An Investigation of Off-Road Vehicle Impacts on Nueces River Fish Assemblages in Uvalde and Zavala Counties, Texas

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Abstract.—The Nueces River in Uvalde and Zavala counties, Texas has been a popular destination for off-road vehicle enthusiasts who drive vehicles within the river channel and use low water areas such as riffles for crossing the river. Concern over impacts to aquatic communities led to this investigation of fish assemblages to determine if impacts to the community were occurring. Fish collections were made at four sites during two separate sampling periods. Differences in fish assemblages were found among sites. Index of Biotic Integrity rated aquatic life uses as high to exceptional at study sites. Similarity indices indicate longitudinal variation, with species composition at the upstream site being most similar to the next site downstream, and most dissimilar to the most downstream site. Off-road vehicle impacts to the fish community were not readily discernable in this analysis. Variation in fish assemblages among sites may be a function of available instream habitat and spring flow influence. Further investigation and monitoring would be needed to fully investigate off-road vehicle impacts to Nueces River fish assemblages.

Off-road vehicle (ORV) use of natural areas has been controversial for decades. The United States government addressed concerns with this activity on federal lands in the 1970's with the issuance of two Executive Orders designed to "ensure that the use of ORVs on public lands will be controlled and directed so as to protect the resources of those lands, to promote the safety of all users of those lands, and to minimize conflicts among the various uses of those lands" (Webb and Wilshire 1983). A number of states have also enacted legislation concerning this activity. Among states with ORV regulations are Washington, Ohio, New York, Arizona, California, Montana and Idaho. The degree to which ORVs are regulated in these states vary from temporary closures in Arizona to complete prohibition within navigable streambeds in Montana without permission or contractual agreement with landowners.

The popularity of all terrain vehicles continues to rise. Concern over ORV activity occurring in state-owned streambeds has now become an issue in Texas in the Brazos, Colorado, Guadalupe, Neches, Nueces, Red River, Rio Grande, San Antonio, and San Jacinto river basins. Dozens of ORV clubs exist in Texas, many of which are very active and carry memberships of more than 60.

Article XVI, § 59 of the Texas Constitution affords the public the right to navigate inland and coastal waters; however, the issue of "use" vs "abuse" has been raised over the past few years. Disagreement stems from the notion of "traditional use" with some stakeholders believing motorized use of streambeds is not a traditional use, while others argue motorized vehicle use of streambeds represent a long held recreational activity dating back to the Ford model T.

The physical impacts attributed to ORV use include destruction of riparian vegetation, compaction of riffle zone substrates, streambank erosion and destabilization, siltation, destruction of natural habitats, loss of natural conditions, degradation of water quality, direct mortality, and wildlife harassment (Webb and Wilshire 1983; Havlick 2002; Texas Chapter American Fisheries Society 2002). Shallow water areas repeatedly used as crossing points by ORVs may be significantly disturbed, affecting benthic communities and higher trophic levels.

Participants in activities such as swimming, fishing, and family outings have voiced concerns regarding safety, but have also expressed concerns about being able to get to their "favorite" spots if vehicle traffic along the channel is prohibited. Suggestions for improved access have been offered to ameliorate this problem.

Attention was recently focused on ORV activity in the Nueces River Basin mostly due to concerns expressed by the Nueces River Authority. The Nueces River has been one of the more popular ORV destinations as illustrated by a 2002 Labor Day rally drawing 108 vehicles (Carmody 2002). In response to concerns about ORV use in the Nueces River basin, G. Garrett (Texas Parks and Wildlife Department [TPWD], personal communication) conducted a fish survey in August 2001 and concluded degradation was occurring in reaches heavily used by ORVs.

As a result of these preliminary findings, a follow up study was conducted. In addition to our evaluation of fish assemblages, the Texas Commission on Environmental Quality (TCEQ) evaluated potential impacts to benthic macroinvertebrates and habitat while the Nueces River Authority collected water samples for analysis. Only the analysis and results of the fish collections are included in this report.

Methods

Study sites.—Four sites on the Nueces River in Uvalde and Zavala counties, Texas were sampled during the periods of April 16-18, 2002 and September 17-18, 2002 (Figure 1). Site 1 (selected to represent slight ORV use) was located in Uvalde County. Sites 2-4 were located in Zavala County. Site 2 had heavy ORV use. Site 3 had moderate to high ORV use. Site 4 had no ORV use. Degree of ORV use was based on Nueces River Authority observations.

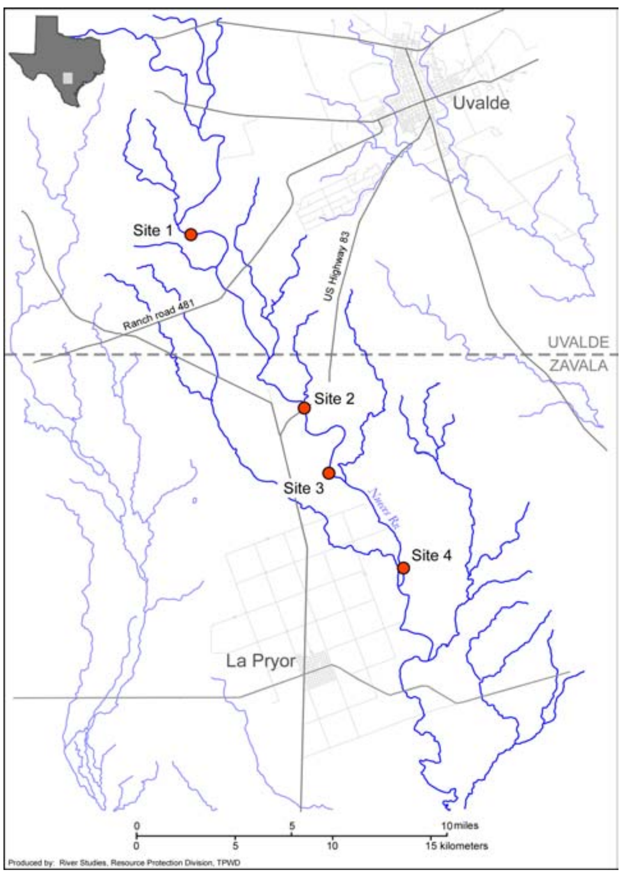

FIGURE 1.—Nueces River sample sites.

Fish sampling.—Available fish habitat within each study area was sampled using seines and backpack electrofishing equipment. A minimum sampling effort of 10 seine hauls and 15 minutes of actual shocking time was established for each site; however, sampling continued until all habitats had been effectively sampled and additional new species were not collected. Four seines comprised of delta weave mesh and having double lead weights were employed. Seine sizes were: 1.8m x 1.2m with 4.8 mm mesh; 4.6m x 1.8m with 4.8mm mesh; 6.1m x 1.2m with 4.8mm mesh; and 9.1m x 1.8m with 6.4mm mesh. Smith-Root backpack electrofishers (model 12-B POW and LR-24) were used for electrofishing.

Fish easily identified in the field were counted and released. All other specimens were preserved using 10% formalin, and transported to the lab for positive identification. Specimens were later transferred to a 70% ethanol solution. All specimens were examined for external deformities, disease, lesions, tumors, and skeletal abnormalities. Taxonomic references used for identification included Hubbs et al. (1991) and Page (1983). Scientific and common names follow Hubbs et al. (1991).

Data analysis.—Data from each site were analyzed using index of biotic integrity (IBI) metrics developed for the Central Texas Plateau ecoregion (Linam et al. 2002). The IBI provides a means of assessing fish assemblage degradation. Results are reported as an aquatic life use. Possible rankings include exceptional, high, intermediate, and limited. In addition sites were compared using the index of similarity as described by Odum (1971). The index of similarity provides a measure of the resemblance of species composition between sample sites. The index is calculated by the following formula:

$$S=2C/(A+B)$$

where S = index of similarity, A = number of species in sample A, B = number of species in sample B, and C = number of species common to both samples. Results range from 0 (entirely dissimilar species composition) to 1.0 (identical species composition).

Results

Site Descriptions

Water clarity at all sites was exceptional. Stream discharge was approximately 47 ft^3/sec during April sampling and approximately 74 ft^3/sec during September sampling (S. Tieman, TCEQ, personal communication).

At site 1 (Figure 1) a few tire tracks and ruts were observed. Instream habitat included a large deep pool with bedrock, cobble, and gravel substrate and a small backwater area with aquatic macrophytes at the upstream end. Additionally, extensive riffles and runs with mostly cobble and gravel substrate were present. Riparian vegetation was mostly absent along the left bank (facing downstream), and primarily brush, grasses, and small deciduous trees along the right bank.

Site 2 was the most heavily used ORV site. Extensive tire tracks and ruts were evident on the flood plain and in the channel at shallow water crossing points. There was little or no vegetation between waters edge and bank full elevation along the left side of the channel. The right bank had a heavily used dirt track, separated from the river's edge by a few deciduous trees and sparse brush. Instream habitat included extensive runs with cobble, gravel, bedrock, and boulder substrate; various riffle zones with mostly gravel and cobble substrate; and a large deep pool with some aquatic macrophyte growth. Instream cover included boulders, root wads, and some logs. A small backwater/side channel area provided additional (well-covered) habitat with some aquatic macrophytes, mostly bedrock, sand, and silt substrate, and large boulders. Riparian vegetation included large deciduous trees, brush, and some grasses.

Site 3 exhibited extensive tire tracks and ruts along the banks and crossing the channel in shallow areas. A large bluff along the right bank forces ORV traffic to the left bank. Instream habitat included a very large deep pool with mostly cobble and gravel substrate; long runs with cobble, gravel, and boulder substrate; and various riffle zones with cobble, gravel, and boulder substrate. Riparian vegetation along the right bank is comprised of deciduous trees, brush, and grasses. The left bank has patchy vegetation but is mostly open area with cobble and gravel substrate.

Instream habitat types at site 4 (control site – no ORV use) included run, glide, riffle, and pool. Substrate consisted of sand, silt, and small gravel in pool habitats and gravel, cobble, and sand elsewhere. Aquatic macrophytes were prolific in some pool habitat and instream cover such as logs, root wads, and overhanging vegetation were common. Riparian vegetation grew to the rivers edge and was a moderately dense community of bunch grasses, forbs, brush, and deciduous trees such as sycamore, oak, and elm.

Fish Collection

Twenty-eight fish species were collected from the Nueces River during this study (Table 1; Appendix A). April sampling yielded 2416 specimens representing 24 species, while 3125 specimens representing 23 species were collected during September. Cumulative data indicate site 4 had the highest species richness (24) as well as the greatest total number of specimens (n=2085), followed by Site 1 and site 2 (each with 19) and site 3 with 18. Site 4 habitats were the most diverse of any site and likely the reason for species richness being greatest there. The dominant species at sites 1, 2 and 3 remained the same between sampling periods. At site 4, central stoneroller *Campostoma anomalum* was dominant in April but was superceded by longear sunfish *Lepomis megalotis* in September. Longear sunfish was dominant at Sites 1 and 3, while Texas shiner *Notropis amabilis* dominated site 2.

Four species were only collected at site 4. These included longnose gar *Lepisosteus osseus,* weed shiner *Notropis texanus,* tadpole madtom *Noturus gyrinus,* and redear sunfish *Lepomis microlophus*. Sand shiner *Notropis stramineus* and Nueces roundnose minnow *Dionda serena* were only collected at site 1. Thirteen species were collected at all study sites. The most numerous species were longear sunfish, Texas shiner, blacktail shiner *Cyprinella venusta*, central stoneroller, and western mosquitofish *Gambusia affinis*.

Nine species were collected in limited numbers (n=5 or less), namely spotted gar *Lepisosteus oculatus*, longnose gar, weed shiner, sand shiner, tadpole madtom, flathead catfish *Pylodictis olivaris*, warmouth *Lepomis gulosus*, redear sunfish, and spotted sunfish *Lepomis punctatus*.

During both sampling periods Texas shiner was the most abundant cyprinid, followed by central stoneroller during April sampling and by blacktail shiner during September sampling.

Gray redhorse *Moxostoma congestum* was the only sucker species collected and was present at all sites except Site 1.

Of four catfish species collected only channel catfish *Ictalurus punctatus* was collected at all sites.
Nine centrarchid species were collected with longear sunfish being most numerous followed by green sunfish *Lepomis cyanellus*. Two species of bass (largemouth bass *Micropterus salmoides* and Guadalupe bass *Micropterus treculi*) were collected.

Four intolerant or sensitive species (Linam and Kleinsasser 1998) were collected. These species included Nueces roundnose minnow, tadpole madtom, Guadalupe bass, and greenthroat darter *Etheostoma lepidum*. None of these species represented a large proportion of the fish community. Greenthroat darters accounted for only 3% of the combined sample.

TABLE 1.—Fish species collected from the Nueces River, Uvalde and Zavala counties, Texas during April and September, 2002.

Species	Common Name	Site 1 Apr	Site 1 Sep	Site 2 Apr	Site 2 Sep	Site 3 Apr	Site 3 Sep	Site 4 Apr	Site 4 Sep
Lepisosteus oculatus	Spotted gar					1		4	
Lepisosteus osseus	Longnose gar							1	
Campostoma anomalum	Central stoneroller	158	173	11	3	11	5	186	10
Cyprinella lutrensis	Red shiner	13	1	2	2	2	1		9
Cyprinella venusta	Blacktail shiner	38	4	56	81	75	48	36	286
Dionda serena	Nueces roundnose minnow	45	7						
Notropis amabilis	Texas shiner	98	5	288	302	133	2		787
Notropis stramineus	Sand shiner	1							
Notropis texanus	Weed shiner								1
Moxostoma congestum	Gray redhorse			3	1	4	2	1	
Astyanax mexicanus	Mexican tetra	34	2		15	1	4		130
Ameiurus natalis	Yellow bullhead	6	7				2	1	2
Ictalurus punctatus	Channel catfish	5	2	2	4	10	2	1	7
Noturus gyrinus	Tadpole madtom							1	
Pylodictis olivaris	Flathead catfish		2	1	1				
Gambusia affinis	Western mosquitofish	89	52	2	7	6	20	20	87
Poecilia latipinna	Sailfin molly	11							3
Lepomis auritus	Redbreast sunfish			2	13	1		1	
Lepomis cyanellus	Green sunfish	2	5	3	3	8	17	7	7
Lepomis gulosus	Warmouth		4		1				
Lepomis macrochirus	Bluegill				1		1		24
Lepomis megalotis	Longear sunfish	530	341	82	77	134	85	126	293
Lepomis microlophus	Redear sunfish								1
Lepomis punctatus	Spotted sunfish			1				1	
Micropterus salmoides	Largemouth bass	1	2	3	4		1	2	5
Micropterus treculi	Guadalupe bass	1	9	4	4	1	1	2	5
Etheostoma lepidum	Greenthroat darter	102	44	5	3	4	3	19	1
Cichlasoma cyanoguttatum	Rio Grande cichlid	4	22	4	26	5	29	4	14
Total number of individuals with disease or anomaly		2	1	0	0	2	0	1	0
Total number of species		17	17	16	18	15	16	17	18
Total number of individuals		1138	682	469	548	396	223	413	1672

Data Analysis

Variation in species composition between sample periods was noted. At site 1, central stoneroller accounted for 13.9% of the total number of specimens collected in April, while in September, they accounted for 25.4%. Texas shiner accounted for 8.6% in April but in September for only 0.7% of the sample (Table 1; Appendix A).

Variation in species composition between sample periods was minimal at site 2.

At site 3, substantial variation between sample periods was observed for some species. Texas shiner accounted for 33.6% of the total number of specimens collected in April, while in September they only accounted for 0.9%. Western mosquitofish and green sunfish accounted for 1.5% and 2.0% in April and 9.0% and 7.6% in September. Finally, in April, Rio Grande cichlid *Cichlasoma cyanoguttatum* accounted for 1.3% but increased to 13.0% of the sample in September.

At site 4, central stoneroller accounted for 45.0% of the total number of specimens collected in April but for only 0.6% in September. Blacktail shiner accounted for 8.7% of the sample in April and 17.0% in September. In April, Texas shiner and Mexican tetra *Astyanax mexicanus* were not collected; however, in September these species accounted for 47.1% and 7.8% respectively. Finally, in April, longear sunfish accounted for 30.5% of the specimens collected while in September they accounted for 17.5%.

Based upon IBI, aquatic life use ranged from high to exceptional (Appendix B). The only site that did not attain an exceptional rating during at least one of the sampling events was site 2 (the site with the heaviest ORV use). It rated as high both times. Site 1 scored as exceptional during April and high during September. The decline in aquatic life use rating was mostly attributed to a lower catch rate in September. Sites 3 and 4 rated as high in April and exceptional in September. The increase in piscivores from 2.5% to 8.5% of the population was the greatest contributor to the higher aquatic life use at site 3 in September. The increase in aquatic life use at site 4 was mostly due to the number of native cyprinid species captured increasing from two in April to five in September.

Index of similarity scores (S) for combined April and September samples portray a longitudinal pattern of similarity with site 1 most similar to site 2 (S=0.789) and least similar to site 4 (S=0.698) (Table 2).

April samples at sites 1, 2, and 3 were similar to September samples (S=0.882, 0.882, 0.839 respectively); however, the April sample for site 4 was substantially different from the September sample for that site (S=0.629) (Table 2).

Discussion

Off-road vehicle impacts to the Nueces River fish assemblage were not readily apparent based upon our analysis of data collected in this study. G. Garrett (*op.cit.*) concluded there were impacts based upon comparisons of seine collections at sites 1 and 2, with the former site representing low ORV use and the latter, higher ORV use. Both sites actually receive some ORV use, though as stated before, site 2 is the most heavily utilized. Our effort, which was comprised of two sampling events using multiple sampling gear at four stations receiving a broad range of ORV use, detected some of the same faunal patterns observed by Garrett. For instance, he observed more species (13) and individuals (156) at site 1 than site 2 (9 species; 81 individuals). Similarly, our seine samples at site 1 contained more species (17 versus 12) and individuals (1302 versus 791) than site 2 (Table 1). However, when electrofishing and seine data are combined, both sites each yielded 19 species, though catch per unit effort was still less at site 2.

Garrett (*op. cit.*) collected no western mosquitofish from site 2 although 33 individuals were collected from site 1. He postulated ORV disturbance of edge habitat and its associated vegetation as the cause for their absence. We collected western mosquitofish using seines at site 2 (n=8), but numbers were substantially less than at site 1 (n=128). Site 4 also yielded a large number of this species. As did Garrett (*op. cit.*), we only collected the environmentally sensitive *Dionda* at site 1. We attribute this to the spring flow influence of Soldiers Camp Springs just upstream of site 1 rather than ORV impacts as none were collected from site 4 either, which received no ORV usage. Contrary to Garrett who reported a substantial proportion of site 2 comprised of tolerant species (based upon his knowledge and experience), we found no substantial difference between stations based on tolerance as defined by Linam *et.al*. (1998).

Both studies observed subtle differences in fish assemblages among sites, but the question is whether those differences are attributable to ORV use or natural variation.

Solely looking at the fish data from each site (with no thoughts of potential outside influences), one might well conclude that the assemblages are responding to a longitudinal gradient associated with the aforementioned Soldiers Camp Springs or demonstrating normal reach to reach variation that may be observed in these types of streams. Our species similarity matrix provides some support for the former. When comparing cumulative data, sites 2 and 3 (which receive the most ORV activity) are most similar, but also share affinity to site 4 (no activity). Site 1 (nearest to the springs) was most closely aligned to site 2, then 3, and then 4, which would seem to support the pattern associated with spring influence.

High species richness and intolerant taxa numbers were observed at each site. No site yielded high percentages of individuals exhibiting disease, tumors, lesions, or other abnormalities. Where deviations from what one would expect from a typical minimally disturbed stream were noted (potential indications of a stressor on the system), no clear pattern was present. For instance, every site (except site 3 during September) yielded an extremely low percentage of piscivores. Low overall catch rates were recorded at site 2 (heavy ORV use) during April, which would lend support to ORV impacts; however, every site sampled in September save for site 4 (no ORV use) also yielded low catch rates. In April though, site 4 yielded a low number of native cyprinids.

Although ORV use has increased in frequency and magnitude over the past decade, the fish assemblage data does not present strong evidence of impacts. It should be noted that the mostly cobble and gravel substrate characteristics of the Nueces River within the study area lend to quick recovery from compaction given bank full flood events which redistribute substrate; however, these substrate characteristics are not general to Texas streams and rivers. Streams with banks and substrates

TABLE 2.—Nueces River fish assemblage comparison using the index of similarity[a].

Site - Month	1 - Apr	1 - Sep	2 - Apr	2 - Sep	3 - Apr	3 - Sep	4 - Apr	4 - Sep
1 - Apr	1.000							
1 - Sep	0.882	1.000						
2 - Apr	0.727	0.788	1.000					
2 - Sep	0.800	0.857	0.882	1.000				
3 - Apr	0.750	0.750	0.839	0.848	1.000			
3 - Sep	0.848	0.848	0.813	0.882	0.839	1.000		
4 - Apr	0.647	0.647	0.788	0.686	0.750	0.727	1.000	
4 - Sep	0.857	0.800	0.706	0.778	0.727	0.882	0.629	1.000

Cumulative Data

	Site 1	Site 2	Site 3	Site 4
Site 1	1.000			
Site 2	0.789	1.000		
Site 3	0.757	0.865	1.000	
Site 4	0.698	0.791	0.857	1.000

[a]Scores range from 0.0 (completely different) to 1.0 (identical).

comprised primarily of sand and silt are more susceptible to bank erosion, compaction, and sedimentation. Because of this, impacts resulting from ORV use in other streams across the state should be investigated on a per stream basis. In addition this study only reflects the present conditions in the Nueces River. It is uncertain what impacts ORVs may have on the fish assemblage over the long-term, should this activity continue to increase and even become a sustained disturbance.

Acknowledgments

Special appreciation is extended to the landowners that graciously allowed us access to the Nueces River through their properties; accessing study sites would have been difficult if not impossible without their permission. We wish to acknowledge Karim Aziz (TPWD) for production of the study site map (Figure 1). We also extend appreciation to Leroy Kleinsasser and Gary Garrett (TPWD), Bob Edwards (University of Texas Pan American), Sidne Tieman and Bill Harrison (TCEQ), and Dr. Tim Bonner of Texas State University for their review and comments on the manuscript. We wish to thank Sky Lewey of the Nueces River Authority for her assistance with site selection, arranging access, field collections, and for providing river information.

References

Carmody, K. 2002. Off-roaders seek fun, leave damage. Austin American Statesman, 25-Aug-2002. Austin, Texas. URL: http://www.austin-statesman.com

Havlick, D.G. 2002. No place distant: roads and motorized recreation on America's public lands. Island Press, Washington D.C. 297 pp.

Hubbs, C., R.J. Edwards, and G.P. Garrett. 1991. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species. The Texas Journal of Science. Vol. 43, No. 4.

Linam, G.W. and L.J. Kleinsasser. 1998. Classification of Texas freshwater fishes into trophic and tolerance groups. River Studies Report No. 14. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. Regionalization of the index of biotic integrity for Texas streams. River Studies Report No. 17. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Odum, E.P. 1971. Fundamentals of ecology. W.B. Saunders Company, Philadelphia, Pennsylvania. Page, L.M. 1983. Handbook of darters. TFH Publications, Inc.

Texas Chapter American Fisheries Society. 2002. Off-road vehicles and their impact on stream environments - a policy statement from the Texas Chapter of the American Fisheries Society. URL: http://www.sdafs.org/tcafs/content/orvpol.htm

Webb, R. H. and H. G. Wilshire (eds.). 1983. Environmental effects of off-road vehicles: impacts and management in arid regions. Springer-Verlag, New York.

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Appendix A
Fish Collection Data

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Fish species collected from the Nueces River at Site 1, Uvalde Co., Texas (16 April 2002).

Species	Common Name	Electrofish (18.06 min)	Seine (13 hauls)
Campostoma anomalum	Central stoneroller	49	109
Cyprinella lutrensis	Red shiner		13
Cyprinella venusta	Blacktail shiner		38
Dionda serena	Nueces roundnose minnow	25	20
Notropis amabilis	Texas shiner		98
Notropis stramineus	Sand shiner		1
Astyanax mexicanus	Mexican tetra		34
Ameiurus natalis	Yellow bullhead	6	
Ictalurus punctatus	Channel catfish	4	1
Gambusia affinis	Western mosquitofish	5	84
Poecilia latipinna	Sailfin molly		11
Lepomis cyanellus	Green sunfish		2
Lepomis megalotis	Longear sunfish	78	452
Micropterus salmoides	Largemouth bass	1	
Micropterus treculi	Guadalupe bass	1	
Etheostoma lepidum	Greenthroat darter	48	54
Cichlasoma cyanoguttatum	Rio Grande cichlid	2	2

Fish species collected from the Nueces River at Site 2, Zavala Co., Texas (18 April 2002).

Species	Common Name	Electrofish (23.15 min)	Seine (11 hauls)
Campostoma anomalum	Central stoneroller	8	3
Cyprinella lutrensis	Red shiner		2
Cyprinella venusta	Blacktail shiner	3	53
Notropis amabilis	Texas shiner		288
Moxostoma congestum	Gray redhorse	3	
Ictalurus punctatus	Channel catfish	1	1
Pylodictis olivaris	Flathead catfish		1
Gambusia affinis	Western mosquitofish		2
Lepomis auritus	Redbreast sunfish	2	
Lepomis cyanellus	Green sunfish	3	
Lepomis megalotis	Longear sunfish	66	16
Lepomis punctatus	Spotted sunfish	1	
Micropterus salmoides	Largemouth bass	2	1
Micropterus treculi	Guadalupe bass	1	3
Etheostoma lepidum	Greenthroat darter	4	1
Cichlasoma cyanoguttatum	Rio Grande cichlid	4	

Fish species collected from the Nueces River at Site 3, Zavala Co., Texas (17 April 2002).

Species	Common Name	Electrofish (22.43 min)	Seine (14 hauls)
Lepisosteus oculatus	Spotted gar	1	
Campostoma anomalum	Central stoneroller	8	3
Cyprinella lutrensis	Red shiner	2	
Cyprinella venusta	Blacktail shiner	1	74
Notropis amabilis	Texas shiner		133
Moxostoma congestum	Gray redhorse	4	
Astyanax mexicanus	Mexican tetra		1
Ictalurus punctatus	Channel catfish	10	
Gambusia affinis	Western mosquitofish	4	2
Lepomis auritus	Redbreast sunfish	1	
Lepomis cyanellus	Green sunfish	8	
Lepomis megalotis	Longear sunfish	89	45
Micropterus treculi	Guadalupe bass		1
Etheostoma lepidum	Greenthroat darter	4	
Cichlasoma cyanoguttatum	Rio Grande cichlid	4	1

Fish species collected from the Nueces River at Site 4, Zavala Co., Texas (17 April 2002).

Species	Common Name	Electrofish (15.23 min)	Seine (13 hauls)
Lepisosteus oculatus	Spotted gar	4	
Lepisosteus osseus	Longnose gar		1
Campostoma anomalum	Central stoneroller		186
Cyprinella venusta	Blacktail shiner		36
Moxostoma congestum	Gray redhorse		1
Ameiurus natalis	Yellow bullhead	1	
Ictalurus punctatus	Channel catfish		1
Noturus gyrinus	Tadpole madtom		1
Gambusia affinis	Western mosquitofish	10	10
Lepomis auritus	Redbreast sunfish		1
Lepomis cyanellus	Green sunfish	7	
Lepomis megalotis	Longear sunfish	86	40
Lepomis punctatus	Spotted sunfish	1	
Micropterus salmoides	Largemouth bass	1	1
Micropterus treculi	Guadalupe bass	1	1
Etheostoma lepidum	Greenthroat darter		19
Cichlasoma cyanoguttatum	Rio Grande cichlid	3	1

Fish species collected from the Nueces River at Site 1, Uvalde Co., Texas (17 September 2002).

Species	Common Name	Electrofish (16.92 min)	Seine (11 hauls)
Campostoma anomalum	Central stoneroller	72	101
Cyprinella lutrensis	Red shiner	1	
Cyprinella venusta	Blacktail shiner		4
Dionda serena	Nueces roundnose minnow		7
Notropis amabilis	Texas shiner	4	1
Astyanax mexicanus	Mexican tetra	2	
Ameiurus natalis	Yellow bullhead	7	
Ictalurus punctatus	Channel catfish	2	
Pylodictis olivaris	Flathead catfish	2	
Gambusia affinis	Western mosquitofish	8	44
Lepomis cyanellus	Green sunfish	5	
Lepomis gulosus	Warmouth	4	
Lepomis megalotis	Longear sunfish	133	208
Micropterus salmoides	Largemouth bass		2
Micropterus treculi	Guadalupe bass		9
Etheostoma lepidum	Greenthroat darter	43	1
Cichlasoma cyanoguttatum	Rio Grande cichlid	16	6

Fish species collected from the Nueces River at Site 2, Zavala Co., Texas (18 September 2002).

Species	Common Name	Electrofish (16.95 min)	Seine (11 hauls)
Campostoma anomalum	Central stoneroller	2	1
Cyprinella lutrensis	Red shiner		2
Cyprinella venusta	Blacktail shiner	8	73
Notropis amabilis	Texas shiner		302
Moxostoma congestum	Gray redhorse	1	
Astyanax mexicanus	Mexican tetra	5	10
Ictalurus punctatus	Channel catfish	4	
Pylodictis olivaris	Flathead catfish	1	
Gambusia affinis	Western mosquitofish	1	6
Lepomis auritus	Redbreast sunfish	13	
Lepomis cyanellus	Green sunfish	3	
Lepomis gulosus	Warmouth	1	
Lepomis macrochirus	Bluegill	1	
Lepomis megalotis	Longear sunfish	54	23
Micropterus salmoides	Largemouth bass	2	2
Micropterus treculi	Guadalupe bass	3	1
Etheostoma lepidum	Greenthroat darter	3	
Cichlasoma cyanoguttatum	Rio Grande cichlid	26	

Fish species collected from the Nueces River at Site 3, Zavala Co., Texas (17 September 2002).

Species	Common Name	Electrofish (19.00 min)	Seine (13 hauls)
Campostoma anomalum	Central stoneroller	4	1
Cyprinella lutrensis	Red shiner	1	
Cyprinella venusta	Blacktail shiner	7	41
Notropis amabilis	Texas shiner	1	1
Moxostoma congestum	Gray redhorse		2
Astyanax mexicanus	Mexican tetra	1	3
Ameiurus natalis	Yellow bullhead	2	
Ictalurus punctatus	Channel catfish	2	
Gambusia affinis	Western mosquitofish	7	13
Lepomis cyanellus	Green sunfish	17	
Lepomis macrochirus	Bluegill	1	
Lepomis megalotis	Longear sunfish	77	8
Micropterus salmoides	Largemouth bass		1
Micropterus treculi	Guadalupe bass	1	
Etheostoma lepidum	Greenthroat darter	3	
Cichlasoma cyanoguttatum	Rio Grande cichlid	27	2

Fish species collected from the Nueces River at Site 4, Zavala Co., Texas (18 September 2002).

Species	Common Name	Electrofish (17.02 min)	Seine (11 hauls)
Campostoma anomalum	Central stoneroller		10
Cyprinella lutrensis	Red shiner		9
Cyprinella venusta	Blacktail shiner	1	285
Notropis amabilis	Texas shiner	21	766
Notropis texanus	Weed shiner	1	
Astyanax mexicanus	Mexican tetra	1	129
Ameiurus natalis	Yellow bullhead	2	
Ictalurus punctatus	Channel catfish	7	
Gambusia affinis	Western mosquitofish	25	62
Poecilia latipinna	Sailfin molly	1	2
Lepomis cyanellus	Green sunfish	7	
Lepomis macrochirus	Bluegill	10	14
Lepomis megalotis	Longear sunfish	208	85
Lepomis microlophus	Redear sunfish	1	
Micropterus salmoides	Largemouth bass	2	3
Micropterus treculi	Guadalupe bass	1	4
Etheostoma lepidum	Greenthroat darter	1	
Cichlasoma cyanoguttatum	Rio Grande cichlid	11	3

Appendix B
Index of Biotic Integrity Results

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Nueces River @ Site 1, Uvalde Co.					
Linam, Jurgensen, Saunders, Mullins, Whisenant			**April-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	17	5
Species Richness and Composition	Number of Fish Species	17	Number of Native Cyprinid Species	6	5
	Number of Native Cyprinid Species	6	Number of Benthic Invertivore Species	1	3
	Number of Benthic Invertivore Species	1	Number of Sunfish Species	2	3
	Number of Sunfish Species	2	Number of Intolerant Species	3	5
	Number of Intolerant Species	3	% of Individuals as Tolerant Species	2.7	5
	Number of Individuals as Tolerants	31	% of Individuals as Omnivores	5.9	5
Trophic Composition	Number of Individuals as Omnivores	67	% of Individuals as Invertivores	79.9	5
	Number of Individuals as Invertivores	909	% of Individuals as Piscivores	0.4	1
	Number of Individuals as Piscivores	4	Number of Individuals in Sample		5
Fish Abundance and Condition	Number of Individuals (Seine)	919	% of Individuals as Non-native species	0.0	5
	Number of Individuals (Shock)	219	% of Individuals With Disease/Anomaly	0.2	5
	Number of Individuals in Sample	1138	Number of Individuals/seine haul	70.7	(5)
	# of Individuals as Non-native species	0	Number of Individuals/min electrofishing	12.13	(5)
	# of Individuals With Disease/Anomaly	2	Index of Biotic Integrity Numeric Score:		**52**
			Aquatic Life Use:		**Exceptional**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 2, Zavala Co.					
Linam, Jurgensen, Saunders, Whisenant			**April-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	4820	Total Number of Fish Species	16	5
Species Richness and Composition	Number of Fish Species	16	Number of Native Cyprinid Species	4	3
	Number of Native Cyprinid Species	4	Number of Benthic Invertivore Species	2	5
	Number of Benthic Invertivore Species	2	Number of Sunfish Species	4	5
	Number of Sunfish Species	4	Number of Intolerant Species	2	5
	Number of Intolerant Species	2	% of Individuals as Tolerant Species	1.5	5
	Number of Individuals as Tolerants	7	% of Individuals as Omnivores	0.4	5
Trophic Composition	Number of Individuals as Omnivores	2	% of Individuals as Invertivores	94.9	5
	Number of Individuals as Invertivores	445	% of Individuals as Piscivores	2.3	1
	Number of Individuals as Piscivores	11	Number of Individuals in Sample		2
Fish Abundance and Condition	Number of Individuals (Seine)	371	% of Individuals as Non-native species	0.4	5
	Number of Individuals (Shock)	98	% of Individuals With Disease/Anomaly	0.0	5
	Number of Individuals in Sample	469	Number of Individuals/seine haul	33.7	(1)
	# of Individuals as Non-native species	2	Number of Individuals/min electrofishing	4.23	(3)
	# of Individuals With Disease/Anomaly	0	Index of Biotic Integrity Numeric Score:		**51**
			Aquatic Life Use:		**High**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 3, Zavala Co.					
Linam, Saunders, Jurgensen, Mullins, Whisenant			**April-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	15	5
Species Richness and Composition	Number of Fish Species	15	Number of Native Cyprinid Species	4	3
	Number of Native Cyprinid Species	4	Number of Benthic Invertivore Species	2	5
	Number of Benthic Invertivore Species	2	Number of Sunfish Species	3	3
	Number of Sunfish Species	3	Number of Intolerant Species	2	5
	Number of Intolerant Species	2	% of Individuals as Tolerant Species	5.3	5
	Number of Individuals as Tolerants	21	% of Individuals as Omnivores	2.5	5
Trophic Composition	Number of Individuals as Omnivores	10	% of Individuals as Invertivores	92.2	5
	Number of Individuals as Invertivores	365	% of Individuals as Piscivores	2.5	1
	Number of Individuals as Piscivores	10	Number of Individuals in Sample		3
Fish Abundance and Condition	Number of Individuals (Seine)	260	% of Individuals as Non-native species	0.3	5
	Number of Individuals (Shock)	136	% of Individuals With Disease/Anomaly	0.5	5
	Number of Individuals in Sample	396	Number of Individuals/seine haul	18.6	(1)
	# of Individuals as Non-native species	1	Number of Individuals/min electrofishing	6.06	(5)
	# of Individuals With Disease/Anomaly	2	Index of Biotic Integrity Numeric Score:		**50**
			Aquatic Life Use:		**High**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 4, Zavala Co.					
Linam, Saunders, Jurgensen, Mullins, Whisenant			**April-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	17	5
Species Richness and Composition	Number of Fish Species	17	Number of Native Cyprinid Species	2	1
	Number of Native Cyprinid Species	2	Number of Benthic Invertivore Species	3	5
	Number of Benthic Invertivore Species	3	Number of Sunfish Species	4	5
	Number of Sunfish Species	4	Number of Intolerant Species	3	5
	Number of Intolerant Species	3	% of Individuals as Tolerant Species	3.1	5
	Number of Individuals as Tolerants	13	% of Individuals as Omnivores	0.5	5
Trophic Composition	Number of Individuals as Omnivores	2	% of Individuals as Invertivores	50.6	3
	Number of Individuals as Invertivores	209	% of Individuals as Piscivores	3.9	3
	Number of Individuals as Piscivores	16	Number of Individuals in Sample		3
Fish Abundance and Condition	Number of Individuals (Seine)	299	% of Individuals as Non-native species	0.2	5
	Number of Individuals (Shock)	114	% of Individuals With Disease/Anomaly	0.2	5
	Number of Individuals in Sample	413	Number of Individuals/seine haul	23.0	(1)
	# of Individuals as Non-native species	1	Number of Individuals/min electrofishing	7.49	(5)
	# of Individuals With Disease/Anomaly	1	Index of Biotic Integrity Numeric Score:		**50**
			Aquatic Life Use:		**High**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 1, Uvalde Co.					
Saunders, Brezina, Mullins, Whisenant			**September-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	17	5
Species Richness and Composition	Number of Fish Species	17	Number of Native Cyprinid Species	5	5
	Number of Native Cyprinid Species	5	Number of Benthic Invertivore Species	1	3
	Number of Benthic Invertivore Species	1	Number of Sunfish Species	3	3
	Number of Sunfish Species	3	Number of Intolerant Species	3	5
	Number of Intolerant Species	3	% of Individuals as Tolerant Species	1.8	5
	Number of Individuals as Tolerants	12	% of Individuals as Omnivores	2.3	5
Trophic Composition	Number of Individuals as Omnivores	16	% of Individuals as Invertivores	69.1	5
	Number of Individuals as Invertivores	471	% of Individuals as Piscivores	3.2	1
	Number of Individuals as Piscivores	22	Number of Individuals in Sample		1
Fish Abundance and Condition	Number of Individuals (Seine)	383	% of Individuals as Non-native species	0.0	5
	Number of Individuals (Shock)	299	% of Individuals With Disease/Anomaly	0.1	5
	Number of Individuals in Sample	682	Number of Individuals/seine haul	34.8	(1)
	# of Individuals as Non-native species	0	Number of Individuals/min electrofishing	0.29	(1)
	# of Individuals With Disease/Anomaly	1	Index of Biotic Integrity Numeric Score:		**48**
			Aquatic Life Use:		**High**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 2, Zavala Co.					
Saunders, Brezina, Mullins, Whisenant			**September-02**	**Ecoregion 30**	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	4820	Total Number of Fish Species	18	5
Species Richness and Composition	Number of Fish Species	18	Number of Native Cyprinid Species	4	3
	Number of Native Cyprinid Species	4	Number of Benthic Invertivore Species	2	5
	Number of Benthic Invertivore Species	2	Number of Sunfish Species	5	5
	Number of Sunfish Species	5	Number of Intolerant Species	2	5
	Number of Intolerant Species	2	% of Individuals as Tolerant Species	2.0	5
	Number of Individuals as Tolerants	11	% of Individuals as Omnivores	0.7	5
Trophic Composition	Number of Individuals as Omnivores	4	% of Individuals as Invertivores	96.4	5
	Number of Individuals as Invertivores	528	% of Individuals as Piscivores	2.4	1
	Number of Individuals as Piscivores	13	Number of Individuals in Sample		2
Fish Abundance and Condition	Number of Individuals (Seine)	420	% of Individuals as Non-native species	2.4	3
	Number of Individuals (Shock)	128	% of Individuals With Disease/Anomaly	0.0	5
	Number of Individuals in Sample	548	Number of Individuals/seine haul	38.2	(3)
	# of Individuals as Non-native species	13	Number of Individuals/min electrofishing	0.13	(1)
	# of Individuals With Disease/Anomaly	0	Index of Biotic Integrity Numeric Score:		**49**
			Aquatic Life Use:		**High**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 3, Zavala Co.					
Saunders, Brezina, Mullins, Whisenant			September-02	Ecoregion 30	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	16	5
Species Richness and Composition	Number of Fish Species	16	Number of Native Cyprinid Species	4	3
	Number of Native Cyprinid Species	4	Number of Benthic Invertivore Species	2	5
	Number of Benthic Invertivore Species	2	Number of Sunfish Species	3	3
	Number of Sunfish Species	3	Number of Intolerant Species	2	5
	Number of Intolerant Species	2	% of Individuals as Tolerant Species	9.4	5
	Number of Individuals as Tolerants	21	% of Individuals as Omnivores	1.8	5
Trophic Composition	Number of Individuals as Omnivores	4	% of Individuals as Invertivores	87.4	5
	Number of Individuals as Invertivores	195	% of Individuals as Piscivores	8.5	5
	Number of Individuals as Piscivores	19	Number of Individuals in Sample		1
Fish Abundance and Condition	Number of Individuals (Seine)	72	% of Individuals as Non-native species	0.0	5
	Number of Individuals (Shock)	151	% of Individuals With Disease/Anomaly	0.0	5
	Number of Individuals in Sample	223	Number of Individuals/seine haul	5.5	(1)
	# of Individuals as Non-native species	0	Number of Individuals/min electrofishing	0.13	(1)
	# of Individuals With Disease/Anomaly	0	Index of Biotic Integrity Numeric Score:		**52**
			Aquatic Life Use:		**Exceptional**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					

Nueces River @ Site 4, Zavala Co.					
Saunders, Brezina, Mullins, Whisenant			September-02	Ecoregion 30	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
	Drainage Basin Size	~4820	Total Number of Fish Species	18	5
Species Richness and Composition	Number of Fish Species	18	Number of Native Cyprinid Species	5	5
	Number of Native Cyprinid Species	5	Number of Benthic Invertivore Species	1	3
	Number of Benthic Invertivore Species	1	Number of Sunfish Species	4	5
	Number of Sunfish Species	4	Number of Intolerant Species	2	5
	Number of Intolerant Species	2	% of Individuals as Tolerant Species	3.0	5
	Number of Individuals as Tolerants	50	% of Individuals as Omnivores	0.7	5
Trophic Composition	Number of Individuals as Omnivores	12	% of Individuals as Invertivores	97.7	5
	Number of Individuals as Invertivores	1633	% of Individuals as Piscivores	1.0	1
	Number of Individuals as Piscivores	17	Number of Individuals in Sample		3
Fish Abundance and Condition	Number of Individuals (Seine)	1372	% of Individuals as Non-native species	0.0	5
	Number of Individuals (Shock)	300	% of Individuals With Disease/Anomaly	0.0	5
	Number of Individuals in Sample	1672	Number of Individuals/seine haul	124.7	(5)
	# of Individuals as Non-native species	0	Number of Individuals/min electrofishing	0.29	(1)
	# of Individuals With Disease/Anomaly	0	Index of Biotic Integrity Numeric Score:		**52**
			Aquatic Life Use:		**Exceptional**
This data should be incorporated with water quality, habitat, and other available biological data to assign an overall score.					