COLORADO RIVER RECOVERY PROGRAM
FY 2017 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(s): 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. 2017
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 2016 sampling data has been included in this version of the report, but 2017 data are not yet available because we finished field sampling in the Yampa River as late as early November in 2017. Thus, data entry and checking is still ongoing, and no analyses of 2017 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 2018.

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 2017 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

In 2017, we sampled control and treatment reaches of Little Yampa Canyon with an effort similar to 2016 and the past. Samples were collected in each reach to document native fish response.

In 2015, 89 samples were collected in the treatment reach of Little Yampa Canyon (where small-bodied smallmouth bass were removed from nearshore habitat) and 55 samples were collected from the control reach (where no small-bodied smallmouth bass were removed). A total of 17 isolated pool samples were among the total as well. In 2016, 80 samples were collected in the treatment reach of Little Yampa Canyon (where small-bodied smallmouth bass were removed from nearshore habitat) and 58 samples were collected from the control reach (where no small-bodied smallmouth bass were removed). A total of 26 isolated pool samples were sampled in 2016.

Number of smallmouth bass sampled and removed in 2015 (n = 5,096) was only slightly lower than that in 2014 (n = 5,122), and was slightly lower than average compared to most other years (Figure 1a). In 2016, smallmouth bass abundance was slightly higher than in 2015. However, density estimates were among the highest noted in 2016, with the exception of 2006, 2010, and 2014 (Fig 1b). The moderately high number collected in 2015 was likely a result moderate flow levels in summer, with the exception of one flooding event in mid-July discussed elsewhere.

Native fish abundance was higher in 2015 compared to 2012-2014, but lower than in 2011 (Figure 2). The 2016 native fish abundance declined slightly from 2015 levels. The 2015 and 2016 native fish abundance in the main channel of the Yampa River remained higher than for 2003-2010, when few native fishes were found, and those mostly only in isolated pools with few predators. In isolated pools, native fishes were also rare and were typically found only when abundance of smallmouth bass was lowest (Figure 3).

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 in 2016. Observation from field sampling in 2017 showed continued low abundance of native fish. In 2003 only a single native fish, 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 sucker, 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 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, the 2008-2010 and 2015-2016 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 in 2016.

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 2013-2016 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 2013-2016.

An additional aspect of work in FY-2010 to 2016 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. 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 2016 sampling at the Researchers Meeting in January 2017.

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. 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 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 stage and water velocity increase 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); the pdf 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.

VIII. Additional noteworthy observations:

IX. Recommendations:

- Present a more complete summary of data regarding the native fish response evaluation at the 2018 Researchers Meeting (if necessary).
- Continue sampling in 2018 and out years, with similar effort as 2017, 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
- Write and finish a study plan 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 2018.

XI. FY 2017 Budget Status
A. Funds Provided: $94,825
B. Funds Expended: $68,229
C. Difference: $26,596
D. Percent of the FY 2017 work completed, and projected costs to complete: about 30% of FY17 tasks remain to be completed.
E. Recovery Program funds spent for publication charges: 0

XII. Status of Data Submission (Where applicable):

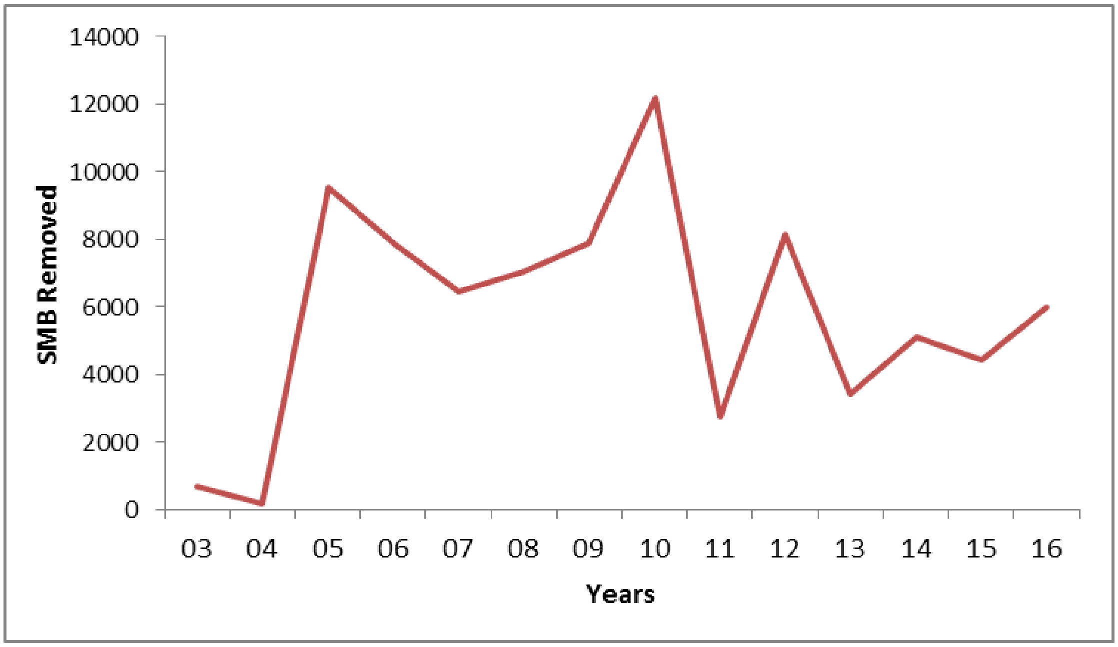
XIII. Signed: Kevin R. Bestgen 12 November 2017
Principal Investigator Date

Literature Cited:

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.

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.

a.



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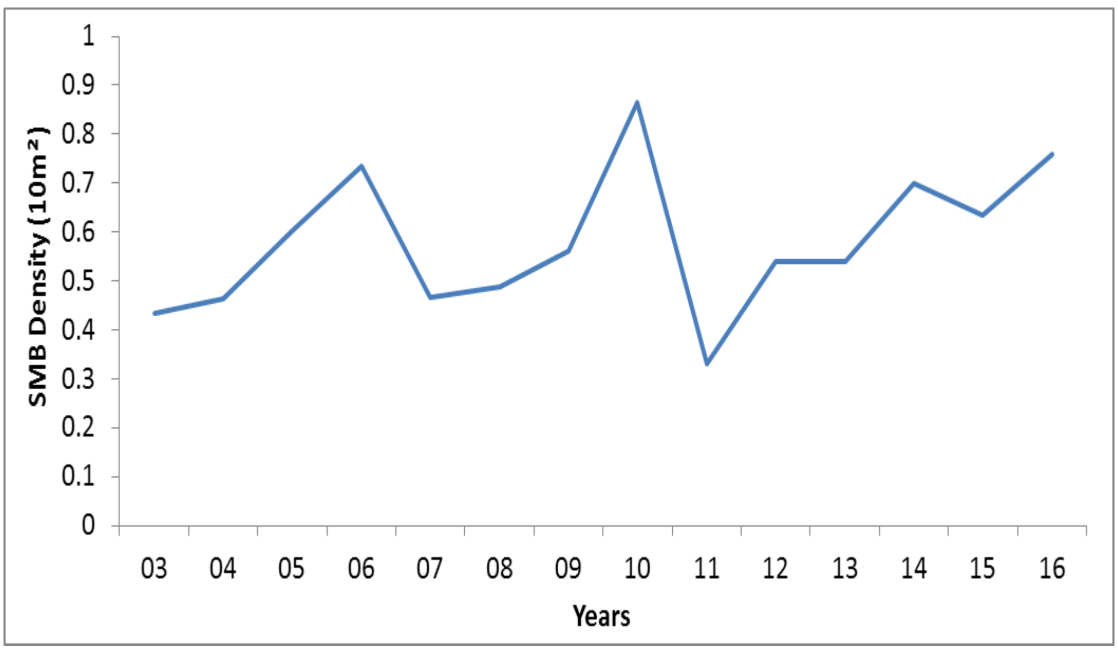

Figure 1. Number of small-bodied smallmouth bass (usually < 100 mm total length) removed from the treatment reach of Little Yampa Canyon, 2003-2016 (panel a) and density of fish captured (panel b).

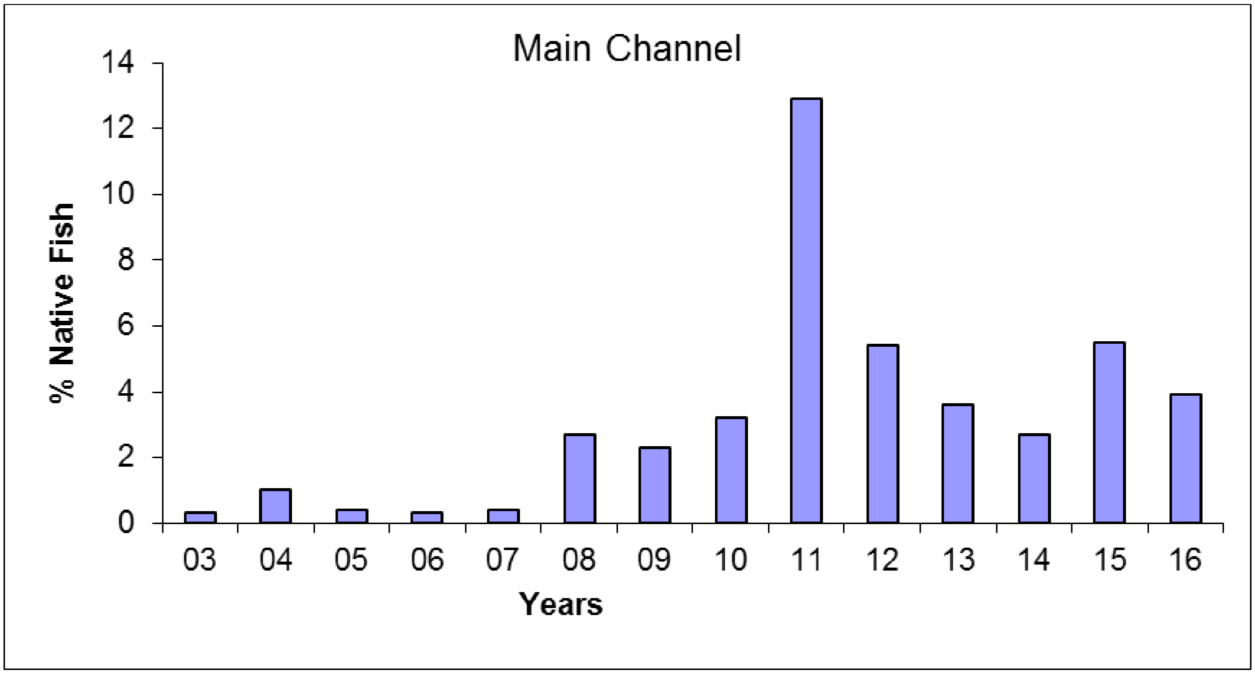

Figure 2. Percent composition of native fishes in the Yampa River, 2003-2016, in samples collected from the main channel in Little Yampa Canyon.

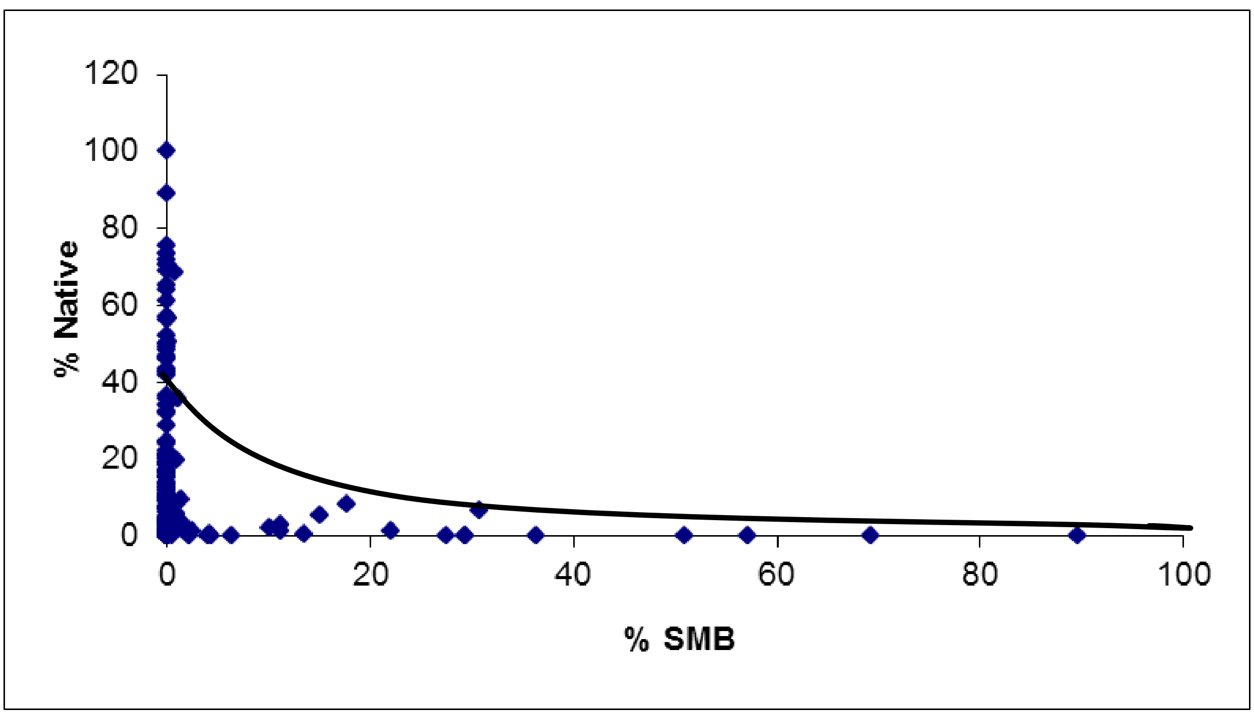

Figure 3. Percent native fishes as a function of percent smallmouth bass in samples collected from isolated pools in the Little Yampa Canyon reach of the Yampa River 2003-2016.

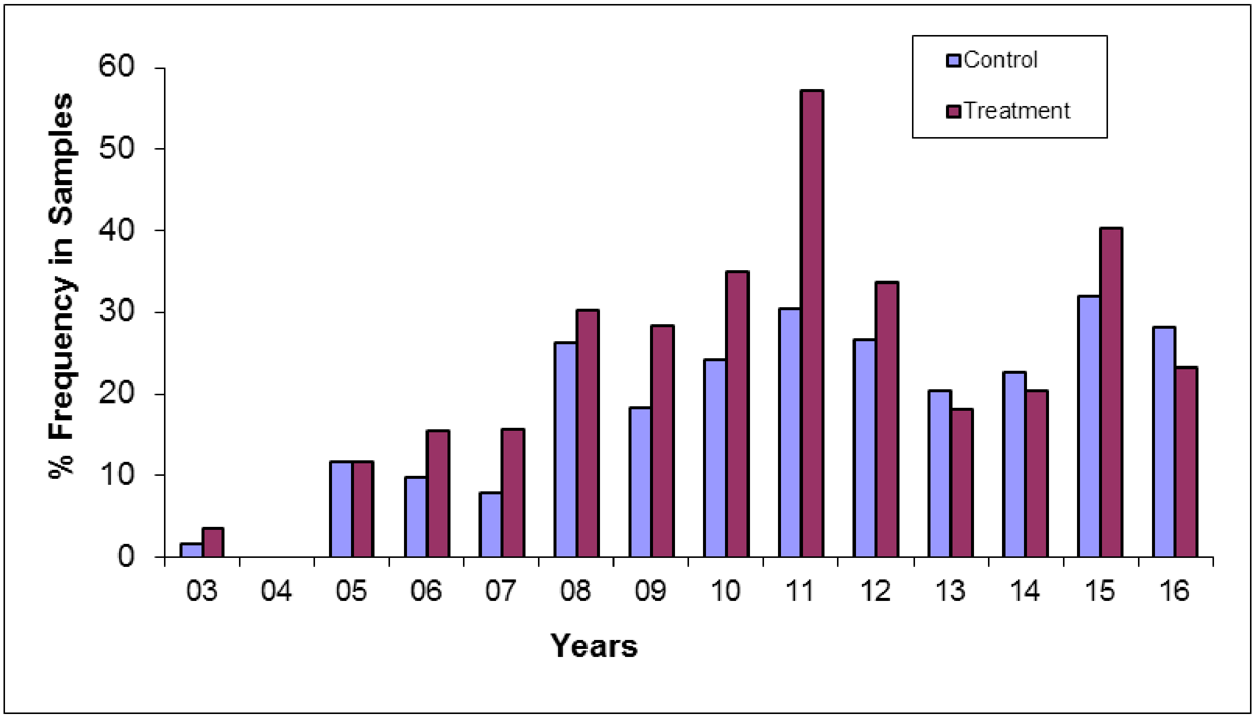

Figure 4. Presence of native fishes (any species) in samples collected in the main channel of the Yampa River in control (no age-0 smallmouth bass removal) and treatment (intensive age-0 smallmouth bass removal) reaches in Little Yampa Canyon, 2003-2016.

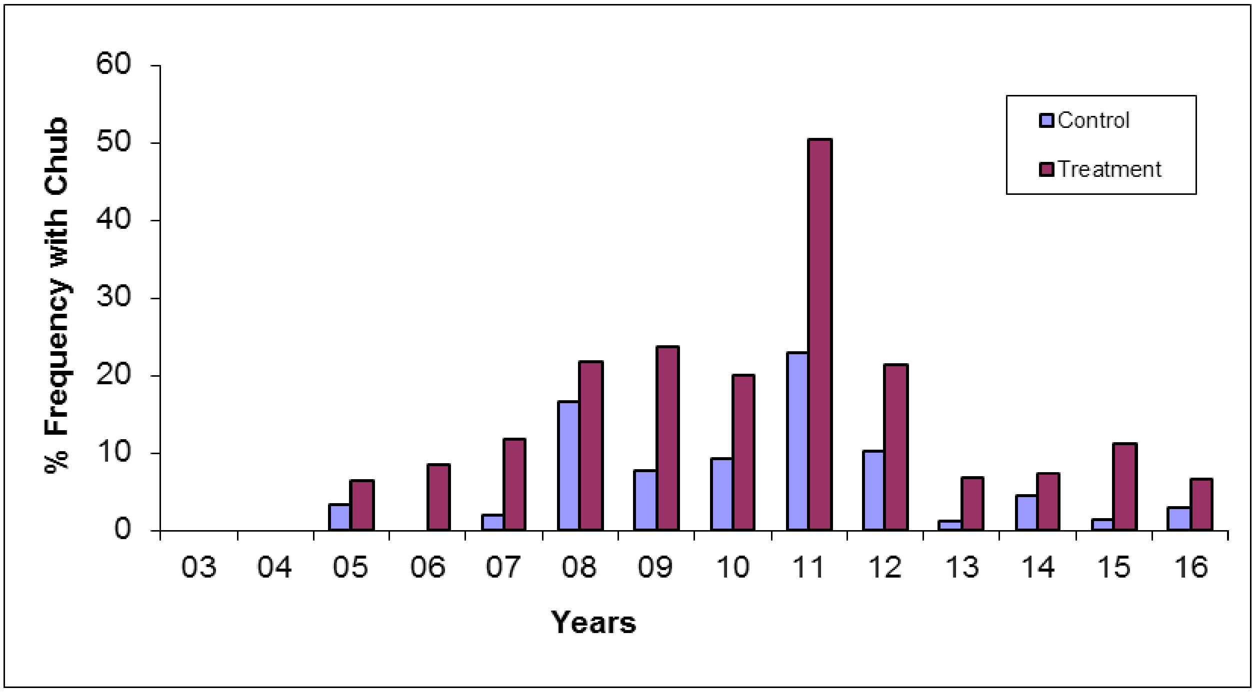

Figure 5. Frequency of roundtail chub in samples collected in the main channel Yampa River in the control (no age-0 smallmouth bass removal) and treatment (intensive age-0 smallmouth bass removal) reaches in Little Yampa Canyon, 2003-2016.

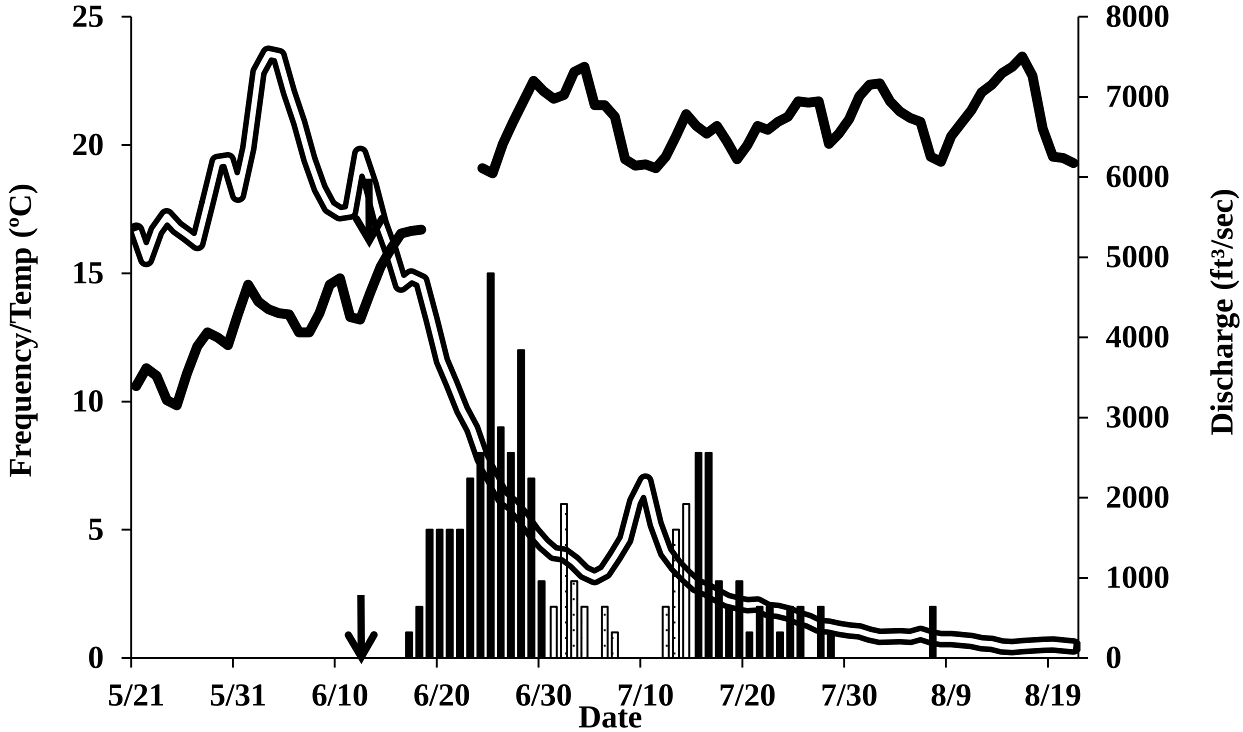

Figure 6. Distribution of hatching dates of smallmouth bass in the Yampa River, Colorado, 2015. The usual pattern of hatching dates results in a mound-shaped distribution. The flow spike on 10 July, and associated turbidity, likely resulted in reduced survival of smallmouth bass larvae produced before, during, and after that spike.