

Fossil Creek Fish Monitoring

Final 2008 Annual Report

Paul C. Marsh, Jerome A. Stefferud, and Sally E. Stefferud

Prepared for Robert W. Clarkson, U.S. Bureau of Reclamation, Phoenix, Arizona

In partial fulfillment of Reclamation Agreement No. 05-CS-32-0180

Marsh & Associates, LLC, Chandler, Arizona

February 20, 2009

Pertinent Findings

Three stream reaches within Fossil Creek were sampled in spring (May) and autumn (August-September) 2008 with baited minnow traps and hoop nets. The purpose of our surveys was to document post restoration project composition and status of the fish community, with emphasis on documenting success of the non-native removal. Six fish species, all native, were encountered within the study area: longfin dace *Agosia chrysogaster*, headwater chub *Gila nigra* plus roundtail chub *Gila robusta*,¹ speckled dace *Rhinichthys osculus*, Sonora sucker *Catostomus insignis*, and desert sucker *Pantosteus clarki*. No non-native fish were detected. Results overall were similar to samples acquired using the same methods during 2005, 2006, and 2007 and provided in earlier reports. Longfin dace was encountered for the first time in autumn 2008 and occurred only in the lower reach; all other species were found in all three reaches. Documentation of longfin dace and chubs immediately above the constructed fish barrier indicate their dispersal downstream from stocking-restocking sites. The composite seasonal samples comprised 2,923 individuals (719 and 2,204 in spring and autumn, respectively). Adult minnows and young-of-year suckers predominated the catch in spring, while age-0 individuals of all species were predominant in autumn. Exclusive of undetermined young-of-year catostomids that comprised about 12% of the spring sample, seasonal differences in relative abundance varied little within species: chubs comprised about 55 and 62%, speckled dace 13 and 27%, Sonora sucker 14 and 8%, and desert sucker 6 and 3% of total numbers in spring and autumn, respectively. Total catch per unit effort (CPUE, number of fish per overnight set) was generally similar to previous samples, with exceptions of relatively high autumn catch in upper and lower reaches, due to chubs and speckled dace in the former instance and to speckled dace in the latter. CPUE otherwise was variable across seasons, reaches, methods, and species. Non-native northern crayfish *Orconectes virilis* was taken in all reaches; its numbers appear stable or increasing. Native Sonora mud turtle *Kinosternon sonoriense* was collected in all reaches

¹ Headwater and roundtail chubs are difficult to differentiate in the field without harm to individual fish; we did not separate the two, and refer here to the two species collectively as “chub.”

and native lowland leopard frog *Rana yavapaiensis* was observed in the upper reach. All animals were released at the site of capture.

Introduction

Background information on Fossil Creek (Fig. 1) and its restoration can be found in a rich and diverse suite of published and unpublished literature including the following: (Minckley and Brooks 1985, Barrett and Maughan 1995, Roberson et al. 1996, APS 1992, Chamberlain 1904, Bouchard and Associates 1995, EnviroNet 1998, FERC 2004, Anon 2005 and abundant references therein, and Weedman et al. 2005). Post-project fish monitoring data are in Marsh et al. (2006, 2007, and 2008).

This report presents results of 2008 annual post-project (i.e., stream renovation, native fish repatriation, and flow restoration) 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 first implemented in autumn 2005 (Marsh et al. 2006), and has been followed since with few and minor modifications. The protocol is subject to future 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 briefly here as performed during spring (May 12-15) and autumn (August 28-29 and September 23-25) 2008.

Three sample reaches (Fig. 1, Table 2) were designated along the approximately 11.3 km stream course between the constructed fish barrier and the “High Falls” located about 1.9 km upstream from Irving at RK 18.4 (measured upstream from the Verde River confluence). Reaches were designated lower (down-) to upper (upstream) as follows: “Above (constructed) Barrier,” (a 0.45 km reach in vicinity of Pool 28), “Below Irving” (a 1.9 km reach between Pool 16 and Irving) and “Below High Falls” (a 1.7 km reach between Irving and the High Falls).

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; 20 baited minnow traps and 10 baited hoop nets were deployed overnight in each reach.

Fishes retrieved from collection gears were identified to species and enumerated by age (size) class according to the convention 0 = young-of-year of species that attain relatively large adult body size, and 1+ = typically adult individuals, 1 or more years of age, for fish that attain large body size; fish that remain relatively small throughout life were not aged. For practical purposes, we considered fish shorter than about 10 cm total length to

represent age-0 and fish longer than 10 cm to represent age-1+. All captured fish were released unharmed near the site of capture.

Fish collections were augmented by visual observations obtained by snorkeling. One large pool in each sample reach, plus a fourth located between lower and middle reaches, were designated for routine evaluation, and 2-4 persons each spent 10 or more minutes during daylight hours 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 durations did not differ among reaches for the autumn 2005 sample (two-sample t-test, $df = 9$, $\alpha > 0.10$; Noether 1971) and 2006, 2007, and 2008 set times were similar, so catch per unit effort (CPUE, number of fish per overnight minnow trap or hoop net set) was calculated and presented for each standardized monitoring data set for each reach (see Marsh et al. 2008). No statistical treatment was applied to the 2008 data. Results below are presented separately for spring and autumn seasons.

Monitoring Results

Spring 2008 minnow traps and hoop nets

The stream was at base flow and water was clear. Evidence of a prior flood flow was provided by re-set substrates and debris deposited more than 2-m (in places) above the stream channel. A USGS gauge on nearby East Verde River recorded flows exceeding 2,000 cfs in that stream in late February 2008.

Above Fish Barrier (lower reach, Fig. 1).--Ten minnow traps and 6 hoop nets were set downstream from pool 28 (Fig. 1), 6 minnow traps and 2 hoop nets were set in and immediately upstream of pool 28, and 4 minnow traps plus 2 hoop nets were deployed upstream from pool 26 between 1450 and 1645 hrs on May 12. Minnow traps and hoop nets were retrieved in a cold rain between 0910 and 1010 hrs on May 13; nominal set duration was 16.9 hrs.

Catch per unit effort (CPUE, number of fish per overnight set) data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Chub, Sonora sucker, desert sucker, and undetermined post-larval suckers were captured (Tables 3 and 4). Total minnow trap catch was 71 individuals (range 0-40 per trap) and CPUE was 3.55. Total hoop net catch was 35 fish (chub and the two suckers; range 0-14 per net) and CPUE was 3.50. All chubs were age-1+, two were adult males exhibiting breeding coloration, and estimated maximum size was 25 cm.

Northern crayfish also were in 2 of 20 minnow traps and 4 of 10 hoop nets (Table 4). There were 0-1 per minnow trap (2 total, CPUE = 0.10) and 0-3 per hoop net (7 total, CPUE = 0.70). One adult Sonora mud turtle was in a hoop net.

Below Irving (middle reach, Fig. 1).--Twenty minnow traps and 10 hoop nets were set between 1220 and 1330 hrs on May 13. Gear was retrieved between 0940 and 1140 hrs on May 14; nominal set duration was 16.2 hrs.

CPUE data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Chub, speckled dace, Sonora sucker, and desert sucker were captured (Tables 3 and 5). Total minnow trap catch (all species combined) was 121 individuals (range 0-20 per trap) and CPUE was 6.05. Total hoop net catch (all species combined) was 258 fish (range 1-107 per net) and CPUE was 28.5.

Chubs were the most abundant species overall in both gears (Table 5). They comprised 93% of the minnow trap catch (CPUE = 5.60) and 86% of the hoop net catch (CPUE = 22.20). All chubs were age-1+ adults and represented multiple age/year classes. Speckled dace was the second most abundant fish in minnow traps (total catch = 6, CPUE = 0.30), and was absent from hoop nets. Sonora sucker comprised < 1% of fish in minnow traps (total catch = 1, CPUE = 0.05), but comprised about 13% of fish in hoop nets (total catch = 33, CPUE = 3.30). All Sonora suckers in both minnow traps and hoop nets were age-1+ adults representing multiple age/year classes. Desert sucker was rare and represented in minnow traps by only one age-0 fish (CPUE = 0.05) and in hoop nets by three age-1+ fish (CPUE = 0.30).

Northern crayfish was in one hoop net (1 individual). Three Sonora mud turtle were in two hoop nets.

High Falls (upper reach, Fig. 1).--Twenty minnow traps and 10 hoop nets were set between 1350 and 1530 hrs on May 13 and retrieved the next day between 0845 and 1045 hrs; nominal set time was 19.3 hrs.

CPUE data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Chub, speckled dace, desert sucker, Sonora sucker, and desert x Sonora hybrids were captured (Tables 3 and 6). Total minnow trap catch (all species combined) was 140 individuals (range 0-32 per trap) and CPUE was 7.00. Total hoop net catch (all species combined) was 94 fish (range 1-63 per net) and CPUE was 9.40.

Chub was the third most abundant species in minnow traps (total catch = 17, CPUE = 0.85) and the most abundant in hoop nets (total catch = 33, CPUE = 3.3); all chub were age-1+ adults (Table 6). Speckled dace was the most abundant fish in minnow traps (58% of total catch, CPUE = 4.05) and the least abundant species in hoop nets (total catch = 3, CPUE = 0.30). Sonora sucker was absent in minnow traps, but comprised 33% of fish in hoop nets (total catch = 31, all age-1+; CPUE = 3.10). Desert sucker was uncommon in minnow traps (total catch = 5 age-1+ fish, CPUE = 0.25), and common in hoop nets (total catch = 25 age-1+ fish, CPUE = 2.50, range to 16 individuals per net). Undetermined young-of-year catostomids were common in both minnow traps (n = 37, CPUE = 1.85) and in hoop nets (n = 25, CPUE = 2.50). Two hybrid desert x Sonora sucker were captured in a hoop net.

Northern crayfish was absent from both minnow traps and hoop nets in this reach. Native lowland leopard frog *Rana yavapaiensis* adults were present, and one was taken by minnow trap. One Sonora mud turtle was taken in each of two hoop nets.

Spring 2008 underwater observations

Five pools were snorkeled during the sample period. One pool was within each of the “Above Barrier,” “Below Irving,” “High Falls” reaches and a fourth was between the two lower reaches. A visit also was made to the pools down- and upstream of the constructed fish barrier. Narratives for each are provided below, down- to upstream.

R.W. Clarkson (U.S. Bureau of Reclamation) visited the constructed fish barrier at 0900 hrs on May 12, 2008 and snorkeled two pools immediately upstream of the barrier and the long pool downstream from the barrier. Upstream, thousands of larval and post-larval fishes up to ca. 25 mm TL and four small northern crayfish were observed during approximately 40 minutes of immersion. Fish were solitary, in loose schools of scores, or widely scattered in group of perhaps 100 individuals. No large fishes of any kind were seen. Results were similar during about 15 minutes of observation downstream of the barrier, but numbers of larval and post-larval fishes were fewer there than upstream. One large northern crayfish was seen downstream. As upstream, no large fishes of any kind was encountered below the barrier.

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 1545 to 1600 on May 12 by four persons (1.00 hrs total effort). Clarity was approximately 10 m and visibility was very good. Small adults (15-20 cm length) of chub, desert sucker, and Sonora sucker were uncommon (fewer than 10 of each species). Larval-to-small juvenile (10-35 mm long) cypriniformes were abundant (thousands), apparently representing multiple cohorts, all young-of-year. No other fish species was detected. Northern crayfish was present but few; those seen were large.

We snorkeled the large pool below the FSR 708 bridge crossing downstream of Irving at approximate UTM 442164E, 3805847N (pool no. 16 in AZGFD stream reach 3A; Fig. 1) from 1508 to 1523 hrs (4 persons, total effort 1.00 hrs) on May 13. This pool was clear and visibility was good (10 m), but lighting was only fair because of cloud cover. Chub of all ages (3-4 year classes) and sizes (to 35 cm long) were common. Speckled dace was present but uncommon; four individuals were seen in the inflow chute at the head of the pool. Desert sucker was common in all sizes to 30 cm long and including breeding individuals of both sexes. Sonora sucker of all sizes to 45-50 cm long also were common. Young-of-year cypriniformes (10-35 mm long) were uncommon and found only in quiet peripheral areas. Northern crayfish was not observed

We snorkeled in the large, deep, steep sided, rock pool below the falls at Irving (approximately UTM 439526E, 380416N; pool no. 1 in AZGFD stream reach 3A; Fig. 1) from 1045 to 1100 hrs (1.00 hr total effort) on May 14. Visibility was good but cloudy

skies reduced available light. The pool outlet was cluttered with boulders to 0.5-m diameter and the previous wide channel was replaced by swift current rushing through the large rocks. Fish numbered in the 100s and were considered common. Chub was most abundant, followed by desert and Sonora suckers in similar numbers to each other. Speckled dace was present but rare, as were young-of-year cypriniformes. No other fish species was detected and northern crayfish was not encountered.

Four persons (1.00 hrs effort) 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) from 1500 to 1515 hrs on May 14. Visibility was good. The outlet channel on river right was blocked by debris and all flow exited the pool across a narrow lip on river left. Total fish numbers were relatively few, but there were multiple cohorts and all sizes of each species that was present. Chub, desert sucker, and Sonora sucker all were uncommon in open water and adjacent to rook walls of the main pool. Speckled dace was uncommon along the perimeter of the pool, and near the outlet in swift, shallow water. No northern crayfish were seen.

Autumn 2008 minnow traps and hoop nets

Above Barrier (lower reach, Fig. 1).--Ten minnow traps and 6 hoop nets were set downstream from pool 28 (Fig. 1), 6 minnow traps and 2 hoop nets were set in and immediately upstream of pool 28, and 4 minnow traps plus 2 hoop nets were deployed upstream from pool 26 between 1445 and 1515 hrs on September 24, 2008 and retrieved the next day between 0830 and 1100 hrs. Nominal fishing time was 19.0 hrs.

CPUE data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Longfin dace, chub, speckled dace, Sonora sucker, and desert sucker were captured (Tables 7 and 8). Total minnow trap catch was 446 individuals (all five species; range 1-49 per trap) and CPUE was 22.3. Total hoop net catch was 86 fish (chub and the two suckers; range 0-29 per net) and CPUE was 3.30.

Longfin dace comprised 16% of the minnow trap catch ($n = 16$; CPUE = 0.80). Chub was more than 85% of total minnow trap catch ($n = 382$, CPUE = 19.10) and was almost entirely age-0 (only 3, age-1+ chub were captured in minnow traps). Speckled dace was 1.3% ($n = 6$, CPUE = 0.3), Sonora sucker was 9.2% ($n = 41$, about half each were age-0 and age-1+; CPUE = 2.05), and desert sucker was 1% ($n = 1$; CPUE = 0.05) of the total minnow trap catch.

Chub (age classes combined) comprised 48% of hoop net catch ($N = 37$; CPUE = 4.10) and were predominated by age-1+ fish ($n = 37$). Sonora sucker (age classes combined) accounted for 47% of the catch ($N = 41$; CPUE = 4.10); most (33 of 41) were age-1+. Desert sucker was represented in the hoop net catch by 4, age-1+ individuals (5% of catch; CPUE = 0.40).

Northern crayfish also were in 9 of 20 minnow traps and 6 of 10 hoop nets (Table 8). There were 0-10 per minnow trap (34 total, CPUE = 1.70) and 0-13 per hoop net (33

total, CPUE = 3.30). One hoop net contained five Sonora mud turtle, and two others each contained one turtle.

Below Irving (middle reach, Fig. 1).—Twenty minnow traps and 10 hoop nets were set between 1354 and 1545 hrs on September 23, 2008 and retrieved the following day between 0800 and 1000 hrs. Average set time was 16.25 hrs.

CPUE data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Chub, speckled dace, and Sonora sucker were captured by minnow traps; total catch was 276 individuals (1-53 individuals per trap) and CPUE was 18.8 fish per set (Tables 7 and 9). Chub, speckled dace, Sonora sucker, and desert sucker were captured in hoop nets. Total catch was 222 fish (1-60 per net) and CPUE was 22.2 fish per set.

Chub comprised 79% of the minnow trap catch (total N = 218, CPUE = 10.90); most (134 of 218) were age-0 fish. Speckled dace contributed 19% of the minnow trap catch (N = 19; CPUE = 2.60). Sonora sucker was 2% of the minnow trap catch (N=6; CPUE = 0.30).

Chub comprised 93% of the hoop net catch (207 individuals; CPUE = 20.70); the great majority (200 of 207) were age-1+ fish. Speckled dace were represented by two individuals that comprised 1% of the hoop net catch; CPUE was 0.20. Sonora sucker was 5% of the hoop net catch (N = 12, CPUE = 1.20); all were age-1 fish. A single age-1+ desert sucker was captured in a hoop net, representing 1% of the catch (CPUE = 0.10).

Northern crayfish was in four minnow traps (CPUE=0.75) and there were 2-6 per trap (CPUE = 0.15). Crayfish was in 5 of 10 hoop nets (1-15 per net; CPUE=2.00). One juvenile Sonora mud turtle was taken from a minnow trap.

High Falls (upper reach, Fig. 1)--Twenty minnow traps and ten hoop nets were set between 1400 and 1630 hrs on August 28, 2008 and retrieved the next day between 0830 and 1050 hrs. Nominal set duration was 18.4 hrs.

CPUE data are summarized for each fish species (Figs. 2-6), for total fish (Fig. 7), and for northern crayfish (Fig. 8). Chub, speckled dace, Sonora sucker, and desert sucker were captured in minnow traps (Table 7 and 10). Total minnow trap catch (all species combined) was 1098 individuals (range 9-120 per trap) and CPUE was 54.90. The same four taxa were captured in hoop nets and the total hoop net catch (all species combined) was 76 fish (range 1-24 per net) and CPUE was 7.60 (Figs. 2 and 5).

Chub accounted for 45% of the minnow trap catch (N = 495; CPUE = 24.75); all were age-0 individuals. Speckled dace was 49% of the minnow trap catch (N = 535; CPUE = 26.75). Sonora sucker (all age-0) was 4% of total minnow trap catch (N = 44; CPUE = 2.20) and desert sucker was 2% of the minnow trap catch (N = 24; CPUE = 1.20).

Chub was 35% of the hoop net catch (N = 29; CPUE = 2.90). Most (18 of 29) were age-1+ fish. A single speckled dace (1% of catch; CPUE = 0.10) was captured in a hoop net. Sonora sucker was 27% of the catch (N = 21; CPUE = 2.10); most (14 of 21) were age-1+. Desert sucker was represented in the hoop net catch by 25 individuals (33% of catch; CPUE = 1.50); most (18 or 25) were age-0.

Northern crayfish was absent from minnow traps, but two hoop nets captured 1 and 2 individuals, respectively. A single Sonora mud turtle was in a hoop net.

Autumn 2008 underwater observations

Five pools were snorkeled during the autumn 2008 sample period. One pool was within each of the “Above Barrier,” “Below Irving,” “High Falls” reaches and a fourth was between the two lower reaches. A visit also was made to the pools down- and upstream of the constructed fish barrier. Narratives are provided below, down- to upstream.

The constructed fish barrier was visited on the morning of September 25, 2008 and the two pools upstream of the structure were examined by two individuals using snorkel gear. Approximately a dozen longfin dace were reliably observed in the first pool upstream, and numerous age-1+ chubs were seen in the second pool upstream. Sonora sucker was common, and young-of-year cypriniformes were throughout the area. One northern crayfish was seen in the second pool. The pool below the constructed barrier was not snorkeled, but two smallmouth bass (> 30 cm long) were observed there.

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 1340 to 1355 on September 24 by four persons (1.0 hr total effort). Visibility was fair. Substrates were covered with silty sediment. Fish were considered only common overall. Chubs of all sizes except very large were common. Sonora and desert suckers of all sizes and ages were uncommon and present in approximately equal abundance; some Sonora sucker were very large, ca. 50 cm long. No other fishes were observed. Northern crayfish was seen but numbers were small.

We snorkeled the large pool below the FSR 708 bridge crossing downstream of Irving at approximate UTM 442164E, 3805847N (pool no. 16 in AZGFD stream reach 3A; Fig. 1). It was examined from 1030 to 1050 hrs by three persons (1.00 hrs total effort) on September 24. Visibility was fair-to good. Chubs were abundant; most were 10-20 cm long, a few were very large, 30-cm or longer. Speckled dace was rare – only two individuals were seen. Sonora sucker, mostly 15-20 cm long, was uncommon-to-common along the bottom in the deepest water. Small and large desert suckers were uncommon in swift water at the head of the pool and along the vertical bedrock walls of the pool. No other fish species and no northern crayfish were detected.

We snorkeled in the large, deep, steep sided, rock pool below the falls at Irving (approximately UTM 439526E, 380416N; pool no. 1 in AZGFD stream reach 3A; Fig. 1)

from 1345 to 1405 hrs (3 persons, total effort 1.00 hrs) on September 23. Water had a greenish-gray cast, and visibility was fair even though the pool was in full sunlight at the time of our visit. Chubs 10-20 cm-long were abundant, those 20-30 cm-long were common, and fish longer than 30 cm were rare. Speckled dace was rare and confined largely to swift water near the substrate at the tail of the pool. Sonora sucker was rare and desert sucker was uncommon. No other fishes and no crayfish were seen.

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 1500 to 1510 hrs by four persons (0.67 hrs effort) on August 28. Visibility was very good in shade to excellent in sunlight. Overall fish abundance, especially of very large individuals, was relatively low. Young chubs were common but large fish were few. Speckled dace was relatively abundant for this site and was considered common overall; some very large individuals (to ca. 18-cm long) were present. Sonora sucker of all sizes was uncommon, while desert sucker of all sizes was common. No other fishes were observed, and no northern crayfish were detected.

Miscellaneous observations.—Three small, non-vocal adult frogs, presumed to be native lowland leopard frog *Rana yavapaiensis*, were seen a short distance downstream from the “High Falls.” Right pectoral fin clips were taken from two series of age-1+ *Gila*, one upstream from Irving and one downstream, and fixed in 95% ethanol for genetic analysis by Dr. Thomas Dowling, School of Life Sciences, Arizona State University, Tempe.

Sample Comparisons

Fossil Creek fish monitoring has been conducted on seven occasions since the 2004 completion of the stream restoration project: four times in autumn, (August-September-October) 2005, 2006, 2007, and 2008, and three in spring (May-June) 2006, 2007, and 2008. Catch per unit effort data for each seasonal sample are summarized by fish species, total fish, and crayfish by reach and gear (minnow trap and hoop net) in Table 11.

Spatial relationships

Relative to past monitoring results, total catch per unit effort (CPUE) in minnow traps in autumn 2008 was substantially greater in the upper and lower reaches (Table 11). This was due to exceptional catches of mostly age-0 chubs in both reaches, and of speckled dace in the upper reach. Otherwise, spatial patterns in fish CPUE are unremarkable.

Non-native northern crayfish has consistently been most abundant in the lower reach, and 2008 samples were no exception. Importantly, CPUE was near or above previously recorded values in both minnow traps and hoops nets in both middle and lower reaches. Abundance of this organism has appeared stable or decreasing since 2005, and it is too early to determine if our most recent data foretell an upward trend in abundance.

Temporal relationships

Estimates of non-native northern crayfish abundance have been consistently highest in autumn samples, and such was the case in 2008 (Table 11). More importantly, as noted above, CPUE in autumn 2008 was among the highest recorded in both middle and lower reaches and in both gear types. However, it is premature to determine if a trend exists.

Summary

No non-native fishes were detected in the treatment reach of Fossil Creek during monitoring surveys performed May and August-September 2008, and we are not aware of any verifiable reports of any non-native fish in the stream since it was treated in autumn 2004. Six native fishes, longfin dace, headwater chub plus roundtail chub, speckled dace, Sonora sucker, and desert sucker were present. Populations of all species were recruiting and appeared healthy; we have not noted any external parasites or indications of disease. Native lowland leopard frog and Sonora mud turtle also were encountered. Non-native crayfish are present and appear stable or locally increasing.

Longfin dace was found in autumn 2008 only in the lowermost reach, but this represents our first encounter with the species since its repatriation in 2004. It is unknown if these are attributed to the repatriation event, or to subsequent stocking (see Weedman et al. 2005, Carter 2008; Table 12). Future monitoring should help determine if a population is re-established. Speckled dace was in upper and middle reaches in spring, and was taken for the first time from the lower reach in autumn 2008. This fish may be expanding its range within the stream. Chubs, and Sonora and desert sucker were in all three reaches in both spring and autumn, and population of all are substantial and recruiting. Numbers of all species were greater in autumn than in spring because of the abundance of age-0 individuals. Chubs were the most abundant species overall and represented more than one-half of the total catch. Speckled dace were second in overall abundance, followed by either Sonora sucker or desert sucker, depending on the season. Longfin dace was the rarest fish in our samples, but observation of this species and chubs immediately above the constructed fish barrier indicate their dispersal downstream from stocking-restocking sites (see Carter 2008; Table 12).

Reintroductions of other species including threatened loach minnow *Tiaroga cobitis* and spikedace *Meda fulgida* and endangered razorback sucker *Xyrauchen texanus* and Sonora (Gila) topminnow *Poeciliopsis occidentalis* were implemented beginning in November 2007, but we have encountered none of these fishes.

Acknowledgements

R. W. Clarkson provided valuable field assistance during our 2008 monitoring of Fossil Creek fishes and we appreciate his hard work and camaraderie. Collections were under permit authorization of the State of Arizona.

Literature Cited

- Anonymous. 2005. Fossil Creek: state of the watershed report. Northern Arizona University, Flagstaff.
- APS (Arizona Public Service Company). 1992. Application for new license for major project – existing dam – for the Childs Irving Hydroelectric Project, FERC Project No. 2069. Phoenix, Arizona.
- Barrett, P.J., and O.E. Maughan. 1995. Spatial habitat selection of roundtail chub (*Gila robusta*) in two central Arizona streams. *Southwestern Naturalist* 40:301-307.
- Bouchard & Associates. 1998. Fossil Creek hydrology and travertine geomorphology, FERC Project No., 2069-003. Final Report, Arizona Public Service Company, Phoenix.
- Carter, C. 2008. Fossil Creek longfin dace stocking, February 12, 2008. Arizona Game and Fish Department, Phoenix. 3 pages (processed).
- Chamberlain, F.W. 1904. Field notes on Fossil Creek, Arizona. Unpublished report, Smithsonian Institution Archives, Washington, DC.
- EnviroNet. 1998. Biological Report. Fossil Creek, Arizona. Arizona Public Service Company Childs & Irving Hydroelectric Plant Relicensing. Federal Regulatory Energy Commission.
- FERC (Federal Energy Regulatory Commission. 2004. Final environmental assessment for surrender of license. Childs Irving. FERC Project 2069-007. Office of Energy Projects, Division of Hydropower – Environment and Engineering. Washington, DC.
- Geoghegan, P. 1996. The management of quality control and quality assurance systems in fisheries science. *Fisheries* 21: 14-18.
- Kutner, M. H., C. J. Nachtsheim, J. Neter, and W. Li. 2005. *Applied Linear Statistical Models*. Fifth Edition. New York, McGraw-Hill/Irwin. 1,396 pages.
- Marsh, P. C. 2005. Fossil Creek fish monitoring. Volume II, Technical Proposal, U.S. Bureau of Reclamation Solicitation No. 05SP320180 dated 04/11/2005. Chandler, AZ. Revised 25 July 2005.
- Marsh, P. C., J. A. Stefferud, and S. E. Stefferud. 2006. Fossil Creek Fish Monitoring Annual Report. U.S. Bureau of Reclamation Agreement No. 05-CS-32-0180. Chandler, AZ. 22 pages.
- Marsh, P. C., J. A. Stefferud, and S. E. Stefferud. 2007. Fossil Creek Fish Monitoring Annual Report. U.S. Bureau of Reclamation Agreement No. 05-CS-32-0180. Chandler, AZ. 29 pages.
- Marsh, P. C., J. A. Stefferud, and S. E. Stefferud. 2008. Fossil Creek Fish Monitoring

Annual Report. U.S. Bureau of Reclamation Agreement No. 05-CS-32-0180. Chandler, AZ. 29 pages.

Minckley, W.L., and J.E. Brooks. 1985. Transplantations of native Arizona fishes: records through 1980. *Journal of the Arizona-Nevada Academy of Sciences* 20:73-89.

Noether, G. 1971. *Introduction to statistics a fresh approach*. Houghton Mifflin Co., Boston MA. 253 pages.

Roberson, J., S. Reger, and C. Benedict. 1996. Fossil Creek fish management report summary of survey data 1994-1996. Statewide Fisheries Investigation Survey of Aquatic Resources Federal Aid Project F-7-M-38. Arizona Game and Fish Department, Flagstaff. Unpaginated.

Weedman, D. A., P. Sponholtz, and S. Hedwall. 2005. Fossil Creek native fish restoration project. Final Project Report, AZGFD, Phoenix. 53 pages.

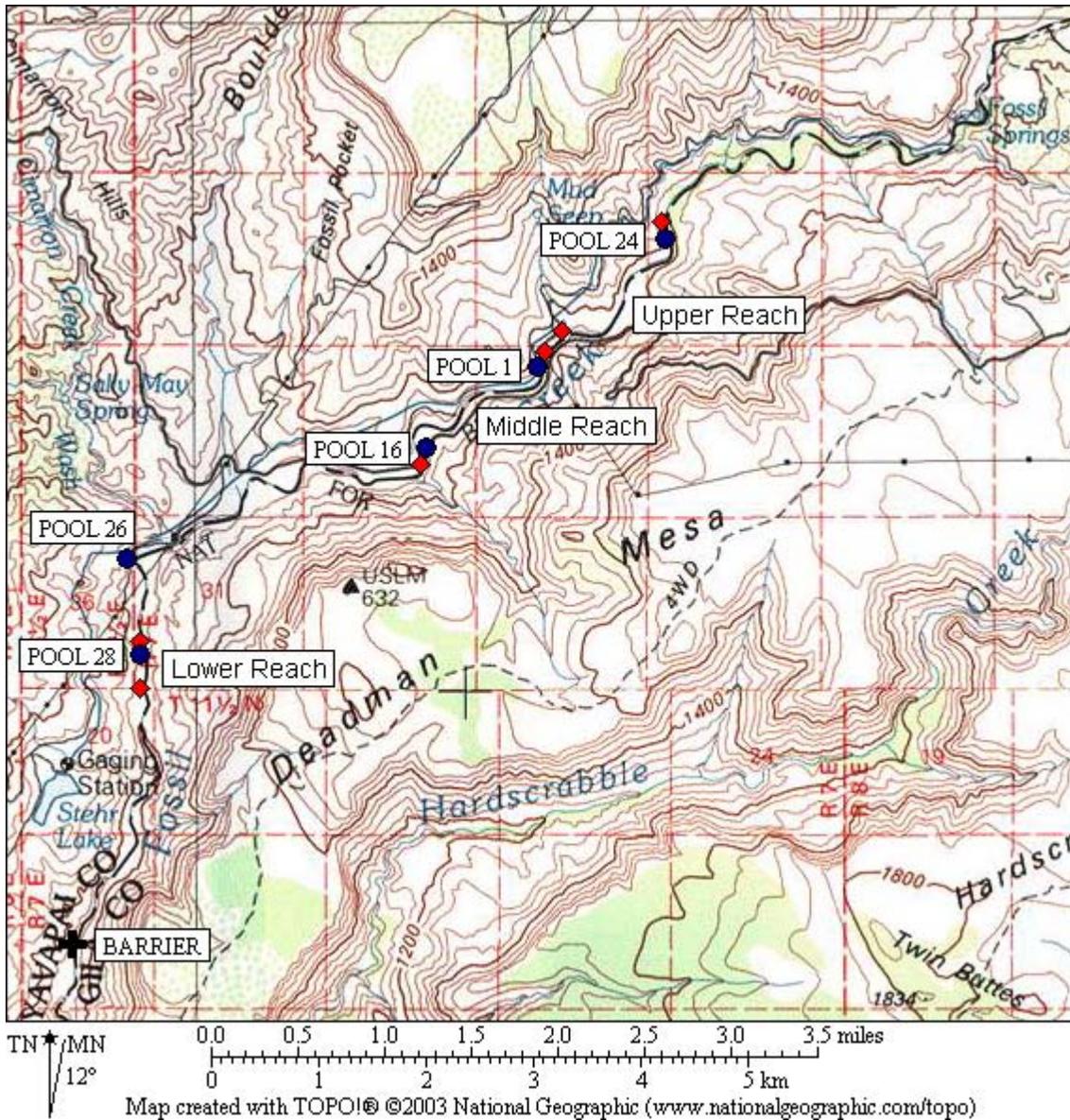


Figure 1. Map of Fossil Creek, Gila and Yavapai counties, Arizona, from Fossil Springs downstream to a constructed fish barrier (+), showing approximate upper, middle, and lower reach boundaries (red diamonds) and pools (blue circles) related to fish monitoring May and September-October 2007. See text and Table 2 for additional information, reach designations, and boundary coordinates.

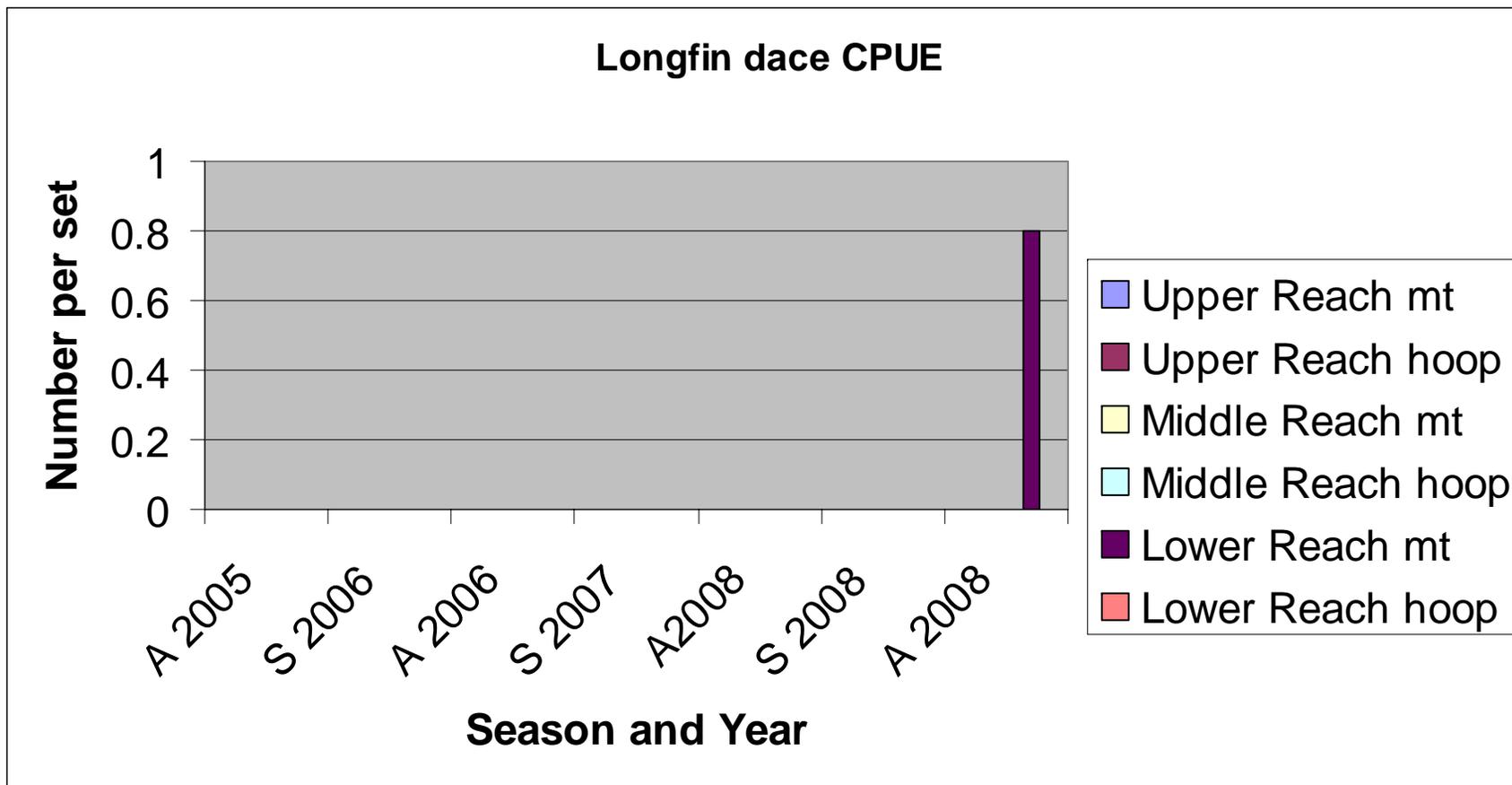


Figure 2. Catch per unit effort (number of fish per overnight set) for longfin dace, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona.

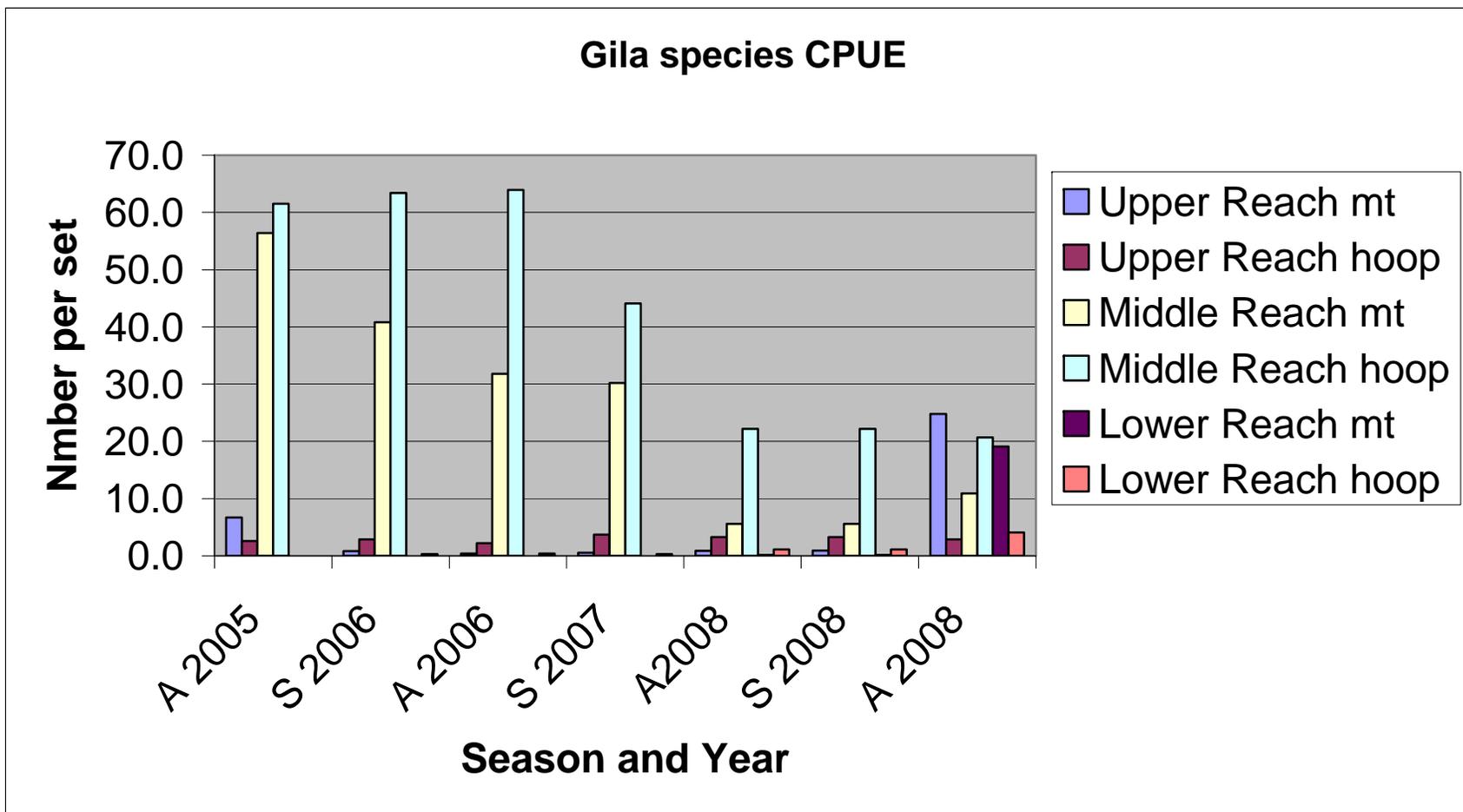


Figure 3. Catch per unit effort (number of fish per overnight set) for *Gila* species (chubs), by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona.

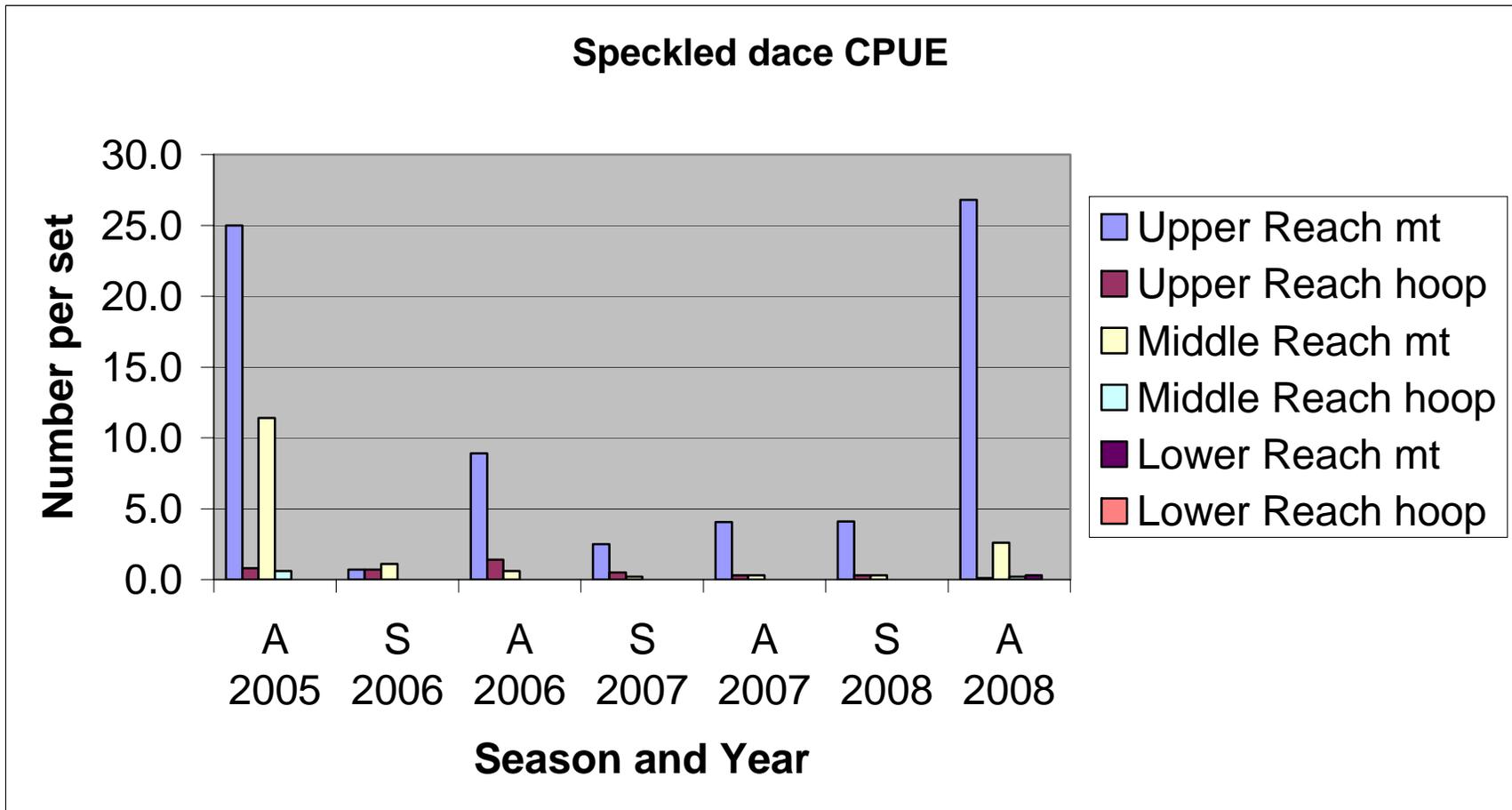


Figure 4. Catch per unit effort (number of fish per overnight set) for speckled dace, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona.

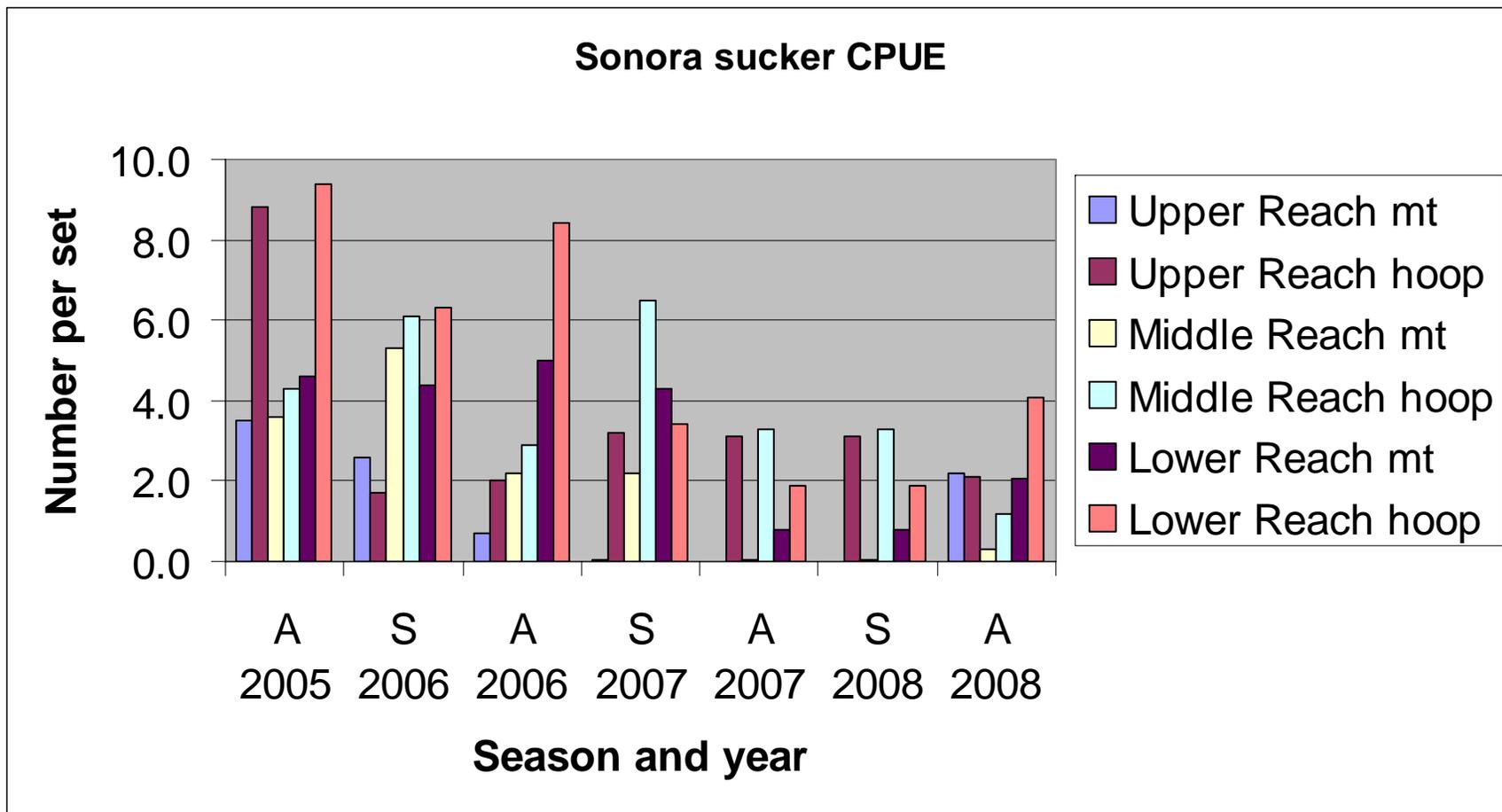


Figure 5. Catch per unit effort (number of fish per overnight set) for Sonora sucker, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona

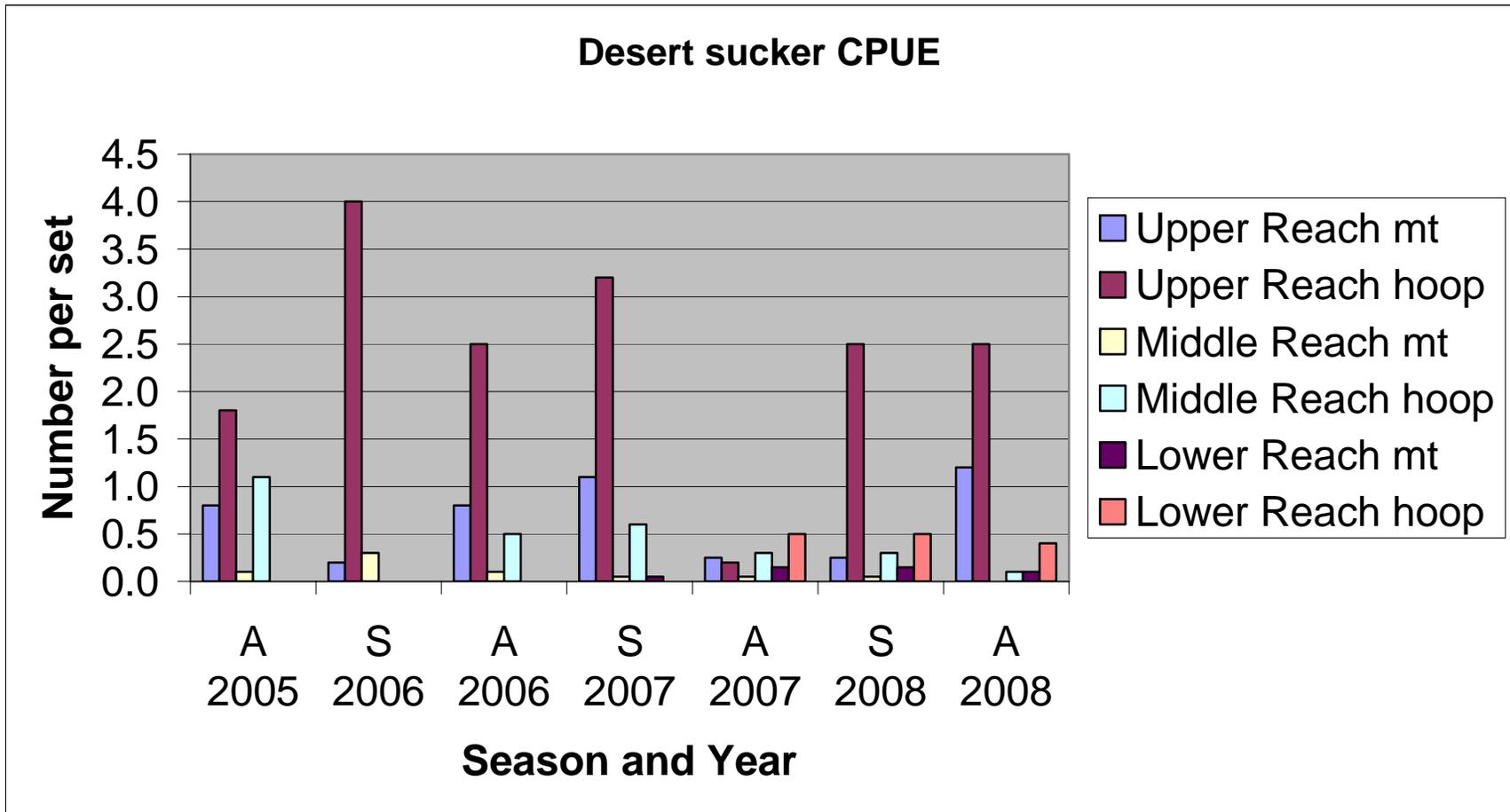


Figure 6. Catch per unit effort (number of fish per overnight set) for desert sucker, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona

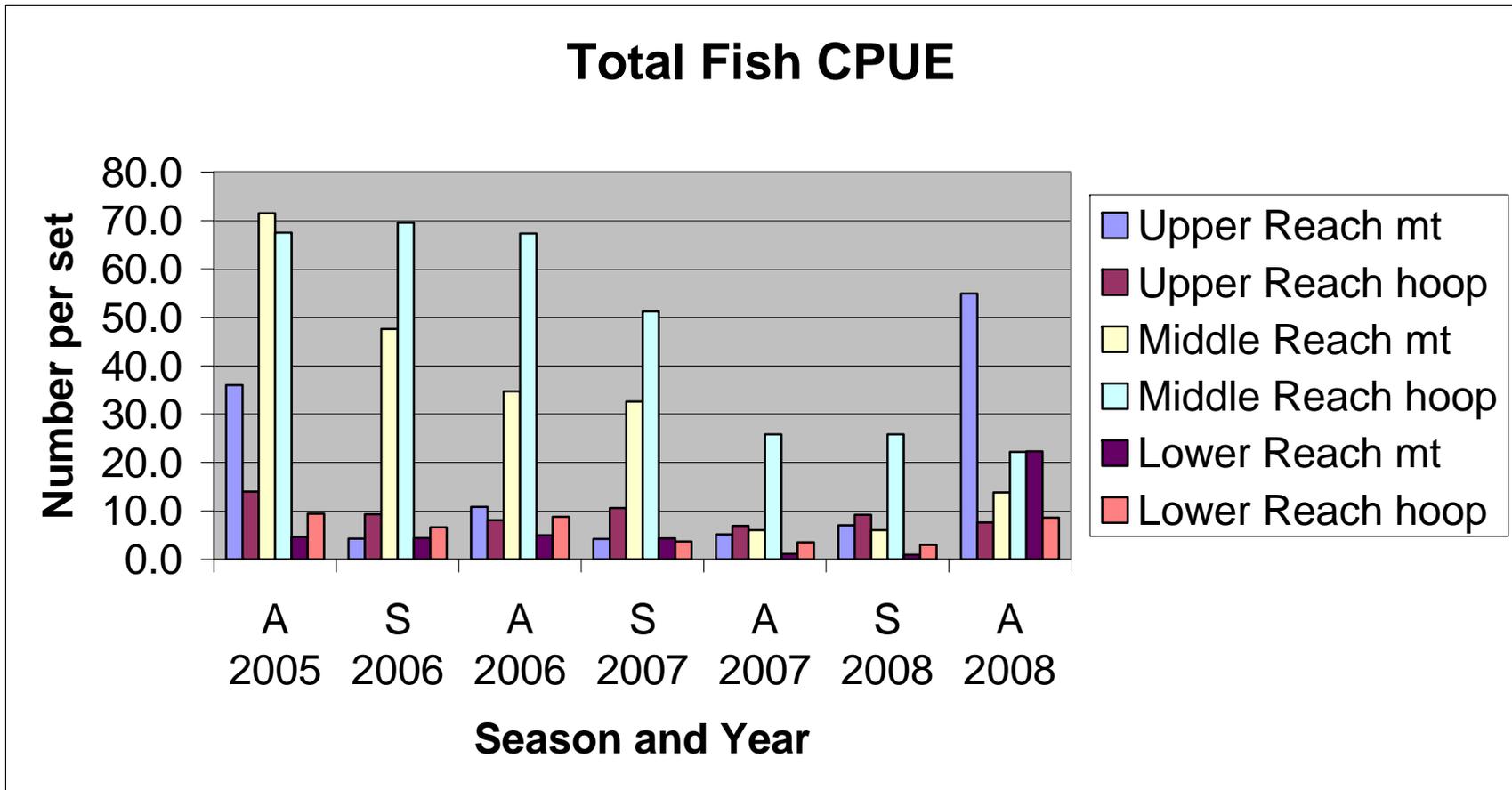


Figure 7. Catch per unit effort (number of fish per overnight set) for total fish, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona.

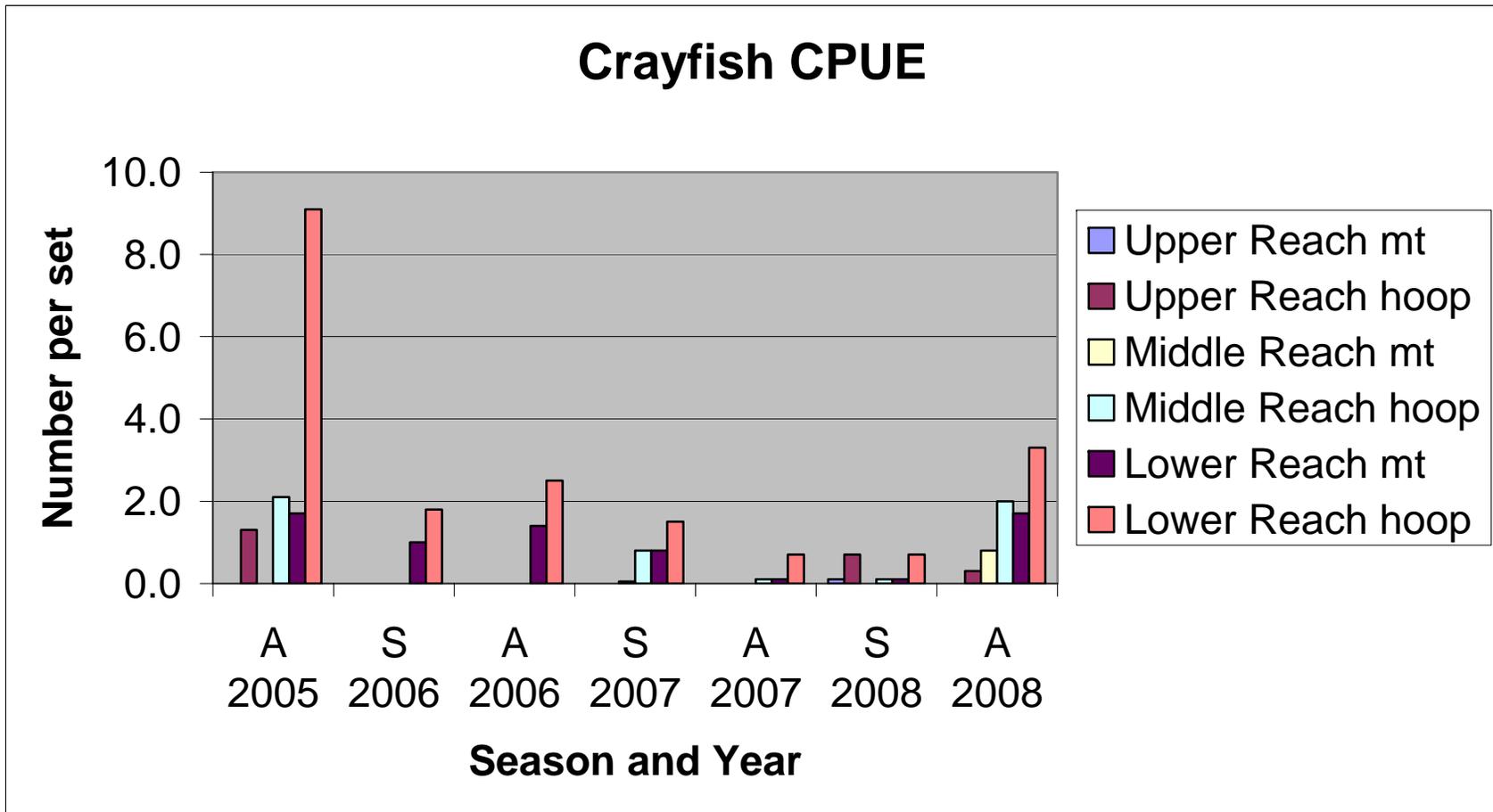


Figure 8. Catch per unit effort (number of fish per overnight set) for crayfish, by season (A = autumn, S = spring) and year (2005-2008) for three reaches (upper, middle, and lower; see Fig. 1) and two gear types (mt = minnow trap, hoop = hoop net) in Fossil Creek, Arizona.

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. Native species that have been or are planned to be stocked independent of the salvage and post-restoration repatriation program are indicated by \$ or \$P, respectively. See footnote on page 1 relative to treatment of headwater and roundtail chubs.

Minnows (Cyprinidae)

*Longfin dace, *Agosia chrysogaster* (Agochr)

Common carp, *Cyprinus carpio*

*Headwater chub, *Gila nigra* (Gilasp)

\$*Loach minnow, *Tiaroga cobitis*

*Roundtail chub, *Gila robusta* (Gilasp)

\$*Spikedace, *Meda fulgida*

*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*

Killifishes (Cyprinodontidae)

\$P*Desert pupfish, *Cyprinodon macularius*

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 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.

Reach designation	Lower UTM	Upper UTM	Length (km [mi])
Above Barrier (lower)	439523E-3803732N	439526E-3804165N	0.45 (0.28)
Below Irving (middle)	442157E-3805817N	443295E-3806787N	1.87 (1.16)
High Falls (upper)	443493E-3807060N	444433E-3808074N	1.69 (1.05)

Table 3. Summary of Fossil Creek fish monitoring data, Spring (May 12-15) 2008.

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

	age (0/1)	Upper Reach		Middle Reach		Lower Reach		Total
		mt	hoop	mt	hoop	mt	hoop	
Gilasp	1	17	33	112	222	3	11	398
Rhiosc	n/a	81	3	6	0	0	0	90
Catins	1	0	31	1	33	16	19	100
Pancla	0	0	0	1	0	0	0	1
	1	5	25	0	3	3	5	41
sucker hybrid	1	0	2	0	0	0	0	2
undet. suckers	0	37	0	1	0	49	0	87
Total		140	94	121	258	71	35	719
Crayfish		0	0	0	1	2	7	10
Lowland leopard frog		1	0	0	0	0	0	1
Sonora mud turtle		0	2	0	3	0	1	6

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

	age (0/1)	Upper	Middle	Lower	Total
		Reach	Reach	Reach	
Gilasp	1	50	334	14	398
Rhiosc	n/a	84	6	0	90
Catins	1	31	34	35	100
Pancla	0	0	1	0	1
	1	7	3	8	18
sucker hybrid	1	2	0	0	2
undet. suckers	0	37	1	49	87
Total		234	379	106	719
Crayfish		0	1	9	10
Lowland leopard frog		1	0	0	1
Sonora mud turtle		2	3	1	6

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

	age (0/1)	Upper Reach		Middle Reach		Lower Reach	
		mt	hoop	mt	hoop	mt	hoop
Gilasp	1	0.85	3.30	5.60	22.20	0.15	1.10
Rhiosc	n/a	4.05	0.30	0.30	0.00	0.00	0.00
Catins	1	0.00	3.10	0.05	3.30	0.80	1.90
Pancla	0	0.00	0.00	0.05	0.00	0.00	0.00
	1	0.25	2.50	0.00	0.30	0.15	0.50
sucker hybrid	1	0.00	0.20	0.00	0.00	0.00	0.00
undet. suckers	0	1.85	0.00	0.05	0.00	2.45	0.00
Total		7.00	9.40	6.05	25.80	3.55	3.50
Crayfish		0.00	0.00	0.00	0.10	0.10	0.70
Sonora mud turtle		0.00	0.20	0.00	0.30	0.00	0.10

Table 4. Fossil Creek standard fish monitoring data, Above Barrier (lower) reach, Spring (May 12-15) 2008.

Site: **LOWER REACH**
 Date: 12-15 May 2008

Gear type: **Minnow Traps (n = 20)**
 Nominal set/run times: 1545-0940 Nominal set duration: 16.9 hours

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10
Gila	1	0	0	0	0	0	0	0	0	0	0
Catins	1	0	0	0	0	0	0	2	2	2	0
Pancla	1	0	0	0	0	1	0	0	0	2	0
undet. suckers	0	0	40	1	8	0	0	0	0	0	0
subtotal		0	40	1	8	1	0	2	2	4	0
Crayfish		0	1	0	0	0	0	0	0	1	0

Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Gila	1	0	0	0	0	0	0	0	3	0	0	3	0.15
Catins	1	0	1	2	3	0	0	0	4	0	0	16	0.80
Pancla	1	0	0	0	0	0	0	0	0	0	0	3	0.15
undet. suckers	0	0	0	0	0	0	0	0	0	0	0	49	2.45
subtotal		0	1	2	3	0	0	0	7	0	0		0.00
Total		0	41	3	11	1	0	2	9	4	0	71	0.95
Crayfish		0	0	0	0	0	0	0	0	0	0	2	0.10

Gear type: **Hoop Nets (n = 10)**
 Nominal set/run times: 1545-0940 Nominal set duration: 16.9 hours

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	1	0	0	1	0	0	2	0	0	0	8	11	1.10
Catins	1	0	0	6	2	0	0	1	0	4	6	19	1.90
Pancla	1	0	1	2	0	0	0	2	0	0	0	5	0.50
Total		0	0	7	2	0	2	1	0	4	14	35	3.00
Crayfish		0	1	0	1	3	0	0	0	2	0	7	0.70
Mud turtle		0	0	0	0	0	0	0	0	0	1	1	0.10

Table 5. Fossil Creek standard fish monitoring data, Below Irving (middle) reach, Spring (May 12-15) 2008.

Site: **MIDDLE REACH**
 Date: 12-15 May 2008

Gear type: **Minnow Traps (n = 20)**
 Nominal set/run times: 1455-0905 Nominal set duration: 16.2 hr

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10
Gilasp	1	0	2	4	7	6	6	5	5	0	0
Rhiosc	n/a	0	0	0	0	0	0	0	0	0	1
Catins	1	0	0	0	0	1	0	0	0	0	0
Pancla	0	0	0	0	0	0	0	0	0	0	1
undet. suckers	0	0	1	0	0	0	0	0	0	0	0
subtotal		0	3	4	7	7	6	5	5	0	2

Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Gilasp	1	3	13	7	8	8	11	7	3	1	16	112	5.60
Rhiosc	n/a	0	0	0	0	0	1	0	0	0	4	6	0.30
Catins	1	0	0	0	0	0	0	0	0	0	0	1	0.05
Pancla	0	0	0	0	0	0	0	0	0	0	0	1	0.05
undet. suckers	0	0	0	0	0	0	0	0	0	0	0	1	0.05
subtotal		3	13	7	8	8	12	7	3	1	20		
Total		3	16	11	15	15	18	12	8	1	22	121	6.05

Gear type: **Hoop Nets (n = 10)**
 Nominal set/run times: 1455-0905 Nominal set duration: 16.2 hr

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	1	18	58	90	21	3	14	6	1	10	1	222	22.20
Catins	1	3	4	17	2	0	3	0	0	3	1	33	3.30
Pancla	1	0	0	0	0	1	0	0	0	2	0	3	0.30
Total		21	62	107	23	4	17	6	1	15	2	258	25.80
Crayfish		0	1	0	0	0	0	0	0	0	0	1	0.10
Mud turtle		0	0	1	0	0	0	2	0	0	0	3	0.30

Table 6. Fossil Creek standard fish monitoring data, High Falls (upper) reach, Spring (May 12-15) 2008.

Site: **UPPER REACH**
 Date: 12-15 May 2008

Gear type: **Minnow Traps (n = 20)**
 Nominal set/run times: 1430-0945 Nominal set duration: 19.3 hr

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10
Gilasp	1	1	2	0	2	0	0	0	0	0	0
Rhiosc	n/a	0	0	9	0	0	2	0	2	1	1
Pancla	1	0	1	0	0	0	0	0	0	0	0
undet. suckers	0	0	0	0	0	0	1	0	0	0	0
subtotal		1	3	9	2	0	3	0	2	1	1
lowland leopard frog		1	0	0	0	0	0	0	0	0	0

Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Gilasp	1	1	0	2	0	5	2	1	0	1	0	17	0.85
Rhiosc	n/a	3	7	5	5	7	13	0	26	0	0	81	4.05
Pancla	1	0	0	0	0	0	0	0	4	0	0	5	0.25
undet. suckers	0	0	0	0	0	0	4	0	2	0	30	37	1.85
subtotal		4	7	7	5	12	19	1	32	1	30		
Total		5	10	16	7	12	22	1	34	2	31	140	7.00
lowland leopard frog		0	0	0	0	0	0	0	0	0	0	1	0.05

Gear type: **Hoop Nets (n = 10)**
 Nominal set/run times: 1430-0945 Nominal set duration: 19.3 hr

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	1	1	4	0	23	0	1	0	4	0	0	33	3.30
Rhiosc	n/a	1	2	0	0	0	0	0	0	0	0	3	0.30
Catins	1	0	2	0	24	0	0	3	2	0	0	31	3.10
Pancla	1	0	0	1	16	1	0	0	3	0	4	25	2.50
sucker hybrid	1	0	2	0	0	0	0	0	0	0	0	2	0.20
Total		2	8	1	63	1	1	3	9	0	4	94	9.40
Sonora mud turtle		1	0	0	0	0	0	0	0	1	0	2	0.20

Table 7. Summary of Fossil Creek fish monitoring data, Autumn (August 28-29 and September 22-24) 2008.

Table 7A. Total catch by reach and method, all standard samples; mt = minnow trap, hoop = hoop net

Species	age (0/1)	Upper Reach		Middle Reach		Lower Reach		Total
		mt	hoop	mt	hoop	mt	hoop	
Agochr	n/a	0	0	0	0	16	0	16
Gilasp	0	495	11	134	7	379	37	1063
	1	0	18	84	200	3	4	309
Rhiosc	n/a	535	1	52	2	6	0	596
Catins	0	44	7	6	12	22	8	99
	1	0	14	0	0	19	33	66
Pancla	0	24	18	0	0	1	0	43
	1	0	7	0	1	0	4	12
Total		1098	76	276	222	446	86	2204
Crayfish		0	3	15	20	34	33	105
Sonora mud turtle		0	1	1	0	0	7	9

Table 7B. Total catch by reach, methods combined, all standard samples

Species	age (0/1)	Upper	Middle	Lower	Total
		Reach	Reach	Reach	
Agochr	n/a	0	0	16	16
Gilasp	0	506	141	416	1063
	1	18	284	7	309
Rhiosc	n/a	536	54	6	596
Catins	0	51	18	30	99
	1	14	0	52	66
Pancla	0	42	0	1	43
	1	7	1	4	12
Total		1174	498	532	2204
Crayfish		3	35	67	105
Sonora mud turtle		1	1	7	9

Table 7C. 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

Species	age (0/1)	Upper Reach		Middle Reach		Lower Reach	
		mt	hoop	mt	hoop	mt	hoop
Agochr	n/a	0.00	0.00	0.00	0.00	0.80	0.00
Gilasp	0	24.75	1.10	6.70	0.70	18.95	3.70
	1	0.00	1.80	4.20	20.00	0.15	0.40
Rhiosc	n/a	26.75	0.10	2.60	0.20	0.30	0.00
Catins	0	2.20	0.70	0.30	1.20	1.10	0.80
	1	0.00	1.40	0.00	0.00	0.95	3.30
Pancla	0	1.20	1.80	0.00	0.00	0.05	0.00
	1	0.00	0.70	0.00	0.10	0.00	0.40
Total		54.90	7.60	13.80	22.20	22.30	8.60
Crayfish		0.00	0.30	0.75	2.00	1.70	3.30
Sonora mud turtle		0.00	0.10	0.05	0.00	0.00	0.70

Table 8. Fossil Creek standard fish monitoring data, Above Barrier (lower) reach, Autumn (August 28-29 and September 22-24) 2008.

Site: **LOWER REACH** Nominal set/run times: 1444-0945
 Date: 24-25 September 2008 Nominal set duration: 19.0 hours
 Gear type: **Minnow Traps (n = 20)**

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	
Agochr	n/a	0	0	0	0	6	1	0	6	0	0	
Gila	0	25	0	7	37	14	4	49	35	0	14	
	1	0	0	0	0	0	0	0	0	0	0	
Rhiosc	n/a	0	0	0	0	0	0	0	0	0	0	
Catins	0	0	1	0	1	5	2	0	5	3	3	
	1	0	0	0	1	0	6	0	0	0	0	
Pancla	0	0	0	0	0	0	1	0	0	0	0	
subtotal		25	1	7	39	25	14	49	46	3	17	226
Crayfish		0	0	2	0	10	7	1	3	0	7	

Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Agochr	n/a	0	0	0	0	0	0	3	0	0	0	16	0.80
Gila	0	41	1	36	42	23	27	5	14	1	4	379	18.95
	1	0	0	0	0	1	1	0	1	0	0	3	0.15
Rhiosc	n/a	0	0	0	0	0	0	6	0	0	0	6	0.30
Catins	0	2	0	0	0	0	0	0	0	0	0	22	1.10
	1	3	0	3	0	1	0	0	5	0	0	19	0.95
Pancla	0	0	0	0	0	0	0	0	0	0	0	1	0.05
subtotal		46	1	39	42	25	28	14	20	1	4	220	
Total		71	2	46	81	50	42	63	66	4	21	446	22.30
Crayfish		2	0	0	1	0	0	1	0	0	0	34	1.70

Gear type: **Hoop Nets (n = 10)**

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	0	0	14	4	0	1	13	1	1	2	1	37	3.70
	1	0	0	0	0	0	0	0	2	1	1	4	0.40
Catins	0	0	4	3	0	0	1	0	0	0	0	8	0.80
	1	3	2	2	0	0	12	0	1	11	2	33	3.30
Pancla	1	1	0	0	0	0	3	0	0	0	0	4	0.40
Total		4	20	9	0	1	29	1	4	14	4	86	8.60
Crayfish		12	13	4	1	0	2	0	1	0	0	33	3.30
Mud turtle		0	0	0	0	0	0	0	1	5	1	7	0.70

Table 9. Fossil Creek standard fish monitoring data, Below Irving (middle) reach, Autumn (August 28-29 and September 22-24) 2008.

Site: **MIDDLE REACH** Nominal set/run times: 1445-0900
 Date: 23-24 September 2008 Nominal set duration: 16.3 hr

Gear type: **Minnow Traps (n = 20)**

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	
Gilasp	0	2	1	2	3	4	7	2	10	1	8	
	1	0	0	3	2	0	0	0	0	7	8	
Rhiosc	n/a	0	0	0	0	1	11	9	25	1	0	
Catins	0	0	0	0	1	0	0	1	2	0	0	
subtotal		2	1	5	6	5	18	12	37	9	16	111
crayfish		0	0	0	2	0	0	0	0	6	4	
Mud turtle		0	0	0	0	0	0	0	0	0	0	

Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Gilasp	0	4	13	20	0	19	11	1	4	14	8	134	6.70
	1	2	12	1	3	0	11	5	12	18	0	84	4.20
Rhiosc	n/a	0	2	0	0	0	0	0	0	0	3	52	2.60
Catins	0	1	0	0	0	1	0	0	0	0	0	6	0.30
subtotal		7	27	21	3	20	22	6	16	32	11	165	
Total		9	28	26	9	25	40	18	53	41	27	276	13.8
crayfish		3	0	0	0	0	0	0	0	0	0	15	0.75
mud turtle		0	0	0	0	0	0	1	0	0	0	1	0.05

Gear type: **Hoop Nets (n = 10)**

Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	0	0	1	2	0	0	0	0	0	0	4	7	0.70
	1	8	0	7	8	7	31	59	52	0	28	200	20.00
Rhiosc	n/a	0	0	0	0	1	1	0	0	0	0	2	0.20
Catins	1	0	0	2	2	0	0	1	3	0	4	12	1.20
Pancla	1	0	0	0	1	0	0	0	0	0	0	1	0.10
Total		8	1	11	11	8	32	60	55	0	36	222	22.20
Crayfish		0	0	1	15	0	0	1	0	1	2	20	2.00

Table 10. Fossil Creek standard fish monitoring data, High Falls (upper) reach, Autumn (August 28-29 and September 22-24) 2008.

Site:	UPPER REACH	Nominal set/run times: 1515-0940											
Date:	28-29 August 2008	Nominal set duration: 18.4 hr											
Gear type:	Minnow Traps (n = 20)												
Species	age (0/1)	1	2	3	4	5	6	7	8	9	10		
Gilasp	0	101	61	53	34	6	14	28	24	8	32	361	
Rhiosc	n/a	2	1	38	19	6	2	10	21	4	85	188	
Catins	0	0	3	2	0	1	0	8	3	5	3	25	
Pancla	0	0	0	0	0	0	0	0	1	0	0	1	
subtotal		103	65	93	53	13	16	46	49	17	120	575	
Species	age (0/1)	11	12	13	14	15	16	17	18	19	20	Total	CPUE
Gilasp	0	3	1	2	17	0	4	32	11	42	22	495	24.75
Rhiosc	n/a	11	9	1	36	46	109	27	57	12	39	535	26.75
Catins	0	3	0	6	3	0	0	0	2	0	5	44	2.20
Pancla	0	9	7	0	2	3	0	0	0	0	2	24	1.20
subtotal		26	17	9	58	49	113	59	70	54	68	523	26.15
Total		129	82	102	111	62	129	105	119	71	188	1098	54.90
Gear type:	Hoop Nets (n = 10)												
Species	age (0/1)	1	2	3	4	5	6	7	8	9	10	Total	CPUE
Gilasp	0	0	0	0	0	1	5	0	0	2	3	11	1.10
	1	0	1	12	0	0	1	2	0	2	0	18	1.80
Rhiosc	n/a	0	0	0	0	0	1	0	0	0	0	1	0.10
Catins	0	0	0	0	0	3	0	3	0	0	1	7	0.70
	1	0	0	2	2	0	2	2	1	5	0	14	1.40
Pancla	0	1	0	0	0	0	0	17	0	0	0	18	1.80
	1	0	1	1	0	0	0	0	0	4	1	7	0.70
Total		1	2	15	2	4	9	24	1	13	5	76	7.60
crayfish		1	0	0	0	0	0	0	2	0	0	3	0.30
Sonora mud turtle		0	0	1	0	0	0	0	0	0	0	1	0.10

Table 11. Comparison by species of minnow trap (mt) and hoop net (hoop) total catch per unit effort (CPUE; fish per overnight set) between autumn (A: September 2005, October 2006, September-October 2007, August-September 2008) and spring (S: May-June 2006, May 2007, and May 2008) among three reaches of Fossil Creek, Arizona (age classes combined). Species abbreviations are provided in Table 1.

Species		Upper Reach		Middle Reach		Lower Reach	
		mt	hoop	mt	hoop	mt	hoop
Agochr	A 2005	0	0	0	0	0	0
	S 2006	0	0	0	0	0	0
	A 2006	0	0	0	0	0	0
	S 2007	0	0	0	0	0	0
	A2008	0	0	0	0	0	0
	S 2008	0	0	0	0	0	0
	A 2008	0	0	0	0	0.8	0
Gilasp	A 2005	6.7	2.6	56.4	61.5	0.0	0.0
	S 2006	0.8	2.9	40.8	63.4	0.0	0.3
	A 2006	0.4	2.2	31.8	63.9	0.0	0.4
	S 2007	0.6	3.7	30.2	44.1	0.0	0.3
	A2008	0.9	3.3	5.6	22.2	0.2	1.1
	S 2008	0.9	3.3	5.6	22.2	0.2	1.1
	A 2008	24.8	2.9	10.9	20.7	19.1	4.1
Rhiosc	A 2005	25.0	0.8	11.4	0.6	0.0	0.0
	S 2006	0.7	0.7	1.1	0.0	0.0	0.0
	A 2006	8.9	1.4	0.6	0.0	0.0	0.0
	S 2007	2.5	0.5	0.2	0.0	0.0	0.0
	A 2007	4.1	0.3	0.3	0.0	0.0	0.0
	S 2008	4.1	0.3	0.3	0.0	0.0	0.0
	A 2008	26.8	0.1	2.6	0.2	0.3	0.0
Catins	A 2005	3.5	8.8	3.6	4.3	4.6	9.4
	S 2006	2.6	1.7	5.3	6.1	4.4	6.3
	A 2006	0.7	2.0	2.2	2.9	5.0	8.4
	S 2007	0.1	3.2	2.2	6.5	4.3	3.4
	A 2007	0.0	3.1	0.1	3.3	0.8	1.9
	S 2008	0.0	3.1	0.1	3.3	0.8	1.9
	A 2008	2.2	2.1	0.3	1.2	2.1	4.1
Pancla	A 2005	0.8	1.8	0.1	1.1	0.0	0.0
	S 2006	0.2	4.0	0.3	0.0	0.0	0.0
	A 2006	0.8	2.5	0.1	0.5	0.0	0.0
	S 2007	1.1	3.2	0.1	0.6	0.1	0.0
	A 2007	0.3	0.2	0.1	0.3	0.2	0.5
	S 2008	0.3	2.5	0.1	0.3	0.2	0.5
	A 2008	1.2	2.5	0.0	0.1	0.1	0.4

(continued on next page)

Table 11. Concluded.

Species		Upper Reach		Middle Reach		Lower Reach	
		mt	hoop	mt	hoop	mt	hoop
Total	A 2005	36.0	14.0	71.5	67.5	4.6	9.4
	S 2006	4.3	9.3	47.6	69.5	4.4	6.6
	A 2006	10.8	8.1	34.7	67.3	5.0	8.8
	S 2007	4.2	10.6	32.6	51.2	4.4	3.7
	A 2007	5.2	6.9	6.0	25.8	1.1	3.5
	S 2008	7.0	9.4	6.1	25.8	3.6	3.5
	A 2008	54.9	7.6	13.8	22.2	22.3	8.6
Crayfish	A 2005	0.0	1.3	0.0	2.1	1.7	9.1
	S 2006	0.0	0.0	0.0	0.0	1.0	1.8
	A 2006	0.0	0.0	0.0	0.0	1.4	2.5
	S 2007	0.0	0.0	0.1	0.8	0.8	1.5
	A 2007	0.0	0.0	0.0	0.1	0.1	0.7
	S 2008	0.1	0.7	0.0	0.1	0.1	0.7
	A 2008	0.0	0.3	0.8	2.0	1.7	3.3

Table 12. Fossil Creek native fish salvage and post-renovation re-stocking by reach.

Species	Number salvaged ²		Mortalities ³		Number re-stocked ⁴		
	R1+R2	R3+R4	R1+R2	R3+R4	R1+R2	R3	R4
Longfin dace	13	0	1	---	12	0	0
<i>Gila</i> spp. ⁵	174	103	17	10	157	93	0
Speckled dace	986	0	80	---	906	0	0
Sonora sucker	44	204	4	20	40	184	0
Desert sucker	344	49	34	5	310	44	0
Total	1561	356	136	35	1425	321	0

² From Table 2, page 8 in Weedman, D.A., P. Sponholtz and S. Hedwall. 2005. Fossil Creek native fish restoration project. Final Report, Arizona Game and Fish Department, Phoenix. 53 pages.

³ Number salvaged times 0.10, except for speckled dace *Rhinichthys osculus* for which the loss of 80 individuals was visually estimated (Weedman et al . 2005)

⁴ Number salvaged less mortalities; stocking dates were between October 28 and November 17, 2004; dates and distribution of fish among reaches provided by USFWS (unpublished data).

⁵ *Gila* spp. includes unknown proportions of headwater chub *Gila nigra* and roundtail chub *G. robusta*, both of which occur in Fossil Creek but which are difficult to individually discriminate in the field.