# Small-bodied Fishes of Tar Creek and Other Small Streams in Ottawa County, Oklahoma

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**Fishes of small streams in Ottawa County, Oklahoma, were collected by seine from July 2004 through October 2005 to provide base-line data on species occurrences in Tar Creek and surrounding watersheds. Nine sites within the study area have been receiving mine drainage contaminated with iron, zinc, lead and cadmium for at least three decades following the cessation of mining in the Tri-State Mining District of Oklahoma, Kansas, and Missouri in the 1960s. No such known contamination exists for the remaining sampling sites which serve as "controls" for any future changes in fishes at the polluted sites. Fifty-three collections were made at 10 sites throughout Tar Creek watershed, and 26 collections were made on surrounding watersheds at sites on Coal, Cow, Little Elm, Hudson, Mud, and Four-mile creeks in Ottawa County. A total of 34 species and hybrid sunfish representing ten families were collected. Faunal composition of impacted streams was compared with non-impacted streams. Species richness, corrected for habitat size, was significantly lower in impacted sites than in non-impacted sites. As planned treatment systems for the mine drainage are implemented, the information in this report will allow evaluation of any changes in fish communities.** 

## INTRODUCTION

The Tar Creek watershed, located in northeastern Oklahoma, is primarily fed by run-off, groundwater feeding from the Boone Aquifer, and discharge from mine seeps. The watershed drains approximately 138 $km^2$ and flows directly into the Neosho River (Fig.1). It is located within a portion of the Tri-State Mining District, a region mined for lead and zinc beginning in the early 1900s (EPA 2005). Cessation of mining activities in the 1960s was followed by an increase in metal contamination in the drainage directly resulting from artesian mine discharge through numerous bore holes. Leachate derived from the run-off of tailings piles located throughout the region also has been linked to stream contamination (OWRB 1983). Surrounding watersheds are not known to receive mine drainage discharge. The scale and level of contamination within the Tar Creek watershed resulted in its designation as a federally funded Superfund Site in 1983 (EPA 2004).

Current large scale remediation projects include plans to minimize leachate from tailings piles and to eliminate or ameliorate mine drainage discharge into the streams. The removal of metals from mine discharge

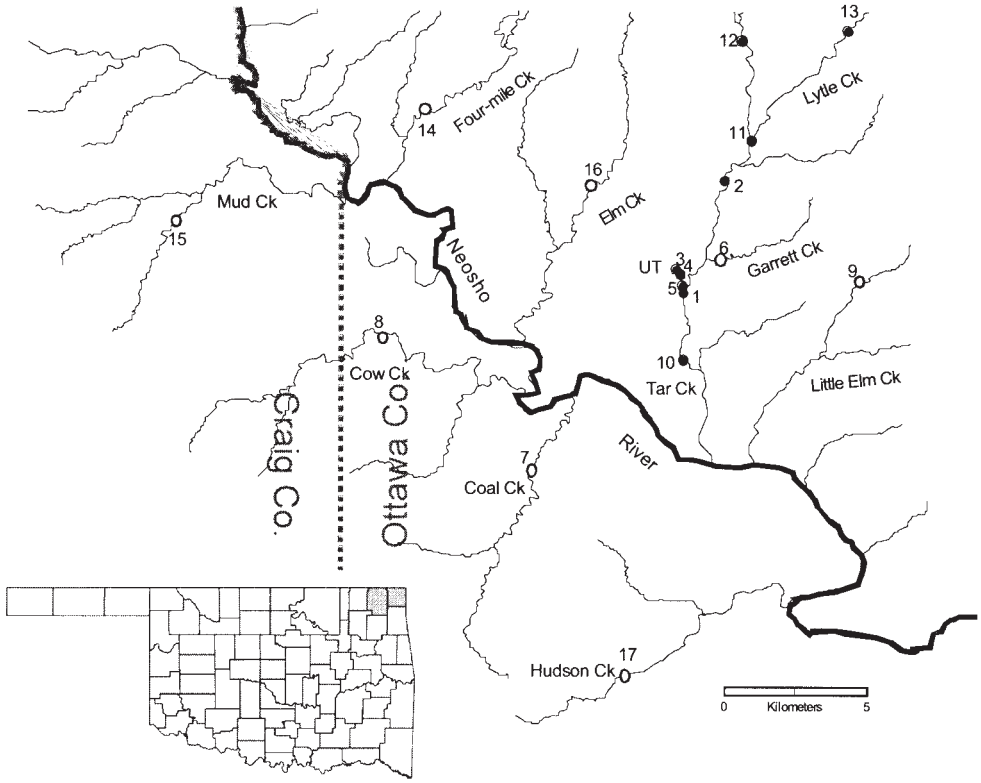


**Figure 1. Map of sampling site locations. Filled circles indicate impacted sites. Open circles indicate non-impacted sites.**

has been recommended (Governor Frank Keating's Tar Creek Superfund Task Force 2000, Nairn et al 2005). A pilot study to determine the feasibility of retaining metals through natural biogeochemical pathways in passive treatment systems is currently underway (Nairn et al 2005, R. Nairn personal communication 2005). Construction of these passive treatment systems for mine drainage discharges that flow to an unnamed tributary (UT) of Tar Creek, located at the southeastern edge of Commerce, Oklahoma, is expected to begin in 2007.

This paper reports the initial results of fish surveys conducted prior to the establishment of treatment systems on the UT. It also serves to establish a baseline of existing fish communities within Tar Creek and its tributaries and to provide a basis for monitoring changes in the fish communities over time. In addition, these surveys help to document fish communities for other small streams in Ottawa County, for which published information is scant (Branson 1967, McNeely 1987). Data from the current study will be used to help assess any future changes in fishes of the Tar Creek watershed in relation to the construction of a passive-treatment system on the UT.

## METHODS

Collections were made using a variety of small-meshed (mesh size = 0.48 cm) seines, ranging 2.4 m to 4.6 m long x 1.2 m deep, in all available habitats at nine permanent sites and eight additional sites to document common, small-bodied fishes. Most fish were identified, counted, and released in the field, with voucher specimens being preserved in 10% formalin. Permanent sites were chosen for continued monitoring of changes in fish population size and structure. Other sites were included to document the ichthyofau-

**Table 1. Location and collection dates of stream sites sampled between July 2004 and October 2005. "Permanent" stations will be monitored monthly through 2007, while "Other" stations are characterized as opportunistic samples or those taken in conjunction with previous studies (those samples collected in July and September 2004). Sites receiving mine drainage discharge (impacted sites) are indicated by an asterisk (*). Coordinates are measured in decimal degrees.**

| Station | Location | Latitude (°N) | Longitude (°W) | Dates Collected |
|---|---|---|---|---|
| **A. Permanent Sites** | | | | |
| *Tar Creek* | | | | |
| **1*** | downstream low-water crossing, E of Hwy 69, Commerce, OK | 36.9117 | 94.8675 | Nov 2004; Apr, May, Jul, Aug, Sep, Oct 2005 |
| **2*** | at Hwy 69 Bridge, Commerce, OK | 36.9436 | 94.8536 | Jul, Sep, Nov 2004; Apr, May, Jul, Aug, Sep, Oct 2005 |
| *Tributaries of Tar Creek* | | | | |
| **3*** | UT, above mine water inflow, Commerce, OK | 36.9213 | 94.8691 | Nov 2004; Apr, May, Jun, Jul, Aug, Sep, Oct 2005 |
| **4*** | UT, below mine water inflow, Commerce, OK | 36.9200 | 94.8695 | Nov 2004; Apr, May, Jun, Jul, Aug, Sep, Oct 2005 |
| **5*** | UT, 2 km below mine water inflow, Commerce, OK | 36.9156 | 94.8664 | Nov 2004; Apr, May, Jun, Jul, Aug, Sep, Oct 2005 |
| **6** | Garrett Ck 3 km upstream of mouth, Commerce, OK | 36.9192 | 94.8583 | Nov 2004; Apr, May, Jun, Jul, Sep, Oct 2005 |
| *Reference Watersheds* | | | | |
| **7** | Coal Ck, 1.21 km S of U.S. 59 | 36.8503 | 94.9272 | Nov 2004; Apr, May, Jun, Jul, Aug, Sep 2005 |
| **8** | Cow Ck, 2.41 km N of U.S. 59 | 36.8936 | 94.9814 | Nov 2004; Apr, May, Jun, Jul, Aug, Sep, Oct 2005 |
| **9** | Little Elm Ck, 3.22 km E of Commerce, OK | 36.9100 | 94.8061 | Apr, May, Jun, Jul, Aug, Sep, Oct 2005 |
| **B. Other Sites** | | | | |
| *Tar Creek* | | | | |
| **10*** | Tar Ck at Central Blvd., Miami, OK | 36.8856 | 94.8681 | Jul, Sep 2004 |
| **11*** | Tar Ck at Douthat Bridge | 36.9581 | 94.8453 | Apr 2005 |
| **12*** | Tar Ck 1.61 km S of KS-OK border, Picher, OK | 36.9869 | 94.8488 | Jul 2004; Apr 2005 |
| *Tributaries of Tar Creek* | | | | |
| **13*** | Lytle Ck near Zincville | 36.9939 | 94.8092 | Apr 2005 |
| *Reference Watersheds* | | | | |
| **14** | Four-mile Ck, 11.27 km W and 0.80 km S of Cardin, OK | 36.9672 | 94.9661 | May 2005 |
| **15** | trib. of Mud Ck, 4.83 km N of Welch, OK and 2.82 km E of U.S. 59 | 36.9318 | 95.0580 | Nov 2004 |
| **16** | Elm Ck, 3.22 km W of Commerce, OK | 36.9436 | 94.9048 | Nov 2004 |
| **17** | Hudson Ck, 9.66 km S of Miami, OK, N of I-44 | 36.7842 | 94.8910 | Nov 2004 |

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na of the area. Site locations, summarized in Table 1, were chosen to ensure similarity in size and structure among streams. Sites on Tar Creek, Lytle Creek, and an unnamed tributary (UT) of Tar Creek, where remediation activities are planned, receive either direct inflow from contaminated mine water or run-off from tailings piles. Sites within streams where contamination is known to occur were designated as impacted sites. No record of similar contamination was found for the remaining eight streams (non-impacted sites). We examined fish community composition and species richness within the region sampled and within impacted and non-impacted stream systems. We used NTSYSpc version 2.11 to calculate Renkonen's Percent Similarity Index (PSI) to compare relative abundance of taxa common to both impacted and non-impacted streams.

Species richness was statistically analyzed using the residuals of a regression analysis between the number of species and the width of the stream from all collections. Mann-Whitney U-tests were conducted using SPSS 13.0 for Windows to compare the residuals of impacted sites and non-impacted sites.

## RESULTS

A total of 11,896 individuals, representing 34 species and sunfish hybrids, *Lepomis* spp., were collected (Table 2). Ten families were represented, dominated by Poeciliidae (79.1%) and Centrarchidae (9.1%). The remaining 11.8% consisted of the families Lepisosteidae, Clupeidae, Cyprinidae, Catostomidae, Ictaluridae, Fundulidae, Atherinopsidae, and Percidae. *Gambusia affinis*, western mosquitofish, were not collected in Four-mile Creek, but were present at all other sites (Table 1).

Collections from the mainstem of Tar Creek and its impacted tributaries yielded 24 species and two hybrid sunfish. Species collected at the impacted sites were dominated by *G. affinis* (83.7% of all individuals captured from impacted sites); relatively large numbers of *Lepomis cyanellus*, green sunfish (5.0%), also characterized these samples. Neonate and juvenile *G. affinis* were observed at sites located along the UT, suggesting resident populations of reproducing adults in the tributary.

Thirty species and six individual sunfish hybrids, *Lepomis* spp., were collected from non-impacted sites. These collections were characterized by large numbers of *G. affinis* (72.4%), followed by *Lepomis macrochirus*, bluegill (4.4%), *Campostoma anomalum*, central stoneroller (3.6%), *Fundulus notatus*, blackstripe topminnow (3.7%), and *Pimephales notatus*, bluntnose minnow (3.3%). Young-of-year *Lepomis* spp. and *Micropterus* spp. were abundant in non-impacted sites, yet were not observed at impacted sites.

Relative abundance of species common to both impacted and non-impacted streams was high ($PSI = 0.84$). Non-impacted streams had a slightly higher proportion of centrarchids (10.8%) compared to impacted streams (8.0%). *Lepomis cyanellus* and *L. macrochirus* were the dominant centrarchids among both impacted and non-impacted streams, while *Micropterus salmoides*, largemouth bass, were more numerous in non-impacted streams. The proportion of cyprinids in non-impacted streams (10.2%) was higher than in impacted streams (4.7%), and the dominant cyprinid species also differed between streams. *Cyprinella lutrensis*, red shiner, and *C. anomalum* were the dominant cyprinids among impacted streams, while non-impacted streams had greater numbers of *C. anomalum* and *P. notatus*.

Furthermore, there was a positive relationship between species richness and stream width (Fig. 2; $R^2 = 0.261$, $P = 0.000$). A residual analysis showed that non-impacted streams had significantly higher species richness corrected for habitat size than impacted streams (Mann-Whitney U-test, $N = 72$, $Z = -5.791$, $P = 0.0001$). Thus, overall the sites among streams impacted by mining remnants have fewer fish species than non-impacted sites.

**Table 2. Fishes sampled from 17 sites on Tar Creek and surrounding watersheds from 2004-2005. N = the total number of individuals of a species, % of Total = the percent of the total catch consisting of a given species, * not included in analysis. Station # = the location (as defined in Table 1) of species capture. Young-of-year denoted as yoy.**

| Genus | Species | N | % of Total | Station # |
|---|---|---|---|---|
| *Lepisosteus* | *osseus* | 2 | 0.02 | 10 |
| *Dorosoma* | *cepedianum* | 6 | 0.05 | 7,8 |
| *Campostoma* | *anomalum* | 279 | 2.35 | 1,2,8,9,10,14,15,16 |
| *Cyprinella* | *lutrensis* | 273 | 2.29 | 1,2,6,7,8,10,15 |
| *Erimystax* | *x-punctatus* | 2 | 0.02 | 10 |
| *Lythrurus* | *umbratilis* | 52 | 0.44 | 2,6,7,8,9,16 |
| *Notomigonus* | *crysoleucas* | 21 | 0.18 | 1,2,3,6,8,10,11 |
| *Notropis* | *atherinoides* | 2 | 0.02 | 7 |
| *N.* | *rubellus* | 1 | 0.01 | 7 |
| *N.* | spp. | 3 | * | 6,10 |
| *Phenacobius* | *mirabilis* | 24 | 0.20 | 8 |
| *Pimephales* | *notatus* | 169 | 1.42 | 7,8,9,10 |
| *P.* | *vigilax* | 2 | 0.02 | 7,8 |
| *Carpiodes* | *carpio* | 1 | 0.01 | 8 |
| *Moxostoma* | *erythrurum* | 2 | 0.02 | 8,10 |
| *Amieurus* | *melas* | 5 | 0.04 | 6,7,10,11 |
| *A.* | *natalis* | 8 | 0.07 | 7,8,16 |
| *Ictalurus* | *punctatus* | 13 | 0.11 | 2,10 |
| *Fundulus* | *notatus* | 393 | 3.30 | 1,2,5,6,7,8,9,10,11,12,13,14,16 |
| *Gambusia* | *affinis* | 9379 | 78.84 | 1,2,3,4,5,6,7,8,9,10,11,12,13,15,16,17 |
| *Labidesthes* | *sicculus* | 68 | 0.57 | 1,7,8,17 |
| *Lepomis* | *cyanellus* | 467 | 3.93 | 1,2,3,4,5,6,7,8,9,10,11,12 |
| *L.* | *gulosus* | 81 | 0.68 | 1,2,6,7,8,10,13,14,15,17 |
| *L.* | *humilis* | 13 | 0.11 | 7,14,16 |
| *L.* | *macrochirus* | 352 | 2.96 | 1,2,5,6,7,8,9,10,11,12,13,14,17 |
| *L.* | *megalotis* | 35 | 0.29 | 1,2,7,8,10,14,16 |
| *L.* | *microlophus* | 14 | 0.12 | 1,3,5,7,10 |
| *L.* | hybrid | 8 | 0.07 | 1,4,6,7,13 |
| *L.* | yoy | 367 | * | 7,8,9 |
| *Micropterus* | *salmoides* | 104 | 0.88 | 1,2,6,7,8,9,10,12,13,14 |
| *M.* | yoy | 32 | * | 7 |
| *Pomoxis* | *annularis* | 8 | 0.07 | 2,6,8,12,13 |
| *Etheostoma* | *chlorosomum* | 9 | 0.08 | 7,8 |
| *E.* | *gracile* | 44 | 0.37 | 1,2,5,6,8 |
| *E.* | *spectabile* | 9 | 0.08 | 2,9,14,16 |
| *E.* | *whipplei* | 8 | 0.07 | 8,15,16 |
| *Percina* | *caprodes* | 9 | 0.08 | 1,7,8 |
| *P.* | *phoxocephala* | 1 | 0.01 | 10 |

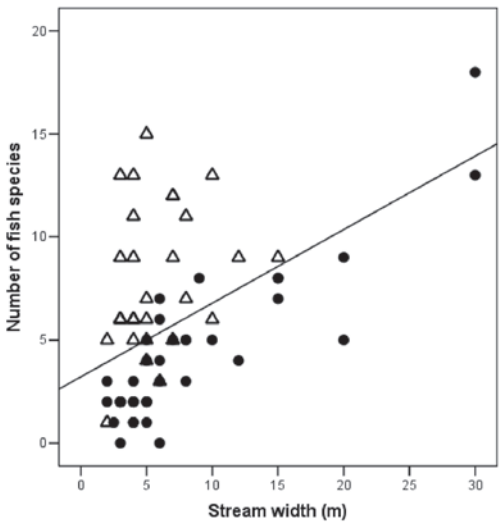


**Figure 2. Number of fish species versus stream width (m) for all collections at 17 stream sites in Northeastern Oklahoma. Filled circles indicate impacted sites. Open triangles indicate non-impacted sites. Residuals of linear regression analysis (*N* = 72, *P* = 0.000) were used to calculated differences in species richness/stream width. Non-impacted sites had significantly more fish species per stream width than impacted sites (Mann-Whitney U-test, *N* = 72, *Z* = -5.791, *P* = 0.0001).**

## DISCUSSION

Species richness in the area was comparable to that of other Oklahoma streams. Ten sites sampled in the Sand Creek watershed including Hickory Creek of the Bird Creek drainage in Osage County resulted in the recording of 23 species (Stewart et al 1999). Furthermore, a survey of the Crutcho Creek drainage in central Oklahoma noted 30 species, 17 of which were collected within Crutcho Creek alone (Matthews and Gelwick 1990). Both studies document communities numerically dominated by cyprinids. Our initial surveys of the Tar Creek and nearby drainages resulted in 34 species and fish communities characterized by large numbers of the poeciliid *G. affinis*. Thus, the species richness of the region is comparable to other Oklahoma regions.

Habitat measurements such as stream width often correlate with the number of species present within a given stream reach (Matthews 1998, Wiberg-Larsen 2000). Wider stream reaches tend to have more species present. Therefore, we could not compare one collection site to another without attention to habitat size. Statistical analysis showed that impacted sites were influenced by something other than stream width as a predictor in the number of species present. Impacted streams had fewer fish species per collection than non-impacted streams.

Species richness among individual sites varied. Permanent sampling sites of non-impacted streams ranged from 24 species at Cow Creek to nine species at Little Elm Creek. Species richness of impacted sites varied from 15 species at Tar Creek (U.S. Hwy 69 bridge, Commerce, OK) to two species (*G. affinis* and *L. cyanellus*) and a *Lepomis* hybrid at the UT below mine water inflow. In spite of differences in richness, impacted and non-impacted sites shared a generally similar ichthyofauna. Poeciliids and centrarchids dominated the fish community composition in each, whereas native minnows or darters made up only a small percent of the community.

Impacted streams were characterized by large numbers of *G. affinis* and *L. cyanellus*, which were two species classified as tolerant to degraded habitat and water quality (Jester et al 1992); thus, it is not surprising to find these two species dominating the waters of the impacted sites. The impacted sites of the region are subjected to elevated concentrations of iron, zinc, lead, cadmium, and other metals, sulfate, and mineral acidity due to the mine drainage discharges (Nairn et al 2005). Despite the availability of suitable habitat within most impacted sites, few darter species were collected. *Etheostoma gracile* and *E. spectabile* were collected at impacted sites, while *E. chlorosomum, E. gracile, E. spectabile*, and *E. whipplei* were collected at non-impacted sites.

Previous collections from non-impacted sites were similar to those in this study. A collection from 20 March 2001 (R. Broughton personal communication 2005) at Little Elm Creek in the vicinity of the current collections yielded a total of only five species and added no new species to the list collected during our survey. Few individuals were collected by Broughton, of what the majority were *C. lutrensis*. Unpublished original field notes of Carl Riggs and Jimmie Pigg are archived in the Sam Noble Oklahoma Museum of Natural History, Norman, OK, and provide historical community data of the area. A historical survey by Carl Riggs, collection number R63-1, on 24 April 1963, yielded seven species in Coal Creek (1.6 km W, 0.4 km N of U.S. Hwy 69) all of which were listed as currently present in this stream. An additional historical collection made by Jimmie Pigg on 19 May 1991 from Elm Creek, (U.S. Hwy 66, 4 km W of Commerce, OK) noted five species (*Amierus melas, Notomigonus crysoleucas, C. lutrensis, L. macrochirus,* and *M. salmoides*) which were not caught in this stream during the current study. It should be noted, however, that Elm Creek was sampled only once during the current study, thus we make no conclusions about change in community structure in this stream.

Fish communities within the study area appear to share similar structures, consisting of a moderately diverse assemblage of species, but with extremely depauperate composition within 0.01 km of the outfall of mine wastes in the UT. Impacted stream sites have lower species richness than non-impacted stream sites. No significant range extensions were reported, and all species were within their general ranges as reported in Miller and Robison (2004). No threatened or endangered species were found. The current study will serve as a baseline for future evaluation of remediation efforts in the Tar Creek watershed. However, further research is needed to evaluate the effects of mine water drainage on communities in impacted streams and to examine differences in fish body condition and reproduction.

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