COLORADO RIVER RECOVERY PROGRAM
FY 2018 ANNUAL PROJECT REPORT

RECOVERY PROGRAM
PROJECT NUMBER: _140_

I. Project Title: Evaluating effects of non-native predator removal on native fishes in the Yampa River, Colorado

II. Bureau of Reclamation Agreement Number: 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 Investigator(s): Larval Fish Laboratory

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IV. Abstract: Control actions for several non-native fish predators have been implemented in rivers of the Upper Colorado River Basin, but effects of those removals on restoration of native fishes is poorly understood. Understanding the response of the native fish community to predator removal is needed to understand if removal programs are having the desired effect. The objective of this project is to document fish community changes in response to predaceous fish removals in a reach of the Yampa River, Colorado. Native species richness increased during the removal period compared to early sampling (2003-2004) conducted in this project, as has native species sampling frequency and abundance, particularly since 2008 through 2012; native fish abundance was reduced in 2013-2015. The 2017 sampling data has been included in this version of the report, but 2018 data are not yet available because we finished field sampling in the Yampa River in late October. Thus, data entry and checking is still ongoing, and no analyses of 2018 data is available yet. When it becomes available we will modify this report and resubmit it. Data will also be incorporated into a long-term summary report.

V. Study Schedule: Ongoing as needed, agreement extends through September 2019.

VI. Relationship to RIPRAP:

REDUCE NEGATIVE IMPACTS OF NONNATIVE FISHES AND SPORTFISH MANAGEMENT ACTIVITIES (NONNATIVE AND SPORTFISH MANAGEMENT)
Green River Action Plan: Yampa and Little Snake Rivers
III.A.1. Implement Yampa Basin aquatic wildlife management plan to

develop nonnative fish control programs in reaches of the Yampa River occupied by endangered fishes. Each control activity will be evaluated for effectiveness and then continued as needed.

Green River Action Plan: Mainstem

III. Reduce negative impacts of nonnative fishes and sportfish management activities (Nonnative and sportfish management)

III.A.2.c Evaluate the effectiveness (e.g., nonnative and native fish response) and develop and implement an integrated, viable active control program.

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

In 2018, we sampled control and treatment reaches of Little Yampa Canyon with an effort similar to 2017 and the past. Samples were collected in each reach to document native fish response. A total of 201 samples was collected from 11 July to 18 October, 2018, including 121 from the treatment reach (where YOY smallmouth bass are removed) and 80 from the control reach (no YOY bass removal).

Number of native fish species collected in main channel samples of the Little Yampa Canyon reach of the Yampa River showed a positive response through time in the period 2003-2011, remained relatively abundant in 2012, declined dramatically in 2013 and 2014, increased slightly in 2015, and then declined slightly through 2017. Observations from field sampling in 2017 showed continued low abundance of native fish. In 2003 only a single native fish species, speckled dace *Rhinichthys osculus*, was captured (n = 4 individuals). In 2004 the number increased to two species, and from 2005-2007, four species were captured. In 2008, six native fishes were collected and in 2009 five, the same number captured in 2010; seven native fishes were collected in 2011, the most ever, and included bluehead, mountain, and flannelmouth suckers, mottled sculpin, speckled dace, roundtail chub, and mountain whitefish. In 2013, five native fishes were collected including bluehead and flannelmouth suckers, roundtail chub, speckled dace, and mottled sculpin, which was the same native species composition as in 2014-2017.

The number of smallmouth bass removed from the treatment reach has declined slightly since 2005 (and especially 2009), but the density in samples has remained relatively constant in both control and treatment reaches (Figure 1). The exception was in 2011, when high and cold flows late in the year apparently suppressed smallmouth bass reproduction and survival. As expected, density of bass in the treatment reach is lower than in the control reach in most years, with the exception of 2009-2012. Density would be expected to be lower due to removal of bass through the sampling season.

Percent composition of native fishes in main channel Yampa River samples is generally low, but has increased over time, especially in the high flow year 2011 (Figure 2). Isolated pools typically support relatively large numbers of native fishes, especially when smallmouth bass are uncommon (Figure 3). This was especially so early in the sampling

period (pre-2008), when such pools harbored the majority of native fish captured in any given year.

The frequency of presence of native fishes in samples has increased since intensive removal of adult and age-0 bass commenced in 2005 (Figure 4). While the total % native fish remains low (e.g., Figure 2), the 2008-2010 and 2015-2017 levels represent a five-fold or more increase over 2007 and before, and the 2011 level has not been realized since sampling began. Presence of native fishes in 2012 samples was also high (comparable to 2008-2010), but slightly less than in 2011, declined dramatically in 2013 and 2014, rose substantially in 2015, and declined slightly through 2017.

Frequency of roundtail chub *Gila robusta* in samples has also increased through time up until 2012 or so but then declined. Roundtail chub were present in substantially larger numbers in the treatment reach where age-0 bass are removed compared to the control reach where no age-0 bass are removed (Figure 5). We interpret these collective patterns as a river-wide response of increasing native fish abundance in 2008 through 2012, perhaps because of higher stream flows and reduced water temperatures. Those same conditions promote later smallmouth bass spawning and slower growth (see below), which may inhibit or reduce predation by that species on native fishes. The larger proportion of native fish in samples in the treatment reach compared to the control is thought a response to removal of large numbers of age-0 smallmouth bass each year. The 2013-2017 decline in roundtail chub is likely due to a high abundance of age-0 and age-1 smallmouth bass from large year-classes produced in 2012 and 2013, and a delayed response by native fishes to bass, declining in 2012 and particularly 2013-2017.

An additional aspect of work in FY-2010 to 2018 (2018 data not shown) was an evaluation of sampling efficiency of our one-pass sampling in specific habitat types. To accomplish that, we sampled in a typical fashion in several locations one or more times. Each time at each site, we sampled with a single pass of electric seine sampling, and then repeated that sampling 1-2 more times to determine removal efficiency of our sampling. In general, in each of the 2010-2016 sampling years, first pass removal constituted about 55-65% of the smallmouth bass present at each site, a relatively high depletion rate. That depletion rate increased to 74% in 2017. Repeated visits from late summer into autumn will allow us to understand recolonization dynamics of those habitats through the year. As is customary, we plan to report results of 2018 sampling at the Researchers Meeting in January 2019.

We made good progress on analysis of otoliths of smallmouth bass collected from the Yampa River through 2012, which added to the population dynamics modeling portion of Project 161, the smallmouth bass data synthesis. The goal is to better understand effects of streamflow and water temperature on timing and duration of smallmouth bass spawning and hatching dates, and growth rates, so strategies to disadvantage reproductive success of that species can be formulated. That information was summarized in a final report, along with similar data from the Green River, which will be useful to guide decisions regarding potential modified flows or temperatures from Flaming Gorge Dam

(Bestgen and Hill 2016). Those modifications would be designed to reduce reproductive success of smallmouth bass in the Green River downstream of Flaming Gorge Dam.

Results of otolith analysis showed that smallmouth bass in the Yampa River study area first hatched well after spring peak flows declined but the specific calendar date varied from early June to early July across years 2005-2012. A main controlling factor to smallmouth bass reproduction appears to be water temperature, as well as habitat availability. For example, when water temperatures warmed earlier in the lower flow year 2007, smallmouth bass hatching began as early as 4 June. In contrast, first hatching of smallmouth bass in the higher flow year 2008, when water temperatures remained colder later, occurred as late 2 July. Even though timing of hatching varied across years, a consistent environmental cue to spawning appeared to be the regular onset of water temperatures of 16°C or higher. Hatching is also consistent with lower water levels and presumably, availability of low velocity nearshore habitat. Peak hatching in the Yampa River occurred about 2-3 weeks after first bass hatched, although in 2009 the peak was only about 10 days after hatching first started. The duration of the spawning season was relatively brief, usually about 4 weeks in most years. Results of hatching date distributions related to flow and water temperature regimes was presented at the Non-native Fish Workshop in 2009 as well as at the Upper Colorado River Researchers Meeting (2010, 2011, 2012, 2013), the Colorado-Wyoming Chapter of the American Fisheries Society (2009), and the Larval Fish Conference in Santa Fe, New Mexico (2010), and the October 2015 Colorado Plateau researchers meeting (Flagstaff, AZ).

An opportunistic flow spike in the Yampa River, a natural event caused by thunderstorms in summer 2015, allowed us to evaluate effects of that spike on bass reproduction and survival (Figure 6). Yampa River flows more than doubled from ~1000 cfs to ~2500 cfs over 3 days and then returned to ~1000 cfs over 3 additional days during the peak period of smallmouth bass hatching. Those observations also demonstrated the potential effects of a flow spike that could be implemented in the regulated Green River in the future. The 10 July flow spike likely resulted in reduced survival of smallmouth bass larvae produced just before, during, and after that flow spike. The mechanism is not precisely known but may have been a product of turbidity, increased flow velocity, reduced water temperatures, or all three factors, all of which are known to reduce survival of early life stages of smallmouth bass (Bestgen and Hill 2016 provide supporting details). Growth of bass was also reduced not only during that period but well after, likely a result of reduced food availability. We also saw similar reductions in captures of Colorado pikeminnow larvae in the lower Yampa River during that event (Project 22f annual report 2016). This information was included in a recently completed description of a flow spike study plan that was submitted to the Recovery Program in November 2018 (Bestgen 2018).

This Yampa River scenario is similar to the one that could be produced by flow spikes released from Flaming Gorge Dam, to affect smallmouth bass in the Green River. Although turbidity fluxes would likely be minimal during such events, increased flow velocity may have a similar effect of reducing bass early life stage survival and growth. We were able to document these patterns since 2005 because of long-term collection of

young bass samples by our Yampa River field crews. It may also be possible to induce a smaller flow spike via releases from Elkhead Reservoir. Such a spike (maximum release about 550 cfs) would be most effective when Yampa Flows are very low, so that the proportional increase in stage and water velocity is maximized. The Elkhead Reservoir release would be increased if paired with a natural storm event, where flow, turbidity, or both were increased.

We have also conducted comprehensive analyses of factors affecting growth rates of age-0 smallmouth bass in the Yampa River. Specifically, we compared intra-annual and inter-annual patterns of bass growth rates and lengths, and related those patterns to thermal and hydrologic characteristics of the Yampa River in the period 2003-2012, as well as in the Green River upstream and downstream of the Yampa River. Intra-annual cohort growth of smallmouth bass varied from 0.66 mm/day in 2005 to 1.12 mm/day in 2006, both in first cohorts of the year. The shortest bass were from cohort 3 in 2008 (mean TL = 40 mm) and the largest in cohort 1 in 2007 (102 mm TL). Early cohort growth rates were faster than later ones in all years because they had the benefit of the entire warm summer season to grow. Bass growth ceased when water temperatures declined to about 10°C. General linear model analyses showed that age-0 bass growth rates were highest, and length was greater in September, in years when water temperatures were high and spring runoff flows declined early. Conversely, bass growth rates were lower, and length was shorter in September, in years when water temperatures were cool and runoff was prolonged. Bass from isolated pools usually grew more slowly than those from the mainstem Yampa River. Quantifying factors that affect growth and ecology of age-0 smallmouth bass in the Yampa River will assist with population dynamics investigations that support optimizing strategies for bass removal, and aid recovery efforts for native fishes in the Upper Colorado River Basin. Results of bass growth rate analyses were presented three times in 2010 (all by Angela Hill), at the Upper Colorado River Researchers Meeting, the Colorado-Wyoming Chapter of the American Fisheries Society, and the Larval Fish Conference in Santa Fe, New Mexico, and the October 2015 Colorado Plateau researchers meeting (Flagstaff, AZ). This information was also incorporated into a population dynamics model for smallmouth bass developed under Project 161, which allows investigation of year-specific effects on growth and subsequent over-winter survival related to Yampa River flow and water temperature.

We also conducted additional smallmouth bass otolith research in spring 2010-2012. The literature is controversial in regards to the number of daily increments and the timing of their deposition in otoliths of smallmouth bass at hatching and swimup. Because this information is critical to our understanding of hatching time and interpretation of hatching date distributions, we raised smallmouth bass embryos in constant and fluctuating temperature regimes at 20°C. Embryos were acquired from the Colorado Division of Wildlife Hatchery at Wray, Colorado. Series of bass from each treatment were preserved through ontogeny to resolve the issue of increment deposition timing and clarity. Those analyses have been completed and the results were published in the North American Journal of Fish Management in 2014 (Hill and Bestgen 2014); an electronic copy of the reprint was sent to the Program list server in spring 2014 as well. We also

used this information to develop a study plan to implement flow spikes from Flaming Gorge Dam to disadvantage reproductive success of smallmouth bass in the Green River. That report is presently under review and will be included in an evaluation of the efficacy of Flaming Gorge Dam flow and water temperature recommendations to assist with recovery of Green River endangered fishes.

White River sampling

We also completed sampling in the White River on four occasions in 2018. That sampling showed continued abundant smallmouth bass. Specific to that effort was sampling conducted before (10 July) and after (21 July) a flush of sediment and water from Kenney Reservoir (19 July) that was designed to reduce or remove algae from water intake structures for the City of Rangely. The release was for 90 minutes and at 1,100 ft^3/sec. Table 1 shows those results, with no apparent effect (slight increase based on catch per unit effort statistics) of the flushing flow on juvenile (mostly age-0) smallmouth bass.

A series of pictures pre- and post-flush were also obtained (Alden Vanden Brink, District Manager, Rio Blanco Water Conservancy District (970 675-5055) and are presented in Appendix I. Those images show cleansing effects of the flows. Also posted is a letter from the Rangely Utilities Department (Donald C. Reed) describing the event and the apparent success with regards to algae removal (page 21of this report).

Lack of apparent success removing age-0 smallmouth bass could be due to many factors including the short flushing time, and the size of bass when the flow began. A 90-minute flow may be insufficient to remove bass, especially when the age-0 bass had already attained mean TL of 37 mm (25-57 mm). Field crews have consistently noticed that susceptibility of young bass to the electric seine is relatively low and their abundance in early July was probably substantially underestimated. Growth of young bass is fast as mean TL of fish increased from 37 mm on 10 July to 50 mm on 24 July, 81 mm on 21 August, and 83 mm by 3 October.

The 1,100 ft^3/sec flood wave began at Kenney Reservoir at 8:05 AM 19 July, and passed the Watson, Utah USGS gage 44 miles (71 river km) downstream with an attenuated peak of 362 ft^3/sec on 20 July, at 3:30 AM (Figure 7, about 19.5 hours later).

Also of note during the 21 August sample period was water flow over the spillway. Notable fish captures included 323 young-of-year black crappie (46-75 mm TL), when none were captured in the two previous sampling periods in July. During the 3 October sample, the spillway had stopped flowing and only 3 YOY black crappie were sampled.

VIII. Additional noteworthy observations:

IX. Recommendations:

- Present a more complete summary of data regarding the native fish response evaluation at the 2019 Researchers Meeting (if necessary).
- Continue sampling in 2019 and out years, with similar effort as 2018, to continue to bolster this important data set and understand the relationship of native fish response to predator removal and flow levels in summer in the Yampa River
- Modify a specific scope of work for smallmouth bass spike flow implementation
- Finish a synthesis of this information that has been collected since 2003.

X. Project Status: A Cooperative Agreement with the Bureau of Reclamation for this project was negotiated and was in place in October 2014 and extends through 2019.

XI. FY 2019 Budget Status
   A. Funds Provided: $93,487
   B. Funds Expended: $72,845
   C. Difference: $21,002
   D. Percent of the FY 2018 work completed, and projected costs to complete: about 25% of FY18 tasks remain to be completed.
   E. Recovery Program funds spent for publication charges: 0

XII. Status of Data Submission: NA

XIII. Signed: Kevin R. Bestgen 12 November 2018
Principal Investigator Date

References

Bestgen, K. R. 2018. Evaluate effects of flow spikes to disrupt reproduction of smallmouth bass in the Green River downstream of Flaming Gorge Dam. Final report to the Upper Colorado River Endangered Fish Recovery Program. Denver, Colorado. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 214. DOI: 10.13140/RG.2.2.33277.61926

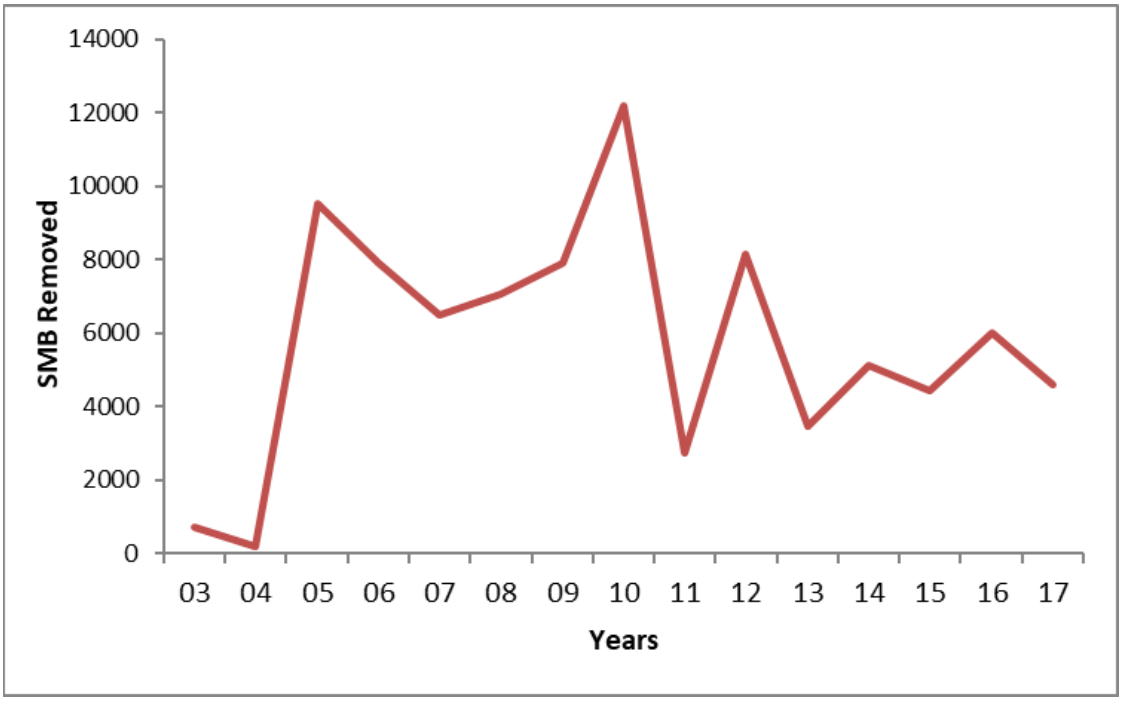
Bestgen, K. R., and A. A. Hill. 2016. River regulation affects reproduction, early growth, and suppression strategies for invasive smallmouth bass in the upper Colorado River basin. Final report to the Upper Colorado River Endangered Fish Recovery Program, Project FR-115, Denver, CO. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 187.

Hill, A. A. and K. R. Bestgen. 2014. Otolith daily increment deposition in age-0 smallmouth bass reared in constant and fluctuating water temperatures. North American Journal of Fisheries Management 34:774-779.

Table 1. Results for White River smallmouth bass sampling in 2018. SMB = smallmouth bass, CSU = Colorado State University. The catch per unit effort data were from electric-seine sampling conducted in two locations just downstream of Kenney Reservoir, near Rangely, Colorado. The first two passes bracket a flushing flow event (90 minutes, 1,100 ft^3/sec) from Kenney Reservoir on 19 July.

				Number of SMB				CPUE (#fish/hr)			
Pass	Sampling Period	Agency	Effort (hrs)	Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	10-Jul	CSU	1.48	95	76	1	172	64.2	51.4	0.7	116.2
2	24-Jul	CSU	1.29	110	44	3	157	85.3	34.1	2.3	121.7
3	21-Aug	CSU	1.44	98	6	2	106	68.1	4.2	1.4	73.6
4	3-Oct	CSU	1.22	286	15	2	303	234.4	12.3	1.6	248.4
			5.43	589	141	8	738	108.5	26.0	1.5	135.9

a.



b.

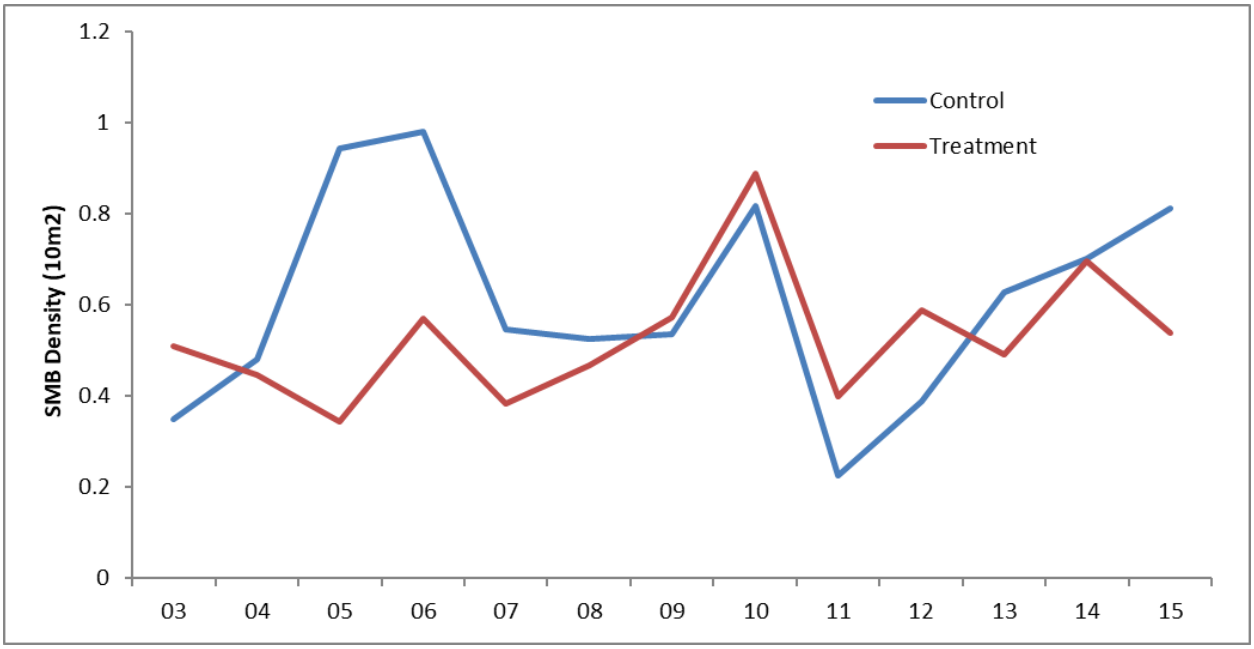


Figure 1. Number of small-bodied smallmouth bass (usually < 100 mm total length) removed from the treatment reach of Little Yampa Canyon, 2003-2017 (panel a) and density of fish in control and treatment reaches (panel b).

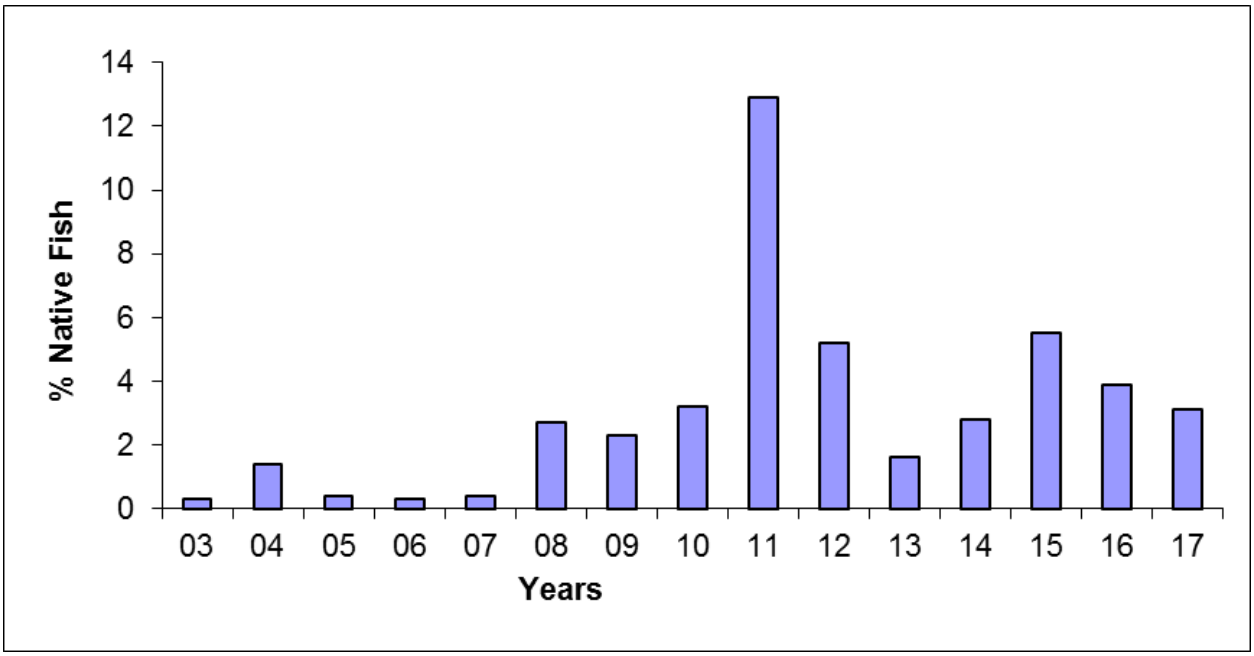


Figure 2. Percent composition of native fishes in the Yampa River, 2003-2017, in samples collected from the main channel in Little Yampa Canyon.

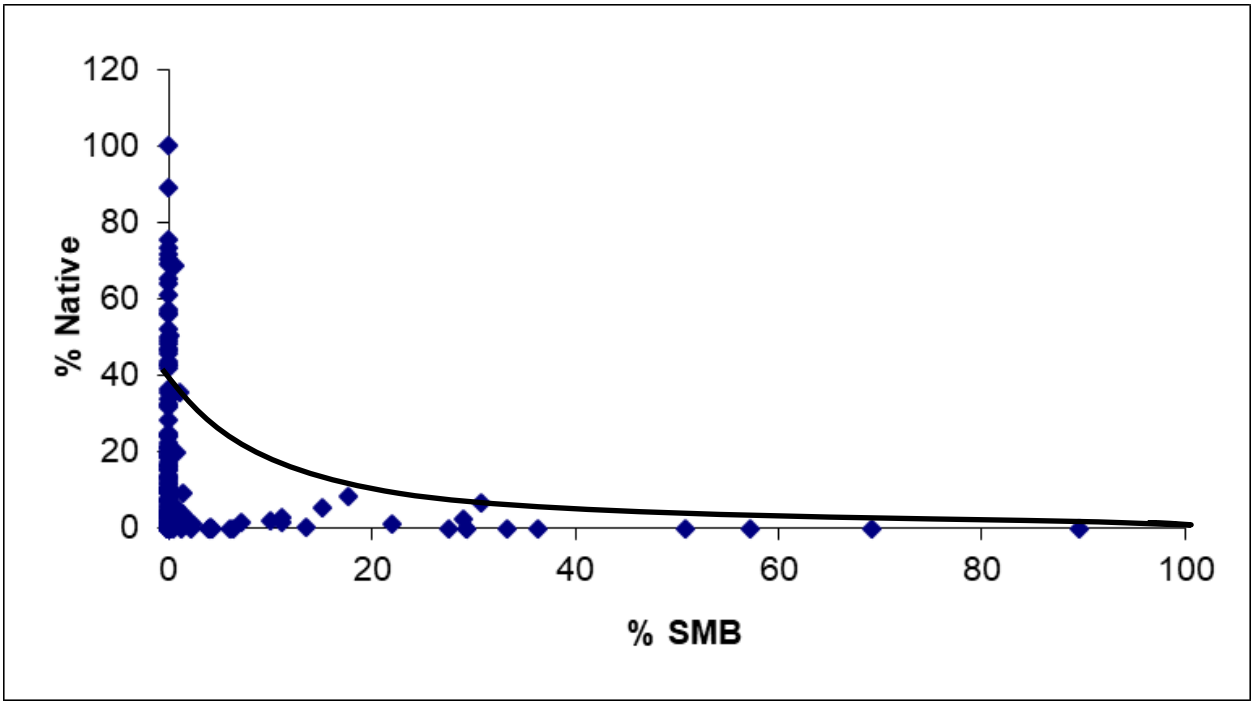


Figure 3. Percent native fishes as a function of percent smallmouth bass in samples collected from isolated pools in the Little Yampa Canyon reach of the Yampa River 2003-2017.

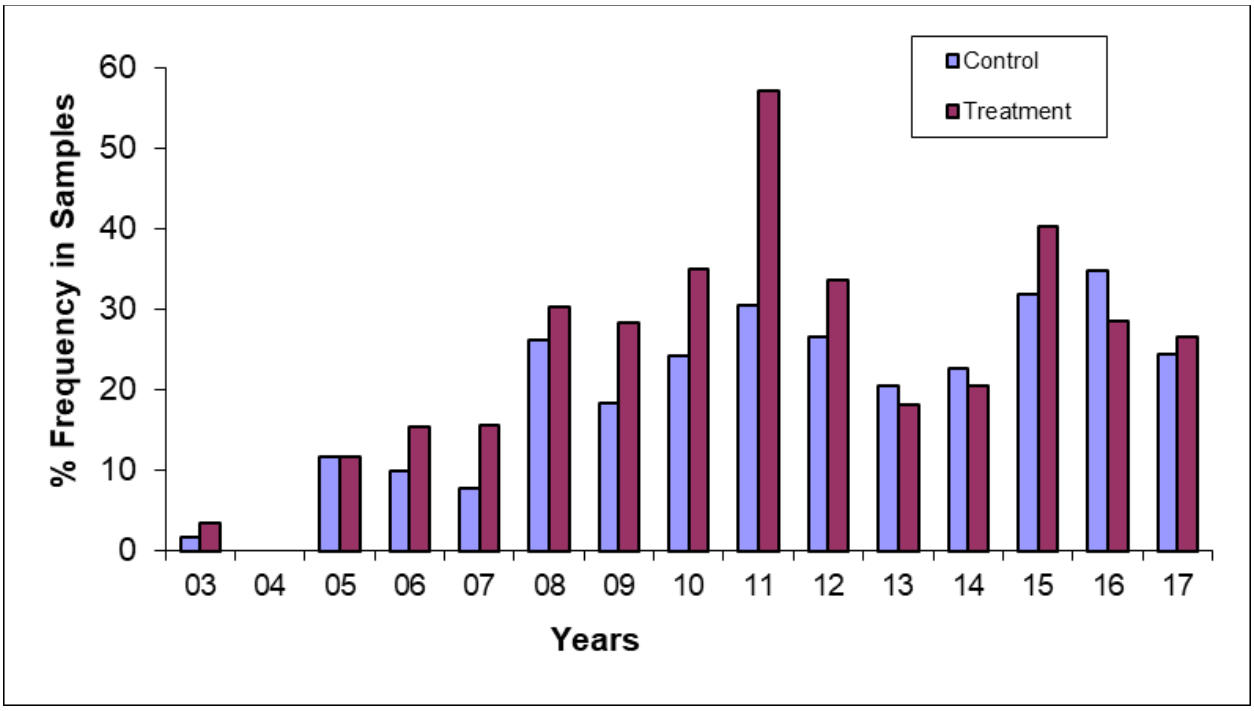


Figure 4. Presence of native fishes (any species) in samples collected in the main channel of the Yampa River in control (no age-0 smallmouth bass removal) and treatment (intensive age-0 smallmouth bass removal) reaches in Little Yampa Canyon, 2003-2017.

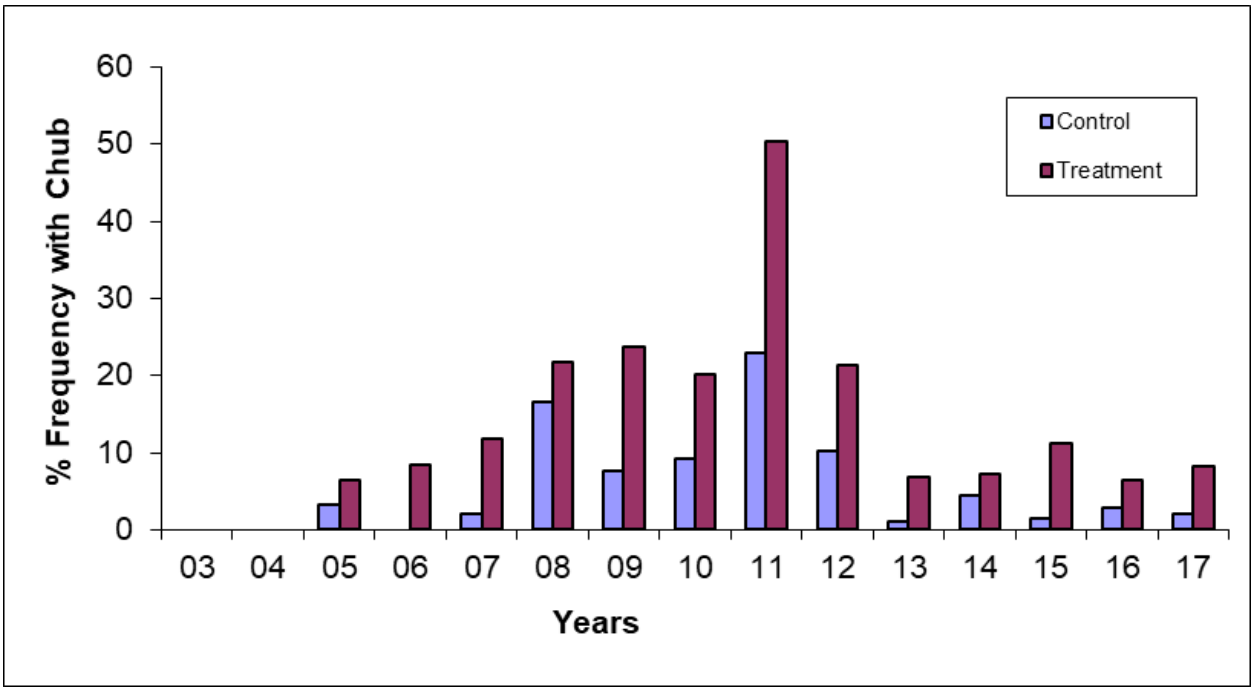


Figure 5. Frequency of roundtail chub in samples collected in the main channel Yampa River in the control (no age-0 smallmouth bass removal) and treatment (intensive age-0 smallmouth bass removal) reaches in Little Yampa Canyon, 2003-2017.

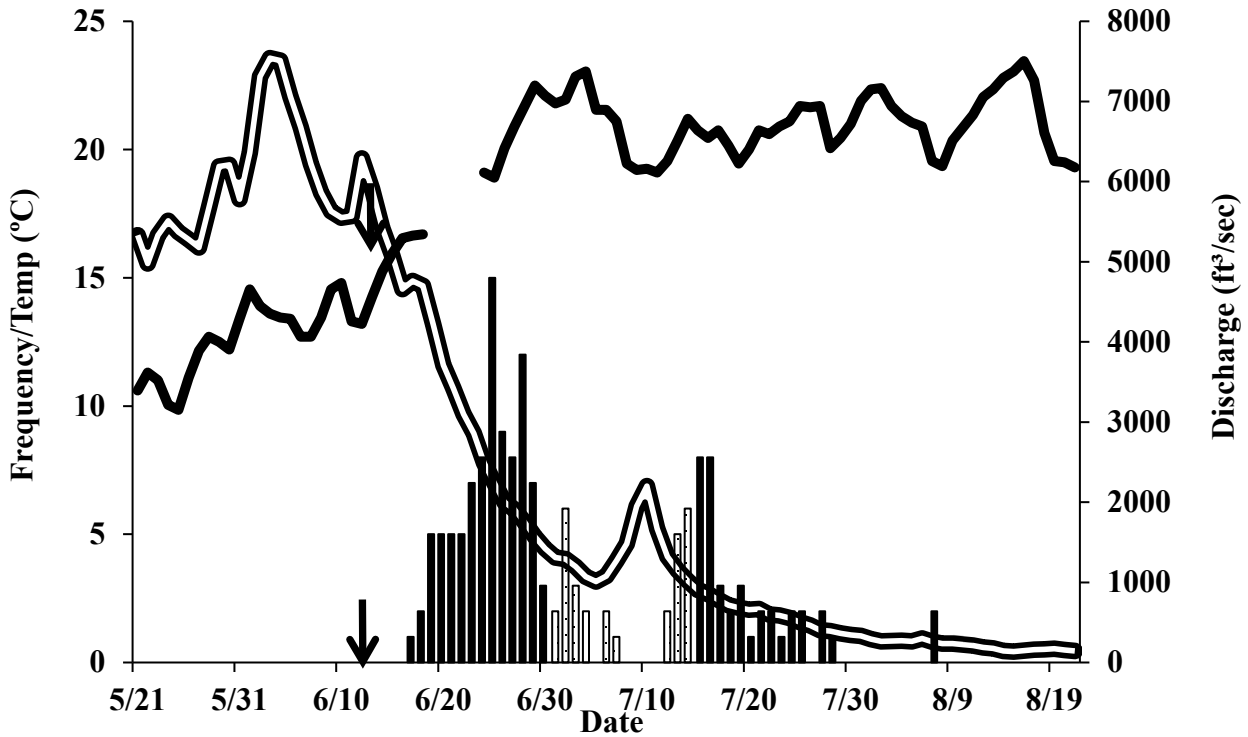


Figure 6. Distribution of hatching dates of smallmouth bass in the Yampa River, Colorado, 2015. Discharge is represented by the open line, and temperature is the solid, black line. The usual pattern of hatching dates results in a mound-shaped distribution. The flow spike on 10 July, and associated turbidity, likely resulted in reduced survival of smallmouth bass larvae produced before, during, and after that spike. The downward pointing arrow is the date of onset of 16°C water temperature.

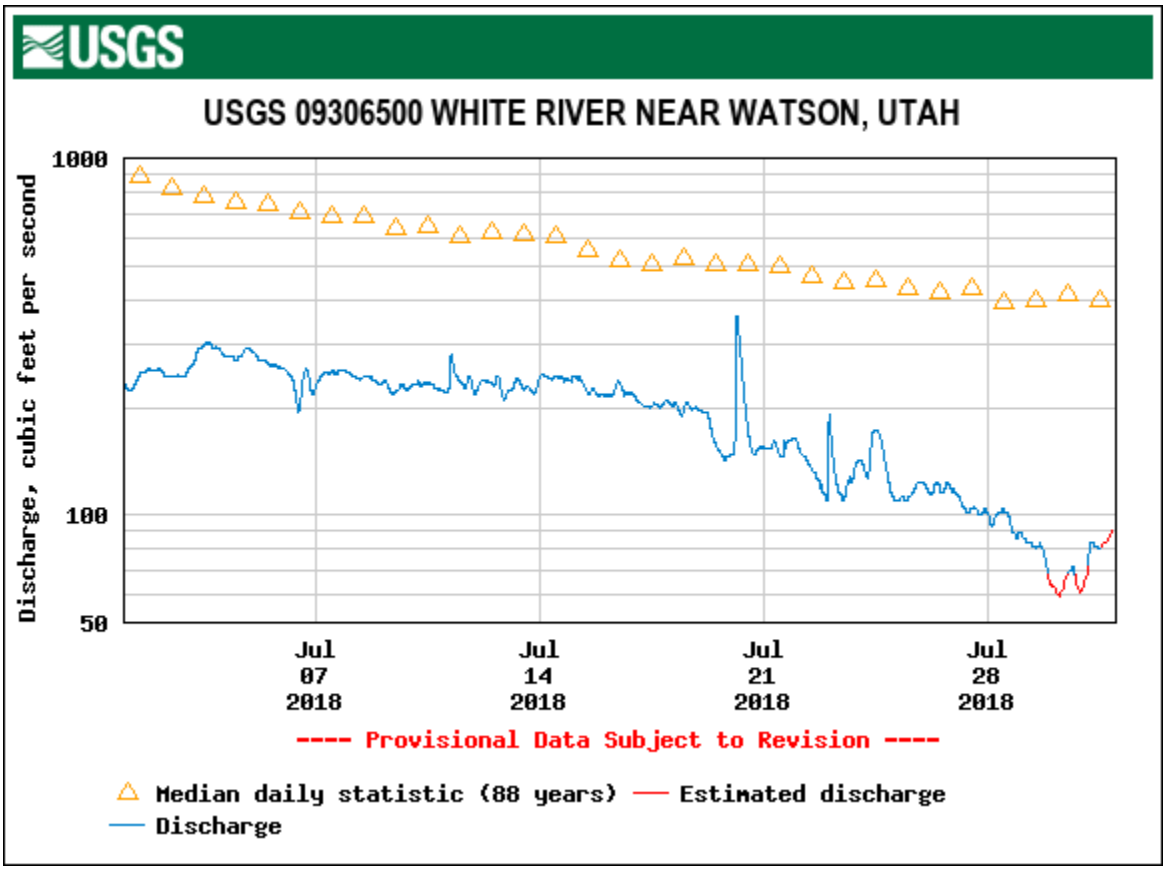


Figure 7. White River discharge in July 2018, showing the attenuated flow peak at 3:30 AM, 20 July (362 ft^3/sec) after release (1,100 ft^3/sec) from upstream Kenney Reservoir at 8:05 AM on 19 July. The Watson, Utah, gage is about 71 river km downstream of Kenney Reservoir.

Appendix I. Paired pictures of White River algae conditions downstream of Kenney Reservoir, near Rangely, Colorado, before and after a 90 minutes flushing flow of 1,100 ft^3/sec from Kenney Reservoir.

Before

After

Before

After

Before

After

Before

After

Before

After

Before

After

TOWN OF RANGELY – Utilities Department

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Subject: Flushing of the White River.

Date: July 23, 2018

From: Don Reed/Utilities Supervisor

On July 19, 2018 at 8:05 a flushing program was activated by the Water Conservancy District as an experimental application below Taylor Draw Dam. This initiative was proposed by Alden Vanden Brink in hopes of cleaning up the banks of the river that has been an ongoing problem for many years and even more predominate this year that results in clogging of the intake screens. The proposal was to turn on the turbine and reach a flow of 1100 cfs which calculates out at almost ½ million gallons per minute This targeted flow should create a scouring effect, and help remove buildup of aquatic algae, filamentous weed and other vegetation that is clogging the screens. The duration time of the scour will be determined by inflows of Kenny Reservoir. Flush was about 2.5 hours.

In conclusion of the flush it was determined as successful in accomplishing the task, on a scale of 1 to 10 it was rated about a plus 7. The Town Engineer took before and after photos from the Dam to the Water Treatment Plant river intake which clearly shows the results. This initiative should be utilized as a tool in aiding the Water Dept. in reducing the overall cost in screen cleaning, and improving water quality, as well as maintaining the White River.

This Department would like to Thank Mr. Vanden Brink and the Water Conservancy for proposing and executing this program. A sincere congratulation on a job well done. Attached is the Data and observations noted during the flushing program.

Submitted By.

Donald C. Reed

Observation Notes and Data Collection.

Note that river intake screens were cleaned just prior to the start of the program. The river pump station is off-line at this time. A raw water sample was collected. The current level of wet well was 9.21 feet.

A.) Initial observation at 8:05 am taken at outlet of Dam. Shows immediate scouring of vegetation on rocks and structures.
B.) Took about 35 minutes to reach the WTP River Intake Facility. Start to see some debris floating by.
C.) At 9:41am start to observe a lot of vegetation flowing down the river, and river is starting to rise.
D.) At 11:40 am reached peak flow and rivers station wet well level is at 12.28 feet and have a lot of debris floating down that has a lot of newer vegetation.
E.) River flow is slowed down and at 4:08 pm river flow is back to normal.

Lab Sample Results

1.) Raw sample from River at intake structure prior to flushing. PH=7.63 Temp 22.1
Alk=142 NTU=13.9 Fluoride=.09

2.) Raw sample from River intake after flushing. PH=7.91 Temp=21.3 Alk=131 NTU 8.8

Note Jocelyn Mullen took a lot of photos and will provide them upon request.