

I. Project Title: **Evaluation of Smallmouth Bass and Northern Pike management in the middle Yampa River.**

II. Bureau of Reclamation Agreement Number: R14AP00001  
*Performance Progress Reports (PPR) attached for CSU and FWS.*

Project/Grant Period: Start date: 10/01/2008  
End date: 09/30/2018  
Reporting period end date: 10/14/2017  
Is this the final report? Yes \_\_\_\_\_ No x

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IV. Abstract:  
This study was an evaluation of whether Smallmouth Bass *Micropterus dolomieu* numbers can be controlled through active removal from reaches of the Yampa River that are critical habitat for Colorado Pikeminnow *Ptychocheilus lucius*. The study area included 103.5 miles of the middle Yampa River from near Craig, Colorado (River Mile, RM 151.0) to Dinosaur National Monument (RM 47.5) and was divided into eight reaches. Boat electrofishing occurred on up to eight occasions (passes) from April through July using two electrofishing jon-boats or rafts that sampled both shorelines. Smallmouth Bass  $\geq 100$  mm were marked and released on one occasion in one reach (Little Yampa Canyon, RM 124.0-100.0) to estimate their abundance, to evaluate how the population responds to removal, and to monitor fish movement and growth. Using mark-recapture methods, we estimated 846 adult Smallmouth Bass (497—1194, 95% CI; CV=21%) inhabited Little Yampa Canyon in 2017, which is approximately equivalent to 2016, but substantially reduced from 2013 and 2014. We estimated that 3,149 sub-adult Smallmouth Bass (489—5,809, 95% CI; CV=43%) inhabited Little Yampa Canyon in 2017. Density in Little Yampa Canyon was 35 adult and 131 sub-adult Smallmouth Bass per mile. In addition to spring boat electrofishing, we removed 4,599 Smallmouth Bass using an electric seine from August through October in the lower 12 miles of Little Yampa Canyon. In total, we captured 10,533 Smallmouth Bass by all gears combined in all sampled reaches, including 6,028 juveniles (<100 mm), 2,858 sub-adults (100-199 mm), and 1,647 adults ( $\geq 200$  mm) in all reaches.

We also removed all Northern Pike from the middle Yampa River study area. Data for Northern Pike were provided to Colorado Division of Wildlife (CPW) biologists and those results are reported in Project # 98a. A final task was to remove adult Northern Pike from the reach between Steamboat Springs and Hayden (RM 194.2—170.6),

identify and prioritize spawning areas, and capture young pike to confirm reproduction and obtain daily otolith ages to pinpoint spawning dates. We removed 175 Northern Pike from the upper Yampa River including 148 captured on three sampling occasions using raft electrofishing and 27 captured using backpack electrofishing.

- V. Study Schedule: *Initial year-2003 Final year- on going.*
- VI. Relationship to RIPRAP:<sup>1</sup> Version: *April 22, 2014*  
Green River Action Plan: Yampa and Little Snake rivers
- III Reduce negative impacts of nonnative fishes and sport fish management activities  
(nonnative and sport fish management).
  - III.B Implement CPW Yampa Basin aquatic wildlife management plan and the Recovery Program’s Yampa River Nonnative Fish Control Strategy. Each control activity will be evaluated for effectiveness and then continued as needed. See also III.A.2.c.1&2 under General Recovery Program Support Action Plan.
    - III.B.1 Prevent nonnative fish introduction; reduce invasion and recruitment.
      - III.B.1.c Remove Northern Pike and Smallmouth Bass above Craig, CO (YS C-3).
      - III.B.1.D. Target spawning areas (YS C-4)
        - III.B.1.D.1 Northern Pike
        - III.B.1.D.2 Smallmouth Bass
      - III.B.2. Control nonnative fishes via mechanical removal.
        - III.B.2.a. Estimate nonnative abundance, status, trends & distribution (YS I-3).
        - III.B.2.c. Identify and evaluate gear types and methods to control nonnative fishes (YS I-5)
          - III.B.2.d. Remove and translocate Northern Pike from the Yampa River. See Hawkins et al 2005. (YS J-1).
          - III.B.2.d. Remove (*formerly* “and translocate”) Northern Pike from the Yampa River. See Hawkins *et al.* 2005. (YS J-1).
          - III.B.2.e. Remove (*formerly* "and translocate") Smallmouth Bass. (YS J-1).
- VII. Accomplishment of FY 2017 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:  
Initial findings and preliminary results for 2017 are provided in the attached Appendices, but are subject to change as data are further analyzed. For comparison with previous results see Hawkins *et al.* 2008; 2009a; 2009b; 2010; 2011; 2012; 2013, 2014, 2015, 2016 and Wright 2009.
- VIII. Additional noteworthy observations: See attached report of preliminary results.

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<sup>1</sup> See RIPRAP at [www.coloradoriverrecovery.org/documents-publications/foundational-documents/RIPRAP/RIPRAPApril2014Z.pdf](http://www.coloradoriverrecovery.org/documents-publications/foundational-documents/RIPRAP/RIPRAPApril2014Z.pdf)

IX. Recommendations:

Recommendations for middle Yampa Smallmouth Bass removal

- Continue mark-recapture efforts to estimate Smallmouth Bass abundance in Little Yampa Canyon.
- Continue Smallmouth Bass removal.
- Continue intensive Smallmouth Bass nest disruption (The Surge) focusing on major production areas, especially in Little Yampa Canyon, South Beach, Lower Juniper, and Upper Maybell.
- Reallocate effort to ensure removal during the spawning period in Upper Maybell.
- Continue using raft EL into the base flow period to increase removal of sub-adult bass.

Recommendations for upper Yampa River Northern Pike removal

- Continue to focus Northern Pike removal in backwaters using raft electrofishing.
- Increase the use of gill and fyke nets in backwaters as appropriate.
- Postpone marking Northern Pike for abundance until 2019.
- Identify spawning period with collection of YOY pike for daily otolith aging.
- Extend removal to a 4th pass during higher flows to confirm the end of spawning.
- Collect attribute data for spawning areas and compile descriptive GIS maps.

X. Project Status: on track and ongoing

XI. FY 2017 Budget Status

A. Funds Provided:	\$415,280
CSU:	\$377,451
FWS-Vernal:	\$21,318
FWS-Grand Junction:	\$16,511
B. Funds Expended:	\$415,280
C. Difference:	\$0
D. Percent of the FY 2017 work completed, and projected costs to complete:	100%
E. Recovery Program funds spent for publication charges:	none

XII. Status of Data Submission (Where applicable): Endangered fish capture data and other database records of field collections will be submitted by early 2018.

XIII. Signed: John Hawkins                      11/14/17  
Principal Investigator                      Date

APPENDICES:

Annual Performance Progress Reports (3)

A: Preliminary Results of Smallmouth Bass removal in the middle Yampa River, 2017

B: Preliminary results of Northern Pike removal in the upper Yampa River, 2017.

## ANNUAL PERFORMANCE PROGRESS REPORT (PPR)

BUREAU OF RECLAMATION AGREEMENT NUMBER: R14AP00001

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: FR-125

Project Title: **Evaluation of Smallmouth Bass and Northern Pike management in the middle Yampa River.**

Principal Investigator: John Hawkins.

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Project/Grant Period:           Start date (Mo/Day/Yr): 1 Oct. 2008  
  End date: (Mo/Day/Yr): 30 Sept. 2018  
  Reporting period end date: 14 Nov. 2017  
  Is this the final report? Yes \_\_\_\_\_ No X

Performance: The Larval Fish Laboratory completed all tasks and objectives of the Smallmouth Bass portion of this work. We obtained an estimate of the number of Smallmouth Bass in Little Yampa Canyon. We coordinated Surge sampling with CPW and USFWS. We conducted one marking pass in Little Yampa Canyon and eight and five passes in Little Yampa Canyon and Lily Park study reaches, respectively. We assisted Colorado Parks and Wildlife in sampling South Beach and Lower Juniper reaches. We removed large numbers of invasive nonnative predators from Critical Habitat on multiple occasions from April through October. We conducted three removal passes for Northern Pike between Steamboat Springs and Highway 40 Bridge and sampled for YOY pike to confirm spawning locations. We produced an annual report on activities in 2017 and plan to present data at meetings in January 2018.

## ANNUAL PERFORMANCE PROGRESS REPORT

BUREAU OF RECLAMATION AGREEMENT NUMBER: R15PG00083

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: 125

Project Title: Middle Yampa smallmouth bass and northern pike removal

Principal Investigator:

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Project/Grant Period:

Start date: 10/01/2014

End date: 09/30/2019

Reporting period end date: 09/30/2017

Is this the final report? Yes \_\_\_\_\_ No  X

Performance:

US Fish & Wildlife Service completed our share of the project (conducting smallmouth bass removal and spawning disruption during the spawning period). We contributed personnel and equipment to address this task for two weeks in July. We submitted data to CSU-LFL, who will compile, analyze, and report on the results.

## ANNUAL PERFORMANCE PROGRESS REPORT (PPR)

BUREAU OF RECLAMATION AGREEMENT NUMBER: R15PG00083

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: 125

Project Title: **Evaluation of Smallmouth Bass and Northern Pike Management in the Middle Yampa River (Surge)**

Principal Investigator: Travis Francis, Fish Biologist  
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Project/Grant Period: Start date (Mo/Day/Yr): 10/1/2014  
End date: (Mo/Day/Yr): 9/30/2019  
Reporting period end date (Mo/Day/Yr): 9/30/2017  
Is this the final report? Yes \_\_\_\_\_ No  X

### Performance:

We were tasked with providing a 3-person field crew for 8 days (total of 24 man days) with administrative support to assist crews from the CSU – Larval Fish Laboratory sometime from mid-June to mid-July. The 2017 smallmouth bass “Surge” effort was targeted to remove smallmouth bass as the Yampa River neared base flows. From July 10-14, we provided two jet-powered, hard-bottomed, electrofishing boats and a 4-person crew for 5 days (20 man days). Then from July 17-20, we provided two electrofishing rafts and a 4-person crew for 5 days (20 man days).

Appendix A:

**Preliminary results of the removal of Smallmouth Bass from the middle Yampa River, 2017.**

Hawkins, J. (CSU), C. Walford, (CSU), D. Tuttle III (CSU) and T. Eyre (CPW).

**Methods-Middle Yampa SMB removal**

The study area was primarily within a 103.5-mile reach of the middle Yampa River, between Craig, Colorado (river mile; RM 151.0) and Dinosaur National Monument boundary (RM 47.5) and consisted of eight reaches totaling 96.1 miles of sampled waters. These reaches were sampled by Colorado Parks and Wildlife (CPW) and Colorado State University-Larval Fish Laboratory (CSU). An additional study area included a 16.5-mile section between Hayden and Craig, Colorado sampled by US Fish and Wildlife Service (FWS). Smallmouth Bass data collected by those agencies are summarized in this report.

Location of study reaches in the middle Yama River.

<u>Reach</u>	<u>Agency</u>	<u>RM</u>	<u>Area sampled (miles)</u>
Lily Park	CSU	47.5 -- 55.5	8.0
Sunbeam	CPW	60.6 -- 71.0	10.4
Lower Maybell	CPW	71.0 -- 79.2	8.2
Upper Maybell	CPW	79.2 – 88.7	9.5
Lower Juniper	CPW	91.0 – 100.0	9.0
Little Yampa Canyon	CSU	100.0 – 124.0	24.0
South Beach	CPW	124.0 – 134.5	10.5
Hayden-Craig	FWS	134.5-151.0	16.5

Fish sampling occurred with boat electrofishing on up to eight occasions (passes) at each reach during runoff from April through July, typically using two electrofishing boats sampling both shorelines continuously downstream. Reaches with higher catch rates received greater effort through more passes. Smallmouth Bass were removed from all reaches except on one pass in Little Yampa Canyon when they were marked and released, primarily to track abundance, but also to monitor movement and growth. On that marking pass, Smallmouth Bass  $\geq 100$ -mm total length were marked with a numbered Floy tag and released. On all other passes in Little Yampa Canyon, and in other reaches, Smallmouth Bass were removed and euthanized upon capture. The primary CSU study sites were Little Yampa Canyon and Lily Park, where all species of fish were captured and measured on all sample occasions to describe and monitor fish community structure and composition.

Smallmouth Bass were assigned to life stages based on their length: juvenile ( $< 100$  mm), sub-adult (100–199 mm), and adult ( $\geq 200$ -mm). Another grouping was created for large piscivorous Smallmouth Bass ( $\geq 325$ -mm) that are considered the highest predatory threat to prey.

We removed other invasive nonnative species including Northern Pike, White Sucker, white sucker hybrids, centrarchids, Black Bullhead, Creek Chub, and Common Carp. Northern Pike data were reported by CPW in their annual report for Project # 98a.

### **Spawning disruption (The Surge)**

In 2017, we completed the eighth year of an intensive removal program (The Surge) targeting spawning bass within Craig, South Beach, Little Yampa Canyon, and Lower Juniper. The goal was to remove large numbers of adult bass and reduce reproductive success by disrupting nest building, spawning, and nest guarding. Field crews and equipment from FWS (Vernal and Grand Junction) assisted with Surge sampling. During the Surge, as flows declined towards base flow, we optimized our catch rates by focusing on reaches with known spawning habitat. Targeted spawning areas included braided river sections, backwaters, scour holes, or pools below debris fans. We used water temperatures of 16°C as the indicator when Smallmouth Bass begin spawning and in 2017 that occurred June 20<sup>th</sup>. Spawning removal occurred from June 27<sup>th</sup> through July 20<sup>th</sup> in Craig, South Beach, Little Yampa Canyon, and Lower Juniper reaches. Fish were removed in target reaches every 2-5 days and some spawning sites were visited up to four times. As flows declined to levels too low for safe Jon-boat navigation (approximately 750 cfs), we shifted to electrofishing rafts.

### **Age-0 Smallmouth Bass removal**

After bass spawning ended, we sampled with an electric seine from August through October and removed primarily Age-0 Smallmouth Bass in a 12-mile Treatment reach in Little Yampa Canyon. An adjacent 12-mile reach in Little Yampa Canyon is a Control reach for Project 140 (“Evaluating the effects of nonnative predator fish removal on the native fishes in the Yampa River”). In addition, we sampled with seines and backpack electrofishing in several habitat types every 5-miles from Craig to lower Cross Mountain Canyon (RM 145—55.5) to determine the relative abundance and distribution of the small-bodied fish community.

### **Results-Middle Yampa SMB removal**

#### **Smallmouth Bass abundance and exploitation**

Using a Lincoln-Petersen model, we estimated 846 adult Smallmouth Bass (497—1194, 95% CI; CV=21%) inhabited Little Yampa Canyon in 2017 (Table 1; Figure 1). We estimated that 3,149 sub-adult Smallmouth Bass (489—5,809, 95% CI; CV=44%) inhabited Little Yampa Canyon in 2017. In 2017, densities of Smallmouth Bass in Little Yampa Canyon were 35 adults and 131 sub-adults per mile (Table 1). Due to poor flow and weather conditions during our initial recapture pass (Pass 4), we had low catch rates that resulted in the capture of only 29 fish >100 mm TL including only three recaptured fish. The next pass (Pass 5) had better conditions and higher, more typical catch rates, so we combined Passes 4 and 5 into a single recapture pass for abundance estimation. Abundance of adult Smallmouth Bass was among the three lowest of the past 14 years (Figure 1). While slightly higher than the 611 adults observed in 2015, and similar to the 882 observed in 2016, the population in Little Yampa Canyon has greatly declined even after the strong year class produced in 2012 that reached adult size in 2014 when 2,254 adults were present in the reach (Figure 1).

Of 117 marked and released adult Smallmouth Bass, 11% (n=24) were recaptured and removed during the entire study period in 2017. Of the 209 sub-adult Smallmouth Bass marked, 27% (n=32) were recaptured and removed during the study period in 2017. Some of these recaptures occurred after the recapture pass and were not used in the Lincoln-Petersen estimate.



### **Exploitation Rates**

We used the number of fish removed by boat electrofishing on all passes divided by the abundance estimate to obtain the exploitation rate of Smallmouth Bass in Little Yampa Canyon. We removed 22% (n=695) of sub-adult and 44% (n=370) of adult Smallmouth Bass from Little Yampa Canyon in 2017 (Table 1).

### **Fish removal effort**

In 2017, we sampled a total of 609.6 hours with boat and raft electrofishing from April through July. Most of that effort occurred in Little Yampa Canyon (251.1 hrs). Other sites with high effort included South Beach (73.2 hrs) and Upper Maybell (64 hrs; Table 2). The other reaches had much lower effort devoted to removing Smallmouth Bass. In Craig, only Surge passes were reported here; several passes prior to the Surge were reported in the FWS Annual report for Project 98b. Last year a primary recommendation was to increase effort at Upper Maybell and that was accomplished in 2017 when effort increased almost three fold from two passes and 22.6 hours of electrofishing in 2016 to seven passes and 64 hours of electrofishing in 2017. We suggest shifting some of the additional effort in the upper Maybell Reach into the spawning period. In Little Yampa Canyon, we angled 86.3 man-hours in 9 days. Six electric-seine (E-Seine) sample passes occurred from August through October for 29.5 hours of effort, similar to the 22.6 hours expended in 2016.

### **Captures by gear type**

We captured 10,533 Smallmouth Bass, including 5,385 captured by boat electrofishing, 549 captured by angling, and 4,599 captured by electric seine (Table 3). We marked and released less than 3% (n=326) of all Smallmouth Bass captured.

We captured fewer large piscivore Smallmouth Bass ( $\geq 325$  mm TL) in 2017 than in prior years. Only 0.3% (n=17) of the total boat electrofishing catch (n=5,385) were large piscivores, compared to about 1% in 2016. In 2017, the percent of piscivores in each reach was very low (<1%), suggesting that larger fish are being suppressed by removal.

During the Surge we increased our effort significantly within a short period of time in known spawning reaches (Craig, South Beach, Little Yampa Canyon, and Lower Juniper). Surge sampling was highly effective because Smallmouth Bass are very territorial and during spawning typically remain near their nests in shallow water where they are highly susceptible to the electrofishing gear. By removing spawning fish from active spawning sites we open habitat to new spawners who are then available for capture on our next pass. When possible we allowed 2-5 days between removal passes for these areas to refill with new fish and then resampled them to remove another wave of spawners. Sampling during spawning was an effective method for obtaining high catch rates of adult bass and disrupting the production of new bass.

At base flow, bass were readily captured with raft electrofishing in backwaters and in outer bends with boulder or rubble cover. Groups of sub-adult and small adult Smallmouth Bass were captured in short, deep backwaters where they were apparently preying on abundant small fishes. Although sub-adult catch rates were lower than past years during the Surge, we still captured a large percent of the total of sub-adults during the Surge. For example, 68% of all sub-adults captured in Little Yampa Canyon, were captured during the Surge. We recommend the continued use of electrofishing rafts to exploit high capture rates of sub-adult Smallmouth Bass during lower flows.

### **Catch Rates- boat electrofishing**

Smallmouth Bass occupy all reaches of the middle Yampa River and catch rates reflect a combination of fish density and sampling conditions on any given pass. We captured 26% fewer Smallmouth Bass with boat electrofishing in 2017 (n=5385) than in 2016 (n=7249). Catch rates or catch per unit effort for adult Smallmouth Bass ( $\geq 200$  mm) captured by boat electrofishing were highest in Upper Maybell (6.3 fish/hr) and Lily Park (4.2 fish/hr). Catch rates were lower in Lily Park compared to 2016 (12 fish/hr) partly because significantly fewer Smallmouth Bass were captured in 2017, but also because on three of the five passes we used techniques that targeted Colorado pikeminnow (Table 2; Figure 2). Sampling techniques that target Colorado Pikeminnow typically require that the electrofishing boat moves with the current downstream, whereas, techniques that target Smallmouth Bass require that the boat moves much slower than the current and works closer to the shore. Passes that targeted Colorado Pikeminnow would reduce catch rates for Smallmouth Bass. Highest catch rates for sub-adult bass were in Upper Maybell (6.7 fish/hr), and Lily Park (4.9 fish/hr), and Craig (4.4 fish/hr; Table 2; Figure 3). Juvenile Smallmouth Bass ( $<100$  mm) catch rate was highest in Craig (7.8 fish/hr) followed by Little Yampa Canyon (3.4 fish/hr) and Lily Park (3.4 fish/hr; Table 2; Figure 3). There is little spawning habitat in Lily Park, so high juvenile abundance there reflects reproduction and dispersal from other reaches.

### **Catch Rates-electric seine**

We captured fewer juvenile Smallmouth Bass with E-seine in 2017 (n=4,417) compared to 2016 (n=6112), even though sampling effort was slightly higher in 2017 with 29.5 hours compared to 26.3 hours in 2016. It appears that year-class-strength was poor in 2015 and 2016, based on few age-1 Smallmouth bass captured in 2016 and 2017, respectively. Environmental effects from flash floods in 2015 had a potentially large effect on success of nesting bass. Contrast this to the strong year classes produced in 2012 and 2013 that persisted up until age 3 (Figure 4). However; even those strong year classes did not persist after age-3, possibly because boat electrofishing catch rates were high for those larger-sized fish.

### **Spawning observations**

Spawning started around June 20 and continued into late July based on adequate habitat, water temperatures, capture of ripe males and females in spawning habitat. Smallmouth Bass were observed or captured over nesting-type habitat in all Surge reaches.

### **Fish Community Sampling**

During nonnative fish removal sampling, we also collected and measured all fish species on all sampling occasions in Little Yampa Canyon and Lily Park. Of significance is the addition of two nonnative species, White Crappie and Yellow Perch (Table 4). Nonnative fish still dominate the fish community, comprising 98% of all fish collected in Little Yampa Canyon, about the same as in 2015 and 2016 (Table 4). Smallmouth Bass and white suckers were the most abundant fishes collected in Little Yampa Canyon. At Lily Park, the most abundant fish captured was native Flannelmouth Sucker comprising 57% of all fish captured, compared to 33% in 2016. This increase reflects that sampling techniques on three occasions targeted Colorado Pikeminnow and Flannelmouth Sucker were more vulnerable to capture using those techniques. For example, Flannelmouth Sucker relative abundance was 67%, 70%, and 76% on Passes 1, 2, and 4, respectively, when the techniques targeted Colorado Pikeminnow. On Passes 3 and 5, when

techniques targeted Smallmouth Bass, relative abundance of Flannemouth Sucker was 31% and 49%, respectively. Because of those high catch rates for Flannemouth Sucker, native fishes comprised 63% of the fish community at Lily Park in 2017, compared to 32% in 2016 (Table 5). Native species comprised less than 2% of the fish community in Little Yampa Canyon, while in Lily Park, native species comprised 63% of the fish community and persist even in the presence of high densities of Smallmouth Bass (Table 5). We captured two Colorado Pikeminnow in Lily Park by electrofishing.

Northern Pike: We shared our Northern Pike data with CPW and it is reported descriptive statistics for Northern Pike that we captured are reported by CPW in their annual report. Of note is a strong 2015 cohort of Northern Pike observed as young-of-year between 75 and 250 mm total length during 2015 sampling. That cohort remained strong in 2016 when they were between 300 and 450 mm TL, but by 2017 there were few remaining (Figure 5).

### **Recommendations for Middle Yampa Smallmouth Bass**

- Continue mark-recapture efforts to estimate Smallmouth Bass abundance in Little Yampa Canyon.
- Continue Smallmouth Bass removal.
- Continue intensive Smallmouth Bass nest disruption (The Surge) focusing on major production areas, especially in Little Yampa Canyon, South Beach, Lower Juniper, and Upper Maybell.
- Reallocate effort to insure removal during the spawning period in Upper Maybell.
- Continue using raft EL into the base flow period to increase removal of sub-adult bass.

### **Acknowledgements**

We thank field crews that assisted with collections. CSU field crew included Carli Baum, Kyle Dick, Drew Ebner, Erik Cristan, Robert Garza, Aly Hink, Kalli Jimmie, Benjamin Kinne, Katherine Lawry, Lance Ostrom, and Jessica Sannwaldt. We thank biologists Ben Felt (CPW, Grand Junction) for loaning us equipment. We thank Travis Francis (FWS, Grand Junction) and Christian Smith (FWS, Vernal, Utah) and their crews for sampling assistance. We thank Kevin McAbee (FWS) for reviewing this report.

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Wright, B. 2009. Middle Yampa River northern pike removal and evaluation: Smallmouth Bass evaluation and limited removal. Project 98a. 2008 Annual Report to the Colorado River Endangered Fish Recovery Program, U. S. Fish and Wildlife Service.

Table 1--- Abundance estimates for sub-adult (100-199 mm) and adult ( $\geq 200$  mm) Smallmouth Bass in 24-mile long Little Yampa Canyon, Yampa River, 2017. Abundance estimated using a Lincoln-Petersen estimator. SE = Standard Error. CV= Coefficient of Variation. Exploitation rate (% removed) calculated as the percent of Smallmouth Bass removed from Little Yampa Canyon by boat electrofishing after the marking passes were completed.

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Life Stage	Abundance	lower – upper 95% CI	SE	CV %	Density #fish/mile	# removed	% removed
Sub-adult	3149	489—5809	1356.9	43	131	695	22%
Adult	846	497—1194	177.8	21	35	370	44%

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Table 2—CPUE (Catch per unit effort) for Smallmouth Bass captured by boat electrofishing, angling, and electric seine (E-Seine) in the middle Yampa River, 2017. Life stages were based on length: juvenile (<100 mm), sub-adult (100-199 mm), and adult (≥200 mm).

<b>Hayden-Craig</b>				Number of fish				CPUE (# fish/hr)			
Pass	Sampling Period	Agency	Effort (Hrs)	Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1-Surge	Jul 10-11	FWS	12.8	66	57	24	147	5.2	4.5	1.9	11.5
2-Surge	Jul 12-13	FWS	12.0	155	68	12	235	12.9	5.7	1.0	19.6
3-Surge	Jul 18-19	FWS	9.2	45	23	6	74	4.9	2.5	0.7	8.1
Total			34.0	266	148	42	456	7.8	4.4	1.2	13.4

<b>South Beach</b>				Number of fish				CPUE (# fish/hr)			
Pass	Sampling Period	Agency	Effort (Hrs)	Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	Apr 16-17	CSU	8.3	--	--	--	--	--	--	--	--
2	May 31	CPW	8.8	11	48	18	77	1.3	5.5	2.1	8.8
3	Jun 7	CPW	10.1	5	5	13	23	0.5	0.5	1.3	2.3
4	Jun 13	CPW	6.7	--	2	5	7	0.0	0.3	0.7	1.0
5	Jun 16	CPW	9.1	7	11	19	37	0.8	1.2	2.1	4.1
6-Surge	Jun30-Jul9	CSU	11.7	60	96	86	242	5.1	8.2	7.3	20.6
7-Surge	Jul 12-13	CSU	4.6	14	52	30	96	3.0	11.3	6.5	20.9
8-Surge	Jul 18-19	CSU	13.9	18	46	11	75	1.3	3.3	0.8	5.4
Total			73.2	115	260	182	557	1.6	3.6	2.5	7.6

<b>Little Yampa Canyon-EL Boat</b>				Number of fish				CPUE (# fish/hr)			
Pass	Sampling Period	Agency	Effort (Hrs)	Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1-CS	Apr 12-18	CSU	23.3	--	--	7	7	--	--	0.3	0.3
2	Apr 25-30	CSU	24.3	19	3	11	33	0.8	0.1	0.5	1.4
3-Mark	May 9-11	CSU	32.9	84	212	122	418	2.6	6.4	3.7	12.7
4-Recap	May 16-21	CSU	32.1	56	18	11	85	1.7	0.6	0.3	2.6
5-Recap	Jun 2-16	CSU	47.9	291	60	110	461	6.1	1.3	2.3	9.6
6-Surge	Jun27-Jul1	CSU	16.6	20	74	132	226	1.2	4.5	7.9	13.6
7-Surge	Jul 8-13	CSU	47.0	245	308	90	643	5.2	6.6	1.9	13.7
8-Surge	Jul 18-20	CSU	27.0	148	232	9	389	5.5	8.6	0.3	14.4
Total			251.1	863	907	492	2262	3.4	3.6	2.0	9.0

Table 2-cont.

**Little Yampa Canyon-E-Seine**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	Aug8-15	CSU	6.6	764	39	--	803	115.2	5.9	0.0	121.1
2	Aug22-28	CSU	6.9	1017	63	--	1080	146.4	9.1	0.0	155.5
3	Sep 6-11	CSU	4.9	1075	21	1	1097	220.3	4.3	0.2	224.8
4	Sep 21-26	CSU	7.8	1396	53	1	1450	179.5	6.8	0.1	186.5
5*	Oct 5-6	CSU	1.3	11	3	--	14	8.6	2.3	0.0	10.9
6	Oct 17	CSU	2.0	154	1	--	155	77.3	0.5	0.0	77.8
Total			29.5	4417	180	2	4599	149.7	6.1	0.1	155.9

\*Pass 5 E-Seine sampling included Isolated Pools where few bass occur.

**Little Yampa Canyon-Angling**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	Aug 11-13	CSU	30	--	99	44	143	--	3.3	1.47	4.77
2	Aug 24-26	CSU	35	--	233	53	286	--	6.66	1.51	8.17
3	Sep 7-9	CSU	21.25	3	85	32	120	0.14	4	1.51	5.65
Total			86.25	3	417	129	549	0.03	4.83	1.50	6.37

**Lower Juniper**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	Apr 14-15	CSU	7.9	--	2	--	2	--	0.3	--	0.3
2-CS	May16-21	CSU	10.0	1	2	11	14	0.1	0.2	1.1	1.4
3	Jun 14	CPW	10.2	8	11	17	36	0.8	1.1	1.7	3.5
4-Surge	Jun 28-29	CSU	9.4	39	104	74	217	4.1	11.0	7.8	23.0
5-Surge	Jul 7-13	CSU	11.5	43	62	36	141	3.7	5.4	3.1	12.3
Total			49.1	91	181	138	410	1.9	3.7	2.8	8.4

**Upper Maybell**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	May 3	CPW	10.6	6	14	50	70	0.6	1.3	4.7	6.6
2	May 10	CPW	11.3	18	138	148	304	1.6	12.2	13.0	26.8
3	May 12	CPW	3.9	7	60	31	98	1.8	15.6	8.0	25.4
4	May 17-23	CPW	11.1	22	121	68	211	2.0	10.9	6.1	19.0
5	Jun 1	CPW	8.6	11	31	34	76	1.3	3.6	3.9	8.8
6	Jun 6	CPW	9.6	5	32	35	72	0.5	3.3	3.7	7.5
7	Jun 15	CPW	9.0	11	35	37	83	1.2	3.9	4.1	9.3
Total			64.0	80	431	403	914	1.2	6.7	6.3	14.3

Table 2—cont.

**Lower Maybell**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	May 1	CPW	8.4	3	5	7	15	0.4	0.6	0.8	1.8
2	May 5	CPW	7.8	2	4	8	14	0.3	0.5	1.0	1.8
3	May 11	CPW	9.5	16	47	13	76	1.7	4.9	1.4	8.0
4	May 24	CPW	8.3	7	14	9	30	0.8	1.7	1.1	3.6
5	Jun 2	CPW	6.6	2	9	12	23	0.3	1.4	1.8	3.5
6	Jun 9	CPW	9.0	15	19	17	51	1.7	2.1	1.9	5.7
Total			49.7	45	98	66	209	0.9	2.0	1.3	4.2

**Sunbeam**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1	May 4	CPW	9.5	1	---	---	1	0.1	--	--	0.1
2	May 9	CPW	9.4	8	10	11	29	0.8	1.1	1.2	3.1
3	May 16	CPW	11.1	1	18	6	25	0.1	1.6	0.5	2.3
4	May 30	CPW	8.6	3	7	4	14	0.4	0.8	0.5	1.6
5	Jun 8	CPW	10.5	2	9	5	16	0.2	0.9	0.5	1.5
Total			49.1	15	44	26	85	0.3	0.9	0.5	1.7

**Lily Park**

Pass	Sampling Period	Agency	Effort (Hrs)	Number of fish				CPUE (# fish/hr)			
				Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes
1-CS	May 1-2	CSU	7.4	--	2	6	8	--	0.3	0.8	1.1
2-CS	May 22-23	CSU	8.8	1	14	54	69	0.1	1.6	6.1	7.8
3	Jun 1	CSU	5.1	50	74	35	159	9.8	14.5	6.9	31.2
4-CS	Jun 13-14	CSU	8.2	2	28	32	62	0.2	3.4	3.9	7.6
5	Jun 17-18	CSU	10.0	80	74	40	194	8.0	7.4	4.0	19.3
Total			39.5	133	192	167	492	3.4	4.9	4.2	12.5

**Totals by Gear Type**

Gear	Sampling Period	Effort (Hrs)	Number of fish				CPUE (# fish/hr)				
			Juv	Sub-adult	Adult	All sizes	Juv	Sub-adult	Adult	All sizes	
EL-Boat	Apr-Jul	609.6	1608	2261	1516	5385	2.6	3.7	2.5	8.8	
Angling	July-Sept	86.3	3	417	129	549	0.03	4.8	1.5	6.4	
E-Seine	July-Oct	29.5	4417	180	2	4599	47.7	6.1	0.1	53.9	
Grand Total			--	6028	2858	1644	10533	--	--	--	--



Table 3— Number of Smallmouth Bass captured in the middle Yampa River, 2017. Includes 326 Smallmouth Bass marked and released in Little Yampa Canyon for abundance estimation.

Reach	Number of fish		
	Boat electrofishing	Angling	E-Seine
Craig	456		
South Beach	557		
Little Yampa Canyon	2262	549	4599
Lower Juniper	410		
Upper Maybell	914		
Lower Maybell	209		
Sunbeam	85		
Lily Park	492		
Total	5385	549	4599

Table 4---Number and relative abundance of fish captured by boat electrofishing in Little Yampa Canyon, Yampa River, Colorado, 2017. Released bass were marked with Floy tags and released for estimating abundance, movement, and growth.

	Removed	Released	Total	Relative Abundance (%)
<b><i>nonnative species</i></b>				
Smallmouth Bass	1928	334	2262	33.52
Northern Pike	51	-	51	0.76
White Sucker	3970	-	3970	58.83
White X Flannelmouth Sucker	9	-	9	0.13
White X Bluehead Sucker	24	-	24	0.36
Creek Chub	171	-	171	2.53
Green Sunfish	37	-	37	0.55
Rainbow Trout	2	22	24	0.36
Brown Trout	-	65	65	0.96
Black Bullhead	6	-	6	0.09
Black Crappie	6	-	6	0.09
White Crappie	1	-	1	0.01
Channel Catfish	-	1	1	0.01
Common Carp	2	-	2	0.03
Brook Stickleback	1	-	1	0.01
Fathead Minnow	-	2	2	0.03
Yellow Perch	1	-	1	<u>0.01</u>
Total nonnatives			6633	98.30%
<b><i>native species</i></b>				
Bluehead Sucker	-	37	37	0.55
Flannelmouth Sucker	-	13	13	0.19
Speckled Dace	-	10	10	0.15
Mountain Whitefish	2	43	45	0.67
Mottled Sculpin	1	4	5	0.07
Roundtail Chub	-	5	5	<u>0.07</u>
Total native			115	1.70%
Total number of fish	6212	536	6748	100.00%

Table 5---Number and relative abundance of fish captured by boat electrofishing in Lily Park, Yampa River, Colorado 2017.

	Removed	Released	Total	Relative Abundance (%)
<b><i>nonnative species</i></b>				
Smallmouth Bass	492	-	492	20.51
Northern Pike	26	-	26	1.08
White Sucker	322	-	322	13.42
White X Flannelmouth Sucker	8	-	8	0.33
White X Bluehead Sucker	6	-	6	0.25
Green Sunfish	2	-	2	0.08
Black Bullhead	1	-	1	0.04
Channel Catfish	-	23	23	0.96
Common Carp	8	-	8	0.33
Total nonnative			888	37.02%
<b><i>native species</i></b>				
Bluehead Sucker	-	123	123	5.13
Flannelmouth Sucker	-	1358	1358	56.61
Mountain Whitefish	-	1	1	0.04
Roundtail Chub	-	27	27	1.13
Colorado Pikeminnow	-	2	2	0.08
Total native			1511	62.98%
Total number	865	1534	2399	100.00%

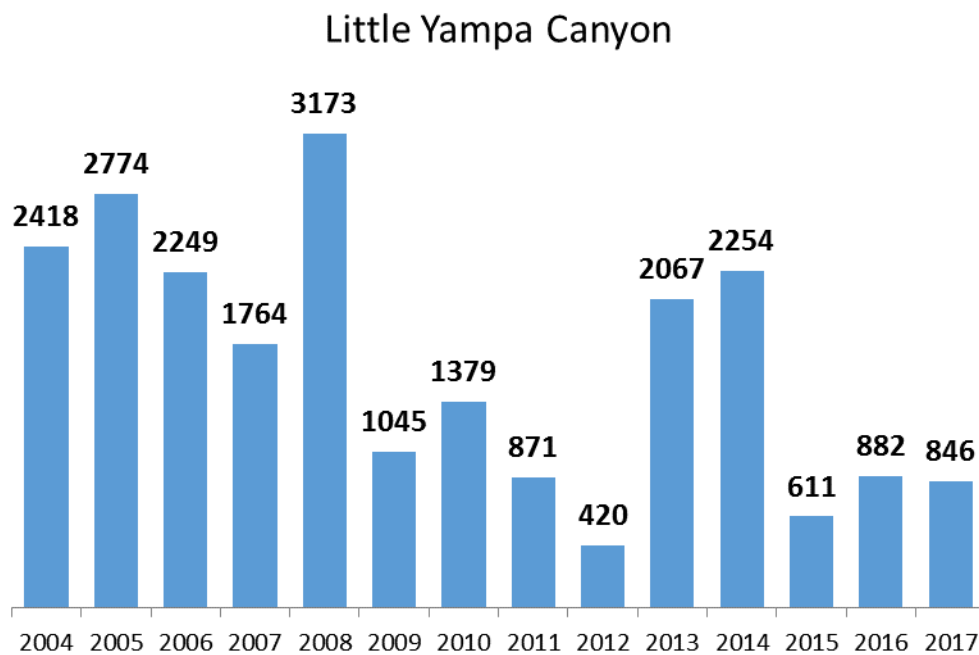


Figure 1---Estimated abundance of adult Smallmouth Bass ( $\geq 200$  mm) in Little Yampa Canyon, Yampa River, 2004—2017. Abundance estimated with a modified Lincoln-Peterson estimator.

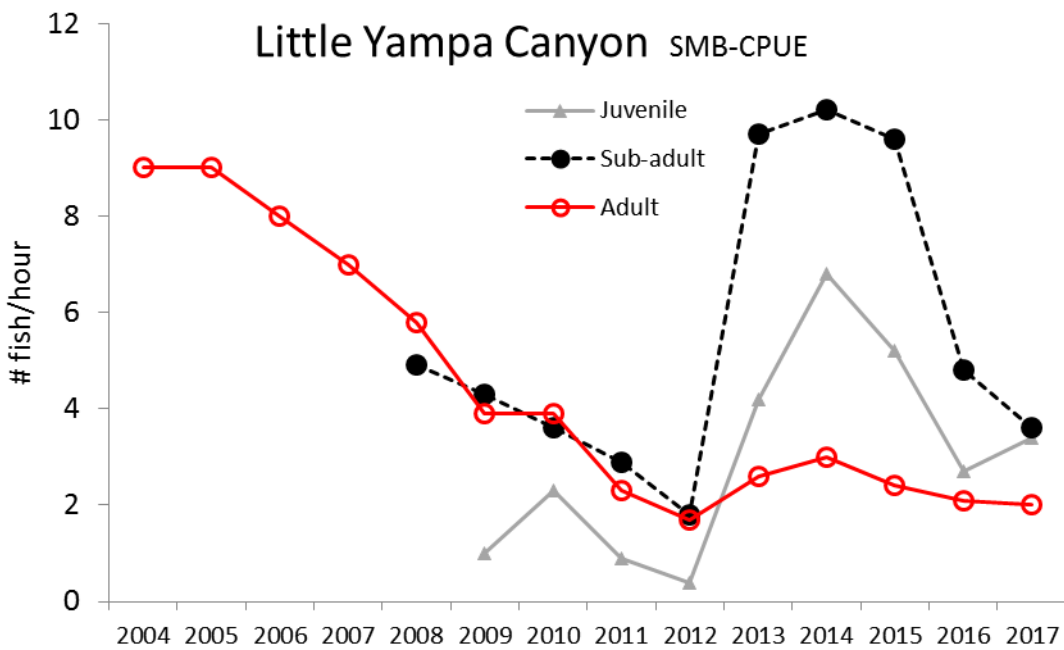
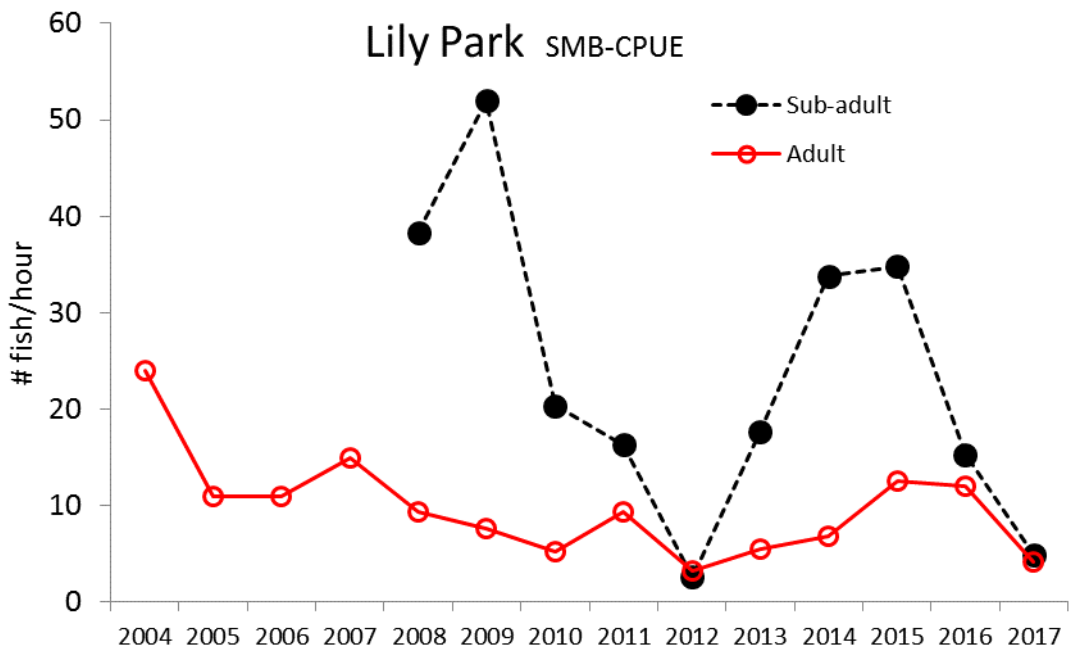


Figure 2—Number of juveniles (<100 mm; Little Yampa Canyon only), sub-adult (100-199 mm), and adult ( $\geq 200$  mm) Smallmouth Bass captured per hour of boat electrofishing in two reaches of the Yampa River, 2004-2017.

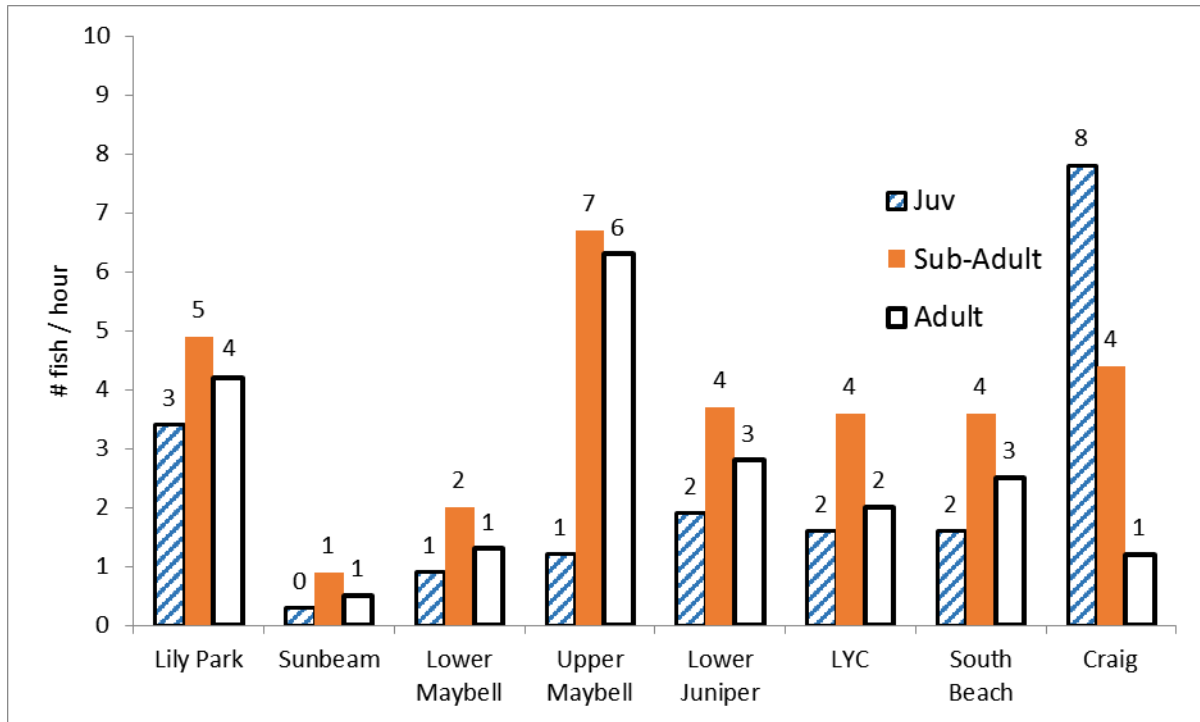


Figure 3—Catch per unit effort along a longitudinal gradient of the middle Yampa River, 2017.

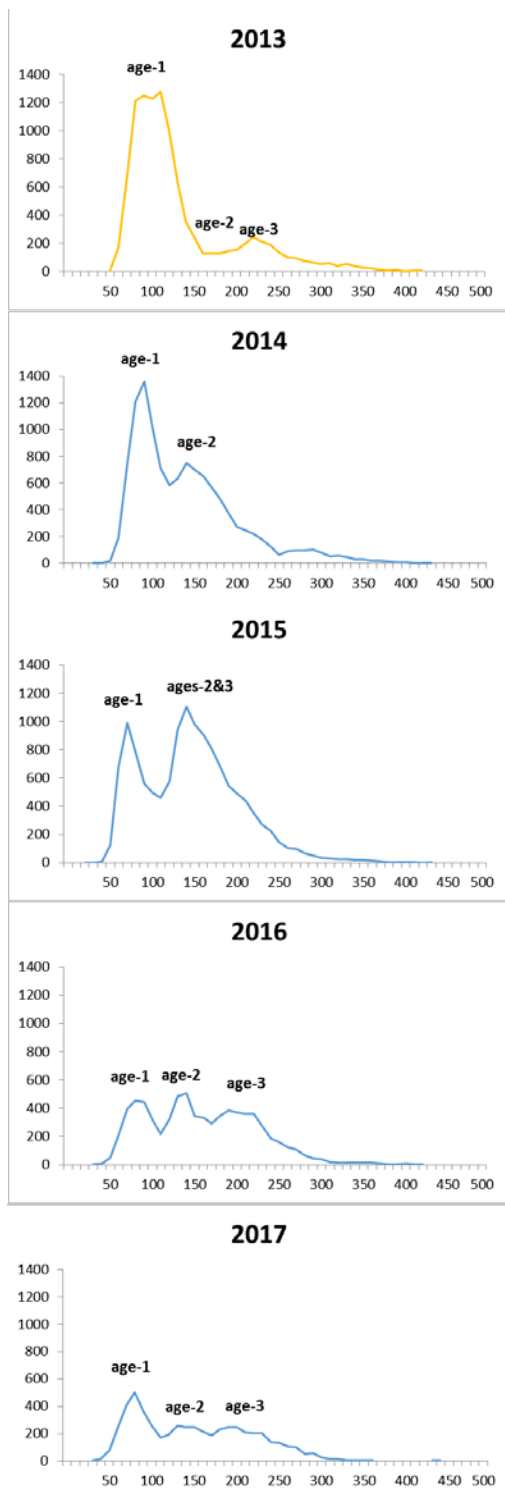


Figure 4—Annual length-frequency of Smallmouth Bass captured by boat electrofishing in the middle Yampa River, 2013-2017.

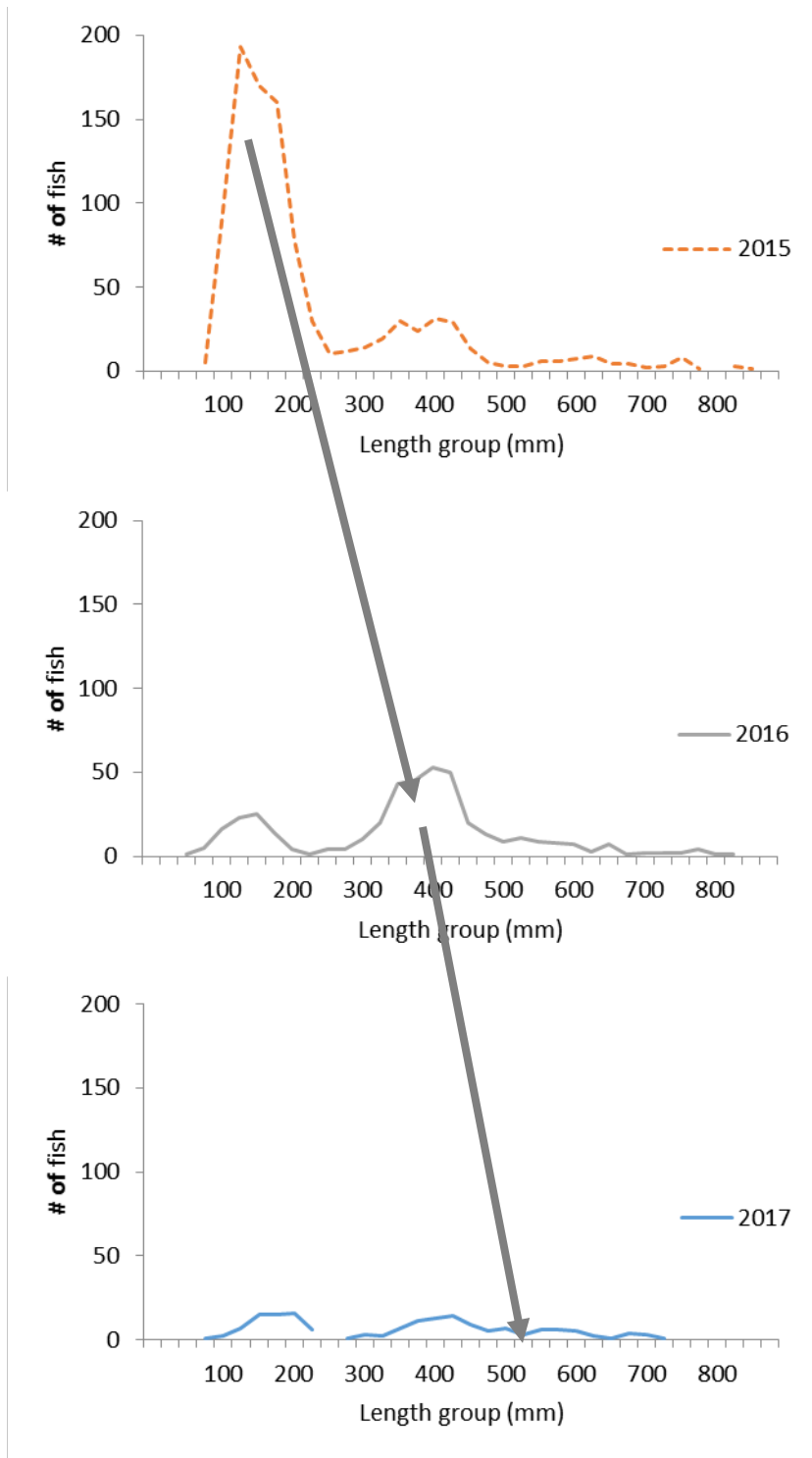


Figure--5 Length-frequency of Northern Pike captured by boat electrofishing in the middle Yampa River by CSU, 2015-2017, showing a strong 2015 cohort seen in 2016, but missing in 2017. Includes pike captured by CSU in South Beach, Little Yampa Canyon, Lower Juniper, and Lily Park. Length group increments are 25 mm.



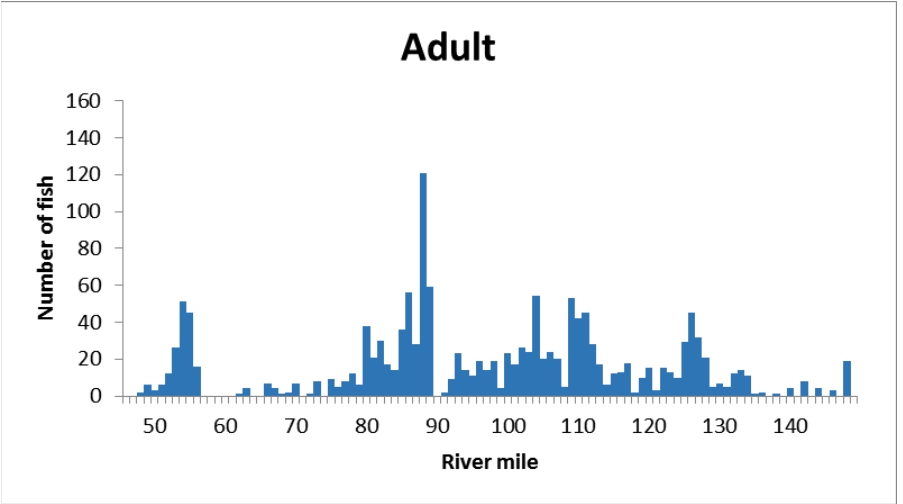
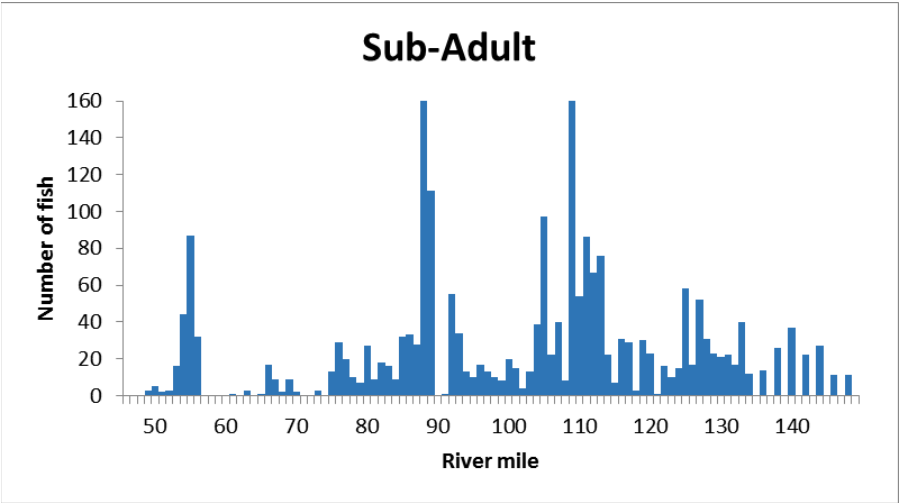
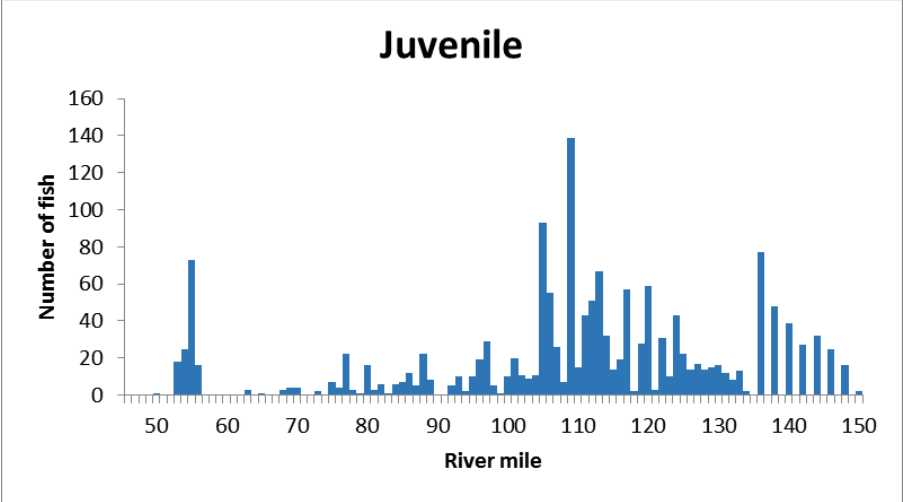


Figure 6—Number of Smallmouth Bass captured per mile in the middle Yampa River, 2017.

Appendix B:

## **Preliminary results of the removal of Northern Pike from the upper Yampa River, 2017.**

Hawkins, J. and D. Tuttle III

### **Introduction**

Northern Pike, *Esox lucius*, are a nonnative gamefish species introduced to the Yampa River in the 1970s (Hawkins et al. 2005). They occupy and have reproducing populations in the Yampa River and in several reservoirs within the basin and are considered a threat to native fishes and other gamefish, such as trout and Mountain Whitefish, *Prosopium williamsoni*. To address this threat, Northern Pike are being removed from the Yampa River downstream of Hayden Pump Station boat ramp near Hayden, Colorado to the confluence with the Green River by the Endangered Fish Recovery Program to benefit endangered fishes in Critical Habitat. Hayden Pump Station boat ramp is located at river mile (RM) 170.6, the distance upstream from the Green River confluence. Colorado Parks and Wildlife (CPW) also removes Northern Pike from Catamount Reservoir and from the Yampa River between Catamount Reservoir and Tree Haus Bridge (RM 194.2) in Steamboat Springs, Colorado to reduce their dispersal downstream into critical habitat and to benefit local trout and Mountain Whitefish populations. This study describes annual results of pike sampling and removal in the reach between Tree Haus Bridge and Hayden Pump Station boat ramp (RM 194.2-170.6). Most of the study site is located within private property, and although electrofishing can occur in the river without touching land, gaining access to launch or take-out boats, set nets, or stop and process fish requires landowner permission. In 2017 and previous years, permission was granted by a majority of landowners.

Our goals were to evaluate Northern Pike removal, describe their abundance, density, distribution, spawning phenology, and identify and rank spawning sites for production potential to assist future management actions.

### **Methods**

We sampled backwaters and sloughs between KOA campground (RM 189.3) and Hayden Pump Station boat ramp (RM 170.6) in the spring with raft electrofishing. We did not raft electrofish the reach between Tree Haus Bridge and KOA due to a lack of backwaters and concern for safely rafting under several low bridges. Backwaters attract and concentrate pike for feeding, resting, conditioning, and spawning. We focused our effort on backwaters where Northern Pike concentrate and are highly vulnerable to capture and we minimized our effort in the main channel where trout and Mountain Whitefish are abundant and Northern Pike are dispersed and difficult to capture. Backwaters were located on satellite maps with GPS and ranked low, medium, high, or none for spawning potential on each sampling occasion. Rankings were based on suitable depth, negligible water velocity, and presence of submerged aquatic or terrestrial vegetation. When electrofishing larger backwaters, we blocked the mouth with a fine-mesh gill net prior to sampling to prevent fish escapement.

We captured all fish and either released them immediately away from the boat or placed them in a tub of fresh water. If a trout or Mountain Whitefish was in duress, we added solar salt and oxygen to the water to reduce their osmoregulatory distress and assist their recovery. Oxygen was diffused through an air stone from a regulator-controlled compressed oxygen bottle. Northern pike were euthanized with an overdose of the FDA approved; fish anesthetic Finquel MS-222 (Methanesulfonate) and trout, Mountain Whitefish, and other fish species were returned

alive to the river. We sampled for young-of-year (YOY) Northern Pike in late summer to confirm spawning and to obtain otoliths for estimating hatch dates. We are currently aging otoliths from those fish to determine precise spawning dates for 2017.

## Results

Raft electrofishing occurred on three occasions between April 11 and April 28 during flows ranging from 479-1030 cfs measured at the Steamboat Springs USGS Gage (gage # 09239500; Figure 1). Raft electrofishing effort totaled 17.1 hours. We set gill nets for 98 hours and pulled gill nets as a seine in several backwaters. We sampled 54 individual backwaters at least once, including 20 sampled at least twice, and 13 sampled on all three passes. In August and September, we sampled selected backwaters for 2.6 hours with a backpack electrofisher to collect YOY Northern Pike for otolith aging.

We removed 175 Northern Pike, including 148 with raft electrofishing and gill nets in spring and 27 with backpack electrofishing in summer. Mean length of pike captured in spring was 575 mm, minimum length was 233 mm, and maximum length was 910 mm (Figure 2). Seventy three percent of the 148 pike captured in spring were large piscivores ( $\geq 450$  mm) considered the greatest threat as predators. We examined all pike externally to determine sex and sexual condition based on the expression of gametes and dissected 142 of those fish to confirm sex, gamete condition, and stomach contents. Of the 148 fish examined, 39% were females, 54% were males, and 7% were undetermined. Prey removed from stomachs of Northern Pike included leaches, Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, Speckled Dace *Rhinichthys osculus*, Creek Chub *Semotilus atromaculatus*, and White Sucker *Catostomus commersonii*. Size of fish consumed ranged from small, 55-mm minnows to a 309-mm Rainbow Trout removed from an 826-mm Northern Pike. Catch rate was highest at 12 pike/hour on the first pass, 8 pike/hour on the second pass, and 7 pike/hour on the third pass (Table 1). Only five juvenile pike (<300 mm) were captured.

Ripe male Northern Pike were captured on every sample occasion from April 4 through April 28 and ripe females were captured from April 13 and April 28 (Table 2). Females are a better indicator of spawning dates because they are ripe for only a few days before and after spawning whereas male fish are often ripe several days to weeks before and after spawning. Peak spawning was in late April, based on the highest percent of females that were ripe between April 20 and April 28, the day we ended sampling. It is likely that spawning continued after our last sample date in 2017, so in 2018, we plan to sample later to better define the end date of spawning.

We observed, but seldom netted, other species including Brown Trout, Rainbow Trout, Mountain Whitefish, Mottled Sculpin, and White Sucker. Of significance was the capture of a small YOY Yellow Perch *Perca flavescens* during backpack electrofishing. This is a new species for the Yampa River Basin.

We recommend obtaining an abundance estimate of pike in the study reach in 2019. We suggest not conducting an estimate in 2018, because our time will be limited due to obligations in downstream middle Yampa reaches where we will be conducting the third and final year of a Colorado pikeminnow estimate. To improve the precision of the estimate typically obtained with a single mark and release event, we suggest that pike be marked and released on two occasions rather than one occasion. We also suggest at least three removal passes after the final release event if environmental conditions allow.

We observed one significant habitat modification in the study reach in 2017. Privately funded stream improvements to enhance trout habitat occurred between river miles 173.5 and 174.5. A Colorado CPW biologist reviewing the U.S. Army Corp of Engineers 404 permit prior to construction suggested closing the entrance to a large backwater to prevent pike from entering and spawning. The construction crew closed the entrance with large boulders and infill in the fall of 2016. Prior to closure, this backwater was a heavily used spawning site. In 2015 and 2016, we captured 18 large spawning pike in this backwater each year. In 2017, pike were unable to access this backwater and likely dispersed to other nearby backwaters upstream where we observed an increase in catch rates. Our work to prioritize backwaters in the study reach should assist biologists reviewing 404 permits and we suggest a similar approach in other reaches as well.

In 2018, we will use GIS techniques to label spawning locations and their attributes. Biologists removing Northern Pike in other parts of the Yampa River should consider collecting attributes that describe spawning potential for spawning areas in their reaches, suggestions for remediation, and willingness of landowner to cooperate with remediation or removal efforts. These reach and site-specific plans should be prioritized for the entire basin and would inform future capital projects or actions by agency managers, assist biologists with mitigation suggestions as they review 404 permits, and inform those doing trout habitat enhancement.

### **Recommendations for Upper Yampa River Northern pike**

- Continue to focus Northern Pike removal in backwaters using raft electrofishing.
- Increase the use of gill and fyke nets in backwaters as appropriate.
- Postpone marking Northern Pike for abundance until 2019.
- Identify spawning period with collection of YOY pike for daily otolith aging.
- Extend removal to a 4<sup>th</sup> pass during higher flows to confirm the end of spawning.
- Collect attribute data for spawning areas and compile descriptive GIS maps.

### **Acknowledgements**

We thank the CSU field crew that assisted with field sampling in 2017 including Kyle Dick, Drew Ebner, Aly Hink, Kallie Jimmie, Lance Ostrom, and Jessica Sannwaldt. Kyle Dick aged Northern Pike otoliths. We also thank CPW personnel in the Steamboat Springs office including Billy Atkinson, Jim Haskins (AWM), and Justin Pollock (DWM) and Yampa Valley landowners who graciously allowed access on private property during sampling. We thank Kevin McAbee for reviewing this report.

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Table 1--Number and catch rate per hour (CPUE) of Northern Pike captured and removed from the upper Yampa River between Steamboat Springs and Hayden, Colorado, 2017. Life stages based on total length: juvenile (Juv.; <300 mm) and adult ( $\geq$ 300 mm).

<b>Spring sampling</b>				Number of fish			CPUE (# fish/hr)		
Pass	Sampling Period	Sampling Gear	Effort (Hrs)	Juv.	Adult	All sizes	Juv.	Adult	All sizes
1	Apr 11-13	Raft EL	5.2	1	62	63	0.2	11.9	12.1
2	Apr 18-20	Raft EL	5.8	0	44	44	0	7.6	7.6
3	May 25-28	Raft EL	6.1	4	37	41	0.7	6.1	6.7
Total			17.1	5	143	148	0.3	8.4	8.7

Table 2—Percent of ripe male and female Northern Pike captured each day in the Yampa River, 2017. Number of fish captured each day in parentheses.

	4/11	4/12	4/13	4/18	4/19	4/20	4/25	4/26	4/28
% ripe males	57%	100%	100%	100%	100%	100%	100%	75%	71%
# males	7	5	17	13	3	8	12	8	7
% ripe females	0%	0%	12%	20%	0%	50%	67%	0%	67%
# females	9	6	17	15	3	2	3		3

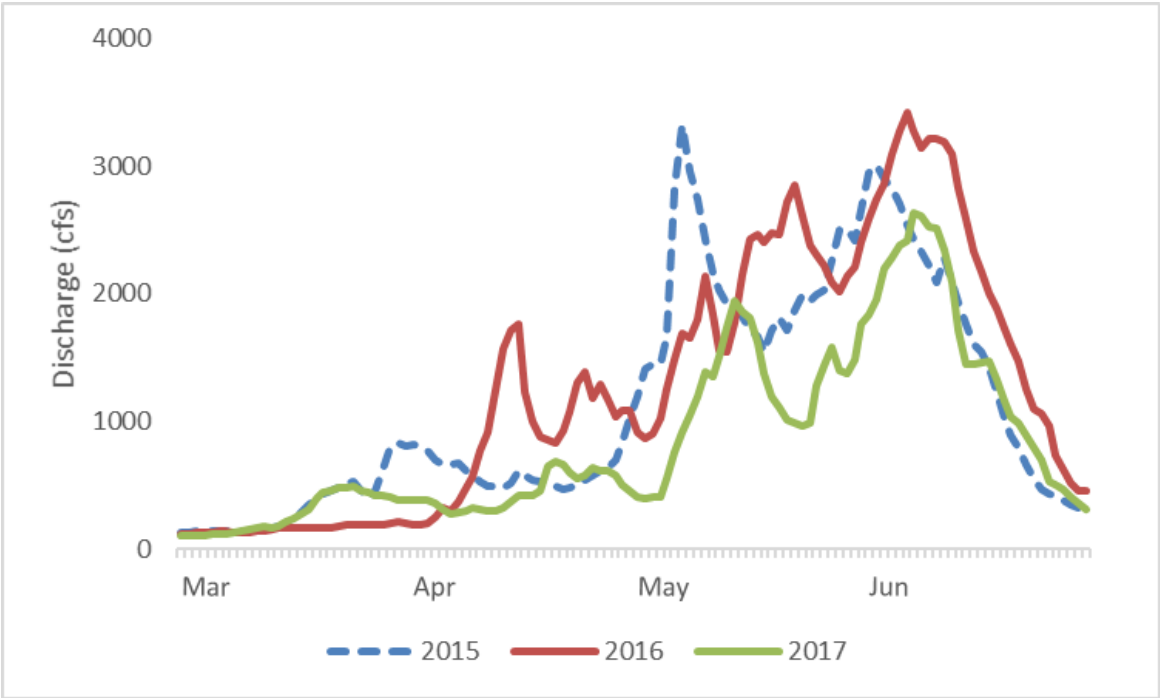


Figure 1— Steamboat gage (USGS# 09239500) discharge, 2015-2017.

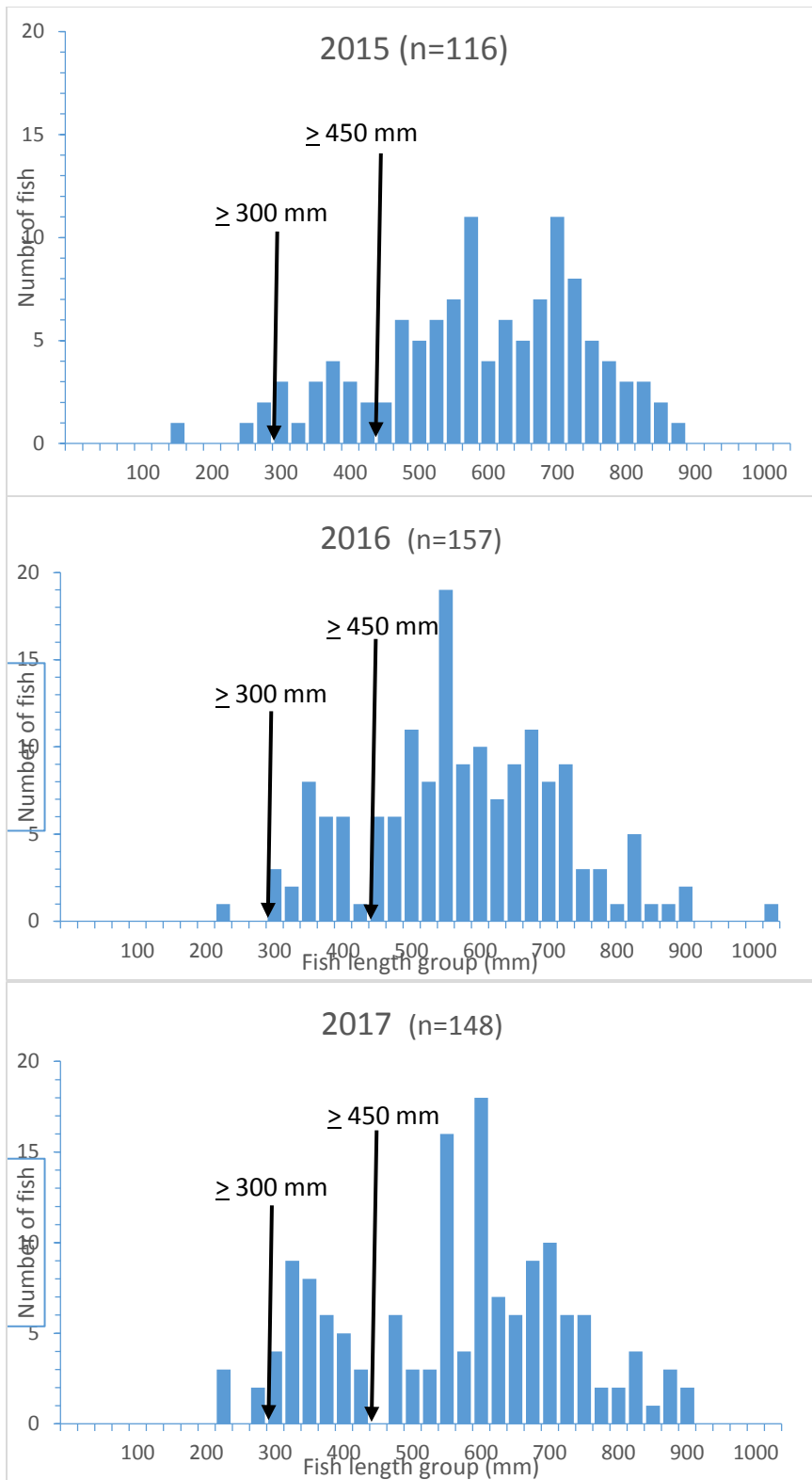


Figure 2—Length frequency of Northern Pike captures in the upper Yampa River, 2015-2017. Vertical arrows indicate the minimum length of adult fish ( $\geq 300$  mm total length; TL) and piscivores ( $\geq 450$  mm TL).