Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Native Fish Monitoring in Reach 3 of the Lower Colorado River

2016–2017 Annual Report

August 2019

Work conducted under LCR MSCP Work Task D08

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U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

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Lower Colorado River Multi-Species Conservation Program

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ACRONYMS AND ABBREVIATIONS

cm	centimeter(s)
CPUE	catch per unit effort
g	gram(s)
kHz	kilohertz
L	liter(s)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
M&A	Marsh & Associates, LLC
m^2	square meter(s)
mg/L	milligram(s) per liter
mL	milliliter(s)
mm	millimeter(s)
PIT	passive integrated transponder
PVC	polyvinyl chloride
Reclamation	Bureau of Reclamation
RM	river mile(s)
SY	study year
TL	total length
UTM	Universal Transverse Mercator

Symbols

°C	degrees Celsius
>	greater than
≥	greater than or equal to
<	less than
%	percent

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EXECUTIVE SUMMARY

Reach 3 of the lower Colorado River between Davis Dam and Parker Dam is surveyed for native fishes annually. Native fish species throughout the Lower Colorado River Basin, including razorback suckers (*Xyrauchen texanus*), bonytail (*Gila elegans*), and flannelmouth suckers (*Catostomus latipinnis*) have experienced decreases in their populations. In 2005, the Lower Colorado River Multi-Species Conservation Program was established to conserve species native to the lower Colorado River. More than 50,000 bonytail and 88,000 razorback suckers have been stocked into Reach 3 (Bureau of Reclamation 2015). A variety of sampling techniques are used to monitor native fish populations. Larval fish, primarily razorback suckers, are monitored with dip nets and submerged lights, and juvenile/adult fish are monitored with trammel nets, electrofishing, and remote passive integrated transponder (PIT) scanning. Among all different sampling techniques for juvenile/adult fish, remote PIT scanning contacted the greatest number of native fishes. All razorback suckers and bonytail are implanted with a PIT tag before being stocked into Reach 3, and all flannelmouth suckers are given a PIT tag at time of capture. Remote PIT tag scanners (PIT scanners) were regularly deployed throughout the upper sections of Reach 3 to passively monitor the native fish populations. In addition to deploying PIT scanners, a new technique was integrated in spring 2017. A BioMark HPR Plus PIT tag reader and a net pole were fastened together and used to scan native fishes while electrofishing. This technique combines electrofishing with PIT scanners to optimize monitoring efforts.

This study incorporates PIT scanning and capture data. PIT scanning data were collected throughout Reach 3 during two study years (SY). SY16 ran from October 1, 2015, through September 30, 2016, and SY17 began October 1, 2016, and ran through September 30, 2017. Capture data were collected during February and March 2017. Razorback suckers spawn from early January through April (Minckley 1983). Razorback suckers are confirmed or suspected of spawning in the river and its associated backwaters from Laughlin, Nevada, downstream to Topock Gorge. A large portion of the monitoring was scheduled to coincide with the razorback sucker spawning season, and PIT scanners were placed at known razorback sucker spawning sites in an effort to increase the number of contacts. Data collected from these PIT scanners, and from other projects and entities, are all compiled into a single database. All monitoring efforts resulted in relatively low contacts of flannelmouth suckers and bonytail – 8 and 17, respectively. Due to limited contacts, no population estimate could be generated for either species; there was higher success in contacting razorback suckers. In total, there were 3,934 individual razorback suckers contacted between two scanning seasons, and 668 of those contacts were detected in both seasons. The Reach 3 razorback sucker population is estimated to be at 5,338 (5,043–5,633; 95% confidence interval) individuals in 2016.

INTRODUCTION

Populations of native fishes endemic to the lower Colorado River (LCR) have declined over the past century. These declines were initially attributed to anthropogenic (human-caused) alterations to the LCR, which dramatically changed the historical hydraulic characteristic of the river (Minckley 1983). More recent research suggests that the introduction of non-native sport fishes is inhibiting the persistence and recovery of these native fishes (Bureau of Reclamation [Reclamation] 2015). Razorback suckers (*Xyrauchen texanus*) and bonytail (*Gila elegans*) have been federally listed as endangered under the Endangered Species Act. Razorback suckers were listed in 1991 and bonytail in 1980. Flannelmouth suckers (*Catostomus latipinnis*) are a species of special concern in Arizona. In 2005, the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) was created to balance the use of the Colorado River water resources with the conservation of native species and their habitats, with an emphasis toward promoting the recovery of species currently listed under the Endangered Species Act (LCR MSCP 2018b). Under the LCR MSCP, the Colorado River is divided into seven specific reaches stretching from Lake Mead to the southernmost border with Mexico. Reach 3 is the focus of this study; it begins at Davis Dam and extends 83 miles to Parker Dam.

To conserve native fish populations in Reach 3, the LCR MSCP is tasked with stocking 6,000 razorback suckers and 4,000 bonytail annually as part of its fish augmentation program (Reclamation et al. 2004). This stocking program is a pivotal component to establishing and maintaining native fish populations (Reclamation 2015). Size at release appears to be the most important factor impacting post-release survival (Kesner et al. 2017). In an attempt to increase survival of stocked fishes, a minimum stocking size for razorback suckers and bonytail was set at 305 millimeters (mm) total length (TL) for Reach 3 (LCR MSCP 2018a). All native fishes released are implanted with a passive integrated transponder (PIT) tag.

The razorback sucker spawning season extends from January through April. Bonytail have not been documented spawning in Reach 3 but have been observed spawning during late June and early July in the upper Green River (Jonez and Sumner 1954). Razorback suckers have been observed spawning near Davis Dam downstream to Needles, California. Larval razorback suckers are abundant in this portion of the reach, but no wild subadult razorback suckers have been documented in recent years. There was natural recruitment of razorback suckers when the reservoir was initially built, but the introduction of non-native sport fishes has since eliminated any natural recruitment (Minckley 1983). Flannelmouth suckers spawn during April and May (Best and Lantow 2012; Mueller and Wydoski 2004), with the majority of spawning occurring near Laughlin, Nevada. Flannelmouth suckers are the only native fish with recently documented recruitment in Reach 3.

Monitoring efforts for native fishes have included conventional methods such as trammel netting and electrofishing. In Reach 3, conventional methods were proven to be problematic at contacting adequate numbers for assessing native fish populations. PIT scanners were first used in Reach 3 in 2011. Since then, PIT scanners has been incorporated into native fish monitoring throughout the LCR.

Results in this report are based on 2016 and 2017 remote scanning and 2017 capture data compiled by all State, Federal, and contracted agencies working on the LCR throughout Reach 3. Specific objectives include:

1. Contact native fishes using remote PIT scanners, electrofishing, and trammel netting in Zone 3-1 and Zone 3-2 (figure 1)

2. Assimilate all Reach 3 razorback sucker contact data collected by any agency

3. Estimate the current repatriate razorback sucker population

4. Collect and preserve larval fish and adult fin clips to assist with determining genetic health of Reach 3 razorback suckers

5. Begin an alternative stocking method study (soft releases) of Reach 3 to evaluate effects of survival with alternative methods

This information will aid in completion of LCR MSCP Work Task D8: Razorback Sucker and Bonytail Stock Assessment, Work Task C31: Razorback Sucker Genetic Diversity Assessment, and Work Task C61: Evaluation of Alternative Stocking Methods for Fish Augmentation in Reach 3.

METHODS

Study Area

Reach 3 encompasses 83 miles of the Colorado River between Davis Dam and Parker Dam. This reach is composed of a flowing riverine component and a reservoir (Lake Havasu). Riverflows are highly regulated from upstream (Davis Dam) and downstream (Parker Dam) releases. For the purpose of this and previous studies, Reach 3 (including Lake Havasu) was broken into four zones based primarily on their habitat types. Immediately downstream from Davis Dam begins Zone 3-1, and it continues down to River Mile (RM) 235. This flowing section of river is very clear and relatively fast, and the shorelines are well developed with rip rap levees. Zone 3-2 runs from RM 235 near Park Moabi Regional Park downstream to RM 217 that incorporates the inflow delta of Lake Havasu. This zone includes a diversity of habitat types and is comprised of

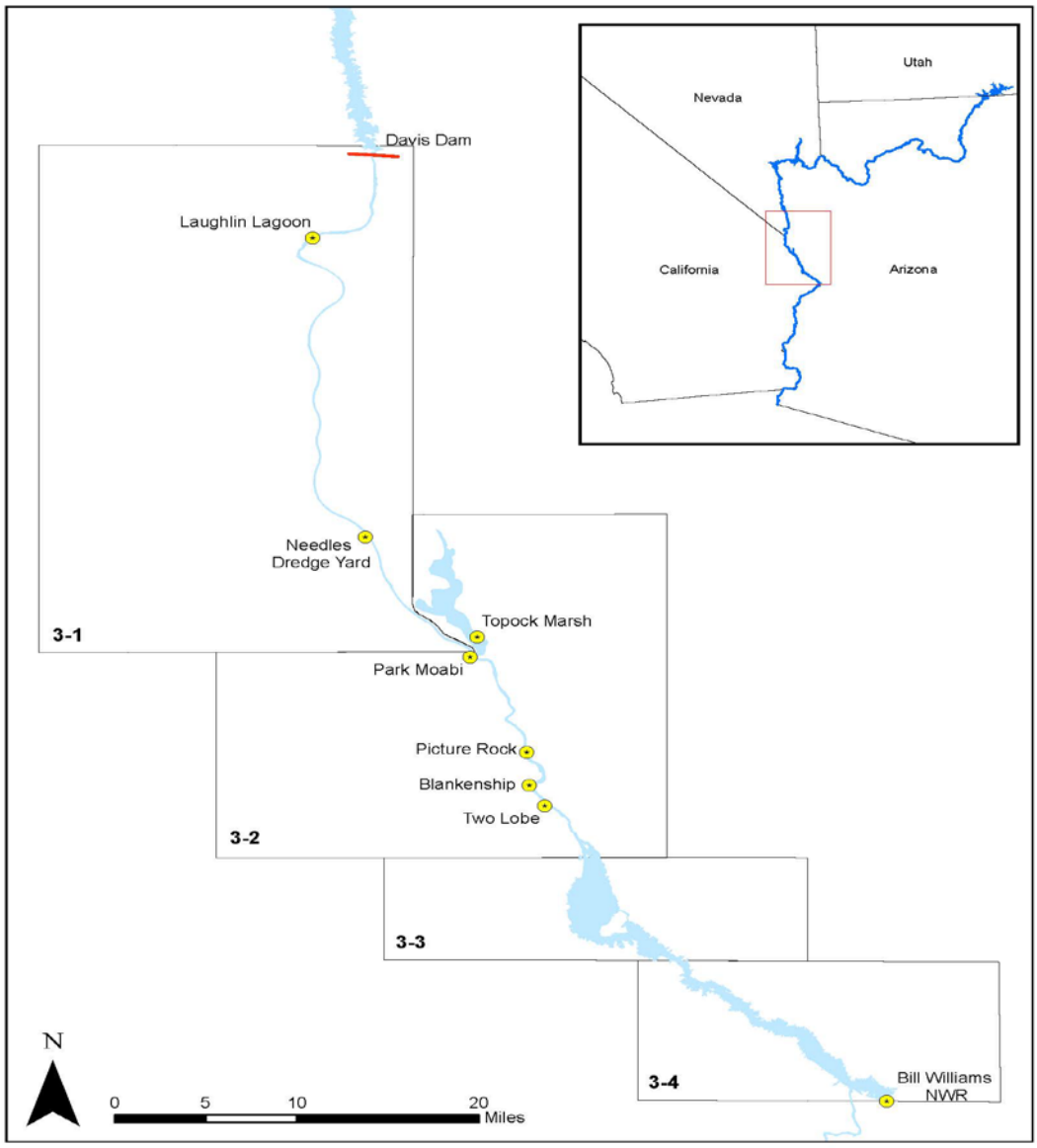

Figure 1.—Overview of Reach 3 of the LCR.

slower flowing river, backwater habitats, eddies, and an abundance of emergent vegetation. Zone 3-3 is within the reservoir and is characterized by gently sloping shorelines. This zone begins at RM 217 and extends down to the upstream side of Copper Canyon, RM 206. Zone 3-4 runs from Copper Canyon downstream to Parker Dam and includes the Bill Williams River National Wildlife Refuge. Figure 1 shows the study area in its entirety, broken out into respective zones. The focus of this project was on Zone 3-1 and Zone 3-2 (figure 2).

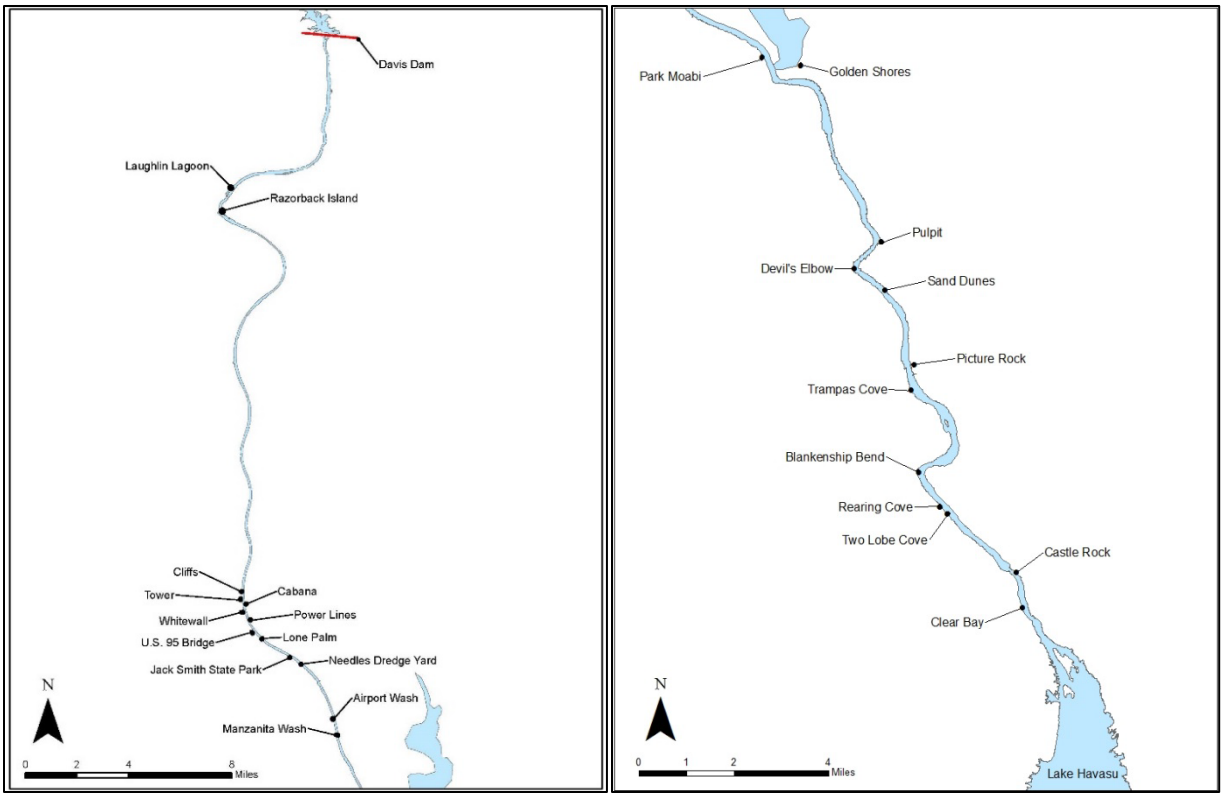

Figure 2.—Common sampling sites along Zone 3-1 (left) and Zone 3-2 (right) in Reach 3, LCR, California, Arizona, and Nevada.

PIT Scanners

PIT scanners were deployed periodically throughout study years (SYs) 2016 and 2017. More specifically, they were deployed for 1 week every month from January 1 through April 30, 2016, and November 1, 2016, through April 30, 2017. These PIT scanners were comprised of a 1.2 x 0.8 meter (m) polyvinyl chloride (PVC) framed antenna attached to a PIT scanner, logger, and a 20.8-ampere-hour battery contained in watertight PVC piping. PIT scanners could be equipped with weights or floats so they could be oriented to lie either flat along the bottom or vertically in the water column. Typically, PIT scanners were deployed during daylight hours and collected the following morning. They were downloaded onsite before being redeployed to a new location. Each unit was assigned and labeled with a unique four-character alpha-numeric code (unit ID, e.g., JL01) for individual identification that allowed data downloads to be matched with deployment locations. During each scanning trip, approximately 25 PIT scanners were deployed daily throughout Zone 3-1 and Zone 3-2, ranging from just below Davis Dam down to the delta of Lake Havasu. Deployment during the spawning season targeted known and suspected spawning locations to increase to likelihood of contacting large groups of fishes. These locations included Laughlin Lagoon, Razorback Island, the Cliffs, White Wall, Power Lines,

Airport Wash, Manzanita Wash, and Park Moabi. PIT scanning information for each individual deployment was recorded on waterproof datasheets with the following: location, unit ID, Universal Transverse Mercator (UTM) zone, UTM easting, UTM northing, depth (m) of deployed unit, date and time deployed, date and time retrieved, scheduled start and end time of PIT scanner (if not continuous), scheduled time interval of PIT scanner, scan time (minutes), unit orientation in water, purpose of scanning, comments, and a check box to indicate if any equipment malfunctioned. All scanning data were incorporated into the Lower Colorado River Native Fish Database (http://www.nativefishlab.net/?page_id=126), and data summaries or queries were performed as needed (Marsh & Associates, LLC 2019).

Electrofishing/Trammel Netting

Electrofishing was conducted throughout razorback sucker spawning grounds near Jack Smith Marina in Needles, California, in Zone 3-1 to seek out potential spawning aggregates that would inform scanning locations in those areas. This effort occurred at night, with one biologist operating the boat equipped with a Smith-Root Generator Powered Pulsator and two biologists with nets present on the bow. All razorback suckers captured were measured for TL (mm), weight in grams (g), sexed, assessed for sexual ripeness, scanned for a 125- or 134.2 (hereafter 134)-kilohertz (kHz) PIT tag, and tagged with a 134-kHz PIT tag if no tag was detected or if only a 125-kHz tag was present. A right pectoral fin clip was taken from individual fish, preserved in a 1 milliliter (mL) snap-cap tube with 95% ethanol, and sent to the Conservation Genetics Laboratory at Wayne State University, Detroit, Michigan, for analyses. All fish were then returned to their point of capture and released.

Trammel netting was conducted over 4 nights in February 2017 in Zone 3-2. Nets were deployed each afternoon and retrieved the following morning. February sampling generally utilizes multifilament trammel nets that are 45.7 or 91.4 m x 1.8 m. These trammel nets are composed of two different-sized mesh nets. The large mesh net measures 30.5 centimeters (cm), and inside of that is a smaller net that measures 3.8 cm. Trammel netting is a technique that safely captures native fishes by entanglement. Any fish that swims into the outer 30.5-cm mesh net becomes entangled within the finer 3.8-cm net. All native fishes captured were processed as described above. Non-native fishes were identified by species and measured in TL. Common carp (*Cyprinus carpio*) and gizzard shad (*Dorosoma cepedianum*) were only enumerated and released. All fishes were then returned to their point of capture and released. All electrofishing and trammel netting data were entered into the comprehensive Lower Colorado River Native Fish Database maintained by Marsh & Associates, LLC, on behalf of all partners engaged in conservation activities for native fishes in the LCR.

A new technique was tested in spring 2017 that incorporated PIT tag scanning with electrofishing. As an alternative to netting all fish, one biologist was equipped with a BioMark HPR Plus PIT tag reader mounted to a net pole (figure 3). This was used to scan fishes while electrofishing in lieu of capturing them. This technique proved to be effective at contacting numerous razorback suckers with minimal effort. While electrofishing, fishes were scanned with the PIT tag reader and the tag data saved to the BioMark HPR Plus memory, eliminating any unnecessary handling of the fishes. This technique was used so biologists could quickly scan multiple fishes while electrofishing.

Figure 3.—Biomark HPR Plus attached to a PIT scanner.

Population Estimates

The modified Petersen formula (Ricker 1975) based on paired census data was used to calculate a single census population estimate (N^*) for razorback suckers in 2016:

$$N^{\wedge} * = \frac{(M+1)(C+1)}{(R+1)}$$

Fish to be included in the estimate must have been tagged and released prior to SY16 (before January 1, 2016). Fish with only a 134-kHz PIT tag release or capture record in the Lower Colorado River Native Fish Database were included in the estimate (i.e., fish tagged with both a 125- and 134-kHz PIT tag were not included).[1] All razorback suckers and bonytail released were stocked into either the river channel, reservoir, or connected backwaters; none were released into isolated pools disconnected from the river. Definitions for *M*, *C*, and *R* from Ricker (1975) have been modified for this population estimate. Mark (*M*) is not the number of fishes tagged and placed into a water body, but the number of fish scanned in a designated marking period (January 1 to April 30, 2016). Catch (*C*) is the number of fishes contacted in the second period of the paired data. The catch period is extended to include all scanning data from November 1, 2016, to August 31, 2017. Recapture (*R*) is the number of fishes contacted in both the mark and catch periods. The population estimate is representative of the razorback sucker population during the marking period (January 2016 – April 2016). Fish contacted more than once in the mark or catch periods were only included in the analysis for their first encounter event in each timeframe. Confidence intervals were assumed to have a normal distribution due to the fact that the recaptures were > 50 (Seber 1973).

When utilizing this estimate, three assumptions are used (Pollock et al. 1990): (1) the population is closed to both deletions and additions, (2) no tags are lost or omitted, and (3) equal catchability of all individuals. These assumptions are satisfied based on the fact that the PIT tags are assumed to be permanent (Zydlewski et al. 2003); natural mortality is the only component affecting the estimate, but its impacts are assumed to be minimal for the population during the mark period; and all individuals are assumed to have an equal chance of being contacted due to the broad scale of the various monitoring surveys.

Larval Fish Collection

Larval razorback suckers are positively phototactic and can be captured at night with a small mesh aquarium dip net as they are attracted to a 12-volt submersible light (Delrose 2011). Larval collection was done monthly starting in January and running through March. Larval fish collection was focused at three primary locations in Reach 3 and downstream from known spawning locations for razorback suckers. The locations were Jack Smith (RM 244), Park Moabi (RM 235), and Pulpit Rock (RM 229) (see figure 2). Jack Smith collections were done from shore, near the inlet along the rocky shoreline; Pulpit Rock collections were done exclusively from a boat; and the Park Moabi collections were a

[1] Due to previous data management practices, the date a fish was double tagged (given a 134-kHz in addition to a 125-kHz tag) cannot be determined. Without this determination, the availability of the fish to PIT scanning equipment during both the marking and capture periods cannot be verified.

combination of boat and shore sampling. Shore sampling in Park Moabi was conducted by the boat launch and docks. A fourth site was sampled on a single occasion in March 2017, as larval fishes were observed in the Sand Dune backwater (RM 227) while conducting other routine monitoring. These fishes were collected during the day without the use of lights. Samples were collected five different times from each of the three primary sites between January and March, except at Pulpit Rock, where the Sand Dune sample took the place of the fifth Pulpit Rock sample. Samples for each site were collected within the same week. Collection gear consisted of two Q-Beam Starfire II underwater fishing lights, two 12-volt batteries, two fine-mesh aquarium nets (0.15 m wide x 0.14 m long, with a 0.28-m handle) that were modified with a wooden dowel to extend the net handle to about 1 m in overall length. Lights were deployed, and sampling began after sunset. Larval fishes were netted and placed, using forceps, into individual 5-mL vials containing 95% non-denatured ethanol for preservation. The vials were grouped by sampling location and labeled to include date, location, UTM coordinates, crew members, start and stop times, number of larvae collected, number of lights used, and other pertinent comments. Sampling was conducted at each location until 25 larval fish were collected.

Razorback Sucker Soft Release Trials

In an effort to evaluate the effects that alternative stocking methods have on the survival of razorback suckers, the LCR MSCP began trials of holding stocked fish in three backwaters (i.e., behind block nets) to allow for acclimation versus direct stocking in which fish are allowed to disperse immediately. These trials aim to assess long-term survival through recontact probabilities utilizing data collected from annual PIT tag scanning surveys. Fish released in trials will continue to be documented in future years, as it may require multiple years of data to evaluate this alternative stocking method.

To facilitate the soft release trials, block nets were installed 1 day prior to when the fish were to be released. Nets were set in three backwaters, Picture Rock, Blankenship, and Two Lobe (see figure 2). The block nets were 0.6-cm mesh, measuring 61 m long and 2.4 m tall, consisting of a float line and lead line. The block nets were stretched across a portion of the cove and tied off to shore; chains were added to the lead line to ensure that the net lay flush along the substrate to prevent fish from escaping. Sites were selected that had ample depth (≥ 1 m) and cover (i.e., submerged or overhanging vegetation) to avoid predation or other environmental factors (i.e., direct sunlight). The approximate areas behind the block nets in 2016 and 2017 were: Two Lobe – 200 square meters (m^2), Blankenship – 322 m^2 (2016) and 158 m^2 (2017), and Picture Rock – 6,301 m^2 (figure 4).

Figure 4.—From top left going clockwise: block nets at Picture Rock, Blankenship (California side), and Two Lobe, and view of razorback suckers behind a block net in Blankenship.

In 2016, razorback suckers were sourced from the Bubbling Ponds Fish Hatchery (Cornville, Arizona) and Lake Mead Fish Hatchery (Boulder City, Nevada). In 2017, all fish came from Lake Mead Fish Hatchery. Fish were transported using a 4,844-liter (L) transport tank (figure 5). Due to size variation in hatchery fish, treatment groups for each stocking location were divided into similar size classes before being stocked. Releasing treatment groups of similar size classes at individual stocking locations will allow for reduced variability and better comparisons of post-stocking survival between paired treatments. The transport tank is divided into three separate compartments (1,628 L each) for different treatment groups. Oxygen was provided via one, 61-cm-long, fine-pore oxygen diffuser and two Fresh-Flo aerators (Fresh-Flo Sheboygan, Wisconsin) per tank. Tanks were salted to a minimum concentration of 5 milligrams per liter [mg/L]), and stress coat (Mars Fishcare North America, Inc.) was added at the recommended dose of 5 mL per 38 L of water. Salt and stress coat were added to minimize stress effects associated with netting and transport. In 2016, fish were transported on February 11, 16, 17, and 18, transporting 1,061, 604, 1,002, and 400 razorback suckers, respectively. In 2017, razorback suckers were transported on February 22 and 24, transporting 749 and 750 fish, respectively (table 1). Each batch of fish had been previously PIT tagged, measured for TL,

Figure 5.—View of fish transport trailer tanks.
Left picture shows transport tank's three chambers installed with fine-pore air stones. The picture on the right is a view of tank release pipes.

Table 1.—Stocking location, fish disposition, date stocked, fish lengths, and number stocked for soft release trials 2016 and 2017

Stocking location	Fish disposition	Date stocked	Fish lengths (minimum–maximum (mm)	Average length (mm)	Number of fish stocked
Two Lobe	Hold	2/11/2016	300–465	336	530
Two Lobe	Release	2/11/2016	300–445	335	531
Blankenship	Hold	2/17/2016	305–485	361	399
Blankenship	Release	2/18/2016	305–500	360	400
Picture Rock	Hold	2/16/2016	350–520	440	604
Picture Rock	Release	2/17/2016	375–490	447	603
Two Lobe	Hold	2/22/2017	312–515	407	249
Two Lobe	Release	2/24/2017	330–502	415	250
Blankenship	Hold	2/22/2017	315–495	408	250
Blankenship	Release	2/24/2017	322–510	423	250
Picture Rock	Hold	2/22/2017	317–501	417	250
Picture Rock	Release	2/24/2017	328–484	413	250

separated based on stocking location, and given a batch number to differentiate for stocking treatment (held versus released). Once loaded, fish were transported from the hatcheries to Park Moabi Regional Park (approximately 175 kilometers from the Lake Mead Fish Hatchery and 414 km from the Bubbling Ponds Fish Hatchery). At Park Moabi, water quality was recorded (dissolved oxygen in mg/L and temperature in degrees Celsius [°C]), and river water was pumped into the transport tanks to aid in acclimating the fish. The transport tanks needed to be within 2 °C of the river water before transfer. Once the tanks were tempered, all fish were assessed for overall health and loaded into two boats.

Each boat was equipped with two transport tanks (409 L tanks in one and 379 L tanks in the other) (figure 6). The transport tanks on the boats were all salted to a minimum concentration of 5 mg/L, and stress coat was added at the recommended dosage. A diaphragm air compressor, powered by a 12-volt battery, provided oxygen to the transport tanks during transport. Once the tanks had been prepped, the fish were netted out of the trailer tanks and transferred into the boat tanks. A net was placed over each transport tank after the fish had been loaded. Fish were placed in specific tanks based on their release locations. Three water changes, approximately 30% of the tanks, were completed during transport to maintain water quality. Water temperatures were taken at each release location prior to releasing any fish. Transport tanks were tempered with river water if temperatures were not within 2 °C. Once the tank water temperatures were ready, fish were netted and released behind or in front of the block net.

Figure 6.—Picture of two 409-L boat transport tanks and aerator setup for the tanks.

To determine if any fish passed the block nets and "escaped," PIT scanners were placed in areas around the block nets to detect fish that escaped. Any fish that escaped the block nets were not included in this study. Razorback suckers that were stocked behind the block nets were given at least 72 hours to acclimate to each backwater. Block nets were checked daily to ensure the chains were still laying on the bottom and to ensure the nets had not been tampered with. Following the 72-hour "hold" period, the block nets were pulled to allow the fish to disperse.

RESULTS

Remote PIT Tag Scanning

For these results, only native fishes released prior to the SY16 are included, and location data are based on the first contact from each SY. Scanning efforts throughout Reach 3 yielded 3,934 razorback suckers, 17 flannelmouth suckers, and 1 bonytail between both scanning seasons. In SY16, 2,409 razorback suckers and 4 flannelmouth suckers were contacted over 14,940 scan-hours. During SY17, 1,525 razorback suckers, 13 flannelmouth suckers, and 1 bonytail were contacted over 32,267 scan-hours. Park Moabi had the highest number of contacts during SY16 and SY17: 32% of all native fishes were contacted in Park Moabi. Power Lines had the next highest contact rate at 16% (figure 7).

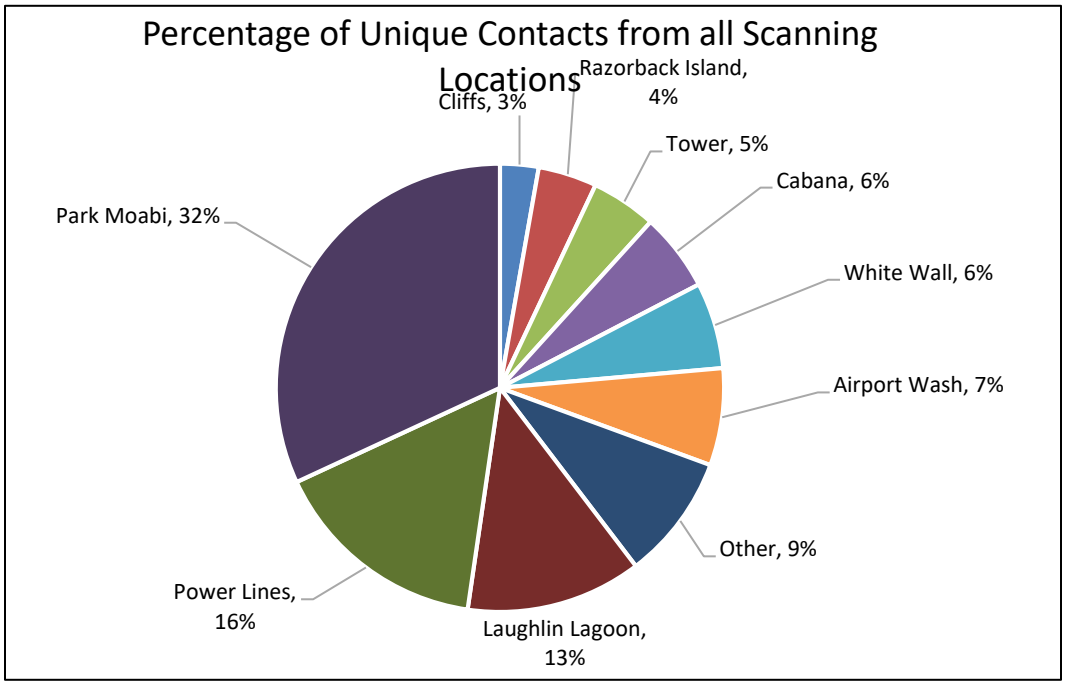

Figure 7.—Percentage of unique contacts in specific scanning locations throughout Reach 3 in SY16 and SY17.

PIT scanners were deployed in backwaters and the river channel. Figure 8 illustrates the percentage of native fishes contacted in either the river channel or backwaters. More than half of all contacts were in the river channel during the scanning seasons (figure 8). Razorback suckers made up a large majority of the contacts (> 99%) due to scanning seasons overlapping with their spawning season. Among all razorback suckers contacted in the river channel, 89% of them were contacted in known spawning areas.

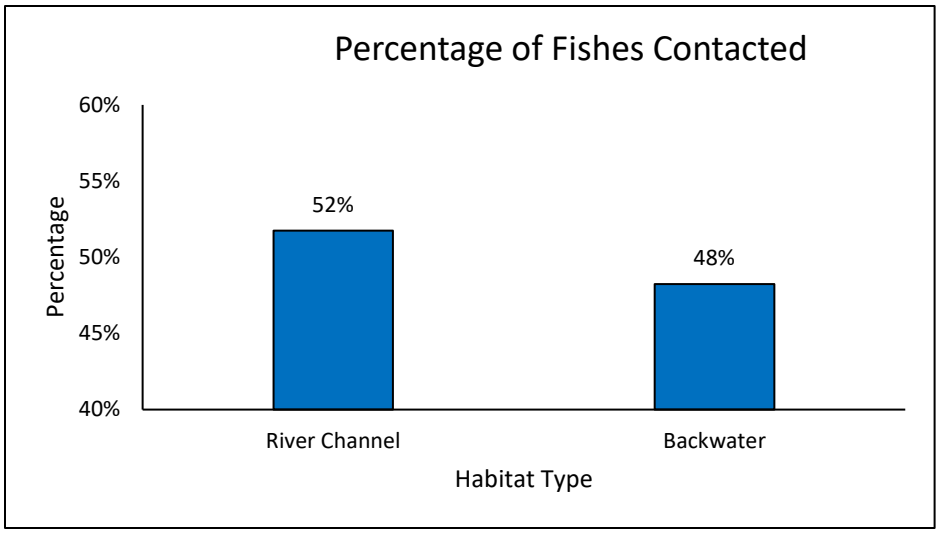

Figure 8.—Percentage of all native fishes scanned in the river channel or backwater habitat.

Park Moabi and Laughlin Lagoon had the highest number of contacts among all backwaters. These two backwaters made up 65% of all the backwater contacts. A high proportion of razorback suckers contacted in Park Moabi or Laughlin Lagoon were also stocked into those same backwaters. There were 497 razorback suckers contacted in Laughlin Lagoon, and 442 of those were stocked there. In Park Moabi, there were 1,251 razorback suckers contacted, 933 of which were stocked there. Figure 9 illustrates the percentage of razorback suckers contacted in Laughlin Lagoon and Park Moabi from SY16 and SY17 that were also stocked into those backwaters. All other backwaters where razorbacks have been stocked have a significantly lower recontact rate (< 1%).

Scanning effort varies throughout the year, but it is relatively consistent during the spawning season. Native fish contacts were highest in January and February, which is also considered to be the peak spawning period for razorback suckers in Reach 3. Figure 10 shows the scanning effort and number of native fishes contacted for each month. Table 2 shows the number of native fishes contacted per hour during the scanning both seasons. Scan times ranged from1,914–8,604 hours. January had the highest frequency of fish contacted, 0.19 fish per hour. May was the lowest frequency for fish contacted, 0.005 fish per hour.

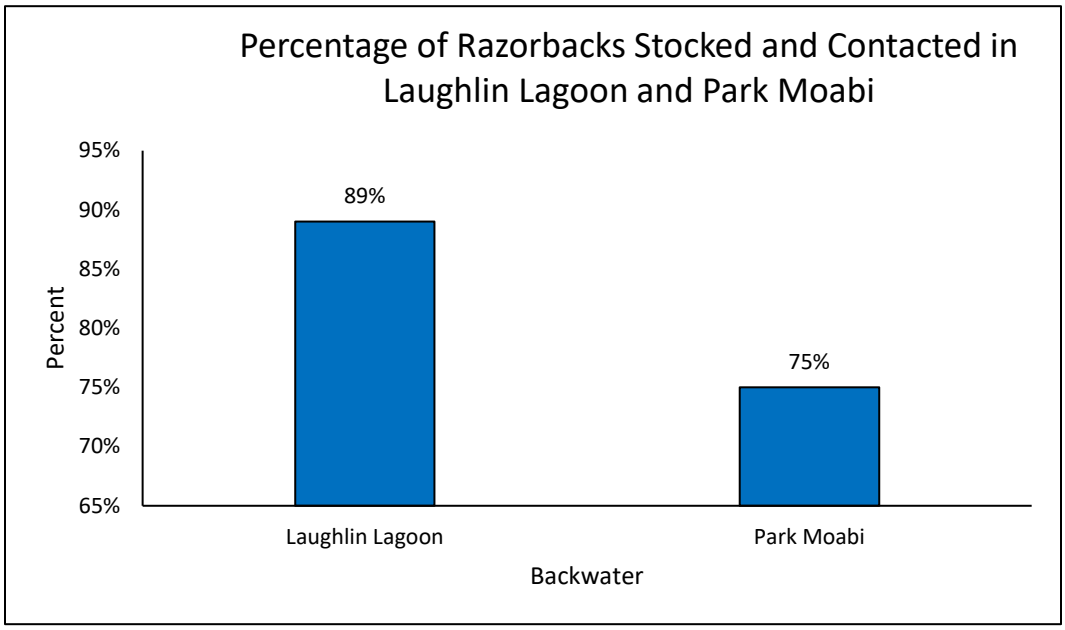

Figure 1.—Percentage of razorback suckers contacted in Laughlin Lagoon and Park Moabi that were also stocked into each respective backwater.

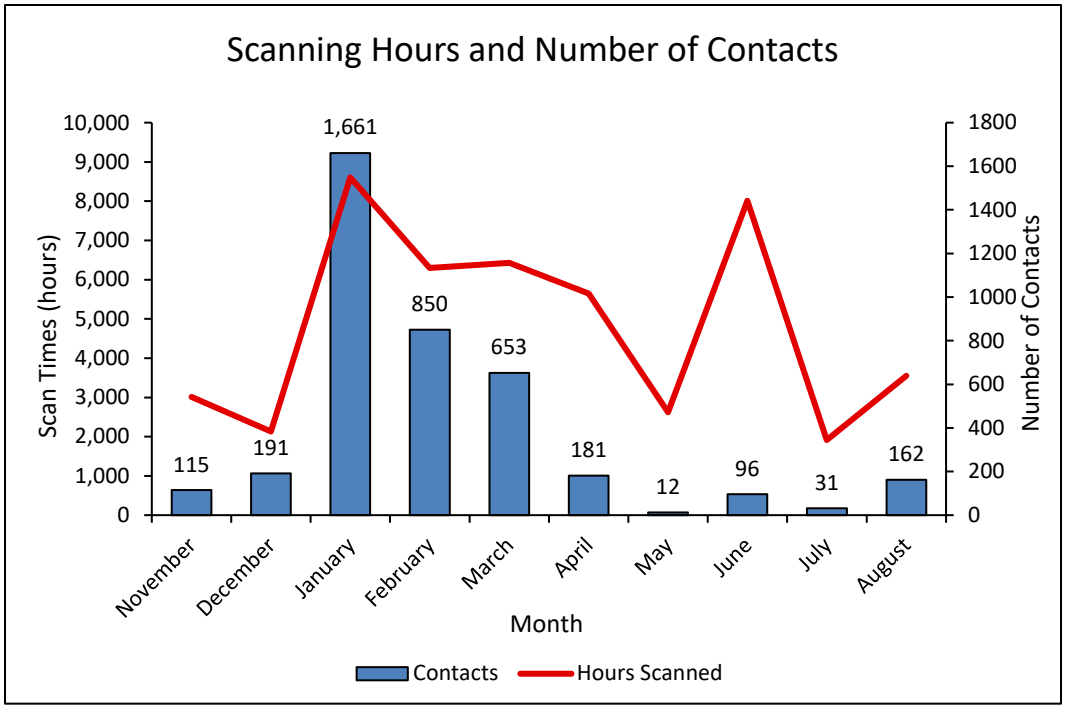

Figure 2.—Number of native fishes contacted each month throughout SY16 and SY17.
Note: January through April were the only months scanned in both years.

Table 1.—Scan-hours for each month and frequency of fishes contacted during scan times

Month	Scanning hours	Total fishes contacted	Fishes contacted per hour
November	3,015	115	0.04
December	2,131	191	0.09
January	8,604	1,661	0.19
February	6,297	850	0.13
March	6,425	653	0.1
April	5,642	181	0.03
May	2,618	12	0.005
June	8,014	96	0.01
July	1,914	31	0.02
August	3,547	162	0.05

Electrofishing/Trammel Netting

An electrofishing trip near Jack Smith Marina in Needles, California, in Zone 3-1, was taken on the night of March 16, 2017, by three Reclamation biologists. The pole-mounted BioMark HPR Plus PIT scanner was used by one biologist, and the other biologists used a net. Eighty-five razorback suckers were contacted: 47 were scanned by the BioMark HPR Plus and 38 were netted. Of the 38 razorback suckers netted, 17 were males and 21 were females. The average TL of razorback suckers collected was 571 mm and ranged from 410–690 mm. The average weight was 2,112 g and ranged from 780–4,750 g. Three razorback suckers were without tags and implanted with a 134-kHz PIT tag. The sex, length, and weight of razorback suckers scanned could not be determined with the BioMark HPR Plus. Generator seconds were not available for this survey due to equipment failure.

A total of 631 fishes of all species were collected in trammel nets during the annual spring monitoring in February. Sampling took place February 6–9, 2017, from Park Moabi Regional Park to the delta of Lake Havasu. Seventeen razorback suckers were collected: nine were female, three were male, and five were unknown. The TL of razorback suckers averaged 487 mm and ranged from 315–620 mm. The weight of razorback suckers averaged 1,259 g and ranged from 350–3,115 g. Thirteen razorback suckers were collected in Park Moabi, two were collected in Blankenship, a single fish was collected in Picture Rock, and a single fish was collected in Pulpit Rock. All fish were already PIT tagged at the time of capture. Seven bonytail were also collected in the Park Moabi. Bonytail had an average TL of 287 mm (278–300 mm) and an average weight of 151 g

(125–180 g). No bonytail were assigned a sex, and all contained a PIT tag. The bonytail collected were from stocking events that took place on October 19 and December 7, 2016. These bonytail were from known stocking events of fish < 305 mm TL, and the LCR MSCP did not seek augmentation credit for these fish.

Larval Sampling

A total of 375 larval razorback suckers were captured in 2017; all of these fish were kept and sent for genetic analysis. Genetic analysis and reporting is captured under LCR MSCP Work Task C31: Razorback Sucker Genetic Diversity Assessment. The larval catch rates peaked in late February and early March, which correlates to razorback sucker peak spawning months. The catch rates and relative abundance of larval razorback suckers were similar to those on Lake Mohave (Lantow 2019, personal communication). Table 3 contains the sampling location, date sampled, minutes sampled, and catch per unit effort (CPUE) for the larval fish collections.

Table 2.—Sampling locations and coordinates, date sampled, time samples, number of larval fish collected, and CPUE

Location	UTM coordinates	Date	Minutes sampled	Larvae captured	CPUE (minutes)
Jack Smith	11S 0720510E 3857539N	1/18/2017	72	25	0.35
Jack Smith	11S 0720510E 3857539N	2/9/2017	15	25	1.67
Jack Smith	11S 0720510E 3857539N	2/21/2017	3	25	8.33
Jack Smith	11S 0720510E 3857539N	2/27/2017	17	25	1.47
Jack Smith	11S 0720510E 3857539N	3/13/2017	5	25	5.00
Park Moabi	11S 0728987E 3845695N	1/20/2017	90	25	0.28
Park Moabi	11S 0727686E 3845981N	2/8/2017	120	25	0.21
Park Moabi	11S 0728887E 3845697N	2/21/2017	11	25	2.27
Park Moabi	11S 0728569E 3845638N	2/27/2017	12	25	2.08
Park Moabi	11S 0728571E 3845635N	3/14/2017	9	25	2.78
Pulpit Rock	11S 0733875E 3845635N	1/19/2017	91	25	0.27
Pulpit Rock	11S 0733791E 3839038N	2/9/2017	17	25	1.47
Pulpit Rock	11S 0733789E 3839035N	2/21/2017	6	25	4.17
Pulpit Rock	11S 0733838E 3839046N	2/27/2017	17	25	1.47
Sand Dune	11S 0734142E 3837179N	3/14/2017	20	25	1.25

Figure 11 shows the steady increase of CPUE over the sampling period before it hits a peak in mid- to late February and then begins to decrease toward the beginning of March. One sampling trip was done in the Sand Dune backwater in place of the final Pulpit Rock sample. All larvae captured were relatively in the same developmental stage.

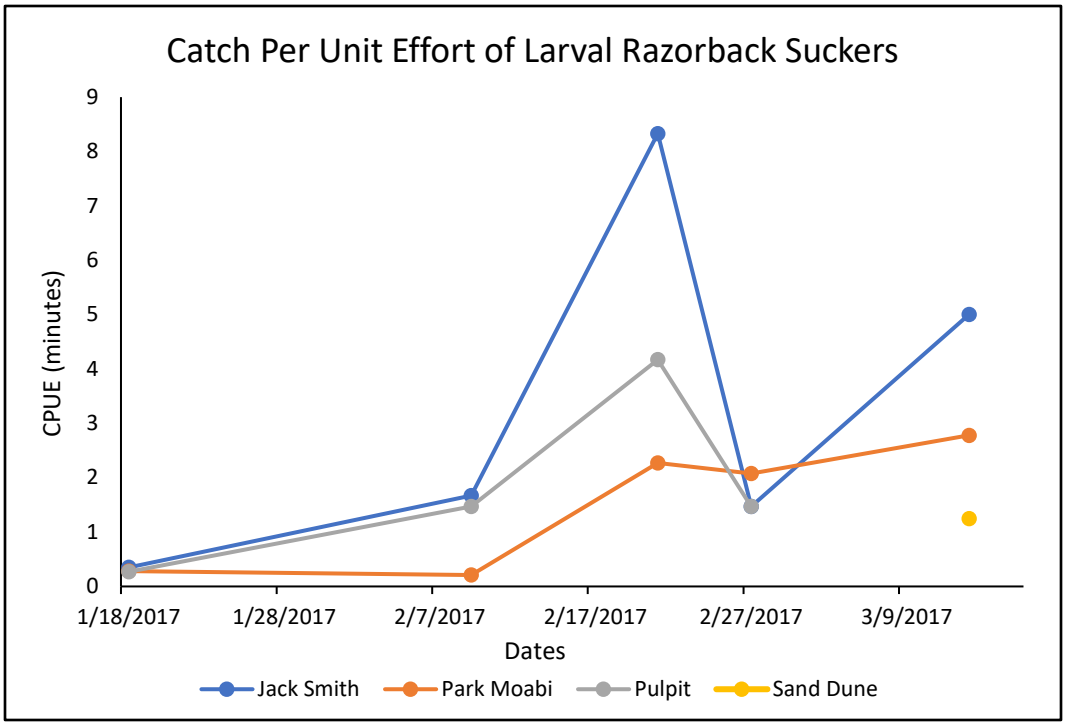

Figure 3.—CPUE (fish/minute) for larval fish at four sampling locations over a 3-month period.

Soft Release

In order to avoid bias due to short-term survival, contact data for razorback suckers used in the soft release trials were not included in the analysis unless the information was collected a minimum of 6 months post-release. All razorback suckers that escaped the block nets were also excluded from the analysis. In 2016 and 2017, the number of fish that escaped the block net were 0 and 0 in Picture Rock, 0 and 9 in Blankenship, and 2 and 6 in Two Lobe, respectively. The number of contacts were analyzed based on their locations and treatment groups (hold or release). The number of contacts for the 2016 soft release trials are low. Contact rates varied between 2 and 6%. Figure 12 shows the percentage of razorback suckers detected from the 2016 soft releases.

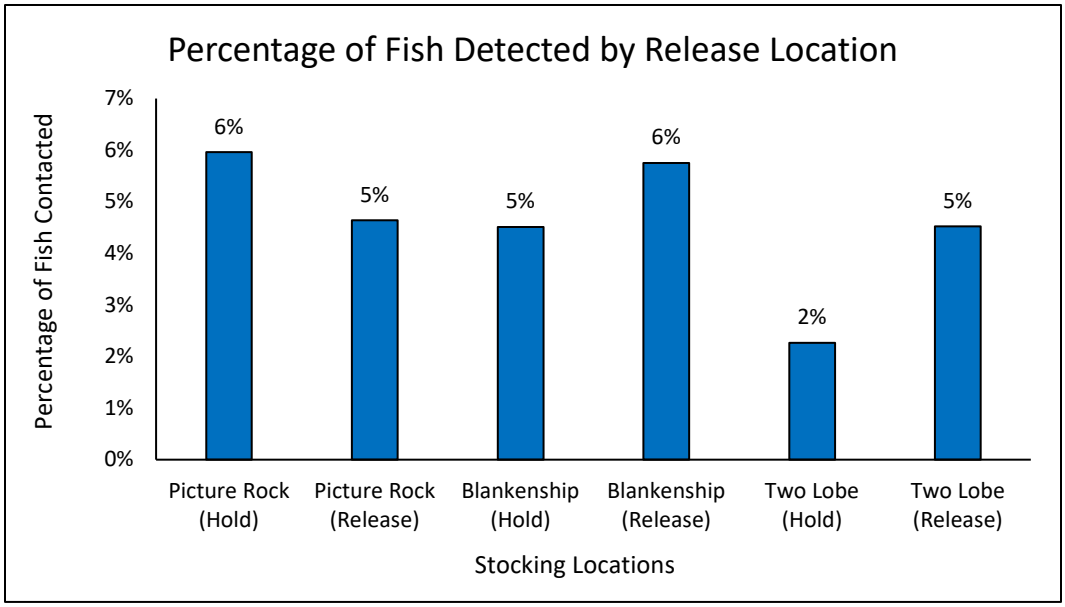

Figure 4.—Percentage of fish detected by release location (soft release February 11, 16, 17, and 18, 2016).

The largest fishes released in 2016 were at Picture Rock, with an average TL of 440 and 447 mm for held and released fishes, respectively. Two Lobe and Blankenship fishes were smaller, with average sizes for held and released fishes being 336 and 335mm TL in Two Lobe and 361 and 360 mm TL in Blankenship. Figure 13 shows the size classes and release locations of any razorback suckers contacted in SY16. Detection data for fish released in 2017 have yet to be analyzed, but it is suspected that several years of scanning will be required to collect enough data for detecting potential differences in contact rates or survival.

Population Estimate

All fishes had to be tagged and released prior to SY16 to be included in the population estimate. The number of contacts for bonytail and flannelmouth suckers were too low to estimate their populations. A total of 2,409 razorback suckers were contacted during the marking period, 1,525 razorback suckers were contacted during the capture period, and 688 were contacted in both the mark and capture periods (table 4). The Chapman modified Petersen equation was used to estimate their population. The population is estimated at 5,338 (5,043–5,633; 95% confidence interval) razorback suckers throughout Reach 3. This is a slight increase from 2015, when the population was estimated to be 4,923 individuals (Kesner et al. 2017).

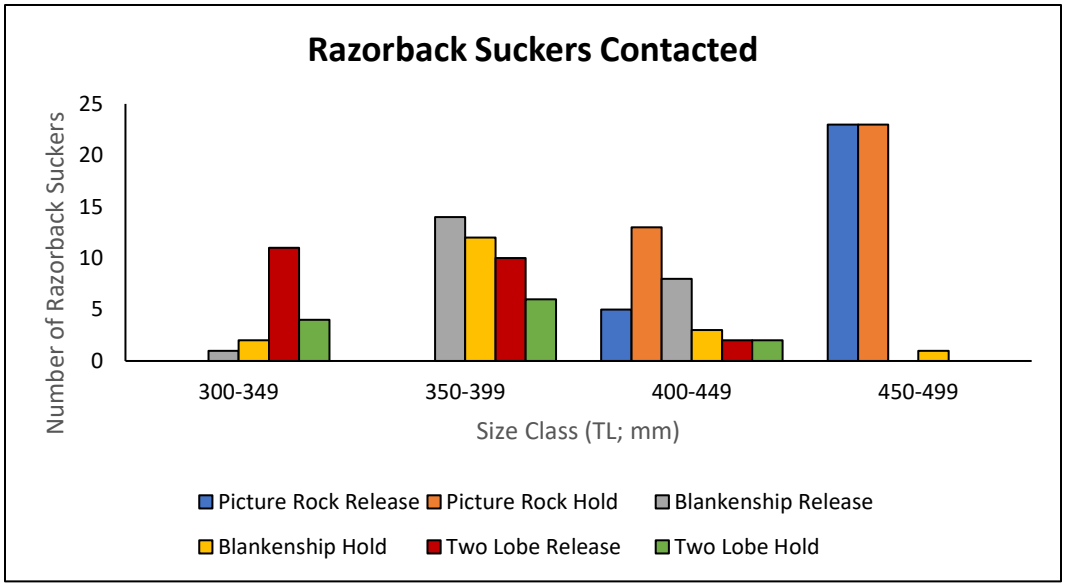

Figure 5.—Number of razorback suckers contacted from soft release trials based on size class.

Table 3.—Razorback sucker population estimates, LCR MSCP Reach 3, 2011–16

Year	Number marked	Number captured	Number recaptured	Population estimates (95% confidence interval)
2011	228	642	59	2,454 (1,868–3,041)
2012	934	1,373	284	4,508 (4,043–4,973)
2013	1,335	1,730	518	4,456 (4,135–4,776)
2014	1,931	2,385	933	4,935 (4,689–5,182)
2015	2,674	2,211	1,201	4,923 (4,735–5,111)
2016	2,409	1,525	688	5,338 (5,043–5,633)

DISCUSSION

Through SY17, there have been more than 50,000 bonytail and 88,700 subadult razorback suckers released into Reach 3 by the LCR MSCP. The presence of razorback suckers and bonytail in the reach continues to be contingent on stocking efforts. Bonytail have not been documented spawning in Reach 3, and estimating the current population has not been possible due to low detection rates. Flannelmouth suckers have been documented spawning and successfully recruiting in Reach 3, and in 2010, their population was estimated to be at 1,536 individuals (Best and Lantow 2012). The razorback sucker population has been stable for a number of years, and in 2016, the estimate exceeded 5,000 fish for the first time.

Low post-stocking survival rates have been observed for bonytail and subadult razorback suckers mainly due to high predation rates from non-native fishes or birds. Released razorback suckers and bonytail have been documented utilizing backwaters following their release. For razorback suckers, backwaters are areas where they can grow into sexual maturity before moving into the river in search of spawning opportunities.

Habitat within backwaters is typically more turbid and comprised of dense areas of bulrush (*Schoenoplectus* spp.). These areas of bulrush make it difficult for the PIT scanners to detect fish. Many native fishes spend a large portion of time in bulrush during the day and are only available to be contacted when they move into open water at night. Park Moabi and Laughlin Lagoon are large backwaters with very suitable habitat. Other species-specific studies and the number of recent contacts within these two backwaters suggest that these are important backwater habitats for all native fishes. Numerous razorback suckers have been contacted in these backwaters >5 years after stocking, which suggests that Park Moabi and Laughlin Lagoon offer suitable long-term habitat for both subadults and sexually mature adults. Spawning razorback suckers have been observed in Laughlin Lagoon and suspected in Park Moabi, but high turbidity in the latter has prevented visual confirmation.

Sexually mature razorback suckers transition to riverine type habitats throughout the year and begin to stage in the river late in the year. In early January, they congregate on spawning grounds near Needles, California, and Laughlin, Nevada. The majority of razorback suckers contacted in the river channel north of Needles, California, are sexually mature. Eighty-nine percent of the razorback suckers scanned in the river channel were adjacent to spawning grounds between Laughlin Lagoon and Needles, California. Razorback suckers contacted on the spawning grounds have generally been in the system between 4 and 6 years. These aggregations of adult fish are critical to this study because they are typically easily contacted in the river channel, which helps assess their population.

Contact results from the soft release trials did not suggest either treatment (held versus released) was more beneficial to razorback suckers at this time. The number of contacted fish is relatively small to date. Continued monitoring may provide enough data for detecting a statistical and biologically important difference in the long-term survival of these fish. As was expected, the difference in size did show a notable difference in detection rates. Throughout its range, it has been well documented that razorback survival rates increase with TL at stocking (Ehlo et al. 2015; Bestgen et al. 2012).

It should be noted that flathead catfish (*Pylodictis olivaris*) have recently been documented further upstream in Reach 3 than in previous years. They are large, non-native piscivorous game fish with large mouths capable of consuming 400-mm fishes. It is unknown how much this species will affect the native

fishes in this reach. Stocking larger razorback suckers could become critical if flathead catfish become more established in the backwaters up through Laughlin Lagoon.

PIT scanning has proven to be one of the most effective methods for monitoring native fish populations. Scanning efforts were focused in Zone 3-2 between Needles, California, and the delta of Lake Havasu; a more concerted scanning effort through Zone 3-1 could be considered. Reach 3-1 has known razorback sucker and flannelmouth sucker spawning areas around Laughlin Lagoon and Razorback Island, but limited scanning is done downstream from Razorback Island and upstream of the Cliffs near Needles, California. Focusing on this stretch of the river could help to potentially find additional spawning aggregations and allow for a more inclusive population estimate. In addition to expanding the scanning locations, the continuation of scanning throughout Zone 3-2 would provide consistent data for annual analyses.

Annual electrofishing surveys could also be considered for locating expanding spawning congregations throughout Reach 3. Utilizing the Biomark HPR Plus proved to be effective at contacting numerous native fishes with minimal effort. If additional congregations are found, these locations could be added to regular scanning efforts. Annual spring and fall netting could also be used to continue monitoring native fish populations and distribution as well as to provide information on growth, size, and genetics, which are otherwise lacking from scanning efforts.

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