

COLORADO RIVER RECOVERY PROGRAM
FY 2016 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
End date: (Mo/Day/Yr): 09/30/2018
Reporting period end date: 09/30/2016
Is this the final report? Yes _____ No X

III. Principal Investigator(s): Matthew J. Breen and Robert C. Schelly
Utah Division of Wildlife Resources
Northeastern Regional Office
318 North Vernal Ave.
Vernal, UT 84078
Phone: 435-781-5315; Fax: 435-789-8343
E-mail: mattbreen@utah.gov

Christopher M. Michaud
Utah Division of Wildlife Resources
Moab Field Station
1165 S. Highway 191- Suite 4
Moab, UT 84532
Phone: 435-259-3784; Fax: 435-259-3785
E-mail: cmichaud@utah.gov

IV. Abstract:

Monitoring of young-of-year (YOY) 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 2016, 150 young-of-year Colorado Pikeminnow were encountered on the lower Colorado River (Reach 1), 426 on the lower Green River (Reach 3), and six on the middle Green River (Reach 4). Catch rates were the fifth highest on record in Reach 1 and the sixth highest on record in Reach 3. However, in Reach 4 catch rates were the seventh lowest on record. Specifically for Green River reaches, base flow levels maintained within a specific range likely contributed to the overwhelming success observed in 2015 and continued success in 2016 (lower Green River), 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 2016 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 12 September 2016 and was completed on 22 September 2016. Beginning at Split Mountain boat ramp (RM 319.3) and concluding at Sand Wash (RM 215.3), 59 of 63 possible backwater habitats (three per 5-mile sub-reach) were sampled; 21 primary, 20 secondary, and 18 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 4,308 m² of suitable habitat was seined in 2016 (primary and secondary backwaters only), which is a slightly smaller area than 2015 (Breen et al. 2015). However, a greater percentage of the available habitat was sampled in 2016 (9.5% of the total habitat area). An additional

2,152 m² of habitat was sampled from tertiary backwaters. Backwater habitat was less abundant in comparison to 2015, but we also observed that backwater location shifted substantially from previous years. For example, long-standing backwaters were covered up by new sand bars on many occasions and locations of newly created sand bars/backwaters were highly unpredictable (i.e., outside river bends contained sand bars instead of inside bends in some cases).

Discharge for the middle Green River is measured at USGS gauge #09261000, located at Jensen, Utah. Peak spring discharge reached 21,100 cubic feet per second (cfs) on 12 June 2016 (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 relatively consistent, with limited influence from monsoonal rain events as observed in August and September 2014 (Breen et al. 2014; Figures 1 and 2). Mean daily discharge was below 3,000 cfs from 11 July 2016 until ISMP sampling was initiated (Figure 2). During this period, mean daily discharge averaged 2,224 cfs (range = 1,960–2,690 cfs; provisional values), which is remarkably similar to the 2015 base flow period (Breen et al. 2015). Mean daily discharge for the sample period was 2,214 cfs (range = 2,120–2,950 cfs; provisional values), which is similar to 2015 values (Breen et al. 2015); with the exception of a higher range attributed to a significant rain event that took place on the last sampling date (Figure 1). Resulting flows on 22 September 2016 exceeded 4,000 cfs, but this occurred after all ISMP samples were completed. Main channel temperatures averaged 19.1 °C (16.8–22.1 °C), whereas mean backwater temperatures were 20.6 °C (17.0–26.3 °C) during the sampling period; both metrics being warmer than 2015 (Breen et al. 2015). Turbidity measurements (cm visibility; mean ± SD) obtained in main channel and backwater habitats were 20.4 ± 2.5 cm (3–>60 cm) and 18.7 ± 1.9 cm (0–>60 cm), respectively, representing better water clarity in both the main channel and in backwaters compared to 2015 (Breen et al. 2015).

In primary and secondary backwaters, we captured six YOY Colorado Pikeminnow, representing the seventh lowest total on record (Tables 1 and 2); one juvenile pikeminnow (TL = 142 mm) was also captured from a secondary backwater. Catch-per-unit-effort (CPUE; fish/100 m²) for YOY pikeminnow (0.14 fish/100 m²) was well below the 5- (1.51 fish/100 m²), 15- (0.99 fish/100 m²), and 27-year averages (1.86 fish/100 m²), and represented the seventh lowest total on record (Table 1). Average total length for YOY Colorado Pikeminnow was 40.3 mm, smaller than the 5- (43.9 mm), 15- (46.8 mm), and 27-year (44.7 mm) averages (Table 1). Primary backwaters accounted for the capture of four YOY Colorado Pikeminnow (44.4% of the total catch), secondary backwaters accounted for two pikeminnow (22.2%), and tertiary backwaters accounted for an additional three pikeminnow (33.3%; Figure 3). Considering all habitats sampled, pikeminnow were captured in six of 59 backwaters (10.2%); 14.3%, 10%, and 5.6% of primary, secondary, and tertiary backwaters, respectively.

Other native species are only reported for captures within primary backwaters to be consistent with previous data summaries (Table 2); this included one Speckled Dace (TL = 38 mm), three *Gila* spp., six Bluehead Sucker, and seven Flannelmouth Sucker.

Secondary and tertiary backwaters accounted for an additional 12 chubs (average TL for 15 total captures = 51.0 mm), 41 blueheads (average TL for 47 total captures = 47.0 mm), and 26 flannelmouth (average TL for 33 total captures = 64.0 mm), comprising 80%, 87%, and 79% of total captures, respectively (Figure 3). Additionally, one adult Razorback Sucker (TL = 433 mm) was captured from a secondary backwater and three unknown native catostomids (TL = 31, 32, 33 mm) were collected from a tertiary backwater. Additionally, tertiary backwaters accounted for 21%, 33%, 42%, and 60% of total Bluehead Sucker, Colorado Pikeminnow, 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, Red Shiner, and Sand Shiner (98% of the total catch; Table 3). We collected a total of 3,592 nonnative fish comprised of eight species in the first seine haul of primary backwaters, which is slightly lower than last year (Breen et al. 2015) and the ninth lowest total in 30 years of sampling (Table 3). In addition, we collected Black Bullhead ($n=1$), Green Sunfish ($n=4$), adult Yellow Perch ($n=2$; 151 and 196 mm TL), and one White Sucker x Flannelmouth Sucker hybrid (62 mm TL) from additional seine hauls in primary backwaters and secondary and tertiary backwaters. Including all seine hauls, a total of 42 age-0 Smallmouth Bass were captured (mean TL = 53.1 mm) from 20 different backwaters (34% of habitats sampled).

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 19 September and concluded on 22 September 2016. Crews sampled low velocity habitats in accordance with ISMP protocols between Green River State Park (RM 120) and the confluence with the Colorado River (RM 0). Researchers completed at least one seine haul in 19 out of 24 possible primary habitats (79.2%) and 11 out of 24 possible secondary habitats (45.8%). A total of 47 seine hauls were executed during ISMP in 2016 out of 96 possible (49%), covering 1,588 m² of low velocity habitat. This figure was down considerably from 2015 (2,031 m²) and the 5-, 15- and 30-year averages (2,519 m², 3,175 m² and 3,451 m², respectively). Low velocity habitats encountered in 2016 were smaller and less numerous than those encountered in 2015 (Breen et al. 2015).

Discharge on the lower Green River is measured at USGS gauge #09315000 located at Green River, Utah. The Green River peaked at 24,600 cfs on 14 June 2016. The average flow for the period of study was 2,170 cfs (Figure 4; provisional values); lower than the average for the same dates over the pre-dam period (2,458 cfs, 1894-1963) and post-dam period (2,893 cfs, 1964-2015). The lower Green River reached base flows ($\leq 3,800$ cfs; average=2,373) on 13 July 2016 and remained there until sampling was initiated. Prior to

ISMP sampling, monsoon events in the Green River sub-basin were of negligible influence and discharge during the base flow period remained relatively consistent (Figure 4). Average main channel temperature in 2016 was 18 °C, cooler than that found in 2015 (20 °C). Similarly, habitat temperatures were cooler in 2016 (19.8 °C) than 2015 (20.8 °C). Turbidity measured in the main channel was higher in 2016 than 2015 (67.3 vs. 75 mm), while turbidity in backwater habitats was lower than that found in 2015 (115.6 vs. 104 mm).

Researchers encountered 426 YOY Colorado Pikeminnow in 2016 (Table 4). This figure is slightly below the number encountered in 2015 (461 YOY), however, well above the 5- and 15-year averages and similar to the 30-year average (161, 183 and 444 fish, respectively). Catch-per-unit-effort in 2016 was 26.8 fish/100 m², well above the 5-, 15- and 30-year averages (6.3, 6.3 and 13.5 fish/100 m², respectively). In 2016, CPUE was the sixth highest in 30 years of ISMP sampling and YOY pikeminnow were widely distributed within the available habitat throughout Reach 3. We averaged 9.3 YOY pikeminnow encounters per seine haul (range= 0-63 fish) with 83% of seine hauls containing at least one Colorado Pikeminnow. Mean total length for YOY Colorado Pikeminnow encountered in 2016 was 41.1 mm (range=21-70 mm), down from 44.9 mm in 2015.

Additionally, crews encountered several other species of native fish within Reach 3 (Table 5). Bluehead Sucker (n=9), Flannelmouth Sucker (n=4) and native suckers (*Catostomus* spp.; Flannelmouth or Bluehead suckers) which could not reliably be identified to species in the field (n=22) were enumerated, measured and released. Nonnative fish were identified and enumerated in the first seine haul of the primary habitat only. In 2016, a total of 7,580 nonnative fish were enumerated, considerably more than the 3,040 encountered in 2015 (Table 6). Small-bodied cyprinids dominated the nonnative encounters; Red Shiner (n=3,730), Sand Shiner (n=2,790) and Fathead Minnow (n=1,055) were enumerated and removed. Black Bullhead (n=3), Channel Catfish (n=1) and Common Carp (n=1) were also enumerated and removed.

Lower Colorado River (Reach 1):

On the lower Colorado River, sampling for the Interagency Standardized Monitoring Program began on 12 September and ended on 15 September 2016. Low velocity habitats between Cisco Landing and the confluence with the Green River (RM 110.5-0) were sampled in accordance with ISMP protocols. Crews surveyed 17 of 22 (77%) possible primary habitats, 11 of 22 (50%) possible secondary habitats, and completed 41 of 88 (47%) possible seine hauls. The area sampled in 2016 (1,454 m²) was slightly greater than that sampled in 2015 (1,251 m²), however, smaller than the 5-, 15- and 30-year averages (1,800 m², 2,275 m², and 2,842 m², respectively).

Discharge for Reach 1 is measured at USGS gauge #09180500 near Cisco, Utah (Figure 5; provisional values). The Colorado River crested at 24,700 cfs on 9 June 2016. Average flow for the period of study was 3,827 cfs, similar to the historic average for those dates (3,922 cfs, 1914-2015). Mean main channel temperature for the period of

study was 18.1 °C, slightly below mean temperature recorded in 2015 (19.5 °C) and the mean for those dates over the period of record (19.3 °C, 2006-2015). Similarly, mean habitat temperature in 2016 (19.3 °C) was lower than that recorded in 2015 (20.7 °C). Average turbidity for both the main channel and low velocity habitats recorded in 2016 (367 mm, 254 mm) was substantially lower than that noted in 2015 (144 mm, 144 mm).

In 2016, 150 YOY Colorado Pikeminnow were encountered on the Colorado River (Table 7). Although encounters were down substantially from 2015 (1,331), CPUE (10.3 fish/100 m²) was higher than the 30-year average (7.4 fish/100 m²) and ranked fifth highest in the 30 year project. On average researchers encountered 3.7 YOY Colorado Pikeminnow per seine haul (range= 0-33 fish); 41% of habitats sampled contained at least one pikeminnow. Mean total length recorded in 2016 was 35.5 mm (range=22-48 mm), considerably larger than in 2015 (28.8 mm) and similar to the 5-, 15-, and 30-year averages (34.6 mm, 38.7 mm and 37.6 mm).

In addition to YOY Colorado Pikeminnow, crews also encountered juvenile Colorado Pikeminnow (n=3; 96, 125, 134 mm), survivors from the large cohort produced in 2015. *Gila* spp. (n=19), Bluehead Sucker (n=4), Flannelmouth Sucker (n=5) and unidentified suckers (n=4; *Catostomus* spp.; Flannelmouth or Bluehead suckers) were encountered (Table 8). Nonnative fish were enumerated only during the first seine haul of the primary habitat within each sub-reach. In 2016, crews encountered a total of 3,104 nonnative fish down from 4,312 enumerated in 2015 (Table 9). Small-bodied cyprinids composed the bulk of encounters, Red Shiner (n=1,828), Sand Shiner (n=825) and Fathead Minnow (426) were enumerated and removed. Black Bullhead (n=1), Bluegill (n=1), Common Carp (n=2), *Gambusia* (n=10), Gizzard Shad (n=7) and Largemouth Bass (n=4) were also enumerated and removed.

VIII. Additional noteworthy observations:

Although total captures were down slightly from last year, 2016 YOY Colorado Pikeminnow catch rates were higher than those recorded in 2015 and the sixth highest in 30 years of sampling on the lower Green River (Table 4). Additionally, researchers encountered 461 YOY pikeminnow during YOY Razorback Sucker sampling on the lower Green River (Dutrow and Creighton 2016). Summer base flows on the Green River maintained within a certain range likely contributed to the successful fall recruitment observed on the lower Green River in 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). 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 2016). Base flow levels fell within these ranges for both reaches in 2015 and 2016. In 2016, we observed a second year of successful fall recruitment on the lower Green River, underscoring the value of

manipulating Flaming Gorge Dam releases as a main recovery action to benefit pikeminnow recruitment.

Unlike Reach 3, the middle Green River (Reach 4) did not receive similar benefits to Colorado pikeminnow recruitment derived from consistent base flows supplemented by Flaming Gorge Dam releases in 2016. Potential explanations may include higher flows late into the summer that overlapped with emergence of a large cohort of larval pikeminnow (Bestgen and Jones 2016) and/or inadequate production of resources to sustain newly colonized pikeminnow larvae (Kevin Bestgen, personal communication) in newly formed backwaters; note the observations of backwater change for Reach 4 mentioned under Task 1 above. Moreover, most Colorado Pikeminnow YOY are produced from fish hatched later in the year (Bestgen et al. 2006). Despite limited fall YOY recruitment in Reach 4, total abundance of nonnative cyprinids was ninth lowest on record for the second year in a row, suggesting that the observed flow range disadvantaged production of these species, which was anticipated for Red Shiners (Bestgen and Hill 2016). Moreover, the strong Colorado Pikeminnow cohort produced in 2015, potentially resulting from achievement of targeted flow ranges (Breen et al. 2015), has demonstrated excellent over-winter survival. More specifically, age-1 pikeminnow have been captured regularly during other projects conducted in the middle Green River throughout 2016 (Schelly et al. 2016; Staffeldt et al. 2016).

Young-of-year Colorado Pikeminnow captures on the lower Colorado River were down considerably from the exceptional numbers recorded in 2015. However, similar to the results from the lower Green River, catch rates were ranked fifth highest in 30 years of ISMP sampling (Table 7). Field crews enumerated an additional 50 YOY Colorado Pikeminnow and 32 age-1 Colorado Pikeminnow during YOY Razorback Sucker sampling under Project 160 (Dutrow and Creighton 2016). Due to an abundance of YOY pikeminnow encountered in the Colorado River in 2016, the Upper Colorado River Endangered Fish Recovery Program launched a seining effort following ISMP. This additional effort was aimed at collecting YOY Colorado Pikeminnow to augment the brood stock held at the Southwestern Native Aquatic Resources and Recovery Center in Dexter, New Mexico. Over the course of two days and 26.9 miles (24% of Reach 1) of intensive seining, researchers collected over 160 YOY pikeminnow.

IX. Recommendations:

- In light of 2015 (reaches 3 and 4) and 2016 (Reach 3) 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 (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. 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.
- 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 2016 Budget Status

- A. Funds Provided: \$66,547
- B. Funds Expended: \$66,547
- 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 (Where applicable):

Data is formatted, has been QA/QC checked, and will be submitted to the USFWS by January 2017.

XIII. Signed: Matthew J. Breen & Christopher M. Michaud 11/10/2016

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.
- Bestgen, K.R., and T. Jones. 2016. Interagency Standardized Monitoring Program (ISMP) assessment of endangered fish reproduction in relation to Flaming operations in the middle Green and lower Yampa rivers: Yampa and middle Green River assessment of Colorado pikeminnow and razorback sucker larvae. Annual report of the Department of Fish, Wildlife, and Conservation Biology, Colorado State University, to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.
- Bestgen, K.R., D.W. Beyers, J.A. Rice, and G.B. Haines. 2006. Factors affecting recruitment of young Colorado Pikeminnow: synthesis of predation experiments, field studies, and individual-based modeling. *Transactions of the American Fisheries Society* 135:1722–1742.
- 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.
- Breen, M.J., R.C. Schelly, and C.M. Michaud. 2015. 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.
- Dutrow, J.A., and K. Creighton. 2016. Assessment of stocked Razorback Sucker reproduction in the lower Green and lower Colorado rivers. Annual report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.
- Staffeldt, R.R., R.C. Schelly, and M.J. Breen. 2016. 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.
- Schelly, R.C., R.R. Staffeldt, and M.J. Breen. 2016. Use of Stewart Lake floodplain by larval and adult endangered fishes. 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 1990–2016 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
2016	6	40.3	33–54	4,308	0.14

*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 1986–2016 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
2016	6	1	3	0	0	7	6	1

*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 1987–2016. 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

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—2016.

Reach 3	YOY Colorado	Mean Length	Length Range	Total Area	CPUE
Year	Pikeminnow	(mm)	(mm)	(m²)	(fish/100m²)
Caught					
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
2016	426	41.1	21-70	1588	26.8

Table 5. The lower Green River (Reach 3), total captures by year for native and endangered fish during young-of-year (YOY) monitoring from 1986-2016. 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
2016	426	0	0	0	0	0	4	9	0

Table 6. The lower Green River (Reach 3), total captures by year for nonnative fish during young-of-year monitoring from 1986-2016. 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
2016	3	0	1	1	1,055	0	0	0	0	3,730	2790	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—2016.

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
2016	150	35.5	22-48	1454	10.32

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

Table 9. The lower Colorado River (Reach 1), total captures by year for nonnative fish during young-of-year monitoring from 1986-2016. 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
2016	1	0	1	0	2	426	10	0	7	4	0	1,828	0	825	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 ($n = 101$).

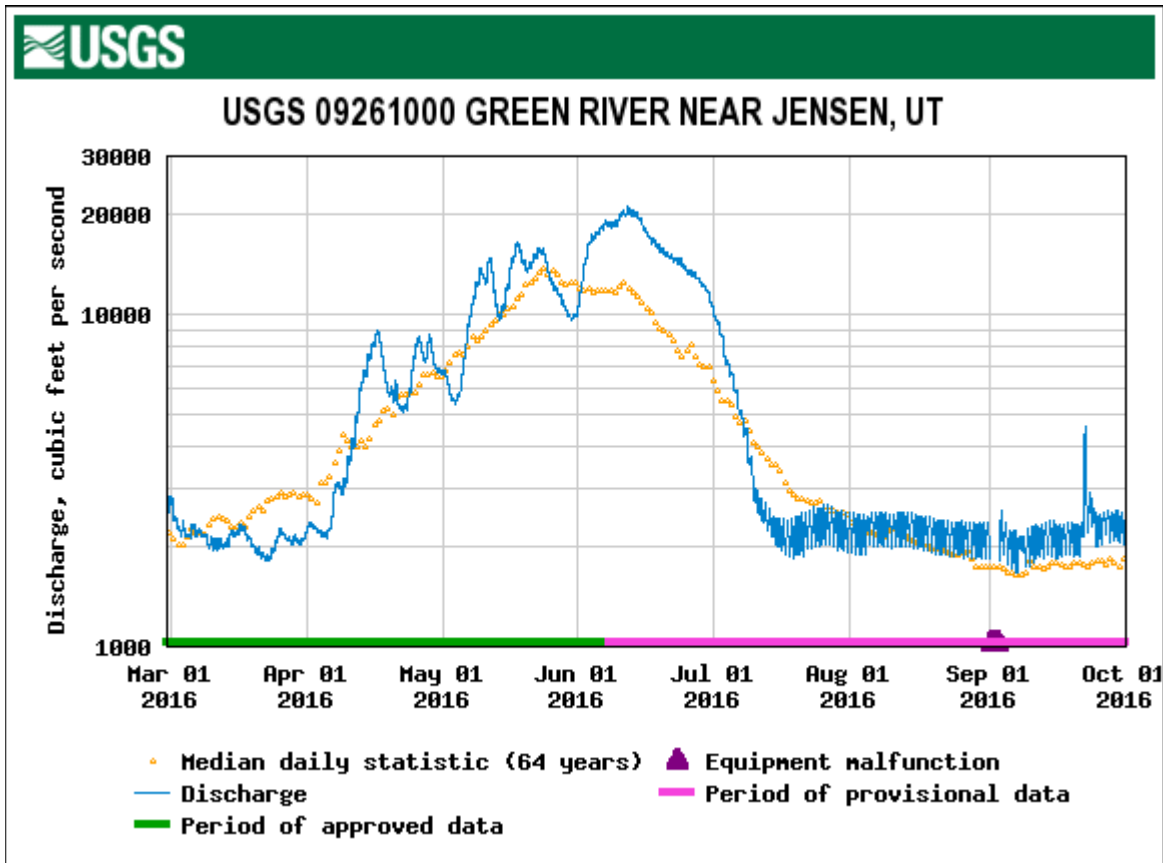


Figure 1. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 01 March 2016 to 01 October 2016.

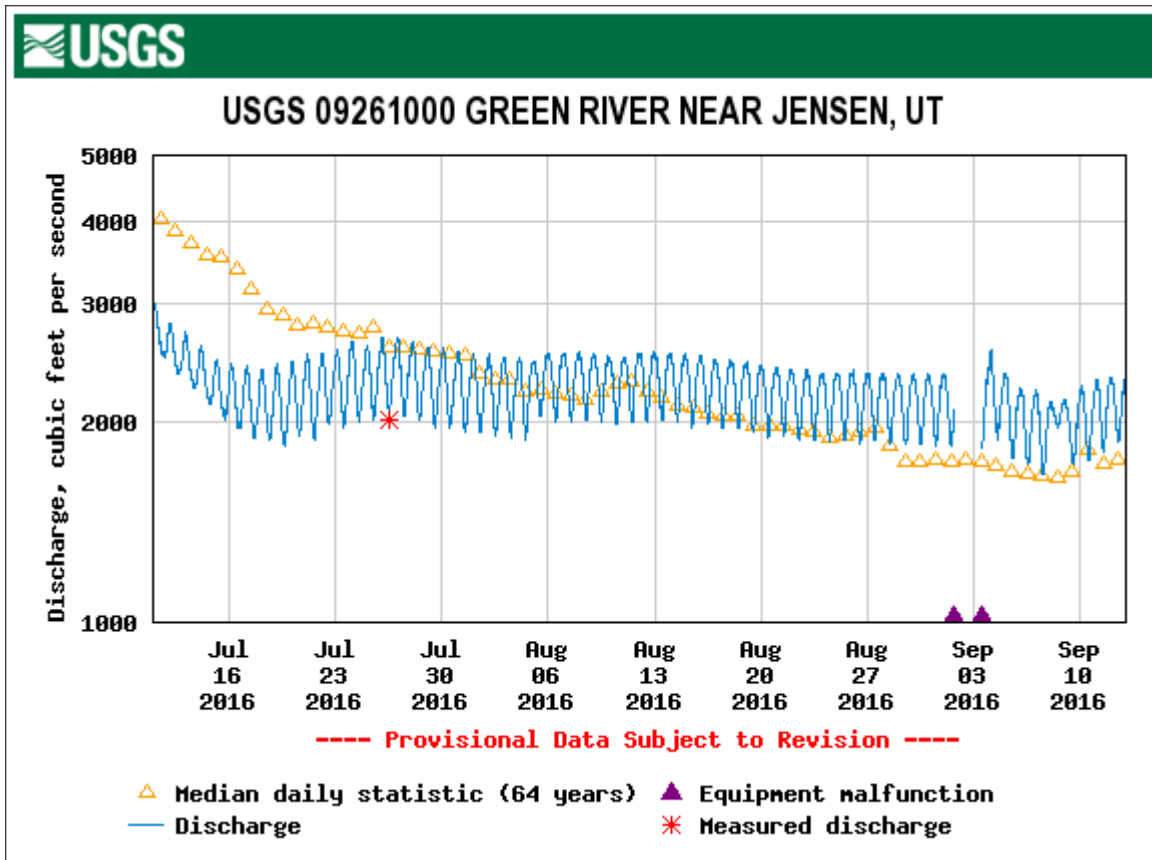


Figure 2. Middle Green River (Reach 4) discharge measured from USGS gage #09261000 at Jensen, Utah for the period of 12 July 2016 to 12 September 2016.

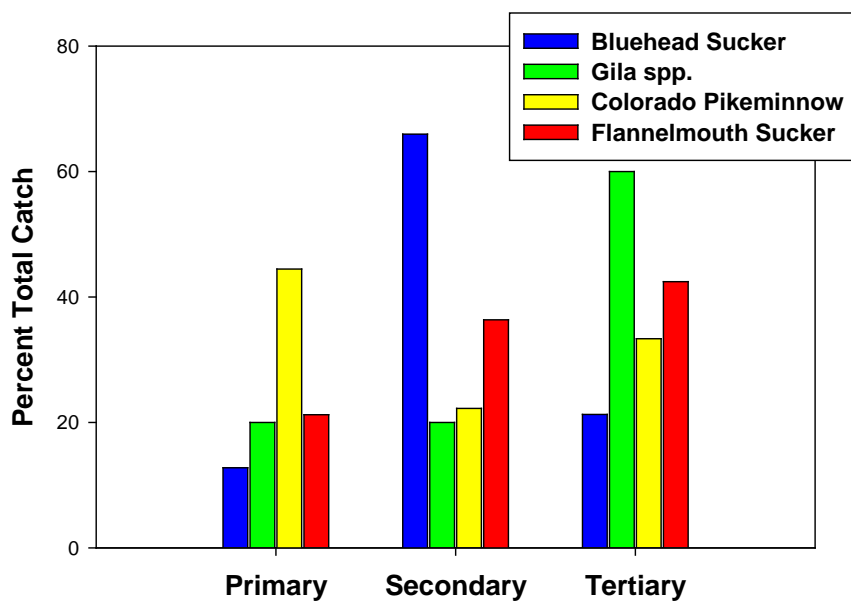


Figure 3. Proportional abundance (percent young-of-year sampled from all backwaters in the middle Green River) of native species captured in primary, secondary and tertiary backwaters during 2016 ISMP sampling.

USGS 09315000 GREEN RIVER AT GREEN RIVER, UT

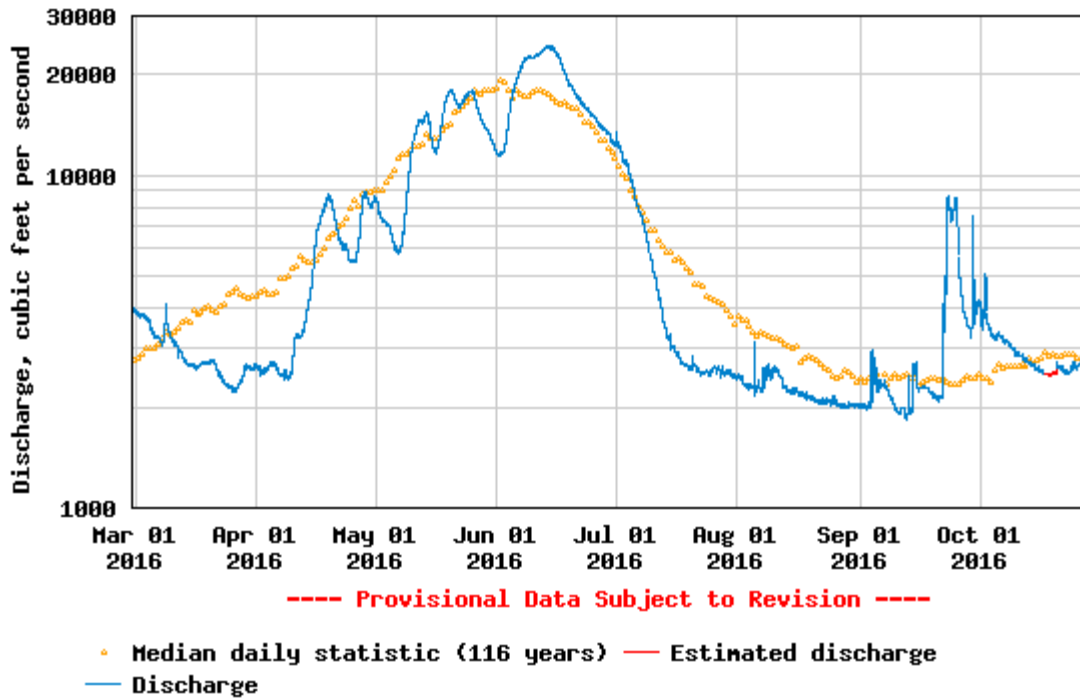


Figure 4. The lower Green River (Reach 3) daily mean flows measured from USGS Gage #09315000 at Green River, Utah from 01 March 2016 to 29 October 2016.



USGS 09180500 COLORADO RIVER NEAR CISCO, UT

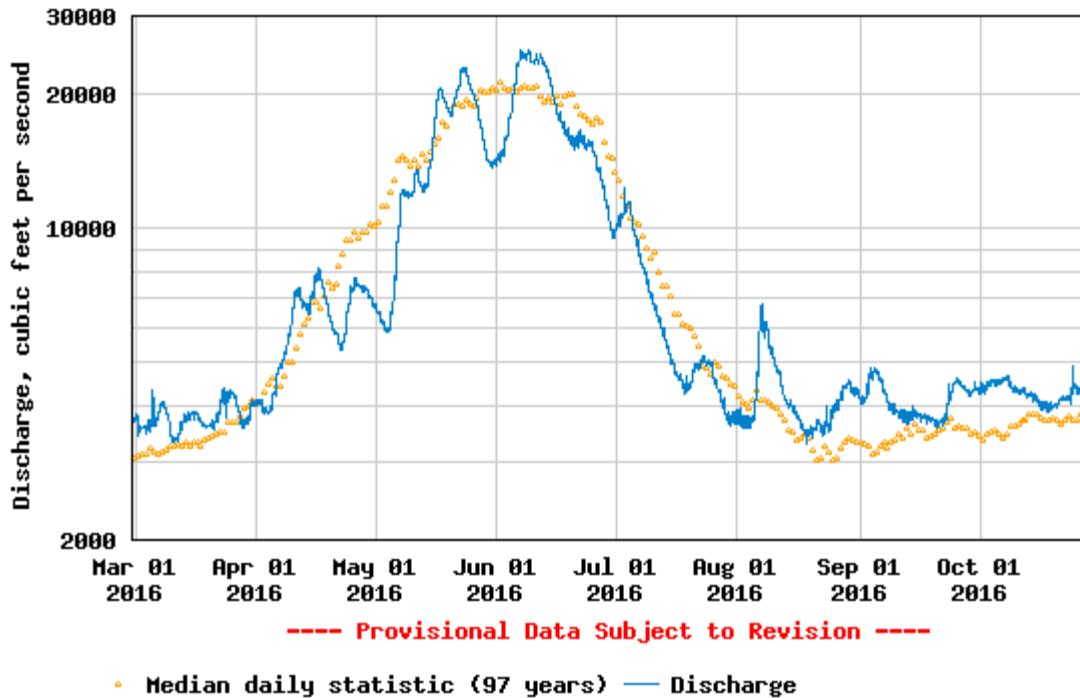


Figure 5. The lower Colorado River (Reach 1) daily mean flows measured from USGS Gage #09180500 near Cisco, Utah from 01 March 2016 to 29 October 2016.