

COLORADO RIVER RECOVERY PROGRAM
FY 2015 ANNUAL PROJECT REPORT

RECOVERY PROGRAM
PROJECT NUMBER: 138

I. Project Title: Annual fall monitoring of young of year Colorado pikeminnow and small-bodied native fishes

II. Bureau of Reclamation Agreement Number(s): R14AP00007
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IV. Abstract:

Monitoring of young-of-year Colorado Pikeminnow (*Ptychocheilus lucius*) is an ongoing project that was initiated in 1986 in the upper Colorado River basin as part of the Interagency Standardized Monitoring Program (ISMP; USFWS 1987) to monitor recruitment success of age-0 endangered fishes. In 2015, 1,331 YOY Colorado Pikeminnow were encountered on the lower Colorado River (Reach 1), 461 on the lower Green River (Reach 3), and 202 on the middle Green River (Reach 4). Catch rates were the highest ever recorded in Reach 1 and the highest in Reach 4 since 1993, which represented the last year before a prolonged crash in pikeminnow recruitment in the Green River. Specifically for Green River reaches, base flow levels maintained within a specific range likely contributed to the overwhelming success observed in 2015, reinforcing the value of manipulating Flaming Gorge Dam releases to aid in pikeminnow recovery.

V. Study Schedule:

1986–On going. It is anticipated that this study will continue indefinitely and will be a component of studies designed to evaluate a variety of management actions.

VI. Relationship to RIPRAP:

GENERAL RECOVERY PROGRAM SUPPORT ACTION PLAN

- V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).
- V.A. Measure and document population and habitat parameters to determine status and biological response to recovery actions.
- V.B.2. Conduct appropriate studies to provide needed life history information.

GREEN RIVER ACTION PLAN: MAINSTEM

- V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).
- V.A. Conduct research to acquire life history information and enhance scientific techniques required to complete recovery actions.

COLORADO RIVER ACTION PLAN: MAINSTEM

- V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).
- V.A. Conduct research to acquire life history information and enhance scientific techniques required to complete recovery actions

VII. Accomplishment of FY 2015 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Task 1. Seining the middle Green River

Middle Green River (Reach 4):

Annual monitoring for young-of-year (YOY) Colorado Pikeminnow began 14 September 2015 and was completed on 24 September 2015. Beginning at Split Mountain boat ramp (RM 319.3) and concluding at Sand Wash (RM 215.3), 57 of 63 possible backwater habitats (three per 5-mile sub-reach) were sampled; 21 primary, 19 secondary, and 17 tertiary. Tertiary backwaters were only sampled in reach four, in an effort to obtain additional information on low-velocity habitat use by native YOY and other small-bodied fishes without the constraints of the ISMP protocol. A total of 4,389 m² of suitable habitat was seined in 2015 (7% of the total habitat area), exceeding the area sampled in 2014, mainly because silt deposition was not a significant factor (see Breen et al. 2014).

Discharge for the middle Green River is measured at USGS gauge #09261000, located at Jensen, Utah. Peak spring discharge reached 15,800 cubic feet per second (cfs) on 21 May 2015 (provisional value), which is slightly above the mean annual peak flow for the period of record (Figure 1). Following spring peak flows, the base flow period was relatively consistent, with limited influence from monsoonal rain events as observed in August and September 2014 (Breen et al. 2014; Figures 1 and 2). With the exception of a

brief period of elevated flows in early July (Figure 1), mean daily discharge remained below 3,000 cfs from 18 July 2015 until ISMP sampling was initiated on 14 September 2015 (Figure 2). During this period, mean daily discharge averaged 2,215 cfs (range = 1,960–2,950 cfs; values provisional).

Conditions during 2015 ISMP efforts differed from previous years. Mean daily discharge for the sample period was 2,197 cfs (range = 1,930–2,400 cfs; values provisional), which is greatly reduced compared to 2014 values (Breen et al. 2014). Main channel temperatures averaged 18.0 °C (15.3–20.7 °C), whereas mean backwater temperatures were 18.4 °C (15.1–24.4 °C) during the sampling period; both metrics being cooler than 2014 (Breen et al. 2014). Turbidity measurements (cm visibility; mean \pm SD) obtained in main channel and backwater habitats were 12.7 ± 9.7 cm (3–>60 cm) and 15.7 ± 18.6 cm (3–>60 cm) respectively, representing better water clarity in the main channel and lower water clarity in backwaters compared to 2014 (Breen et al. 2015). However, it is worth noting that variability among measurements was much greater in 2015.

In primary and secondary backwaters, we captured 202 YOY Colorado Pikeminnow, representing the ninth highest total over 30 years of sampling effort (Tables 1 and 2); juvenile pikeminnow were not observed in 2015. Catch-per-unit-effort (CPUE; fish/100 m²) for YOY pikeminnow (4.6 fish/100 m²) far exceeded the 5- (1.52 fish/100 m²), 15- (0.97 fish/100 m²), and 26-year averages (1.95 fish/100 m²), and represented the fourth highest total on record (Table 1). Average total length for YOY Colorado Pikeminnow was 37.5 mm, smaller than the 5- (44.8 mm), 15- (47.3 mm), and 26-year (44.9 mm) averages (Table 1); growth patterns being consistent with cooler temperature regimes (e.g., Breen et al. 2011). Primary backwaters accounted for the capture of 71 YOY Colorado Pikeminnow (only 26% of the total catch). However, sampling within secondary backwaters accounted for 131 pikeminnow (48%) and tertiary backwaters accounted for an additional 73 pikeminnow (26%; Figure 3). Considering all habitats sampled, pikeminnow were captured in 25 of 57 backwaters (44%); 33%, 53%, and 47% of primary, secondary, and tertiary backwaters respectively. Of the 275 total pikeminnow captured from all backwaters sampled, the highest densities occurred in the farthest upstream and downstream portions of the study reach (i.e., in close proximity to Split Mountain and Sand Wash), including two seine hauls completed in a primary habitat at RM 304.7 that produced 55 YOY pikeminnow and a single seine haul completed in a secondary habitat at RM 217.8 with 57 YOY pikeminnow captures.

Other native species are only reported for captures within primary backwaters to be consistent with previous data summaries (Table 2); this included four *Gila* spp., six Flannelmouth Sucker, and 25 Bluehead Sucker. Secondary and tertiary backwaters accounted for an additional two chubs (average TL for 6 total captures = 52.2 mm), nine Flannelmouth (average TL for 15 total captures = 65.3 mm), and 135 Blueheads (average TL for 160 total captures = 36.4 mm), comprising 33%, 60%, and 84% of total captures respectively (Figure 3). Additionally, tertiary backwaters accounted for 5%, 26%, and 27% of total Bluehead Sucker, Colorado Pikeminnow, and Flannelmouth Sucker captures

respectively (Figure 3), demonstrating the importance of monitoring a third backwater in each sub-reach.

Also to match past data summaries, nonnative species captured during ISMP sampling are only reported for the first seine haul within primary backwaters. Samples continue to be dominated by small-bodied nonnative cyprinids, mainly Fathead Minnow, Red Shiner, and Sand Shiner (98% of the total catch; Table 3). We collected a total of 3,897 nonnative fish comprised of six species in the first seine haul of primary backwaters, which is the ninth lowest total in 29 years of sampling (Table 3). In addition, we collected Black Bullhead ($n=1$), Black Crappie ($n=8$), Channel Catfish ($n=19$), Gizzard Shad ($n=13$), and Smallmouth Bass ($n=2$) from additional seine hauls in primary backwaters and secondary and tertiary backwaters. Smallmouth Bass measured 76 and 92 mm TL, which may represent either age-0 or age-1 fish given that ideal flows and temperatures to promote successful spawning and subsequent growth have been limited over the past two years (e.g., Schelly et al. 2015).

Task 2. Seining the lower Green River and the Colorado River

Lower Green River (Reach 3):

Sampling for the Interagency Standardized Monitoring Program, on the lower Green River, began on 22 September and was completed on 27 September 2015. We sampled low velocity habitats, in accordance with ISMP protocols, between Green River State Park and the confluence of the Green and Colorado rivers (RM 120-0). Crews executed at least one seine haul in 22 of 24 possible primary habitats and 16 of 24 possible secondary habitats. A total of 65 seine hauls were completed out of 96 possible. Researchers surveyed a total of 2,031 m² of habitat (Table 4), which exceeds the area sampled in 2014 (1,670 m²), but is lower than the 29-year average (3,500 m²). Habitat conditions encountered during sampling in 2015 were a vast improvement over those encountered in 2014 (Breen et al. 2014). Silt deposition in low velocity habitats, which substantially diminished sampling efficiency in 2014, was far less evident in 2015.

Discharge for the lower Green River is measured at USGS gauge #09315000 located at Green River, Utah (Figure 4). Spring peak flow occurred on 23 May 2015, measuring 16,200 cfs. Average flow for the period of study was 2,662 cfs, similar to average flows across those dates for the period of record (2,725 cfs, 1894-2014), and slightly below average for the post-dam period (3,012 cfs, 1964-2014). Average main channel temperature through the period of study was 20.0 °C; slightly cooler than in 2014 (21.7 °C). Average habitat temperatures, however, were substantially cooler in 2015 (20.8 °C) than 2014 (24.9 °C). Comparing average turbidity, the main channel was less turbid in 2015 than 2014 (75 mm vs. 43 mm); paradoxically, habitat turbidity was greater in 2015 than 2014 (104 mm vs. 130 mm).

Young-of-year Colorado Pikeminnow captures in 2015 were the eighth highest achieved during ISMP sampling (1986-present) on the lower Green River. Researchers

encountered 461 pikeminnow, which is substantially greater than both the five- and 15-year averages and similar to the 29-year average (95, 199 and 444 encounters, respectively; Table 4). Catch-per-unit-effort for this reach was the sixth highest on record. Crews captured 22.7 fish per 100 m², a rate considerably higher than the five-, 15- and 29-year averages (2.7, 5.6 and 13.1 fish/100 m² respectively; Table 4). Mean total length (44.9 mm) was slightly larger in 2015 than the five-, 15- and 29-year averages (39.1, 41.7 and 39.5 mm; Table 4). Of 65 total seine hauls, 53% contained one or more YOY Colorado Pikeminnow.

It should be noted that 77% of the 461 pikeminnow encountered on the lower Green River were captured in a single seine haul (sample #GR1535). This seine haul was the second completed in a large backwater at Fort Bottom (RM 40.6). Interestingly, the first haul from the same backwater produced only four pikeminnow. Truncating this data point leaves 108 YOY pikeminnow encountered and a CPUE of 5.4 fish/100 m²; these figures are more similar to the five- and 15-year averages (2.7 and 5.6 fish/100 m² respectively).

Due to the unique distribution of high quality habitat encountered in 2015, additional sampling was conducted. We completed eight seine hauls that were not fully compliant with ISMP protocols. These seine hauls were intended to collect data on high quality pikeminnow habitat which, due to location or sampling order within 5-mile sub-reaches, could not be included in the ISMP data set (i.e., Tables 4-5). One was an additional (third) seine haul in a large primary habitat and seven were from four tertiary habitats. Twenty-four YOY pikeminnow were enumerated over the 290 m² sampling area, yielding a catch rate of 8.3 fish/100 m². Seventy-five percent of the eight additional seine hauls contained at least one YOY pikeminnow. Extending sampling beyond ISMP protocol can yield valuable information. Sampling tertiary habitats is potentially advantageous, especially during years with relatively poor habitat availability. The inclusion of tertiary sampling in ISMP should be considered where high value habitat would be otherwise excluded and the additional effort is logistically feasible.

Other native fishes encountered include *Gila* spp. (n=6), Flannelmouth Sucker (n=9) and Speckled Dace (n=9; Table 5). Nonnative fishes were counted only within the first seine haul of primary habitats and totaled 3,040 individuals. Of the nonnatives enumerated, 99% were small-bodied cyprinids: Fathead Minnow (n=570), Red Shiner (n=1,969) and Sand Shiner (n=466; Table 6).

Lower Colorado River (Reach 1):

We sampled for the Interagency Standardized Monitoring Program on the lower Colorado River from 14 September through 17 September 2015. Researchers seined low velocity habitats, in accordance with ISMP protocols, between Cisco Landing and the confluence of the Colorado and Green rivers (RM 110.5-0). Sixteen of 22 possible primary habitats and eight of 22 possible secondary habitats were sampled with a total of 36 out of 88 possible seine hauls completed. The total area sampled in 2015 was the second lowest on

record at 1,251 m² (Table 7); about half of the total area surveyed in 2014 (2,544 m²) and substantially less than the 29-year average (2,897 m²).

The reduced area sampled in 2015 is the result of two factors. First, available habitat (as per ISMP protocol) was not particularly abundant within reach one during sampling in 2015. This is evidenced by the fact that crews were able to complete only 41% of 88 possible seine hauls. Second, due to the large number of YOY pikeminnow frequently encountered (see below), researchers limited the length of seine hauls performed within reach one. This tactic reduced the number of pikeminnow captures to a level which limited mortality rate during enumeration.

Discharge for the lower Colorado River is measured at USGS gauge #09180500, located near Cisco, UT (Figure 5). The Colorado River peaked on 13 June 2015 at 31,700 cfs. Average flow for the period of study was 4,625 cfs, slightly above average flows for those dates for the period of record (3,860 cfs, 1913-2014). Average main channel and backwater temperatures were considerably lower in 2015 (19.5 °C and 20.7 °C respectively) than those recorded in 2014 (21.1 °C and 22.8 °C respectively). Main channel turbidity was substantially lower in 2015 when compared to 2014 (144 mm vs. 78 mm) and backwater turbidity was also somewhat reduced compared to 2014 (144 mm vs. 126 mm).

Researchers encountered 1,331 YOY Colorado Pikeminnow during ISMP sampling in 2015. This is the largest number of YOY pikeminnow encountered within reach one since the initiation of the Interagency Standardized Monitoring Program in 1986. It is also well above the five-, 15- and 29-year averages (30, 56, and 119 encounters respectively; Table 7). Catch-per-unit-effort in 2015 was 106.4 fish/100 m², well above the five-, 15- and 29-year averages (1.8, 1.9 and 4 fish/100 m² respectively; Table 7). This is the highest CPUE achieved for all reaches since ISMP began in 1986 (Tables 1, 4, and 7). Mean total length for 2015 (28.8 mm) was considerably smaller than the five- and 15-year averages, but similar to the 29-year average (34, 40 and 28 mm respectively; Table 7). Eighty-six percent of the 36 seine hauls completed in reach one contained at least one YOY pikeminnow.

Several other species of native fishes were also encountered during ISMP sampling in 2015. *Gila* spp. (n=3), Flannelmouth Sucker (n=120) and six unidentified suckers (preserved and pending identification at the CSU Larval Fish Lab) were captured (Table 8). A total of 4,312 nonnative fishes were enumerated during the first seine haul of all primary habitats encountered on the lower Colorado River. Seventy-seven percent of nonnative captures were of small-bodied cyprinids belonging to three species: Fathead Minnow (n=556), Red Shiner (n=1,696) and Sand Shiner (n=1,089). Black Bullhead (n=617), Gizzard Shad (n=261) and *Gambusia* spp. (n=87) were also captured (Table 9).

VIII. Additional noteworthy observations:

Regardless of sampling reach, YOY Colorado Pikeminnow captures in 2015 were among the highest recorded to date (Tables 1, 2, 4, and 7). Furthermore, the number of YOY pikeminnow encountered within reach one was the highest recorded since the initiation of

the Interagency Standardized Monitoring Program in 1986. In addition, total abundance in reach four was the highest since 2009 and 2010, and before that 1993, which represented the last year of good production prior to a significant long-term crash in annual fall recruitment (Breen et al. 2011). Likewise, CPUE of YOY pikeminnow exceeded most years in all reaches (Tables 1, 4, and 7). Specifically, catch rates were the highest ever recorded for reach one, the sixth highest on record for reach three, and the highest since 1993 in reach four.

With specific mention to Colorado Pikeminnow fall recruitment in the Green River (reaches three and four), base flows maintained within a certain range likely contributed to the river-wide success observed in 2015. More specifically, analysis of available data obtained from 1979–2012 demonstrates that abundance of YOY Colorado Pikeminnow was above average in reach three when mean August–September base flow levels were 1,700–3,800 cfs and above average in reach four with mean August–September flows between 1,700–3,000 cfs (Bestgen and Hill, In Review). Furthermore, at moderate flow levels within the above ranges, backwater abundance and area may be optimized, thus providing sufficient habitat to maximize survival of YOY pikeminnow following larval transport to nursery areas (Bestgen and Hill, In Review). Base flow levels fell within these ranges for both reaches in 2015 and we observed a significant increase in fall recruitment, underscoring the value of manipulating Flaming Gorge Dam releases as a main recovery action to benefit pikeminnow recruitment.

IX. Recommendations:

- In light of 2015 fall recruitment success under relatively stable base flow conditions, the Recovery Program should strive to reach Green River base flow targets suggested by Bestgen and Hill (In Review) so that we can accumulate several years of comparable environmental data for a better understanding of adequate flows necessary for successful recruitment of Colorado Pikeminnow. Furthermore, it is crucial that such activities occur as soon as possible and for several years to bolster current population declines, given that Colorado Pikeminnow take between 5-8 years to reach reproductive maturity.
- Continue to monitor annual relative abundance of post-larval Colorado pikeminnow in the middle and lower Green River and the lower Colorado River to assess long-term trends in annual fall recruitment.
- Pending recommendations to be provided in the forthcoming Project #158 Interim Report, determine whether sampling tertiary backwaters in the middle Green River to evaluate native fish response to nonnative removal is a necessary component of this project. However, continue with collection of this information under this project until a replacement exists given that valuable insights have been obtained each year.
- Develop a measure or scale to describe localized hydrologic/climatic events,

specifically flash flood events. Although the magnitude and timing of peak flows have been found to influence YOY abundance and growth, we do not have an adequate measure for localized events that can affect a significant percentage of backwater habitats.

X. Project Status:

On track and ongoing

XI. FY 2015 Budget Status

- A. Funds Provided: \$58,826
- B. Funds Expended: \$58,826
- C. Difference: \$0
- D. Percent of the FY 2015 work completed, and projected costs to complete: 100%
- E. Recovery Program funds spent for publication charges: \$0

XII. Status of Data Submission (Where applicable):

Data is formatted, has been QA/QC checked, and will be submitted to the USFWS by January 2016.

XIII. Signed: Matthew J. Breen & Christopher M. Michaud 11/25/2015
Principal Investigators Date

XIV. Literature Cited

Bestgen, K.R. and A.A. Hill. In Review. Reproduction, abundance, and recruitment dynamics of young Colorado pikeminnow in the Green and Yampa rivers, Utah and Colorado, 1979-2012. Final report to the Upper Colorado River Endangered Fish Recovery Program, Project FW 51 BW-Synth, Denver, CO. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 183.

Breen, M.J., M. Swasey, P. Badame, K. Creighton. 2011. Upper Colorado River basin young-of-year Colorado pikeminnow (*Ptychocheilus lucius*) monitoring: summary report 1986-2009. Final report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.

Breen, M.J., J.T. Herdmann, and C.M. Michaud. 2014. Annual fall monitoring of young of year Colorado pikeminnow and small-bodied native fishes. Annual report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.

Schelly, R.C., R.R. Staffeldt, and M.J. Breen. 2015. Nonnative fish control in the middle Green River. Annual Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.

USFWS. 1987. Interagency standardized monitoring protocol handbook. U.S. Fish and Wildlife Service. Grand Junction, CO.

Table 1. Total Abundance, mean total length (TL), and mean catch-per-unit-effort (CPUE; fish/100 m²) for young-of-year (YOY) Colorado pikeminnow collected during ISMP monitoring from 1990–2015 in the middle Green River (Reach 4). To be consistent with previous years, this table only contains individuals captured in the first two backwaters of a sub-reach.

Year	Total Abundance	TL (mm)	Range (mm)	Total Area Sampled (m²)	CPUE (Fish/100m²)
1990	341	45.4	28 – 80	5,093	5.5
1991	524	38.2	21 – 65	5,077	10.3
1992	183	43.1	26 – 133	4,697	3.9
1993	305	36.4	21 – 59	3,960	7.7
1994	15	67.2	60 – 80	4,356	0.3
1995	75	34.5	21 – 48	3,792	2
1996	79	39.4	25 – 60	3,912	2
1997	22	36	28 – 49	3,734	0.6
1998	73	38.5	22 – 61	4,986	0.9
1999	12	33.7	25 – 45	3,897	0.3
2000	31	50.9	37 – 76	3,798	0.8
2001	8	46.9	36 – 67	4,496	0.2
2002	0	–	–	5,202	0
2003	2	52	52 – 52	4,696	0.04
2004	60	43.8	31 – 63	4,686	1.28
2005	8	48.6	35 – 60	4,190	0.2
2006	5	45.8	36 – 50	7,490	0.07
2007	3	73.3	69 – 76	5,782	0.05
2008	18	43.9	36 – 56	4,994	0.36
2009	325	43.7	22 – 71	7,503	4.3
*2010	454	37.9	24 – 58	–	–
2011	0	–	–	7,852	0
2012	2	53.5	39–68	7,805	0.03
2013	97	51.7	35–82	6,735**	1.37**
2014	45	36.3	25–67	3,118	1.44
2015	202	37.5	25–64	4,389	4.6

*Four YOY Colorado pikeminnow were not included because they were not measured; area measurements were incomplete, therefore CPUE calculations were not possible.

**Total area does not include one backwater excluded due to lack of measurements. Five pikeminnow collected in this backwater were included in total abundance, but not CPUE.

Table 2. Native fish captures during young-of-year (YOY) monitoring from 1986–2015 in the middle Green River (Reach 4). Colorado Pikeminnow abundance reflects captures from primary and secondary backwaters sampled in each sub-reach; abundance of other native species reflects captures from primary backwaters only. In some years, species other than Colorado Pikeminnow were only enumerated during the first seine haul within primary backwaters. Species collected include YOY Colorado Pikeminnow (CS YOY; 10–99 mm), juvenile pikeminnow (CS JUV; 100–399 mm), unidentified *Gila* spp. (CH), Razorback Sucker (RZ), Roundtail Chub (RT), Flannelmouth Sucker (FM), Bluehead Sucker (BH), and Speckled Dace (SD).

Year	CS YOY	CS JUV	CH	RZ	RT	FM	BH	SD
1986	492	0	32	0	0	47*	47*	132
1987	209	10	19	0	0	67	277	2
1988	885	36	5	0	0	120	1	6
1989	62	0	41	0	0	16	80	3
1990	341	47	22	0	0	0	9	2
1991	524	0	7	0	0	0	0	0
1992	183	0	4	0	1	2	115	11
1993	305	0	40	0	0	54	80	7
1994	15	0	13	0	0	38	32	10
1995	75	0	6	0	0	20	62	33
1996	79	0	6	0	1	31	53	7
1997	22	0	42	0	0	12	73	8
1998	73	0	63	1	0	25	49	6
1999	12	0	43	0	0	18	20	16
2000	31	0	3	1	0	6	12	2
2001	8	0	23	0	0	78	0	0
2002	0	0	3	0	0	3	0	0
2003	2	0	2	0	0	4	2	0
2004	60	0	12	0	0	16	2	1
2005	8	2	13	0	0	7	3	2
2006	5	0	0	0	0	5	0	0
2007	3	1	2	0	0	10	11	0
2008	18	0	0	0	1	12	6	0
2009	325	0	0	0	13	57	36	1
2010	454	1	0	0	0	2	38	1
2011	0	3	0	0	1	57	35	0
2012	2	0	0	0	1	11	1	0
2013	97	0	0	0	0	1	1	0
2014	45	0	0	3	0	8	6	0
2015	202	0	4	0	0	6	25	0

*Suckers not identified to species, thus half of suckers were applied to bluehead and half to flannelmouth.

Table 3. Total abundance of nonnative fish collected during young-of-year monitoring in the middle Green River (Reach 4) from 1987–2011. Only fish enumerated in primary backwater first seine hauls are included. Species collected include Black Bullhead (BB), Black Crappie (BC), Bluegill (BG), Channel Catfish (CC), Common Carp (CP), Fathead Minnow (FH), Green Sunfish (GS), Gizzard Shad (GZ), Northern Pike (NP), Red Shiner (RS), Smallmouth Bass (SM), Sand Shiner (SS), Walleye (WE), and White Sucker (WS).

YEAR	BB	BC	BG	CC	CP	FH	GS	GZ	NP	RS	SM	SS	WE	WS
1987	0	0	0	1	3	873	8	0	0	9,757	0	462	0	0
1988	2	0	0	7	2	620	13	0	0	4,072	0	159	0	0
1989	0	0	0	7	43	865	22	0	0	4,025	0	284	0	0
1990	0	0	0	1	4	1,386	0	0	0	5,395	0	87	0	0
1991	0	0	0	14	5	1	1	0	0	64	0	0	0	0
1992	1	0	0	3	15	1,653	5	0	0	3,178	0	440	0	0
1993	0	0	0	17	13	1,512	3	0	0	4,677	0	49	0	0
1994	0	1	0	0	0	2,757	1	0	0	28,903	0	1,890	0	0
1995	0	0	0	0	6	1,304	1	0	0	3,229	1	188	0	0
1996	0	0	0	0	5	486	8	0	0	2,871	0	1,265	0	0
1997	0	4	0	0	11	1,067	3	0	0	1,010	1	1,152	0	3
1998	7	11	0	3	8	1,569	17	0	1	2,400	0	474	0	1
1999	3	3	0	0	23	407	68	0	0	1,832	0	533	0	0
2000	2	3	0	0	12	1,436	15	0	0	10,860	0	8,072	0	0
2001	1	10	0	6	0	371	0	0	0	4,512	0	283	0	0
2002	0	5	1	0	1	1,303	39	0	0	11,516	0	1,059	0	1
2003	0	1	0	0	48	89	0	0	0	3,847	0	49	0	0
2004	0	1	0	4	1	337	8	0	0	5,524	0	1,207	0	5
2005	0	18	0	1	1	204	0	0	0	3,654	0	552	0	0
2006	0	7	3	0	98	1,431	1	5	0	19,365	0	2,060	0	3
2007	9	0	0	10	16	327	0	3	0	5,754	6	3,940	0	13
2008	1	16	0	3	40	155	102	0	0	1,121	5	821	0	7
2009	0	4	0	0	17	108	1	2	0	2,101	1	417	0	5
2010	1	0	0	1	38	231	15	0	0	3,596	0	959	0	8
2011	5	3	0	0	13	867	14	0	0	1,682	2	301	0	0
2012	0	0	0	6	1	189	0	22	0	2,379	1	583	0	0
2013	0	4	0	1	1	323	21	1	0	6,102	23	4,018	1	55
2014	0	0	0	4	31	471	2	6	0	924	3	466	0	36
2015	0	0	0	0	12	518	41	0	0	2,354	0	966	0	6

Table 4. The lower Green River (Reach 3) total numbers, lengths and mean catch-per-unit-effort (CPUE; fish/100 m²), by year for young-of-year Colorado Pikeminnow caught during ISMP monitoring conducted from 1986—2015.

Reach 3	YOY Colorado	Mean Length	Length Range	Total Area	CPUE
Year	Pikeminnow	(mm)	(mm)	(m²)	(fish/100m²)
1986	813	28.63		1964	41.40
1987	849	36.32		2831.8	29.98
1988	2892	39.41		3076.4	94.01
1989	1494	38.79		4261.8	35.06
1990	418	41.82		6516.6	6.41
1991	186	38.81		2822.2	6.59
1992	122	40.62		5181.6	2.35
1993	1616	37.36		4435.4	36.43
1994	354	37.36	14-74	3797.8	9.32
1995	56	49.98	23-99	2548	2.20
1996	410	24.94	13-45	2888.6	14.19
1997	39	41.4	19-75	2709.8	1.44
1998	252	33.1	19-40	3050.2	8.26
1999	384	32.1	18-68	4055.8	9.47
2000	705	26.8	15-38	5760	12.24
2001	17	37.9	21-88	5962	0.29
2002	22	43.2	30-68	4644.5	0.47
2003	124	64.9	22-90	4005.8	3.10
2004	80	60.1	30-96	1974	4.05
2005	63	46	26-84	2937.6	2.14
2006	331	31.2	23-41	4936	6.71
2007	686	40.3	23-80	3138	21.86
2008	60	44.8	26-95	2018	2.97
2009	423	35.32	20-46	2548	16.60
2010	131	29.86	15-45	2868	4.57
2011	17	22	15-26	1796	.95
2012	293	50.27	18-109	4716	6.21
2013	31	52.83	22-80	2381	1.30
2014	5	40.6	33-48	1670	0.30
2015	461	44.9	22-79	2031	22.7

Table 5. The lower Green River (Reach 3), total captures by year for native and endangered fish during young-of-year (YOY) monitoring from 1986-2015. Species listed are: YOY Colorado Pikeminnow (CS YOY; 10-99 mm), juvenile pikeminnow (CS JUV; 100-399 mm), unidentified *Gila* spp. (CH), Bonytail (BT), Humpback Chub (HB), Razorback Sucker (RZ), Flannelmouth Sucker (FM), Bluehead Sucker (BH), and Speckled Dace (SD). In most years, species other than CS were only enumerated during the first seine haul within primary backwaters.

Year	CS YOY	CS JUV	CH	BT	HB	RZ	FM	BH	SD
1986	813	0	15	0	0	0	0	0	24
1987	849	9	1	0	0	0	5	1	0
1988	2892	109	0	0	0	0	2	0	2
1989	1494	59	1	0	0	0	17	0	0
1990	418	21	0	0	0	0	0	0	7
1991	186	3	0	0	0	0	0	2	2
1992	122	12	18	0	0	0	3	7	4
1993	1616	2	0	0	0	0	12	33	43
1994	354	0	7	0	1	0	0	1	6
1995	56	1	5	0	0	0	12	17	35
1996	410	1	0	0	0	0	1	21	20
1997	39	8	2	0	0	0	0	2	2
1998	252	0	0	0	0	0	0	3	30
1999	384	0	2	0	0	0	90	5	24
2000	705	3	1	0	0	0	0	0	5
2001	17	0	0	0	0	0	0	0	3
2002	22	0	1	0	0	0	4	0	4
2003	124	0	5	0	0	0	0	0	2
2004	80	0	0	0	0	0	1	1	0
2005	63	1	0	0	0	0	0	0	0
2006	331	0	6	0	0	0	0	0	0
2007	686	0	1	2	0	0	0	0	0
2008	60	1	0	0	0	0	8	0	1
2009	423	0	1	0	0	0	0	0	2
2010	131	3	0	0	0	0	7	3	12
2011	17	0	0	0	0	0	1	0	0
2012	293	0	2	0	0	2	9	0	0
2013	31	0	0	0	0	0	0	0	0
2014	5	0	0	0	0	0	7	0	0
2015	461	0	6	0	0	0	9	0	9

Table 6. The lower Green River (Reach 3), total captures by year for nonnative fish during young-of-year monitoring from 1986-2015. Only fish enumerated in primary backwater first seine hauls are included to maintain consistency among years and reaches. Species listed: Black Bullhead (BB), Black Crappie (BC), Channel Catfish (CC), Common Carp (CP), Fathead Minnow (FH), *Gambusia* spp. (GA), Green Sunfish (GS), Gizzard Shad (GZ), Largemouth Bass (LG), Red Shiner (RS), Sand Shiner (SS), White Sucker (WS), and Yellow Bullhead (YB).

YEAR	BB	BC	CC	CP	FH	GA	GS	GZ	LG	RS	SS	WS	YB
1986	7	0	4	12	87	0	9	0	0	663	4	0	0
1987	0	0	1	0	34	0	5	0	0	1,303	4	0	0
1988	1	0	110	2	1,790	7	1	0	0	4,317	38	0	0
1989	1	0	73	1	170	0	3	0	0	5,826	113	0	0
1990	1	0	37	4	228	0	0	0	0	9,599	129	0	0
1991	0	0	8	3	314	0	2	0	0	7,746	1,123	0	0
1992	1	0	24	1	500	0	0	0	0	2,737	180	0	0
1993	1	0	11	1	249	0	0	0	0	3,443	1,362	0	0
1994	0	0	6	8	500	1	8	0	0	8,007	1,196	0	0
1995	7	0	4	16	363	0	6	0	0	3,478	969	0	0
1996	0	0	0	0	1,097	2	2	0	0	11,858	3,751	0	0
1997	0	0	17	1	79	4	3	0	0	855	320	1	0
1998	0	6	0	1	120	17	0	0	0	1,709	178	0	0
1999	0	1	2	37	340	1	0	0	0	845	156	0	0
2000	3	0	12	3	234	0	1	0	0	3,591	574	4	0
2001	0	0	6	0	0	0	0	0	0	0	0	0	0
2002	0	0	122	2	14,721	0	1	0	0	26,710	2,135	0	0
2003	5	0	11	1	201	0	12	0	0	4,707	43	0	0
2004	3	0	7	0	215	0	1	0	0	297	190	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	2	1	6	3	1,187	1	4	0	1	8,623	0	0	0
2007	0	0	23	0	2,183	0	0	1	2	8,807	35	0	0
2008	0	2	13	116	1,074	0	0	1	1	4,458	250	0	6
2009	0	0	3	0	1,044	0	0	1	0	2,766	15	0	0
2010	0	0	0	0	150	0	5	4	0	1,028	1,025	0	0
2011	0	8	6	15	314	0	0	0	0	1,842	1,096	0	0
2012	8	0	5	5	3,085	0	4	15	0	2,043	8,620	0	3
2013	0	0	19	6	1,025	0	6	6	0	2,550	9,975	0	0
2014	1	0	3	11	47	0	0	0	0	658	866	0	0
2015	2	0	26	0	570	0	5	2	0	1,969	466	0	0

Table 7. The lower Colorado River (Reach 1) total numbers, lengths and mean catch-per-unit-effort (CPUE; fish/100m²), by year for young-of-year Colorado Pikeminnow caught during ISMP monitoring from 1986—2015.

Reach 1	YOY Colorado Pikeminnow	Mean Length	Length Range	Total Area Sampled	CPUE
Year	Caught	(mm)	(mm)	(m²)	(fish/100m²)
1986	192	27.86	17-36	1343.6	14.29
1987	176	40.93		2225.8	7.91
1988	172	47.98		3786.8	4.54
1989	132	42.67		3739.2	3.53
1990	179	41.90		2565.8	6.98
1991	150	34.17		2271	6.61
1992	151	33.55		3663.2	4.12
1993	206	32.28	22-47	2858.8	7.21
1994	142	64.07	32-96	3139.8	4.52
1995	85	20.46	11-35	2890	2.94
1996	866	39.6	20-81	4113.8	21.05
1997	12	18.3	13-34	2774.8	0.43
1998	88	34.5	20-60	4663.8	1.89
1999	13	25	19-43	4710	0.28
2000	398	45.7	25-82	6389.6	6.23
2001	17	42.3	23-65	4046.8	0.42
2002	25	57.2	32-87	3033.8	0.82
2003	0	N/A	N/A	2837.8	0.00
2004	16	47	33-63	1620	0.99
2005	19	36.1	28-48	1722	1.10
2006	4	42	27-53	1682.4	0.24
2007	24	37.2	28-47	2802	0.86
2008	0	N/A	N/A	2568	0.00
2009	243	32.75	15-63	2193.4	9.46
2010	27	35.93	26-61	2630.4	1.03
2011	59	24.15	18-36	1195.2	4.94
2012	54	56.65	53-83	2240	2.41
2013	1	31	31	1769	0.05
2014	8	32.25	23-43	2544	0.31
2015	1331	28.75	16-51	1251	106.39

Table 8. The lower Colorado River (Reach 1), total captures by year for native and endangered fish during young-of-year (YOY) monitoring from 1986-2015. Species listed are: YOY Colorado Pikeminnow (CS YOY; 10-99 mm), juvenile pikeminnow (CS JUV; 100-399 mm), unidentified *Gila* spp. (CH), Razorback Sucker (RZ), Flannelmouth Sucker (FM), Bluehead Sucker (BH), and Speckled Dace (SD). In most years species other than CS were only enumerated during the first haul within primary backwaters.

Year	CS YOY	CS JUV	CH	RZ	FM	BH	SD
1986	192	0	194	0	0	0	41
1987	176	2	27	0	2	7	2
1988	172	37	11	0	4	0	0
1989	132	7	130	0	2	3	2
1990	179	11	6	0	4	2	0
1991	150	0	8	0	1	0	5
1992	151	1	45	0	2	25	9
1993	206	3	216	0	69	198	23
1994	142	0	15	0	0	11	1
1995	85	0	119	0	2	176	28
1996	866	0	30	0	3	87	29
1997	12	0	4	0	1	12	4
1998	88	0	11	0	1	8	9
1999	13	2	1	0	0	1	0
2000	398	9	21	0	1	58	0
2001	17	0	1	0	0	0	1
2002	25	0	35	0	0	1	0
2003	0	0	0	0	0	0	0
2004	16	0	4	0	9	5	0
2005	19	0	0	0	0	0	0
2006	4	0	0	0	9	1	3
2007	24	0	0	0	2	0	0
2008	0	0	0	0	4	8	0
2009	243	0	0	0	5	3	1
2010	27	3	2	0	15	0	0
2011	59	0	3	0	31	0	2
2012	54	0	0	3	39	4	0
2013	1	0	5	0	0	1	0
2014	8	0	0	0	3	0	0
2015	1331	0	3	0	120	0	0

Table 9. The lower Colorado River (Reach 1), total captures by year for nonnative fish during young-of-year monitoring from 1986-2015. Only fish enumerated in primary backwater first seine hauls are included to maintain consistency among years and reaches. Species listed: Black Bullhead (BB), Black Crappie (BC), Bluegill (BG), Channel Catfish (CC), Common Carp (CP), Fathead Minnow (FH), *Gambusia* spp. (GA), Green Sunfish (GS), Gizzard Shad (GZ), Largemouth Bass (LG), Plains Killifish (PK), Red Shiner (RS), Smallmouth Bass (SM), Sand Shiner (SS), Walleye (WE), White Sucker (WS), and Yellow Bullhead (YB).

YEAR	BB	BC	BG	CC	CP	FH	GA	GS	GZ	LG	PK	RS	SM	SS	WE	WS	YB
1986	0	0	0	4	0	456	2	0	0	1	6	1,077	0	240	0	0	0
1987	1	0	0	10	1	233	1	0	0	0	0	2,159	0	428	0	0	0
1988	0	0	0	0	4	10,650	0	1	0	0	36	1,786	0	2,161	0	0	0
1989	11	0	0	8	12	3,613	0	2	0	0	9	6,973	0	951	0	1	0
1990	2	0	2	11	4	5,698	1	1	0	1	10	6,593	0	889	0	0	0
1991	1	0	0	8	1	2,632	0	0	0	0	6	4,368	0	1,652	0	1	0
1992	1	0	0	0	1	2,809	2	7	0	0	7	6,470	0	3,991	0	1	0
1993	3	0	0	1	8	2,091	4	1	0	0	0	3,870	0	1,449	0	2	0
1994	1	0	0	1	2	4,795	14	34	0	0	0	4,393	0	2,520	0	2	0
1995	2	0	0	17	3	1,105	71	2	0	1	0	1,079	0	926	0	0	0
1996	0	0	2	1	0	2,591	3	15	0	1	8	3,851	0	5,998	0	0	0
1997	0	0	0	12	2	37	3	0	0	2	0	1,244	0	224	0	0	0
1998	0	0	0	1	0	265	1	6	0	0	2	6,297	0	8,751	0	0	0
1999	0	1	1	21	3	137	1	1	0	0	2	1,891	0	2,303	0	0	0
2000	4	0	0	0	1	1,265	24	2	0	1	0	15,099	0	22,343	0	1	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	1	0	0	4	3	4,963	1	0	0	0	1	11,691	0	2,920	0	0	0
2003	2	0	0	0	1	2,192	4	0	0	0	7	788	0	1,162	0	0	0
2004	0	0	0	0	1	352	0	0	0	0	0	625	0	535	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	1	2	0	4	1	159	94	10	0	2	1	3,030	0	103	0	0	1
2007	1	0	0	1	5	597	52	0	15	0	0	1,063	1	0	0	6	0
2008	0	0	0	1	5	280	1	0	17	1	0	536	0	5	0	1	1
2009	3	7	0	0	6	260	36	0	57	0	0	3,124	0	12	0	0	0
2010	0	0	0	2	0	377	3	0	174	5	0	657	0	622	1	0	0
2011	0	6	0	0	2	24	12	0	20	3	0	1345	0	58	0	0	0
2012	36	0	0	15	14	3,182*	2	6	70	2	0	471*	0	5,204*	0	0	0
2013	5	0	0	24	1	666	0	1	116	1	2	1,566	2	4,640	0	0	0
2014	0	0	0	23	1	55	0	4	23	0	3	974	0	399	0	0	0
2015	617	0	0	1	0	556	87	1	261	2	1	1,696	0	1,089	0	1	0

*1,990 nonnative cyprinids were not identified to species. Based on the percentage of Sand Shiner (58.8%), Fathead Minnow (35.9%), and Red Shiner (5.3%) positively identified in this reach, these fish were applied proportionately to Sand Shiner ($n = 1,117$), Fathead Minnow ($n = 682$), and Red Shiner ($n = 101$).

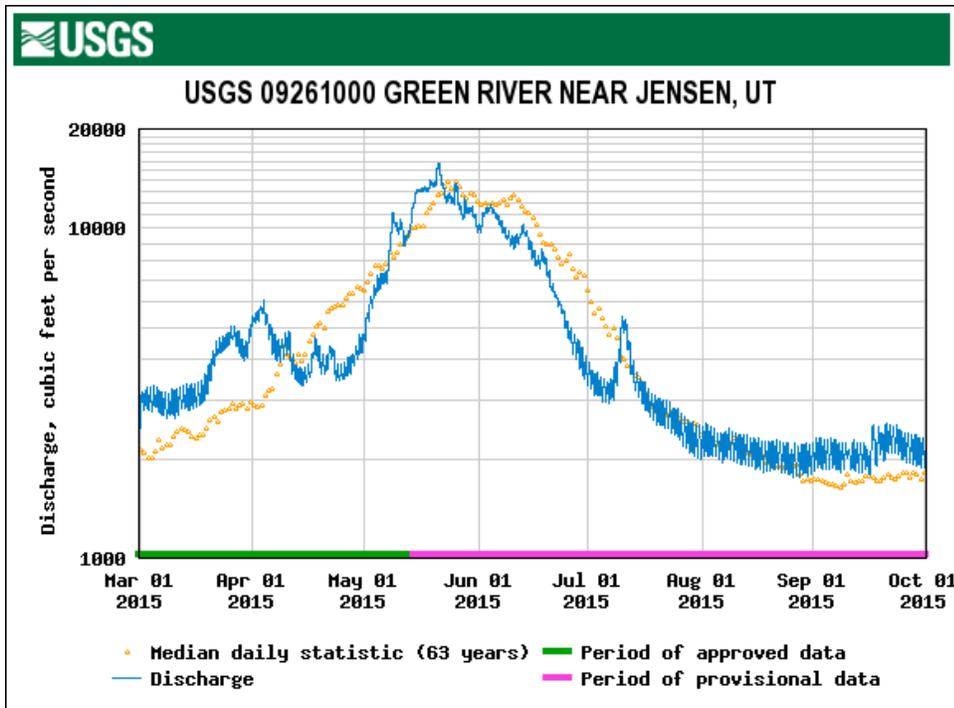


Figure 1. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 01 March 2015 to 01 October 2015.

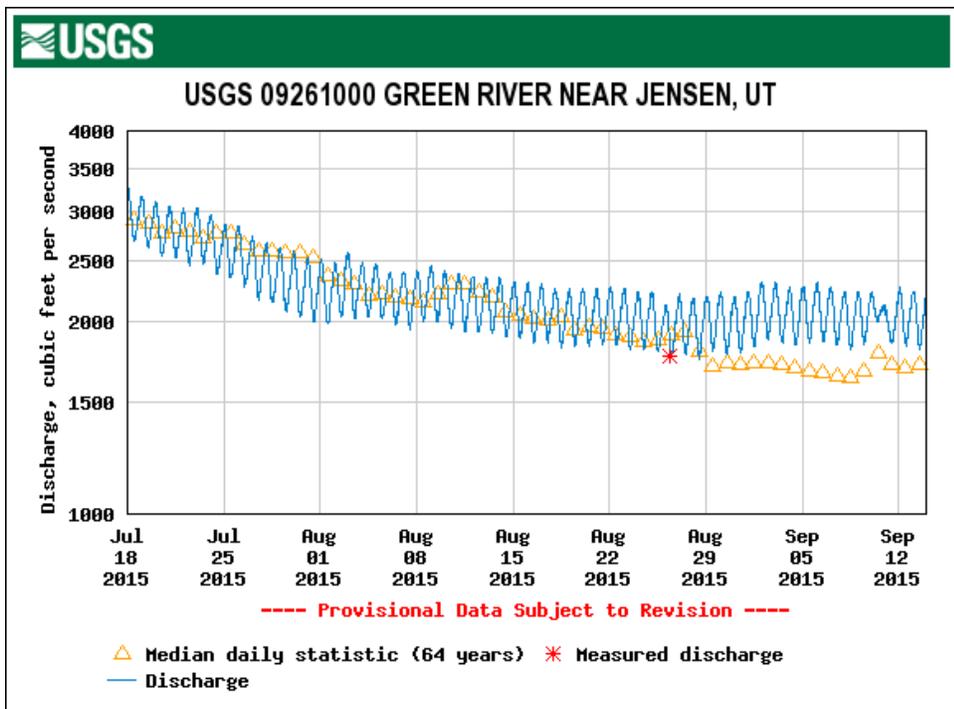


Figure 2. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 18 July 2015 to 13 September 2015.

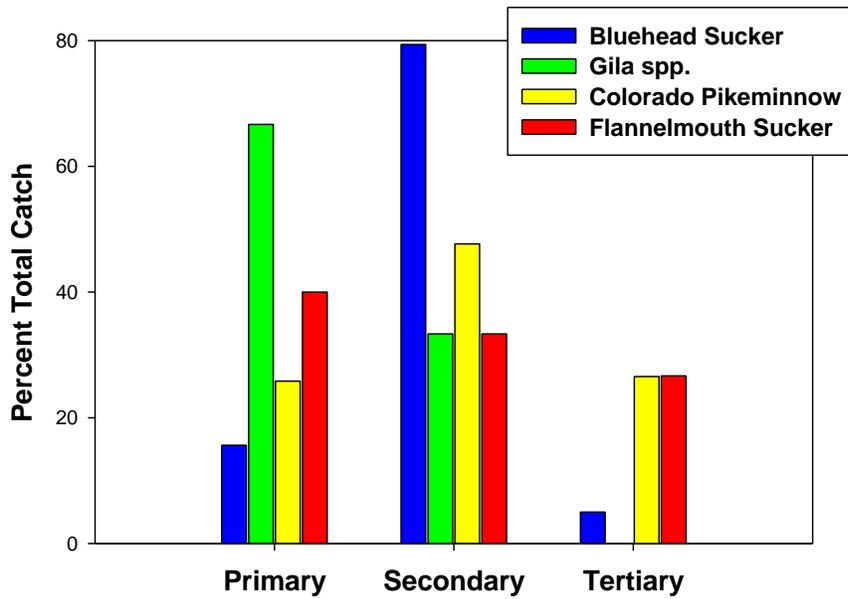


Figure 3. Proportional abundance (percent young-of-year sampled from all backwaters in the middle Green River) of native species captured in primary, secondary and tertiary backwaters during 2015 ISMP sampling.

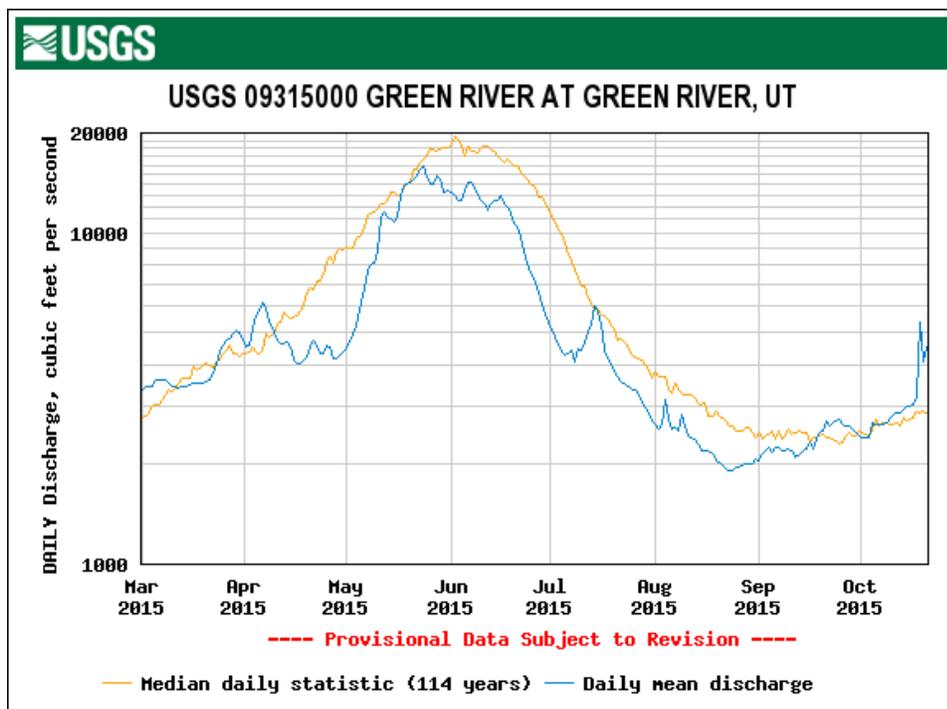


Figure 4. The lower Green River (Reach 3) daily mean flows measured from USGS Gage #09315000 at Green River, Utah from 1 March 2015 to 21 October 2015.

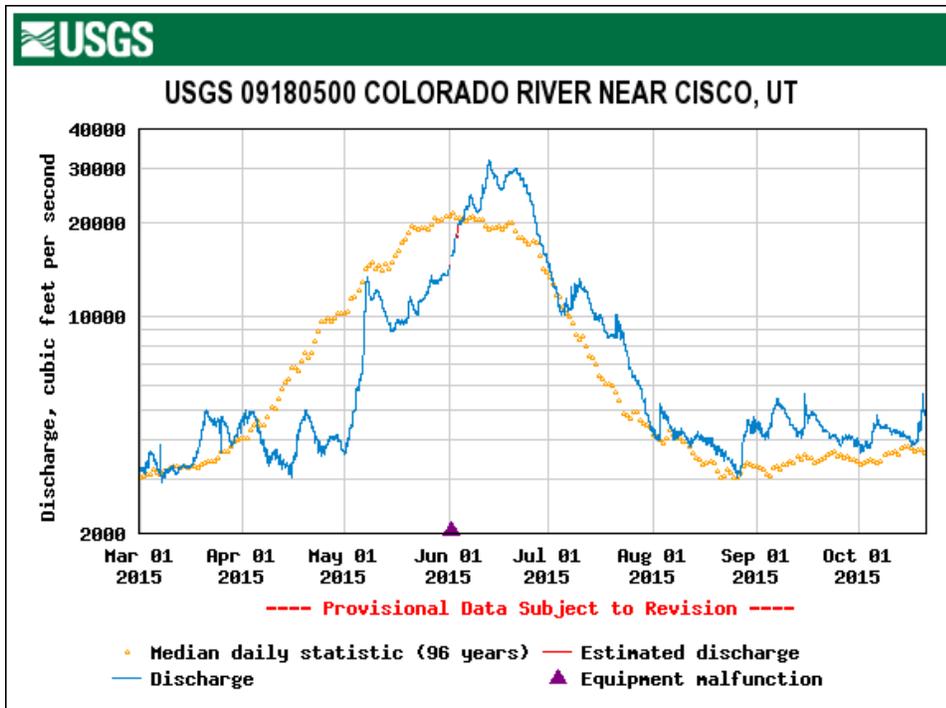


Figure 5. The lower Colorado River (Reach 1) daily mean flows measured from USGS Gage #09180500 near Cisco, Utah from 1 March 2015 to 21 October 2015.