Muleshoe Cooperative Management Area Native Fish Restoration Monitoring and Stocking During 2009

Anthony Robinson, Ross Timmons, David Boyarski, and Clay Crowder
Arizona Game and Fish Department
5000 W. Carefree Highway
Phoenix, AZ 85086

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The 2009 native fish monitoring and native stocking activities within the Muleshoe Cooperative Management Area in the Galiuro Mountains of Arizona were cooperative undertakings of multiple agencies, organizations, and volunteers. Involved in the design and execution of the 2009 work were individuals from The Nature Conservancy (Bob Rogers, Larry Young, Ken O'Brien, Bets Stover, and C. Anderson), Bureau of Land Management (Heidi Blasius), Arizona Game and Fish Department (Ross Timmons, David Orabutt, Clayton Crowder, Suzanne Ehret, Amy Bailey, and Tony Robinson), U.S. Fish and Wildlife Service (Mary Richardson, L. Wada, and Doug Duncan), and U.S. Bureau of Reclamation (Rob Clarkson).

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INTRODUCTION

During 2007 and 2008 four listed-fish species were stocked into six waters within the Muleshoe Cooperative Management Area (CMA), in the Galiuro Mountains of Arizona (Appendix 1, Figures 1 and 2; Robinson 2008). During these two years spikedace *Meda fulfida* and loach minnow *Rhinichthys cobitis* were stocked into Redfield Canyon within the reach upstream of the confluence with Swamp Spring Canyon. Both species also were stocked into Hot Springs Canyon within an approximate 500-m reach just upstream of the confluence of Wildcat Canyon. Lineages of both species originated from Aravaipa Creek, directly so in 2007, but in 2008 from stock propagated at Bubbling Ponds Hatchery Research Facility. Gila topminnow *Poeciliopsis occidentalis* and desert pupfish *Cyprinodon macularius* were stocked into Swamp Springs Canyon, Cherry Spring Canyon, Secret Spring, and Headquarters Spring. Gila topminnow *Poeciliopsis occidentalis* were of Bylas Springs lineage, and originated from Arizona State University in 2007 and from The Nature Conservancy's (TNC) Lower San Pedro River Preserve ponds near Dudleyville during 2008. Desert pupfish *Cyprinodon macularius* originated from TNC's Lower San Pedro River Preserve ponds near Dudleyville both years.

The first post-stocking annual monitoring was completed on September 16, 2008 (the day before the 2008 fish stockings; Robinson 2008). Gila topminnow were present in each of the three sites where they were stocked the previous year. Desert pupfish were present in Secret Springs and Swamp Springs Canyon, but none were found in Cherry Spring Canyon. Both loach minnow and spikedace were present in both Redfield Canyon and Hot Springs Canyon.

This report summarizes the results of the native fish monitoring during March and September 2009 and subsequent stockings during September 2009. The goal of the stocking program is to establish populations within the systems where the species are stocked (i.e., to repatriate the species to the systems). A population is considered to have established (a successful repatriation) when it is reproducing to the point where it is self-sustaining (Griffith et al. 1989, Bright and Smithson 2001, Armstrong and Seddon 2007). The objectives of monitoring were to: 1) verify persistence of fish species since stocking; 2) detect recruitment of young (and hence reproduction) into the population; 3) evaluate if relative abundance (measured as catch-per-unit effort) increases over time (i.e., from the starting point of zero); 4) determine if species have dispersed outside of the stocking area; and 5) report any non-native fish species captured during monitoring. The objective of the supplemental stockings is to increase the number of individuals to help a population establish.

STUDY AREA

The Muleshoe CMA is located on the southwestern edge of the Galiuro Mountains in southern Arizona. The Muleshoe CMA is jointly managed by U. S. Bureau of Land Management (BLM), U. S. Forest Service, and TNC. The 57,500 acre CMA contains major portions of the Redfield Canyon, Cherry Springs Canyon, and Hot Springs Canyon watersheds, all of which are tributaries of the San Pedro River. The Nature Conservancy's Muleshoe Ranch CMA headquarters is located along Hot Springs Canyon at a location previously known as Hookers Hot Springs.

Prior to fish stockings in 2007, fish species reported from Redfield Canyon included Sonora sucker *Catostomus insignis*, longfin dace *Agosia chrysogaster*, speckled dace *Rhinichthys*

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osculus, Gila chub *Gila intermedia*, and green sunfish *Lepomis cyanellus* (Griffith and Tiersch 1989, Bureau of Land Management 1998). Gila topminnow were stocked into Redfield Canyon in 1977 (Minckley and Brooks 1985) but did not persist. In Swamp Springs Canyon only longfin dace have been recorded (SONFISHES database; Bob Rogers, The Nature Conservancy, personal communication). Fish species reported from the Hot Springs Canyon drainage include the same four native fishes found in Redfield Canyon and desert sucker *Catostomus clarki* (SONFISHES database; Bureau of Land Management 1998). No fish were present in Headquarters Spring, Secret Spring, or Headquarters Hill Spring prior to stockings in 2007-2009.

Fish monitoring and stockings described in this report occurred within the following waters: Redfield Canyon and its tributary Swamps Springs Canyon, Cherry Spring Canyon, Hot Springs Canyon, and three isolated and unnamed springs (referred to as Secret Spring, Headquarters Spring, and Headquarters Hill Spring) within the Hot Springs Canyon drainage. The three isolated springs are located near the Muleshoe Ranch headquarters: Headquarters Spring is about 25 m east of and down the hill from the dormitory building at the edge of the Hot Springs Canyon river bed, Headquarters Hill Spring is about 25 m west and up the hill from the casitas, and Secret Spring is about 600 m southwest of the Muleshoe Ranch headquarters. Length of perennial water in the streams was estimated to be 16.3 km in Redfield Canyon drainage, 20.1 km in Hot Springs Canyon, and 1.1 km in Cherry Spring Canyon, but during dry periods is likely much less and interrupted (Bureau of Land Management 1998).

Each of the major stream courses was divided into sections (reaches) to facilitate a stratified random sampling design or to encompass stocking locations (Appendix 1, Figures 1 and 2). Reaches in Hot Springs Canyon were: Reach 1 = from Bass Canyon down 1.4 km to Wildcat Canyon, Reach 2 = from Wildcat Canyon down 1.7 km to the second unnamed tributary from the south, and Reach 3 = from the lower end of Reach 2 down 3.7 km to the first unnamed tributary from the south. The upper half of Reach 3 was not considered for monitoring because it was canyon bound and mostly pool habitat, and thus likely provides less habitat for spikedace or loach minnow. Reaches in Redfield Canyon were: Reach 1 = from the Swamp Springs Canyon confluence upstream approximately 1.5 km in Redfield Canyon to the first tributary from the east (the approximate location of the waterfall at UTM coordinates 564212mE, 3590025mN; NAD 83), and Reach 2 = from Swamp Springs Canyon confluence downstream about 2.9 km to an unnamed tributary from the north (561433mE and 3589266mN; NAD 83). Most of Reach 2 was dry during a green sunfish *Lepomis cyanellus* removal effort in June 2009 (Bob Rogers, The Nature Conservancy, personal communication). The two reaches designated in Swamp Springs Canyon were: Lower = an approximately 300 m long section beginning approximately 1.3 km upstream of the mouth, and Upper = an approximately 1 km section beginning approximately 4.2 km upstream from the mouth, in the vicinity of the southern unnamed tributary that drains Cherry Spring Peak.

METHODS

MONITORING

Spikedace and Loach Minnow

Annual monitoring of spikedace and loach minnow was completed during September 14 and 15, 2009 in Hot Springs Canyon and on September 15, 2009 for Redfield Canyon. Fixed and randomly selected 100-m long sites (transects) were sampled in Redfield Canyon (Figure 1) and

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Hot Springs Canyon (Figure 2). The same four fixed sites in Redfield Canyon and three fixed sites in Hot Springs Canyon that were sampled during 2008 (Robinson 2008) were again sampled in 2009. Three additional random sites in each stream were selected in the office by mapping the stream courses (National Geographic TOPO! software), dividing the lengths into 100-m-long segments, and using a random number table to select sites within an identified reach. Total number of sites in each stream was what could be feasibly sampled by two crews of three people in one day.

Fish sampling within each 100-m transect was dependent upon habitat type. Runs and pools were sampled using a backpack electrofisher (Smith Root model LR24) moving upstream in a single pass, and stunned fish were netted with 3 mm-mesh dip nets. Cobble riffles were sampled by a combination of electrofishing and kick seining; the lower end was blocked with a 3 mm-mesh seine and then beginning about 2-5 m upstream, the segment was shocked downstream while sweeping and rolling the substrate material with feet toward the seine. When the electrofisher reached the seine, the person(s) holding the net swept it upwards to capture fish. Fish were processed and data were recorded after each segment was sampled.

In addition to and outside of the 100-m transects, crews conducted targeted-habitat sampling within each reach if they determined they had time to do so. Runs, eddies and pools (presumed spikedace habitat) were sampled either by electrofishing or by seining. Seining was done in a downstream direction, moving faster than the current. Cobble-bottom riffles (presumed loach minnow habitat) were sampled with a combination of kick-seining and electrofishing as described above. Each seine haul or electrofishing-kick-seining was a separate event and was considered a separate site. Data were recorded after each seine haul or kick-seining event.

Captured fish were identified to species and counted. All spikedace and loach minnow captured were measured (mm total length, TL). Other species were counted within two size classes: 20-40 mm and > 40 mm for speckled dace and longfin dace, and 20-100 mm and >100 mm for suckers and Gila chub. Fish smaller than 20 mm TL were categorized as larvae. After processing, fish were released alive back to the site from which they were captured. Data recorded for each sampling effort included: site name, site location (GPS coordinates), length of site, date, time, participants, gear type, gear settings, gear dimensions, effort (seconds shocked or length and width of seining or dip netting), species of fish captured, size class of fish, and counts of individuals within each species-size-class category. Habitat information was collected at the 100-m sites. Habitat data recorded included: percentage of site composed of each habitat type (cascade, riffle, run, pool), and percentage of site composed of each substrate type (clay, silt, sand, gravel, pebble, cobble, boulder). Water quality was measured using EXTECH Instruments Inc. meters and included water temperature (°C), pH, and conductivity (µS) using an ExStik EC500 meter and dissolved oxygen (mg/L) using an ExStik II dissolved oxygen meter.

Gila Topminnow and Desert Pupfish

Monitoring for Gila topminnow and desert pupfish was conducted six months (March 30-31, 2009) and one year (September 14 and 15, 2009) after the September 2008 stocking. Sampling was completed throughout the Secret Spring pond and Headquarters Spring pool. Within Cherry Spring Canyon and Swamp Springs Canyon the stocking locations and areas immediately upstream and downstream of the stocking locations were sampled. In upper Swamp Springs

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Canyon, sampling during March 2009 occurred in a 400-m reach encompassing the stocking sites (the upper end of the reach was about 30 m upstream of the upper stocking site), whereas September sampling occurred in an approximately 50 m reach encompassing the stocking locations. Fish were sampled using Promar® collapsible minnow traps (0.46 m long x 0.3 m wide, with 2 mm mesh) and dip nets (3 mm mesh, 1.5 m long pole), and occasionally with seines (3 mm mesh, and typically 2 m long by 1.5 m tall). Collapsible minnow traps were baited with dry dog food. Six or seven traps were set upon arrival at each site, and were pulled two to three hours later. An attempt was made to conduct a minimum of 10 dip net sweeps at each site. If seining was attempted, we conducted a minimum of 3 hauls.

After each seine haul, dip net sweep, or trap pull, captured fish were held in buckets or the nets in the water until they could be identified, counted and data recorded. After processing, fish were released alive back to the area from which they were captured. Data recorded for each sampling effort included: site name, site location (GPS coordinates), date, time, participants, gear type, gear dimensions, effort (length and width of seining or dip netting, and duration of trap set in minutes), species of fish captured, size class of fish (≤ 1 cm or > 1 cm), and counts of individuals within each species-size-class category. Water quality information recorded included water temperature (°C), dissolved oxygen (mg/L), pH, and conductivity (µS).

FISH STOCKINGS

Plans to stock all four listed species (spikedace, loach minnow, desert pupfish, and Gila topminnow) into waters within the Muleshoe CMA, as was done in 2007 and 2008, were altered based on monitoring results and a limited supply of available fish. Bubbling Ponds Hatchery Research Facility had relatively few Aravaipa lineage spikedace and loach minnow (< 400 of each species) available for stockings during autumn 2009 and there were three streams (Fossil Creek, Redfield Canyon, and Hot Springs Canyon) scheduled for supplemental stockings. In addition, spikedace and loach minnow abundance in Aravaipa Canyon during October 2009 was estimated to be low (Dr. Peter Reinthal, University of Arizona personal communication). Also, based on monitoring, spikedace and loach minnow numbers and available habitat were estimated to be greater in Hot Springs Canyon than in Redfield Canyon. Therefore, representatives from Arizona Game and Fish Department (AZGFD), U. S. Fish and Wildlife Service, U. S. Bureau of Reclamation, and U. S. Bureau of Land Management discussed the potential stockings and decided to not translocate any spikedace or loach minnow directly from Aravaipa Creek and to stock all available Aravaipa Creek lineage spikedace and loach minnow at Bubbling Ponds Hatchery Research Facility into Hot Springs Canyon.

Numbers of desert pupfish at the various captive localities were also limited because of stockings elsewhere in the state, and AZGFD shifted its strategy from stocking desert pupfish into all available suitable sites to first trying to establish populations in a number of ponds in isolation from other fish species. Once the pond populations are abundant enough, then pupfish will be translocated to streams and springs to try to establish populations in those locations. In addition, based on monitoring, either few or no desert pupfish were captured in any of the Muleshoe CMA waters where they were stocked so it was unclear whether or not desert pupfish had established populations in these locations. Therefore agency representatives agreed that the best course of action would be to stock all available desert pupfish, and only this species, into Headquarters

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Hill Spring, and if that population establishes, to use it as a source of fish to stock other waters in the Muleshoe CMA.

Availability of Bylas lineage Gila topminnow was also somewhat limited, as the TNC Lower San Pedro Preserve ponds had been drained and improved during the winter of 2008-2009 and relatively few topminnow stocked back, and the population abundance had not yet increased to what it was estimated to be before the pond improvements. However, and more importantly, based on monitoring information Gila topminnow populations were thriving at each of the waters where they were stocked, eliminating the need for additional stockings. Therefore agency representatives agreed that the Gila topminnow populations within the Muleshoe CMA did not need supplemental stockings during 2009.

All fish used in the 2009 stockings were acquired from Bubbling Ponds Hatchery Research Facility. Spikedace and loach minnow were transported in a 200-gal fish transport tank in the bed of a truck whereas desert pupfish were transported in a 100-qt cooler. Water in the containers was treated with salt to attain a concentration of 3-5 ppt, and was aerated with electric bubblers. Upon arrival at a site, fish were transferred to 5-gal buckets that had battery powered aerators attached to their lids and hand-carried to the stocking site. To minimize stress to the fish, at the stocking site water was tempered to stream conditions by exchanging approximately 25% of the bucket water with stream water every 10-15 minutes, making 2-4 exchanges until the water in the bucket is within 1.5˚C of the stream temperature. After the tempering process, the fish were individually removed from the bucket with a dip net, identified to species, counted and released to the stream. Fish were observed after release and stress behaviors (e.g., loss of equilibrium, rapid respiration, etc.) noted.

RESULTS AND DISCUSSION

MONITORING

Spikedace and Loach Minnow

Seven species of fish were captured in Redfield Canyon during September 2009 (Table 1). Speckled dace was the most abundant species captured, followed by Gila chub, Sonora sucker, spikedace, loach minnow, longfin dace, and Gila topminnow (Table 2). Both spikedace and loach minnow were captured, so it can be concluded that they have persisted in Redfield Canyon. Captured loach minnow ranged from 48 to 65 mm TL and spikedace from 57 to 70 mm TL, and the length frequency distribution for both species was unimodal (Figure 2), so we did not find any clear evidence of an age-0 age class or even more than one age class in Redfield Canyon. Transects Permanent-4 and Random-4 (Figure 1) in the reach downstream of Swamp Springs Canyon confluence were dry, and all transects sampled were within the stocking reach (upstream of Swamp Springs Canyon), so we did not collect any data that would allow us to evaluate whether or not spikedace and loach minnow have dispersed outside of the stocking reach. More individuals of both species were captured in September 2009 than in September 2008 (12 spikedace and 1 loach minnow; Robinson 2008). The increase could have been simply an artifact of the greater numbers stocked in 2008 than in 2007, or reproduction may have occurred and the population actually increased, or may represent different sampling methods or sample variation. If populations of both species actually increased, there is an increased likelihood that they will continue to increase in abundance to the point where they can persist after stochastic events such as floods or drought. Continued monitoring will be used to detect such changes in

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abundance. Catch rates of spikedace and loach minnow were not compared between years because all spikedace or loach minnow were captured in single-pass electrofishing efforts during 2009 and none were captured using this method in 2008; they were captured using other gear types which were not used in 2009.

The Gila topminnow in Redfield Canyon were all captured in reach 2, in the intermittent pools immediately downstream of the Swamp Springs Canyon confluence. Gila topminnow were observed while walking the banks in this section, and so were opportunistically sampled with dip nets. In 11 of 12 dip net sweeps 34 Gila topminnow were captured (mean 6.42 fish/m^2±1.33 SE). In addition, more than a dozen Gila topminnow were observed in each of three intermittent pools further downstream; the furthest were approximately 450 m downstream of the confluence with Swamp Springs Canyon.

Results of the fish survey in Hot Springs Canyon were somewhat similar to that of Redfield Canyon. The same species of fish and one additional species, desert sucker, were captured (Table 1). Longfin dace and speckled dace were by far the most abundant species followed by Gila chub, desert sucker, spikedace, loach minnow, and Sonora sucker (Table 2). Both spikedace and loach minnow have persisted and the numbers captured were greater than during the 2008 monitoring when 4 spikedace and 12 loach minnow were captured (Robinson 2008). Possible reasons for the putative increase are the same as those given for Redfield Canyon. If catch rates of longfin dace or speckled dace are any indication of potential abundance, it seems likely that both spikedace and loach minnow can become much more abundant. Captured spikedace ranged from 47 to 63 mm TL and loach minnow from 41-65 mm TL, and the length frequency distribution for both species was unimodal (Figure 3), which provides no indication of an age-0 age class for either species in Hot Springs Canyon during 2009. However, it is possible that the 41 mm loach minnow was an age-0 fish produced early in the spring; the next longest loach minnow was 47 mm TL and is presumed to be age-1. We captured both spikedace and loach minnow in transect Permanent-2, approximately 1.4 km m downstream of Wildcat Canyon (Figure 2), indicating that both species have dispersed downstream of the stocking reach. There was evidence of a recent small flood (muddy banks and vegetation depressed in a downstream direction), so it is possible fish moved downstream during this or another flood event.

Gila Topminnow and Desert Pupfish

Gila topminnow were captured in all, and desert pupfish in some, of the sites where they had been stocked in 2007 and 2008 (Figures 1 and 2) during monitoring in both March (Table 3) and September 2009 (Table 4). In Secret Spring, 145 Gila topminnow and 4 desert pupfish were captured in 10 minnow traps and 22 dip net sweeps during March 2009. More Gila topminnow were captured in minnow traps in Secret Spring during September 2009 (3,905) than during September 2008 (1,590), but more traps were set in 2009 and catch rates were actually lower in 2009 (mean 78.68 fish/h) compared to 2008 (mean 133.45 fish/h). Of the 4,080 Gila topminnow captured during September 2009, 12.5% were <10 cm TL (putative juveniles), which coupled with the numbers of fish captured indicates that this species has established a population in Secret Spring. Desert pupfish numbers in Secret Spring remained low in September 2009 (6 captured) as they were in September 2008 (10 captured), and only one of the six captured in September 2009 was a juvenile so we can conclude that fish are persisting but it is still unclear if they have established a population in Secret Spring.

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At Headquarters Spring, 272 Gila topminnow and 2 desert pupfish were captured in March 2009 (Table 3), but in September 2009 (Table 5) only Gila topminnow were captured. Approximately one third (31.3%) of the 879 Gila topminnow captured in Headquarters Spring during September were categorized into size classes, of these 275 fish 53% were <10 mm TL. Therefore, we conclude that Gila topminnow have established a population in Headquarters Spring, but it seems likely that desert pupfish have not and may be extirpated.

In Cherry Spring Canyon, Gila topminnow and desert pupfish were captured both during March and September 2009 (Tables 3 and 4). In March 2009, 28 Gila topminnow and 10 desert pupfish were captured in 10 minnow traps and 14 dip net sweeps. In September 2009, 125 Gila topminnow but only 5 desert pupfish were captured. In addition, an estimated 500 Gila topminnow were observed in the pool where they were stocked in 2008 (Robinson 2008). The increased numbers of topminnow could have been a result of the supplemental stocking of 275 additional desert pupfish in September 2008. However, approximately 8% of the Gila topminnow captured in September 2009 were <10 mm TL, indicating that reproduction had occurred. Gila topminnow may be in the process of establishing in Cherry Spring Canyon; information collected during September 2010 monitoring will either support or refute this hypothesis. Only a handful of desert pupfish were captured in Cherry Spring Canyon during 2009, compared with none captured in September 2008. The pupfish captured in 2009 might have been individuals that persisted since the September 2008 supplemental stocking of 275 desert pupfish. In addition, all of the pupfish captured in 2009 were adults. Therefore it is unclear as to whether or not desert pupfish are establishing a population in Cherry Spring Canyon.

In Swamp Springs Canyon, Gila topminnow were captured in both March and September 2009 (Tables 3 and 4), but desert pupfish were only captured in March 2009. The upper site was monitored in both periods, but the lower site was only monitored in September 2009. In March 2009 14 Gila topminnow and 6 desert pupfish were captured (10 minnow traps, 2 dip net sweeps and 16 seine hauls) all at or within about 30 m of stream encompassing the two upper stocking sites although approximately 400 m of stream was sampled. Gila topminnow were present in September 2009 at both the lower site and the upper site. At the upper site all topminnow were again captured in the immediate vicinity of the stocking sites, but that may be because traps were only set in or in the immediate vicinity of the stocking locations. A total of 921 Gila topminnow were captured near the upper site in September 2009, which is an increase from the 275 that were stocked in September 2008. In addition, of the 331 Gila topminnow that were categorized to length classes, 24.5% were <10 mm TL. The increase in numbers and evidence of reproduction indicate that the species has established a population in upper Swamp Springs Canyon. Continued monitoring will provide information to assess whether or not the population will persist through various stochastic events. At the lower site, 83 Gila topminnow were captured in September 2009; unfortunately only 4 of those were categorized as to size class (half were <10 mm TL). In contrast to the upper site which was sampled using minnow traps, the lower site was sampled using seines and dip nets, which may explain the differences in numbers of fish captured in the two locations. Given that Gila topminnow tend to live less than 1 year, and the fact that 250 were stocked in October 2007 into the lower site, it is possible that they are reproducing and persisting at the lower site, or individuals might have washed down from the

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upper site. Regardless, Gila topminnow do not appear to be thriving at the lower site. However as mentioned before, 34 Gila topminnow were captured in Redfield Canyon just downstream of the confluence with Swamp Springs Canyon, and others were observed further downstream; approximately 1,850 m downstream of the lower stocking site in Swamp Springs Canyon. The lowest 1 km of Swamp Springs Canyon is typically dry, indicating that the topminnow dispersed during flooding.

Physical Environment

During the September 2009 survey, habitat in Redfield Canyon was comprised mostly of pools with intervening riffles, whereas that in Hot Springs Canyon was comprised of mostly runs (Figure 4). Substrate types were reflective of the habitat types in the two streams, as Redfield Canyon had predominantly (~65%) pebble-sized and larger sized substrates, whereas Hot Springs Canyon had approximately equal percentages of small and large-sized substrates (Figure 4). The one pool in Cherry Spring Canyon where habitat data were recorded had substrates comprised of 10% silt, 35 % gravel, 5% cobble, and 50% bedrock. Habitat and substrate types were not quantified in Swamp Springs Canyon or Secret Spring.

FISH STOCKINGS

Spikedace and loach minnow (Aravaipa Creek lineage) were transported in a 200-gal tank in the back of a pickup truck from Bubbling Ponds Hatchery Research Facility to Hot Springs Canyon October 28, 2009. Most of the fish were F1 generation, but a few were wild-caught brood-stock. At Hot Springs Canyon, fish were transferred to buckets and carried to the stocking sites. Stream temperature was approximately 3°C cooler than bucket water temperature (17°C), therefore three exchanges with stream water were done approximately 10 minutes apart to temper the water to stream conditions. One spikedace and four loach minnow died during the transportation-tempering process. Between 1300 h and 1330 h 156 loach minnow were stocked, 87 at the lower location and 69 at the upper location (Figure 5). Spikedace were also stocked at two locations during the same time period; 212 in the lower location and 174 at the upper location for a total of 386 individuals (Figure 5). Both spikedace and loach minnow behaved normally upon release and did not exhibit stress behaviors.

Two hundred desert pupfish (Santa Clara Slough stock originally from Dexter National Fish Hatchery) were transported via truck from Bubbling Ponds to the Muleshoe Ranch Headquarters on the same date. At the Muleshoe Headquarters, fish were transferred to 5-gal buckets and carried to Headquarters Hill Spring (Figure 5). Water temperature in the pond was 22.0°C but only 15.0°C in the buckets upon arrival at 1430 h. Four water exchanges were made to temper bucket water to stream conditions; four pupfish died during the transportation-tempering process. At approximately 1510 h, 196 desert pupfish were stocked; fish behaved normally afterwards.

RECOMMENDATIONS

The environmental assessment for the establishment of aquatic vertebrate species into Muleshoe CMA waters (Bureau of Land Management 2004) indicated that stockings of the T&E fish species would occur every year for five years, at which time success (establishment of a self-sustaining population) of the action would be evaluated. The assessment also indicated that monitoring of the populations would occur during the five years of augmentation to determine the success of the stockings, and continue for at least five years after stocking ceased. The T&E

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fish species were stocked during 2007, 2008, and 2009, so if the plan outlined in the environmental assessment is followed and fish are available, stockings should continue until 2011 and monitoring until at least 2016. However, for the reasons given in the results and discussion, during 2009 we did not stock all of the waters with all of the species where they had been stocked during 2007 and 2008. If sufficient numbers of spikedace and loach minnow are available in 2010 and 2011, then more should be stocked into both Redfield Canyon and Hot Springs Canyon. If fewer fish are available, then partners (AZGFD, BLM, BOR, FWS, and TNC) should meet and decide which stream to stock. Similarly, for desert pupfish, we will likely stock waters other than Headquarters Hill Spring only if we have sufficient numbers of fish available. If the Headquarters Hill Spring stocking is successful, fish from that pool will be used to stock other sites on the Muleshoe Ranch CMA. In addition, if analysis of data from monitoring continues to indicate that Gila topminnow are established in each of the waters where they were stocked, then no additional supplemental stockings will be necessary as the goal of the stockings (to establish self-sustaining populations) for this species will have been achieved. The Muleshoe Native Fishes Team, established during development of the project, will meet at the five-year point to determine future actions, which could include some form of regular monitoring to periodically update data on the status of the species, and to determine if any problems have occurred or adjustments need to be made.

The study design and methods appear to be sufficient to address objectives 1 (verifying persistence), 2 (detecting recruitment), and 4 (detecting dispersal) for all species, and also appeared sufficient to address objective 3 (change in abundance) for Gila topminnow and possibly desert pupfish. It is unclear whether the current design and methods are sufficient to detect a change in abundance of loach minnow or spikedace. We use catch-per-unit effort as an index of abundance, and not the absolute number of fish captured, but regardless, catch rates will depend on the number of fish in a reach, the number of fish captured, and the amount of effort in a given reach. Similar to 2008, more loach minnow were captured when riffles were sampled using a combination of backpack electrofishing and kick seining, then when just single-pass electrofishing was used. Employing multiple sampling techniques should increase the probability of capturing rare species (George et al. 2009). However, the combined method was not used in Redfield Canyon or in all 100-m transects in Hot Springs Canyon. The combined method was not used in Redfield Canyon because the crews thought that sufficient numbers of loach minnow and spikedace were captured with single pass electrofishing. Because field crews made the decision on where to use the combined method versus single-pass electrofishing, the number of efforts of each sampling technique will not be consistent from year to year within a given 100-m transect. Because the number of loach minnow captured in a given 100-m transect may depend upon which sampling method is used, a change in numbers from one year to the next could be the result of sampling technique efficiency or changing population levels. Conducting a single electrofishing pass upstream through each 100-m transect seems to be the simplest, and least biased method of sampling the fish community. This method may result in fewer loach minnow captured in the 100-m transects, but would likely result in more valid comparisons between years. However, resultant sample sizes would be low (seven in Redfield Canyon and six in Hot Springs Canyon) so temporal change in abundance might not be very detectable. We recommend that partners meet to discuss monitoring study design and implementation.

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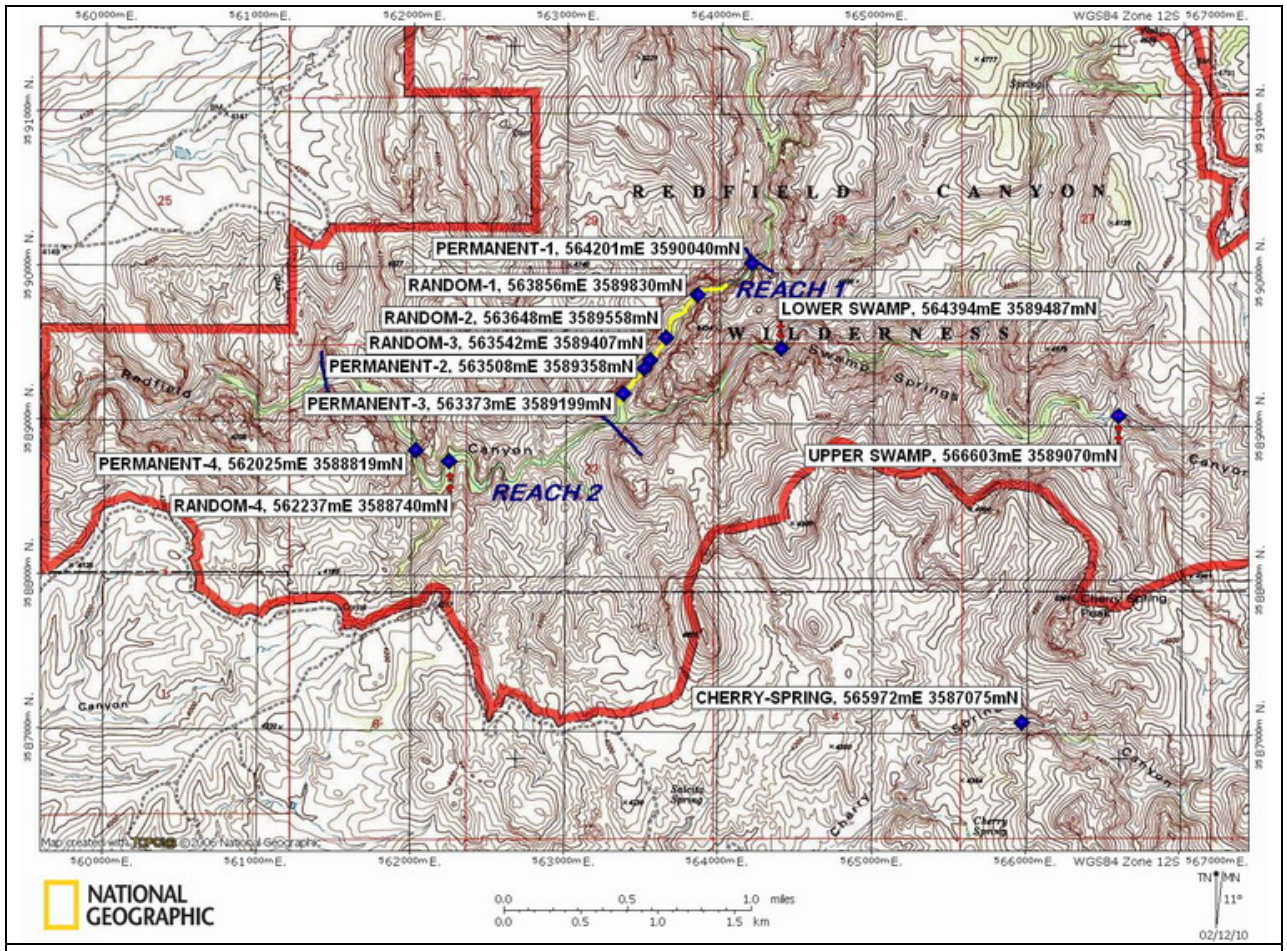

Figure 1. Map showing locations (blue diamonds) of fish monitoring sites in Redfield Canyon, Swamp Springs Canyon, and Cherry Spring Canyon within the Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona during 2009. In Redfield Canyon, the map shows two reaches (delineated with blue lines), the locations of permanent and randomly selected 100-m long sites, and the segment of the stream, highlighted in yellow, within which spikedace and loach minnow were stocked during 2007 and 2008. In Swamp Springs Canyon desert pupfish and Gila topminnow were stocked into the lower monitoring site in 2007 and the upper site during 2008. The monitoring location shown in Cherry Spring Canyon was stocked with Gila topminnow and desert pupfish during 2007 and 2008. The thick red line is the boundary of Redfield Canyon Wilderness.

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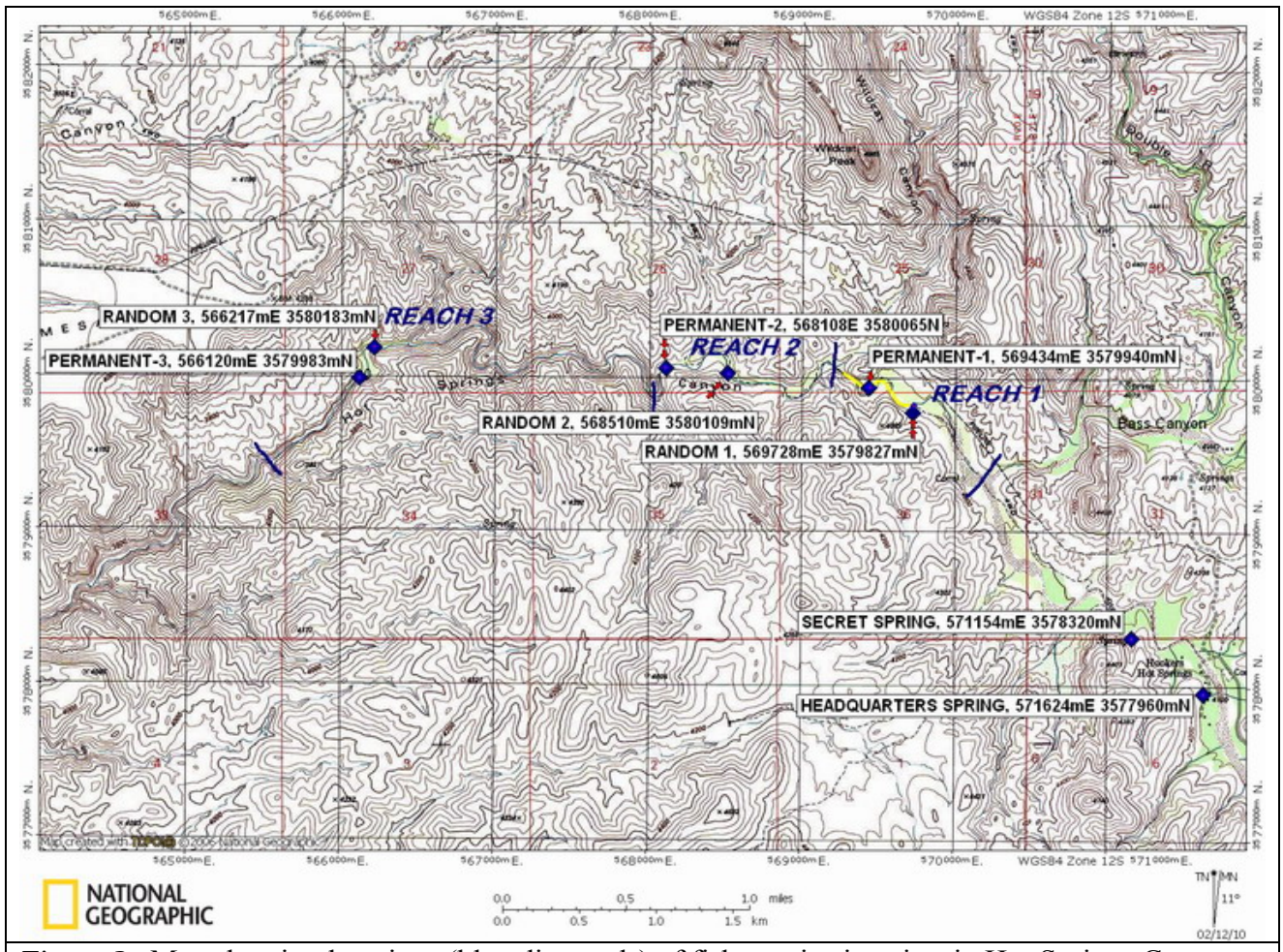

Figure 2. Map showing locations (blue diamonds) of fish monitoring sites in Hot Springs Canyon downstream of the Muleshoe Ranch Headquarters (Hookers Hot Springs) within the Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona during 2009. In Hot Springs Canyon north (downstream) of Bass Canyon, the map shows three reaches (delineated with blue lines), the locations of permanent and randomly selected 100-m long sites, and the segment of the stream highlighted in yellow, within which spikedace and loach minnow were stocked during 2007 and 2008. Secret Spring where Gila topminnow and desert pupfish were stocked during 2007 and Headquarters Spring where the same two species were stocked in 2008 are also shown.

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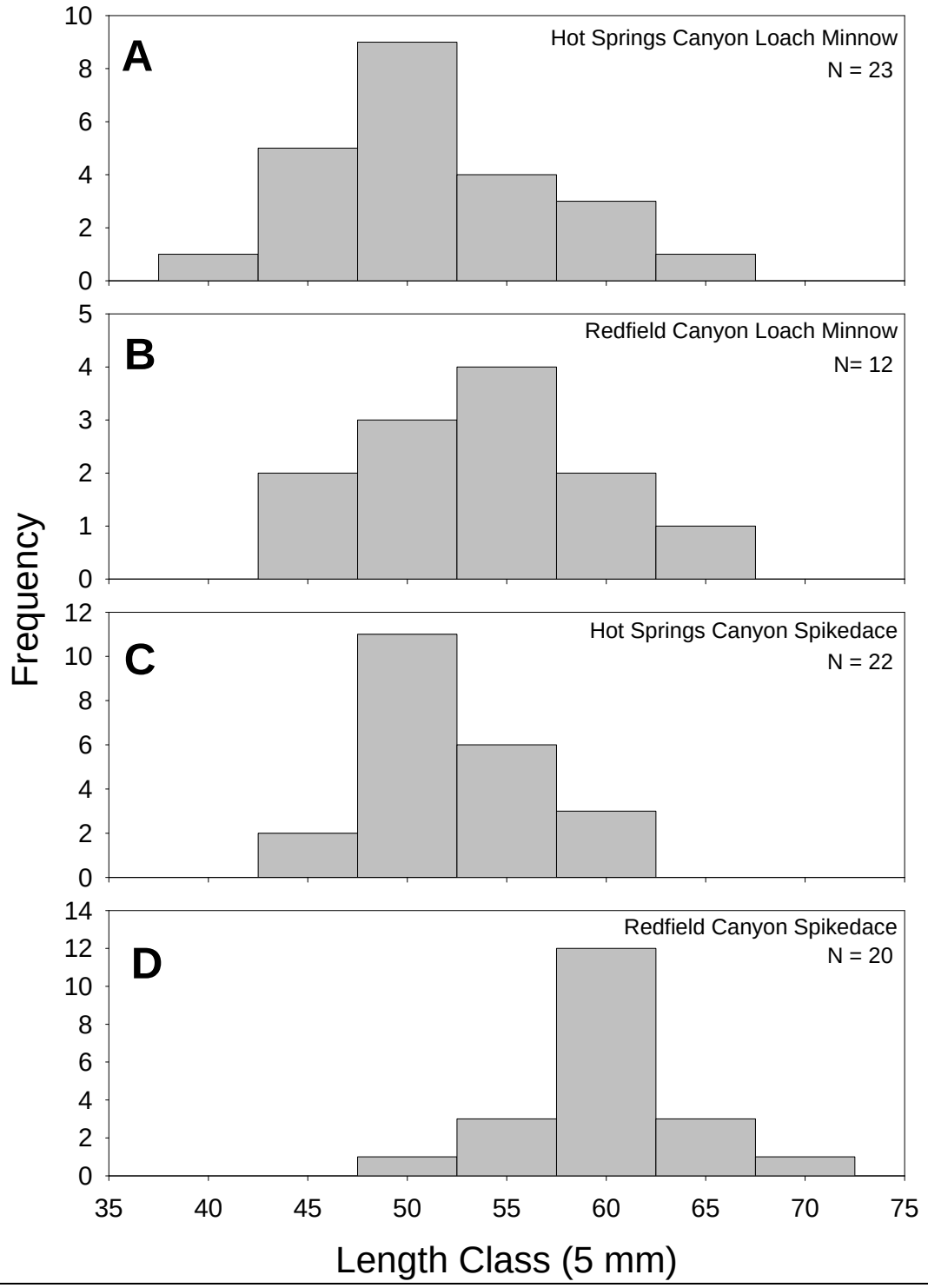

Figure 3. Length frequency (5-mm classes) distributions of loach minnow in (A) Hot Springs Canyon and (B) Redfield Canyon and spikedace in (C) Hot Springs Canyon and (D) Redfield Canyon on September 15, 2009.

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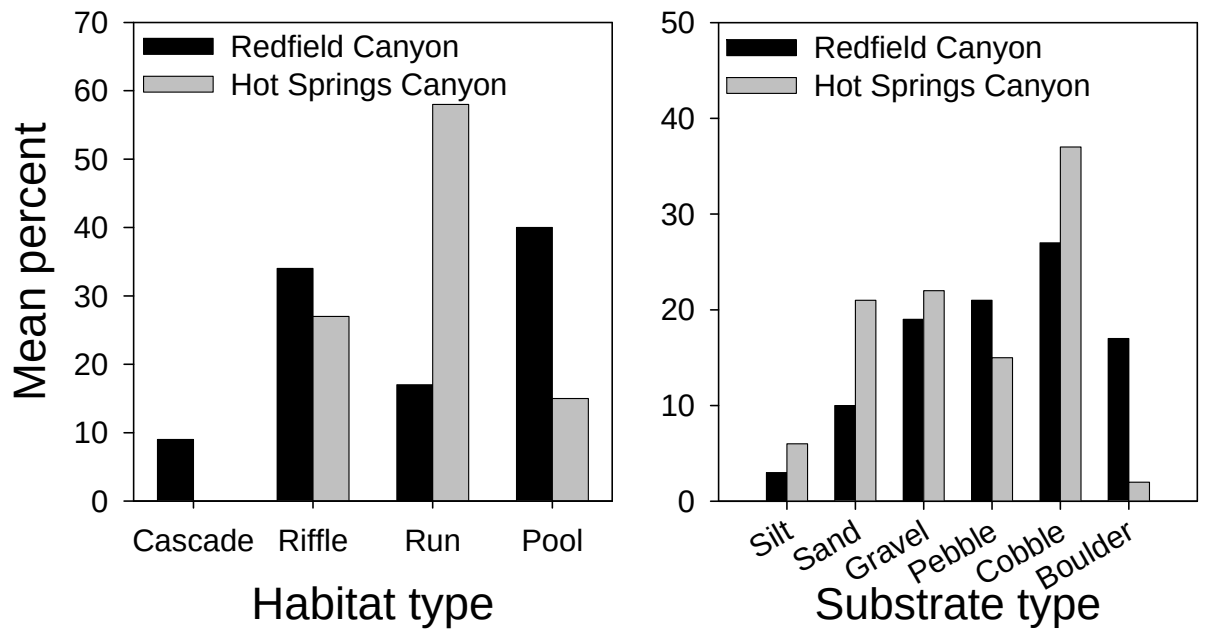

Figure 4. Percent habitat types and substrate types in 100-m fish survey reaches in Redfield Canyon (N=3) and Hot Springs Canyon (N=3), Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona on September 16, 2008.

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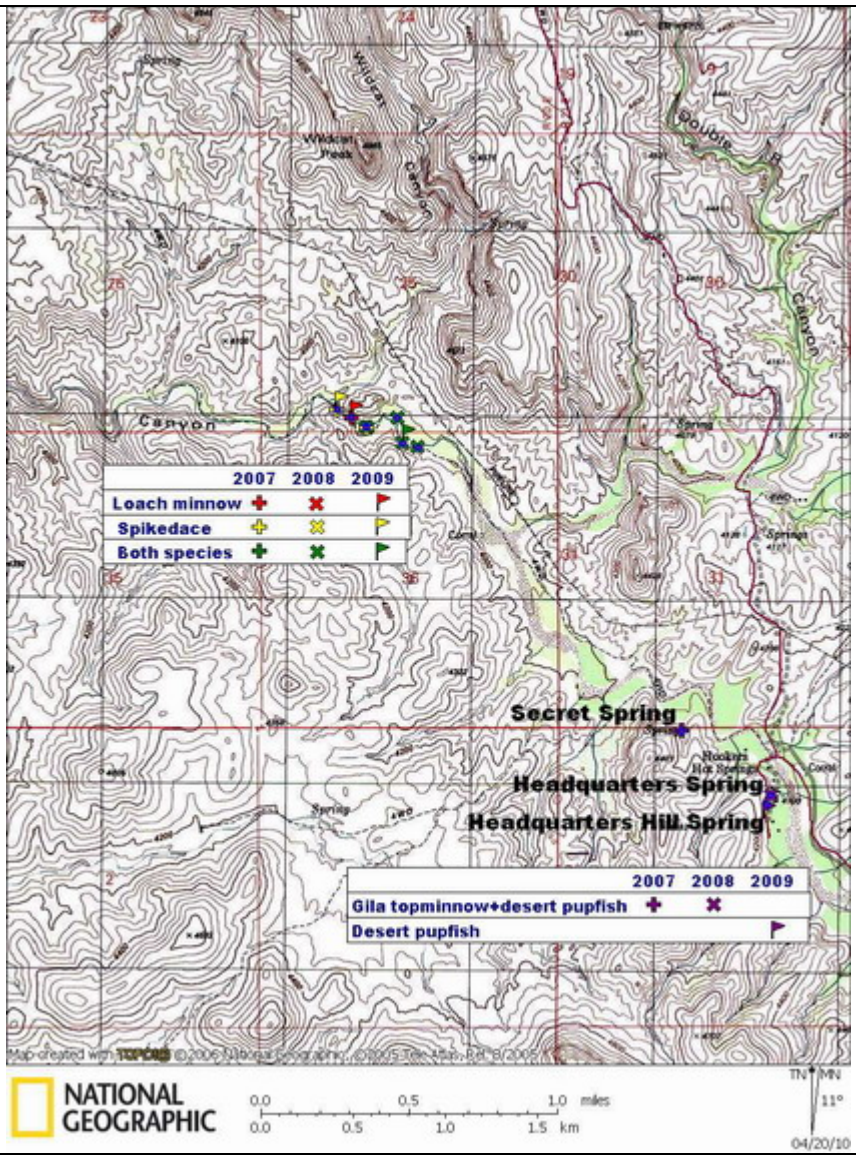

Figure 5. Map showing 2007, 2008, and 2009 native fish stocking locations in Hot Springs Canyon drainage, Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona.

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Table 1. Numbers of fish of each species captured (all gear types) within 100-m transects in Hot Springs Canyon and Redfield Canyon, Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona on September 15, 2009. Transects Opportune-1 and Opportune-2 were not 100-m long but rather just locations outside of the 100-m transects that were sampled. Oportune-2 in Hot Springs Canyon was the portion between Permanent-2 and Random-2 where we completed three 4-m long backpack electrofishing+kick seining efforts. Opportune-1 in Redfield Canyon was an area dip netted just downstream of Swamp Springs Canyon confluence.

Water	Reach	Transect	Spikedace	Loach minnow	Speckled dace	Longfin dace	Gila chub	Desert sucker	Sonora sucker	Gila topminnow	Total
Hot Springs Canyon	1	Permanent-1	9	18	89	252	27	19	17	0	431
		Random-1	0	2	260	131	0	0	0	0	393
		All	9	20	349	383	27	19	17	0	824
	2	Permanent-2	15	3	42	61	1	5	1	0	128
		Random-2	0	0	44	71	6	5	0	0	126
		Opportune-2	0	0	7	12	0	1	0	0	20
		All	15	3	93	144	7	11	1	0	274
	3	Permanent-3	0	0	12	67	0	0	0	0	79
		Random-3	0	0	16	107	0	1	0	0	124
		All	0	0	28	174	0	1	0	0	203
	All	Total	24	23	470	701	34	31	18		1301
Redfield Canyon	1	Permanent-1	2	3	0	0	31	0	17	0	53
		Permanent-2	0	1	34	0	8	0	4	0	47
		Permanent-3	0	0	73	1	35	0	21	0	130
		Random-1	18	5	0	0	19	0	3	0	45
		Random-2	0	2	56	0	5	0	8	0	71
		Random-3	0	1	60	0	8	0	6	0	75
		All	20	12	223	1	106	0	59	0	421
	2	Opportune-2	0	0	0	0	0	0	0	34	34
		Total	20	12	223	1	106	0	59		455

2ASLDRedfield000058

Table 2. Number of fish captured (#) and mean and standard error (SE) catch rates for backpack electrofishing (#/min) and combination backpack electrofishing plus kick seining (#/min and #/m2) in three reaches of Hot Springs Canyon and one reach of Redfield Canyon, September 15, 2009. Reach definitions are given in the methods.

Water	Reach	Sample type and number of efforts	Stat.	Spikedace	Loach minnow	Speckled dace	Longfin dace	Gila chub	Desert sucker	Sonora sucker	Total
Hot Springs Canyon	1	Backpack electrofish+kick seine (N = 8)	#	4	18	125	133	0	0	0	280
			#/min	1.15	7.26	49.45	50.84	0.00	0.00	0.00	108.70
			SE	(1.15)	(1.98)	(14.96)	(11.47)	(.00)	(.00)	(.00)	(23.95)
			#/m2	0.13	0.69	4.81	4.89	0.00	0.00	0.00	10.51
			SE	(.13)	(.19)	(1.28)	(1.04)	(.00)	(.00)	(.00)	(2.03)
		Backpack electrofish (N = 5)	#	5	2	224	250	27	19	17	544
			#/min	0.30	0.14	14.99	13.28	1.41	1.22	1.05	32.39
			SE	(.21)	(.14)	(7.06)	(3.77)	(.87)	(.98)	(.77)	(7.11)
	2	Backpack electrofish+kick seine (N = 13)	#	7	2	39	29	0	2	1	80
			#/min	2.52	0.74	10.84	7.10	0.00	0.58	0.42	22.20
			SE	(1.79)	(.50)	(2.79)	(1.60)	(.00)	(.39)	(.42)	(2.72)
			#/m2	0.15	0.05	0.85	0.61	0.00	0.04	0.03	1.73
			SE	(.11)	(.04)	(.23)	(.15)	(.00)	(.03)	(.03)	(.21)
			#	8	1	54	115	7	9	0	194
		Backpack electrofish (N = 5)	#/min	0.82	0.12	3.89	7.94	0.47	0.63	0	13.87
			SE	(0.58)	(0.12)	(0.74)	(1.92)	(0.28)	(0.32)	0	(1.9)
	3	Backpack electrofish (N = 4)	#	0	0	28	174	0	1	0	203
			#/min	0.00	0.00	0.97	6.18	0.00	0.03	0.00	7.18
			SE	(.00)	(.00)	(.18)	(1.14)	(.00)	(.03)	(.00)	(1.28)
	All	Backpack electrofish+kick seine (N = 21)	#	11	20	164	162	0	2	1	360
			#/min	2.00	3.22	25.55	23.76	0.00	0.36	0.26	55.15
			SE	(1.18)	(1.06)	(7.09)	(6.41)	(.00)	(.25)	(.26)	(12.94)
			#/m2	0.14	0.29	2.36	2.24	0.00	0.02	0.02	5.07
			SE	(.08)	(.10)	(.65)	(.61)	(.00)	(.02)	(.02)	(1.21)
		Backpack electrofish (N= 14)	#	13	3	306	539	34	29	17	941
			#/min	0.40	0.09	7.02	9.35	0.67	0.67	0.37	18.57
			SE	(.22)	(.06)	(2.89)	(1.66)	(.34)	(.37)	(.29)	(3.84)
Redfield Canyon	1	Backpack electrofish (N = 10)	#	20	12	223	1	106	0	59	421
			#/min	0.24	0.21	3.89	0.00	1.68	0.00	1.15	7.19
			SE	(.20)	(.09)	(1.55)	(.00)	(.42)	(.00)	(.30)	(1.39)

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Table 3. Number of individuals captured (#), mean catch-per-unit effort (#/h for traps and #/m^2 for dip nets and seines), and standard error (SE) of the mean for three different gear types used to survey for Gila topminnow and desert pupfish on March 30 and 31, 2009 in four waters within the Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona. Sample size (N) is the number of collapsible minnow traps set, dip-net sweeps, or seine hauls. Catch-per-unit effort was not calculated for dip nets in Headquarters Spring or upper Swamp Springs Canyon because area sampled was not recorded.

Water	Gear		Gila topminnow	Desert pupfish	Longfin dace	Total
Cherry Spring Canyon	Minnow trap (N=5)	#	12	7	0	19
		#/h	0.87	0.52	0.00	1.40
		SE	(.55)	(.52)	(.00)	(1.02)
	Dip net (N=10)	#	16	3	0	19
		#/m^2	4.32	0.81	0.00	5.14
		SE	(2.46)	(.58)	(.00)	(2.53)
Headquarters Spring	Minnow trap (N=10)	#	78	2	0	80
		#/h	3.32	0.08	0.00	3.40
		SE	(1.74)	(.05)	(.00)	(1.75)
	Dip net (N=14)	#	195	0	0	195
Secret Spring	Minnow trap (N=10)	#	857	6	0	863
		#/h	34.21	0.23	0.00	34.44
		SE	(17.69)	(.10)	(.00)	(17.75)
	Dip net (N=22)	#	108	0	0	108
		#/m^2	26.50	0.00	0.00	26.50
		SE	(8.96)	(.00)	(.00)	(8.96)
Swamp Springs Canyon	Minnow trap (N=10)	#	11	4	173	188
		#/h	0.35	0.13	5.35	5.83
		SE	(.23)	(.07)	(1.71)	(1.83)
	Dip net (N=2)	#	0	2	22	24
	Seine (N=16)	#	3	0	681	684
		#/m^2	0.03	0.00	14.06	14.09
		SE	(.03)	(.00)	(3.58)	(3.58)

2ASLDRedfield000060

Table 4. Number of individuals captured (#), mean catch-per-unit effort (#/h for traps and #/m^2 for dip nets and seines), and standard error (SE) of the mean for three different gear types used to survey for Gila topminnow and desert pupfish on September 14 and 15, 2009 in four waters within the Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona. Sample size (N) is the number of collapsible minnow traps set, dip-net sweeps, or seine hauls. Catch-per-unit effort was not calculated for dip nets in Secret Spring or lower Swamp Springs Canyon because area sampled was not recorded.

Water	Gear		Gila topminnow	Desert pupfish	Longfin dace	Speckled dace	UID larvae	Total
Secret Spring	Minnow trap (N=12)	#	3905	6	0	0	0	3911
		#/h	78.68	0.14	0.00	0.00		78.81
		SE	(11.82)	(.07)	(.00)	(.00)		(11.85)
	Dip net (N=10)	#	175	0	0	0	0	175
Headquarters Spring	Minnow trap (N=10)	#	284	0	0	0	0	284
		#/h	8.43	0.00	0.00	0.00		8.43
		SE	(5.48)	(.00)	(.00)	(.00)		(5.48)
	Seine (N=7)	#	595	0	0	0	0	595
		#/m^2	27.06	0.00	0.00	0.00	0.00	27.06
		SE	(11.41)	(.00)	(.00)	(.00)	(.00)	(11.41)
Cherry Spring Canyon[1]	Minnow trap (N=10)	#	119	5	0	0	0	124
		#/h	5.51	0.23	0.00	0.00		5.73
		SE	(3.46)	(.18)	(.00)	(.00)		(3.43)
	Dip net (N=18)	#	6	0	0	0	0	6
		#/m^2	3.75	0.00	0.00	0.00	0.00	3.75
		SE	(2.18)	(.00)	(.00)	(.00)	(.00)	(2.18)
Swamp Springs Canyon-upper	Minnow trap (N=10)	#	952	0	332	10	0	1294
		#/h	16.78	0.00	5.82	0.18		22.78
		SE	(3.26)	(.00)	(1.10)	(.09)		(2.61)
Swamp Springs Canyon-lower	Dip net (N=17)	#	5	0	8	0	0	13
	Seine (N=3)	#	78	0	86	0	3	167
		#/m^2	8.67	0.00	9.56	0.00	0.33	18.56
		SE	(.88)	(.00)	(2.89)	(.00)	(0.33)	(2.62)

[1]An additional estimated 500 Gila topminnow were visually observed in Cherry Spring Canyon.

2ASLDRedfield000061

Appendix 1. Summary of species stocked and stocking location information for seven waters within the Muleshoe Cooperative Management Area, Galiuro Mountains, Arizona during 2007-2009.

Water	Reach	Species	Date	Site name	Meters from bottom of reach	Easting (NAD 83)	Northing (NAD 83)	Number Stocked
Redfield Canyon	Swamp Springs Canyon upstream to 1st eastern trib	Loach minnow	10/4/2007		613	563625	3589507	77
			10/4/2007		904	563760	3589433	44
			10/4/2007		1134	563932	3589858	92
			9/17/2008		1212	564011	3589842	200
			9/17/2008		1258	564013	3589918	200
			9/17/2008		924	563768	3589918	120
			9/17/2008		881	563732	3589744	120
			9/17/2008		813	563688	3589683	120
			9/17/2008		746	563674	3589617	120
			9/17/2008		501	563674	3589414	120
		Spikedace	10/4/2007		1180	564027	3589881	192
			9/17/2008		924	563768	3589918	100
			9/17/2008		881	563732	3589744	100
			9/17/2008		813	563688	3589683	100
			9/17/2008		746	563674	3589617	100
			9/17/2008		134	563354	3589126	100
Hot Springs Canyon	Bass Canyon to Wildcat Canyon	Loach minnow	10/4/2007		160	569319	3579964	205
			9/17/2008		717	569706	3579826	250
			9/17/2008		609	569620	3579844	249
			9/17/2008		476	569592	3579986	250
			9/17/2008		255	569422	3579933	250
			10/28/2009		160	569334	3579986	87
			10/28/2009		609	569624	3579847	69
		Spikedace	10/4/2007		68	569265	3580026	105
			10/4/2007		255	569424	3579941	105
			9/17/2008		717	569706	3579826	125

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Water	Reach	Species	Date	Site name	Meters from bottom of reach	Easting (NAD 83)	Northing (NAD 83)	Number Stocked
			9/17/2008		609	569620	3579844	125
			9/17/2008		476	569592	3579986	125
			9/17/2008		255	569422	3579933	125
			10/28/2009		68	569277	3580018	212
			10/28/2009		609	569624	3579847	174
Swamp Springs Canyon	Lower	Gila topminnow	10/4/2007		1275	564394	3589487	249
		Desert pupfish	10/4/2007		1275	564394	3589487	248
	Upper		9/17/2008		4245	566576	3589070	225
			9/17/2008		4267	566603	3589070	50
		Desert pupfish	9/17/2008		4245	566576	3589070	225
			9/17/2008		4267	566603	3589070	48
Cherry Spring Canyon	Bradberry site upstream to directly south of Cherry Spring Peak	Gila topminnow	10/4/2007	Lower pool	2077	565981	3587090	130
			10/4/2007	Upper pool	2100	565977	3587082	134
			9/17/2008	Lower pool	2077	565981	3587090	275
		Desert pupfish	10/4/2007	Lower pool	2077	565981	3587090	148
			10/4/2007	Upper pool	2100	565977	3587082	98
			9/17/2008	Lower pool	2077	565981	3587090	275
Secret Spring		Gila topminnow	10/4/2007			571100	3578303	499
		Desert pupfish	10/4/2007			571100	3578303	496
Headquarters Spring		Gila topminnow	9/17/2008			571624	3577960	275
		Desert pupfish	9/17/2008			571624	3577960	290
Headquarters Hill Spring		Desert pupfish	10/28/2009			571603	3577909	196

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