

COLORADO RIVER RECOVERY PROGRAM
FY 2014 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 Protocol (ISMP; USFWS 1987) to monitor recruitment success of age-0 endangered fishes. In 2014, monsoonal rain events greatly affected habitat conditions (i.e., an increased sediment load inundated previously suitable low-velocity habitats) in the Colorado and Green rivers, which led to differential catch rates by reach. More specifically, Colorado pikeminnow catch rates were well below the 10-yr average on both the lower Green and Colorado rivers, whereas catch-per-unit-effort was higher than the 10- and 15-yr averages on the middle Green River.

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 2014 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 15 September 2014 and was completed on 23 September 2014. Beginning at Split Mountain boat ramp (RM 319.3) and concluding at Sand Wash (RM 215.3), 48 of 63 possible backwater habitats (three per 5-mile sub-reach) were sampled; 19 primary, 16 secondary, and 13 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 3,118 m² of suitable habitat was seined in 2014, which is the lowest on record (Table 1) given that two primary, five secondary, and eight tertiary backwaters were not sampled or completely unavailable due to poor habitat conditions. More specifically, a recently formed silt layer inundated the majority of low-velocity habitats at the time the project was conducted, either partially or entirely filling in backwater areas (i.e., several feet of silt with only inches of open water remaining).

Lack of habitat availability in the fall of 2014 was a reflection of recent, irregular flow patterns experienced in the middle Green River. As measured at the Jensen, Utah gauge (USGS gauge #09261000), peak spring discharge reached 20,100 cubic feet per second (cfs) on 08 June 2014 (provisional value), which exceeds the mean annual peak flow of 18,863 cfs for the previous 66 years of record (Figure 1). Following spring peak flows, base flow conditions were above average (Figures 1 and 2), and exceeded the Recovery Program Director's Office flow request to the U.S. Bureau of Reclamation of approximately 2,400 cfs at the Jensen gauge achieved through manipulation of Flaming Gorge Dam releases. Beyond an above average base flow regime, several irregular peaks in flow occurred during an active monsoon season in the upper basin, with emphasis on one major event approximately two weeks prior to the initiation of sampling (Figure 2). Specifically, on 29 August 2014 discharge reached 5,800 cfs (provisional value), far exceeding the 68 year median value for this same date of 1,750 cfs and drastically altering habitat conditions from flash flooding and increased sediment load at numerous locations (also based on UDWR–Vernal field crew observations working on Project #123b at this time).

In addition to events that played a major role in habitat alteration prior to sampling, conditions during 2014 ISMP efforts differed from previous years. Mean daily discharge for the sample period was 2,705 cfs (range = 2,380–3,280 cfs), far exceeding 2013 values as well as the period of record (Harding et al. 2013). Main channel temperatures averaged 19.5 °C (15.4–22.7 °C), whereas mean backwater temperatures were 20.8 °C (13.5–27.1 °C) during the sampling period; both metrics several degrees warmer than 2013 (Harding et al. 2013). Turbidity measurements [centimeter (cm) visibility; mean \pm SD] obtained in main channel and backwater habitats were 9.2 ± 3.1 cm (5–31 cm) and 16.2 ± 5.7 cm (3–14 cm) respectively. Although this is the first year turbidity measurements have been incorporated into ISMP sampling in reach four, and thus we have no basis for comparison, based on personal observations during prior sampling efforts water clarity was substantially lower in 2014 than typically observed this time of year.

In primary and secondary backwaters, we captured 45 YOY Colorado pikeminnow, while juvenile Colorado pikeminnow were absent. Catch-per-unit-effort (CPUE; fish/100 m²) for YOY Colorado pikeminnow (1.44) was higher than the 10- (0.87 fish/100 m²) and 15-yr averages (0.72 fish/100 m²), but slightly lower than the 25-yr average (1.82 fish/100 m²; Table 1). Average total length for YOY Colorado pikeminnow was 36.3 mm, smaller than the 10- (48.3 mm), 15- (48.3 mm), and 25-yr (45.2 mm) averages (Table 1). Growth patterns were consistent with cooler temperature regimes and a limited growing season associated with prolonged high flow scenarios (Breen et al. 2011). Primary backwaters accounted for the capture of 37 YOY Colorado pikeminnow (56% of the total catch); however, sampling within tertiary backwaters accounted for an additional 21 Colorado pikeminnow (32%; Figure 3).

Other native species captures are only reported for the first seine haul within primary backwaters, to match past data summaries (Table 2); this included two *Gila* spp. (total

length, TL = 32 and 46 mm), three razorback sucker (average TL = 88 mm; 73–101 mm), six bluehead suckers (average TL = 43 mm; 40–49 mm), and eight flannelmouth suckers (average TL = 56.5 mm; 47–83 mm). Secondary and tertiary backwaters accounted for an additional nine chubs (31–52 mm), two razorbacks (TL = 91 and 128 mm), 35 blueheads (36–53 mm), 20 flannelmouth (36–74 mm), and four unidentified native suckers (average TL = 31.8 mm; 27–42 mm), comprising 75%, 40%, 85%, 71%, and 100% of total captures respectively (Figure 3). Native sucker captures increased substantially over last year, with the addition of razorback sucker not observed in ISMP sampling since 2000, and were comparable to previous high flow years (e.g., 2011) when adequate spawning and rearing habitat was more abundant and available for a longer duration (Table 2). Additionally, tertiary backwaters accounted for 67% of total chub captures (Figure 3), again demonstrating the importance of monitoring of a third backwater in each sub-reach.

Seine samples continue to be dominated by small-bodied nonnative cyprinids, mainly fathead minnow, red shiner, and sand shiner (Table 3). However, we only collected a total of 1,943 nonnative fish comprised of nine species in the first seine haul of primary backwaters, which is the second lowest total on record (Table 3). In addition, we collected one plains killifish from a secondary backwater.

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

Lower Green River (Reach 3):

Sampling in reach three began on 15 September and concluded on 18 September 2014. Data was collected for the 120-mile reach of the Green River from Green River State Park (river-mile 120) to its confluence with the Colorado River (river-mile 0). The reach was broken into 5-mile sub-reaches. Two backwaters were sampled in each sub-reach, with two seine hauls performed within each habitat, when possible. Out of 24 total sub-reaches, 12 were not sampled due to a lack of suitable Colorado pikeminnow habitat. Fourteen backwaters were seined out of 48 possible, with 23 seine hauls completed out of 96 possible. A total area 1,670 m² of suitable habitat was surveyed in 2014 (Table 4), which is considerably lower than the amount of habitat surveyed in 2013 (2,381 m²) and the 28-yr average (3,565 m²). Main channel temperatures fluctuated between 19 and 23 °C (mean 21.7 °C). Habitat temperatures varied between 19 and 28 °C (mean 24.9 °C).

Discharge as measured at the USGS gauging station in the town of Green River, Utah (#09315000) fluctuated between 3,180 and 3,490 cfs during the 4-day interval in which sampling took place (Figure 4). Mean flow for this period was 3,317 cfs, which is greater than historic mean flows (1894-2013) of 2,665 cfs and post-dam mean flows (1964–2013) of 2,853 cfs for the same 4-day period. This year the lower Green River reached its peak flow of 20,600 cfs on 10 June. Mean peak flow based on 119 years of observation (1895-2014) is considerably higher at 27,958 cfs. Mean post-dam peak flow

(1964–2014) is 22,454 cfs. Minimum discharge recorded between peak and ISMP sampling occurred on 18 August 2014 (2,580 cfs).

All sampling was conducted with a 4 m x 1 m x 4 mm beach seine. Five YOY Colorado pikeminnow were captured along this 120-mile reach of the Green River (Table 4). All individuals were measured for total length prior to release. One Colorado pikeminnow expired while the crew was processing the fish. Totals in 2014 were considerably lower than the 10- (211.5), 15- (224.5) and 28-yr (459.6) averages. Catch-per-unit-effort for 2014 was 0.30 fish/100 m², below that for 2013 (1.3 fish/100 m²) and the 10-, 15- and 28-year averages (6.7, 6.2 and 13.6 fish/100 m² respectively). Mean total length of YOY Colorado pikeminnow captured in reach three in 2014 was 40.6 mm, smaller than that found in 2013 (52.8 mm) and similar to the 10- (41.3 mm), 15- (41.2 mm) and 28-yr (39.5 mm) average lengths. In 2014, Colorado pikeminnow lengths ranged from 33 to 48 mm.

No endangered fish species were encountered other than Colorado pikeminnow within reach three in 2014 (Table 5). Seven YOY flannelmouth suckers were captured as were six species of nonnative fishes (Tables 5 and 6). Nonnative fish were only enumerated during the first seine haul of the primary habitat for each sub-reach sampled. Nonnative fish included sand shiner (n=866), red shiner (n=658), fathead minnow (n=47), channel catfish (n=3), common carp (n=11), and black bullhead (n=1). A total of 1,586 nonnative fish were enumerated in reach three in 2014, considerably fewer than the 13,587 collected in 2013.

Available habitat encountered during the 2014 field season was the lowest on record (Table 4). Habitat sampled this year was down 30% from that surveyed in 2013 and 52% below the 28-yr average. Total abundance of YOY Colorado pikeminnow and CPUE showed similar trends. Researchers captured only five Colorado pikeminnow (lowest count on record) and had a CPUE of 0.30 (2nd lowest on record). Monsoonal weather patterns developed within the Green River watershed in early August and persisted through the period of study. Discharge, and consequently river elevation, increased dramatically and remained high through the months of August and September. These events flooded backwaters and embayments. As the water receded, just prior to sampling, silt was deposited in these target environments. The end result was a reduction in the habitat available for sampling (as per ISMP protocol) and decreased habitat quality in areas which crews seined.

Lower Colorado River (Reach 1):

Monitoring for YOY Colorado pikeminnow began on 22 September and ended on 25 September 2014. One hundred and ten miles of the Colorado River from Cisco Landing (RM 110.5) to the confluence with the Green River (RM 0) was surveyed. The reach was broken into 5-mile sub-reaches. Two areas of suitable habitat were surveyed within each sub-reach and two seine hauls were performed per habitat when possible. Eighteen out of 22 sub-reaches were surveyed and 39 out of 88 possible seine hauls completed. A total

area of 2,544 m² of suitable YOY Colorado pikeminnow habitat was surveyed in 2014, which is higher than the area surveyed in 2013 (1,769 m²) but lower than the 28-yr average of 2,909 m² (Table 7). For the sampling period, average main channel temperature of the Colorado River was 21.1°C. Actual measurements varied between 20 and 22°C. Average habitat temperature was 22.8°C and ranged from 19 to 29°C.

Mean discharge on the Colorado River for the period 22-25 September 2014 was 5,821 cfs, considerably higher than mean discharge for these dates based on 94 years of record (4,018 cfs) as measured at the gauging station near Cisco, Utah (# 09180500; Figure 5). Discharge fluctuated between 4,100 and 5,160 cfs over the four day sampling period. The Colorado River peaked on 3 June 2014 at 37,200 cfs, which is greater than the mean maximum discharge (based on 95 years of record) of 34,329 cfs. Minimum discharge recorded between peak and ISMP sampling occurred on 8 September 2014 (3,730 cfs).

Eight young-of-year Colorado pikeminnow were captured during ISMP sampling within the 110.5 mile reach of the Colorado River (Table 7). This number is greater than 2013 (n=1), however, well below the 10-, 15- and 28-yr averages (44.7, 60, and 123.3 fish respectively). Likewise, CPUE in 2014 (0.31 fish/100 m²) was greater than that of 2013 (0.05 fish/100 m²), but below the 10-, 15-, and 28-yr averages (2.1, 1.9 and 4.1 fish/100 m²). Mean total length was 32.3 mm, also lower than the 10-, 15-, and 28-yr averages (38.1, 39.5, and 38.1). High flows contributed to cooler main channel water temperatures through the summer months. Average water temperature from 01 May to 30 September 2014 (18.7°C) was cooler than the same interval in 2013 and the average for the last eight years (21°C and 19.7°C respectively), corresponding with smaller YOY Colorado pikeminnow on average in 2014. This relationship between total length and peak flow supports previous observations of the negative correlation between mean total length of fall YOY Colorado pikeminnow and spring peak flow in this reach (Breen et al. 2011).

In addition to Colorado pikeminnow, three YOY flannelmouth suckers were captured (Table 8). Nine species of nonnative fish totaling 1,482 individual fish were captured and enumerated during ISMP in 2014 (Table 9): red shiner (n=974), sand shiner (n=399), fathead minnow (n=55), gizzard shad (n=23), channel catfish (n=23), green sunfish (n=4), smallmouth bass (n=3), plains killifish (n=3), and common carp (n=1). This figure is substantially less than that of 2013 (7,024).

VIII. Additional noteworthy observations:

Razorback sucker YOY were captured on the middle Green River (reach four) for the first time since 1998 and 2000, when a single individual was collected each year during ISMP sampling (Table 2). With the first year of implementation of the Larval Trigger Study Plan (LTSP; Ad Hoc Committee 2012) without dry to moderately dry hydrology, a total of five YOY razorback sucker were collected from three different backwater habitats. Although lacking absolute certainty, there is a distinct possibility that these fish recently migrated from Stewart Lake, one of many LTSP study wetlands, which was completely drained just prior to ISMP sampling (Schelly et al. 2014). Young-of-year

razorback sucker were captured in backwaters ranging from 0.3 miles upstream to 17.8 miles downstream from the Stewart Lake outlet canal. Regardless of the wetland of origin, capture of YOY razorback sucker following a successful year of LTSP implementation indicates a successful transition from wetland nursery habitats to riverine habitats once a larger size was achieved in a single growing season (Schelly et al. 2014). This is a key result as the Recovery Program moves forward with the recovery of this species.

As reported in reach-specific results above, monsoonal weather patterns and subsequent flash flooding with elevated sediment loading greatly affected 2014 ISMP sampling throughout the upper Colorado River basin (i.e., heavy siltation of low-velocity habitats in all reaches). However, differential results were observed. Despite limited habitat availability, CPUE of YOY Colorado pikeminnow was greater than recent averages in the middle Green River (reach four), indicating successful recruitment in light of altered nursery habitats. The Colorado River (reach one) showed similar trends in flow as the Green River, however, backwater habitats were more abundant and seining conditions were slightly more favorable. Nonetheless, all reaches, with the exception of native species in reach four, experienced a considerable reduction in suitable habitat and a consequent decline in fish capture, also exemplified by some of the lowest nonnative captures in all reaches to date. For example, nonnative captures were second lowest on record for the middle Green River and the total number of fish captured on the Colorado River in 2014 (1,493) was 81% below the 28-yr average and down 79% from 2013 (7,868 and 7,031 respectively).

Here we provide a more detailed account specific to reach three to further illustrate the extent that Colorado pikeminnow nursery habitats were affected. The Price and San Rafael rivers, tributaries of the Green River, frequently fluctuated between 20 and 1,000 cfs through much of July, August, and September 2014. Flash flood events on these major and countless minor tributary streams increased the sediment load carried by Green River. Flows in the lower Green River fluctuated through much of the summer and fall, the most dramatic oscillations occurring in the four weeks prior to sampling. Flow increased from 2,740 cfs on 20 August to 6,600 cfs on 27 August, and then rapidly decreased to 3,100 cfs. A second spike occurred on 9 September 2014; discharge increased and briefly registered 5,240 cfs. As a result, the majority of embayments, backwaters and tributary streams on the lower Green River were completely silted in. Those that remained were difficult to seine due to heightened mud depths. Total fish capture (native and nonnative) was down 88% when compared to 2013 and 79% compared to the 28-yr average (1,598 vs. 13,618 and 7,473 respectively). Overall lack of habitat, poor quality habitat and difficult seining conditions all contributed to low CPUE of native and nonnative fishes alike.

IX. Recommendations:

- Continue to monitor annual relative abundance of post-larval Colorado pikeminnow in the middle Green River, lower Green River and lower Colorado River to assess long-term trends in annual fall recruitment.
- Strive to more closely meet base flow request goals 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, transport to backwater nursery areas, and adequate rearing habitats.
- 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.
- Temperature trends on the lower Green River and lower Colorado River cannot be examined because continuous temperature data is not available from current local gauges. Determine if temperature is as directly correlated to YOY survival as flow or major climatic events. If it is concluded that temperature is an important factor to consider, devise method to collect more accurate temperature data.
- 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 2014 Budget Status

- A. Funds Provided: \$54,221
- B. Funds Expended: \$54,221
- C. Difference: \$0
- D. Percent of the FY 2014 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 2015.

XIII. Signed: Matthew J. Breen & Christopher M. Michaud 11/7/2014
Principal Investigators Date

XIV. Literature Cited

- 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.
- Harding, I., M.J. Breen, J.A. Skorupski Jr., C.M. Michaud, and K.L. Creighton. 2013. 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.
- Larval Trigger Study Plan (LTSP) Ad Hoc Committee. 2012. Study plan to examine the effects of using larval sucker occurrence in the Green River as a Trigger for Flaming Gorge Dam. Final Report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, CO.
- Schelly, R.S., J.T. Herdmann, and M.J. Breen. 2014. Use of Stewart Lake floodplain by larval and adult endangered fishes. Annual Report submitted to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, CO.
- USFWS. 1987. Interagency standardized monitoring protocol handbook. U.S. Fish and Wildlife Service. Grand Junction, CO.

Table 1. The middle Green River (Reach 4) 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 YOY monitoring from 1990–2014. *To be consistent with previous years, information in this table contains only 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	5093	5.5
1991	524	38.2	21 – 65	5077	10.3
1992	183	43.1	26 – 133	4697	3.9
1993	305	36.4	21 – 59	3960	7.7
1994	15	67.2	60 – 80	4356	0.3
1995	75	34.5	21 – 48	3792	2
1996	79	39.4	25 – 60	3912	2
1997	22	36	28 – 49	3734	0.6
1998	73	38.5	22 – 61	4986	0.9
1999	12	33.7	25 – 45	3897	0.3
2000	31	50.9	37 – 76	3798	0.8
2001	8	46.9	36 – 67	4496	0.2
2002	0	–	–	5202	0
2003	2	52	52 – 52	4696	0.04
2004	60	43.8	31 – 63	4686	1.28
2005	8	48.6	35 – 60	4190	0.2
2006	5	45.8	36 – 50	7490	0.07
2007	3	73.3	69 – 76	5782	0.05
2008	18	43.9	36 – 56	4994	0.36
2009	325	43.7	22 – 71	7503	4.3
*2010	454	37.9	24 – 58	–	–
2011	0	–	–	7852	0
2012	2	53.5	39–68	7805	0.03
2013	97	51.7	35–82	6735**	1.37**
2014	45	36.3	25–67	3118	1.44

*Four YOY Colorado pikeminnow were not included because they were not measured.

**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. The middle Green River (Reach 4), total captures for native fish during young-of-year monitoring from 1986–2011. 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

*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), white sucker (WS), and yellow bullhead (YB).

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

Table 4. The lower Green River (Reach 3) total numbers, lengths and mean catch-per-unit-effort (CPUE; fish/100 m²), by year for YOY Colorado pikeminnow caught during young-of-year monitoring for the period of 1986—2014.

Reach 3	YOY Colorado	Mean Length	Length Range	Total Area	CPUE
Year	Pikeminnow	(mm)	(mm)	(m²)	(fish/100m²)
Year	Caught	(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

Table 5. The lower Green River (Reach 3), total captures by year for native and endangered fish during young-of-year monitoring from 1986-2014. Species listed are: YOY Colorado pikeminnow (CS YOY; 10-109 mm), juvenile pikeminnow (CS JUV; 110-399 mm), and 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 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

Table 6. The lower Green River (Reach 3), total captures by year for nonnative fish during young-of-year monitoring from 1986-2014. 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 (GA), green sunfish (GS), gizzard shad (GZ), largemouth bass (LG), northern pike (NP), 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	NP	PK	RS	SM	SS	WE	WS	YB
1986	7	0	0	4	12	87	0	9	0	0	0	0	663	0	4	0	0	0
1987	0	0	0	1	0	34	0	5	0	0	0	0	1,303	0	4	0	0	0
1988	1	0	0	110	2	1,790	7	1	0	0	0	0	4,317	0	38	0	0	0
1989	1	0	0	73	1	170	0	3	0	0	0	0	5,826	0	113	0	0	0
1990	1	0	0	37	4	228	0	0	0	0	0	0	9,599	0	129	0	0	0
1991	0	0	0	8	3	314	0	2	0	0	0	0	7,746	0	1,123	0	0	0
1992	1	0	0	24	1	500	0	0	0	0	0	0	2,737	0	180	0	0	0
1993	1	0	0	11	1	249	0	0	0	0	0	0	3,443	0	1,362	0	0	0
1994	0	0	0	6	8	500	1	8	0	0	0	0	8,007	0	1,196	0	0	0
1995	7	0	0	4	16	363	0	6	0	0	0	0	3,478	0	969	0	0	0
1996	0	0	0	0	0	1,097	2	2	0	0	0	0	11,858	0	3,751	0	0	0
1997	0	0	0	17	1	79	4	3	0	0	0	0	855	0	320	0	1	0
1998	0	6	0	0	1	120	17	0	0	0	0	0	1,709	0	178	0	0	0
1999	0	1	0	2	37	340	1	0	0	0	0	0	845	0	156	0	0	0
2000	3	0	0	12	3	234	0	1	0	0	0	0	3,591	0	574	0	4	0
2001	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	122	2	14,721	0	1	0	0	0	0	26,710	0	2,135	0	0	0
2003	5	0	0	11	1	201	0	12	0	0	0	0	4,707	0	43	0	0	0
2004	3	0	0	7	0	215	0	1	0	0	0	0	297	0	190	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	2	1	0	6	3	1,187	1	4	0	1	0	0	8,623	0	0	0	0	0
2007	0	0	0	23	0	2,183	0	0	1	2	0	0	8,807	0	35	0	0	0
2008	0	2	0	13	116	1,074	0	0	1	1	0	0	4,458	0	250	0	0	6
2009	0	0	0	3	0	1,044	0	0	1	0	0	0	2,766	0	15	0	0	0
2010	0	0	0	0	0	150	0	5	4	0	0	0	1,028	0	1,025	0	0	0
2011	0	8	0	6	15	314	0	0	0	0	0	0	1,842	0	1,096	0	0	0
2012	8	0	0	5	5	3,085	0	4	15	0	0	0	2,043	0	8,620	0	0	3
2013	0	0	0	19	6	1,025	0	6	6	0	0	0	2,550	0	9,975	0	0	0
2014	1	0	0	3	11	47	0	0	0	0	0	0	658	0	866	0	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 YOY Colorado pikeminnow caught during young-of-year monitoring for the period of 1986—2014.

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

Table 8. The lower Colorado River (Reach 1), total captures by year for native and endangered fish during young-of-year monitoring from 1986-2014. 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 haul within primary backwaters.

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

Table 9. The lower Colorado River (Reach 1), total captures by year for nonnative fish during young-of-year monitoring from 1986-2014. 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 (GA), green sunfish (GS), gizzard shad (GZ), largemouth bass (LG), northern pike (NP), 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	NP	PK	RS	SM	SS	WE	WS	YB
1986	0	0	0	4	0	456	2	0	0	1	0	6	1,077	0	240	0	0	0
1987	1	0	0	10	1	233	1	0	0	0	0	0	2,159	0	428	0	0	0
1988	0	0	0	0	4	10,650	0	1	0	0	0	36	1,786	0	2,161	0	0	0
1989	11	0	0	8	12	3,613	0	2	0	0	0	9	6,973	0	951	0	1	0
1990	2	0	2	11	4	5,698	1	1	0	1	0	10	6,593	0	889	0	0	0
1991	1	0	0	8	1	2,632	0	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	0	7	6,470	0	3,991	0	1	0
1993	3	0	0	1	8	2,091	4	1	0	0	0	0	3,870	0	1,449	0	2	0
1994	1	0	0	1	2	4,795	14	34	0	0	0	0	4,393	0	2,520	0	2	0
1995	2	0	0	17	3	1,105	71	2	0	1	0	0	1,079	0	926	0	0	0
1996	0	0	2	1	0	2,591	3	15	0	1	0	8	3,851	0	5,998	0	0	0
1997	0	0	0	12	2	37	3	0	0	2	0	0	1,244	0	224	0	0	0
1998	0	0	0	1	0	265	1	6	0	0	0	2	6,297	0	8,751	0	0	0
1999	0	1	1	21	3	137	1	1	0	0	0	2	1,891	0	2,303	0	0	0
2000	4	0	0	0	1	1,265	24	2	0	1	0	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	0
2002	1	0	0	4	3	4,963	1	0	0	0	0	1	11,691	0	2,920	0	0	0
2003	2	0	0	0	1	2,192	4	0	0	0	0	7	788	0	1,162	0	0	0
2004	0	0	0	0	1	352	0	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	0
2006	1	2	0	4	1	159	94	10	0	2	0	1	3,030	0	103	0	0	1
2007	1	0	0	1	5	597	52	0	15	0	0	0	1,063	1	0	0	6	0
2008	0	0	0	1	5	280	1	0	17	1	0	0	536	0	5	0	1	1
2009	3	7	0	0	6	260	36	0	57	0	0	0	3,124	0	12	0	0	0
2010	0	0	0	2	0	377	3	0	174	5	0	0	657	0	622	1	0	0
2011	0	6	0	0	2	24	12	0	20	3	0	0	1345	0	58	0	0	0
2012	36	0	0	15	14	3,182*	2	6	70	2	0	0	471*	0	5,204*	0	0	0
2013	5	0	0	24	1	666	0	1	116	1	0	2	1,566	2	4,640	0	0	0
2014	0	0	0	23	1	55	0	4	23	0	0	3	974	0	399	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 ($n = 101$).



USGS 09261000 GREEN RIVER NEAR JENSEN, UT

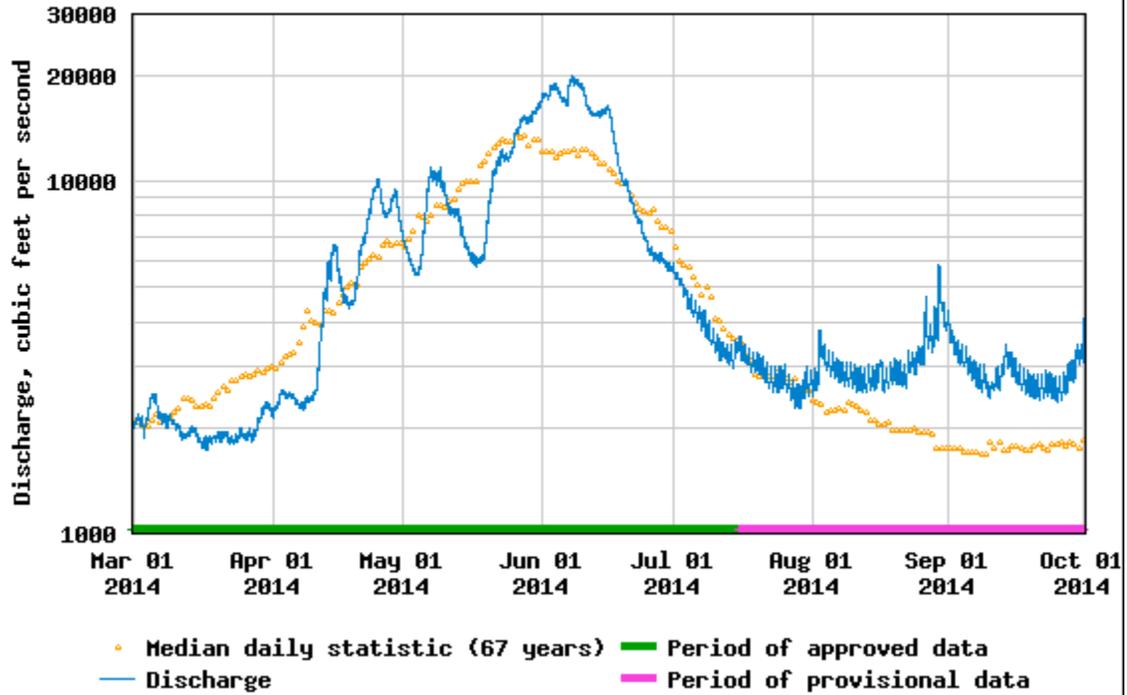


Figure 1. Middle Green River (Reach 4) discharge measured from USGS gauge #09261000 at Jensen, Utah for the period of 01 March 2014 to 01 October 2014.

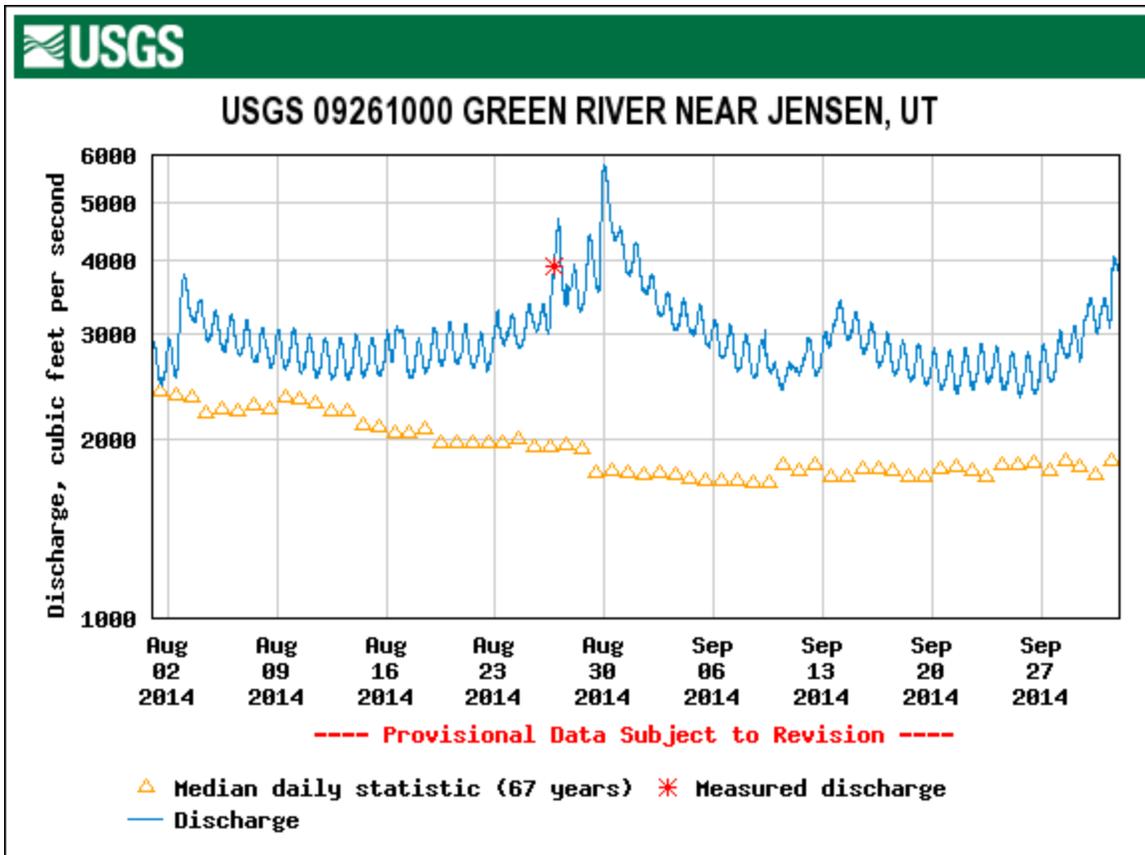


Figure 2. Middle Green River (Reach 4) discharge measured from USGS gauge #09261000 at Jensen, Utah for the period of 01 August 2014 to 01 October 2014.

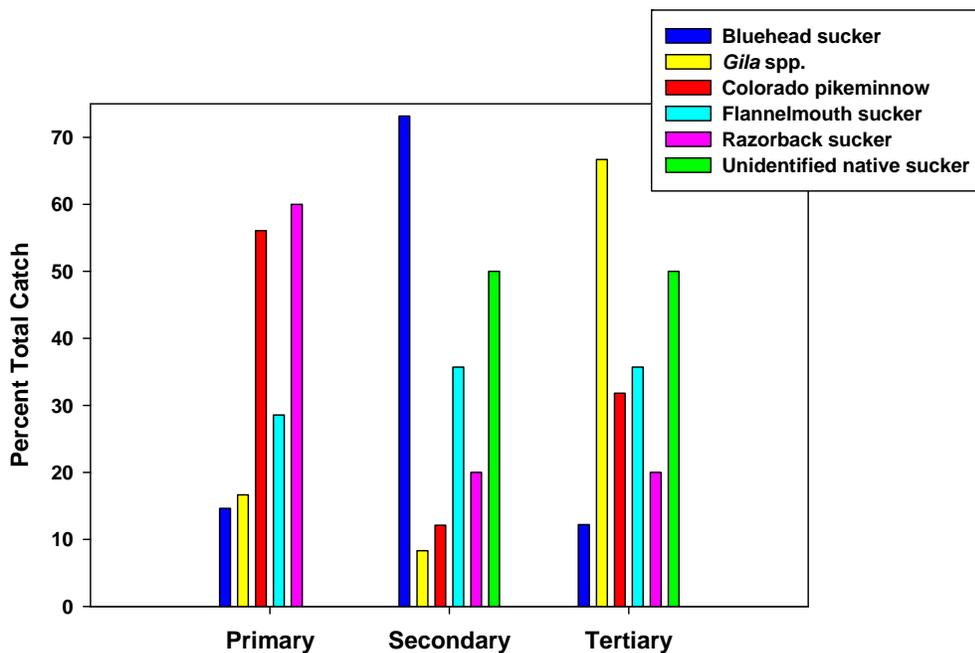


Figure 3. Proportional abundance (percent young-of-year sampled from all backwaters in the middle Green River) of native species in primary, secondary and tertiary backwaters.



USGS 09315000 GREEN RIVER AT GREEN RIVER, UT

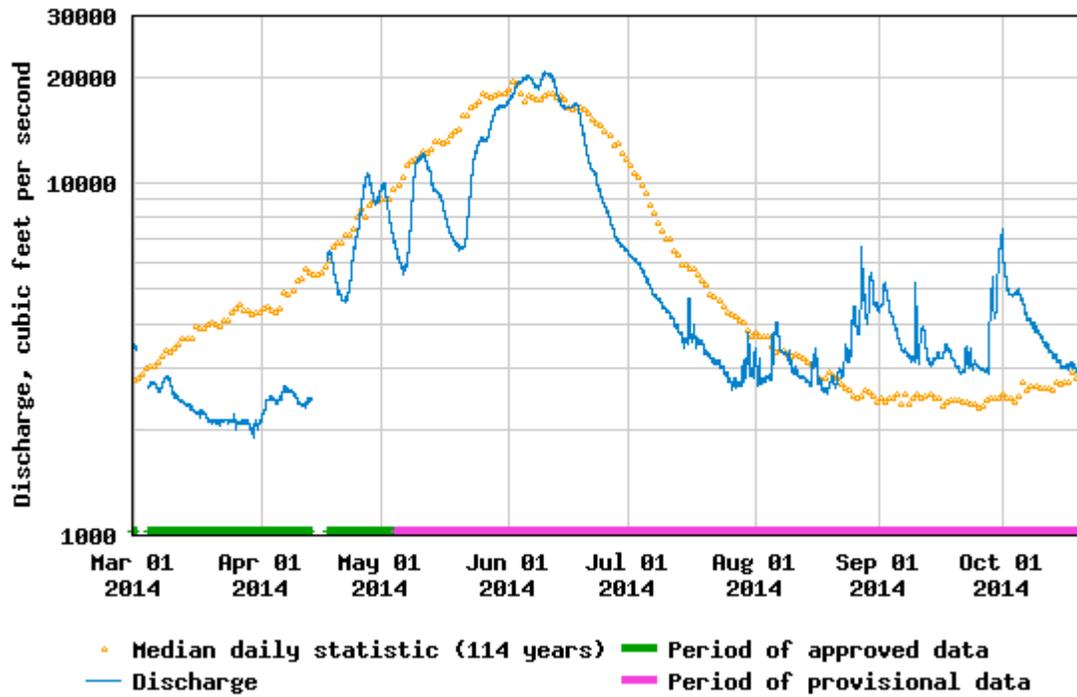


Figure 4. The lower Green River (Reach 3) daily mean flows measured from USGS Gauge #09315000 at Green River, Utah from 1 March 2014 to 21 October 2014.



USGS 09180500 COLORADO RIVER NEAR CISCO, UT

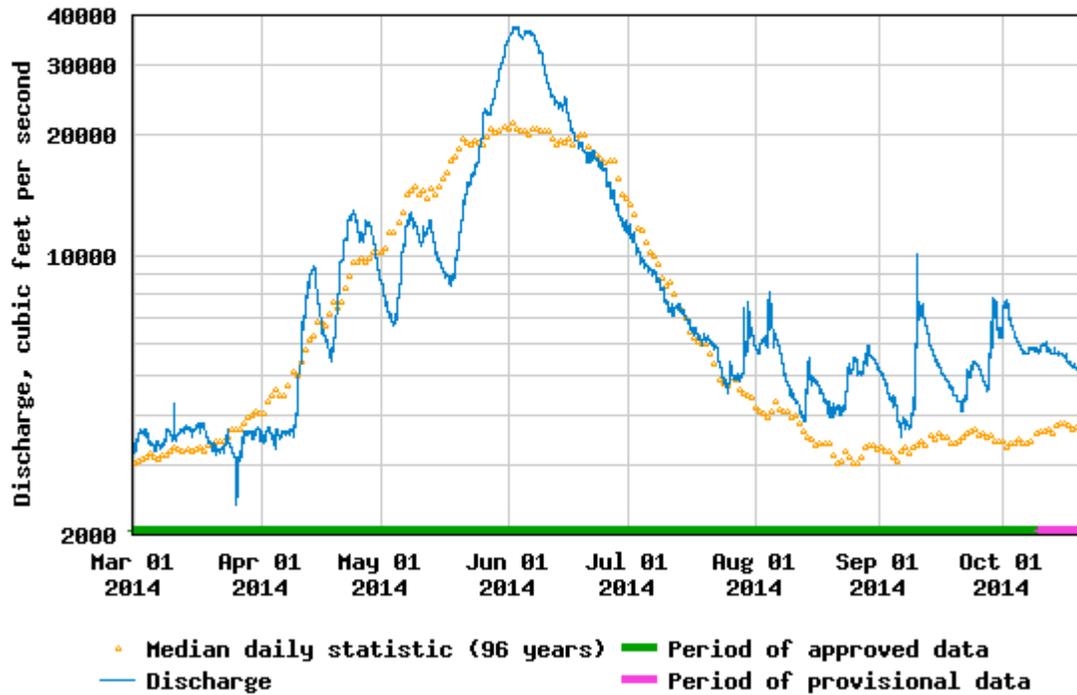


Figure 5. The lower Colorado River (Reach 1) daily mean flows measured from USGS Gauge #09180500 near Cisco, Utah from 1 March 2014 to 21 October 2014.