COLORADO RIVER RECOVERY PROGRAM<br>FY 2011 ANNUAL PROJECT REPORT

RECOVERY PROGRAM<br>PROJECT NUMBER: RZ-Recr

I. Project Title: Razorback emigration from the Stirrup floodplain (RM 275.7)

II. Principal Investigator(s):

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III. Project Summary

Important rearing habitat for razorback sucker (*Xyrauchen texanus*) is thought to be floodplain wetlands (Wydoski and Wick 1998; Muth et al. 1998; Lentsch et al. 1996; Modde 1996; Tyus and Karp 1990). Reproduction by razorback sucker occurs on the ascending limb of the spring hydrograph allowing enough time between hatching and swim up for larvae to enter the system when highly productive floodplain habitats are accessible (Muth et al. 1998). This seasonal timing of razorback sucker reproduction indicates possible adaptation for using floodplain habitats for rearing purposes (Muth et al. 1998). It is unclear, however, how long young razorback sucker tend to stay in the floodplain before moving back out into the river.

The Green River Floodplain Management Plan (2003) identifies the Stirrup floodplain as a high priority habitat for recovery of the endangered razorback sucker, bonytail (*Gila elegans*), and Colorado pikeminnow (*Ptychocheilus lucius*). The natural levee surrounding the Stirrup was breached at the downstream end in March 1997 in an effort to increase the frequency of connectivity of the floodplain to the river. The floodplain now connects at around 14,000 cfs and can fill to approximately 20 acres during spring peak flows (Birchell and Christopherson 2004).

Though it is not extremely large, the Stirrup floodplain is one of the few floodplain habitats in the middle Green River that retains enough water and overall depth to over-winter fish and therefore, it may provide habitat to support razorback suckers over multiple years. Because of its potential to overwinter fish and singular breach, this site was chosen for a study to research the timing of razorback sucker emigration from highly productive floodplain habitats to the river. Surplus PIT-tagged razorback suckers from Ouray National Fish Hatchery were stocked into the Stirrup floodplain in 2007, 2008, and 2009 after connection.

IV. Study Schedule: Initial year - FY - 2007 Final year - FY 2011

V. Relationship to RIPRAP:

GENERAL RECOVERY PROGRAM SUPPORT ACTION PLAN

II. Restore habitat (habitat development and maintenance)

II.A. Restore flooded bottomland habitats

II.A.1. Conduct inventory of flooded bottomlands habitat for potential restoration

GREEN RIVER ACTION PLAN: MAINSTEM

II. Restore habitat (habitat development and maintenance)

II.A. Restore and manage flooded bottomland habitat

II.A.1. Conduct site restoration

II.A.2. Acquire interest in high-priority flooded bottomland habitats between Ouray NWR and Jensen to benefit endangered fish

II.A.2.a. Identify and evaluate sites

IV. Manage genetic integrity and augment or restore populations (stocking endangered fishes)

VI. Accomplishment of FY 2010 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

**Task 1. Pump water from the river into the Stirrup floodplain. This includes preparation of compliance documents for both the BLM and Utah Division of Water Rights.**

To increase overwinter survival of remaining stocked razorback sucker and bonytail, water was pumped into the floodplain in the fall of 2010 (November 9–23) and 2011 (November 15–21) just prior to ice cover. On both occasions, pumping was discontinued when we observed backflow out of the floodplain (i.e., wetland completely full).

**Task 2. Stock razorback sucker in the Stirrup floodplain.**

Razorback suckers stocked by Ouray National Fish Hatchery 2007-2009:

2007 – 1632 Age-2 stocked 6/25/2007 (2005 age class)
1633 Age-1 stocked 10/16/2007 (2006 age class)

There was a severe fish kill overwinter 2007. We know we had some survival, but we also know that many of the fish died from low oxygen levels.

2008 – 1000 YOY stocked 10/09/2008 (125 mm average; 2008 age class)
2000 Age-1 stocked 7/1/2008 (256 mm average; 2007 age class)
1047 Age-1 stocked 7/23/2008 (2007 age class)
952 Age-2 stocked 7/1/2008 (2006 age class)

We did not document a fish kill overwinter between 2008 and 2009.

2009 – 1727 Age-1 stocked 6/10/2009 (2008 age class)

There was a partial winter kill between 2009 and 2010 due to low oxygen levels. However, we did record RZ, stocked in 2008, moving out of the Stirrup in June 2010.

Following extensive floodplain augmentation in 2010, we did not document a fish kill overwinter between 2010 and 2011 and did observe RZ stocked in 2009 moving out in 2011.

2011 – 6804 Age-2 bonytail (2009 age class; 205 mm average when tagged previous fall) were stocked by Wahweap Fish Hatchery on 4/7/2011

**Task 3. Monitor water quality and species assemblage in Stirrup floodplain.**

Water quality was monitored on seven dates in 2011 (Table 1) following 2010 fall pumping and floodplain connection in 2011. Measurements from our multi-probe sonde, set to record at 30 second intervals, were averaged for approximately five minute readings taken during each sampling event. It appears that adequate oxygen levels were maintained year-round (Table 1), which likely prevented a fish kill entirely overwinter between 2010 and 2011.

We sampled fish on two separate occasions following the additional bonytail stocking and the extensive floodplain connection observed in 2011 (Figure 1) in order to determine bonytail residence following connection and whether larval razorback sucker were entrained in the floodplain (i.e., present as young-of-year). From 26-29 July 2011 we set 10 fyke nets (small and large mesh) throughout the wetland for three nights (i.e., 30 fyke net sets altogether) and conducted boat electrofishing along three transects that encompassed near shore and deepwater habitats (total effort = 5,795 s). Catch predominantly consisted of green sunfish, black bullhead, fathead minnow, and carp during the July sampling effort (Table 2). However, one razorback sucker (TL = 383 mm) was captured twice during successive electrofishing transects. This fish was not stocked in the Stirrup floodplain or detected moving into the floodplain; it was originally stocked into the mainstem Green River by ONFH in the fall of 2010. From 14-18 November 2011 we strategically placed 13 fyke net sets and two trammel net sets to take advantage of inflow currents during fall pumping that likely attracted fish to the area near the floodplain breach. Catch predominantly consisted of red shiner, fathead minnow, black bullhead, carp, and green sunfish during the November sampling (Table 2). Although we did not collect any endangered fishes during November fyke-netting, of particular interest is an unknown darter spp. that was collected during each sample date and in multiple nets (Table 2). These individuals were preserved and we are awaiting final species identification (Larval Fish Lab). The trammel net was placed just below the inflow where the floodplain narrows towards the breach (i.e., last defense for fish that were missed by fyke nets). Only two trammel net sets were used because fyke nets proved extremely effective (Table 2) and overnight ice near the edges of the wetland affected trammel net sets. Although only two fish were collected with trammel nets, one was an untagged juvenile pikeminnow (TL = 322 mm).

Additionally, a trial run using a floating PIT-reader (Peter MacKinnon, with the help of Vernal CRFP) was conducted to determine if PIT-tagged fish could be detected in the Stirrup floodplain on 10 May 2011. Using a raft rigged with a trolling, also pushed at times in shallower water, the crew searched the inflow area (during initial connection) for about one hour. Altogether, 12 unique tags were detected; crews ensured that these were from live fish. Five of these fish were bonytail stocked into the Stirrup in 2011, five fish were razorbacks stocked into the Stirrup (4 from 2008 and 1 from 2009), and two fish were razorbacks tagged and released at the Baeser floodplain (one was released into the Green River). Three of these fish, all bonytail, were detected in the floodplain breach.

**Table 1.** Water quality measurements at the Stirrup floodplain. Open water measurements were taken from mid-water column and measurements during ice cover were taken near the substrate, at mid-water column, and just below the ice surface.

| Date | Temp. (°C) | DO (mg/L) | pH | Cond. (µS) | Ice Depth (in.) | Snow Depth (in.) |
|---|---|---|---|---|---|---|
| 1/20/2011 | 4.7 | 9 | 8.2 | 596 | 10-12 | 1-2 |
| 2/15/2011 | 4.4 | 8.1 | 7.6 | 670 | 10-12 | 2-3 |
| 3/14/2011 | 7.5 | 16.6 | 8.6 | 662 | 9.5* | 0 |
| 4/21/2011 | 13.1 | 7.4 | 9.3 | 498 | – | – |
| 8/1/2011 | 26.9 | 11.3 | 9.7 | 383 | – | – |
| 9/13/2011 | 22.6 | 9.7 | 9.7 | 379 | – | – |
| 10/24/2011 | 12.3 | 7.9 | 9.3 | 402 | – | – |

***** Ice conditions unstable during measurement (i.e., soft ice that was melting fast).

**Table 2.** Fish sampling conducted at the Stirrup floodplain. Data from similar gear types used during each sampling event (July or November) was combined.

| | July Sampling | | November Sampling | |
|---|---|---|---|---|
| Species | Fyke Nets | Electrofishing | Fyke Nets | Trammel Nets |
| black bullhead | 176 | – | 1033 | 1 |
| bluegill | 17 | 34 | 135 | – |
| carp | 76 | 72 | 393 | – |
| Colorado pikeminnow | – | – | – | 1 |
| darter spp. | 18 | – | 52 | – |
| fathead minnow | 176 | – | 1148 | – |
| green sunfish | 622 | 15 | 220 | – |
| razorback sucker | – | 1 | – | – |
| red shiner | 7 | – | 1554 | – |
| redside shiner | – | – | 1 | – |
| sand shiner | 4 | – | 5 | – |
| white sucker | 7 | 3 | 28 | – |

**Task 4. Set up stationary PIT tag reader during spring peak flows.**

The reader and antennas were in place on 13 April 2011; antenna 1 was closest to the river, antenna 4 was closest to the floodplain, and antenna 3 was in between – all antennas were separated by approximately 20 feet. Antennas were initially tuned until 21 April 2011 when we were able to replace an underwater connector to the exciter cable, at which time all antennas were functioning well (i.e., minimal noise levels and detecting all field test tags easily). Even without conducting any fine-tuning prior to floodplain connection (21 April to 8 May), detection efficiency[1] remained relatively high for antenna 1 (89.7%) and antenna 4 (92.4%). Once flows came up, the antennas required re-tuning which was conducted on 8 May 2011. After this time, test tags were no longer fired because the reader was detecting real tags (most of the time). The first tag was detected by the antennas in the floodplain breach on 11 May 2011 at 0603. However, we may have experienced some data loss due to a full memory on the multiplexer, which maxes out at 5,310 records and deletes the earliest records to add new information. This occurred because communication with the reader was not possible during site visits on the 9th and 10th of May (disallowing a download) because the HyperTerminal routing information to the field computer was reset and required IT assistance. Unfortunately, during this time the unique mode (set at one minute intervals hereafter) was disabled which quickly filled the memory. Despite this discrepancy, data loss was probably minimal during this time and we feel that the first fish detection is an accurate reflection of when they began moving out of the floodplain. Specifically, 25 cm depth is required throughout the entire breach before fish begin to move freely between the river and floodplain (see previous annual report). On 10 May 2011, breach depth was measured at four locations (between 1100 and 1200) and was 11 cm near the floodplain, which only consisted of sheet flow at the time. Given the lag time in flows (Figure 1), breach depth great enough for fish movement likely did not occur until the morning of 11 May 2011, which would also be consistent with the timing from our 2010 results.

Although antenna 3 was fully operational during the entire connection period, antennas 1 and 4 stopped functioning due to water damaged from prolonged inundation (antennas were completely submerged for an extended period due to high peak flows). Antenna 1 was detecting test tags and real tags until 5 June 2011, after which time it did not detect anything due to lack of antenna current. Antenna 4 stopped firing test tags after 3 June 2011, but continued to detect real tags on 4 June 2011, which was its last day of detections. Once flows receded we determined that there was moisture inside of the antennas that affected the wire coils. We have since consulted with other researchers using this same equipment and determined that an appropriate solution to prevent future leaks and antenna damage will be using a final seal using water weld.

**Task 5. Download PIT tag data and monitor PIT tag array**

Over the entire connection period, which lasted for 69 days (Figure 1), we had a total of 20,884 detections with all three antennas combined. Of these detections, we identified 1,216 unique fish

[1] Detection efficiency is defined here as the number of test tags actually fired / the number of test tags that should have been fired by that antenna (set to occur once per hour) x 100.

that were detected in the floodplain breach; only one that is not yet accounted for. In the interest of providing an annual report to the Recovery Program in a timely fashion, we will only briefly summarize fish detected by stationary antennas at the Stirrup floodplain breach during operation in 2011. We will provide an addendum to this report that will consist of a complete summary of capture histories at a later date (prior to the 2012 field season).

Of the 1,216 unique individuals we detected 1,129 bonytail that were stocked in the Stirrup on 7 April 2011, which constitutes 16.6% of the stocked fish. Although we have not assessed directional movement for this report, we suspect that the majority of these fish were moving out of the floodplain. Regardless, this is likely a gross underestimate of the number of stocked bonytail that left the floodplain given that extremely high peak flows (Figure 1) substantially widened and deepened the breach providing new avenues of movement around the antennas. One of these bonytail was subsequently recaptured during trammel netting in the Baeser floodplain on 21 October 2011. In addition, we detected 10 bonytail that were stocked by the Wahweap Fish Hatchery in other locations in 2011.

Overall, we detected 63 razorback suckers in the floodplain breach. Six of these fish were from the 2008 year class that were originally stocked in the Stirrup floodplain in 2009 (now age 3 fish). Twenty-two of these fish were originally stocked in the Baeser floodplain, including three fish that were previously documented at the Stirrup. Thirty-five of these razorbacks were originally stocked in the middle Green River by ONFH.

Finally, we detected 13 Colorado pikeminnow in the floodplain breach. Eight of these fish were originally tagged in the middle Green River, many with previous detections at the Stirrup. Five were originally tagged in the lower Green River. We did come across an interesting capture history for one fish that deserves a brief mention. One Colorado pikeminnow was originally tagged in 2001 in the Green River at RM 26.8 during pikeminnow population estimates. In 2008, this fish was recaptured during pikeminnow population estimates in the White River at RM 17.2. The following year, smallmouth bass removal crews recaptured this fish in the Green River at RM 329.8 before we finally detected it once again at the Stirrup in 2011.

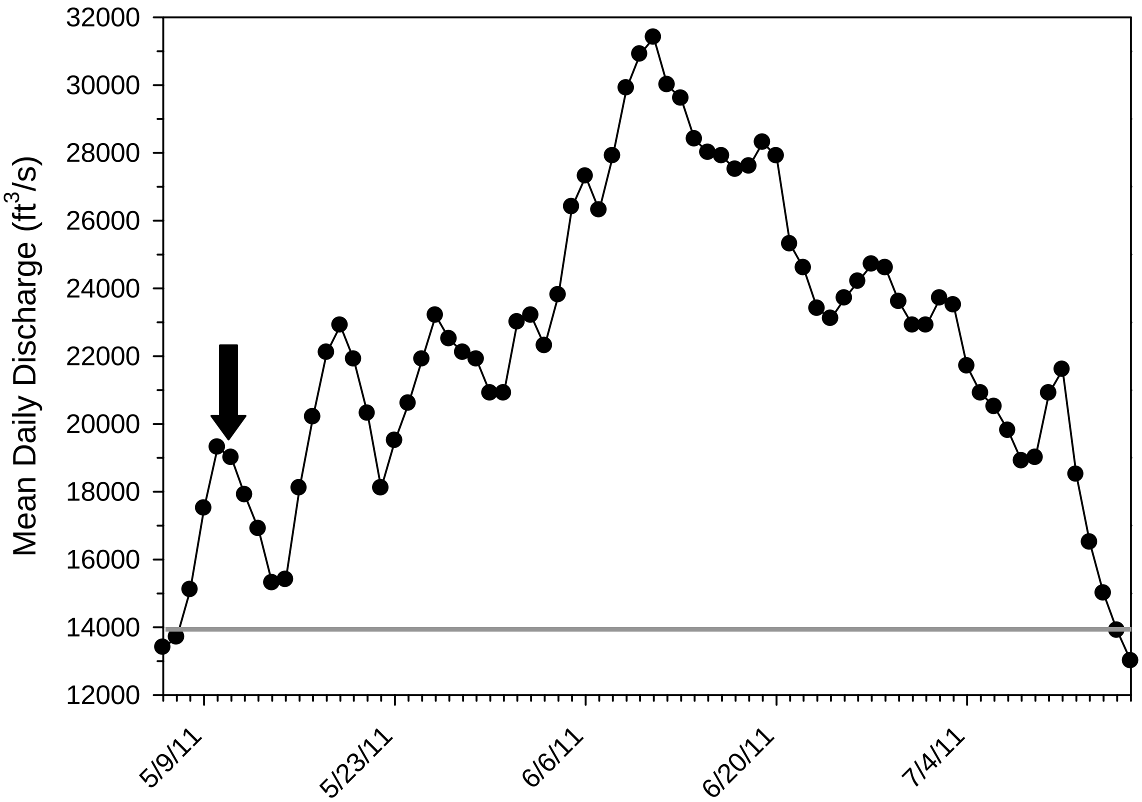


**Figure 1**. Mean daily discharge for the Green River at Jensen, Utah (USGS; provisional data). The Stirrup floodplain connects to the river at approximately 14,000 cfs (grey line); however, at this flow, water is entering the breach, but without depth of approximately 25 cm the entire route to the floodplain, fish will not move. Therefore, fish did not start moving into/out of the floodplain until 11 May 2011 (indicated by an arrow). Note that lag time for flows from Jensen to the Stirrup is approximately 24 hours.

**Task 6. Summarize results/findings/submit final report**

Annual report to Recovery Program November 2011.
The revised version of the final report will be submitted in January 2012.

VII. Recommendations:

- Given that an abundance of fish (bonytail, razorback sucker, and Colorado pikeminnow) originally stocked in Green River floodplains or main channel habitats were detected moving into or out of the Stirrup floodplain during the extensive floodplain connection period in 2011, we suggest that stationary PIT antennas provide an integral tool for determining vital life-history and habitat use information on endangered Colorado River fishes. Although single breach wetlands are ideal for detecting movement of fishes between wetland and riverine habitats, we recommend that this work or a similar study be focused on another wetland other than the Stirrup. Due to increased depth, which may provide refugia from low DO levels overwinter and avian predation (identified in Hedrick et al. In Review), a larger surface area, and the ability to manipulate water levels and outflow for a movement study, we recommend that the Stewart Lake floodplain would provide an ideal setting for continuation of this project and/or further development of a similar floodplain habitat use study.

- We recommend continuation of this work (stationary antennas) in the Stirrup if additional fish are stocked there.

- We recommend that future stocking, regardless of species, should occur in the fall so that overwinter survival estimation can be incorporated into the study design and as mentioned, future stockings would be more appropriate for the Stewart Lake floodplain.

- Three antennas should be the minimum number of antennas used for detecting movement, especially during longer sampling durations when equipment difficulties are inevitable. If the project is continued, all three of our antennas will require repairs and rebuilds, which should be a normal consideration for field equipment that is used for multiple seasons.

VIII. Project Status:

The project is ongoing and on track.

IX. FY 2010 Budget Status

A. Funds Provided: $17,579
B. Funds Expended: $17,579
C. Difference: $0
D. Percent of the FY 2010 work completed, and projected costs to complete: 100%
E. Recovery Program funds spent for publication charges: $0

X. Status of Data Submission:

2011 data will be submitted in December 2011.

XI. Signed: *Matthew J. Breen* 11/30/2010
Principal Investigator Date

XII. Literature Cited

Birchell, G.J. and K. Christopherson. 2004. Survival, growth, and recruitment of larval and juveniles razorback sucker (*Xyrauchen texanus*) introduced into floodplain depressions of the Green River, Utah. Utah Division of Wildlife Resources, publication no. 04-15, Salt Lake City, Utah.

Lentsch, L., T. Crowl, P. Nelson, and T. Modde. 1996. Levee removal strategic plan. Utah Division of Wildlife Resources, Salt Lake City, UT. 21 pp.

Modde, T. 1996. Juvenile razorback sucker (*Xyrauchen texanus*) in a managed wetland adjacent of the Green River. Great Basin Naturalist 56:375-376.6

Muth, R.T., G.B. Haines, S.M. Meismer, E.J. Wick, T.E. Chart, D.E. Snyder, and J.M. Bundy. 1998. Reproduction and early life history of razorback sucker in the Green River, Utah and Colorado, 1992 – 1996. Final Report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, CO. 62 pp.

Tyus, H.M. and C.A. Karp. 1990. Spawning and movements of razorback sucker, *Xyrauchen texanus*, in the Green River basin of Colorado and Utah. Southwestern Naturalist 35:427-433.

Wydoski, R.S. and E.J. Wick. 1998. Ecological value of floodplain habitats to razorback suckers in the Upper Colorado River Basin. Final Report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, SO. 55 pp.

COLORADO RIVER RECOVERY PROGRAM
FY 2011 ANNUAL PROJECT REPORT: **ADDENDUM**

RECOVERY PROGRAM
PROJECT NUMBER: RZ-Recr

I. Project Title: Razorback emigration from the Stirrup floodplain (RM 275.7)

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This addendum is a continuation of the *Accomplishment of FY 2011 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings* for Task 5 only.

**Task 5. Download PIT tag data and monitor PIT tag array**

Over the connection period, which lasted for 69 days (Breen 2011), we had a total of 20,884 detections. Of these detections, we identified 1,216 unique fish using the floodplain breach. In the Annual Report (Breen 2011), we only briefly summarized fish detected at the Stirrup floodplain breach in 2011. Therefore, this addendum consists of an extended analysis of fish detections, including information on the timing /direction of fish movement, potential mechanisms explaining fish movement, and the outcome of fish stocked in the Stirrup floodplain.

For additional clarity before presenting further analyses, we briefly summarize the 1,216 unique fish encountered by the stationary antennas. We detected 1,129 bonytail that were stocked in the Stirrup floodplain in April 2011 (16.6% of the 6,804 stocked fish), 10 bonytail that were stocked elsewhere in the basin, six razorback suckers that were originally stocked in the Stirrup floodplain in 2009 (now age-3 fish), 57 razorback suckers that were stocked elsewhere in the basin (22 from Baeser floodplain; 35 from the middle Green River), 13 Colorado pikeminnow (8 that were tagged in the middle Green River; 5 that were tagged in the lower Green River), and one fish that is not accounted for.

The Stirrup floodplain first connected to the Green River on 8 May 2011 (Breen 2011); however, initial connection only fills the wetland at first (Figure 1a-b), which explains why fish were not detected initially. For example, on 10 May 2011 (Figure 1c), breach depth was only 11 cm deep near the floodplain, which only consisted of sheet flow at the time. Sufficient depth was not present throughout the entire breach for fish movement until 11 May 2011 when depth averaged 31.6 cm in the breach and was 70 cm near the floodplain (Figure 1d). This result is consistent with Hedrick et al. (2012), who suggested that a 25 cm depth throughout the breach was needed.

Based on observations reported by Hedrick et al. (2012), we initially hypothesized that depth and turbidity would provide necessary cover making fish more prone to moving through the breach corridor and that discharge levels in the breach would provide the necessary flow cues to initiate movements. To further investigate factors that initiate fish movements in the floodplain breach, we monitored depth, turbidity, and discharge in the breach on several dates. There was a positive association between mean depth and the number of fish detected in the breach (Figure 2). Focusing specifically on 13 and 18 May 2011, which closely follows initial peaks in breach depth, we detected the most fish. However, this relationship is only marginally significant, likely due to the limited number of observations and our inability to measure depth during extremely high water (i.e., not possible on 27 May and after 31 May 2011). There was a positive association between turbidity and fish movement, but this relationship was not significant (Figure 3) or biologically meaningful (i.e., increased fish detection with higher visibility). However, more fish were detected on 13, 18, and 27 May which occurred just after or during turbidity events (Figure 3). Nevertheless, turbidity is a function of discharge as turbid water enters the breach then settles out when inflows decrease, thus making it difficult to determine this relationship without extensive measurements. Moreover, breach discharge, which was highest at over 16 cfs during initial floodplain connection, was highly variable during the month of May (Figures 4 and 5). We did not detect a significant relationship between discharge and fish detections in the breach (Figure 4), but it does appear that fish movement follows a flow cue initiating movements given that the most fish were detected on 13 and 18 May following individual peaks in discharge. Regardless, this relationship was difficult to interpret because there were three smaller peaks in discharge, which also resulted in backflow out of the floodplain, as mainstem flows fluctuated before the final peak in early June (Figure 5).

Overall, at least one fish was detected in the floodplain breach every single day from 11 May 2011 until 16 July 2011. Once sufficient depth was present (i.e., these dates with the exception of 15-16 July when final outflow occurred in the breach as connection was finally lost), the floodplain breach provided a substantial movement corridor. Most razorback sucker and Colorado pikeminnow were detected in the breach during initial connection in the month of May, especially following two smaller peaks in flow, whereas fewer fish were detected during some of the highest flows in June and July (Figure 6). This pattern was even more pronounced for bonytail, where almost all detections occurred by early June (Figure 7). We did not specifically assess directional movement for all 1,216 fish detected; however, we suspect that the majority of the bonytail were moving out of the floodplain. An abundance of bonytail detections closely follows each of three peaks in main channel flows, with a tapering effect after the first spike in bonytail detections (Figure 7). After these initial pulses of detections, a less obvious fourth and fifth peak in bonytail detections also ensued (Figure 7). The decrease in detections with each pulse in discharge, and the fact that bonytail were rarely observed after 5 June 2011 (Figure 7), provides strong evidence that bonytail stocked in the Stirrup moved out of the floodplain permanently as soon as the opportunity presented itself, operating along with flow cues from fluctuating water levels in the mainstem Green River. In addition, extensive fish sampling (i.e., multiple techniques and collection periods) in the wetland following riverine connection did not produce a single bonytail (Breen 2011), thus providing further evidence that bonytail stocked in the Stirrup floodplain successfully transitioned into the Green River.

In summary, 2011 provided an excellent opportunity to gather valuable information on the importance of extended high flows for endemic endangered fishes and their respective use of floodplain habitats. We found that floodplain use is extensive during high flow scenarios; we detected more razorback sucker, Colorado pikeminnow, and bonytail in the floodplain breach than all previous study years combined (see Hedrick et al. 2012). With that, several fish were detected in multiple years demonstrating that these fishes revisit wetland habitats regularly. Bonytail were stocked in the Stirrup floodplain for the first time, and we found that the majority of stocked fish that survived likely moved out of the floodplain during the same year they were stocked as age-2 fish. The life-history of this species is largely unknown, but floodplains may play an important role in their life histories. For instance, floodplains may provide an alternative stocking location rather than the main channel to potentially increase bonytail survival upon release into the wild. This year did not allow for an estimation of survival, which was not the original intent of this project, but our results indicate high survival rates of stocked fish for at least one month post-stocking. As for the duration of floodplain use by razorback sucker, fish we detected were originally stocked in 2009 and moved out of the floodplain after two winters as age-3 fish, which is consistent with age-class specific emigration by this species in previous study years (Hedrick et al. 2012).

VII. Recommendations:

After additional analyses conducted for this addendum, the following recommendations provided below are in addition to what has already been suggested in the 2011 Annual Report.

- Floodplain connection alone does not dictate fish movement between floodplain and riverine habitats. As we demonstrated, breach depth is an important factor limiting fish movement. The Stirrup floodplain connects to the Green River at approximately 14,000 cfs, but this flow does not ensure adequate depth for fish movement throughout the entire floodplain-river corridor. Similar to Hedrick et al. (2012), our results indicate that flows of approximately 18,000 cfs are necessary to allow free movement in the floodplain breach. Therefore, future Green River flow requests should strive for 18,000 cfs to reach recovery goals when considering the Stirrup floodplain.

- We detected over 16% of bonytail originally stocked in the Stirrup floodplain in the floodplain breach during high flow connection, which is likely a gross underestimation given that extremely high flows provided additional avenues of movement around our stationary antennas. We also provided several lines of evidence suggesting that bonytail detected in the floodplain breach successfully transitioned into riverine habitats after occupying the floodplain for an entire month. Therefore, we suggest that floodplain habitats are a viable option for an alternative stocking locations rather than riverine habitats to potentially increase bonytail survival upon release into the wild.

XI. Signed: *Matthew J. Breen* *10/24/2012*

Principal Investigator Date

XII. Literature Cited:

Breen, M.J. 2011. Razorback emigration from the Stirrup floodplain. Annual report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, CO.

Hedrick, T.N., A.R. Breton, and S.P. Keddy. 2012. Razorback sucker survival and emigration from the Stirrup floodplain, middle Green River, Utah 2007-2010. Publication Number 12-10. Final report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, CO.


**Figure 1.** The Stirrup floodplain breach photographed each day from 8-11 May 2011 (a-d respectively) near the wetland during the initial connection period.

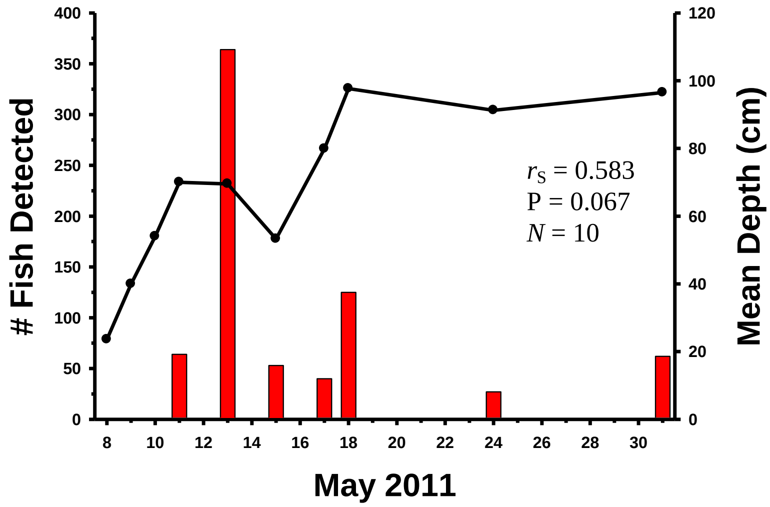


**Figure 2.** Unique fish (red bars) detected by stationary antennas in the Stirrup floodplain breach on 10 days when breach depth (measured at four locations) was recorded. A Spearman Correlation Coefficient ($r_S$) was used to determine a relationship between these variables.

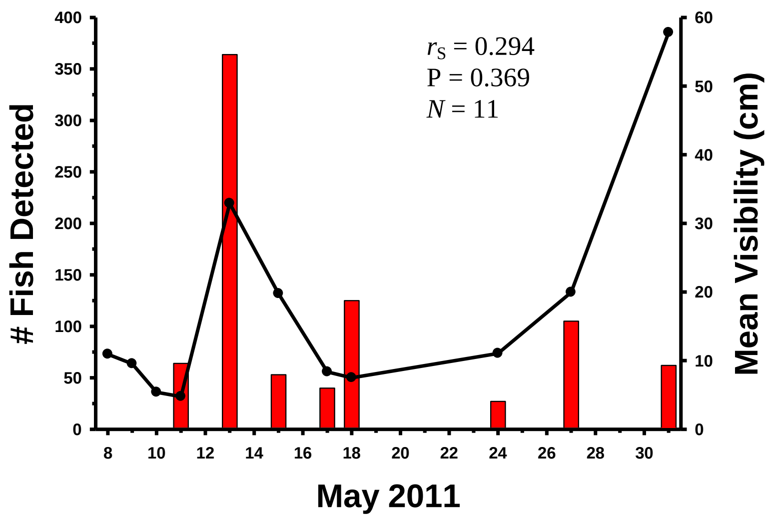


**Figure 3.** Unique fish (red bars) detected by stationary antennas in the Stirrup floodplain breach on 11 days when turbidity (measured as the depth of visibility) was recorded. A Spearman Correlation Coefficient ($r_S$) was used to determine a relationship between these variables.

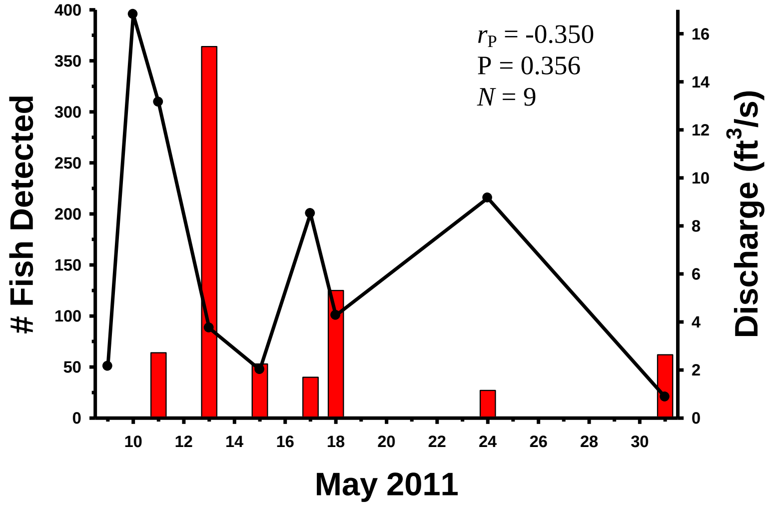


**Figure 4.** Unique fish (red bars) detected by stationary antennas in the Stirrup floodplain breach on nine days when discharge (measured with a Marsh-McBirney flow meter at a single permanent transect) was recorded. A Pearson Correlation Coefficient ($r_P$) was used to determine a relationship between these variables.

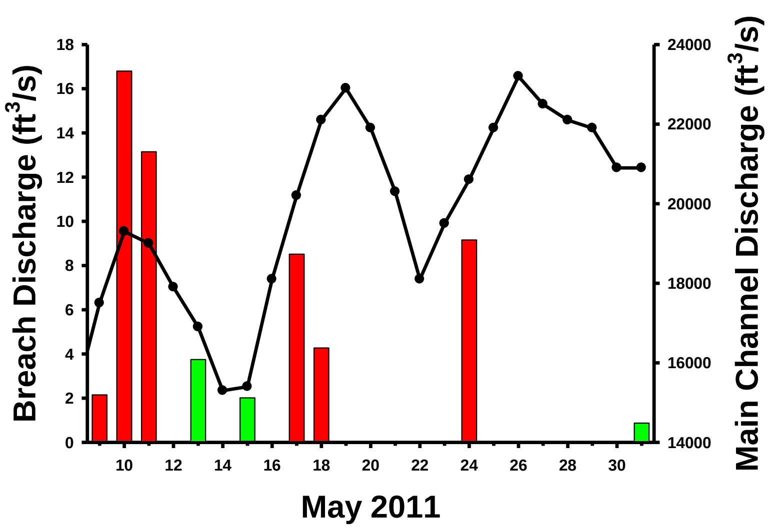


**Figure 5.** Discharge in the Stirrup floodplain breach (bars; measured with a Marsh-McBirney flow meter at a single permanent transect) in relation to discharge in the mainstem Green River (measured at the USGS Jensen guage with a 24-hr lag time). Red bars represent inflow towards the floodplain, whereas green bars indicate outflow.

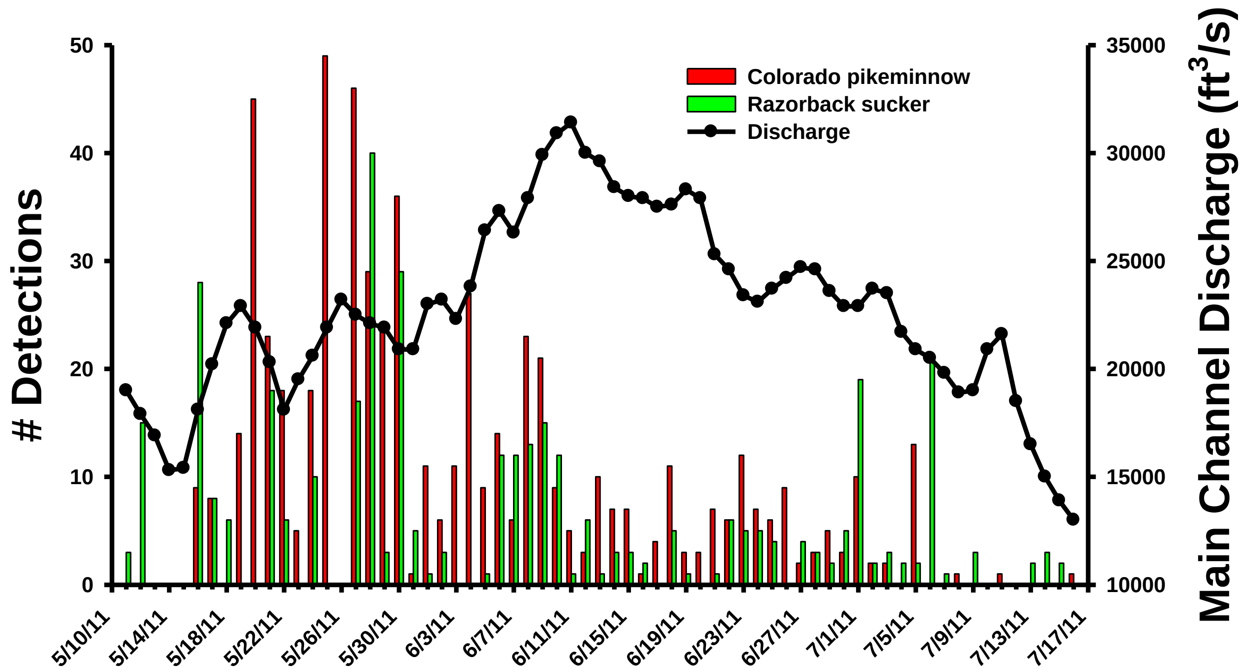


**Figure 6.** Total detections (red and green bars) of razorback sucker and Colorado pikeminnow by stationary antennas in the Stirrup floodplain breach in relation to main channel discharge.

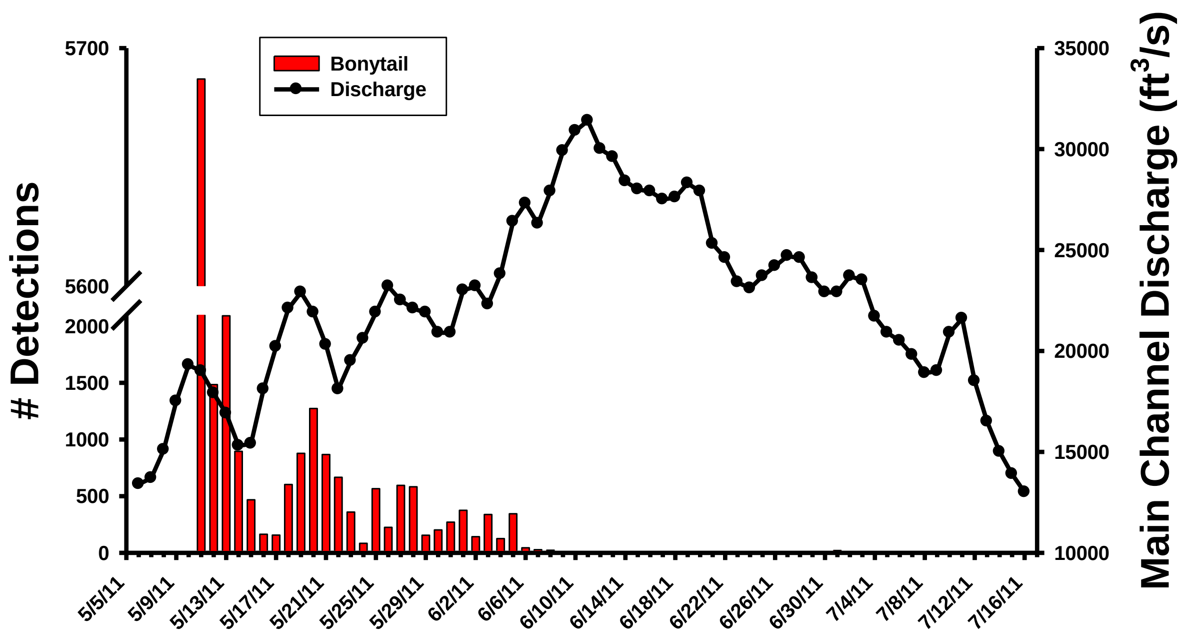


**Figure 7.** Total bonytail detections (red bars) by stationary antennas in the Stirrup floodplain breach in relation to main channel discharge. Note the break in the scale for the left y-axis.