# Fossil Creek Fish Monitoring

Annual Report

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## Pertinent Findings

Fossil Creek was chemically treated in autumn 2004 to eliminate non-native fishes above a constructed fish barrier, and historical flow of about 43 cubic feet per second (cfs) was restored to the stream in summer 2005. We sampled in September 2005 with minnow traps and hoop nets among three stream reaches within the treatment reach. The purpose of our survey was to document post-project composition and status of the fish community, with emphasis on documenting success of the non-native removal. Five fish species, all native, were encountered within the study area: headwater chub *Gila nigra* plus roundtail chub *Gila robusta*,[1] speckled dace *Rhinichthys osculus*, Sonora sucker *Catostomus insignis*, and desert sucker *Pantosteus clarki*. All species were in upper and middle reaches, while only Sonora sucker was in the lower reach. The composite sample of 2,262 individuals was comprised primarily of young-of-year; adults of all species were present but uncommon. Chubs comprised about 60%, speckled dace 24%, Sonora sucker 15%, and desert sucker 2% of total numbers. Total catch per unit effort (CPE, number of fish per overnight set) was greatest for both methods in the middle reach, intermediate in the upper reach, and lowest in the lower reach. CPE varied among reaches: chub was about an order of magnitude more abundant in the middle reach than in the upper reach. CPE of speckled dace, Sonora sucker and desert sucker differed among species but within a species was similar across reaches. Statistical analysis indicated significant location (reach) effects for all species, and significant gear and interaction effects for speckled dace. Non-native northern crayfish *Orconectes virilis* was in all reaches and most abundant in the lower, and native Sonora mud turtle *Kinosternon sonoriense* was collected only in the middle reach. Non-native smallmouth bass *Micropterus dolomieu* was the only fish detected during underwater observations immediately downstream of the constructed barrier.

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[1] Headwater and roundtail chubs are difficult to differentiate in the field without harm to individual fish, and we did not separate the two. A protocol was established during the Fossil Creek planning effort that assumed chub above Irving were *G. nigra*, and those below Irving were *G. robusta.* We chose not to follow that convention until the species' respective local geographic distributions can be verified and refer here to the two species collectively as "chub."

## Introduction

Fossil Creek (Fig. 1) is a perennial, spring-fed stream located in Gila and Yavapai counties, Arizona, and tributary to Verde River in the Gila River basin. The stream is home to a suite of six native fish species (Table 1) including four minnows (headwater chub, roundtail chub, longfin dace, speckled dace) and two suckers (desert sucker, Sonora sucker). Native Gila topminnow and razorback sucker also have been stocked (Minckley and Brooks 1985, Barrett and Maughan 1995). Non-native fishes that have been documented from Fossil Creek include common carp, green sunfish, smallmouth bass, flathead catfish, and yellow bullhead (Roberson et al. 1996; Table 1). Fossil Creek is relatively well studied, in part because of its intrinsic values, unique physical chemistry, and intact native fish fauna, but largely and most recently as a result of the recent hydropower decommissioning project (see below). A large and rich suite of published and gray literature has been produced on the stream and its biota (see, for example Arizona Public Service (APS) 1992, Chamberlain 1904, Bouchard and Associates 1995, EnviroNet 1998, Federal Energy Regulatory Commission 2004, FWS unpublished; and abundant references therein). Land ownership along Fossil Creek is Coconino and Tonto National Forests on the north and south, respectively, interspersed with a few small private parcels. Access to the stream is on foot or at bridge crossings of Forest Service Road (FSR) 708.

A fish barrier was constructed on lower Fossil Creek in autumn 2004 and a portion of the stream, tributaries, constructed channels, and watershed stock tanks were treated with ichthyocides to eliminate non-native fishes in autumn-winter 2004-2005 as part of a larger hydroelectric facility decommissioning and flow/native fish restoration project. Native fishes salvaged prior to the renovation were repatriated to the stream at the end of the project. The overall project includes restoration in June 2005 of approximately 1220 L/s (43 cfs) of spring flow to the stream channel, and future lowering by 1.3-m and eventual removal a 7.6-m high diversion dam. Discharge in the channel prior to flow restoration was primarily seepage of about 5 L/s below the diversion dam, augmented downstream by spring and tributary inputs to about 60 L/s at the fish barrier. Fossil Springs (the primary stream source) is at river kilometer (RK) 22.4 above the Verde River, into which Fossil Creek flows, the diversion dam is at RK 22.1, and the fish barrier is at RK 7.4. A small hydroelectric power generation facility, now out of service, is located at Irving, near RK 17.

This report presents results of annual post-project (i.e., stream renovation and native fish repatriation) fish monitoring. The study was implemented specifically to detect the presence of nonnative fishes and assess the status of the repatriated native fish assemblage.

## Methods

A standardized fish monitoring protocol was developed by the authors and finalized in cooperation with Reclamation (Marsh 2005). That protocol was implemented for the first time as related in this report. The protocol is subject to future modification and refinement as appropriate or required by experience or other considerations, and any such modifications or other changes will be detailed in future reports. The protocol is summarized here as performed during September 19-23, 2005.

Three sample reaches (Fig. 1, Table 2) were designated along the approximately 11.3 km (7.0 mile) stream course between the constructed fish barrier and the "High Falls" located about 1.9 km upstream from Irving at RK 18.4. Reaches were designated lower (down-) to upper (upstream) as "Above (constructed) Barrier," "Below Irving" and "Below High Falls." Standard gears were deployed within a discrete portion of each reach, referenced as "actual" in Table 2, and opportunistically elsewhere. Universal Transverse Mercator (UTM) coordinates (NAD27) were acquired for each reach using a handheld Garmin GPS receiver.

Standard methods were minnow trapping, hoop netting, and snorkeling. Gears were deployed to represent available habitat types and as appropriate for each gear type, and in a consistent manner so that similar effort was expended in each reach, and these collections were supplemented by other, opportunistic sampling.

Minnow traps were 18-inches long x 10-inches diameter and either ⅛ or ¼-inch mesh galvanized hardware cloth. Traps were suspended at various depths and in a variety of calm water habits within the stream channel, and baited with a small handful of Aquamax pellets contained in a small bag of fine nylon mesh, tethered by a length of nylon twine. Ten traps (nominally, four ⅛-inch and six ¼-inch mesh) were set in each reach, typically deployed in the afternoon and retrieved the following morning.

Hoop nets were 48-inches long with a single throat and two, 24-inch diameter steel hoops set 30 inches apart. Netting was ¼-inch Ace knotless nylon mesh. Hoop nets were deployed in a variety of quiet-to-swift water habitats with the cod end upstream, and baited with a small handful of Aquamax pellets contained in a small bag of fine nylon mesh, tethered by a yoke at the open end and single line at the cod end. Ten hoop nets nominally were set in each reach, typically deployed in the afternoon and retrieved the following morning, i.e., 15 to 20 hrs of immersion.

Fishes retrieved from collection gears were identified to species, enumerated by age (size) class according to the convention 0 = young-of-year of species that attain relatively large adult body size, and 1 = post young-of-year of fish that attain large body size; fish that remain relatively small throughout life were not aged. All captured fish were released unharmed near the site of capture. Total length (TL) of some individuals was visually estimated. Data were recorded individually for each set of each gear type.

Fish collections were augmented by visual observations obtained by snorkeling. One large pool was designated in each sample reach, and 2-3 persons each spent 20 or more minutes inspecting all available habitats and assessing presence, sizes, and subjective abundance of each species encountered. A brief narrative of observations was recorded.

Field data were tabulated and summarized. Mean minnow trap or hoop net set times did not differ among reaches (two-sample t-test, $df = 9$, $\alpha > 0.10$; Noether 1971) so catch per unit effort (CPE, number of fish per overnight minnow trap or hoop net set) was calculated and presented for each standardized monitoring data set for each reach. A two-way Analysis of Variance (ANOVA) was used to test for significant differences ($\alpha = 0.05$) between locations (3 levels: lower, middle, and upper reaches), and between gear types (minnow trap or hoop net) by comparing means of catch for each species by each method. The Least Squares Means Tukey Multiple Comparisons test was used (Kutner et al. 2005). Data were transformed for normality using the expression $Y' = (Y+1)^{-0.2}$.

## Monitoring Results

Minnow traps and hoop nets

Above Barrier (lower reach, Fig. 1).--The stream upon our arrival in this reach on the afternoon of 19 September was at "base" flow of approximately 43 cfs, clear, and lacked aquatic vegetation except for sparse marginal stands of cattail *Typha latifolia*. Substrate in non-riffle/cascade reaches contained much sand, and there were accumulations of silt in slack water areas. Larger rocks were mostly smooth with little apparent diatom film or "Aufwuchs" community development. Ten minnow traps and 10 hoop nets were set between 1700 and 1825 hrs in runs to 1-meter deep and flowing pools of similar depth.

Minnow traps and hoop nets were retrieved between 1030 and 1130 hrs on 20 September; nominal set time for each individual device was 17.5 hrs. Only Sonora sucker was captured (Table 3), and specimens were in all devices except for one minnow trap (Table 4). Total minnow trap catch was 46 individuals (range 0-10 per trap) and catch per unit effort (CPE, number of fish per overnight set) was 4.6. Total hoop net catch was 94 fish (range 1-21 per net) and CPE was 9.4. All fish were young-of-year except three individuals estimated to be ca. 10, 10, and 15 cm TL, all captured by hoop net.

Northern crayfish also was in all devices except for one minnow trap (Table 4). There were 0-5 per trap (17 total, CPE = 1.7) and 1-22 per net (91 total, CPE = 9.1) per hoop net.

Below Irving (middle reach, Fig. 1).--The stream upon our arrival in this reach early in the afternoon on 20 September was at "base" flow of approximately 43 cfs and very clear. Monospecific stands of cattail, horsetail *Equisetum* sp., and phragmites *Phragmites australis* were sparse-to-dense along margins or run-type habitats. Substrate in most areas was abundant inorganic fines, some gravels and larger materials, and Coarse Particulate Organic Material (CPOM) such as leaves, twigs, stick and branches.

Ten minnow traps and 10 hoop nets were set between 1450 and 1700 hrs in runs to 1-meter deep and flowing pools of similar depth.

An opportunistic sample was collected in this reach with a single ⅛-inch mesh minnow trap that was set at 1345 in the Irving power plant outfall channel immediately adjacent to and more than a meter above the stream level, with a steep drop. The wetted portion of the site was only a few meters long, ⅓-meter wide, and perhaps 15-cm deep, filled with at most a few 100s of L of clear water. The minnow trap captured 12 young-of-year chub in 20 minutes. This is an important result because the outfall channel was chemically treated and should have been devoid of fish, yet at least some fish persisted in this peripheral habitat. The outfall channel was desiccated upstream of this site into the abandoned power plant, and isolated downstream by a drop of more than a meter into Fossil Creek, so natural reinvasion appeared unlikely. Fortunately, in this instance the survivors all were native, but it is possible that other fishes including undesirable non-native species could have survived in other, similar but not sampled places.

A brief thunderstorm with light rain occurred during the night of 20-21 September, but there was no discernable effect on stream flow or water clarity. Minnow traps and hoop nets were retrieved between 0845 and 1110 hrs on 21 September; nominal set time for each individual device was 17.6 hrs. Two of each device were reset and run later in the day; see results below. Chub, specked dace, Sonora sucker, and desert sucker were captured (Table 3), and specimens were in all devices (Table 5). Total minnow trap catch (all species combined) was 715 individuals (range 13-156 per trap) and CPE was 71.5. Total hoop net catch (all species combined) was 675 fish (range 4-138 per net) and CPE was 67.5.

Chub was in all minnow traps and hoop nets, was the most abundant species in overall in minnow traps (79% of catch, CPE = 56.4) and in hoop nets (91% of catch, CPE = 61.5), and was the most abundant species in each individual capture device with exception of one minnow trap (Table 5). Speckled dace was overall the second most abundant fish in minnow traps (total catch = 114, CPE = 11.4), but this was because of the contribution of 111 individuals that were in a single trap. It was in only one other trap, which contained three individuals. Speckled dace was uncommon in hoop nets (total catch = 6, CPE = 0.6), and was taken by only two of 10 sets that contained 5 and 1 individuals, respectively (Table 5). Sonora sucker comprised 5% of fish in minnow traps (total catch = 36, CPE = 3.6) and was in all but two of these devices (range 1-8 individuals per trap). Similarly, Sonora sucker comprised about 6% of fish in hoop nets (total catch = 43, CPE = 4.3) and was in all hoops (range 1-15 individuals per net). Desert sucker was rare and occurred in only one minnow trap (total catch = 1, CPE = 0.1), and in three of 10 hoop nets (total catch = 11, CPE = 1.1, range of 1-7 individuals per net).

Northern crayfish was absent from minnow traps, but present in six of 10 hoop nets in this reach (Table 5). There were 1-8 per net (21 total, CPE = 2.1). Each of two hoop nets also contained a single Sonora mud turtle.

In addition to the standard monitoring described above, two minnow traps and two hoop nets from those described above were reset at 0825 on the same day, in the middle reach in the large pool below the falls at Irving (designated pool no. 1 in the 2004 AZGFD stream reach 3A treatment protocol). These were run at 1700 (nominal set time 8.6 hrs). Because these were fished short-term and only during daylight hours, results are not comparable with standard overnight sets and thus are reported separately. The two minnow traps captured 188 fish (18% chub, 81% speckled dace, and 1% Sonora sucker, plus two northern crayfish (Table 6). The two hoop nets captured 44 individuals (68% chub, 25% speckled dace, 5% Sonora sucker, and 2% desert sucker, plus one northern crayfish (Table 6). All fishes were young-of-year with exception of two chub estimated 12-14 cm long.

High Falls (upper reach, Fig. 1).--Upon our arrival in this reach early in the afternoon on 21 September, conditions were unchanged from those noted previously at other reaches. Flow was approximately 43 cfs and clear. Monospecific stands of cattail, horsetail, and phragmites were sparse-to-dense along margins of run-type habitats, especially in the first several hundred meters upstream from Irving. Ten minnow traps and 10 hoop nets were set between 1345 and 1515 hrs in runs to 1-meter deep and flowing pools of similar depth.

Minnow traps and hoop nets were retrieved between 0945 and 1215 hrs on 22 September; nominal set time for each individual device was 20.0 hrs. Chub, specked dace, Sonora sucker, and desert sucker were captured (Table 3), and specimens were in all devices except two hoop nets that were fishless (Table 7). Total minnow trap catch (all species combined) was 360 individuals (range 3-181 per trap) and CPE was 36.0. Total hoop net catch (all species combined) was 140 fish (range 0-92 per net) and CPE was 14.0.

Chub was in six of 10 minnow traps and six of 10 hoop nets, and was the second most abundant species in minnow traps (total catch = 67, CPE = 6.7) and in hoop nets (total catch = 26, CPE = 2.6). It was rarely the most abundant species in any individual capture device (Table 7). Speckled dace was the most abundant fish in minnow traps (67% of total catch, CPE = 11.4), and was in all individuals traps. In contrast speckled dace was uncommon in hoop nets (total catch = 8, CPE = 0.8), and was taken by five of 10 sets that each contained 1 to 3 individuals (Table 7). Sonora sucker was the second most abundant species overall (25% of total catch), comprised 10% of fish in minnow traps (total catch = 35, CPE = 3.5) and was in six of ten of these devices (range 1-14 individuals per trap). In contrast, Sonora sucker comprised about 63% of fish in hoop nets (total catch = 88, CPE = 8.8), but was in only four hoops (range 2-65 individuals per net). Desert sucker was uncommon in minnow trap (total catch = 8, CPE = 0.8), and in hoop nets (total catch = 18, CPE = 1.8, range of 1-9 individuals per net).

Northern crayfish was absent from minnow traps and from five of 10 hoop nets in this reach (Table 7). There were 1-5 per net (13 total, CPE = 1.3). Four hoop nets also contained 1 to 3 Sonora mud turtle (total catch of 7).

Underwater observations

We snorkeled four pools during the sample period. Two pools were within our "Above Barrier" reach, and one each was within the "Below Irving" and "High Falls" reaches. Narratives are provided below, down- to upstream.

The large, deep, steep sided, rock pool at approximately UTM 439526E-3804165N (designated pool no. 28 in the 2004 AZGFD stream reach 4A treatment protocol; Fig 1) was selected for snorkeling in the "Above Barrier" reach, and it was examined from 0900 to 0945 on 20 September by three persons (2.25 hrs total effort). The pool was greater than 3-m deep with a strong current, and a substrate comprised of sand, fine materials, and CPOM, mostly leaves and twigs from terrestrial vegetation. Schools of up to several dozen plus a few singles of juvenile (to ca. 8 cm) Sonora sucker were seen, mostly associated with shoreline cover, exposed roots, and cut banks. No other fish species was detected. Northern crayfish was present.

We snorkeled the large pool below the FSR 708 bridge crossing downstream of Irving at approximate UTM 4422164E, 3805847N (pool no. 16 in AZGFD stream reach 3A; Fig. 1) from 1400 to 1420 hrs (3 persons, total effort 1.0 hrs). This pool was clear, very deep (5 to 6 meters), with a swift laminar current. Aquatic vegetation was lacking; substrate was either soft organic materials (leaves and twigs), sand or bedrock. About one-half of the circumference of the pool was vertical bedrock. No large fish of any species was observed. Fishes that were present were observed mostly around the periphery of the pool or in the inlet and outlet areas; none was in the deepest parts. Chub young of year were abundant; mostly 3 to 5 cm long, but a few were perhaps 10 cm in length. Speckled dace was common in shallow, swift water over rocky bottoms at the pool outlet and inlet. Sonora sucker was present but not common, mostly around the periphery; desert sucker was common on walls and rock faces where individuals were actively feeding. Northern crayfish was common on soft bottom sediments.

We snorkeled in the large, deep, steep sided, rock pool below the falls at Irving as described above (approximately UTM 439526E, 380416N; pool no. 1 in AZGFD stream reach 3A; Fig. 1). It was examined from 1630 to 1650 hrs by three persons (1.0 hrs total effort). The pool was greater than 5-m deep, with very strong and complex currents resulting from the 3-m waterfall at the head of the pool, and substrate comprised predominately of fine materials and CPOM, mostly leaves and twigs; cobble was present along the perimeter and tail of the pool. About three-quarters of the circumference of the pool was vertical bedrock. Juvenile chub were abundant throughout the water column in the pool. At least three large (ca. 35-cm long) adult chub were seen, none with characteristic breeding coloration, and all in deep water near the bottom. Speckled dace of all ages and sizes were abundant among cobbles in the swift, shallow (less than 0.5-meter deep) water in the stream channel at the downstream end of the pool. One large (ca. 50-cm long) adult Sonora sucker was on the bottom in the deepest water. Desert sucker was common on the bottom, along rock walls of the pool, and along shallow cobble edges; all individuals were smaller than about 15 cm. No other fish species was detected.

We snorkeled in the large, deep, steep sided, rock pool below the high falls above Irving (approximately UTM 444433E 3808075N; pool no. 24 in AZGFD stream reach 2; Fig. 1). It was examined from 1630 to 1650 hrs by two persons (1.0 hrs total effort). The pool was deeper than 5-m, with a very strong circular current, and a substrate comprised of fine materials and CPOM, mostly leaves and twigs; cobble and gravel were present along about 25% of the circumference and in the tailrace. Juvenile chub were abundant throughout the water column in the pool. At least three large (ca. 35-cm long) adult roundtail chub were seen, none with characteristic breeding coloration, and all in deep water near the bottom. Speckled dace of all ages and sizes were abundant among cobbles in the swift, shallow (less than 0.5-meter deep) water in the stream channel at the downstream end of the pool. One large (ca. 50-cm long) adult Sonora sucker was on the bottom in deepest water. Desert sucker was common on the bottom and along rock walls of the pool; all individuals were smaller than about 15 cm. No other fish species was detected.

The constructed fish barrier on Fossil Creek (Fig. 1) was visited on the morning of 23 September. One each ⅛ and ¼-inch mesh, baited minnow traps were set in quiet margins among cattail stands adjacent to the flowing channel below the barrier from approximately 1000 to 1040 hrs. No fish were captured in these traps. Four persons snorkeled for approximately 2 hours and inspected all available habitats throughout the area from the base of the barrier downstream for about 75 meters. It was a sunny, calm day and visibility was fair to good. Only non-native smallmouth bass *Micropterus salmoides* was seen. Most fish were 12 to 15 cm in length and a few were to a maximum of about 25 cm. No young-of-year were detected. Northern crayfish was common throughout the area. No fish of any species was seen immediately above the barrier where one person observed for approximately 10 minutes; northern crayfish was abundant.

## Statistical treatments

Raw catch data were not normally distributed, and logarithmic transformation $Y' = (Y+1)^{-0.2}$ helped but still did not normalize the data except for Sonora sucker (Table 8). ANOVA on transformed data showed there were significant location (reach) effects for all four fish species ($df = 3, 54$), and significant gear and gear-location interaction effects for speckled dace ($df = 3, 54$); other pair-wise comparisons were non-significant (Table 8). Chub and desert sucker showed significant location effects for all pair-wise reach combinations (lower-upper, lower-middle, and upper middle), and Sonora sucker showed a significant effect only for the lower-upper reach contrast (note that Sonora sucker was present in all three sample reaches while the other species were absent from the Above Barrier [lower] reach). Speckled dace showed significant location, gear and interaction effects ($df = 3, 54$); the latter involving only minnow traps and the comparisons of lower-upper and middle-upper reaches (again note that speckled dace was not present in the lower reach).

## Summary

No non-native fishes were detected in the treatment reach of Fossil Creek during a monitoring survey performed 19-23 September 2005. Five native fishes, headwater chub, roundtail chub, speckled dace, Sonora sucker, and desert sucker were present, primarily as young-of-year accompanied by a few, larger adults, indicating successful reproduction and recruitment since the stream renovation and fish repatriation project conducted in autumn 2004.

Only one fish species, Sonora sucker, was present in the lowermost reach, and its abundance was low compared with upstream reaches. All post-project repatriation sites were upstream of Irving, and Sonora sucker apparently was the only species that had dispersed downstream by the time of our monitoring. Results of future sampling may allow comparison of dispersal dynamics among native fishes and lead to recommendations to enhance future project that repatriate native stream fishes.

Finally, we note the absence from collections of longfin dace, which was known to occupy Fossil Creek historically and at the time of project implementation. If this native fish is not found during the next monitoring period, we recommend its reintroduction from an appropriate, geographically nearby population. Such reintroduction could be simultaneous with introduction of other species including threatened loach minnow *Tiaroga cobitis* and spikedace *Meda fulgida*, which were deemed suitable for the stream in the Environmental Assessment developed for the project (FERC 2004).

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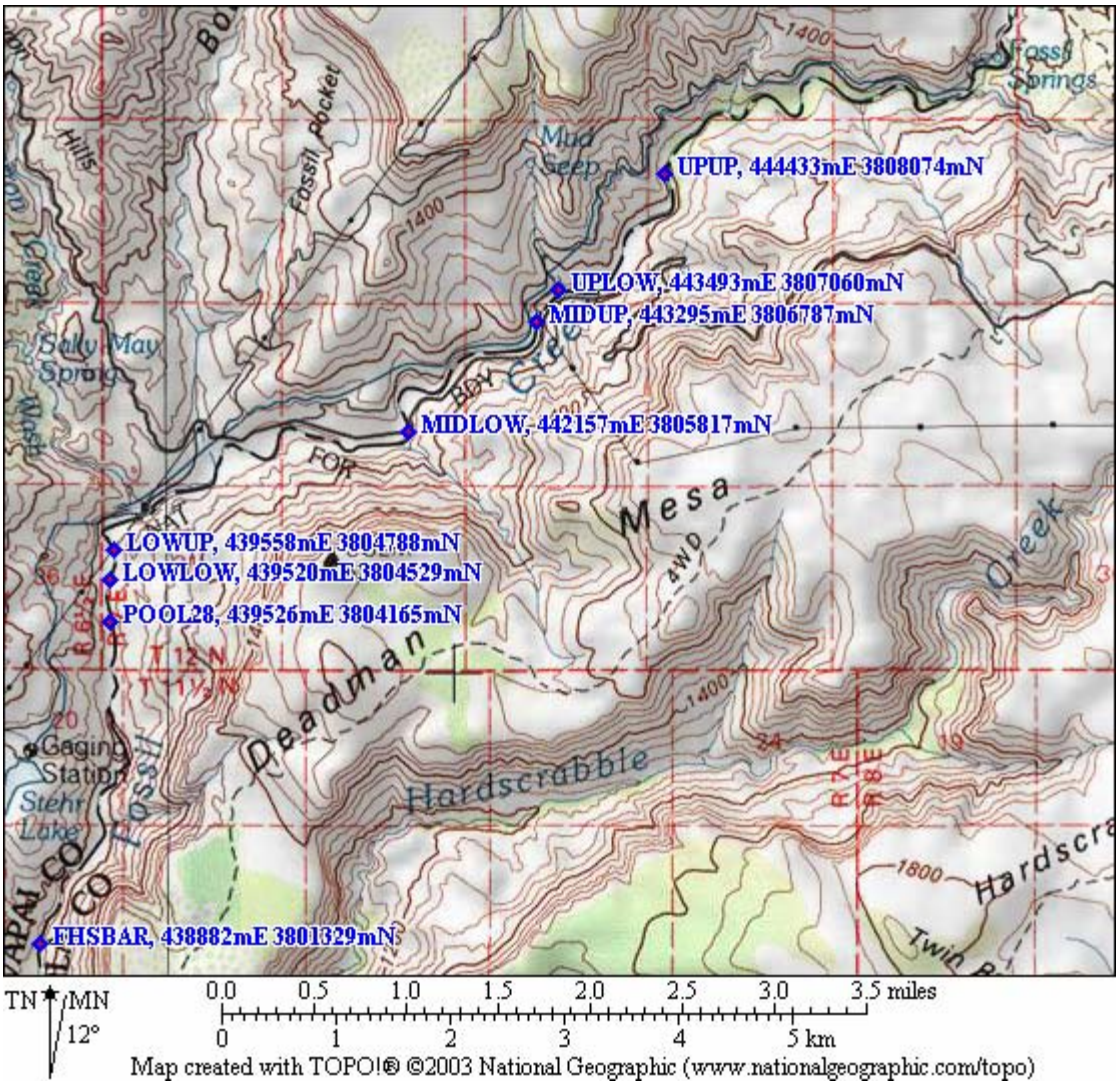


Figure 1. Map of Fossil Creek, Gila and Yavapai counties, Arizona, from Fossil Springs downstream to a constructed fish barrier, showing features related to fish monitoring September 19-23, 2005. UTM coordinates are given for upper and lower boundaries of upper, middle and lower monitoring reaches, for Pool 28, and for the constructed fish barrier (FSHBAR). Pool 16 (treatment reach 3A) is immediately downstream of the UTM marked MIDLOW, Pool 1 (treatment reach 3A) is immediately downstream of the UTM marked MIDUP, and Pool 24 (treatment reach 2) is immediately downstream of the UTM marked UPUP. See text for further information.

Table 1. Common and scientific names of families and species of native (indicated by *) and non-native fishes known from Fossil Creek, Arizona, and abbreviations used in tables. See footnote on page 1 relative to treatment of headwater and roundtail chubs.

| | |
|---|---|
| Minnows (Cyprinidae) | |
| *Longfin dace, *Agosia chrysogaster* | |
| Common carp, *Cyprinus carpio* | |
| *Headwater chub, *Gila nigra* | (gilasp) |
| *Roundtail chub, *Gila robusta* | (gilasp) |
| *Speckled dace, *Rhinichthys osculus* | (rhiosc) |
| Suckers (Catostomidae) | |
| *Sonora sucker, *Catostomus insignis* | (catins) |
| *Desert sucker, *Pantosteus clarki* | (pancla) |
| *Razorback sucker, *Xyrauchen texanus* | |
| Catfishes (Ictaluridae) | |
| Yellow bullhead, *Ameiurus natalis* | |
| Flathead catfish, *Pylodictis olivaris* | |
| Livebearers (Poeciliidae) | |
| *Gila topminnow, *Poeciliopsis occidentalis* | |
| Basses and Sunfishes (Centrarchidae) | |
| Green sunfish, *Lepomis cyanellus* | |
| Smallmouth bass, *Micropterus dolomieu* | |

Table 2. Approximate lower (downstream) and upper (upstream) limits and approximate lengths of each nominal monitoring reach sampled along Fossil Creek, Pinal and Yavapai counties, Arizona, 19-23 September 2005. Universal Transverse Mercator coordinates (UTMs) in NAD27 datum, Zone 12S. The reach designated "new actual" is to be implemented during future surveys.

| Reach designation | Lower UTM | Upper UTM | Length (km [mi]) |
|---|---|---|---|
| Above Barrier | | | |
| Actual | 439520E-3804529N | 439558E-3804788N | 0.26 (0.16) |
| New actual | 439523E-3803732N | 439526E-3804165N | 0.45 (0.28) |
| Below Irving | 442157E-3805817N | 442157E-3805817N | 1.87 (1.16) |
| High Falls | 443493E-3807060N | 444433E-3808074N | 1.69 (1.05) |

Table 3. Summary of Fossil Creek fish monitoring data, 19-23 September 2005.

Table 3A. Total catch by reach and method, all standard samples; mt = minnow trap, hoop = hoop net

| | Upper Reach | | Middle Reach | | Lower Reach | | |
|---|---|---|---|---|---|---|---|
| | mt | hoop | mt | hoop | mt | hoop | Total |
| gilasp | 67 | 26 | 564 | 615 | 0 | 0 | 1272 |
| rhiosc | 250 | 8 | 114 | 6 | 0 | 0 | 378 |
| catins | 35 | 88 | 36 | 43 | 46 | 94 | 342 |
| pancla | 8 | 18 | 1 | 11 | 0 | 0 | 38 |
| | | | | | | | |
| Total | 360 | 140 | 715 | 675 | 46 | 94 | 2030 |

Table 3B. Total catch by reach, methods combined, all standard samples

| | Upper Reach | | Middle Reach | | Lower Reach | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | Total |
| gilasp | 93 | | 1179 | | 0 | | 1272 |
| rhiosc | 258 | | 120 | | 0 | | 378 |
| catins | 123 | | 79 | | 140 | | 342 |
| pancla | 26 | | 12 | | 0 | | 38 |
| | | | 0 | | | | |
| Total | 500 | 0 | 1390 | | 140 | | 2030 |

Table 3C. Catch per unit effort (no. fish per standard overnight minnow trap or hoop net set) by reach and by method. Mt = minnow trap, hoop = hoop net

| | Upper Reach | | Middle Reach | | Lower Reach | |
|---|---|---|---|---|---|---|
| | Mt | hoop | Mt | hoop | Mt | hoop |
| gilasp | 6.7 | 2.6 | 56.4 | 61.5 | 0 | 0 |
| rhiosc | 25 | 0.8 | 11.4 | 0.6 | 0 | 0 |
| catins | 3.5 | 8.8 | 3.6 | 4.3 | 4.6 | 9.4 |
| pancla | 0.8 | 1.8 | 0.1 | 1.1 | 0 | 0 |
| | | | | | | |
| Total | 36 | 14 | 71.5 | 67.5 | 4.6 | 9.4 |
| | | | | | | |
| crayfish | 0 | 1.3 | 0 | 2.1 | 1.7 | 9.1 |

Table 4. Fossil Creek standard fish monitoring data, Above Barrier reach, 19-20 September 2005.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site: | "Above Barrier" = Lower Reach | | | | | | | | | | | |
| Date: | 19-20 Sept 2005 | | | | | | | | | | | |
| Gear type: | minnow trap | | | | | | | | | | | |
| Nominal set/run times: 1700-1030 | | | | Nominal set duration: 17.5 hours | | | | | | | | |
| Comments: | traps 1-4 were 1/8-inch mesh, traps 5-10 were 1/4-inch mesh | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Catins | 8 | 10 | 1 | 7 | 0 | 3 | 2 | 4 | 5 | 6 | 46 | 4.6 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | 1 | 2 | 5 | 1 | 0 | 2 | 2 | 1 | 2 | 1 | 17 | 1.7 |
| | | | | | | | | | | | | |
| Site: | "Above Barrier" = Lower Reach | | | | | | | | | | | |
| Date: | 19-20 Sept 2005 | | | | | | | | | | | |
| Gear type: | hoop net | | | | | | | | | | | |
| Nominal set/run times: | | 1700-1030 | | Nominal set duration: 17.5 hours | | | | | | | | |
| Comments: | all hoops were single throat, 4' long x 2' diameter x 1/4-inch mesh | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Catins | 11 | 10 | 6 | 20 | 7 | 7 | 1 | 4 | 7 | 21 | 94 | 9.4 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | 7 | 22 | 20 | 12 | 11 | 1 | 4 | 10 | 1 | 3 | 91 | 9.1 |

Table 5. Fossil Creek standard fish monitoring data, Below Irving reach, 20-21 September, 2005.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site: | "Below Irving" = Middle Reach | | | | | | | | | | | |
| Date: | 20-21 Sept 2005 | | | | | | | | | | | |
| Gear type: | minnow trap | | | | | | | | | | | |
| Nominal set/run times: | | 1450-0825 | | Nominal set duration: | | 17.6 hr | | | | | | |
| Comments: traps 1-4 were 1/8-inch mesh, traps 5-10 were 1/4-inch mesh | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Gilrob | 44 | 100 | 80 | 37 | 39 | 30 | 64 | 106 | 51 | 13 | 564 | 56.4 |
| Rhiosc | 111 | | | | 3 | | | | | | 114 | 11.4 |
| Catins | 1 | 1 | 8 | 2 | | 6 | 6 | 6 | 6 | | 36 | 3.6 |
| Pancla | | | | | | | | | 1 | | 1 | 0.1 |
| | | | | | | | | | | | | |
| Total | 156 | 101 | 88 | 39 | 42 | 36 | 70 | 112 | 58 | 13 | 715 | 71.5 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | |
| Site: | "Below Irving" = Middle Reach | | | | | | | | | | | |
| Date: | 20-21 Sept 2005 | | | | | | | | | | | |
| Gear type: | hoop net | | | | | | | | | | | |
| Nominal set/run times: | | 1450-0825 | | Nominal set duration: | | 17.6 hr | | | | | | |
| Comments: | all hoops were single throat, 4' long x 2' diameter x 1/4-inch mesh | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Gilrob | 52 | 2 | 41 | 109 | 61 | 7 | 82 | 134 | 112 | 15 | 615 | 61.5 |
| Rhiosc | 5 | 1 | | | | | | | | | 6 | 0.6 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Catins | 2 | 1 | 3 | 7 | 5 | 1 | 2 | 4 | 15 | 3 | 43 | 4.3 |
| Pancla | 2 | | 1 | 7 | | 1 | | | | | 11 | 1.1 |
| | | | | | | | | | | | | |
| Total | 61 | 4 | 45 | 123 | 66 | 9 | 84 | 138 | 127 | 18 | 675 | 67.5 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | | | 3 | 7 | 1 | 1 | | 1 | | 8 | 21 | 2.1 |
| mud turtle | | | | | | | 1 | | | 1 | 2 | 0.2 |

Table 6. Fossil Creek fish monitoring data, short-term sets, Below Irving reach, 21 September, 2005.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Two minnow traps and two hoop nets were set in the pool below the falls at Irving. | | | | | | | | |
| These short-term data are not comparable with overnight sets and thus are reported separately. | | | | | | | | |
| CPE was not computed. | | | | | | | | |
| | | | | | | | | |
| Site: | "Below Irving" = Middle Reach | | | | | | | |
| Date: | 21-Sep-05 | | | | | | | |
| Gear type: | minnow trap plus hoop net | | | | | | | |
| Nominal set/run times: | | 0825-1700 | | | | | | |
| Nominal set duration: | | 8.6 hrs | | | | | | |
| Comments: | trap 1 was 1/8" mesh, trap 2 was 1/4" mesh, and gears 3 and 4 were standard hoop nets | | | | | | | |
| | | | | | | | | |
| Species | | 1 | 2 | total | | 3 | 4 | total |
| | | | | | | | | |
| gilrob | | 26 | 8 | 34 | | 22 | 8 | 30 |
| rhiosc | | 143 | 10 | 153 | | 9 | 2 | 11 |
| catins | | 1 | | 1 | | 1 | 1 | 2 |
| pancla | | | | | | 1 | | 1 |
| | | | | | | | | |
| total | | 170 | 18 | 188 | | 33 | 11 | 44 |
| | | | | | | | | |
| by-catch | | | | | | | | |
| crayfish | | | 2 | 2 | | | 1 | 1 |

Table 7. Fossil Creek standard fish monitoring data, High Falls reach, 21-22 September, 2005.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site: | "High Falls" = Upper Reach | | | | | | | | | | | |
| Date: | 21-22 Sept 2005 | | | | | | | | | | | |
| Gear type: | minnow trap | | | | | | | | | | | |
| Nominal set/run times: | | 1345-0945 | | Nominal set duration: | | 20.0 hrs | | | | | | |
| Comments: | traps 1-4 were 1/8-inch mesh, traps 5-10 were 1/4-inch mesh | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Gilasp | 27 | 4 | 5 | 0 | 23 | | | 6 | 2 | | 67 | 6.7 |
| Rhiosc | 140 | 1 | 66 | 6 | 3 | 5 | 15 | 11 | 1 | 2 | 250 | 25 |
| Catins | 14 | 6 | 1 | | 1 | 1 | | 12 | | | 35 | 3.5 |
| Pancla | | | 1 | | | | 4 | 1 | 1 | 1 | 8 | 0.8 |
| | | | | | | | | | | | | |
| Total | 181 | 11 | 73 | 6 | 27 | 6 | 19 | 30 | 4 | 3 | 360 | 36 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | | | | | | | | | | | 0 | 0 |
| | | | | | | | | | | | | |
| Site: | "High Falls" = Upper Reach | | | | | | | | | | | |
| Date: | 20-21 Sept 2005 | | | | | | | | | | | |
| Gear type: | hoop net | | | | | | | | | | | |
| Nominal set/run times: | | 1345-0945 | | Nominal set duration: | | 20.0 hrs | | | | | | |
| Comments: | all hoops were single throat, 4' long x 2' diameter x 1/4-inch mesh | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Species/Rep | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | total | CPE |
| | | | | | | | | | | | | |
| Gilasp | 1 | 2 | 16 | 1 | 0 | | | 0 | 1 | 5 | 26 | 2.6 |
| Rhiosc | 1 | 0 | 2 | 0 | 0 | 1 | 3 | 0 | | 1 | 8 | 0.8 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Catins | 3 | 2 | 65 | 18 | 0 | | | 0 | | | 88 | 8.8 |
| Pancla | 2 | 1 | 9 | 3 | 0 | | 3 | 0 | | | 18 | 1.8 |
| | | | | | | | | | | | | |
| Total | 7 | 5 | 92 | 22 | 0 | 1 | 6 | 0 | 1 | 6 | 140 | 14 |
| | | | | | | | | | | | | |
| by-catch | | | | | | | | | | | | |
| Crayfish | | 2 | 5 | 4 | 1 | | | 1 | | | 13 | 1.3 |
| mud turtle | | | | | | 1 | 3 | 1 | | 2 | 7 | 0.7 |

Table 8. Results of two-way ANOVA, Fossil Creek standard fish monitoring data, 19-22 September 2005. For each species the left column provides cell means, the center column provides p-values for the F-statistic (not shown) based on raw data ANOVA , and the right column provides p-values for the F-statistic (not shown) based on transformed data ANOVA plus results of pair-wise comparisons (t-statistics not shown).

Cell means

Raw data

Transformed data

Chub, *Gila nigra* plus *Gila robusta*

| | Gear | |
|---|---|---|
| Location | MinnowTrap | HoopNet |
| 1-Lower | 0 | 0 |
| 2-Middle | 56.4 | 61.5 |
| 3-Upper | 6.7 | 2.6 |

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | <0.0001 |
| Gear effect: | no | 0.96 |
| Interaction effect: | no | 0.82 |

Y'=(Y+1)^-0.2 (does not normalize)

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | <0.0001 |
| Gear effect: | no | 0.24 |
| Interaction effect: | no | 0.62 |
| Pair-wise Comparisons | | p-value |
| Lower-Middle | | <0.0001 |
| Middle-Upper | | <0.0001 |
| Lower-Upper | | <0.0001 |
| Gear are non-significant | | |

Speckled dace, *Rhinichthys osculus*

| | Gear | |
|---|---|---|
| Location | MinnowTrap | HoopNet |
| 1-Lower | 0 | 0 |
| 2-Middle | 11.4 | 0.6 |
| 3-Upper | 25 | 0.8 |

| | | p-value |
|---|---|---|
| Location Effect: | no | 0.22 |
| Gear effect: | no | 0.06 |
| Interaction effect: | no | 0.27 |

Y'=(Y+1)^-1.2 (does not normalize)

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | <0.0001 |
| Gear effect: | **yes** | 0.008 |
| Interaction effect: | **yes** | 0.004 |
| Pair-wise Comparisons | | p-value |
| Lower/Minn-Upper/Minn | | <0.0001 |
| Mid/Minn-Upper/Minn | | <0.0001 |
| Lower/Minn-Mid/Minn | | Non-sig |

Table 8, concluded.

Sonora sucker, *Catostomus insignis*

| | Gear | |
|---|---|---|
| Location | MinnowTrap | HoopNet |
| 1-Lower | 4.6 | 9.4 |
| 2-Middle | 3.6 | 4.3 |
| 3-Upper | 3.5 | 8.8 |

| | | p-value |
|---|---|---|
| Location Effect: | no | 0.57 |
| Gear effect: | no | 0.14 |
| Interaction effect: | no | 0.7 |

Y'=(Y+1)^-0.2 (normalizes)

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | 0.007 |
| Gear effect: | no | 0.29 |
| Interaction effect: | no | 0.57 |

| Pair-wise Comparisons | p-value |
|---|---|
| Lower-Upper | 0.0049 |
| Gear are non-significant | |

Desert sucker, *Pantosteus clarki*

| | Gear | |
|---|---|---|
| Location | MinnowTrap | HoopNet |
| 1-Lower | 0 | 0 |
| 2-Middle | 0.1 | 1.1 |
| 3-Upper | 0.8 | 1.8 |

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | 0.35 |
| Gear effect: | no | 0.1 |
| Interaction effect: | no | 0.5 |

Y'=(Y+1)^-2 (does not normalize)

| | | p-value |
|---|---|---|
| Location Effect: | **yes** | 0.0008 |
| Gear effect: | no | 0.22 |
| Interaction effect: | no | 0.42 |

| Pair-wise Comparisons | p-value |
|---|---|
| Lower-Upper | 0.0005 |
| Lower-Middle | non-sig |
| Middle-Upper | non-sig |
| Gear are non-significant | |