

COLORADO RIVER RECOVERY PROGRAM
FY 2018 ANNUAL PROJECT REPORT

RECOVERY PROGRAM
PROJECT NUMBER: FR-115

- I. Project Title: Monitoring effects of Flaming Gorge Dam releases on the Lodore and Whirlpool Canyon fish communities
- II. Bureau of Reclamation Agreement Numbers: R14AP00001
Project/Grant Period: Start date (Mo/Day/Yr): 1 Oct. 2014
End date: (Mo/Day/Yr): 30 Sept. 2018
Reporting period end date: 30 Sept. 2018
Is this the final report? Yes _____ No X
- III. Principal Investigators: Lead Agency: Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University; Bureau of Reclamation; U.S. Fish and Wildlife Service

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- IV. Abstract: The primary purpose of this study is to determine the cumulative effect that flow and temperature regimes downstream of Flaming Gorge Dam have had on the fish community of the Green River in Lodore and Whirlpool canyons and to recommend how to monitor effects into the future. A secondary purpose is to determine the distribution and abundance of the humpback chub population in Whirlpool Canyon to serve as the basis for future monitoring efforts. Finally, a third purpose is to remove nonnative fishes present in the study reach. Future monitoring will be needed to evaluate the contribution of the Whirlpool Canyon population of humpback chub to the overall recovery of the species, and to monitor response of the fish community to removal of smallmouth bass, particularly in the Whirlpool Canyon reach of the Green River. A portion of nonnative fish removal work is devoted to better understanding the reproductive ecology of smallmouth bass in the Green River study area. The collection of young-of-year smallmouth bass, and analysis of otolith microstructure, will allow determination of hatching dates of bass relative to streamflow and water temperature patterns. This

information may be useful to understand if flow releases from Flaming Gorge Dam may be useful to disadvantage smallmouth bass in the study area. Northern pike are also a species targeted in removal efforts and occur mainly in upstream Browns Park. Information gathered will be used to evaluate the relative benefit of flow and temperature regimes from Flaming Gorge Dam to native and endangered fishes in the Green River compared to effects on distribution and abundance of non-native fishes.

V. Study Schedule: Initial Year: 2002; Final Year: Not determined

VI. Relationship to RIPRAP:

Green River Action Plan: Mainstem.

II.D. Evaluate and revise as needed, flow regimes to benefit endangered fish populations.

VII. Accomplishment of FY 2018 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Task 1: Thermographs

We assisted with temperature data collection in Lodore and Whirlpool canyons by removing thermographs from the river in July and September¹, resetting new ones in their place, and establishing/checking new locations in both lower Lodore Canyon near the existing site, and in lower Mitten Park on river right in 2014²; that monitoring continues through 2018. Over the past decade, the thermal regime of the Green River upstream of the Yampa River has varied. The section experienced a relatively warm regime from 2002-2007 (2005 was cool) when water temperatures routinely exceeded 20°C at the Gates of Lodore, and exceeded 25°C in 2002-2003 and 2006-2007. Cool thermal regimes prevailed for much of the 2008-2011 period, when water temperatures exceeded 20°C for just a few days each summer (Figure 1). Water temperatures were warmer in 2012 and 2013 but cooler in 2014-2018, when mean daily water temperature only occasionally exceeded 20°C at the Gates of Lodore (gauge 404417108524900).

In 2016, Green River water temperatures at the Gates of Lodore were increasing in May consistent with warming air temperatures to maxima near 20°C, but during high flow releases (up to 9100 cfs) from late May until the end of June, declined to less than 12°C (Figure 1B-2016). Water temperatures did not exhibit the typical sag observed during 2016 releases in May and June 2017 (Figure 1B-2017), because water temperatures were already cold and flows were very high early in spring. Comparison of water temperatures from releases at Flaming Gorge Dam to the Gates of Lodore (Figure 1B & 1C) showed little warming downstream in those high flow periods. Water temperature recovered slightly downstream but only after high flows ceased. Highest water temperatures in

¹ Thermograph data will be provided by U.S. Fish and Wildlife Service, Lakewood, and by Utah State University, at up to 10 other localities in the Green River.

² That Mitten Park location is across the river from the long-term site, but was relocated downstream in July 2018 to a less sediment-prone area.

2017 were in late-July but daytime maxima exceeded 20°C for only a couple days. Water temperatures in 2018 more closely approximated those in 2016, with reduced temperatures during spring releases, but warmed to at or above 20°C in daytime for portions of the summer.

Water temperature differences between the cooler Green River and the warmer Yampa River were large in 2017 (Figure 2), particularly after the first Colorado pikeminnow larva was observed on 1 July. For example, in the period when Colorado pikeminnow larvae were present (1 July to 9 August), the Green River was 5°C cooler or more than the Yampa River on 22 days. Mean water temperature difference in that period was 5.7°C, with a maximum of 9.0°C. In 2018, in the period when Colorado pikeminnow larvae were present (20 June to 3 August), the Green River was cooler than the Yampa River by 5°C or more on 17 days. Mean water temperature difference in that period was 4.6°C, with a maximum of 5.7°C.

Task 2: Sample main channel fish community (large-bodied fishes).

We completed two electrofishing trips through the study area in 2018, as prescribed in the study proposal. We reported on data collected through 2006 in a summary report. Data entry and verification is complete for 2007-2016; 2018 data is preliminary but is included in this report. We are in the process of summarizing data for an updated synthesis report, which will include electrofishing data through 2018.

A total of 11 native species, 20 nonnative species, and several hybrids have been collected in the study area by all sampling gears in the period 2002-2018 (Table 1, Figures 3 and 4). White crappie is a relatively new species, collected with seines in Whirlpool Canyon in 2016. The most species are captured by electrofishing, followed by seining, and trammel netting. In 2018, the most abundant native species in the Lodore Canyon study area captured by electrofishing were native flannelmouth sucker (9.7 fish/hr captured) but formerly abundant bluehead sucker continues to decline in this reach (1.4 fish/hr); native fishes were only about 35% (52% in 2017, 54% in 2016, 61% in 2015) of all fishes captured. Bluehead sucker declines are consistent and long-term, a trend that should be followed in this and other populations. Mountain whitefish were more abundant than bluehead sucker in Lodore Canyon in 2017 and 2018, which is not typical. Brown trout, common carp, white sucker, channel catfish, and smallmouth bass, in descending order, were the most abundant nonnative fishes captured in the Lodore Canyon study area.

Native fishes were more abundant in downstream Whirlpool Canyon, where 51% (63% in 2017, 70% in 2016, 71% in 2015) of all fishes collected by electrofishing were native, which was substantially higher than in upstream Lodore Canyon. A main difference was higher abundance of bluehead sucker and lower abundance of brown trout in Whirlpool Canyon. Conversely, coolwater mountain whitefish was more abundant in Lodore Canyon than Whirlpool Canyon. Among nonnative fishes, coolwater brown trout were more abundant in upstream Lodore Canyon and warmwater smallmouth bass and channel

catfish were more abundant downstream in Whirlpool Canyon.

Abundance patterns of fishes in the study area that were captured in electrofishing samples beginning in 1994-1996 reflected a dynamic community for both nonnative and native fishes (Figures 3 and 4). For example, nonnative brown trout was abundant through time in Lodore Canyon and apparently increased in 2012, declined in abundance in 2013-2017 to relatively lower levels, but increased in 2018. Brown trout abundance increased slightly in Whirlpool Canyon in 2012-2014 but was uncommon in 2015-2018. Only in 2008 was that species abundant there due to large numbers captured near Jones Creek, a location sampled only sporadically because of presence of anglers and campers. Channel catfish reached a peak in abundance in both Lodore and Whirlpool canyons in the 2005-2008 period but have declined steadily since, although abundance in 2016 in both Lodore and Whirlpool Canyon reaches increased. Note the 1994-1996 abundance as the lowest in the period of record in Lodore Canyon. Common carp abundance appears to be declining in both reaches over time, especially in Whirlpool Canyon, even though 2015-2016 and 2018 abundance increased slightly in each reach. Northern pike abundance is low overall but highest in Lodore Canyon. The spike in 2016 abundance in Lodore Canyon was from only five individuals, but abundance further increased in 2017 to the second highest level ever (first was 2005-2007) and dropped slightly in 2018 (n = 6 captured). Northern pike abundance in Whirlpool Canyon is low and none were captured in 2013-2017 (one in 2018), likely a byproduct of high removal in the upstream Yampa River which reduces movement into downstream reaches. Browns Park pike removal efforts in 2011-2018 are discussed more extensively below.

Smallmouth bass abundance in Lodore and Whirlpool canyons showed slightly different patterns. In Whirlpool Canyon, bass abundance peaked in 2005-2007, and 2013, but have declined since that time to lower levels. That 2013 increase may be the result of warm water temperatures in 2012, leading to successful spawning that produced many age-1 fish in 2013. While earlier declines may reflect substantially increased removal effort beginning in 2007 and lack of high recruitment through 2011, bass respond positively to warmer temperatures in some years. Whirlpool Canyon bass abundance declines may be due to continued and intensive removal there. Smallmouth bass abundance in Lodore Canyon peaked in 2009 and 2010, declined through 2012, increased slightly in 2013 as for Whirlpool Canyon, and then continued lower through 2018, when only 5 smallmouth bass were captured in the reach (65 captured in Whirlpool Canyon). White sucker abundance increased in Lodore Canyon through 2009 but then declined through 2015, with a slight increase in 2016-2017. With the exception of 2008, white suckers in Whirlpool Canyon were relatively uncommon through 2018.

Native bluehead sucker are becoming uncommon in Lodore Canyon, were moderately abundant in Whirlpool Canyon, but in each reach abundance is declining. Even in Whirlpool Canyon, where abundance increased in 2013-2014, declines have been observed since. Colorado pikeminnow abundance has been variable and relatively low over the study period, increased in 2010 and 2012 in each reach, low overall in 2015, increased in 2016 (n = 6 fish), but only a single fish was captured in 2017 (Whirlpool). The finding of pikeminnow in upstream Vermillion Creek in 2011-2018 is discussed

below. Flannemouth sucker, the most common large-bodied native fish in the study area, has been declining over time in Lodore and Whirlpool canyons, even though in each reach its abundance increased in 2015 and 2016 to average or above average levels. Flannemouth sucker was most abundant in 2008 in Whirlpool Canyon. Mountain whitefish abundance increased rather dramatically in the study area in some years such as 2009-2010, 2012, and 2016-2018 but were uncommon before 2007 and from 2013-2015. Increased salmonid abundances in both reaches may be a response to cooler water temperatures.

Abundance of all chub species declined rather dramatically, especially since 2002-2004, patterns also reflected by trammel net sampling. Capture of a few chubs in 2013 electrofishing in Lodore Canyon increased abundance there temporarily, but 2014 abundance was reduced in both reaches, none were captured in either Lodore or Whirlpool Canyon reaches in 2015 or 2017, and only one was captured in each of 2016 and 2018, both in Whirlpool Canyon.

In 2018, we did not conduct a dedicated trammel net sampling trip because of looming budget issues that may have affected our ability to conduct work in October (FY 2019). Instead, we sampled with trammel nets during our late September electrofishing sampling trip at previously productive locations in Whirlpool Canyon. The 23.5 net hrs (one 75-ft long net fished for one hour is 1 net hr) sampled eddies and pools at the upstream end of Whirlpool Canyon and at Hail Camp, but captured only common carp (n = 1), white sucker (5), channel catfish (4), and flannemouth sucker (3); no chubs of any kind were captured. Water was clear and relatively high, although net locations were identical to those used in the past and higher captures of all species were expected.

Beginning in 2005, northern pike were detected nearly every year in Browns Park. Initially, only smaller pike were captured in seine samples taken in backwaters in July and September at Swinging Bridge near the Colorado-Utah state line. Their continued presence motivated additional floodplain sampling in an attempt to remove as many adults as possible. Thus, beginning in 2011 and continuing through 2018, we increased sampling effort for removal of northern pike in the Browns Park reach of the Green River. During the high flow year 2011 in May and June many large pike, some exceeding 900 mm TL (n=22, 11-39 inches, 271-984 mm) were captured and removed; all were from a relatively restricted river reach about 1-mile long. During that sampling, two adult Colorado pikeminnow *Ptychocheilus lucius* were captured, one by angling and another in a trap net. This was unusual because pikeminnow are thought rare in the 56-mile long reach between Flaming Gorge Dam and the upstream end of Lodore Canyon which includes the Swinging Bridge area. In 2012, we captured additional northern pike in the Browns Park reach during a relatively brief period of high flows. Interestingly, only three young-of-year were captured in summer and autumn, which was perhaps a function of the brief period of floodplain inundation. No young of year northern pike were captured in 2013 in Browns Park, again likely a result of relatively short-term floodplain inundation. This is in spite of capture of ripe northern pike in late May and early June, indicating reproduction was likely taking place. More details on pike abundance and spawning patterns were presented at the non-native fish workshop in

December 2013.

In 2014, continued backwater and floodplain habitat sampling occurred with trammel and fyke nets from 26 May to 20 June. A total of 12 adult northern pike was captured and ranged from 626-794 mm TL (1814-3657 g). Most were captured in Beaver Creek (n = 7), but northern pike were also captured at or near Hog Lake (n = 2) or in Vermillion Creek (n = 3). The Vermillion Creek pike were the first ones captured there in any sampling period. In spite of warm water temperatures earlier in the season, many pike were still in reproductive condition in late May to mid-June. Of the ten fish whose sex was determined, six were females.

We captured a total of 13 age-0 northern pike in 13 July 2014 seine sampling in Browns Park at the mouth of Beaver Creek, ranging in size from 44 to 61 mm TL. An additional seven age-0 northern pike were captured in seine sampling on 14 September at Beaver Creek (n = 6) and Hog Lake (n=1), ranging in size from 174 to 218 mm TL.

Northern pike sampling and removal in 2015 began on 12 May and continued through 9 June. Due to extensive habitat availability and high initial fish catch, sampling was focused primarily in the State Line and Beaver Creek reach; all other accessible backwaters and tributaries in the Refuge were sampled opportunistically during this period, however. Nine adult northern pike (289 – 776 mm, 260 – 2800 g) were captured. As in 2014, most were captured in Beaver Creek (n = 4), but the State Line backwater (n = 2), a backwater near Spitzie Bottom (n = 2), and Vermillion Creek (n = 1) produced pike. All adult northern pike were male. In addition to trammel netting for adults, intensive nighttime light-trapping for age-0 pike was conducted for the entire sampling period. As with trammel netting, effort focused on the State Line backwater to Beaver Creek reach, but some efforts were made in other backwaters.

Light trapping in 2015 produced one age-0 northern pike (30 mm TL) in Beaver Creek on 23 May. A single age-0 northern pike was collected in seine sampling in Browns Park on 19 July. This individual was 126 mm and was captured near the boat ramp at Crook Campground.

Sampling in 2016 in Browns Park National Wildlife Refuge occurred between 11 May and 18 June 2015. Sampling was carried out by a crew of two to six individuals. Trammel nets measuring 15 m x 2 m were the primary gear used for adult fish, with some supplementary angling. A total of 54 net sets were made, totaling 353.67 net hours. Two boat electrofishing passes were conducted; the first covered the left bank between river miles 380.3 (Swinging Bridge Boat Ramp) and 372.2 (Crook Campground Boat Ramp) and the second was conducted between river miles 372.2 and 366 and included the lower 400 meters of Vermillion Creek. Boat electrofishing effort totaled 3.44 hours. Light traps were deployed in backwaters at night to detect the presence of larval fish, northern pike being the primary target species. We focused light trap sampling efforts in the backwaters and main channel shoreline between the state line and the Swinging Bridge boat ramp. Up to five light traps were deployed most nights, and effort totaled 743.97 trap hours.

Sampling in 2017 in Browns Park National Wildlife Refuge occurred between 8 May and 15 June. Sampling was carried out by a crew of two to six individuals. Trammel nets measuring 15 m x 2 m were the primary gear used for adult fish, with some supplementary angling. A total of 49 net sets were made, totaling 381.43 net hours. Light traps were deployed in backwaters at night to detect the presence of larval fish, northern pike being the primary target species. We focused light trap sampling efforts in the backwaters and main channel shoreline between the state line and the Swinging Bridge boat ramp. Up to five light traps were deployed most nights, and effort totaled 953 trap hours.

During the 2017 study, 199 individual adult fish were captured, down considerably from the 864 in 2016 (Appendix I). Of these, 34 were native species, with most of the remainder being nonnative suckers (white sucker) or hybrids and salmonids, and all were released alive. Light traps yielded a total of 3 fish; all were YOY northern pike and were preserved and identified in the lab.

Additionally, prolonged inundation of vegetated backwaters, tributaries, and channel margin habitat, locations suitable for reproduction of northern pike, likely contributed to more extensive reproduction of that species than has been documented in previous years. Seine sampling in the mouth of Beaver Creek and other Browns Park locations (Hog Lake, Crook Campground) on 16 July 2017 yielded the highest documented numbers of young-of-year northern pike (31 total) since young-of-year fish sampling in the Refuge began in 2002 (Figure 5). Additional YOY northern pike were captured at Beaver Creek in September. The YOY fish varied widely in length and represent several spawning bouts over the extended high flow season. We plan to age those fish using otolith daily increments to understand better the duration of the spawning season.

In 2018, sampling was carried out by a crew of two to seven individuals. Trammel nets measuring 15 m x 2 m were the primary gear used for adult fish, with some seine sampling and supplementary angling. A total of 39 trammel net sets were made, totaling 247 net hours. Light traps were deployed in backwaters at night to detect the presence of larval fish, northern pike being the primary target species. We focused light trap sampling efforts in the backwaters and main channel shoreline between the state line and the Swinging Bridge boat ramp. Up to five light traps were deployed on most nights, and effort totaled 455 trap hours.

During 2018 sampling, 159 individual adult fish were captured by trammel nets (Appendix I). Of these, 17 were native species, hybrids of native species, salmonids, or unidentified, and all were released alive. The remaining 142 individuals were nonnative species, mostly white suckers or their hybrids, and were euthanized. Colorado pikeminnow were captured only in Vermillion Creek. Light traps yielded no young-of-year northern pike.

The hydrology in the Green River below Flaming Gorge Dam during May and June of 2018 was relatively low. Peak flow was the second lowest in the previous eight years of

record, at 6,400 cubic feet per second (cfs), achieved on 29 May. Only 14 days of flows above 3,000 cfs were reached, making 2018 hydrology similar to that of 2012 and 2013, both notably low flow years (2013 with a peak of 5,450 cfs and 12 days above 3,000 cfs, and 2012 with a peak of 7,920 cfs and 12 days above 3,000 cfs).

The total fish capture for 2018 is unusually low. We hypothesize this is a latent effect of the record high flows from Flaming Gorge in 2017. The 130 days of flow above 8,600 cfs in 2017 may have prompted dispersal of adult fish resident to the Browns Park reach of the Green River. It is also possible that those flows decreased the suitability of the habitat in the reach by another mechanism. We were also surprised by the low abundance of northern pike captured in samples in 2018, after finding age-0 pike in high numbers in 2017. It may be that those now age-1 pike were not yet susceptible to our capture techniques although some of those fish were captured in downstream reaches.

The discovery of Colorado pikeminnow upstream near Swinging Bridge in spring 2011 motivated additional Green River sampling in Browns Park National Wildlife Refuge on 21-22 June via boat electrofishing. Two crews sampled from Swinging Bridge downstream 14 miles to Vermillion Creek, a tributary to the Green River a short distance upstream of the boundary of Dinosaur National Monument. High flows benefitted sampling efforts because of increased access to productive habitats. One adult pikeminnow was captured in the Green River near Crook Campground. High Green River flows also allowed access to the lower end of Vermillion Creek, where an additional 8 adult pikeminnow (23-27 inches, 595-692 mm total length,) were captured; at least three more were observed but not captured. In all, only five pikeminnow had been previously tagged and two of those were tags with number series that have not been used for many years, which may indicate that those fish reside in that section of the Green River for substantial periods of the year. Vermillion Creek, a relatively small, turbid, and low flow system, was relatively warm at 72°F (22°C) compared to the Green River (48°F, 9°C); during these captures several individual pikeminnow were tuberculate (nearing reproductive readiness) likely because of the warm water. High reproductive condition for pikeminnow was not expected because of high, late, and cold flows and because pikeminnow in the downstream Yampa River did not spawn until late July in 2011. Very high densities of suckers, both native flannelmouth sucker *Catostomus latipinnis*, non-native white sucker *Catostomus commersonii*, and their hybrids, were also captured. Findings also supported the importance of floodplain wetlands and flooded tributary mouths for enhancing condition of endangered fishes like Colorado pikeminnow. In spring 2012, we captured three additional pikeminnow at or in the mouth of Vermillion Creek, in spite of relatively low effort. Consecutive years of capture at that location suggest that the mouth of Vermillion Creek may be a concentration area for pikeminnow in spring.

In spring 2014, we captured six Colorado pikeminnow in or at the mouth of Vermillion Creek in fyke nets; an additional pikeminnow was captured at Beaver Creek. Captures were from 28 May to 11 June and each fish was captured only once. Colorado pikeminnow ranged in length from 502 – 756 mm TL (1162-4309 g) and six of the seven were previously tagged; one was tagged for the first time. One of those individuals that

we captured (8 June) was also detected by a PIT tag detection array set in Vermillion Creek a few days earlier (4 June)³. Two additional individuals were also detected by arrays, but we did not capture those fish. Thus, a total of nine Colorado pikeminnow adults was encountered in 2014 between 1-16 June and eight were from Vermillion Creek.

On 3 June, flows increased from Flaming Gorge Dam to 4,350 cfs, peaked on 7 June at 9,090 cfs and by 18 June flows were declining to or were below Flaming Gorge Dam maximum powerplant flows of 4,650 cfs or less. One pikeminnow was detected in the mouth of Vermillion Creek on 28 May at low base flows of 872 cfs. All pikeminnow except the first one were captured in or near Vermillion Creek during high flows (2-18 June) when the mouth of Vermillion Creek was inundated, and the Green River was cold (about 10°C). Vermillion Creek was warm and > 20°C for most of that high flow period.

In 2015, 17 individual Colorado pikeminnow (483–713 mm, 1300–3650 g) were captured in Browns Park. Of these, 12 were captured in Vermillion Creek within 100 m of the mouth over a span of five days (4 – 8 June). Four of the Vermillion Creek individuals were captured twice or more during this time. The remaining five Colorado pikeminnow were captured throughout the Refuge at State Line backwater (n = 1), Beaver Creek (n = 2), near Spitzie Bottom (n = 1), and in a backwater above Crook Campground (n = 1). Only three individuals were not tagged; these were given new PIT tags at capture. With the exception of one individual angled at Beaver Creek, all were captured with trammel nets. The Vermillion Creek individuals were captured after high-volume releases from Flaming Gorge had concluded, and water temperatures at the time of capture ranged from 13.9 to 24.4°C. Daytime main channel temperatures were not taken during this time but just downstream, minimum and maximum daily water temperatures were cooler at about 13-17C (Figure 1b).

Two electrofishing trips were conducted through Browns Park in June to access backwaters and other habitats otherwise inaccessible for trammel netting. On 3 June, sampling was conducted with a raft-based Smith Root GPP electrofisher between the Swinging Bridge and Crook Campground boat ramps (river miles 380.4 to 372.2) and focused on backwaters and vegetated shoreline on the left bank. Sampling for this trip totaled 9177 seconds. On 18 June, sampling was conducted from the Crook Campground boat ramp to just below Vermillion Creek (river miles 372.2 to 366.1), focusing on backwaters and vegetated shoreline on both banks and on the lower 400 meters of Vermillion Creek. Sampling totaled 1398 seconds above Vermillion Creek, 1446 seconds in Vermillion Creek, and 368 seconds below.

In 2016, all 10 Colorado pikeminnow captured with electrofishing and trammel nets were captured in the lower 400 meters of Vermillion Creek during higher flow releases from Flaming Gorge Dam; one of these individuals was captured twice. During trammel netting in Vermillion Creek, water temperatures were between 17.0 and 20.9 degrees Celsius. Main channel Green River water temperatures were not taken on those days, but

³ both a flat plate and a submersible antenna was deployed in the mouth of Vermillion Creek on 3 June (A. Webber, U.S. Fish and Wildlife Service, Vernal, Utah)

were measured between 8.1 and 9.9 degrees Celsius during June sampling; the 2017 water temperatures differences in Vermillion Creek and the mainstem Green River are shown as an example (Figure 6). Two PIT tag antennas were deployed in lower Vermillion Creek to learn more about use of the tributary by Colorado pikeminnow and other tagged species of interest in the river. A total of 62 detections were made by the antennas, comprising 24 individuals. Of these fish, 20 were known Colorado pikeminnow and one was a known flannelmouth sucker. The species of the remaining three individuals are currently unknown. Five of the pikeminnow captured in Vermillion Creek (four by trammel nets and one by boat electrofishing) were also detected by the PIT tag antennas between 27 May and 17 June. Individuals detected by the PIT tag antennas were detected between 1 and 9 times, with a mean detection frequency of 2.7 times.

In 2017, we set two wagonwheel-type PIT tag detectors in Vermillion Creek, one near the mouth and the other upstream near the creek inflow to the large backwater formed by high flows from the Green River. The results were surprising, as we documented over 28,000 hits from PIT tags on the two detectors, with nearly 75% of those from a single fish. The biggest surprise was presence of 74 individual Colorado pikeminnow documented in the spring period in Vermillion Creek. Additional fish detected included 10 flannelmouth suckers and one flannelmouth x bluehead sucker hybrid.

Some of the Colorado pikeminnow were detected within a month later either at or near the Colorado pikeminnow spawning area in lower Yampa Canyon, and at least three were detected by PIT antennas in downstream Tusher diversion. A total of 10 PIT tags were unidentifiable either because they were never recorded or are not in any available database.

Also notably absent were any fishes that may have been derived from Flaming Gorge Reservoir. Opportunities for escapement were likely higher in 2017 than in the past due to high and extended releases throughout the spring and early summer. Kokanee salmon, burbot, Utah chub, and lake trout are among the taxa that might be expected escaping from Flaming Gorge Dam, each of which has been detected in past sampling either in this study or other locations downstream.

A total of five Colorado pikeminnow were captured in Vermillion Creek in 2018 with trammel nets, and all on 2 June. Relatively brief and low flows, especially compared to 2017, may have restricted use of lower Vermillion Creek in 2018 (Figure 1). The same two wagonwheel-type PIT tag detectors were placed in the same locations as 2017 in Vermillion Creek on 16 May 2018 to learn more about use of the tributary by Colorado pikeminnow and other tagged fishes in the river. They remained in place until 14 June and were operational and detecting tags through at least 6 June. The two antennas logged 589 encounters from 13 individual fish. Nine of those were Colorado pikeminnow, and included three of the five fish captured by trammel nets, so a total of 11 individual pikeminnow were noted in 2018. Colorado pikeminnow detections were from 16 May to 6 June. Three flannelmouth suckers were also detected, and one detected tag remains unidentified. With the exception of one flannelmouth sucker, all fish detected in

Vermillion Creek in 2018 were detected there in 2017. Three of the Colorado pikeminnow and the one unidentified fish were detected in the Yampa River with antennas between 4 June and 23 June following their last detection in Vermillion Creek.

Task 3: Sample small-bodied fish community.

Nearly 200 seine samples were collected in the study area from middle Browns Park downstream to the lower end of Rainbow Park during summer and autumn 2018. We have begun identification of summer and autumn samples. We will update seine capture data in the synthesis report when fish in samples are identified and cataloged.

An additional task in this scope of work was to analyze otoliths from age-0 smallmouth bass captured in the Green River study area. This work will assist with understanding smallmouth bass spawning periodicity to assist with disruption of reproduction of that species via flow releases from Flaming Gorge Dam. Studies in other parts of the range of smallmouth bass have shown that weather-related water temperature reductions or floods reduce their spawning success and number of offspring (See references in Bestgen and Hill 2016, smallmouth bass report). Reduced water temperatures often result in abandonment of spawning nests by the guarding male bass, after which developing eggs and just-hatched young are susceptible to predation and other mortality factors. Sampling in the Green River and other areas has shown that higher stream flow, often coupled with increased water turbidity, sweeps weak-swimming young bass away from nests or quiet near-shore habitat, and results in high mortality.

Portions of this work were reported at the January 2010-2018 Researchers Meetings. We found that smallmouth bass in the Green River-Lodore Canyon study area first hatched well after spring peak releases declined and just slightly after (usually within one week) mean daily water temperatures regularly exceeded 16°C in the period 2003-2012 (Figure 7, note axis change for 2011 to accommodate the late spawning initiation). Hatching date distributions were very similar in 2008 and 2009, reflecting the similar flow and temperature regimes in those years. Hatching date and the extent of the reproductive season was much shorter in 2011 when high flows were relatively cool, and hatching did not begin in 2011 until after bass had *finished* hatching in nearly every other year. The 2012 water temperatures suggest a relatively late initiation of hatching as well, and that is supported by capture of very few and relatively small bass in Lodore Canyon in a late-July sampling trip.

We have submitted and obtained approval of a report that synthesizes smallmouth bass hatching date distribution and growth data (Bestgen and Hill 2016). We also prepared a study plan to use flow spikes to disrupt smallmouth bass spawning success downstream of Flaming Gorge Dam. That study plan was completed and approved by the Biology Committee in early November 2018. That report has been finalized and submitted to the Recovery Program. Elements of the report will be used to develop an evaluation of success of flow and water temperature recommendations to bolster native fish populations in the Green River.

Drift net sampling documented high downstream displacement of small-bodied smallmouth bass during high turbidity and flow events in 2004 and 2007. Such flow and turbidity events may have been responsible for low abundance of smallmouth bass < 100 mm TL in summer 2004, and subsequent low number of Age-1 smallmouth bass in 2005 (data in RIP annual reports; Badame et al. synthesis report; discussion in Bestgen et al. 2006; 2007; Bestgen and Hill 2016). Unfortunately, high flows in 2011 prevented sampling of the Green River because sampling crews were unable to cross the very high Yampa River to reach the Green; drift sampling in 2012 and 2014-2018 was completed for portions of the summer but few smallmouth bass were captured.

Task 4: Sample larval drift and process samples.

We collected 117 Green River drift net samples from 26 June to 9 August in 2018. A total of 192 young fish were captured, including four smallmouth bass (14-17 mm TL) and one northern pike (139 mm TL).

Task 5: Identify, count and measure preserved samples of small-bodied fish (seine hauls).

We have completed identification of 2017 samples and are progressing with 2018 samples.

Task 6: Prepare and submit annual report.

This report. Need to finalize the summary report for the synthesis of data available since the inception of this study.

- VIII. Additional noteworthy observations: Continued use by Colorado pikeminnow of lower Vermillion Creek. The low abundance of northern pike was somewhat surprising in 2018 given high abundance of young northern pike following high and extended 2017 flows in the Browns Park reach of the Green River, and downstream.
- IX. Recommendations: Continue with sampling in 2019. Implement findings of the smallmouth bass synthesis report and recommendations in the study plan to disadvantage smallmouth bass using flow spikes in the Green River.
- X. Project Status: On Track and Ongoing.
- XI. FY 2018 Budget Status
 - A. Funds Provided: \$139,091
 - B. Funds Expended: \$101,668
 - C. Difference: \$37,423, will be used to complete sample work and analyses, participate in the Green River flow evaluation team. Funding was also included to begin a flow spike investigation per the study plan, but since that work was not planned we did not spend the funding.
 - D. Percent of the FY 2018 work completed about 70%, no additional funds needed.

- E. Recovery Program funds spent for publication charges:
- XII. Status of Data Submission: endangered fish data submitted
- XIII. Signed:

Kevin R. Bestgen	12 November 2018
Principal Investigator	Date

Table 1.—List of fishes captured in the Green River, from Browns Park downstream to Rainbow Park with electrofishing, trammel nets, and seining, 2002-2018. White crappie is new to the list beginning in 2016. N = native, I = introduced.

Species	Status	Electrofishing	Trammel netting	Seining
Mountain whitefish	N	X		X
Humpback chub	N	X	X	
Bonytail	N	X	X	X
Roundtail chub	N	X	X	X
Colorado pikeminnow	N	X	X	X
Speckled dace	N	X		X
Bluehead sucker	N	X	X	X
Flannelmouth sucker	N	X	X	X
Razorback sucker	N	X		
Mountain sucker	N			X
Mottled sculpin	N	X		X
Cutthroat trout	I	X		
Brook trout	I	X		
Rainbow trout	I	X		X
Brown trout	I	X	X	
Northern pike	I	X		X
Red shiner	I	X		X
Common carp	I	X	X	X
Creek chub	I			X
Fathead minnow	I			X
Sand shiner	I			X
Redside shiner	I	X		X
White sucker	I	X	X	X
WS x FM		X	X	
FM x BH		X		
WS x BH		X		
RZB x FM		X		X
Channel catfish	I	X	X	X
Black bullhead	I	X		X
Bluegill	I	X		X
Green sunfish	I	X		X
Smallmouth bass	I	X	X	X
White crappie	I			X
Walleye	I	X		
Iowa darter	I			X

Table 2. Number of fish of selected species captured by sampling trip (July and September) in the Lodore (LD) and Whirlpool Canyon (WH) reaches of the Green River, 2016 (upper table) and 2017 (lower table), and 2018 (page below).

2016

Species	July LD	July WH	Sept LD	Sept WH	July Total	Sept Total	LD Total	WH Total	Grand Total
flannelmouth sucker	307	116	200	163	423	363	507	279	786
bluehead sucker	99	125	51	75	224	126	150	200	350
brown trout	163	0	179	3	163	182	342	3	345
channel catfish	74	83	67	62	157	129	141	145	286
mountain whitefish	71	8	137	32	79	169	208	40	248
white sucker	40	3	40	5	43	45	80	8	88
common carp	35	7	27	15	42	42	62	22	84
flannelmouth x white sucker	24	0	37	4	24	41	61	4	65
smallmouth bass	14	18	13	6	32	19	27	24	51
mottled sculpin	6	2	7	3	8	10	13	5	18
rainbow trout	5	3	5	3	8	8	10	6	16
bluehead x white sucker	2	2	5	3	4	8	7	5	12
Colorado pikeminnow	3	0	2	1	3	3	5	1	6
northern pike	3	0	2	0	3	2	5	0	5
flannelmouth x bluehead sucker	0	2	2	0	2	2	2	2	4
reidside shiner	0	0	3	0	0	3	3	0	3
red shiner	0	2	0	0	2	0	0	2	2
flannelmouth x razorback sucker	0	1	0	0	1	0	0	1	1
razorback sucker	0	0	0	1	0	1	0	1	1
roundtail chub	0	0	0	1	0	1	0	1	1
speckled dace	1	0	0	0	1	0	1	0	1
walleye	1	0	0	0	1	0	1	0	1
Totals	848	372	777	377	1220	1154	1625	749	2374

2017

Species	July LD	July WH	Sept LD	Sept WH	July Total	Sept Total	LD Total	WH Total	Grand Total
flannelmouth sucker	214	49	146	147	263	293	360	196	556
brown trout	68	12	150	19	80	169	218	31	249
mountain whitefish	6	2	86	53	8	139	92	55	147
bluehead sucker	23	48	12	60	71	72	35	108	143
white sucker	33	18	66	20	51	86	99	38	137
channel catfish	24	53	22	25	77	47	46	78	124
common carp	19	7	26	4	26	30	45	11	56
smallmouth bass	3	22	7	1	25	8	10	23	33
flannelmouth x white sucker	16	2	10	3	18	13	26	5	31
rainbow trout	1	11	0	19	12	19	1	30	31
mottled sculpin	10	6	5	9	16	14	15	15	30
northern pike	2	0	8	0	2	8	10	0	10
bluehead x white sucker	3	0	3	2	3	5	6	2	8
speckled dace	0	1	0	2	1	2	0	3	3
creek chub	0	0	2	0	0	2	2	0	2
flannelmouth x bluehead sucker	0	1	1	0	1	1	1	1	2
reidside shiner	0	0	2	0	0	2	2	0	2
Colorado pikeminnow	0	0	1	0	0	1	1	0	1
walleye	0	0	0	1	0	1	0	1	1
flannelmouth x razorback sucker	0	0	0	0	0	0	0	0	0
razorback sucker	0	0	0	0	0	0	0	0	0
red shiner	0	0	0	0	0	0	0	0	0
roundtail chub	0	0	0	0	0	0	0	0	0
Totals	422	232	547	365	654	912	969	597	1566

2018

Species	July LD	July WH	Sept LD	Sept WH	July total	Sept total	LD total	WH total	Grand total
brown trout	247	17	396	21	264	417	643	38	681
flannelmouth sucker	131	116	77	26	247	103	208	142	350
mountain whitefish	53	11	156	41	64	197	209	52	261
bluehead sucker	27	135	14	27	162	41	41	162	203
white sucker	47	58	51	16	105	67	98	74	172
channel catfish	16	80	19	16	96	35	35	96	131
common carp	86	15	15	2	101	17	101	17	118
smallmouth bass	4	51	1	14	55	15	5	65	70
rainbow trout	3	36	8	21	39	29	11	57	68
mottled sculpin	7	12	17	13	19	30	24	25	49
white sucker x flannelmouth sucker	6	5	7	0	11	7	13	5	18
green sunfish	3	9			12		3	9	12
northern pike	3	1	3		4	3	6	1	7
white sucker x bluehead sucker	1	3			4		1	3	4
speckled dace	2	1			3		2	1	3
Colorado pikeminnow	1	1			2		1	1	2
cutthroat trout		1			1			1	1
walleye	1			1	1	1	1	1	2
black bullhead				1		1		1	1
bluehead sucker x flannelmouth sucker			1			1	1		1
roundtail chub		1			1			1	1
total	638	553	765	199	1191	964	1403	752	2155

A.

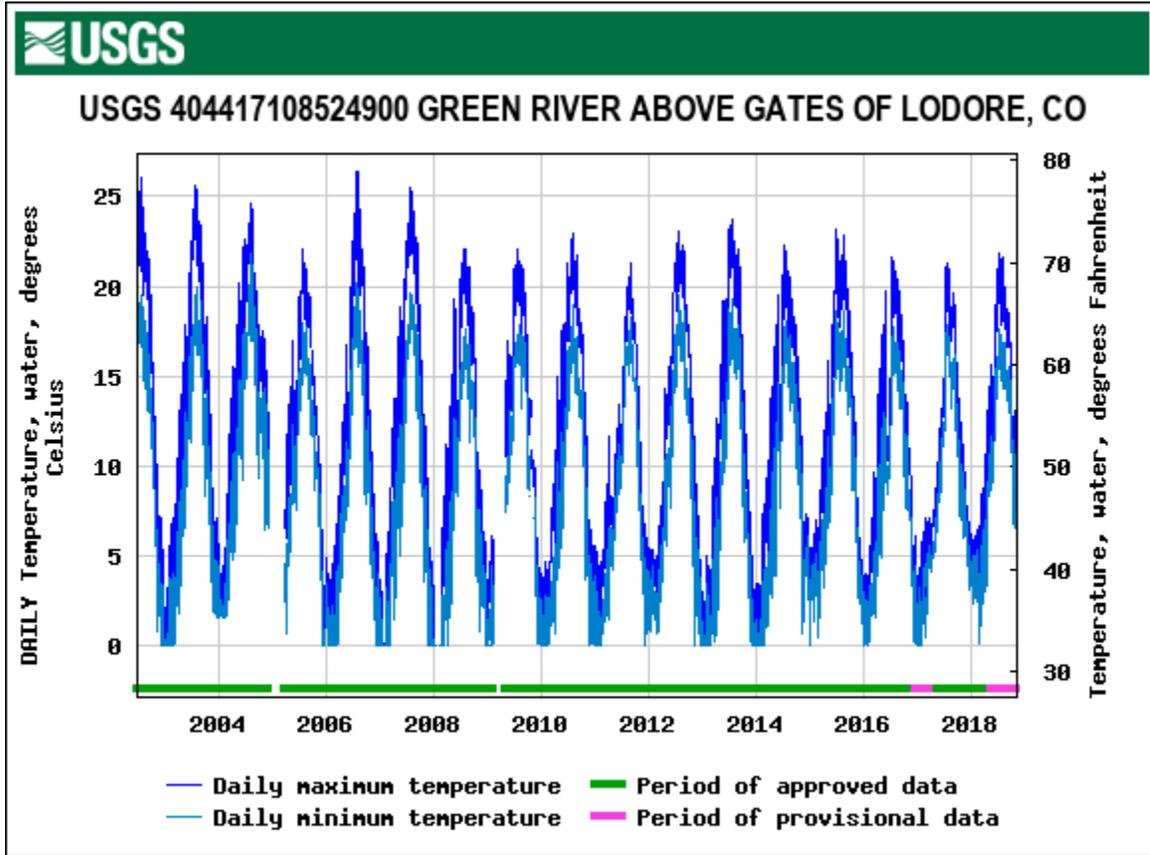
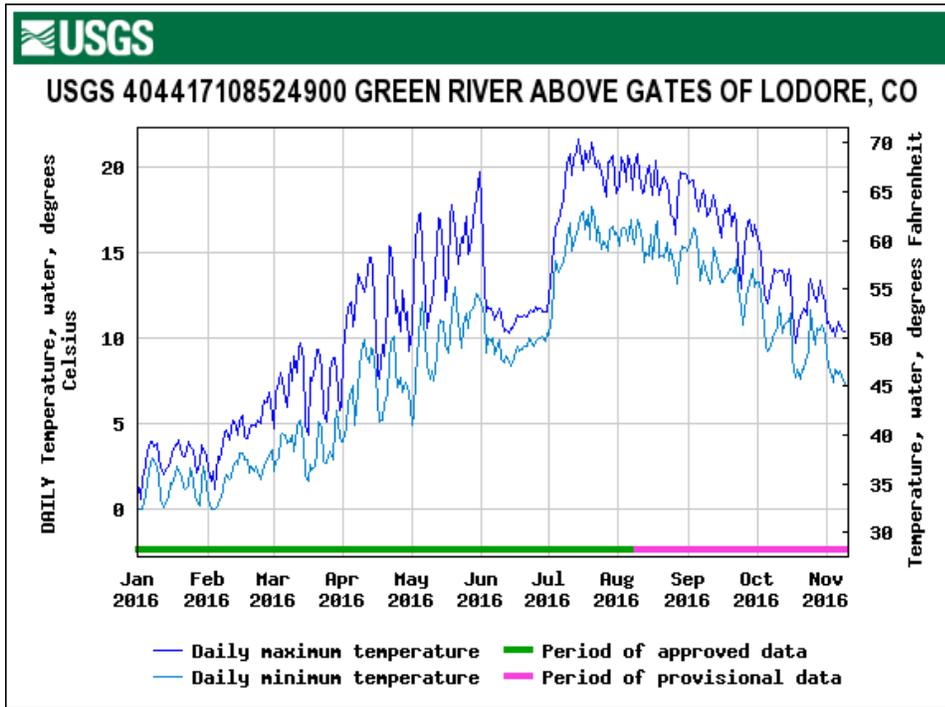


Figure 1 in part, described below

B-2016.



B-2017.

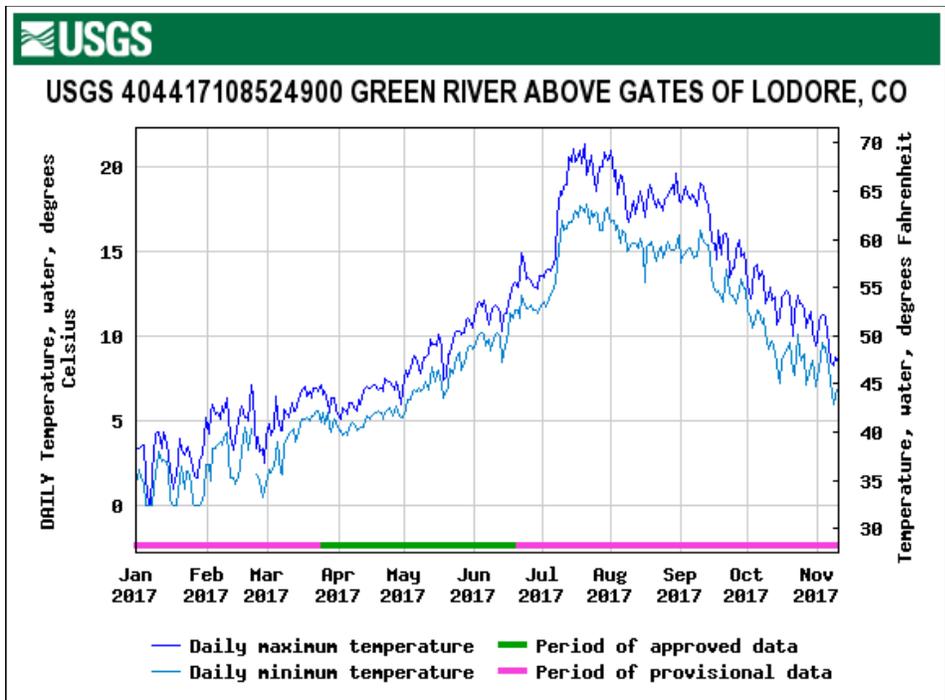


Figure 1 in part, described below

B-2018.

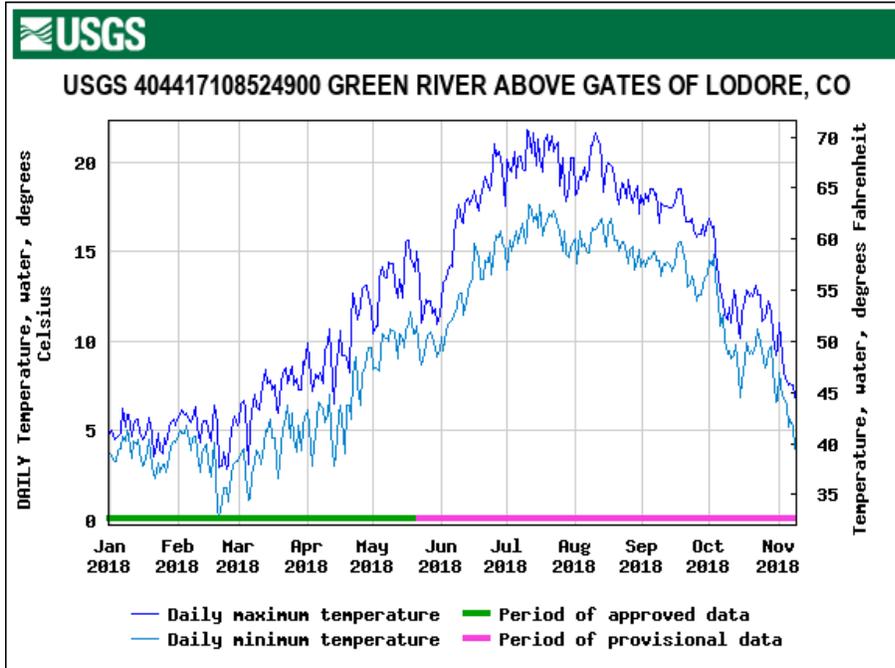
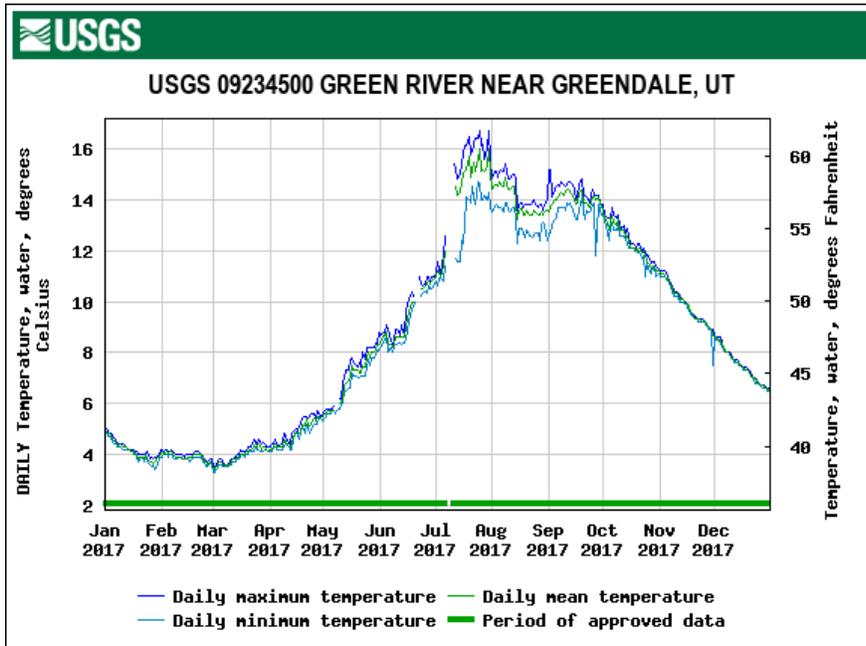


Figure 1 in part, described below

C-2017.



C-2018.

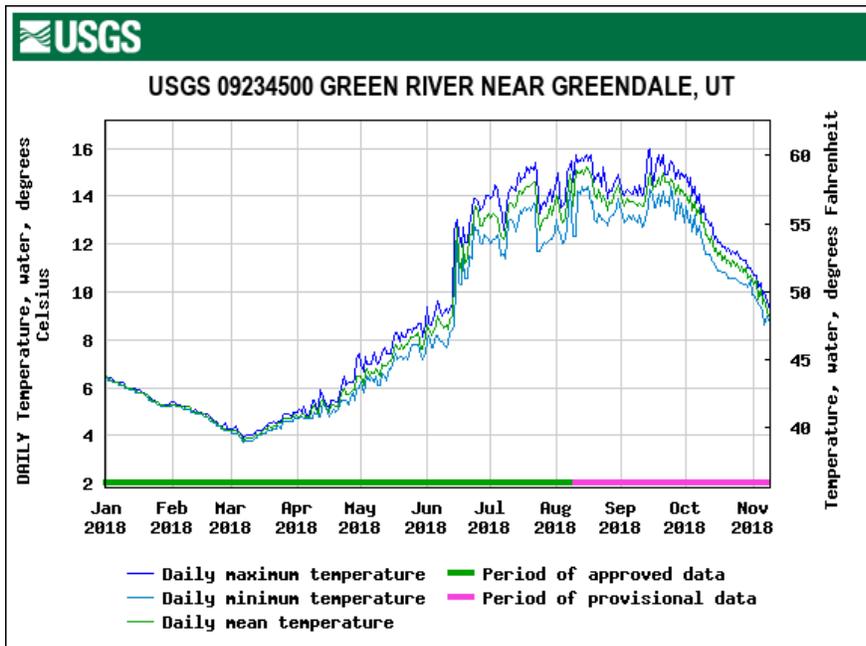
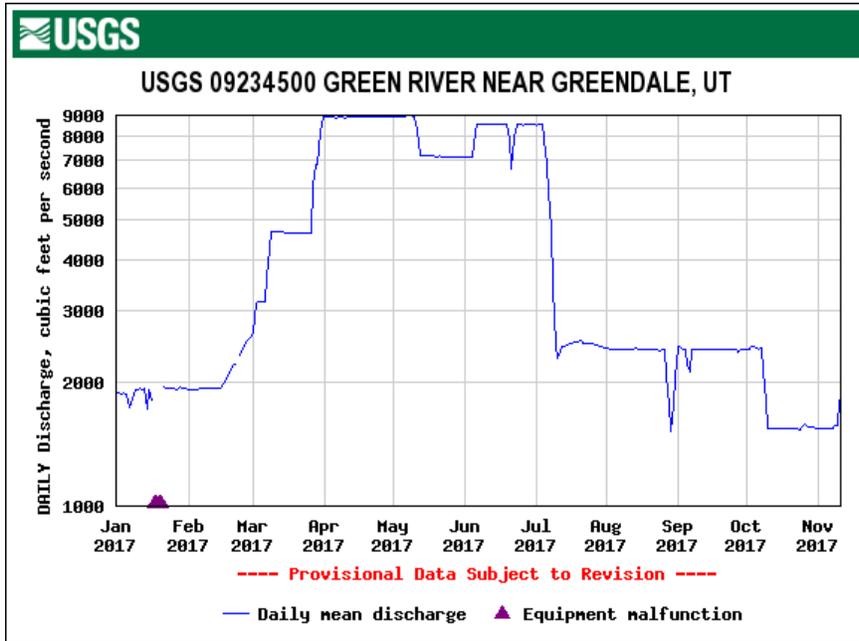


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D-2017.



D-2018.

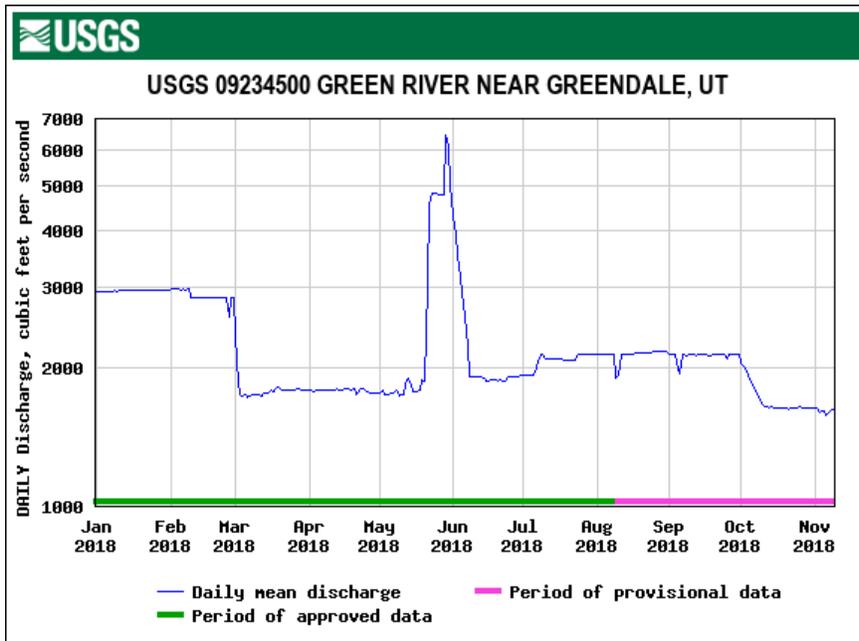
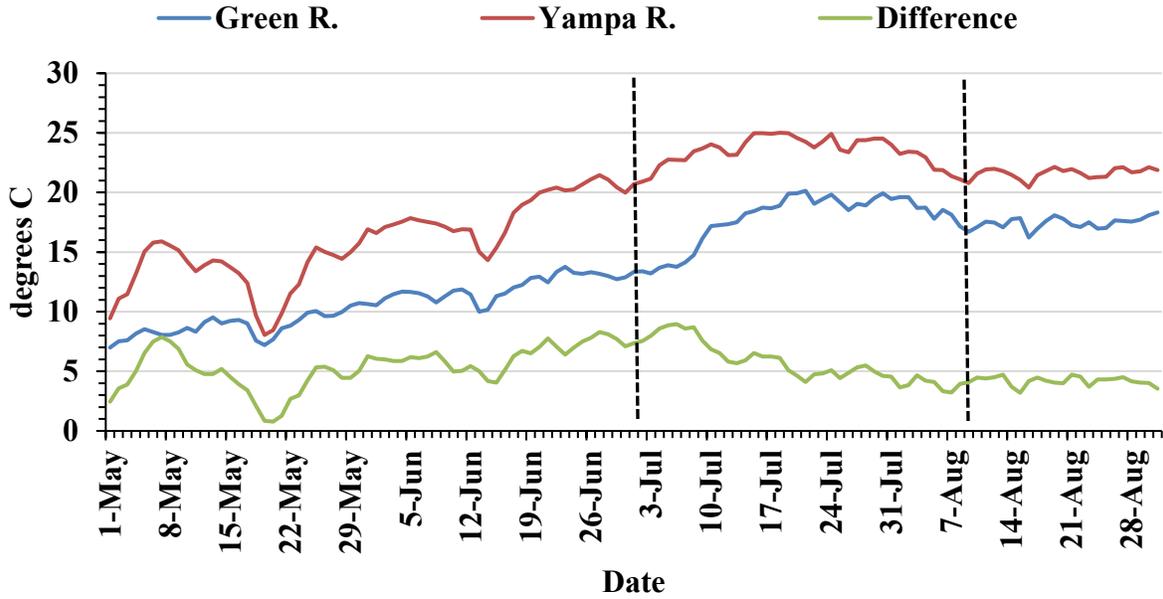


Figure 1. Green River water temperatures at the Gates of Lodore, near the Dinosaur National Monument campground, June 2002- November 2018 (Panel A, preceding pages) and 2016-2018 (panels B-2016, B-2017, and B-2018 preceding pages). Panels C-2017 and C-2018 and D-2017 and D-2018 represent 2017 and 2018 mean daily water temperature and flow, respectively, at the Greendale gauge just downstream of Flaming Gorge Dam.

Green R.-Yampa R. water temperatures, 2017



Green R.-Yampa R. water temperatures, 2018

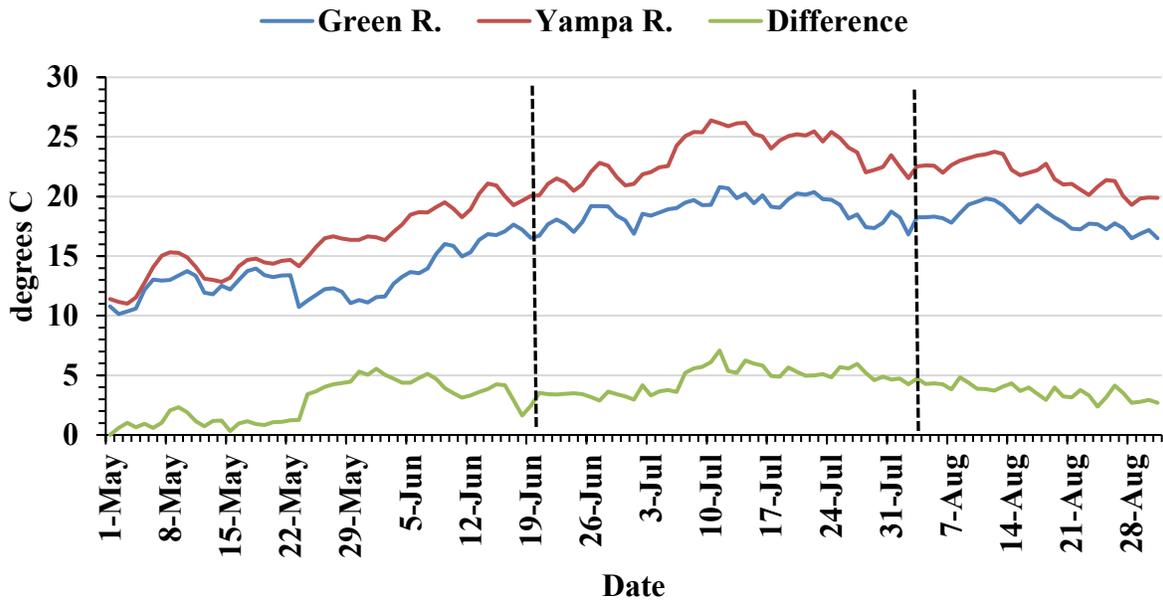


Figure 2. Water temperature differences between the Green River (USFWS gage just upstream of the Yampa River in Echo Park) and the Yampa River (USFWS just upstream of the Green River in Echo Park), late spring and summer 2017 and 2018. Data were from the Upper Colorado River Endangered Fish Recovery Program website. The dashed lines represent the period of first to last presence of Colorado pikeminnow larvae in the lower Yampa River (Project 22f annual report).

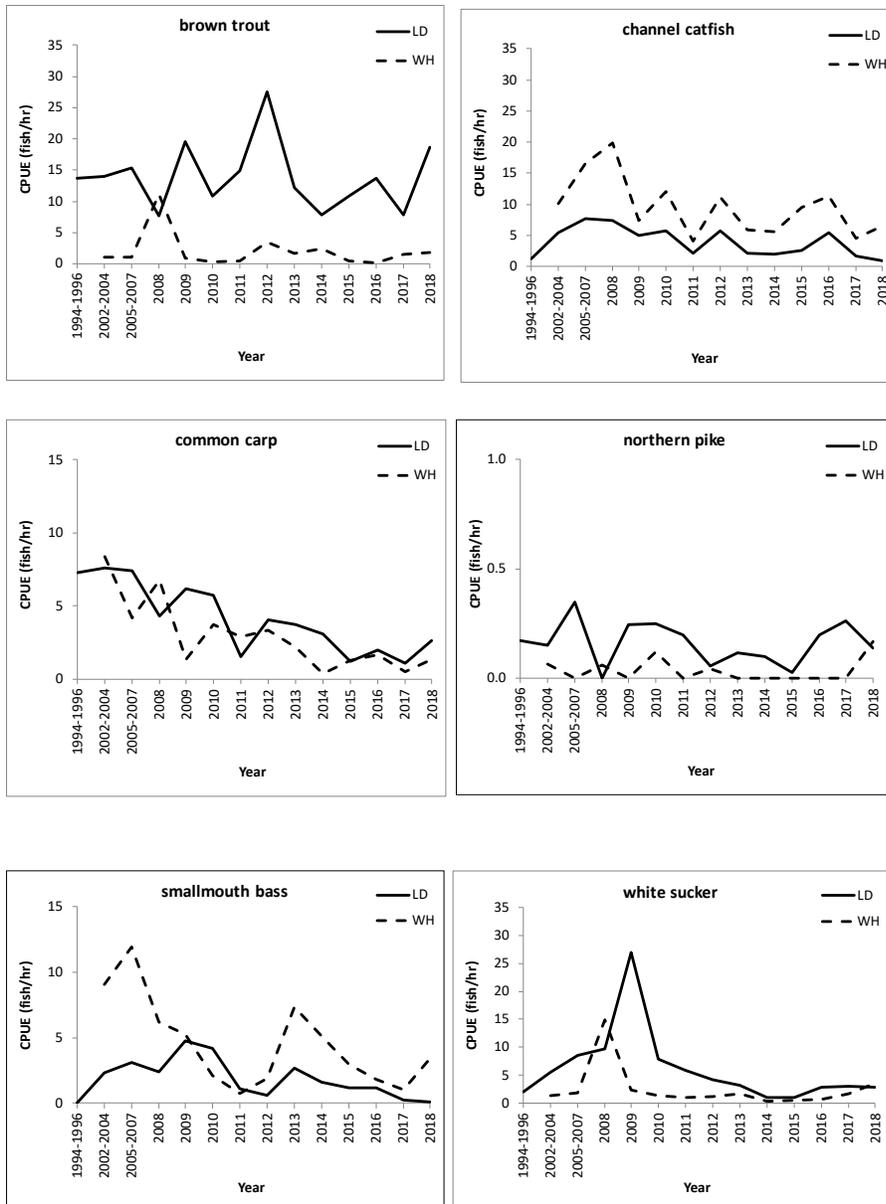


Figure 3.—Number of brown trout, channel catfish, common carp, northern pike, smallmouth bass, and white sucker captured per hour of raft electrofishing effort in four reaches of Lodore Canyon and two reaches of Whirlpool Canyon, Green River, Colorado and Utah, in from 1994-2018. LD is Lodore Canyon and WH is Whirlpool Canyon.

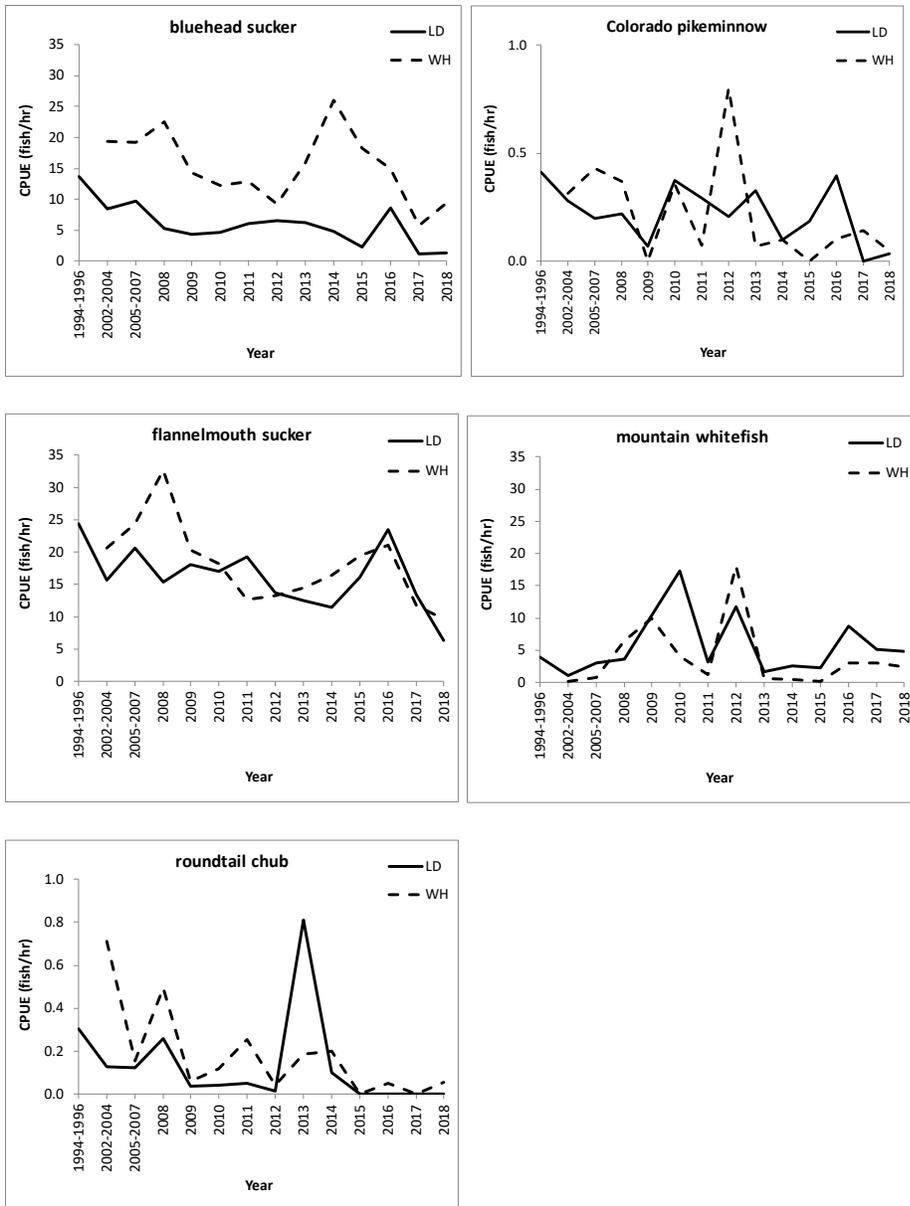


Figure 4.—Number of bluehead sucker, Colorado pikeminnow, flannelmouth sucker, mountain whitefish, and roundtail chub captured per hour of raft electrofishing effort in four reaches of Lodore Canyon and two reaches of Whirlpool Canyon, Green River, Colorado and Utah, from 1994-2018. LD is Lodore Canyon and WH is Whirlpool Canyon.



Figure 5. Photograph showing young-of-year northern pike from several spawning events captured in Beaver Creek, summer 2017, following an extended high flow from Flaming Gorge Dam in spring and summer.

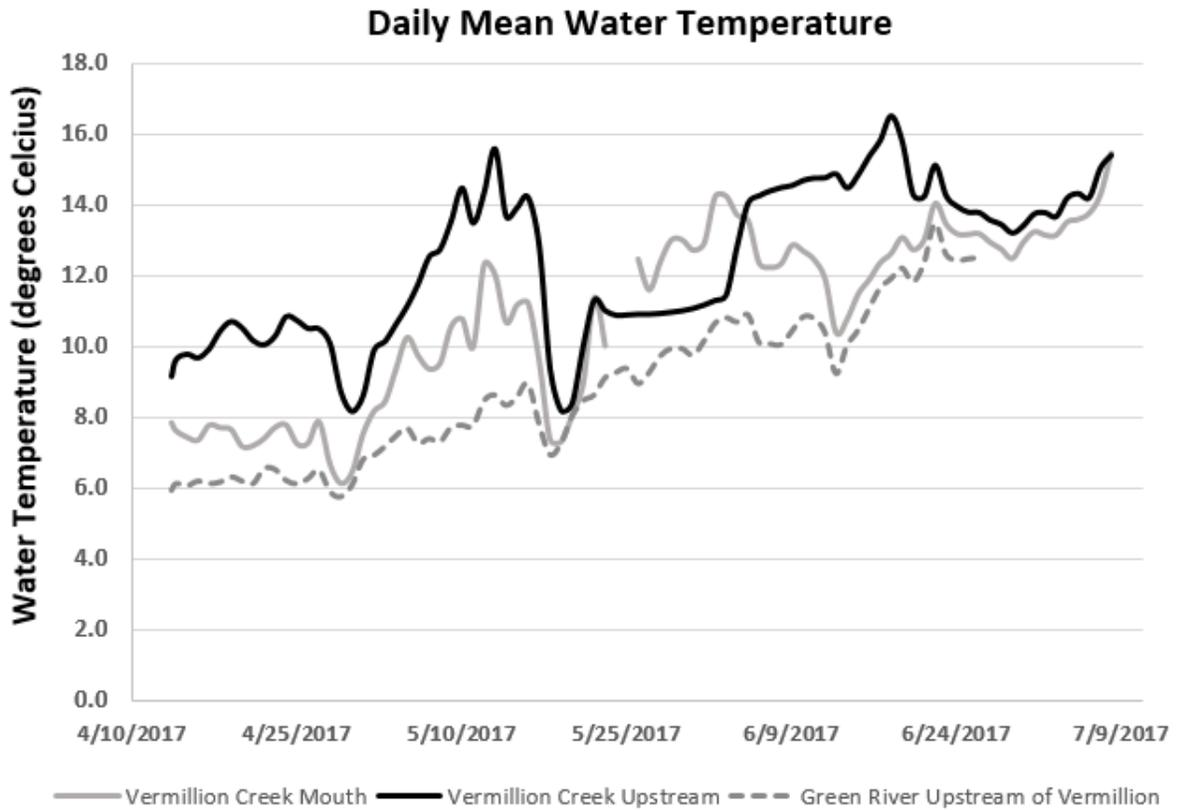


Figure 6. Water temperature differences in upstream and downstream Vermillion Creek and the adjacent main stem Green River in spring and summer 2017.

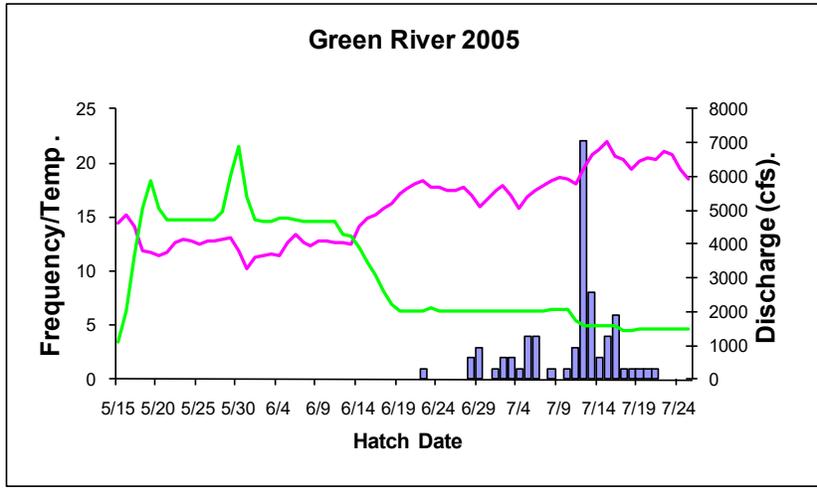
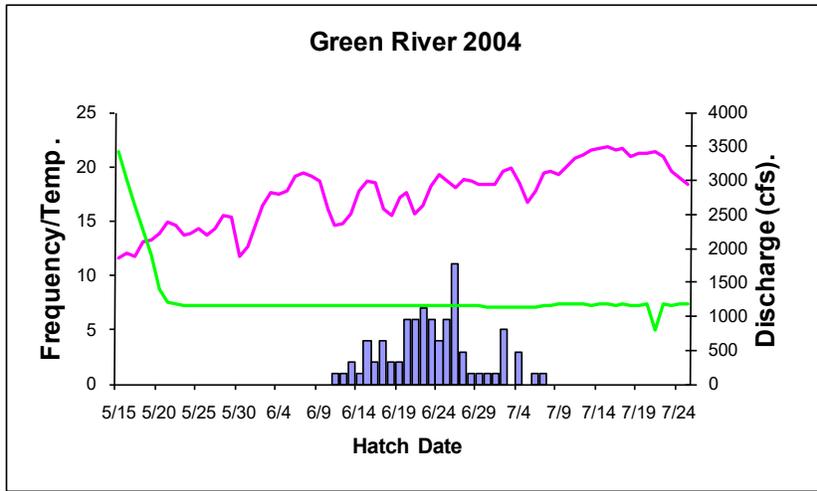
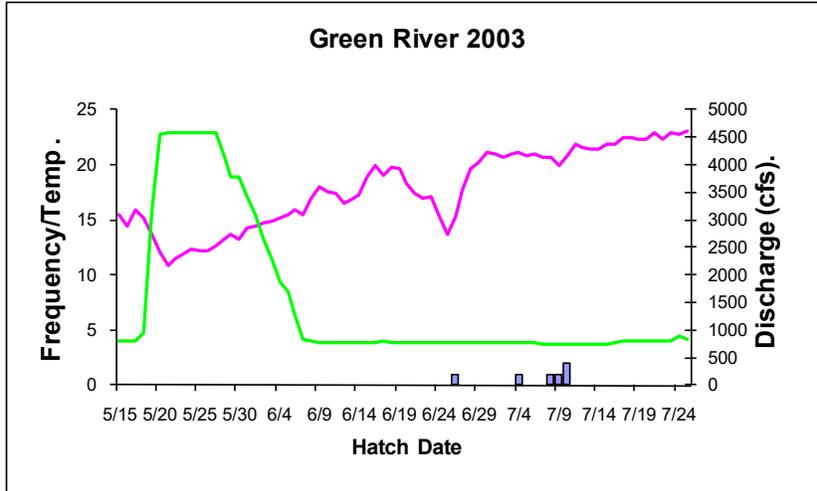


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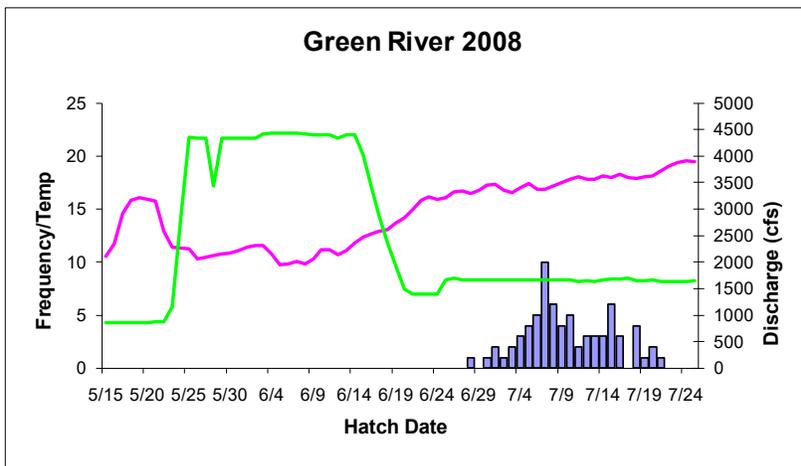
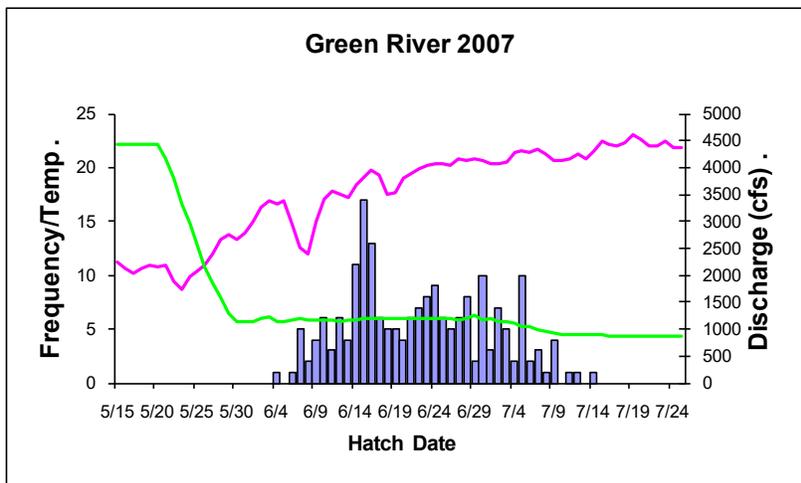
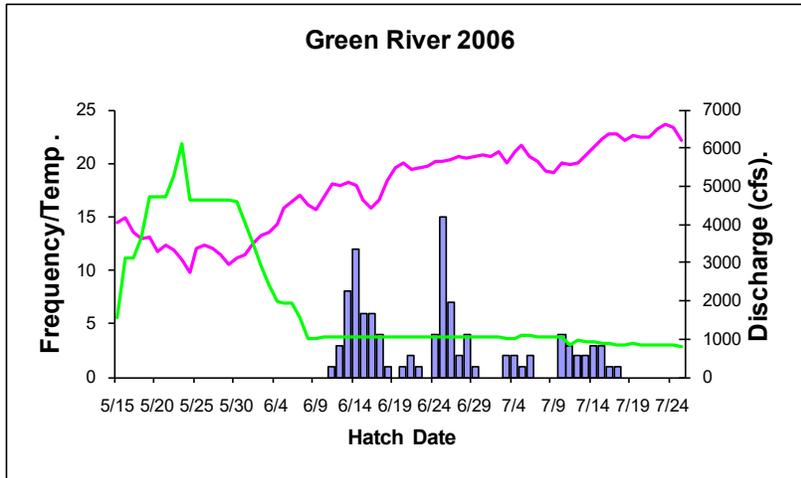


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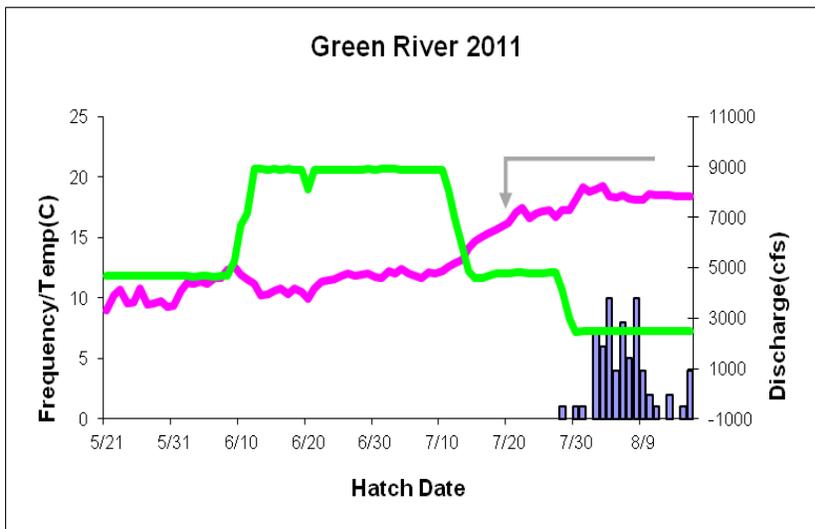
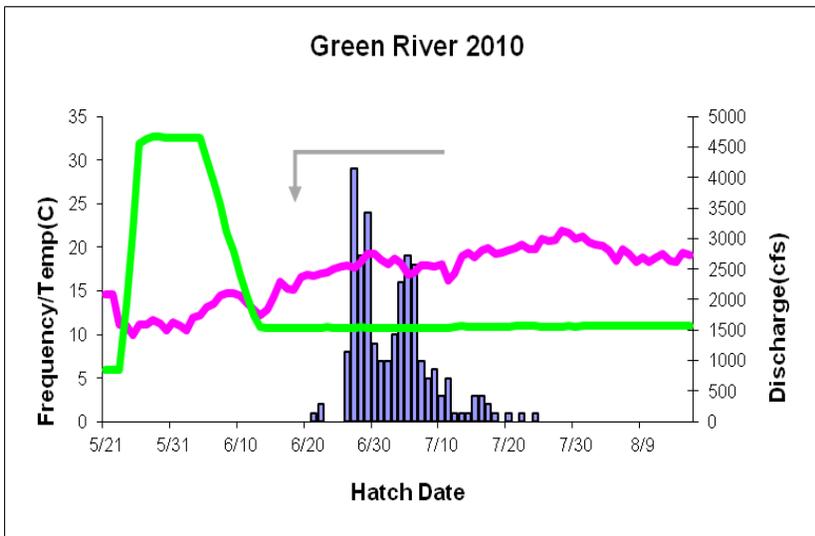
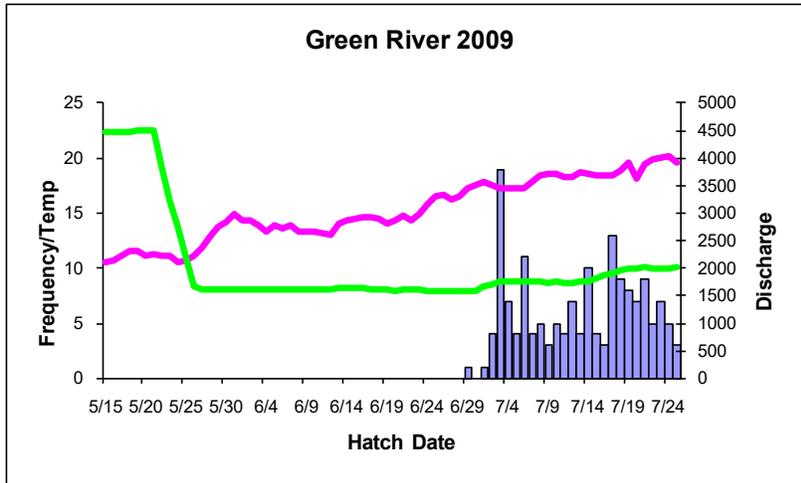


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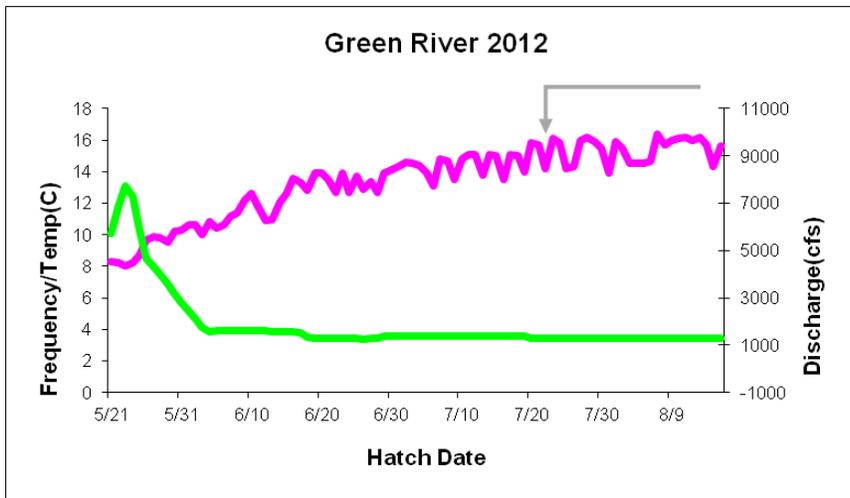


Figure 7.—Distributions of hatching dates of Age-0 smallmouth bass estimated by otolith daily increment analysis, 2003-2011, and first hatching and hatch duration in 2012. Bass were collected from the Green River in Lodore Canyon. Left vertical axis is the frequency of fish in the histograms or water temperature (increasing but variable trace through time, red if in color); right vertical axis is Green River discharge (in cubic feet per second and is depicted by a declining or stable line time, green if in color). Data are presented and discussed in Bestgen and Hill (2016).

Appendix I. Browns Park sampling results, spring 2017 (upper table) and spring 2018 (lower table).

Trammel Netting, 2017	
Species	Total
Colorado pikeminnow	10
bluehead sucker	0
bluehead sucker x flannelmouth sucker	0
flannelmouth sucker	22
mountain whitefish	2
brown trout	2
rainbow trout	1
northern pike	10
white sucker	101
white sucker X flannelmouth sucker	40
white sucker X bluehead sucker	2
channel catfish	2
common carp	7
Total	199
CPUE (fish/net hr)	0.52

Trammel Netting, 2018	
Species	Total
Colorado pikeminnow	5
bluehead sucker	0
bluehead sucker x flannelmouth sucker	1
flannelmouth sucker	8
mountain whitefish	1
brown trout	2
rainbow trout	0
northern pike	2
white sucker	79
white sucker X flannelmouth sucker	37
white sucker X bluehead sucker	5
channel catfish	0
common carp	19
Total	159
CPUE (fish/net hr)	0.64

ANNUAL PERFORMANCE PROGRESS REPORT (PPR)

BUREAU OF RECLAMATION AGREEMENT NUMBER: R14AP00001

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: FR-115

Project Title: Monitoring effects of Flaming Gorge Dam releases on the Lodore and Whirlpool Canyon fish communities

Principal Investigators: Kevin R. Bestgen, K. Zelasko, C. T. Wilcox, and A. A. Hill.

Larval Fish Laboratory

Dept. of Fish, Wildlife, and Conservation Biology

Colorado State University

Ft Collins, Colorado 80523

970-491-1848/ fax 970-491-5091

kbestgen@colostate.edu

Project/Grant Period: Start date (Mo/Day/Yr): 1 Oct. 2014
 End date: (Mo/Day/Yr): 30 Sept. 2018
 Reporting period end date: 30 Sept. 2018
 Is this the final report? Yes _____ No X

Performance: The Larval Fish Laboratory completed two sampling trips with assistance from the USFWS, Vernal, Utah. Samples were collected and preserved and data on large-bodied fishes was collected. Samples are being identified and data are yet being analyzed, as some information was only recently collected. We also produced an annual report on activities and will prepare presentations based on data at workshops or meetings in January 2018.

ANNUAL PERFORMANCE PROGRESS REPORT

BUREAU OF RECLAMATION AGREEMENT NUMBER: R15PG00083

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: FR-115

Project Title: Monitoring effects of Flaming Gorge Dam releases on the Lodore and Whirlpool Canyon fish communities

Principal Investigator:

M. Tildon Jones
1380 S 2350 W, Vernal, UT 84078
tildon_jones@fws.gov; 435-789-0351 x14

Project/Grant Period:

Start date: 10/01/2014

End date: 09/30/2019

Reporting period end date: 09/30/2018

Is this the final report? Yes _____ No X

Performance: USFWS provided personnel and equipment to assist CSU LFL in completing two electrofishing and seining passes from the Gates of Lodore through Rainbow Park, thereby fulfilling our commitments to tasks 1 and 2. Trammel netting in Whirlpool Canyon, which is typically conducted on a separate trip, was combined with the second pass this year.