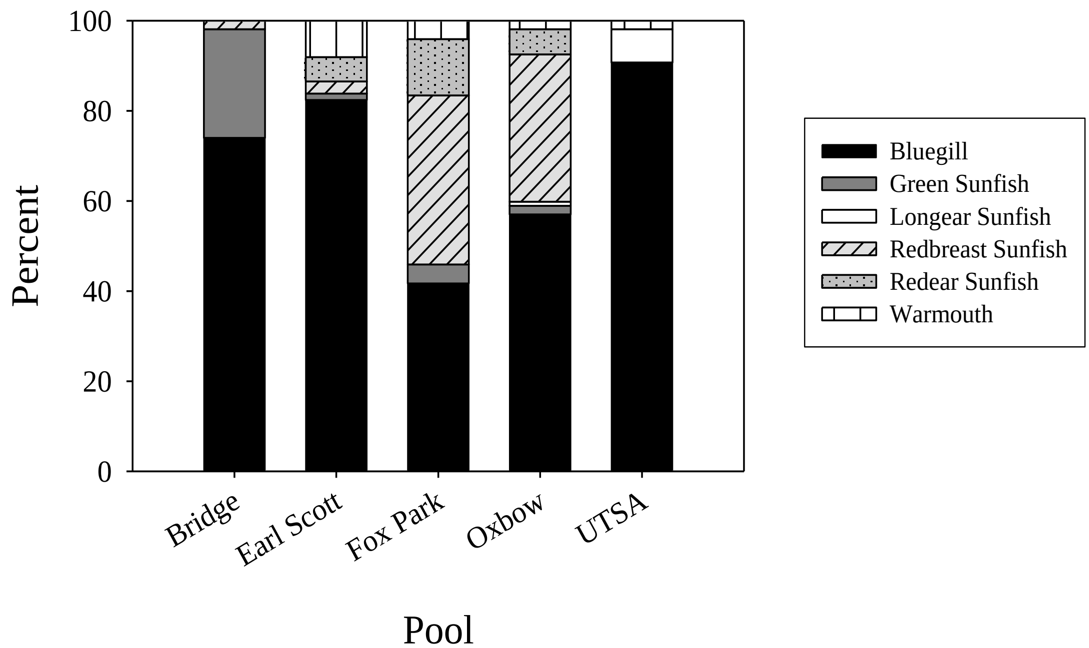

Figure 4. Percent composition of sunfish species collected from five pools within the study reach of northern Leon Creek in 2019.

Sunfish comprised from 5% (SE= 2) to 68% (SE = 5) of total fish catch in Leon Creek pools (Figure 5). Catch frequency of sunfish was dependent on pool ($\chi 2 = 750.6$, DF = 4, $P < 0.0001$). Pairwise testing revealed that sunfish catch frequency was significantly lower in the two smallest pools (Bridge and UTSA) than in all other pools ($\chi 2 = 77.99 - 450.70$, DF = 1, $P < 0.0005$) and was similar among Earl Scott, Fox Park, and Oxbow pools ($\chi 2 = 0.2 - 4.6$, DF = 1, $P = 0.0330 - 0.6506$).

Largemouth bass comprised from 3% (SE < 1) to 94% (SE = 1) of total fish catch in Leon Creek pools (Figure 6). Catch frequency of largemouth bass was dependent on pool ($\chi 2 = 1988.6$, DF = 4, $P < 0.0001$). Pairwise testing showed that largemouth bass catch frequency was greater in UTSA Pool than in all other pools ($\chi 2 = 242.6 – 1948.3$, DF = 1, $P < 0.0001$), similar among Earl Scott, Fox Park, and Oxbow pools ($\chi 2 < 0.1$, DF = 1, $P = 0.3434 - 0.8327$), and lower in Bridge Pool than in all other pools ($\chi 2 = 87.7 - 1948.3$, DF = 1, $P < 0.0001$).

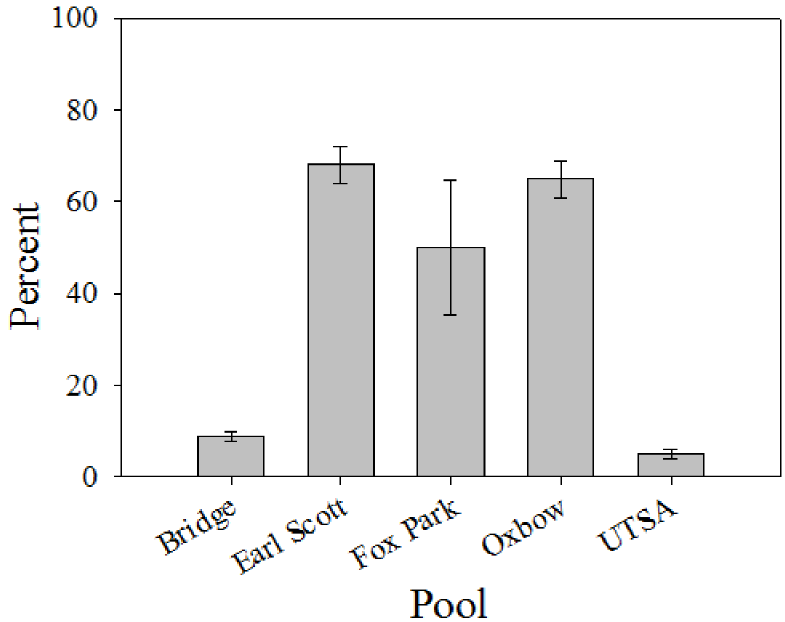

Figure 5. Percent of total fish catch that was sunfish (combined species) by pool in five pools located within the study reach of northern Leon Creek in 2019. Error bars represent standard error.

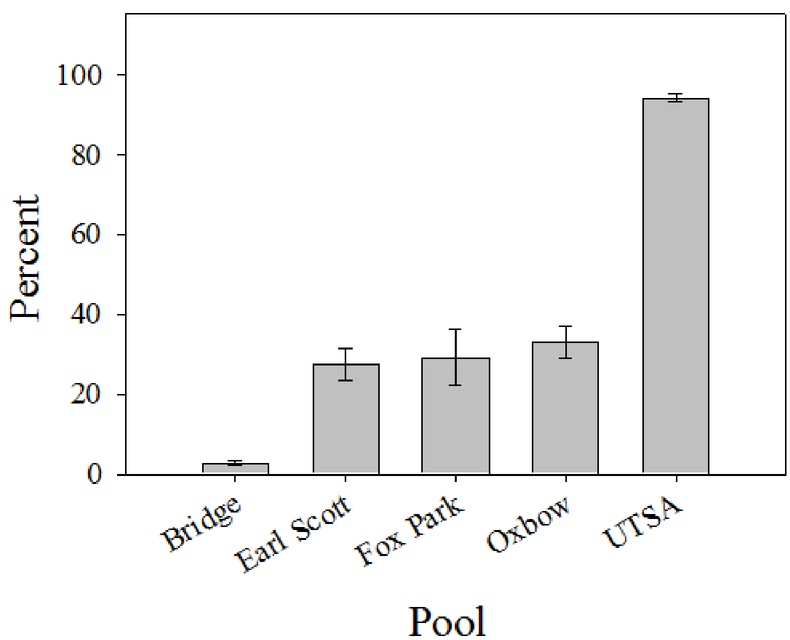

Figure 6. Percent of total fish catch that was largemouth bass by pool in five pools located within the study reach of northern Leon Creek in 2019. Error bars represent standard error.

Fish size comparisons

Both juvenile and adult fishes were collected from Leon Creek pools and fish size varied among pools for both recreationally and non-recreationally important species (Table 5). Sunfish ranged in length from 20 to168 mm in Bridge, from 67 to 207 mm in Earl Scott, from 28 to 212 mm in Fox Park, from 55 to 233 mm in Oxbow, and from 64 to 149 mm in UTSA pools. Mean length of sunfish differed among pools ($F = 89.4$, $DF = 4$, $P < 0.0001$), and was generally greater for larger pools. Sunfish mean length was significantly greater in Earl Scott (118 mm, SE = 3), Fox Park (130 mm, SE = 10), and Oxbow (149 mm, SE = 4) pools, than in UTSA (89 mm, SE = 4) and Bridge (66 mm, SE = 3) pools (Figure 7). Additionally, sunfish mean length was significantly greater in UTSA Pool than in Bridge Pool and greater in Oxbow Pool than in Earl Scott Pool. Largemouth bass length ranged from 49 to 496 mm in Bridge, from 34 to 480 mm in Earl Scott, from 35 to 241 mm in Fox Park, from 55 to 508 mm in Oxbow, and from 40 to 80 mm in UTSA pools. Mean length of largemouth bass differed among pools ($F = 505.3$, $DF = 4$, $P < 0.001$) and generally was greater for larger pools. Pairwise comparisons revealed that largemouth bass mean length was significantly greater in Earl Scott (215 mm, SE = 26) and Oxbow (188 mm, SE = 14), than in UTSA (52 mm, SE = 1), Bridge (126 mm, SE = 20), and Fox Park (75 mm, SE = 15), which were smaller size pools (Figure 8). Adult black bullhead were present in Earl Scott, Fox Park, and Oxbow pools, while only juveniles or no black bullhead were collected from other pools. Adult-sized gizzard shad were present in Bridge, Earl Scott, and Oxbow pools, while juvenile-sized gizzard shad were collected from only Bridge Pool.

Table 5. Minimum, maximum, and mean length (mm) with standard error (SE) by sampling season and mean length combined for both spring and fall with SE of fishes collected from five study pools located within the study reach of northern Leon Creek in 2019. Dashes indicate sample size was insufficient to compute mean or SE.

			Spring		Fall		Combined	
	Minimum	Maximum	Mean	SE	Mean	SE	Mean	SE
			Earl Scott					
Black Bullhead	30	322	224	97	-	-	224	97
Bluegill	67	149	109	109	115	2	112	2
Gizzard Shad	367	425	367	-	425	-	396	29
Green Sunfish	96	96	96	-	-	-	96	-
Largemouth Bass	33	480	212	39	219	30	215	25
Redbreast Sunfish	175	207	-	-	191	16	191	16
Redear Sunfish	130	173	170	3	133	3	151	11
Warmouth	106	185	118	7	185	-	129	13
			Fox Park					
Black Bullhead	295	295	-	-	295	-	295	-
Bluegill	28	146	70	16	135	7	96	14
Green Sunfish	168	168	-	-	168	-	168	-
Largemouth Bass	35	241	48	3	143	33	75	15
Redbreast Sunfish	84	212	84	-	178	9	167	13
Redear Sunfish	75	156	75	-	148	8	124	25
Warmouth	106	106	106	-	-	-	106	-
			Oxbow					
Black Bullhead	310	310	310	-	-	-	310	-
Bluegill	55	216	131	11	133	5	133	4
Gizzard Shad	425	460	443	18	-	-	443	18
Green Sunfish	78	88	88	-	78	-	83	5
Largemouth Bass	55	508	193	30	186	16	188	14
Longear Sunfish	75	75	75	-	-	-	75	-
Redbreast Sunfish	92	220	159	7	192	6	176	5
Redear Sunfish	118	233	220	7	149	31	196	18
Warmouth	84	186	-	-	135	51	135	51
			Bridge					
Black Bullhead	15	72	15	1	71	1	15	2
Bluegill	20	160	81	2	55	3	60	3
Mosquitofish	29	46	-	-	38	4	38	4
Gizzard Shad	71	365	216	143	365	-	265	97

Table 5 continued.

Green Sunfish	47	168	118	11	77	4	85	5
Largemouth Bass	49	496	92	12	203	54	126	20
Mexican Tetra	65	71	68	3	-	-	68	3
Redbreast Sunfish	56	140	140	-	56	-	98	42
			UTSA					
Bluegill	28	150	88	5	-	-	88	5
Mosquitofish	32	48	45		33	1	42	2
Largemouth Bass	40	80	54	<1	-	-	52	<1
Longear Sunfish	95	110	103	3	-	-	103	3
Mexican Tetra	84	84	84	-	-	-	84	-
Unknown Sunfish	87	149	118	31	-	-	118	31
Warmouth	64	64	64	-	-	-	64	-

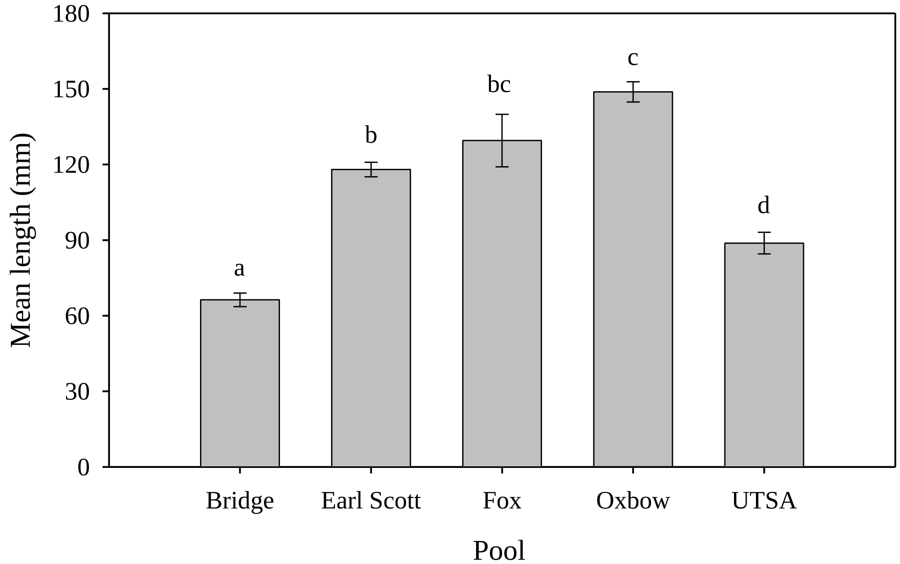

Figure 7. Mean length of combined sunfish species collected from five pools located within the study reach of northern Leon Creek in 2019. Error bars represent standard error. Mean lengths not denoted with the same letter differed significantly ($P < 0.05$).

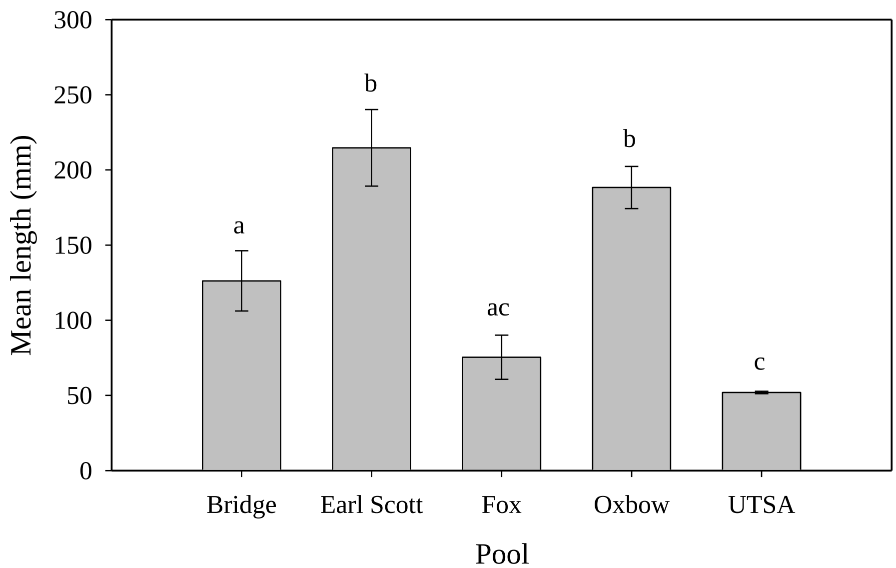

Figure 8. Mean length of largemouth bass collected from five pools located within the study reach of northern Leon Creek in 2019. Error bars represent standard error. Mean lengths not denoted with the same letter differed significantly ($P < 0.05$).

CHAPTER FIVE: DISCUSSION

Largemouth bass and sunfish were the primary recreationally important fishes collected from pools in northern Leon Creek. Texas anglers most prefer to catch largemouth bass (50%; Kyle et al. 2016), and while not as popular, sunfish are a diverse sportfish group that forms an essential part of recreational fishing (Roe et al. 2002; Chen et al. 2003; Jackson 2003), particularly in urban fisheries (Balsman and Shoup 2008). Catch frequency and size of both largemouth bass and sunfish varied among pools indicating recreational angling potential also differed among pools. A greater number of quality-sized largemouth bass (> 305 mm) and sunfish (> 152 mm) were collected from Earl Scott and Oxbow, the two largest pools, than from the other three pools. Legally harvestable-size largemouth bass (> 356 mm) were present in three of the five pools sampled (Bridge, Earl Scott, and Oxbow). Small largemouth bass (< 80 mm), which were likely young-of-year fish born in 2019, predominated the largemouth bass catch in the three smaller pools. This was especially evident during spring sampling (late May-early June). Largemouth bass begin spawning in early spring when water temperature reaches 16°C (Fishes of Texas 2020), which occurs in March in south Texas. Largemouth bass grow to a length of 50 mm about three months after hatching (Dreves and Timmons 2001). Leon Creek supported a myriad of sunfish species. Bluegill was numerically the predominant sunfish present in all five pools, and redbreast sunfish had the largest mean size of sunfish in three of the five pools.

Cibolo and Salado creeks are two other ephemeral streams in San Antonio. The River Studies Team of TPWD along with the San Antonio River Authority conducted fish community surveys in both streams in the past. In an unpublished data set provided by Gordon Linam of TPWD, 10 of the 11 fish species collected in Leon Creek were collected in Salado (out of 23 total species) and Cibolo Creek (out of 44 total species). Black bullhead, which ranges throughout Texas (TPWD 2020[e]), was the only species present in Leon Creek that was not collected in the other two streams. Redbreast sunfish, the only species not native to Texas collected from Leon Creek, was also collected in Salado and Cibolo Creeks. Greater species richness in these two creeks compared to Leon Creek may be a function of greater sampling intensity and time frame. Cibolo Creek was sampled at seven sites across twelve years and Salado Creek was sampled at seven different sites across four years. Sampling for this study occurred in a single year within a relatively short stream reach.

Differences in fish community structure and fish size among Leon Creek pools are likely attributable to the ephemeral nature and dynamic hydrology of Leon Creek, and morphological differences among pools. Fish may be less likely to emigrate out of larger, deeper pools (Earl Scott and Oxbow) because smaller pools likely offer less refugia from higher flow velocities. Additionally, duration of connectivity may influence fish emigration out of pools. Pool connectivity events that are short-term (hours) may facilitate temporary or short-distance fish emigration out of residence pools. In contrast, pool connectivity events that are long-term (days) would seemingly promote permanent and more distant relocation of fish. The negative impact of a prolonged period of low rainfall and lack of connectivity on pool habitat (pool size and depth) is likely greater for small, shallow pools than larger, deeper pools. During periods of drought, fish inhabiting small, shallow pools are at a higher risk of mortality due to predation, harvest by anglers, and anoxic conditions than fish residing in larger, deeper pools. In this study, sizes of Bridge and UTSA pools were about 50% smaller during fall sampling than spring sampling, with considerably fewer fish collected during fall sampling than spring sampling from both. In contrast, size of Earl Scott and Oxbow pools were similar during spring and fall sampling, with similar or higher numbers of fish collected during fall compared to spring. Larger pools in Leon Creek likely serve as a source of fish recolonization into the smaller ephemeral pools.

This study was unable to document fish emigration among study reach pools. Pool connectivity occurred on three days between spring and fall sampling, but only one of the 89 fish tagged during spring was recaptured during the fall and this individual was recaptured from the same pool in which it was tagged. The recapture of a single fish could suggest that extensive fish emigration occurred between spring and fall sampling. Additional research is necessary to understand fish movement in response to Leon Creek pool connectivity.

The number of angler visits to Texas urban fisheries can be substantial. Angler visits to 14 Neighborhood Fishin' program waterbodies in 2012 averaged 9,844 (Mauk 2015). The number of angler visits to a reach of the South Concho River within San Angelo, Texas, was 4,126 in 2019 (Wright 2020). Although the number of angler visits to the five Leon Creek pools was not estimated, the entirety of Leon Creek likely supports a similarly high number of angler visits. Potential fishing locations along Leon Creek are numerous as this study included only an estimated 8% of the pools occurring along Leon Creek.

Visitation to greenway trails can be substantial, and users of these trails may engage in multiple outdoor recreational activities, including angling. Betz et al. (2003) estimated potential visitation of 416,213 for a 23 km greenway trail in Georgia. Visitation to a 23 km trail in Indiana averaged 25,573 visits during September 2000 (Lindsey and Nguyen 2004). Keith (2016) counted a total of 464 users from a fixed location on the LCG trail during a total of fifteen 30-minute observation periods, which suggests that the LCG trail is also highly utilized. Most users of the LCG trail are either walkers/runners or bikers (99%) and resided nearby the trail (mean distance traveled = 6 km; Keith 2016). Nationally, 29% of bikers, 43% of walkers, and 26% of runners also participate in angling. The LCG trail attracts a high number of outdoor recreationalists who are already anglers or potentially could become anglers to close proximity of an urban angling location.

Success of an urban fishery is driven by awareness, accessibility, and quality of the opportunity (Balsman and Shoup 2008). More intensive management of Leon Creek may increase its significance as an urban fishery. Largemouth bass and sunfish were the predominant recreationally important species in studied pools, thus future fisheries management efforts may center on maintaining or enhancing populations of these species. Implementation of more restrictive harvest regulations would minimize the chance of overharvest and conserve these populations. The current harvest regulation for Leon Creek allows anglers to harvest up to five largemouth bass > 356 mm in length and unlimited sunfish per day. The TPWD uses a mandatory catch and release regulation for largemouth bass and sunfish ("C&R1" and "C&R2;" TPWD 2019[b]) at two urban locations, Bedford Boys Ranch Pond in Fort Worth, Texas and Lake Kyle in Kyle, Texas. The "C&R1" regulation additionally protects catfishes from angler harvest. The "C&R2" regulation would be ideal for Leon Creek to maximize populations of largemouth bass and sunfish, as it precludes harvest of both. Mauk (2015) found that only 11% of Texas urban anglers stated they needed to catch and harvest fish to enjoy their fishing experience, thus angling satisfaction may not be correlated with fish catch and harvest. Alternatively, Hunt et al. (2012) reported satisfaction of catfish anglers increased as catch increased, thus some catch and harvest may be necessary to keep anglers interested and active in fishing (Eades and Lang 2012). Fish community sampling in Leon Creek pools showed a high abundance of juvenile largemouth bass (< 203 mm). Abundant juvenile largemouth bass existed in pools within the study reach suggesting that supplemental stocking of fingerling largemouth bass is not needed. Fisheries habitat enhancement efforts such as native vegetation plantings and fish attractor installations are not recommended due to Leon Creek experiencing frequent high flow events which would likely damage these efforts.

Improved awareness of Leon Creek as an angling opportunity may increase its significance as an urban fishery. Signs signifying trails to pools, advising fish harvest regulations and fishing license requirements, educating LCG users about the importance of aquatic habitat, and instructing anglers to pick up after themselves could be installed adjacent to Leon Creek pools. These signs would effectively convey Leon Creek as an angling opportunity and promote such to the multitude of walkers/runners and bikers that utilize the LCG trail. While the TPWD lists fish stockings in urban waterbodies on their website and the TPWD-San Antonio Fisheries District office operates a Facebook page describing their activities and promoting fishing, no strategic marketing has been conducted specific to angling in Leon Creek. Promotion of Leon Creek as an angling opportunity could be accomplished through Facebook advertising targeting individuals interested in outdoor recreation activities. Additionally, fishing demonstrations and aquatic education programs may be conducted on-site at Leon Creek to introduce and educate individuals about fishing and Leon Creek. These events could correspond with TPWD's free fishing day which is the first Saturday in June of each year so participants would not be required to purchase a fishing license.

APPENDICES

Appendix A: TPWD Volunteer Letter

TEXAS PARKS & WILDLIFE

Life's better outside.

November 5, 2020

University of Texas at San Antonio (UTSA),

I am writing to inform that Ms. Madeliene Buchanan, UTSA graduate student, has served as a Texas Parks and Wildlife Department (TPWD)-Inland Fisheries Division volunteer from December 2018 to present. During this time, Ms. Buchanan assisted with a variety of activities. The plurality of her volunteer efforts was helping TPWD conduct fisheries sampling in Leon Creek and a utilization study of Leon Creek Greenway in San Antonio. Ms. Buchanan worked alongside my staff, and following training, she collected data independently. These studies involved collection of fish from Texas public waters and surveying users via application of short questionnaire. The TPWD has authority over fish and wildlife in the public domain of Texas (Section 12.001 Parks and Wildlife Code). Although, the TPWD mandates a scientific collection permit for individuals and entities collecting fish and wildlife from the public domain of Texas, it does not impose this requirement on itself. The TPWD regularly performs in-person interviews of constituents (anglers, park users, etc.), as was done by Ms. Buchanan and my staff at the Leon Creek Greenway. The TPWD does not require any specialized training or certification for staff and volunteers to perform these in-person surveys. Ms. Buchanan preformed all activities relating to the above-described studies as a TPWD volunteer and under direction of TPWD-Inland Fisheries staff. Should you have any questions, please feel free to contact me.

Thank you,

Randy Myers
TPWD-Inland Fisheries
District Fisheries Biologist
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To manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations.

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VITA

Madeliene Buchanan is from the state of Texas. She studied biology at Texas A&M University and earned her Bachelor’s degree in biology in 2012. She then continued her education by earning an Associate of Applied Science in veterinary technology in 2015 from Palo Alto College. She has now earned a Master’s degree in environmental sciences from The University of Texas at San Antonio in 2020. Her future plans include obtaining a job in the environmental science field.