COLORADO RIVER RECOVERY PROGRAM
FY 2017 ANNUAL PROJECT REPORT

RECOVERY PROGRAM
PROJECT NUMBER: 160

I. Project Title: **Assessment of Stocked Razorback Sucker Reproduction in the Lower Green and Lower Colorado Rivers**

II. Bureau of Reclamation Agreement Number: R14AP00007

Project/Grant Period: Start Date: 05/01/2014
End date: 09/30/2018
Reporting period end date: 09/30/2017
Is this a final report? Yes____ No__X__

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IV. Abstract: Determining the location, timing, extent, and success of razorback sucker spawning is essential for evaluating the effectiveness of the stocking program, identifying recruitment, and guiding future management. This study was designed to determine the spawn timing as well as presence/absence and distribution of young-of-year (YOY) razorback suckers in the Green River downstream from the town of Green River and in the Colorado River downstream of Moab. The study was prompted by increasing razorback sucker encounters, the presence of multiple age classes, and congregations of ripe razorback suckers (2001-2003 and 2006-2008; Bestgen et al 2012, UDWR unpublished data) during Colorado pikeminnow surveys. Larval razorbacks have been successfully collected since the beginning of the project by either light trapping and/or seining. In 2017, on the lower Green River the total razorback larvae captured and CPUE was less than that in the last three years. Despite this, the number of larvae captured on the lower Green River remains high and demonstrates an increase relative to 2010-2013. On the lower Colorado River, total larvae captured and CPUE was greater than that of the last three years and continues to show a steady increase since sampling began in 2014.

V. Study Schedule: Initial year 2009, final year ongoing.

VI. Relationship to RIPRAP:

GENERAL RECOVERY PROGRAM SUPPORT ACTION PLAN

V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).

V.A. Measure and document population and habitat parameters to determine status and biological response to recovery actions.

V.B.2. Conduct appropriate studies to provide needed life history information.

GREEN RIVER ACTION PLAN: MAINSTEM

V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).

V.A. Conduct research to acquire life history information and enhance scientific techniques required to complete recovery actions.

COLORADO RIVER ACTION PLAN: MAINSTEM

V. Monitor populations and habitat and conduct research to support recovery actions (research, monitoring, and data management).

V.A. Conduct research to acquire life history information and enhance scientific techniques required to complete recovery actions

VII. Accomplishment of FY 2017 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Task 1: Lower Green River light trap sample collection:

Larval light trap samples were collected at sites between river miles 14.2 (Horse Canyon) and 119.6 (Saleratus Wash). Three sampling events occurred in conjunction with Green River Colorado pikeminnow estimates (Project #128; 5/4/2017 - 6/16/2017). A total of 126 light trap samples were collected and of those, 112 samples were sent to the Colorado State University Larval Fish Laboratory (CSU LFL) for identification. During the study, main channel temperatures ranged from 13.0°C to 21.0°C with a median temperature of 18.0°C. Temperatures within the habitats sampled ranged from 14.5°C to 26.0°C with a median temperature of 19.0°C.

The total number of razorback larvae captured on the lower Green River in 2017 was 5,360 (Figure 1; Table 1). The mean catch per unit effort (CPUE) was 43 larvae per trap night (Figure 2). The 2017 total larvae captured and mean CPUE is less than that in each of the previous three years (2014-2016), but 2017 total capture of razorback sucker larvae (n = 5,360) was still over 5 times the total number of larvae captured from 2009 through 2011 (n = 1,002; Figure 1). Cumulatively, from 2010 through 2013 there was a total of 5,820 larvae caught; whereas from 2014 through 2017 there was a total of 28,627 larvae caught. The 2010 through 2013 capture totals are only 20% of the 2014 through 2017 capture totals. Substantially higher catch rates in the last four years parallel an increasing trend in adult abundance (Zelasko et al. 2018).

Estimated spawning and hatch dates for captured razorback suckers were calculated using

formulas developed by Muth et al. (1998) and Bestgen et al. (2002) with data presented by Bozek et al. (1990). First, hatch dates for individual larvae captured were back-calculated by taking the difference between total length of captured larvae from average length at hatching (8.0 mm) divided by 0.3 mm (average daily growth rate of wild larvae observed by Muth et al. (1998) (Bestgen et al. 2002). The result is an estimate of days since hatching, which was then subtracted from the capture date to determine hatch date. For spawning dates, a linear regression model was fitted using data for the incubation times required at different water temperatures from Bozek et al. (1990; Figure 13). Incubation times were estimated to vary between approximately 6 and 20 days based on Bozek et al. (1990). The regression equation shown in Figure 13 was then used to predict incubation days based on the 10-day rolling average water temperature (for previous 10 days) on estimated date of hatching. The resulting estimated incubation days were then subtracted from hatch dates to determine spawning dates.

In general, razorback suckers spawn in the lower Green River from early April through early May when water temperatures are between 10 – 16°C and when degree days range between 350 – 1100 (Bestgen et al. 2002). Degree days are the sum of instantaneous water temperatures between January 1st and the earliest date of spawning (Bestgen et al. 2002). Spawning generally begins 28 to 78 days prior to the highest flow day during spring runoff and nearly always before water temperatures reach 14°C (Bestgen et al. 2002).

In 2017, razorback sucker spawning in the lower Green River was estimated to have begun on March 28th, about 74 days prior to peak spring runoff (6/10/2017) and when degree days were at 413 (Figure 4). Spawning was estimated to have begun early when compared to the range of spawn timing provided by Bestgen et al. (2002). Water temperatures during the 2017 estimated spawning period ranged from 10°C to 20°C (Figure 5). The number of larvae captured reached a maximum five days after the first peak in runoff on the first descending limb of the hydrograph (Figure 6). Temperature and discharge data were taken from the USGS gage 09315000 at Green River, UT.

In 2017 on the lower Green River, mean daily discharge began to steadily rise in February and created a more sustained period of spring runoff starting earlier than usual (data from USGS gauge 09315000 at Green River, UT). This was a result of Flaming Gorge Dam releases intended to manage inflows from a well above average snowpack that winter. From early February into mid-March, as flows increased, water temperatures were still averaging below 10°C. These atypical conditions may have contributed to a portion of razorbacks spawning earlier when temperatures were not ideal for egg incubation and subsequent hatching (Zelasko, et al. 2011; Bozek et al. 1990). Experimentation and field studies suggest that inappropriate temperature regimes can contribute to poor reproductive success of razorback suckers (Zelasko, et al. 2011; Bozek et al. 1990). Some spawning in 2017 may have occurred during an inopportune time for successful incubation and hatching.

The mean total length of razorback larvae that were captured on the lower Green River and measured at CSU LFL was 11.6 mm (n = 3,688; maximum number measured per

sample was 100). This is consistent with larvae sizes from the last five years which have been between 10 and 12 mm.

Additional native and non-native species captured during 2017 light trapping efforts on the lower Green River can be found in Table 1 and Table 3, respectively. Other non-native fish captured (not reported in Table 3) include: red shiner, sand shiner, and fathead minnow.

Task 2: Lower Green River sample for YOY and age 1+ razorback sucker:
Seine samples were collected between river miles 2.7 and 119.6 (Saleratus Wash) during two sampling trips (7/24/2017 - 9/2/2017). A total of 3,638 m^2 was seined in 70 seine hauls within 48 habitats. These habitats included backwaters which constituted 58.3% of all areas sampled, flooded tributaries (18.8%), embayments (10.4%), runs (8.3%), and shorelines (4.2%). During the study, main channel temperatures ranged from 23.0°C to 27.5°C with a median temperature of 26.0°C. Habitat temperatures ranged from 20.5°C to 31.0°C with a median temperature of 26.0°C.

There were 22 samples of YOY fish collected during seining and sent to the CSU LFL for identification. Of those samples, five contained YOY razorback suckers and two contained possible YOY razorback suckers. There were a total of nine YOY razorback suckers captured, ranging in size from 32 to 62 mm total length, with a median total length of 39 mm (Table 2). The two possible YOY razorback suckers both had a total length of 25 mm. During the seining effort, there were no age 1+ razorback suckers captured

In the past nine years of sampling (2009-2017), the capture of razorbacks via seining has not yielded any obvious trends over time, and in general, very few YOY razorbacks have been captured. In 2015, when light trapping capture rates reached an unprecedented high, there were no razorbacks captured during the seining effort for this study. However, in 2012 when light trapping capture rates were relatively low, five YOY razorbacks were captured during seining efforts. This lack of consistency may be attributed to the rarity of YOY razorbacks that survive past the larval stage or the fact that YOY razorbacks don't often utilize habitats that can be effectively seined.

In general, the consistently low numbers of razorback suckers found during seining efforts and the lack of juvenile razorback suckers captured across the basin suggests that razorback suckers may not be surviving past their larval stage (Zelasko et al. 2018) or we are not successful at capturing them. Factors that may decrease survival include: reduced flows and temperatures downstream of dams, reduced nursery habitat available, and egg or larvae predation by non-natives (Zelasko et al. 2018). Other young sucker species have been captured in faster moving, shallow, cobble-bar habitats that are difficult to seine. More investigation into other sampling techniques for capturing YOY and age 1+ razorback suckers and experimentation with these techniques could be useful. Additionally, expanding the sampling range and types of habitats sampled could also indicate where to focus our effort.

There were a total of 68 native fish that were captured during seining efforts on the lower Green River (Table 2). Of those native fish, 92% (n = 63) were captured during the earlier sampling period which occurred 7/24/2017 – 7/26/2017. During this sampling period, 35 seines were hauled and 23 habitats were sampled. During the July sampling period, main channel Secchi measurements ranged from 20 to 70 mm and habitat measurements ranged from 20 to 270 mm (only five habitats had Secchi readings over 100 mm). The rest of sampling occurred 8/30/2017 – 9/02/2017, during which 35 seines were hauled and 25 habitats were sampled. During this sampling period, main channel Secchi measurements ranged from 235 to 375 mm and habitat measurements ranged from 135 to 500 mm (only six habitats had Secchi readings under 200 mm).

Additional native and non-native species captured during 2017 seining efforts on the lower Green River can be found in Table 2 and Table 3, respectively. Other non-native fish captured (not reported in Table 3) include: red shiner, sand shiner, and fathead minnow.

Task 3: Colorado River light trap sample collection:

Light trap samples were collected at sites between river miles 21.2 and 63.8 (Courthouse Wash) during three sampling events (5/15/2017 - 6/22/2017). A total of 80 light trap samples were collected and of those, 75 samples were sent to the CSU LFL for identification. During the study, main channel temperatures ranged from 14.0°C to 24.0°C with a median temperature of 18.5°C. Habitat temperatures ranged from 14.0°C to 27.0°C with a median temperature of 20.0°C.

The total number of razorback larvae captured in the Colorado River was 1,882 (Figure 7; Table 1). The mean CPUE was 24 larvae per trap night (Figure 8). Both the total number of larvae captured and the mean CPUE have shown an increasing trend since 2014 (Figure 7; Figure 8). During both 2017 and 2016 sampling, more larvae were captured in the Lathrop (RMI 21-23) and Potash (RMI 42-44) reaches than in the Moab (RMI 52-67) reach (Figure 9).

In 2017, razorback sucker spawning in the Colorado River was estimated to have begun on April 9th, about 62 days prior to peak spring runoff (6/10/2017) and when degree days were at 586 (Figure 10). Water temperatures during this estimated spawning period ranged from 10°C to 17°C (Figure 11). The number of larvae captured reached a maximum 11 days after peak runoff on the descending limb of the hydrograph (Figure 12). Temperature and discharge data were taken from the USGS gauge 09180500 at Cisco, UT.

The mean total length of razorback larvae that were captured on the Colorado River and measured at CSU LFL was 11.9 mm (n =1,710; maximum number measured per sample was 100).

Additional native and non-native species captured during 2017 light trapping efforts on the Colorado River can be found in Table 1 and Table 3, respectively. Other non-native fish captured (not reported in Table 3) include: red shiner, sand shiner, and fathead

minnow.

Task 4: Colorado River sample for YOY and age 1+ razorback sucker:
Seine samples were collected between river miles 0.3 and 80.1 during two sampling events (7/18/2016 - 8/24/2016). A total of 5,758 m^2 was seined in 117 seine hauls within 74 unique habitats. These habitats included backwaters which constituted 51.4% of all areas sampled, flooded tributaries (20.3%), shorelines (14.9%), embayments (9.5%), isolated pools (2.7%), and runs (1.4%). During the study, main channel temperatures ranged from 22.0°C to 27.5°C with a median temperature of 23.0°C. Habitat temperatures ranged from 19.0°C to 32.0°C with a median temperature of 25.0°C.

Thirteen samples of YOY fish were collected during seining and sent to the CSU LFL for identification. Of those samples, three contained YOY razorback suckers. There were a total of seven YOY razorbacks identified, ranging in size from 32 to 70 mm total length, with a median total length of 50 mm (Table 2). During the seining effort, there were no age 1+ razorback suckers captured.

Again, as with on the lower Green River, it is clear that numbers of razorback suckers captured during seining are low. It may be worthwhile to investigate new sampling techniques and locations.

There were a total of 86 native fish that were captured during seining efforts on the lower Green River (Table 2). Of those native fish, 86% (n = 74) were captured during the earlier sampling period which occurred 7/18/2017 – 7/27/2017. During this sampling period, 51 seines were hauled and 32 habitats were sampled. During the July sampling period, main channel Secchi measurements ranged from 5 to 220 mm and habitat measurements ranged from 20 to 290 mm (not including one measurement of 550 mm in an isolated pool). The rest of sampling occurred 8/22/2017 – 9/02/2017, during which 66 seines were hauled and 42 habitats were sampled. During this sampling period, main channel Secchi measurements ranged from 180 to 560 mm and habitat measurements ranged from 140 to 690 mm (only 2 habitats had Secchi readings under 200 mm). This data also suggests that more native fish are being captured via seining when water is more turbid.

Additional native and non-native species captured during 2017 seining efforts on the Colorado River can be found in Table 2 and Table 3, respectively. Other non-native fish captured (not reported in Table 3) include: red shiner, sand shiner, and fathead minnow. There were 13 juvenile Colorado pikeminnow captured during this effort.

Task 5: Preliminary sample identification, data entry, analysis and reporting:
All data has been entered. Collected samples were submitted to the CSU LFL for identification, and results are reported here.

VIII. Additional noteworthy observations:

Colorado River Inflow to Lake Powell Sampling Effort:

One additional sampling trip was conducted in the inflow area of the Colorado River into Lake Powell. Light trap, minnow trap and seine samples were taken between river miles 196.6 and 167.6 (North Wash/Lake mile 140) (6/27/2017 - 6/29/2017). River miles are taken from Belknap's Canyonlands River Guide where the Glen Canyon Dam is considered mile 0.

A total of 30 light trap samples were taken, and of those 29 were sent to CSU LFL for identification. Habitats sampled included flooded tributaries and lake shorelines. Habitat, main channel, and lake temperatures were not recorded. The total number of razorback larvae captured was 232 (Table 1). The mean CPUE was 7.7 larvae per trap night. The mean length of larvae captured was 12.4 mm. The total catch and mean CPUE is not significant relative to that on the lower Green and Colorado, however the presence of these larvae is notable and demonstrates that there are razorbacks utilizing this habitat. It is, however, difficult to compare this sampling effort to sampling on the lower Green and Colorado (discussed in Task 1 and Task 3) due to the difference in the timing. Generally, we do not sample for larvae at the end of June when the majority of razorback larvae have grown into YOY fish. Given the presence of larvae in Lake Powell at the Colorado inflow, it may be beneficial to expand our sampling effort to incorporate sites below the Colorado and Green River confluence. It is also recommended that future larval sampling of the inflow area occurs between early May and mid-June if possible in order to allow for better data comparison between reaches.

A total of 261 m^2 was seined (using a larval seine) in 18 seine hauls within 8 unique habitats. Seined habitats included backwaters, flooded tributaries, and shorelines. Eleven seine samples were preserved and sent to CSU LFL for identification. The total number of razorback captured in this effort was nine (Table 2). There were eight larvae captured with a minimum total length of 10 mm and a maximum of 20 mm. The median total length of larvae was 13.5 mm. There was one YOY razorback captured with a total length of 33 mm. Generally, razorback suckers are considered larvae only up to a total length of 27-30 mm, after exceeding this total length they have developed morphological features consistent with juvenile stages (Muth at al. 2004).

A total of 12 minnow traps were set for three nights (6/27/17 – 6/30/17). Habitats sampled with minnow traps included river and lake shorelines, at depths ranging from 2 to 10 meters. Fish from one trap were preserved and sent to CSU LFL. This preserved sample was lost at some point during processing. Other fish caught in these traps were two black crappie, two largemouth bass, and one common carp. The low catch per trap night of the minnow traps and lack of native fish captured suggest that this sampling method is not very effective at this location. Minnow traps are not recommended for future sampling efforts in this area.

During sampling, dense flooded vegetation was observed lining the shorelines between river miles 183 and 167 (Figure 14). As spring runoff increases the level of Lake Powell, the flooded vegetation may be beneficial habitat for the YOY and juvenile native fish. The habitat is expansive and both boat access and access by foot were limited. Thus, distribution of sampling effort throughout these areas was difficult. In order to sample

these zones more effectively, other techniques or more effort may be needed.

Additional native and non-native species captured during 2017 light trapping and seining efforts at the Colorado inflow to Lake Powell can be found in Tables 1, 2, and 3. Other non-native fish captured (not reported in Table 3) include: red shiner, sand shiner, and fathead minnow.

IX. Recommendations:

- Continue sampling via light trapping for larval razorback sucker in both the Colorado and Green Rivers (May-June) to determine success and timing of reproduction.
- Consider expanding light trap sampling below confluence of the Green and Colorado Rivers to determine extent of larval drift.
- Continue seining in both the Colorado and Green Rivers (July-September) to determine successful recruitment of YOY and juvenile razorback suckers.
- Consider expanding seining sampling below the confluence of the Green and Colorado Rivers in an effort to capture YOY and juvenile razorback sucker which may move out of zero-velocity habitats by mid to late summer.
- Consider using alternative sampling techniques in addition to seining to aid in the capture of YOY and age 1+ razorback sucker.

X. Project Status: On track and ongoing.

XI. FY 2017 Budget Status

A. Funds Provided:	$59,423
B. Funds Expended:	$59,423
C. Difference:	$ 0
D. Percent FY 2017 work completed:	100%
E. Recovery Program funds spent for publication charges:	$ 0

XII. Status of Data Submission: All data has been submitted.

XIII. Signed: Karen Burke — 11/03/2020
Principal Investigator — Date

XIV. Literature cited:

Bestgen, K.R., K.A. Zelasko, and G.C. White 2012. Monitoring reproduction, recruitment, and population status of razorback sucker in the upper Colorado River basin. Final report of Larval Fish Laboratory at Colorado State University to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.

Bestgen, K.R., G.B. Haines, R. Brunson, T. Chart, M. Trammell, R.T. Muth, G. Birchell, K.Christopherson, and J.M. Bundy. 2002. Status of wild razorback sucker in the Green River Basin, Utah and Colorado, determined from basinwide monitoring and other sampling programs. Draft Report of Colorado State University Larval

Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Breen, M.J., R.C. Schelly, and C.M. Michaud. 2016. Annual fall monitoring of young of year Colorado pikeminnow and smallbodied native fishes. Annual report of Utah Division of Wildlife Resources Station to Upper Colorado River Endangered Fish Recovery Program. Denver, CO.

Bozek, M. A., L. J. Paulson, and G. R. Wilde. 1990. Effects of ambient Lake Mohave temperatures on development, oxygen consumption, and hatching success of the razorback sucker. Environmental Biology of Fishes 27:255—263.

Hedrick, T.N., A.R. Breton and S.P. Keddy. 2012. Razorback Sucker Survival and Emigration from the Stirrup Floodplain, Middle Green River, Utah, 2007-2010. Report of Utah Division of Wildlife Resources to Upper Colorado River Basin Endangered Fish Recovery Program.

Muth, R. T., G. B. Haines, S. M. Meismer, E. J. Wick, T. E. Chart, D. E. Snyder, and J. M. Bundy. 1998. Reproduction and early life history of razorback sucker in the Green River, Utah and Colorado, 1992–1996. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R. T., D. E. Snyder, and C.L. Bjork. 2004. Catostomid Fish Larvae and Early Juveniles of the Upper Colorado River Basin, Morphological Descriptions, Comparisons, and Computer-Interactive Key. Contribution 139 of the Colorado State University Larval Fish Laboratory to Colorado Division of Wildlife.

Zelasko, K.A., K.R. Bestgen, and G.C. White. 2018. Abundance and survival rates of razorback suckers Xyrauchen texanus in the Green River, Utah, 2011-2013. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Zelasko, K.A., K. R. Bestgen, and G.C. White. 2011. Survival Rate Estimation of Hatchery-Reared Razorback Suckers *Xyrauchen texanus* stocked in the Upper Colorado River Basin, Utah and Colorado, 2004-2007. Final Report of Colorado State University Larval Fish Laboratory to Colorado River Implementation Program Project Number 159.

Table 1. Number of identifiable native fish larvae captured via light trapping at all three reaches sampled (n is the number of light traps). Fish were only included that were identifiable to species level (or to the genus level for the "unknown chub" i.e. *Gila sp*.).

Reach	razorback sucker	flannelmouth sucker	bluehead sucker	unknown chub	Colorado pikeminnow	speckled dace
Green River (RMI 14.2-119.6) n=126	5360	812	69	1	1	1
Colorado River (RMI 21.2-63.8) n=80	1882	85	1045	2		
Lake Powell Inflow (RMI 167.6-196.6) n=30	232	12	287	1		1
Total	7474	909	1401	4	1	2

Table 2. Number of identifiable native fish captured via seining at all three reaches sampled (n is the number of seine hauls). Fish were only included that were identifiable to species level (or to the genus level for the "unknown chub" i.e. *Gila sp.*).

Reach	razorback sucker	flannelmouth sucker	bluehead sucker	unknown chub	Colorado pikeminnow	speckled dace
Green River (RMI 2.7-119.6) n=70	9	35	20	2	1	3
Colorado River (RMI 0.3-80.1) n=117	7	29	23	11	13	1
Lake Powell Inflow (RMI 167.6-196.6) n=18	9*	3	23	1		1
Total	25	67	66	14	14	5

*Eight of nine were larval razorbacks, one was YOY; a larval seine was used at the Lake Powell inflow due to the timing of this sampling effort.

Table 3. Number of identifiable non-native fish captured via light trapping and seining at all three reaches sampled. Fish were only included that were identifiable to species level. Species abbreviations are as follows: BC = black crappie; BB = black bullhead; CC = channel catfish; CP = common carp; GS = green sunfish; GZ = gizzard shad; LG = largemouth bass; SM = smallmouth bass; WE = walleye; WS = white sucker.

Reach	Sampling method	BC	BB	CC	CP	GS	GZ	LG	SM	WE	WS
Green River (RMI 2.7-119.6)	Light Trapping				104						6
	Seining	5	46	462	428	43	29				75
Colorado River (RMI 0.3-80.1)	Light Trapping				9		149				49
	Seining	69	8	90	118	12	751	36	4	1	6
Lake Powell Inflow (RMI 167.6-196.6)	Light Trapping	1			837		60				5
	Seining	1			2		145				4
Total	Both	76	54	552	1498	55	1134	36	4	1	145

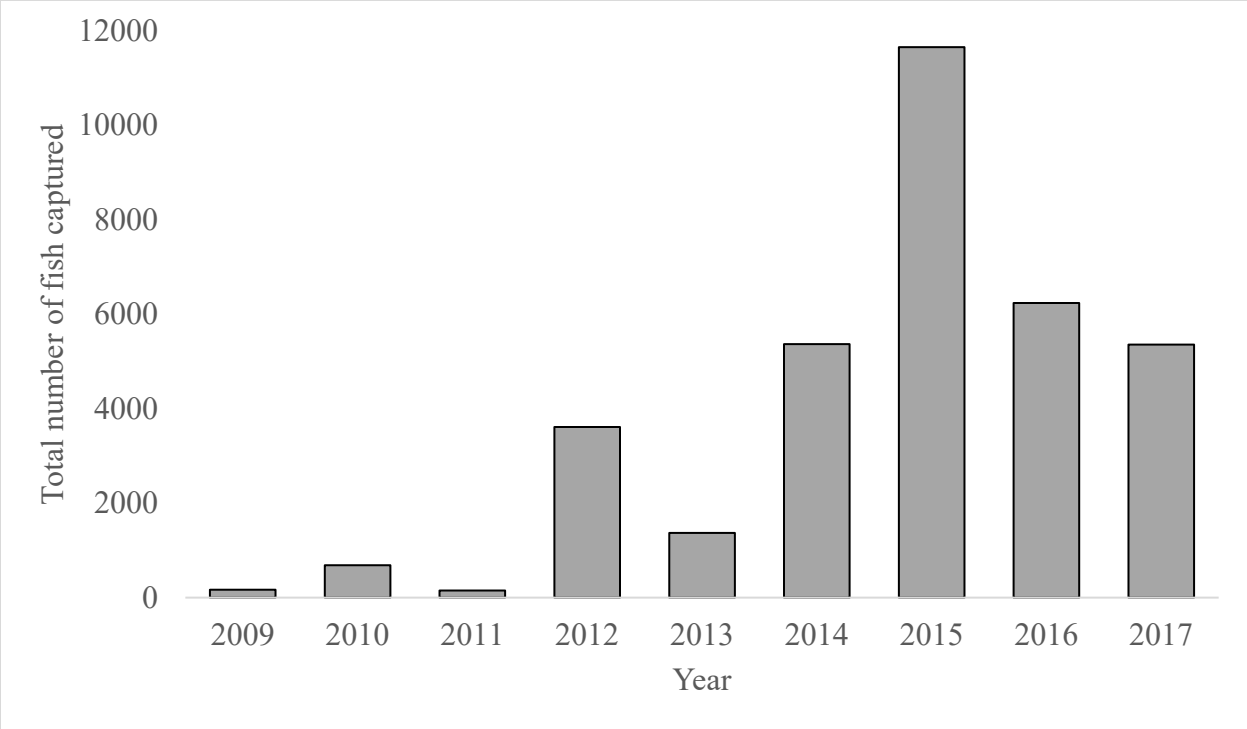

Figure 1. Total numbers of razorback sucker larvae captured by light trapping at all sites in the lower Green River by year.

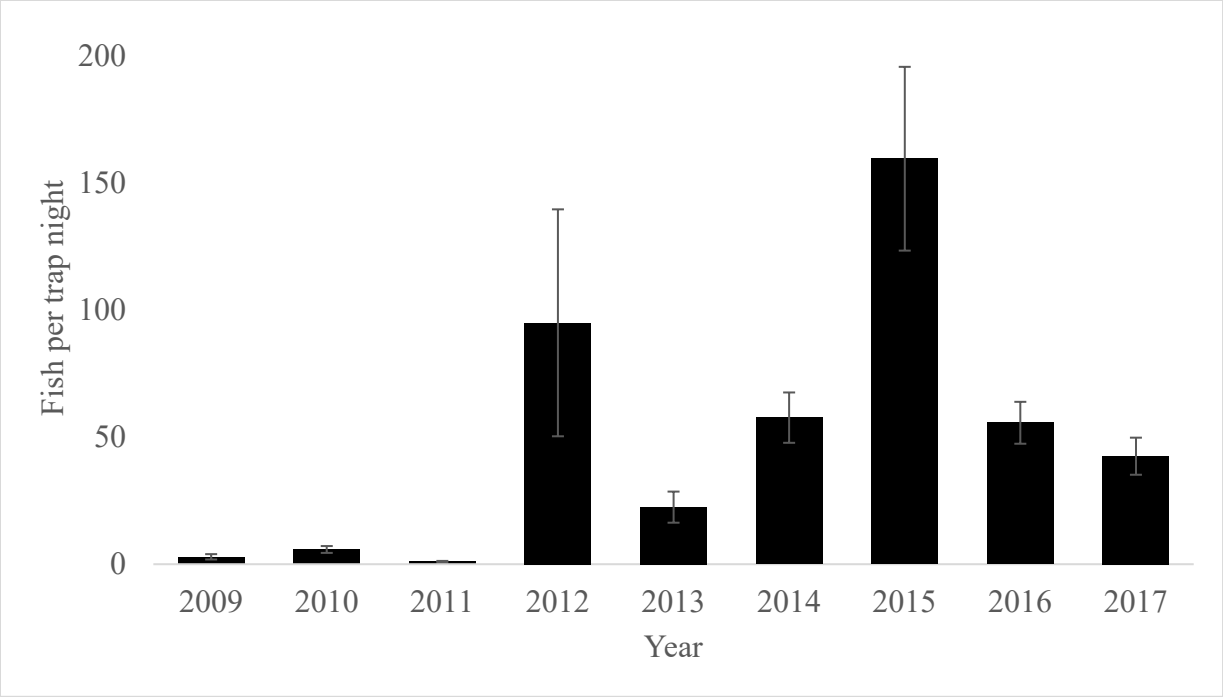

Figure 2. Mean catch per unit effort (razorback sucker larvae per trap night) for larval light trapping by year for all sites on lower Green River. Error bars represent standard error.

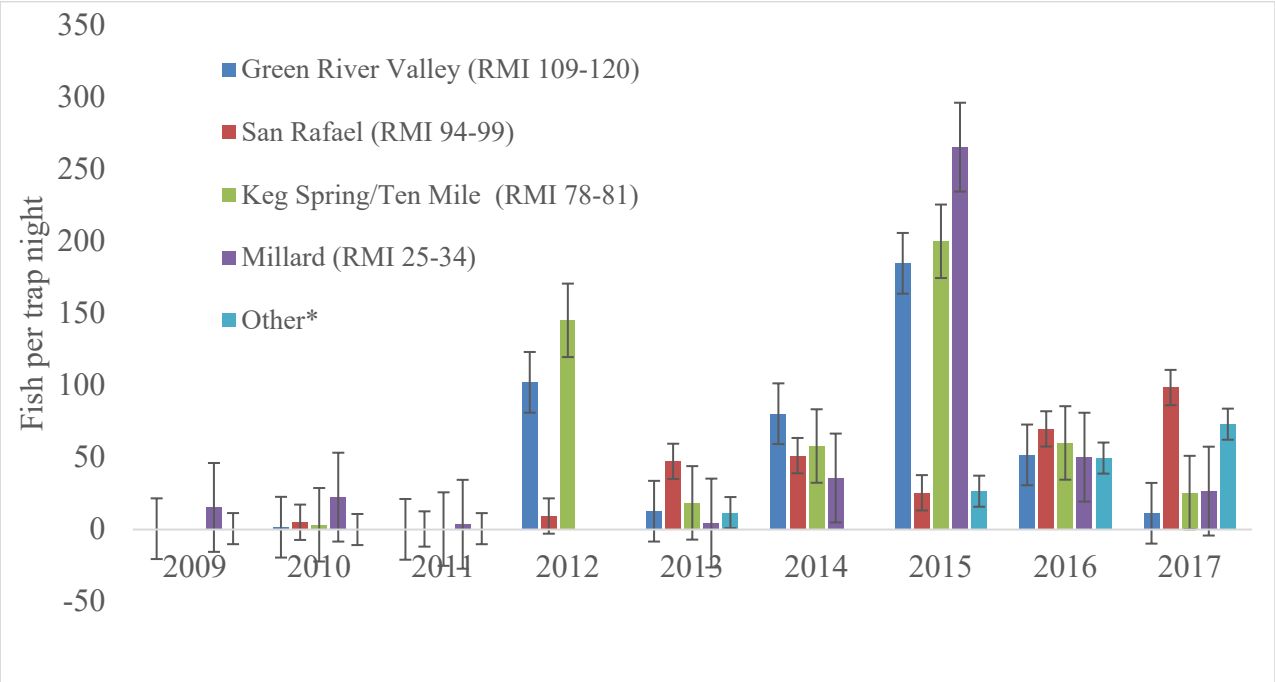

Figure 3. Catch per unit effort (razorback sucker larvae per trap night) for larval light trapping by year and by reach in the lower Green River. *Other sites include: river miles 101.7 (2009); 19.5, 101.5, and 105.4 (2010); 59.2 (2011); 19.8, 21.6, 67.5 (2013); 4.2, 14.2, 15.1, 39.4 (2016); 52.2, 67.5, 37.5, 39.4, 15.1, 14.2 (2017).

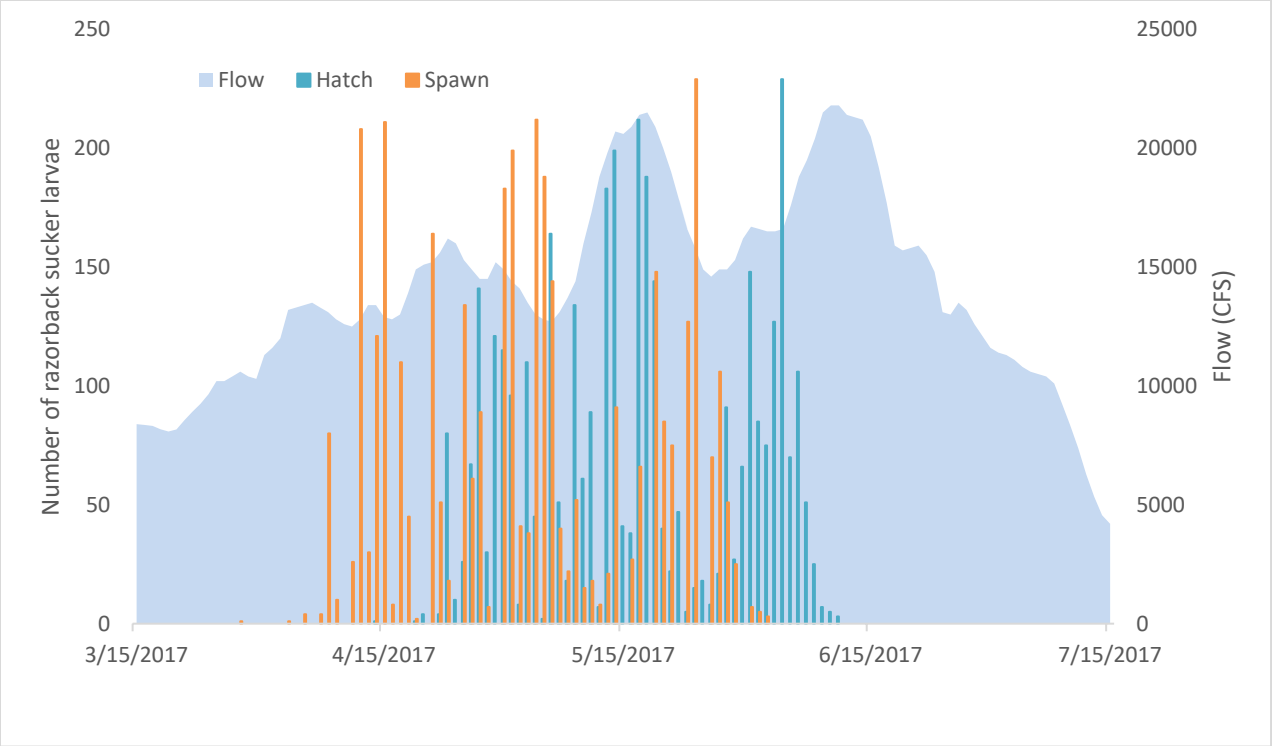

Figure 4. Estimates for the number of razorback sucker larvae per hatching and spawning date in the lower Green River and corresponding mean daily discharge from USGS gauge 09315000 at Green River, UT.

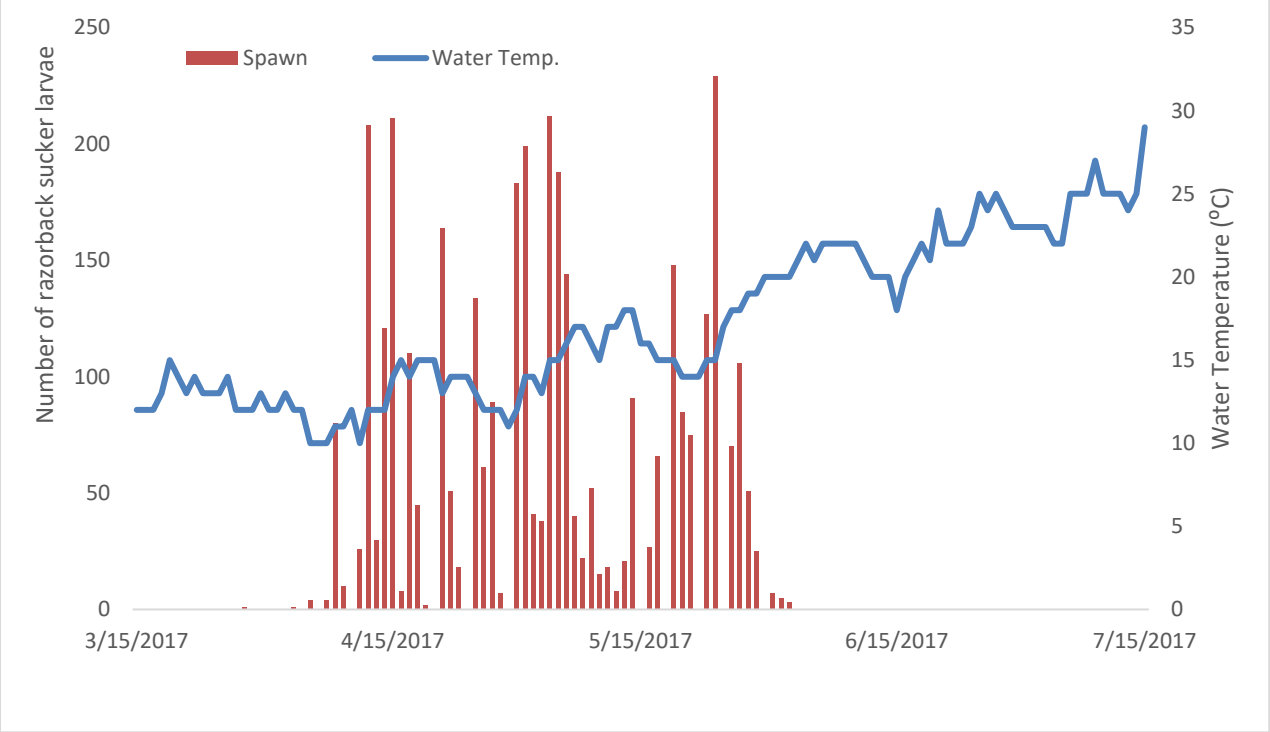

Figure 5. Water temperature from USGS gauge 09315000 at Green River, UT, and estimated spawn dates for razorback sucker larvae captured by light trapping in the lower Green River.

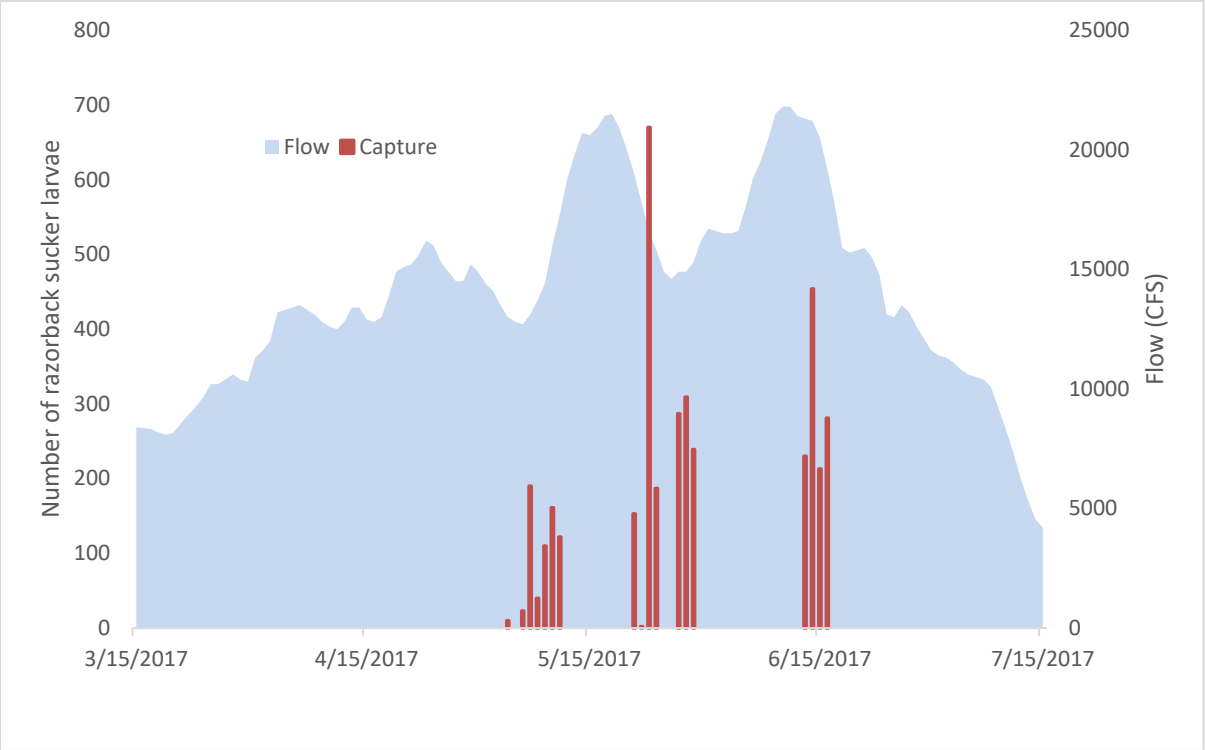

Figure 6. Number of razorback sucker larvae captured per date and corresponding mean daily discharge for the lower Green River from USGS gauge 09315000 at Green River, UT.

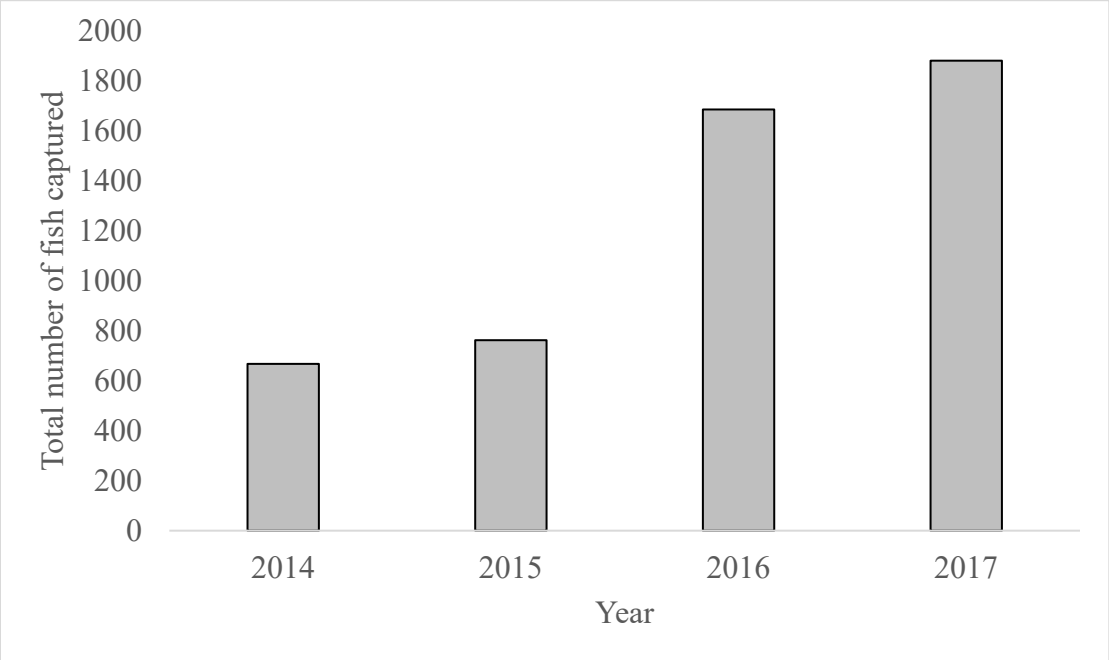

Figure 7. Total numbers of razorback sucker larvae captured by light trapping at all sites in the lower Colorado River by year.

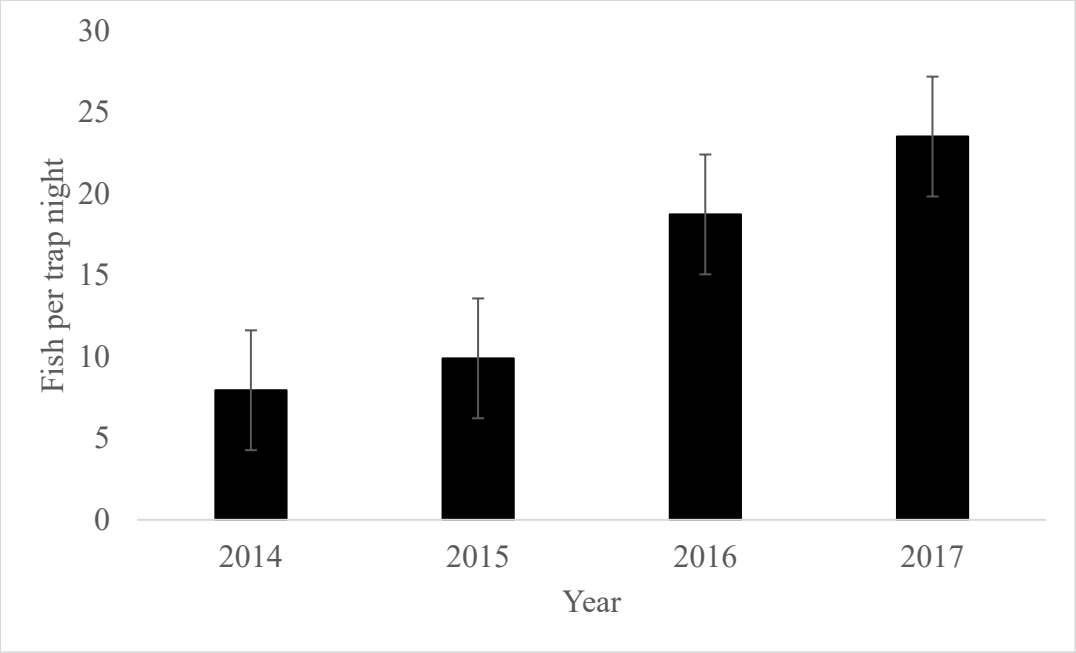

Figure 8. Mean catch per unit effort (razorback sucker larvae per trap night) for light trapping by year for all sites on lower Colorado River. Error bars represent standard error.

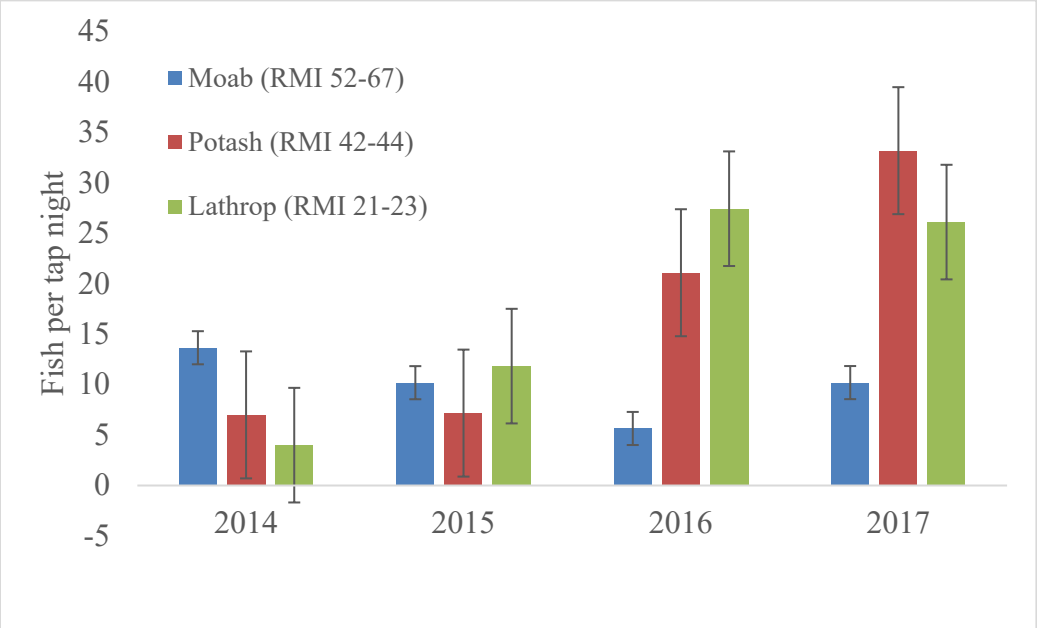

Figure 9. Catch per unit effort (razorback sucker larvae per trap night) for larval light trapping by year and by reach in the lower Colorado River.

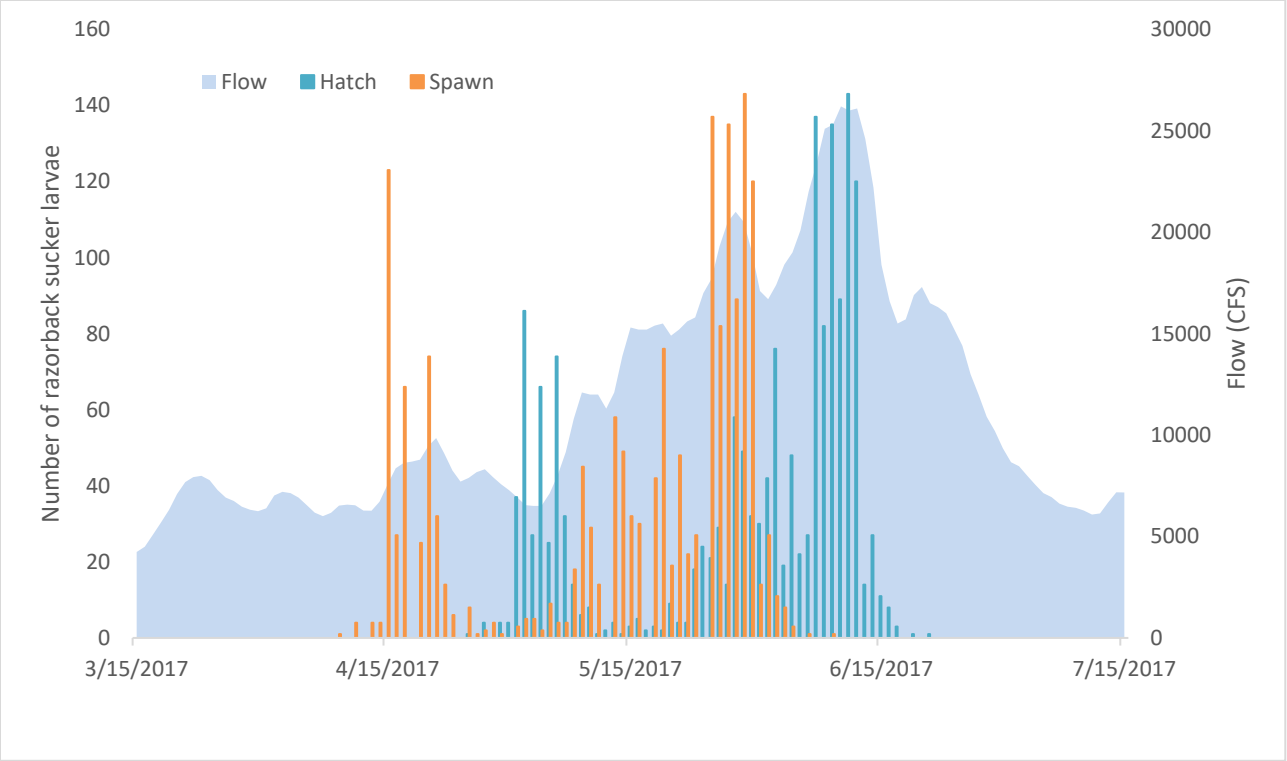

Figure 10. Estimates for the number of razorback sucker larvae per hatching and spawning date in the lower Colorado River and corresponding mean daily discharge from USGS gauge 09180500 at Cisco, UT.

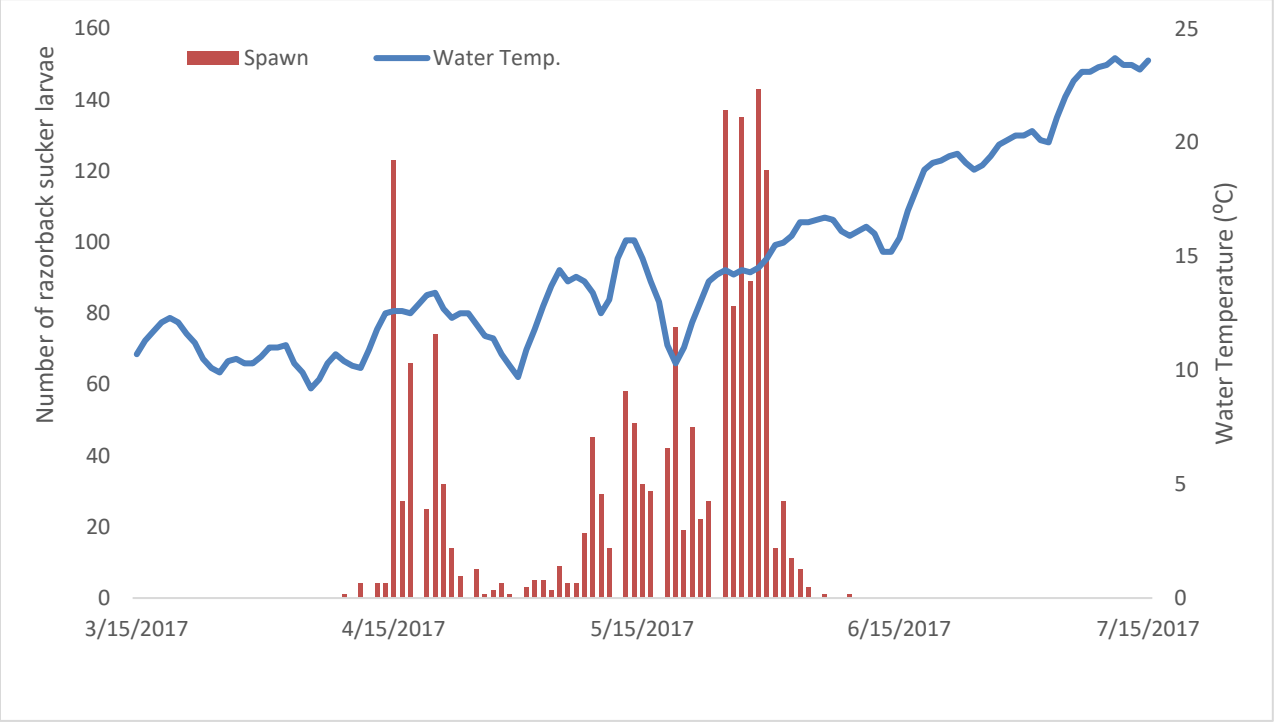

Figure 11. Water temperature from USGS gauge 09180500 at Cisco, UT, and estimated spawn dates for razorback sucker larvae captured by light trapping in the lower Colorado River.

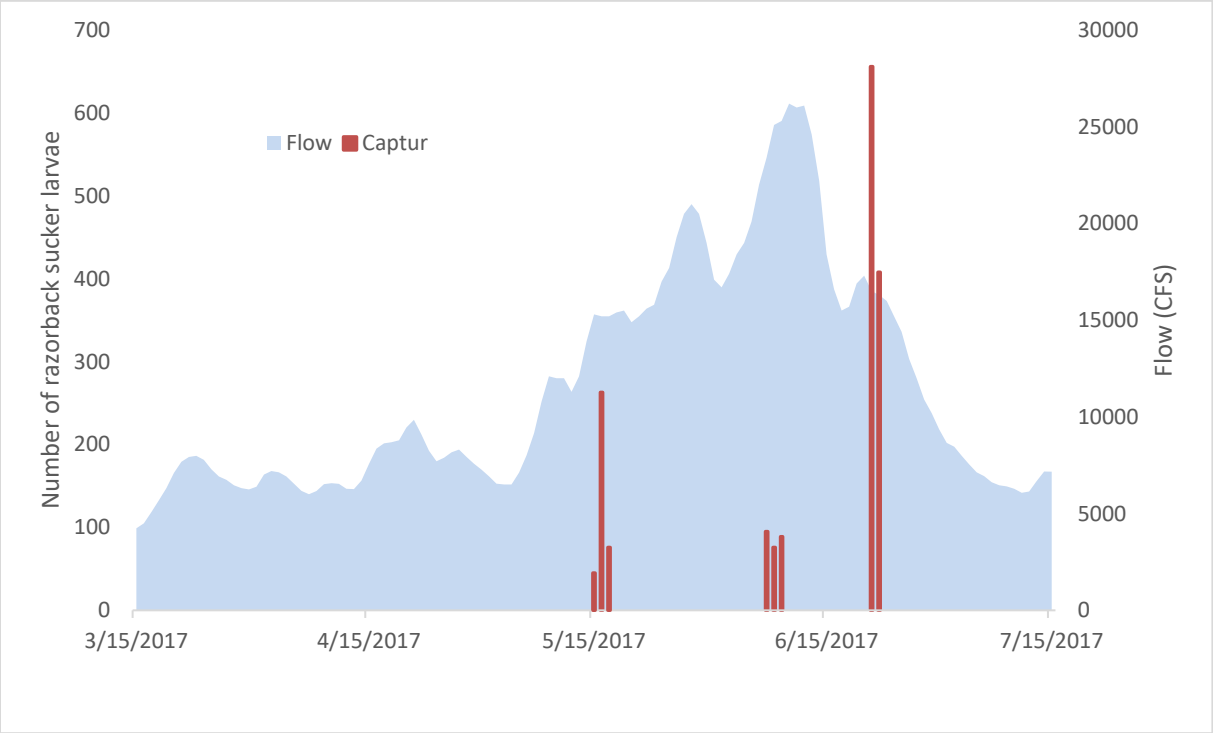

Figure 12. Number of razorback sucker larvae captured per date and corresponding mean daily discharge for the lower Colorado River from USGS gauge 09180500 at Cisco, UT.

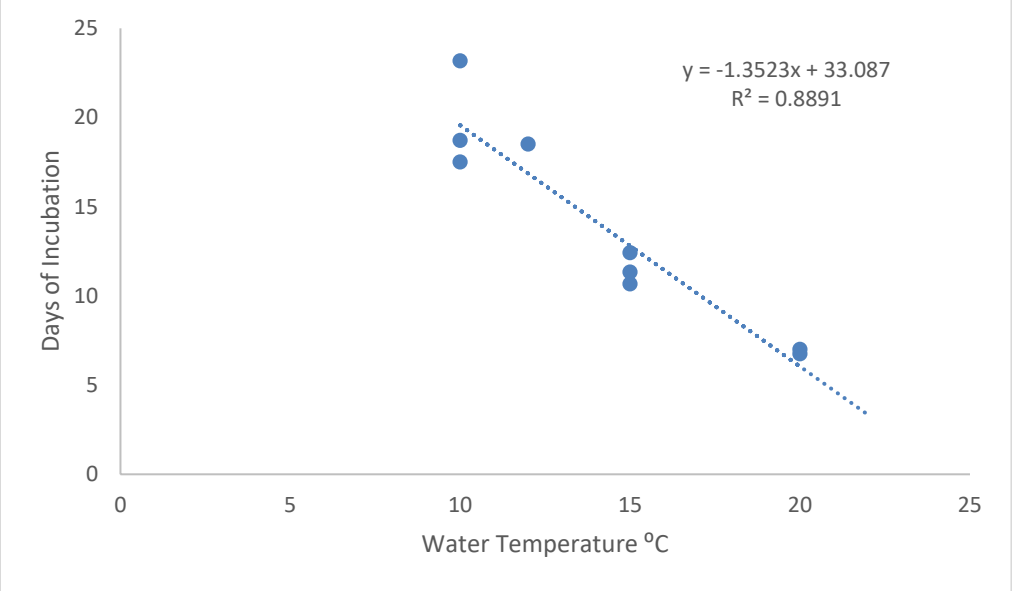

Figure 13. Regression model and equation used to calculate incubation days which were used to determine spawning dates. Data used to form this regression model is from Bozek et al. (1990).

Figure 14. Flooded vegetation near the confluence of the Dirty Devil River and North Wash in the inflow area of the Colorado River to Lake Powell.