

COLORADO RIVER RECOVERY PROGRAM
FY 2017 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
Project/Grant Period: Start date (Mo/Day/Yr): 05/01/2014
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Is this the final report? Yes _____ No X

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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 (USFWS 1987) to monitor recruitment success of age-0 endangered fishes. In 2017, two young-of-year (YOY) Colorado pikeminnow were encountered on the lower Colorado River (Reach 1), 25 on the lower Green River (Reach 3), and one on the middle Green River (Reach 4). Catch rates were the fourth lowest on record in Reach 1, seventh lowest on record in Reach 3, and fourth lowest on record in Reach 4. Specifically for Green River reaches, base flows throughout July–September were elevated due to Flaming Gorge Dam (FGD) releases, with far fewer days within the desired range for pikeminnow recruitment (i.e., 1,700–3,000 cfs for Reach 4, not reached until August 5; 1,700–3,800 cfs for Reach 3, not reached until July 30) than 2015–2016. As with years of excellent YOY recruitment (e.g., 2015), limited recruitment in 2017 provides additional supporting evidence for the importance of manipulating FGD releases effectively as we move forward with recovery efforts.

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 2017 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 (*Ptychocheilus lucius*) began 18 September 2017 and was completed on 26 September 2017. Beginning at Split Mountain boat ramp (RM 319.3) and concluding at Sand Wash (RM 215.3), 58 of 63 possible backwater habitats (three per 5-mile sub-reach) were sampled; 20 primary, 19 secondary, and 19 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 Interagency Standardized Monitoring Program (ISMP) protocol (USFWS 1987). A total of 3,740 m² of suitable

habitat was seined in 2017 (primary and secondary backwaters only), which is less area than 2016 (Breen et al. 2016). Note that seine area and subsequent CPUE calculations excluded the first seine haul of a secondary backwater because seine haul length was not recorded; pikeminnow were absent from this seine haul. Excluding the aforementioned seine haul, 6.8% of the available habitat was sampled from primary and secondary backwaters in 2017. An additional 1,256 m² of habitat was sampled from tertiary backwaters. Given sustained above average discharge during the base flow period that continued throughout sampling efforts (see below); backwater habitat availability was compromised compared to previous years (Breen, personal observation). For example, backwaters that we would typically sample were covered up and/or connected upstream by higher water levels or filled in by newly created sand bars. Additionally, locations of newly created sand bars/backwaters were highly unpredictable (i.e., outside river bends contained sand bars instead of inside bends in many cases).

Discharge for the middle Green River is measured at USGS gauge #09261000, located at Jensen, Utah. Peak spring discharge reached 18,300 cubic feet per second (cfs) on 9 June 2017 (provisional value), which is well above the mean annual peak flow for the period of record (Figure 1). Following spring peak flows, the base flow period was consistently higher than the period of record (Figure 2), with the exception of a few days where Flaming Gorge Dam (FGD) releases were temporarily decreased for dam maintenance; mean daily discharge dropped below 2,000 cfs from 30-31 August 2017. Mean daily discharge was below 4,000 cfs from 11 July 2017 until ISMP sampling was initiated, but did not fall below 3,000 cfs until 5 August 2017 (Figure 2). From 11 July 2017 until 18 September 2017, mean daily discharge averaged 2,910 cfs (range = 1,910–3,930 cfs; provisional values). Mean daily discharge for the sample period was 2,757 cfs (range = 2,670–2,840 cfs; provisional values), which exceeds 2016 values by more than 500 cfs (Breen et al. 2016). Main channel temperatures averaged 14.8 °C (12.0–18.2 °C), whereas mean backwater temperatures were 15.6 °C (11.1–23.3 °C) during the sampling period; both metrics being substantially cooler than 2016 (Breen et al. 2016). Turbidity measurements (cm visibility; mean ± SD) obtained in main channel and backwater habitats were 11.4 ± 6.6 cm (2–25 cm) and 15.5 ± 8.5 cm (2–46), respectively, representing limited water clarity with greater variability in both habitat types compared to 2016 (Breen et al. 2016).

We captured one YOY Colorado pikeminnow from a secondary backwater, representing the third lowest total on record (Tables 1 and 2); one juvenile pikeminnow (TL = 114 mm) was also captured from a primary backwater. Catch-per-unit-effort (CPUE; fish/100 m²) for YOY pikeminnow (0.027 fish/100 m²) was well below the 5- (1.52 fish/100 m²), 15- (1.00 fish/100 m²), and 28-year averages (1.86 fish/100 m²), and represented the fourth lowest catch rate on record (Table 1). Although not directly comparable to previous averages with only a single YOY pikeminnow capture in 2017 (TL = 52 mm), this individual was larger than the 5- (43.6 mm), 15- (47.2 mm), and 28-year (45.0 mm) averages (Table 1).

Other native species are only reported for captures within primary backwaters to be consistent with previous data summaries (Table 2); this included five bluehead sucker (*Catostomus discobolus*), five flannelmouth sucker (*Catostomus latipinnis*), and eight *Gila* spp. Secondary and tertiary backwaters accounted for an additional 71 blueheads (average TL for 76 total captures = 40.0 mm), 11 flannelmouth (average TL for 16 total captures = 56.0 mm), five *Gila* spp. (average TL for 13 total captures = 65.0 mm), and three speckled dace (*Rhinichthys osculus*) (average TL = 42.0 mm) comprising 93%, 69%, 38%, and 100% of total captures, respectively (Figure 3). Excluded from Table 2, we also collected three unknown (anterior end crushed and unidentifiable) native catostomids (TL = 23, 26, 41 mm) from primary and tertiary backwaters (Figure 3). Additionally, tertiary backwaters accounted for 12%, 25%, and 31% of total bluehead sucker, flannelmouth sucker, and *Gila* spp. 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 (*Pimephales promelas*), red shiner (*Cyprinella lutrensis*), and sand shiner (*Notropis stramineus*) (99.4% of the total catch; Table 3). We collected a total of 5,925 nonnative fish comprised of nine species in the first seine haul of primary backwaters, which is higher than last year (Breen et al. 2016) and the eleventh highest total in 31 years of sampling (Table 3). In addition, we collected three channel catfish (*Ictalurus punctatus*) (TL = 54, 57, 143 mm) and one northern pike (*Esox lucius*) (TL = 294 mm) from additional seine hauls in primary, secondary, and tertiary backwaters.

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

Lower Green River (Reach 3):

Utah Division of Wildlife Resources began sampling for the ISMP on Reach 3 on 19 September and concluded on 22 September 2017. Crews sampled 120 river miles, in accordance with ISMP protocols, from Green River State Park (RM 120) to the confluence with the Colorado River (RM 0), completing at least one seine haul in 30 of 48 (63%) possible habitats. Only 46 of 96 (48%) possible seine hauls were completed, yielding the second lowest area sampled (1,642 m²) since the inception of the project. During sampling in 2017, nearly all habitats encountered were small, shallow and bedded with deep silt. Although we took no formal measurements of total habitat within Reach 3, crews sampled most of what was available.

Discharge on the lower Green River is measured at USGS gauge #09315000 at Green River, Utah (Figure 4). The Green River peaked at 21,800 cfs on 10 June 2017 and maintained elevated flows through late July. The river reached base flow ($\leq 3,800$ cfs) on 30 July 2017. During ISMP sampling in 2017, flows averaged 3,045 cfs, considerably higher than flows for those same dates in 2016 (2,170 cfs; Breen et al. 2016) and the pre-dam period average (2,458 cfs, 1894-1964) and similar to the post-dam period average

(2,900 cfs, 1964-2016). Main channel temperatures averaged 18.5 °C (17-20 °C) while habitat temperatures averaged 19.7 °C (15-25 °C) in 2017. Both values were similar to 2016. Main channel turbidity (mm visibility; mean \pm SD) was lower in 2017 (83 ± 6 mm) than 2016. Habitat turbidity in 2017 (118 ± 40 mm) was similar to 2016.

Researchers encountered 25 YOY Colorado pikeminnow during ISMP sampling in 2017 (Tables 4 and 5). This figure is down considerably from 2016 (426 fish) and below the 5-, 15- and 30-year averages (243, 210 and 432 fish, respectively). Catch rates on the lower Green River ranked the seventh lowest since the inception of ISMP. Colorado pikeminnow CPUE in 2017 was 1.52 fish per 100 m², lower than CPUE in 2016, the 5-, 15-, and 30-year averages (26.83, 11.46, 8.05 and 12.97 fish per 100 m² respectively). Of 30 habitats sampled in Reach 3, only 17% contained pikeminnow. Mean Colorado pikeminnow total length was 34.6 mm (range = 29-55 mm), which is lower than that from 2016 and the 5-, 15-, and 30-year averages (41.1, 45.9, 43.2 and 40.1 mm, respectively).

In addition to pikeminnow, researchers encountered flannelmouth sucker (n=10), bonytail (*Gila elegans*) (n=1) and speckled dace (n=1) within Reach 3 (Table 5). All native species were identified, measured for total length and released. Crews identified and enumerated nonnative species on the first seine haul within primary habitats only (Table 6). Channel catfish (n=1), common carp (*Cyprinus carpio*) (n=3), green sunfish (*Lepomis cyanellus*) (n=1), gizzard shad (*Dorosoma cepedianum*) (n=3), and white sucker (*Catostomus commersoni*) (n=4) were encountered. However, the majority (99.8%) of nonnative fishes encountered in 2017 were small-bodied cyprinids: fathead minnow (n=692), red shiner (n=5,467) and sand shiner (n=1,028).

Lower Colorado River (Reach 1):

Sampling on the lower Colorado River (Reach 1), began on 13 September 2017 and ended on 16 September 2017. All sampling followed ISMP protocol from Cisco boat ramp (RM 110.5) to the confluence with the Green River (RM 0). Crews sampled 18 of 44 (41%) possible habitats, completed 32 of 88 (36%) possible seine hauls, and sampled 1,002.5 m² of rearing habitat. The amount of habitat sampled in 2017 ranks the lowest in 31 years of ISMP sampling. There was remarkably little zero-velocity habitat available on the lower Colorado River in 2017.

Discharge on the lower Colorado River is measured at USGS gauge #09180500 near Cisco, Utah (Figure 5). The Colorado River peaked on 10 June 2017 at 26,300 cfs and maintained elevated flows (> 5,000 cfs) through 16 August 2017. Mean discharge for the period of study was 4,205 cfs, similar to the average for the period of record (3,913 cfs; 1913-2016). Average main channel temperature was 21.4 °C (20-22 °C), and average habitat temperature was 22.6 °C (19-26.5 °C) in 2017, both metrics are warmer than 2016 (Breen et al. 2016). Main channel turbidity (mm visibility; mean \pm SD) was similar in 2017 (364 ± 270 mm) and 2016. Habitat turbidity in 2017 (225 ± 124 mm) was also similar to 2016.

Crews captured two YOY Colorado pikeminnow in 2017 (Tables 7 and 8). This is well below the number of pikeminnow encountered in 2016 (150 fish). Catch-per-unit-effort in 2017 was the fourth lowest on record (0.20 fish/100 m²). This figure is lower than CPUE calculated for 2016 and the 30-year average (10.32 and 7.25 fish/100 m² respectively). Median total length for 2017 was 40.5 mm (range = 28-53 mm).

In addition to young-of-year pikeminnow, crews encountered one chub (*Gila* spp.) too small to identify to species (Table 8). The majority (99.8%, Table 9) of nonnative fishes encountered in 2017 belonged to three species, all small-bodied cyprinids: fathead minnow (n=408), red shiner (n=968) and sand shiner (n=692). Other nonnative fish included black bullhead (*Ameiurus melas*) (n=2), black crappie (*Pomoxis nigromaculatus*) (n=5), common carp (n=5), *Gambusia* spp. (n=25), green sunfish (n=2), gizzard shad (n=74) and smallmouth bass (*Micropterus dolomieu*) (n=3).

VIII. Additional noteworthy observations:

Above average base flows in all reaches likely explains poor YOY Colorado pikeminnow recruitment observed in 2017. Summer base flows on the Green River maintained within a certain range likely contribute to successful fall recruitment (Bestgen and Hill 2016). More specifically, analysis of available data obtained from 1979–2012 demonstrates that abundance of YOY Colorado pikeminnow was above average in Reach 3 when mean August–September base flow levels were 1,700–3,800 cfs and above average in Reach 4 with mean August–September flows between 1,700–3,000 cfs (Bestgen and Hill 2016). In Reach 4, base flows far exceeded levels from 2015 and 2016 (Breen et al. 2015, 2016) when FGD experimental releases were implemented. Specifically, mean daily discharge only remained below 3,000 cfs for 45 days until sampling was initiated in 2017 vs. 64 days in 2016 (Breen et al. 2016) and 59 days in 2015, which was consequently a very successful year for YOY pikeminnow recruitment (Breen et al. 2015). Moreover, average base flows in Reach 4 were nearly 700 cfs higher than the 2015 and 2016 base flow periods (Breen et al. 2015, 2016). Discharge for Reach 3 on the lower Green River reached the target base flow range (1,700 – 3,800 cfs) on July 30 and remained within this range through ISMP sampling on September 19, 2017. Similar to Reach 4, discharge was within the target range for 51 days in 2017, considerably fewer days than in 2016 and 2015 (68 and 63 days, respectively). In Reach 3, average discharge through the base flow period in 2017 was considerably higher than either 2016 or 2015 (2,997 vs. 2,373 and 2,440, respectively). As a consequence of higher base flows in Reach 4, water temperatures were far cooler in 2017, potentially limiting growth and survival of pikeminnow as well (Breen et al. 2011).

The availability of zero-velocity nursery habitat has changed over time on the lower Green and Colorado rivers. Although no formal assessment of habitat availability has been made in recent years, it appears as though zero-velocity habitat is diminishing through time. Similar to research conducted for a comprehensive backwater synthesis in the middle Green River (Grippio et al. 2017), a deeper understanding of the mechanics of

nursery habitat creation and maintenance are necessary to manage Reaches 1 and 3. Strategically designed releases from FGD on the Green River (Bestgen and Hill 2016, Trammell et al. 1999) and the Aspinall Unit on the Gunnison River (Trammell and Chart 1999) could be employed in the restoration of nursery habitat within the lower canyons. Furthermore, the relationship between habitat availability and YOY-pikeminnow recruitment is not thoroughly understood, however, it does not appear to be a limiting factor. This is exemplified in results from ISMP in 2015 and 2016 (Breen et al. 2015, 2016), where crews encountered large numbers of Colorado pikeminnow while noting an overall dearth of quality zero-velocity habitats. The lack of quality nursery habitat may have considerable influence, however, on overwinter survival of YOY pikeminnow and subsequent recruitment into juvenile age-classes and therefore should be addressed.

IX. Recommendations:

- In light of 2015 (reaches 3 and 4) and 2016 (Reach 3) fall recruitment success under relatively stable base flow conditions and poor recruitment in 2017 with higher base flows, the Recovery Program should strive to reach Green River base flow targets suggested by Bestgen and Hill (2016) 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. Continue with collection of this information under this project until a replacement exists given that valuable insights have been obtained each year.
- Develop a method of quantifying changes in habitat availability and quality over time. We should explore the use of experimental releases from Flaming Gorge dam and the Aspinall Unit to restore nursery habitat on the lower Green and Colorado rivers and the use of remote sensing technologies to track habitat change over time.
- Determine optimal base flows for recruitment of YOY Colorado pikeminnow on the lower Colorado River (Reach 1). Similar work has been done for Reaches 3 and 4 on the Green River (Bestgen and Hill 2016). The establishment of this metric may aid in increasing our understanding of the complex relationship

between recruitment success and flow in the upper Colorado River basin.

X. Project Status: On track and ongoing

XI. FY 2017 Budget Status

- A. Funds Provided: \$67,933
- B. Funds Expended: \$67,933
- C. Difference: \$0
- D. Percent of the FY 2016 work completed, and projected costs to complete: 100%
- E. Recovery Program funds spent for publication charges: \$0

XII. Status of Data Submission:

Data is formatted, has been QA/QC checked, and will be submitted to the USFWS by January 2018.

XIII. Signed: Matthew J. Breen & Christopher M. Michaud 11/06/2017

Principal Investigators

Date

XIV. Literature Cited

- Bestgen, K.R. and A.A. Hill. 2016. 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.
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- Grippio, M., K.E. LaGory, D. Waterman, J.W. Hayse, L.J. Walston, C.C. Weber, A.K. Magnusson, and X.H. Jiang. 2017. Relationships between flow and the physical characteristics of Colorado pikeminnow backwater nursery habitats in the middle Green River, Utah. Final Report prepared by Argonne National Laboratory Environmental Science Division to the Upper Colorado River Endangered Fish Recovery Program, Project FW 51 BW-Synth, Denver, CO.
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- Trammell, M. and T. Chart. 1999. Aspinall studies: evaluation of nursery habitat availability and Colorado pikeminnow young-of-year habitat use, in the Colorado River, Utah, 1992-1996. Publication Number 99-18. Utah Division of Wildlife Resources, Salt Lake City, UT.
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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 1990–2017 in the middle Green River (Reach 4). To be consistent with previous years, this table only contains individuals captured in primary and secondary backwaters of each sub-reach.

Year	Total Abundance	TL (mm)	Range (mm)	Total Area Sampled (m²)	CPUE (Fish/100m²)
1990	341	45.4	28 – 80	5,093	6.695
1991	524	38.2	21 – 65	5,077	10.321
1992	183	43.1	26 – 133	4,697	3.896
1993	305	36.4	21 – 59	3,960	7.702
1994	15	67.2	60 – 80	4,356	0.344
1995	75	34.5	21 – 48	3,792	1.978
1996	79	39.4	25 – 60	3,912	2.019
1997	22	36	28 – 49	3,734	0.589
1998	73	38.5	22 – 61	4,986	1.464
1999	12	33.7	25 – 45	3,897	0.308
2000	31	50.9	37 – 76	3,798	0.816
2001	8	46.9	36 – 67	4,496	0.178
2002	0	–	–	5,202	0
2003	2	52	52 – 52	4,696	0.043
2004	60	43.8	31 – 63	4,686	1.280
2005	8	48.6	35 – 60	4,190	0.191
2006	5	45.8	36 – 50	7,490	0.067
2007	3	73.3	69 – 76	5,782	0.052
2008	18	43.9	36 – 56	4,994	0.360
2009	325	43.7	22 – 71	7,503	4.332
2010*	454	37.9	24 – 58	–	–
2011	0	–	–	7,852	0
2012	2	53.5	39–68	7,805	0.026
2013	97	51.7	35–82	6,735**	1.366**
2014	45	36.3	25–67	3,118	1.443
2015	202	37.5	25–64	4,389	4.602
2016	6	40.3	33–54	4,308	0.139
2017	1	52	–	3,740***	0.027

*Four YOY Colorado pikeminnow were excluded 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.

***The first seine haul of a secondary backwater was excluded because seine haul length was not recorded; pikeminnow were absent from this seine haul.

Table 2. Native fish captures during young-of-year (YOY) monitoring from 1986–2017 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 (*Xyrauchen texanus*) (RZ), roundtail chub (*Gila robusta*) (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
2016	6	1	3	0	0	7	6	1
2017	1	1	8	0	0	5	5	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 1987–2017. 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
2016	0	17	0	2	31	348	0	0	0	2,293	9	882	0	10
2017	0	2	0	0	9	327	4	7	0	3,070	2	2,495	0	9

Table 4. The lower Green River (Reach 3) total numbers, lengths and catch-per-unit-effort (CPUE; fish/100 m²), by year for young-of-year Colorado pikeminnow caught during ISMP monitoring conducted from 1986—2017.

Reach 3	YOY Colorado	Mean Length	Length Range	Total Area	CPUE
Year	Caught	(mm)	(mm)	(m²)	(fish/100m²)
1986	813	28.6	–	1,964	41.40
1987	849	36.3	–	2,831.8	29.98
1988	2,892	39.4	–	3,076.4	94.01
1989	1,494	38.8	–	4,261.8	35.06
1990	418	41.8	–	6,516.6	6.41
1991	186	38.8	–	2,822.2	6.59
1992	122	40.6	–	5,181.6	2.35
1993	1,616	37.4	–	4,435.4	36.43
1994	354	37.4	14-74	3,797.8	9.32
1995	56	50.0	23-99	2,548	2.20
1996	410	24.9	13-45	2,888.6	14.19
1997	39	41.4	19-75	2,709.8	1.44
1998	252	33.1	19-40	3,050.2	8.26
1999	384	32.1	18-68	4,055.8	9.47
2000	705	26.8	15-38	5,760	12.24
2001	17	37.9	21-88	5,962	0.29
2002	22	43.2	30-68	4,644.5	0.47
2003	124	64.9	22-90	4,005.8	3.10
2004	80	60.1	30-96	1,974	4.05
2005	63	46.0	26-84	2,937.6	2.14
2006	331	31.2	23-41	4,936	6.71
2007	686	40.3	23-80	3,138	21.86
2008	60	44.8	26-95	2,018	2.97
2009	423	35.3	20-46	2,548	16.60
2010	131	29.9	15-45	2,868	4.57
2011	17	22.0	15-26	1,796	0.95
2012	293	50.3	18-109	4,716	6.21
2013	31	52.8	22-80	2,381	1.30
2014	5	40.6	33-48	1,670	0.30
2015	461	44.9	22-79	2,031	22.7
2016	426	41.1	21-70	1,588	26.8
2017	25	34.6	29-55	1,642	1.52

Table 5. The lower Green River (Reach 3), total captures by year for native and endangered fish during young-of-year (YOY) monitoring from 1986-2017. 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	2,892	109	0	0	0	0	2	0	2
1989	1,494	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	1,616	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
2016	426	0	0	0	0	0	4	9	0
2017	25	0	0	1	0	0	10	0	1

Table 6. The lower Green River (Reach 3), total captures by year for nonnative fish during young-of-year monitoring from 1986-2017. 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 (*Ameiurus natalis*) (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
2016	3	0	1	1	1,055	0	0	0	0	3,730	2,790	0	0
2017	0	0	1	3	692	0	1	3	0	5,467	1,028	4	0

Table 7. The lower Colorado River (Reach 1) total numbers, lengths and catch-per-unit-effort (CPUE; fish/100m²), by year for young-of-year Colorado pikeminnow caught during ISMP monitoring from 1986—2017.

Reach 1	YOY Colorado	Mean Length	Length Range	Total Area	CPUE
Year	Pikeminnow	(mm)	(mm)	(m²)	(fish/100m²)
	Caught				
1986	192	27.9	17-36	1,343.6	14.29
1987	176	40.9	—	2,225.8	7.91
1988	172	48.0	—	3,786.8	4.54
1989	132	42.7	—	3,739.2	3.53
1990	179	41.9	—	2,565.8	6.98
1991	150	34.2	—	2,271	6.61
1992	151	33.6	—	3,663.2	4.12
1993	206	32.3	22-47	2,858.8	7.21
1994	142	64.1	32-96	3,139.8	4.52
1995	85	20.5	11-35	2,890	2.94
1996	866	39.6	20-81	4,113.8	21.05
1997	12	18.3	13-34	2,774.8	0.43
1998	88	34.5	20-60	4,663.8	1.89
1999	13	25	19-43	4,710	0.28
2000	398	45.7	25-82	6,389.6	6.23
2001	17	42.3	23-65	4,046.8	0.42
2002	25	57.2	32-87	3,033.8	0.82
2003	0	—	—	2,837.8	0.00
2004	16	47	33-63	1,620	0.99
2005	19	36.1	28-48	1,722	1.10
2006	4	42	27-53	1,682.4	0.24
2007	24	37.2	28-47	2,802	0.86
2008	0	—	—	2,568	0.00
2009	243	32.8	15-63	2,193.4	9.46
2010	27	35.9	26-61	2,630.4	1.03
2011	59	24.2	18-36	1,195.2	4.94
2012	54	56.7	53-83	2,240	2.41
2013	1	31	31	1,769	0.05
2014	8	32.3	23-43	2,544	0.31
2015	1,331	28.8	16-51	1,251	106.39
2016	150	35.5	22-48	1,454	10.32
2017	2	40.5	28-53	1,002.5	0.20

Table 8. The lower Colorado River (Reach 1), total captures by year for native and endangered fish during young-of-year (YOY) monitoring from 1986-2017. 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	1,331	0	3	0	120	0	0
2016	150	3	19	0	5	4	0
2017	2	0	1	0	0	0	0

Table 9. The lower Colorado River (Reach 1), total captures by year for nonnative fish during young-of-year monitoring from 1986-2017. 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 (*Fundulus zebrinus*) (PK), red shiner (RS), smallmouth bass (SM), sand shiner (SS), walleye (*Sander vitreus*) (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	1,345	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
2016	1	0	1	0	2	426	10	0	7	4	0	1,828	0	825	0	0	0

2017 | 2 5 0 0 5 408 25 2 74 0 0 968 3 692 0 0 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 ($n = 101$).

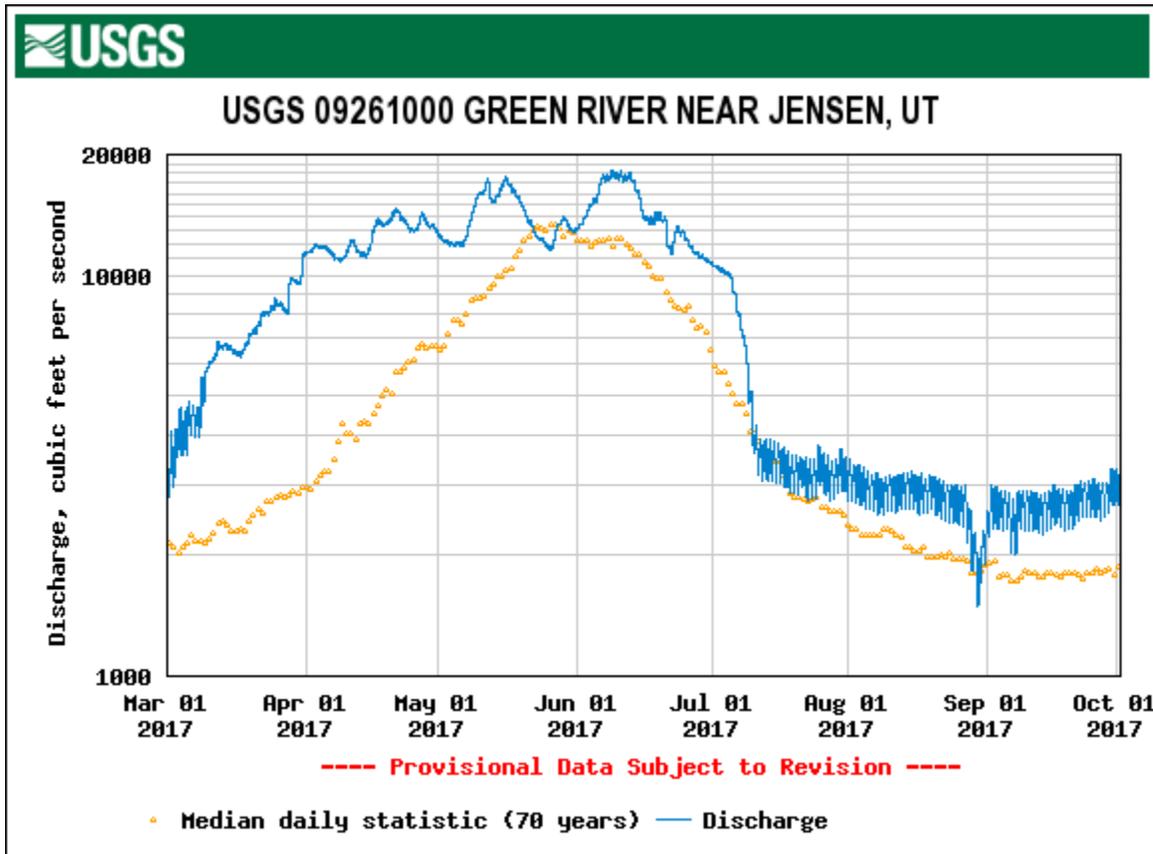


Figure 1. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 1 March 2017 to 1 October 2017.

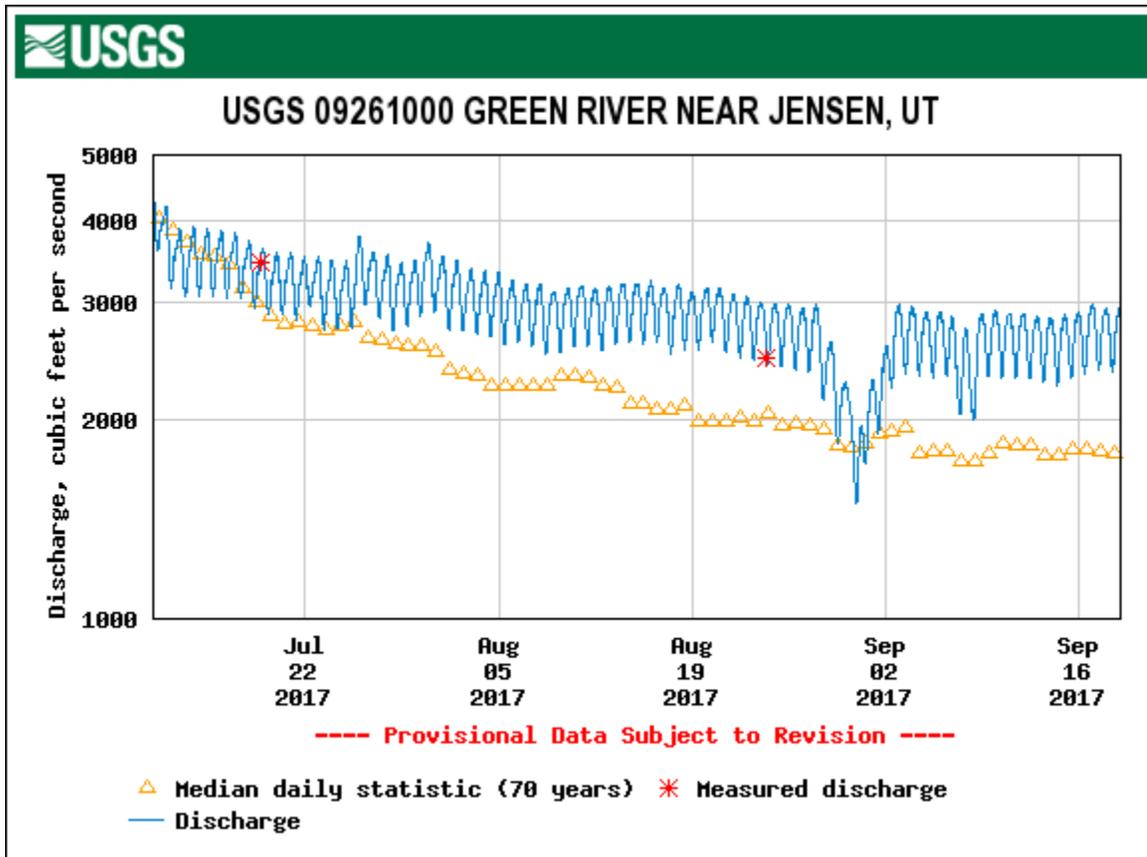


Figure 2. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 11 July 2017 to 18 September 2017.

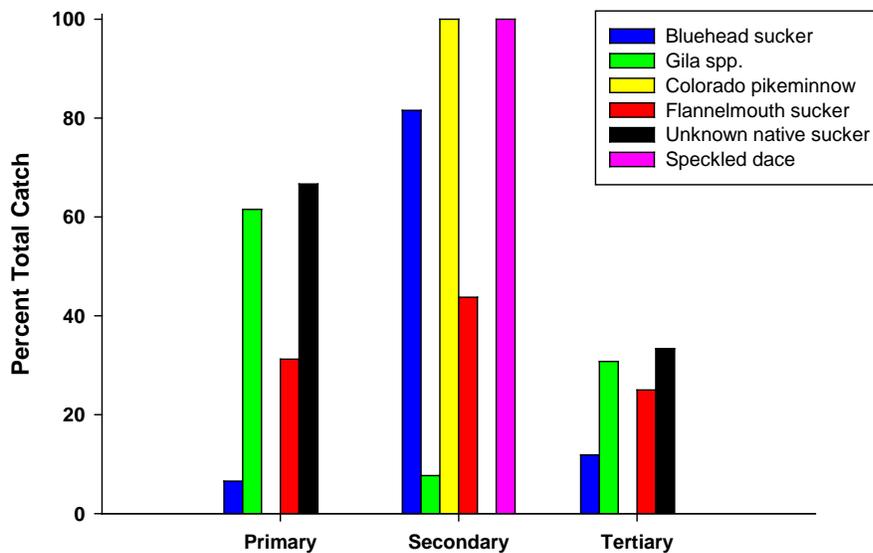


Figure 3. Proportional abundance (percent young-of-year sampled from all backwaters in the middle Green River) of native species captured in primary, secondary and tertiary backwaters during 2017 ISMP sampling. Juvenile Colorado pikeminnow are excluded.

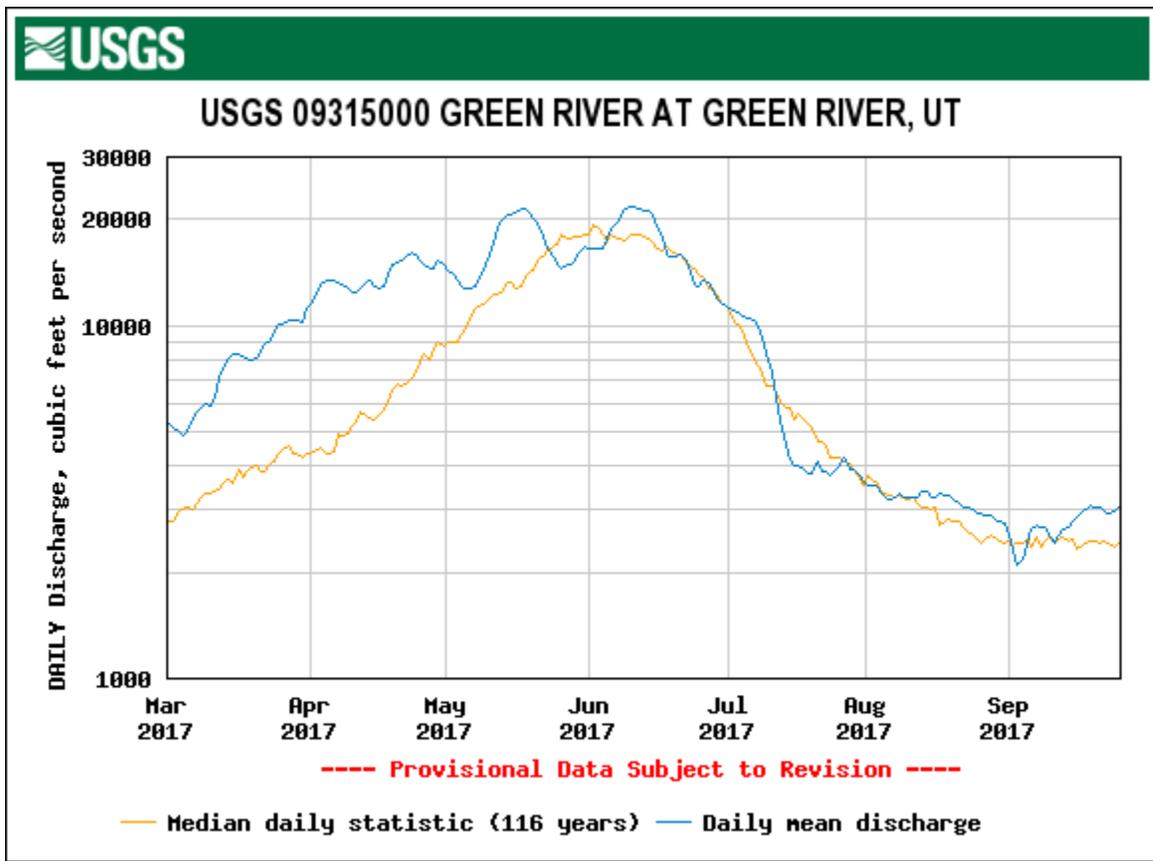


Figure 4. The lower Green River (Reach 3) daily mean flows measured from USGS Gage #09315000 at Green River, Utah from 1 March 2017 to 27 September 2017.

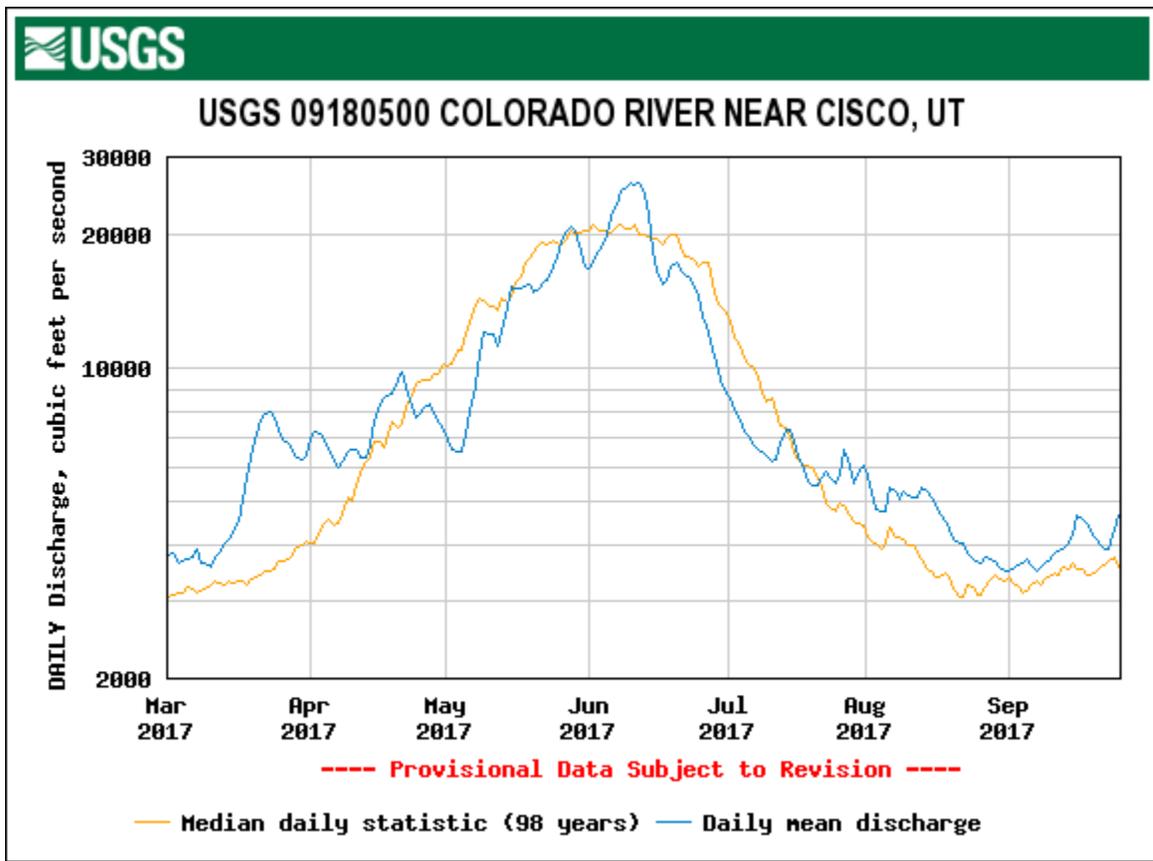


Figure 5. The lower Colorado River (Reach 1) daily mean flows measured from USGS Gage #09180500 near Cisco, Utah from 1 March 2017 to 27 September 2017.