Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Razorback Sucker (*Xyrauchen texanus*) Investigations at the Colorado River Inflow Area, Lake Mead, Nevada and Arizona

2013 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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Lower Colorado River Multi-Species Conservation Program

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ACRONYMS AND ABBREVIATIONS

AICc	corrected Akaike's information criterion
ANOVA	analysis of variance
asl	above sea level
BIO-West	BIO-WEST, Inc.
CI	confidence interval
cm	centimeter(s)
CPUE	catch per unit effort
CRI	Colorado River inflow area of Lake Mead
FL	fork length
ft	foot/feet
in	inch(es)
km	kilometer(s)
L	liter(s)
LMWG	Lake Mead Work Group
m	meter(s)
mi	mile(s)
mm	millimeter(s)
MS-222	tricaine methanesulfonate
NDOW	Nevada Department of Wildlife
PIT	passive integrated transponder
Reclamation	Bureau of Reclamation
RKM	river kilometer
RM	river mile
SL	standard length
SUR	submersible ultrasonic receiver
TL	total length
USFWS	U.S. Fish and Wildlife Service

Symbols

%	percent
±	plus or minus

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EXECUTIVE SUMMARY

In 2010, the Bureau of Reclamation (Reclamation), under the Lower Colorado River Multi-Species Conservation Program, initiated a project to evaluate razorback sucker (*Xyrauchen texanus* [Abbott]) use of the Colorado River inflow area of Lake Mead (CRI). The project is based on a biological opinion from the U.S. Fish and Wildlife Service (USFWS) that recommended Reclamation begin a project to "…examine the potential habitat in the lower Grand Canyon for the species, and institute an augmentation program in collaboration with USFWS, if appropriate" (USFWS 2007). The project was also recommended in the comprehensive report that reviewed 10 years of razorback sucker monitoring on Lake Mead (Albrecht et al. 2008a). Several of the recommendations from this report were highlighted by the Lake Mead Work Group for inclusion in its long-term management plan (Albrecht et al. 2009), and investigating the CRI for razorback sucker presence was the first item from that plan to be implemented. This report presents the results of the fourth year of efforts to determine the status of razorback suckers at the CRI.

Based on research conducted during long-term Lake Mead razorback sucker investigations, efforts involved tagging and releasing pond-reared razorback suckers into the CRI in 2010 and 2011 and tracking these fish using sonic telemetry techniques. In 2013, efforts were initiated to implant wild fish with acoustic transmitters, which resulted in the surgical implantation of one wild fish at the CRI. Additionally, we were tasked with capturing, implanting, and releasing 10 hatchery-reared sonic fish from the Nevada Department of Wildlife's Lake Mead Fish Hatchery into the lower Grand Canyon. This was accomplished by stocking the fish near Separation Canyon to track movement and habitat use of razorback suckers within the lower Grand Canyon. In 2013, all sonic-tagged razorback suckers were followed via manual tracking (similar to long-term razorback sucker monitoring methods) and passive tracking (using submersible ultrasonic receiver technology). In total, 17 sonic-tagged fish were contacted at the CRI in 2013. Contact was made with eight fish released at the CRI in 2010 and 2011, one newly implanted sonic-tagged fish captured and released at the CRI in 2013, and eight newly implanted fish stocked into the lower Grand Canyon in 2013. The number of contacts totaled 32 active and 9,710 passive detections. As of May 2013, 20 sonic-tagged fish that have been released at the CRI or within the lower Grand Canyon remain active or are presumed active. One sonic-tagged fish, released at the CRI in 2010, was located in Las Vegas Bay for the majority of the season and last detected at that location. Perhaps most interesting was the utilization of the Colorado River by sonic-tagged fish in 2013. Two of the 2010 and two of the 2011 sonic-tagged fish were located via submersible ultrasonic receivers or manual tracking above the Pearce Ferry Rapid, and even as high as Spencer Creek in April and May 2013, along with sonic-tagged fish released into the lower Grand Canyon this season.

Using the sonic-tagged fish, as well as previous knowledge about potential spawning areas to guide efforts, sampling for catostomid larvae occurred on 11 nights during the 2013 spawning period (February – May). Larval sampling did not result in the capture of razorback or other native sucker larvae.

Trammel netting was used to capture adult fish where concentrations of razorback suckers were suspected, and fin ray specimens were obtained from previously unaged razorback suckers for aging purposes. From 70 net-nights, 4 wild razorback suckers, 4 wild razorback x flannelmouth sucker hybrids, 271 flannelmouth suckers (*Catostomus latipinnis*), and a single bluehead sucker (*Catostomus discobolus*) were captured at the CRI. Of these fish, 3 razorback suckers and 22 flannelmouth suckers were recaptured fish. One of the wild razorback suckers was a 2-year-old juvenile measuring 215 millimeters total length; this fish was also recaptured the following day. The other two razorback suckers were recaptured, wild fish from the 2012 stocking event. Aging of the juvenile fish verified recruitment through 2011 at Lake Mead and marked the first case in which a young, juvenile razorback sucker has been documented at the CRI.

The goal to document the continued presence of razorback suckers at the CRI was met during 2013 sampling efforts. This was accomplished by using sonic-tagged razorback suckers to locate wild razorback suckers, mark captured razorback suckers, sample for larval fish, determine razorback sucker habitat use, and employ aging techniques to continue characterizing the age structure and recruitment patterns of the razorback sucker population at the CRI. Since 2010, 55 razorback suckers (24 of which were unique and wild) and 17 razorback x flannelmouth suckers (15 of which were unique and wild) have been captured. Additionally, 82 razorback sucker larvae have been captured from multiple spawning areas at the CRI. With each study year at the CRI, more has been learned regarding Lake Mead razorback sucker populations and the techniques needed to improve sampling effectiveness and efficiency. Many questions must still be addressed, and the study could be improved through building a larger dataset over subsequent years. Future goals for the study include continuing to study the razorback sucker population at the CRI using sonic tracking, larval sampling, and netting efforts. This will enable better characterization of razorback sucker habitat at the CRI and improve our ability to locate additional groups of fish or spawning areas in the vicinity. Also of interest is continual investigation of razorback sucker use of the Colorado River proper to gain a better perspective of lake/riverine interactions and their importance for this species, as well as other physicochemical and biological factors that allow for continued Lake Mead razorback sucker recruitment.

INTRODUCTION AND BACKGROUND

The razorback sucker (*Xyrauchen texanus* [Abbott]) is one of four endemic, large-river fish species of the Colorado River basin presently considered endangered by the U.S. Department of the Interior (U.S. Fish and Wildlife Service [USFWS] 1991). The other three species are the Colorado pikeminnow (*Ptychocheilus lucius*), bonytail chub (*Gila elegans*), and humpback chub (*Gila cypha*). Razorback suckers were historically widespread and common throughout the larger rivers of the Colorado River basin (Minckley et al. 1991). The current distribution and abundance of razorback suckers are greatly reduced from historic levels, mainly because of the construction of main stem dams and the resultant cool tailwaters and reservoir habitats that replaced a warm, riverine environment (Holden and Stalnaker 1975; Joseph et al. 1977; Wick et al. 1982; Minckley et al. 1991). Razorback suckers persisted in several reservoirs constructed in the Lower Colorado River Basin; however, these populations consisted primarily of adult fish that apparently recruited during the first few years of reservoir formation. Because of a lack of sustained recruitment, the populations of long-lived adults disappeared 40–50 years following reservoir creation and the initial recruitment period (Minckley 1983). Riverine razorback sucker populations in the Upper Colorado River Basin also have declined, as recruitment has not occurred at significant levels since the construction of these main stem dams (Bestgen et al. 2011). It is thought that predation by bass (*Micropterus* spp.), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), sunfish (*Lepomis* spp.), and other nonnative species is the primary reason for the lack of razorback sucker recruitment throughout its original distribution (Minckley et al. 1991; Marsh et al. 2003).

It was widely believed that the trends of razorback sucker decline observed in the Colorado River were also occurring in Lake Mead. Razorback sucker numbers, initially high in Lake Mead, decreased noticeably in the 1970s, and no razorback suckers were collected during the 1980s (Minckley 1973; McCall 1980; Minckley et al. 1991; Holden 1994; Sjoberg 1995). However, in the early 1990s, Nevada Department of Wildlife (NDOW) personnel were informed by local anglers that the species was still present in two localized areas of Lake Mead: Las Vegas Bay and Echo Bay. Limited sampling efforts initiated by NDOW soon confirmed the presence of remnant populations of razorback suckers in Lake Mead. In 1996, the Southern Nevada Water Authority, in cooperation with NDOW, initiated the Lake Mead studies to attempt to identify some of the basic population dynamics of razorback suckers in Lake Mead. BIO-WEST, Inc. (BIO-WEST), was contracted to design and conduct the study with collaboration from the Southern Nevada Water Authority and NDOW. Other cooperating agencies included the Bureau of Reclamation (Reclamation), National Park Service, Colorado River Commission of Nevada, and the USFWS. This work eventually led to the discovery of several groups of wild fish spawning and recruiting in the reservoir, and these groups currently represent the only known recruiting and naturally

expanding population of razorback suckers within the entire Colorado River basin (Albrecht et al. 2008a, 2010a, 2010b, 2013; Kegerries et al. 2009; Shattuck et al. 2011).

Larval razorback suckers were found in the Colorado River inflow area of Lake Mead (CRI) during 2000 and 2001, but despite opportunistic netting efforts, no adult razorback suckers were captured at that time (Holden et al. 2001; Abate et al. 2002; Albrecht et al. 2008a). In 2008, the Arizona Game and Fish Department captured a large, adult razorback sucker during annual gill netting efforts in Gregg Basin. The NDOW also captured two adult fish in the Virgin Basin. These captures emphasized the possibility that other razorback sucker populations may exist in areas of Lake Mead that were not being studied under the current Lake Mead razorback sucker monitoring efforts.

More recently, a comprehensive review evaluating the entire Lake Mead razorback sucker dataset obtained from 1996 to 2007 was finalized (Albrecht et al. 2008a). This report provided a summary of the methods used and cumulative findings from Lake Mead razorback sucker research to date. The comprehensive review also provided recommendations for future monitoring and research on Lake Mead. These recommendations were incorporated into a long-term management plan that serves as a guide for future razorback sucker studies on Lake Mead (Albrecht et al. 2009). This plan is used and updated by the Lake Mead Work Group (LMWG), which comprises the various agencies involved with Lake Mead razorback suckers.

One of the major tasks of the management plan is to explore other locations in Lake Mead for existing razorback sucker populations. Based on the location of known populations, which occur in areas with some turbidity and (at times) vegetative cover, the CRI was identified as the most logical area to investigate first. In addition, a biological opinion from the USFWS on the Proposed Adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead recommended Reclamation begin a project to "…examine the potential habitat in the lower Grand Canyon for the species, and institute an augmentation program in collaboration with USFWS, if appropriate" (USFWS 2007). Thus, the LMWG decided to begin investigative efforts at the CRI with the goal of identifying whether an unknown population exists within the upper end of Lake Mead. This was the first new task in the management plan to be implemented and is the first step in meeting the conservation measure from the USFWS in its 2007 biological opinion (USFWS 2007; Albrecht et al. 2009).

As recently as 2009, there was an apparent surge in razorback sucker recruitment, and overall numbers of young, juvenile fish increased at known spawning areas in Lake Mead (Albrecht et al. 2008a; Kegerries et al. 2009). It was hypothesized that the potential to successfully document razorback suckers at the CRI would likely be very high at that time. Given the recent success of monitoring fish

implanted with improved sonic tags, it was concluded that renewed efforts at the CRI would help clarify whether an additional spawning population existed within Lake Mead (Albrecht et al. 2008a; Kegerries et al. 2009). Thus, BIO-WEST proposed initiating telemetry and limited sampling efforts at the CRI in 2010. Combining stocking and tracking of sonic-tagged razorback suckers, trammel netting, and larval sampling increased the potential of finding a new spawning population of razorback suckers at the CRI. This resulted in the confirmation of a new Lake Mead spawning aggregate (Albrecht et al. 2010a). In addition to providing a greater understanding of habitat use and movement patterns within Lake Mead, sampling this additional population provided even more information regarding the overall recruitment patterns of Lake Mead razorback suckers, which will undoubtedly help identify the conditions that are conducive to these unique recruitment events.

Furthermore, the CRI provided information regarding the impact, scale, and magnitude of lake level and habitat changes in relation to razorback sucker spawning. As a result of fluctuating lake levels, razorback sucker spawning locations and spawning habitat use have changed. Habitat at the CRI has changed during the past decade at a much larger spatial scale than at other spawning areas throughout the lake (e.g., Las Vegas Bay, Echo Bay, and Muddy River/Virgin River inflow). For example, during 2001–2003, BIO-WEST sampled the Pearce Ferry and Grand Wash Bay areas, which were all accessible by boat. Currently, the lentic portion of Lake Mead only extends to the mouth of Iceberg Canyon. Above that interface, several kilometers (km) of once-lentic habitats are now riverine and essentially part of the Colorado River proper. Thus, compared with the remainder of Lake Mead, the scale of change at the CRI has been fairly large (kilometers of habitat change compared with meters [m] of change at the known spawning locations). This disparity provided a unique opportunity to evaluate razorback sucker use of an area that has been drastically modified and has remained dynamic since the lake was impounded. The CRI may also provide insight into what we can and should expect in terms of future spawning activity, particularly at the Muddy River/Virgin River inflow area and other known spawning locations within the lake, if lake levels decline.

The overall goal of this project was to determine the presence or absence of a razorback sucker population within the CRI. This goal was met in 2010, 2011, 2012, and 2013 by accomplishing the following objectives:

- Use sonic-tagged razorback suckers to locate and capture wild razorback suckers in various life stages and track movement patterns of any existing population

- Mark captured juvenile and adult razorback suckers for individual identification using passive integrated transponder (PIT) tags

- Use a combination of sonic telemetry data, larval razorback sucker capture-location information, and juvenile/adult razorback sucker netting data to determine habitat use of this unique population

- Use nonlethal aging techniques to characterize the age structure and potential recruitment patterns associated with a razorback sucker population at the CRI

Given the findings of wild razorback suckers at the CRI in 2010, the overall objectives remained the same for 2011 and 2012 but with twice the field effort and manpower compared to 2010. This increased effort was meant to capitalize on the sampling opportunity presented by recent razorback sucker recruitment, cover more area, and increase the likelihood of capturing more individuals. With this increased effort, more resources were spent in the Colorado River proper trying to understand the relationship between the riverine environment and lentic habitat utilization of razorback suckers during the spawning season.

In 2013, all sampling efforts were strictly confined to the period of January – May, and efforts were similar to the intensive field efforts conducted during the original 2010 study year. As such, efforts in 2013 resembled more of a monitoring type of effort. This report does not present sonic telemetry data obtained from other, non-spawning period months and, as such, is a departure from the typical results in other annual Lake Mead razorback sucker reports (Albrecht et al. 2008b, 2010b, 2013; Kegerries et al. 2009.; Shattuck et al. 2011; Kegerries and Albrecht 2013). Other information and data from previous studies are included when applicable.

STUDY AREAS

The 2013, CRI study activities occurred within Gregg Basin of Lake Mead and the Colorado River upstream to Separation Canyon in the lower Grand Canyon near River Kilometer (RKM) 386 (River Mile [RM] 240) (figure 1).

Definitions for various portions of the CRI in which the study was conducted shall be referred to using the following terms:

- Lake Mead proper begins where the flooded portion of the river channel widens and velocity is reduced.

- The Colorado River proper is simply the flowing river. Depending on conditions, this area may or may not be accessible by large boat.

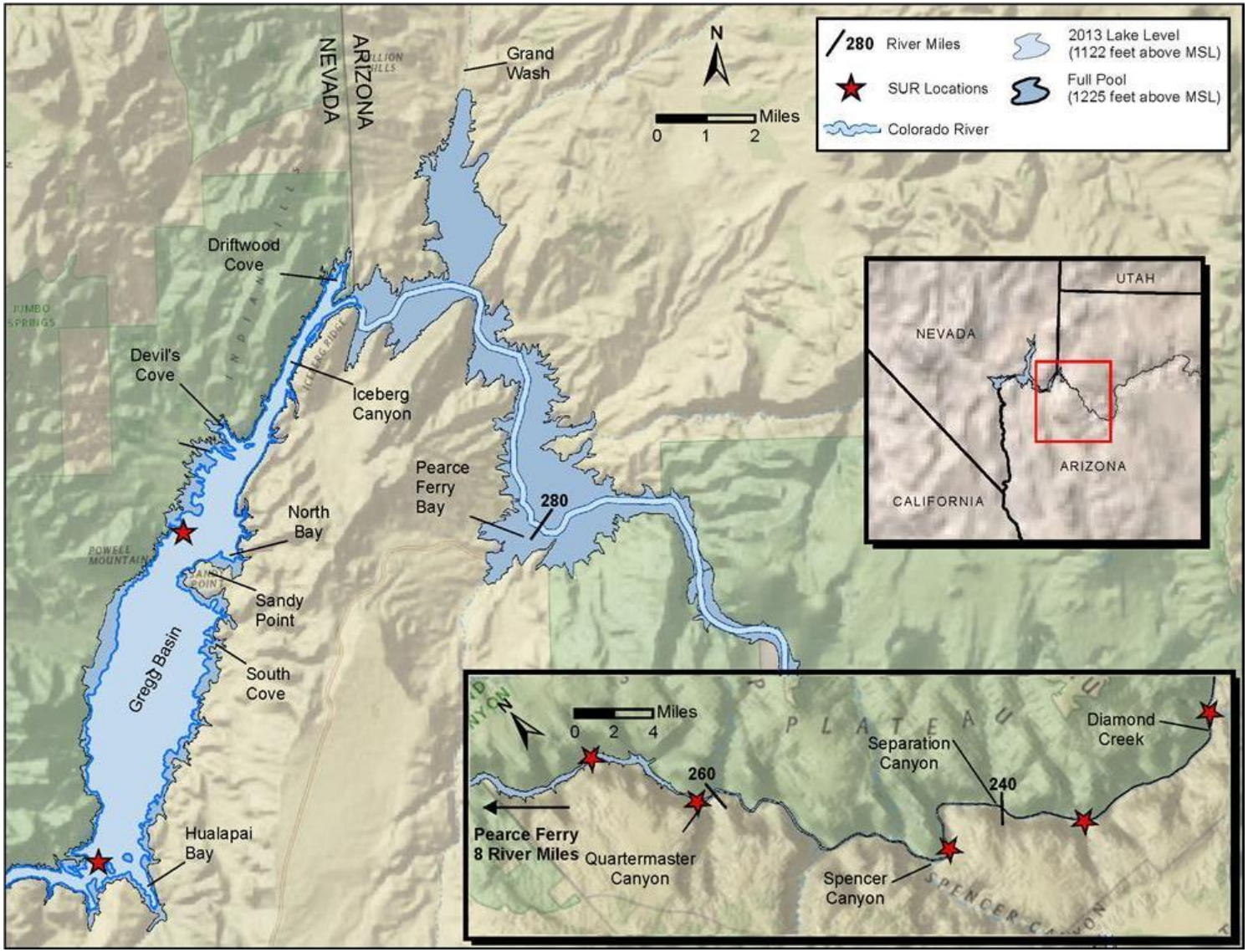

Figure 1.—General study area at the CRI.

- Interface is the area where the river proper meets the lake proper. This area may or may not have flow, is typically turbid, and is transitory and highly dynamic in nature.

METHODS

Lake Elevation

Month-end lake elevations for the 2013 field season (January 1 – May 10, 2013) were reported in meters above sea level (asl) and obtained from Reclamation's Lower Colorado Regional Office Web site (Reclamation 2013). The effect of fluctuating lake levels on razorback sucker habitat was documented by written observations and/or photographs during sampling trips to the CRI.

Sonic Tagging

In response to recommendations contained in Kegerries and Albrecht (2013 to use wild fish for replacement of sonic-tagged fish at the CRI, one wild razorback sucker captured at the CRI was surgically implanted with a sonic tag on March 27 and released at the point of capture. Details regarding this fish are included in the trammel netting section of the results.

In addition, and at the request of Reclamation, BIO-WEST worked collaboratively with the LMWG to surgically implant acoustic transmitters and stock 10 razorback suckers into the Colorado River proper. The purpose of this effort was to help understand razorback sucker use of both Lake Mead and the Colorado River proper and to help provide a holistic approach to understanding the role of lake and riverine habitats that appear to be utilized by razorback suckers at the CRI (Kegerries and Albrecht 2013). This group of fish was released below Separation Canyon (approximately RKM 386 [RM 241]) in the lower Grand Canyon on April 9. BIO-WEST worked collaboratively with the Arizona Game and Fish Department and NDOW to obtain a stocking permit and transport these hatchery-reared fish from NDOW's Lake Mead Hatchery to the Pearce Ferry boat launch where they were then transported to the release location. As specified in the stocking permit, the 10 tagged fish had to be stocked within the confines of the Lake Mead full-pool demarcation within the lower Grand Canyon (RKM 381 [RM 237]). All possible measures were taken to mitigate disease and other unintentional species introductions, as required by the Arizona Game and Fish Department stocking permit, while strictly following NDOW's protocols for preventing the spread of quagga mussels (*Dreissena rostriformis bugensis*) (Senger and Sjoberg 2011).

Sonotronics Model CT-05-48-I (48-month) tags were used for all fish surgically implanted in 2013. The 48-month tags had a water weight of 12 grams and measured 79 millimeters (mm) long by 15.6 mm in diameter. Tag frequencies ranged from 70–79 kilohertz, and because each tag had a unique code, individual fish could be readily distinguished.

The following surgical protocol was established from procedures developed by Valdez and Nilson (1982), Kaeding et al. (1990), and Valdez and Trinca (1995) for humpback chubs; Tyus (1982) for Colorado squawfish (pikeminnow); and Valdez and Masslich (1989) for Colorado squawfish (pikeminnow) and razorback suckers (Albrecht et al. 2008a, 2010a, 2013; Kegerries and Albrecht 2011; Shattuck et al. 2011). A transmitter air weight to fish weight of 2 percent (%) (Bidgood 1980; Marty and Summerfelt 1990) was used as a guideline to ensure that the tags were not too large for the fish being tagged. Surgery was performed on shore or in the hatchery and involved one surgeon and two assistants. The assistants recorded data, captured pertinent photographs, and monitored fish respiration. BIO-WEST biologists conducted the surgeries, demonstrated current surgical practices, and provided instruction on updated tagging methodologies to other field biologists. Prior to surgery, each fish was placed in a live well containing fresh lake water. All surgical instruments were cold sterilized with iodine and 90% isopropyl alcohol and allowed to air dry on a disposable sterile cloth. Razorback suckers were initially anesthetized in 40 liters (L) of lake water with a 50 mL/L^{-1} clove oil/ethanol mixture (Bunt et al. 1999). After anesthesia was induced, total length (TL), fork length (FL), standard length (SL), and the weight of each fish were recorded. Fish were then placed dorsal-side down on a padded surgical cradle for support during surgery. The head and gills were submerged in 20 L of fresh lake water with a maintenance concentration of 25 mL/L^{-1} clove oil/ethanol anesthetic (Bunt et al. 1999). Following fish introduction to the maintenance anesthetic, the surgeon made an approximate 2-centimeter (cm) incision on the left side, posterior to the left pelvic girdle. A PIT tag was placed into the incision, followed by the transmitter, which was pushed between the pelvic girdle and urogenital pore. The incision was closed with 2–4 sutures using a 3-0 Maxon absorbable poliglecaprone 25 monofilament suture with an attached PS-1 reverse-cutting, curved needle. Surgery times typically ranged from 2–5 minutes per fish.

After surgical procedures were completed, fish were allowed to recover and were closely monitored until equilibrium was maintained. Once fully recovered, tagged fish were either released at their original point of capture (for wild fish) or taken by boat to predetermined release points within the full pool footprint of Lake Mead (within the lower Grand Canyon). Upon release, all fish were re-examined for signs of stress. Tracking ensued immediately after release and continued intensively following surgical implantations.

Active Sonic Telemetry and Tracking

During February through May, sonic-tagged fish were tracked weekly (sometimes daily) depending on the field schedule and weekly project goals. Fish searches were conducted largely along shorelines, with listening points approximately 0.8 km apart, depending on shoreline configuration and other factors that could impact signal reception. Sonic equipment is line-of-sight, and any obstruction can reduce or block a signal. Also, telemetry signals are often reduced in shallow, turbid, and swift water environments. Active tracking consisted of listening underwater for coded sonic tags using a Sonotronics USR-08 ultrasonic receiver (or earlier model) and DH4 directional hydrophone or TH-2 omnidirectional hydrophone. The directional hydrophone was lowered into the water and rotated 360 degrees to detect the presence of sonic-tagged fish. Once a signal was detected, the position of the sonic-tagged fish was pinpointed by moving in the fish's direction until the signal was heard in all directions with the same intensity. The omnidirectional hydrophone was towed behind the boat at a slow speed until a signal was detected. After detection, the fish was located using the directional hydrophone with the method previously described. In all cases, sonic tag numbers, Global Positioning System locations, and habitat characteristics were recorded.

Passive Sonic Telemetry and Data Collection

Along with active tracking methods, submersible ultrasonic receivers (SUR) were deployed in various locations throughout the CRI. The advantage to using SURs is their ability to autonomously record continuous telemetry data day or night. With an approximate 9-month battery life and the ability to detect ultrasonic transmitters, SURs save valuable field time while collecting additional telemetry data; they can be particularly useful in difficult-to-access field locations (Sonotronics 2013).

A SUR was placed at the southern end of Gregg Basin, near the mouth of Hualapai Bay, to track fish moving in and out of the basin (see figure 1). This SUR has been utilized since the study began in 2010. Another SUR has remained near the CRI, although the exact location of this SUR has changed several times since 2010 to adjust for changing lake levels and to optimize data collection as the location of the river/lake interface changed (Kegerries and Albrecht 2013). Just prior to the 2013 field season, the Colorado inflow SUR was deployed off an island just north of Sandy Point (see figure 1).

Again in 2013, two additional SURs were used in an effort to monitor fish movement in and out of the Colorado River proper. A SUR was deployed near the bat cave at RKM 429.7 (RM 267) where it currently remains. Another SUR was deployed near Quartermaster Canyon (RKM 418.4 [RM 260]) where it, too, remains. In an effort to maintain contact with newly stocked sonic-tagged fish in

the lower Grand Canyon, three additional SURs were deployed by the National Park Service. The upstream-most SUR was placed near Diamond Creek at approximately RKM 364 (RM 226), another SUR was deployed near Bridge Canyon at approximately RKM 375 (RM 233), and the third SUR was deployed near Spencer Canyon at approximately RKM 393 (RM 244) (see figure 1). The Diamond Creek SUR was deployed on April 6, while the other two were deployed on April 16.

All SURs were programmed to detect implanted, active, sonic tag frequencies using Sonotronic's SURsoft software. The semibuoyant SURs were then suspended from an anchor (e.g., rock, anchor, or block) using approximately 18 inches [in] of rope. A lead of vinyl-coated cable was secured to the anchor as the SUR was deployed and allowed to sink to the lake/river bottom. The cable was secured on shore and concealed. Data were retrieved from SURs frequently by pulling the SUR into the boat and downloading the data via Sonotronic's SURsoft software. These data were then processed through Sonotronic's SURsoftDPC software to ascertain the time, date, and frequency of positive sonic-tagged fish detections within 2 millisecond-interval units (e.g., a range of 898–902 for a 900-interval tag). To avoid any false-positive contacts due to environmental "noise" in data analysis, a minimum of two records were required within 5 minutes of one another for a SUR record to be considered valid. Once data were identified as valid based on the requirements outlined above, the resulting dataset, as obtained from the SURs, was further scrutinized against active telemetry records. This was done to establish movement timelines of individual sonic-tagged fish and further solidify that all positive SUR contacts, as reported herein, are indeed informative, realistic, useful, and valid.

Adult Studies

Trammel Netting

Adult fish were captured using trammel nets 274.4 m long by 1.8 m deep with internal panels of 2.54-cm mesh and external panels of 30.48-cm mesh. Nets were generally set with one end near shore in 3.05–9.15 m of water, with the net stretched out into deeper areas. All trammel nets were set in the late afternoon (just before sundown) and pulled the next morning (shortly after sunrise). Netting locations were selected based on the locations of sonic-tagged fish, the location or presence of concentrated larval fish, and knowledge of previous razorback sucker capture locations.

Fish were taken from nets, and live fish were held in large, 94.6-L coolers filled with lake water. Razorback suckers and/or flannelmouth suckers (*Catostomus latipinnis*) were isolated from other fish species and held in aerated live wells. All but the first five common carp and gizzard shad (*Dorosoma cepedianum*) were enumerated and returned to the lake, while other species (including five common carp and five gizzard shad) were identified, measured for TL, weighed,

and released at the capture location. Razorback suckers, flannelmouth suckers, or suspected razorback sucker x flannelmouth sucker hybrids were scanned for PIT tags. If the individuals were not recaptured fish, they were PIT tagged, measured (including TL, SL, and FL), weighed, and released at the point of capture. Native sucker species selected for age determination were anesthetized with tricaine methanesulfonate (MS-222) and placed dorsal-side down on a padded surgical cradle for support while a segment of the second pectoral fin ray was collected. Because of the presence of hybrid suckers at the CRI, as well as other genetic work being done on Lake Mead razorback suckers, genetic material was also removed from wild razorback suckers (including suspected hybrids). This consisted of a small piece of tissue obtained from the caudle fin, preserved in 95% ethanol, and then provided to Reclamation for further laboratory analysis.

Growth

Razorback sucker annual growth information was gathered from recaptured individuals in trammel netting collections. Recaptured individuals were only measured once during the spawning season, to avoid handling stress, and were only used for annual growth analysis if approximately one sampling year had passed between capture occasions. Recently stocked individuals were excluded from the dataset and analyses to account for discrepancies in environmental conditions (e.g., a hatchery- or pond-reared individual recently stocked into a wild environment) and to allow for the yearly cycles of gonadal and somatic growth. The annual growth for razorback suckers was calculated for each individual using the difference in TL (mm) between capture periods. If the data were available, the mean annual growth was calculated separately for stocked and wild individuals.

Larval Sampling

The primary larval sampling method was developed by Burke (1995) and other researchers on Lake Mohave. The procedure uses the positive phototactic response of larval razorback suckers to capture them. After sundown, two to four 12-volt “crappie” lights were connected to a battery, placed over each side of the boat, and submerged in 10.2–25.4 cm of water. Two to four netters equipped with long-handled aquarium dip nets were stationed to observe the area around the lights. Larval razorback suckers that swam into the lighted area were dip-netted out of the water and placed into a holding bucket. The procedure was repeated for 15 minutes at 4–12 sampling sites on each night attempted. Larvae were identified and enumerated as they were placed in the holding bucket and then released at the point of capture when sampling at a site was complete.

Because of the vast sampling area, turbidity, flowing water, and the potential for larval drift at the CRI, larval light traps were also deployed as a method to capitalize on efforts to collect catostomid larvae. These traps were set out either

overnight or for several hours after sunset in an effort to cover more area and sample those areas that were not conducive to the method described above (i.e., flowing portions of the river). The larval light traps were deployed by tying a lead rope to the vegetation near shore in suspected spawning areas. A light stick was inserted into the trap and allowed to float freely. The light traps were collected the next morning or after the desired deployment time. The catch bowls were checked for the presence of larval fish. All larval fish present were identified, enumerated, and returned to the lake.

Because other native sucker species are present at the CRI, suspected larval razorback suckers were preserved in 10% formalin for microscopic verification using the key to catostomid fish larvae developed by Snyder and Muth (2004). It should be noted that not all larvae were preserved for identification; only those that were questionable or otherwise difficult to identify in the field were preserved for verification.

Spawning Site Identification

During the 17 years of razorback sucker monitoring on Lake Mead, it has been found that multiple methods are needed to identify and pinpoint annual razorback sucker spawning sites. The basic, most effective spawning site identification procedure has been to track sonic-tagged fish and identify their most frequented areas. Once a location is identified as heavily used by sonic-tagged fish, particularly during crepuscular hours, trammel nets are typically set in an effort to capture adult razorback suckers. Captured fish are then evaluated for signs of ripeness, which are indicative of spawning. After the initial identification of a possible spawning site through sonic-tagged razorback sucker habitat use and other, untagged juvenile or adult trammel net captures, larval sampling is conducted to validate whether successful spawning occurred. Examples of the effectiveness of these techniques are evident in the descriptions provided by Albrecht and Holden (2005) regarding the documentation of a new spawning aggregate near Fish Island in the Overton Arm of Lake Mead. This same general approach has also been used effectively at the CRI from 2010 to present.

Age Determination

A nonlethal technique using fin ray sections was developed in 1999 to age captured Lake Mead razorback suckers (Holden et al. 2000). As in past Lake Mead razorback sucker studies, an emphasis of our 2013 CRI efforts involved collecting fin ray sections from razorback suckers for aging purposes using this technique. Specimens were also obtained from suspected hybrid suckers and bluehead suckers (*Catostomus discobolus*). Finally, fin rays from a subset of the captured flannelmouth suckers were obtained for age determination purposes, but those results will not be reported herein.

During the 2013 spawning period, new fish captured via trammel nets were anesthetized, and a single, approximately 6.00-mm-long segment of the second left pectoral fin ray was surgically removed. Fish were anesthetized with a lake-water bath containing MS-222, sodium chloride, and a slime-coat protectant to reduce surgery-related stress, speed recovery, and avoid accidental injury to fish that may thrash during surgical procedures. During the surgery, standard processing was conducted (weighing, measuring, and PIT tagging), and a pectoral fin ray sample was surgically collected using custom-made bone snips originally developed by BIO-WEST. These surgical tools consist of a matched pair of finely sharpened chisels welded to a set of wire-stripping pliers. The connecting membrane between fin rays was cut using a scalpel blade, and the section was placed in a labeled envelope for drying. All surgical equipment was cold sterilized before use, and subsequent wounds were packed with antibiotic ointment to minimize post-surgical bacterial infections and promote rapid healing. All native suckers undergoing fin ray extraction techniques were immediately placed in a recovery bath of fresh lake water containing a slime-coat protectant and sodium chloride, allowed to recover, and released as soon as they regained equilibrium and appeared recovered from the anesthesia. Vigilant monitoring was conducted during all phases of the procedure.

In the laboratory, fin ray segments were embedded in thermoplastic epoxy resin and heat cured. This technique allowed the fin rays to be perpendicularly sectioned using a Buhler isomet low-speed saw. Resultant sections were then mounted on microscope slides, sanded, polished, and examined under a stereo-zoom microscope. Each sectioned fin ray was aged independently by at least two readers. Sections were then reviewed by all readers in instances in which the assigned age was not agreed upon. If age discrepancies remained after the second reading, a third reader viewed the structure, and all three readers collectively assigned an age to the individual. For further information regarding the evolution of our fin ray aging technique, refer to Albrecht and Holden (2005), Albrecht et al. (2006), Albrecht et al. (2008a), and other annual Lake Mead razorback sucker reports.

Population Estimation

In 2013, a population estimate was produced in the program MARK. The estimate was generated using data exclusive to the CRI and is based on mark-recapture data from 2010 to 2013. Models produced in the program MARK were tested and ranked to produce the most precise and informative estimate.

There were 52 capture events for the CRI estimate (2010–2013). Stocked fish were not used in the population estimate unless they had survived a minimum of 1 year in Lake Mead. It was assumed that an adult, stocked fish that had survived 1 year in Lake Mead was able to avoid predation and contribute progeny to the population (Albrecht and Holden 2005; Modde et al. 2005). Within the program MARK, the models were ranked according to their relative goodness-of-fit value

(according to the corrected Akaike's Information Criterion [AICc] values) to determine which model fit the dataset best. The population model with the highest ranked AICc value is reported herein.

RESULTS

Lake Elevation

After a high elevation of 342 m (1,122 feet [ft]) asl in January 2013, lake levels receded steadily to a low elevation of 339 m (1,112 ft) asl by May 10 (figure 2). During the first sampling event in February 2013, the lake level was approximately 3.4 m lower than in February 2012. A steady lake level decline was observed from January to May 2013 (figure 2). With the exception of 2011, this same trend has been observed on Lake Mead for more than a decade (figure 2). The effects of littoral habitat inundation at higher water levels and desiccation at lower lake levels were evident while habitats changed relatively quickly (based on visual observations) within the CRI during the time of sampling.

Telemetry

Seventeen sonic- and radio-tagged fish have been released into the CRI since 2010, with stocking events occurring in 2010, 2011, and 2013 (table 1). Ten sonic-tag implanted razorback suckers were stocked into the lower Grand Canyon in 2013, with an additional wild fish captured, implanted, and released at the CRI (table 1). For a more detailed description of fish released, release locations, and data collected in 2010 and 2011, refer to Albrecht et al. (2010c) and Kegerries and Albrecht (2011).

In total, 17of the 27 sonic-tagged fish released in the CRI and lower Grand Canyon were contacted 9,744 times (34 active and 9,710 passive) from January to May 2013 at the CRI (table 1). Of these 17fish, 4 were stocked in 2010, 4 were stocked in 2011, 1 was from the 2013 wild fish stocking at the CRI, and 8 were from the 2013 stocking event in the lower Grand Canyon. To date, 15 of these sonic-tagged fish are presumed to have functioning tags, are active, and detectable (table 1). One tag from 2010 and another from 2011 have remained stationary all season, in addition to two stationary tags (one from 2010 and one from 2011) reported during previous sampling seasons (table 1) (Kegerries and Albrecht 2011, 2013). Three combination radio/acoustic tags implanted during the 2011 stocking event have expired; therefore, these fish were not detected in 2013 (table 1). In addition to the 17 sonic-tagged fish detected at the CRI, one fish from the 2010 stocking event (code 357) was detected in Las Vegas Bay as recently as May 9, 2013, and has been reported there since 2012 (Albrecht et al. 2013).

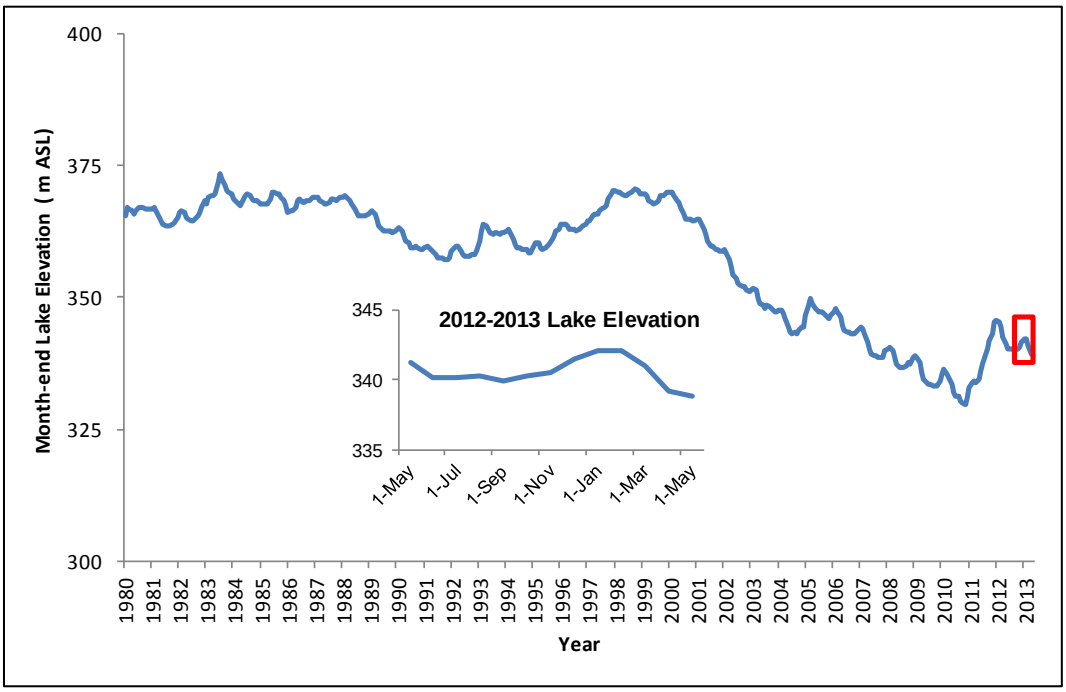

Figure 2.—Lake Mead month-end elevations, January 1980 – May 2013 (inset shows red, boxed area of graph).

In summary, of the 27 fish that have been tagged at the CRI since 2010, 16 are confirmed active, 4 are presumed active although they were not detected in 2013, and 7 tags are expired or stationary.

Early in 2013 (January – February), sonic-tagged fish stocked in 2010 and 2011 were observed using the CRI, particularly the interface from Sandy Point to Iceberg Canyon (figure 3). Upstream movement of these fish was documented throughout the spawning season (March – May). In fact, four of the seven active fish documented at the interface in January and February had moved above the Pearce Ferry Rapid and were contacted in the lower Grand Canyon in May 2013 where they were last documented (figure 3). The furthest upstream movement observed for three of these fish was to Spencer Creek (RKM 393 [RM 244]) in the lower Grand near each other and newly stocked fish released near Separation Canyon in 2013 (figure 3). It should be noted that BIO-WEST was only permitted to run boats as high as Separation Canyon; therefore, no tracking activities occurred upstream of RKM 386 (RM 240).

Wild, sonic-tagged fish 367, which was captured from the CRI and implanted in March 2013, continued to utilize habitats in close proximity to Devil's Cove, where it was originally captured (figure 3). This continued for several weeks until the fish moved downstream out of the CRI, into Gregg Basin, and was last detected by the SUR in the southern portion of Gregg Basin on May 8

Table 1.—Tagging and stocking information, location, date of last contact, and current status of sonic-tagged fish released into the CRI from 2010 to 2013 and found using CRI habitats during the 2013 study year

Source location[a]	Date tagged	Tag code	Total length (mm)	Sex[b]	Stocking location[a]	Last location[a]	Date of last contact	Contacts made in 2013[C]	Current tag status	Estimated expiration
Fish tagged in 2013										
CRI	3/27/2013	367	560	M	CRI	CRI	5/7/2013	80 total 7 active 73 passive	Active	2017
NDOW	4/9/2013	3747	521	F	LGC	LGC	5/7/2013	1 total 1 active 0 passive	Active	2017
NDOW	4/9/2013	4448	475	F	LGC	LGC	4/9/2013	0 total 0 active 0 passive	Presumed active	2017
NDOW	4/9/2013	4455	484	F	LGC	LGC	4/9/2013	0 total 0 active 0 passive	Presumed active	2017
NDOW	4/9/2013	3338	464	F	LGC	LGC	4/18/2013	13 total 0 active 13 passive	Active	2017
NDOW	4/9/2013	4555	484	F	LGC	LGC	4/23/2013	12 total 0 active 12 passive	Active	2017
NDOW	4/9/2013	4658	510	F	LGC	LGC	5/7/2013	1 total 1 active 0 passive	Active	2017
NDOW	4/9/2013	4666	479	M	LGC	LGC	4/23/2013	1 total 1 active 0 passive	Active	2017
NDOW	4/9/2013	5556	500	F	LGC	LGC	4/23/2013	1 total 1 active 0 passive	Active	2017
NDOW	4/9/2013	5557	479	M	LGC	LGC	4/20/2013	2 total 0 active 2 passive	Active	2017
NDOW	4/9/2013	5668	532	F	LGC	LGC	5/7/2013	2 total 2 active 0 passive	Active	2017

Table 1.—Tagging and stocking information, location, date of last contact, and current status of sonic-tagged fish released into the CRI from 2010 to 2013 and found using CRI habitats during the 2013 study year

Source location[a]	Date tagged	Tag code	Total length (mm)	Sex[b]	Stocking location[a]	Last location[a]	Date of last contact	Contacts made in 2013[C]	Current tag status	Estimated expiration
Fish tagged in 2011										
FDLB	1/5/2011	447	505	M	CRI	CRI	2/19/2013	1 total 1 active 0 passive	Stationary	2015
FDLB	1/5/2011	3546	496	M	CRI	CRI	5/1/2013	2,185 total 2 active 2,183 passive	Active	2015
FDLB	1/5/2011	3666	504	M	CRI	CRI	8/17/2011	0 total 0 active 0 passive	Stationary	2015
FDLB	1/5/2011	3774	509	M	CRI	LGC	5/7/2013	6,700 total 2 active 6,698 passive	Active	2015
FDLB	1/5/2011	5578	487	M	CRI	CRI	4/10/2013	573 total 3 active 570 passive	Active	2012
FDLB	1/5/2011	5767	515	M	CRI	CRI	5/21/2012	0 total 0 active 0 passive	Expired	2012
FDLB	1/5/2011	5768	530	F	CRI	CRI	8/17/2011	0 total 0 active 0 passive	Expired	2012
FDLB	1/5/2011	6678	565	M	CRI	CRI	2/8/2012	0 total 0 active 0 passive	Expired	2012
Fish tagged in 2010										
FDLB	2/23/2010	227	486	M	GB	LGC	5/7/2013	3 total 3 active 0 passive	Active	2014
FDLB	2/23/2010	249	511	M	CRI	LGC	5/7/2013	150 total 3 active 147 passive	Active	2014
FDLB	2/23/2010	258	502	M	CRI	CRI	7/18/2012	0 total 0 active 0 passive	Presumed active	2014

Table 1.—Tagging and stocking information, location, date of last contact, and current status of sonic-tagged fish released into the CRI from 2010 to 2013 and found using CRI habitats during the 2013 study year

Source location[a]	Date tagged	Tag code	Total length (mm)	Sex[b]	Stocking location[a]	Last location[a]	Date of last contact	Contacts made in 2013[C]	Current tag status	Estimated expiration
FDLB	2/23/2010	267	534	F	GB	CRI	1/18/2012	0 total 0 active 0 passive	Presumed Active	2014
FDLB	2/23/2010	339	501	M	CRI	CRI	3/27/2013	9 total 1 active 8 passive	Stationary	2014
FDLB	2/23/2010	348	516	M	GB	GB	4/11/2012	0 total 0 active 0 passive	Stationary	2014
FDLB	2/23/2010	357	490	M	GB	LVB	5/9/2013	2 total 2 active 0 passive	Active	2014
FDLB	2/23/2010	485	517	M	CRI	CRI	5/6/2013	8 total 4 active 4 passive	Active	2014

[a] Locations: CRI = Colorado River inflow area, NDOW = Nevada Department of Wildlife native fish hatchery, LGC = Lower Grand Canyon between Pearce Ferry and Separation Canyon, FDLB = Floyd Lamb State Park, GB = Gregg Basin, and LVB = Las Vegas Bay.
[b] Sex: M = male, and F = female.
[c] Number of contacts are presented using active sonic telemetry techniques, passive sonic telemetry techniques (i.e., SURs), and in total (the number of active and passive contacts combined). Refer to the active and passive sonic tracking methodologies in this report for details.

(figure 3). This fish provided the majority of netting and larval sampling guidance for much of the spawning period at the CRI, and it appears to be healthy and active.

Of the 10 fish sonic tagged and stocked into the lower Grand Canyon in 2013, 8 were located via passive and active tracking methods after their release date of April 9, 2013. All eight fish were contacted downstream from their original release location by May 9, 2013, even though two of these fish displayed initial upstream movement. Two of the eight sonic-tagged fish were located as far downstream as the bat cave SUR by April 23 (figure 3). Four of these fish were located in close proximity to fish stocked in 2010 and 2011 and located near Spencer Creek on April 23 and May 7 (figure 3).

Interesting movements by sonic-tagged fish were documented in 2013 (figure 4). Sonic fish 227, 249, and 3774 all began the 2013 season at the CRI near the interface, but they later moved upstream and were last documented near Spencer Creek below Separation Canyon in the lower Grand Canyon (figure 4). Sonic-tagged fish 367's movement, as described earlier, is depicted graphically in

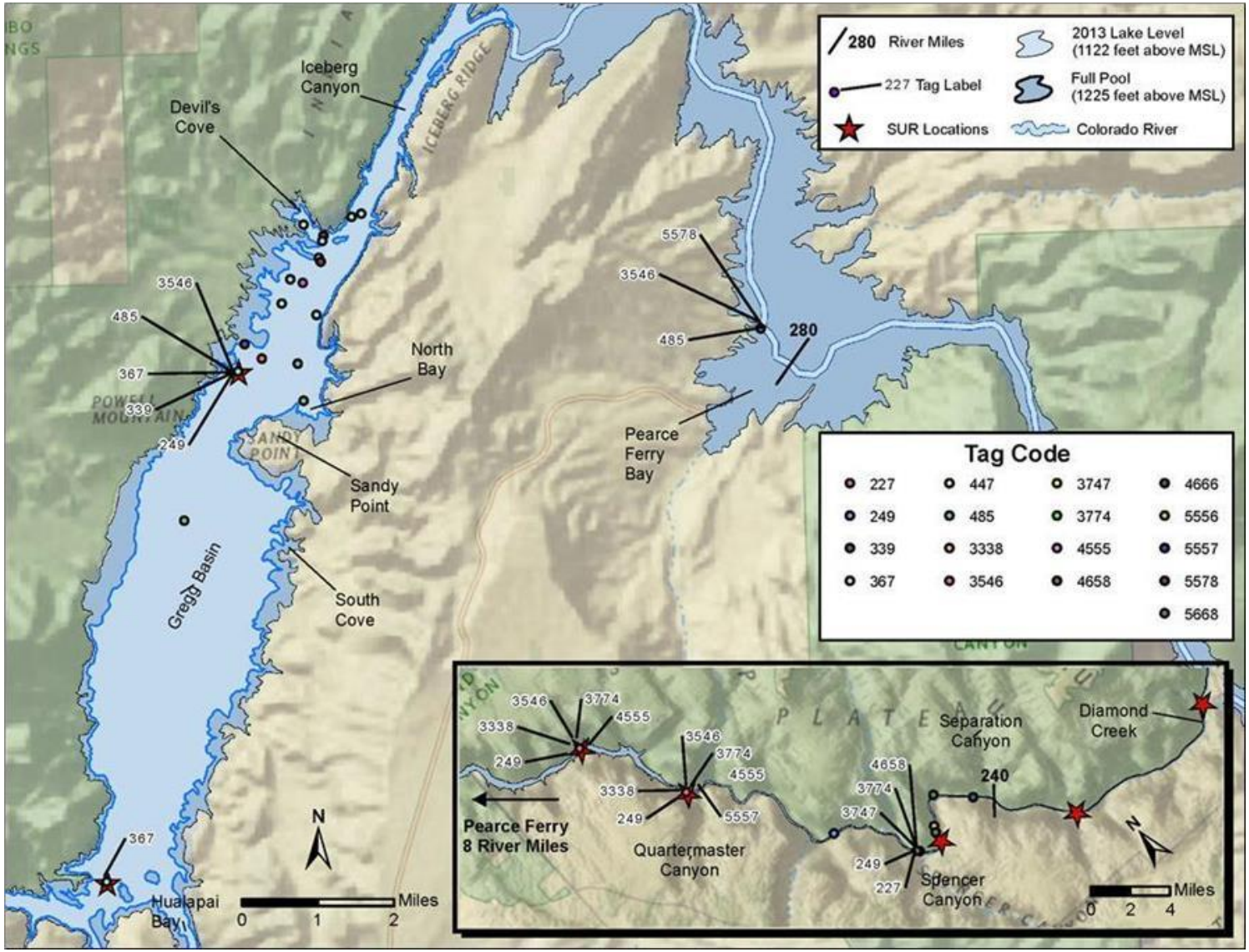

Figure 3.—Distribution of sonic-tagged fish at the CRI from January to May 2013.

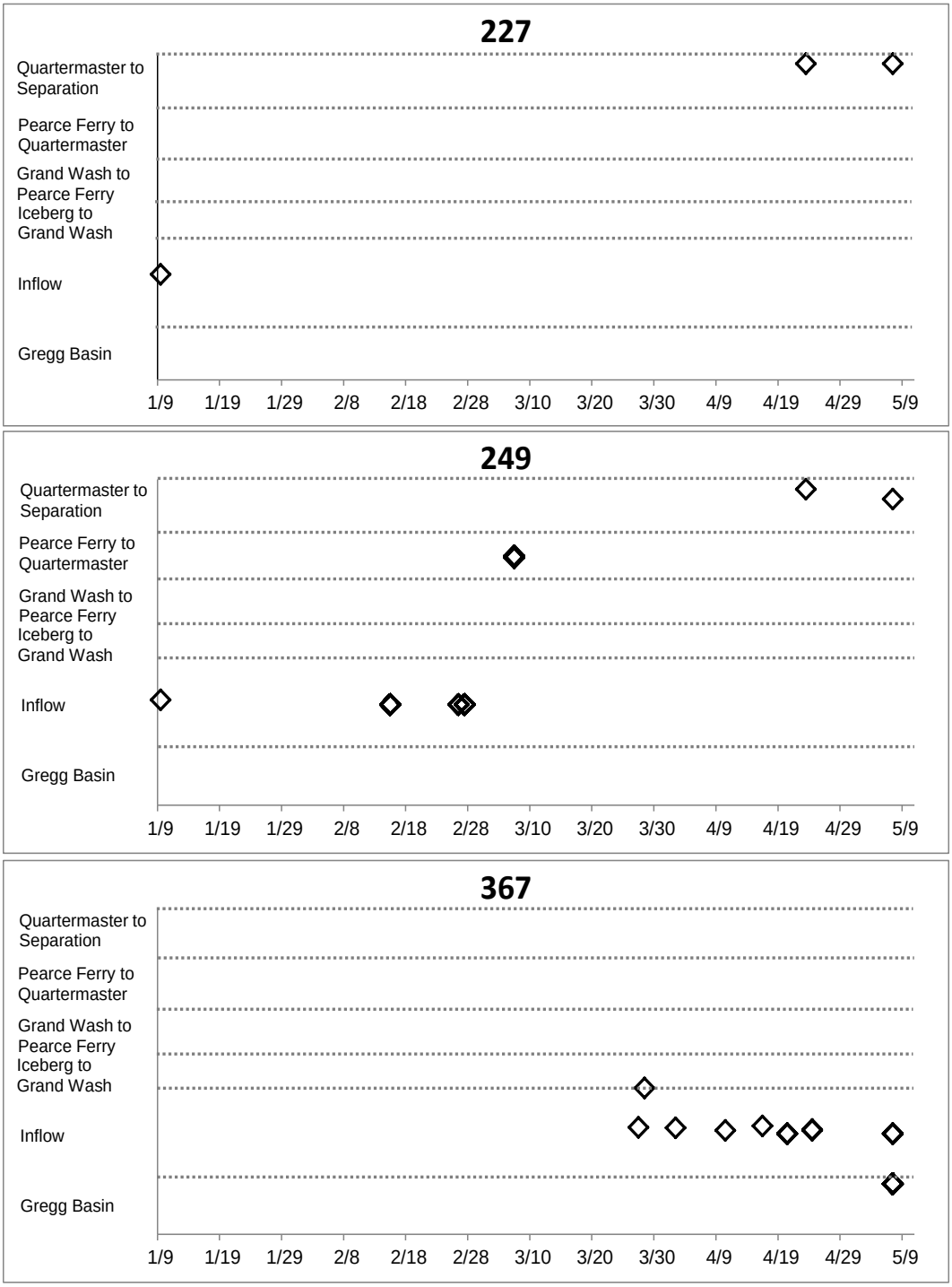

Figure 4.—Movement derived from active and passive sonic telemetry at the CRI from January to May 2013.

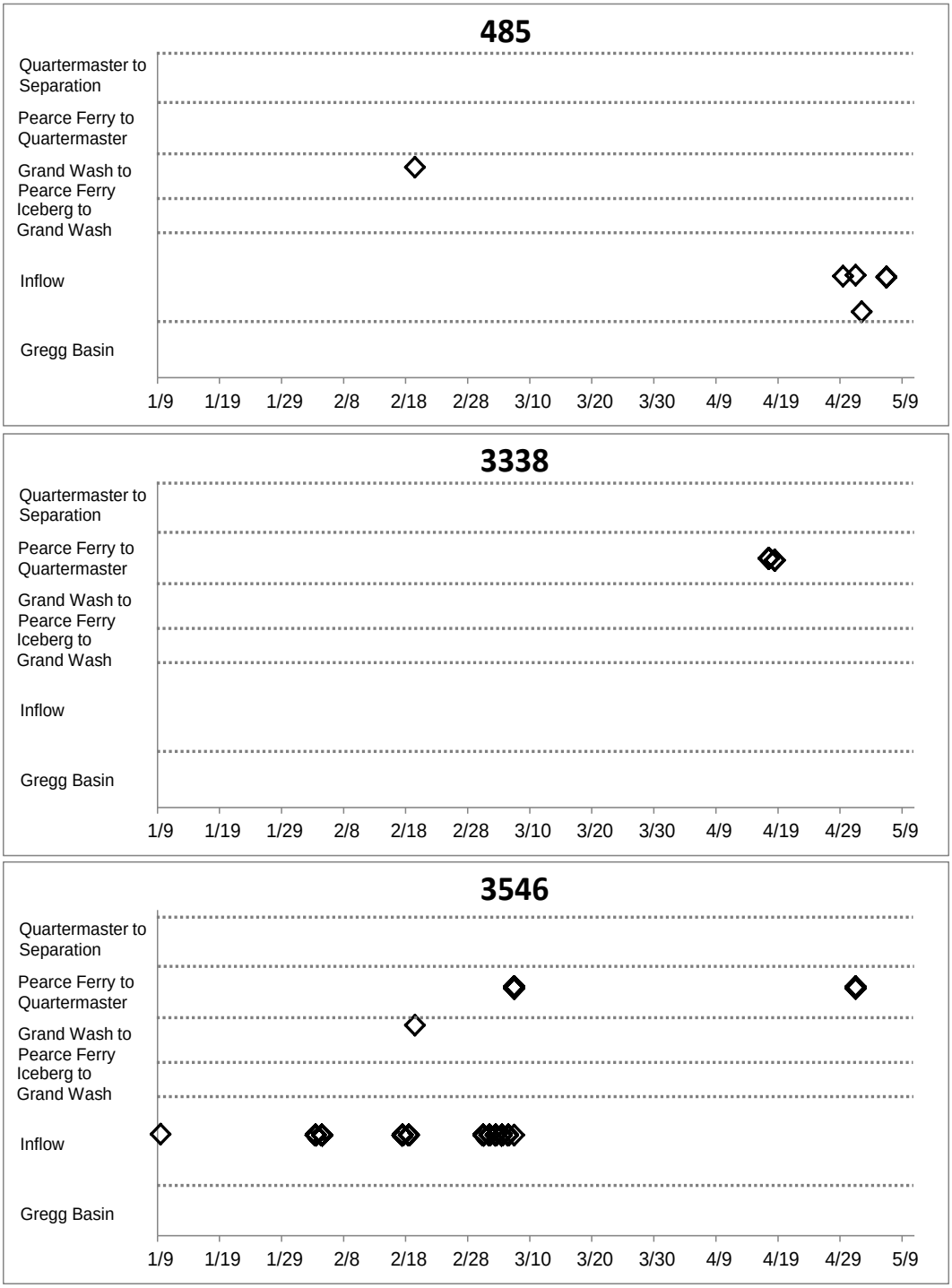

Figure 4.—Movement derived from active and passive sonic telemetry at the CRI from January to May 2013.

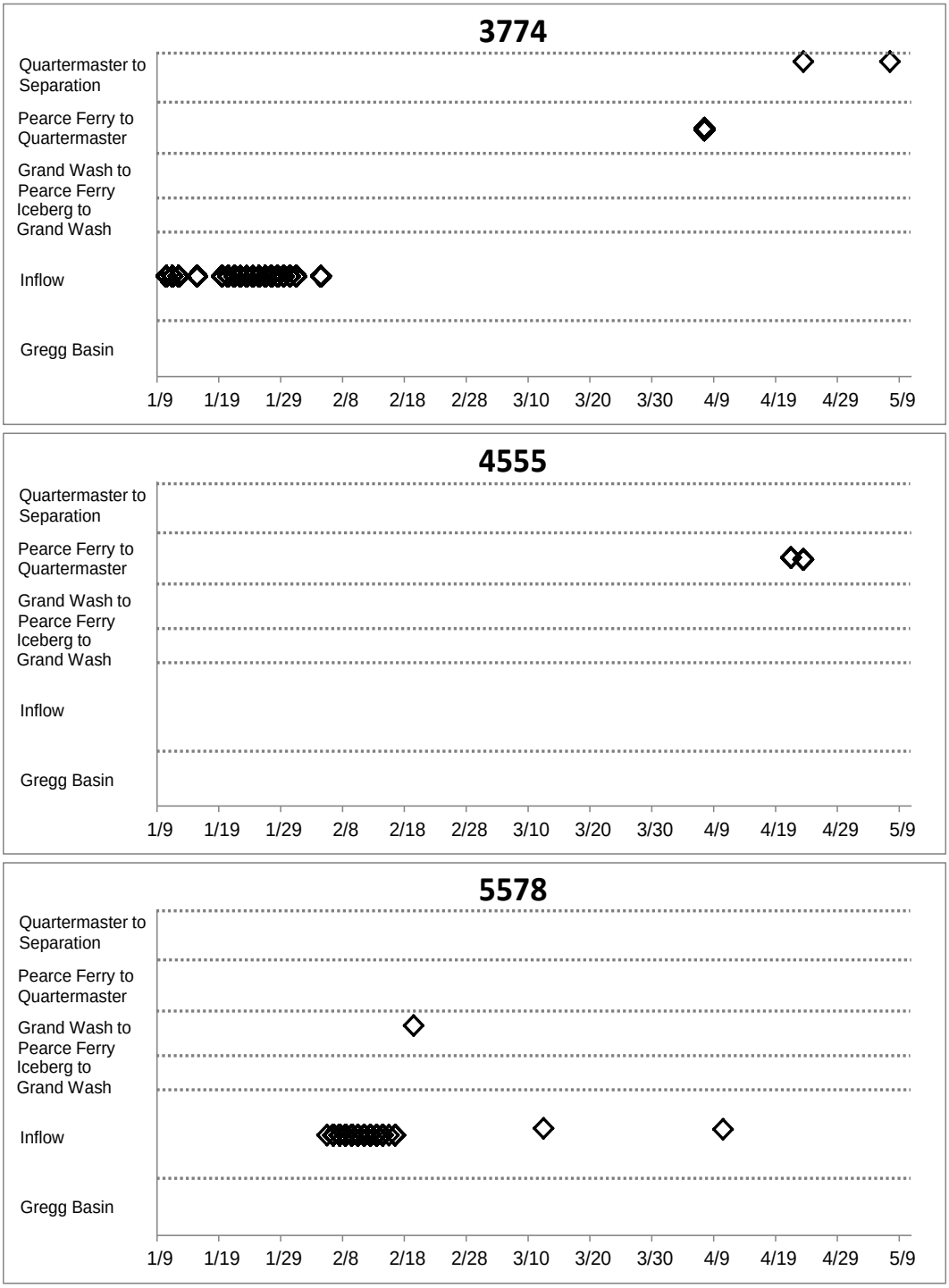

Figure 4.—Movement derived from active and passive sonic telemetry at the CRI from January to May 2013.

figure 4, which shows its movement out of the CRI as it passed through the SUR in the southern portion of Gregg Basin in early May. The first contact with fish 485 was in February when it was located just below the Pearce Ferry Rapid. This fish was not contacted again until it was found occupying habitat in and around the North Beach area at the CRI (see figure 4). Sonic-tagged fish 3546 moved from the CRI to the Pearce Ferry Rapid in February before returning back to the CRI in early March. Since then, this fish was detected at the bat cave and Quartermaster SURs as it made its way upstream (see figure 4). Sonic-tagged fish 5578 was also located near the CRI in early February before being contacted near the Pearce Ferry Rapid later that month. Contacts were also made with this individual in March and April at the CRI. Newly stocked fish 3338 and 4555 were detected by the Quartermaster and bat cave SURs as they moved downstream post-release near Separation Canyon (see figure 4). Other fish not depicted in figure 4 either had a limited number of contacts or did not display movement; therefore, they were not depicted graphically.

Adult Sampling

Trammel Netting

Trammel netting was conducted for a total of 70 net-nights at the CRI from February through May 2013, with an additional two nets set for a total of 3 hours and 22 minutes during the day (table 2). Trammel netting was generally concentrated near the CRI because this area was frequented by sonic-tagged fish and because of previous successes capturing razorback suckers there during the 2010–12 field seasons. Much of this effort was expended along the western shoreline below the mouth of Iceberg Canyon with minimal effort along the east shoreline from the interface south to North Bay (figure 5).

Table 2.—Trammel netting effort at the CRI during 2013 showing both overnight net sets and shorter duration hourly net sets

Month	Overnight net sets	Hourly net sets
February	15	–
March	39	–
April	15	1
May	1	1
Total	**70**	**2**

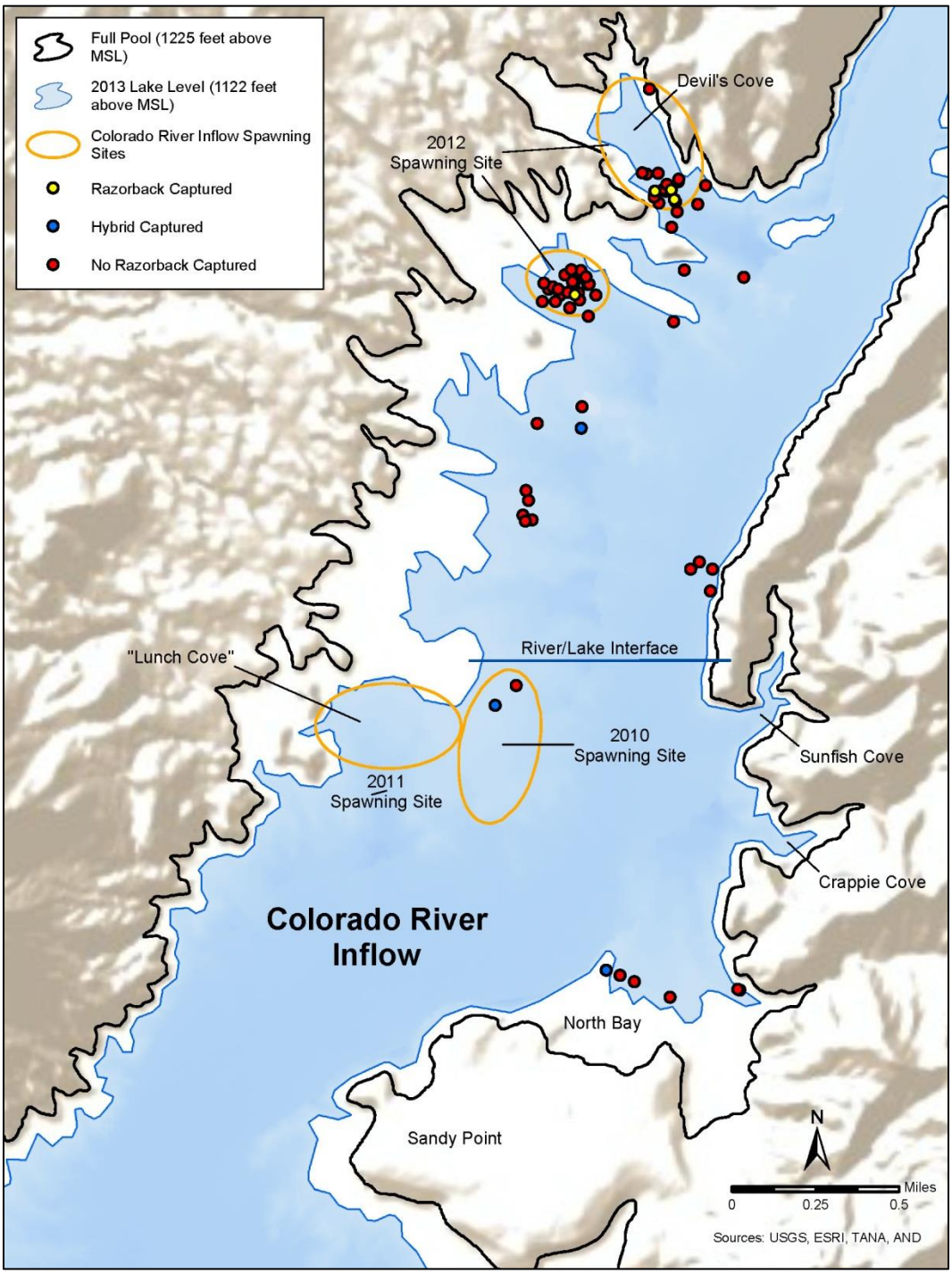

Figure 5.—Trammel netting locations and numbers of fish captured at the CRI, January – May 2013.

In 2013, we expended more than twice the effort of the 2010 field season and nearly 2.5 times less effort than expended during the 2011 and 2012 field seasons, as directed by the scope of work. Trammel netting resulted in the capture of four razorback suckers in 2013, all of which were wild individuals (table 3). These captures represented three unique individuals; one which was a new fish captured twice in 2013. The other two razorback suckers were originally captured in March 2012. The only new, wild fish captured in 2013 was a juvenile measuring 215 mm; this is the smallest razorback sucker captured to date in Lake Mead and the first juvenile to be captured from the CRI (table 3).

Table 3.—Date, PIT tag, size, and status information for razorback suckers and razorback sucker x flannelmouth sucker hybrids stocked or captured at the CRI during 2013

Date	Species[a]	PIT tag number	Sonic code	Date[b] (original)	Recapture (status)	TL (mm)	FL (mm)	SL (mm)	Wt[c] (g)	Sex[d]
2/27/2013	RS	384.1B796EF482		3/1/2012	YES (WILD)	610	574	536	2,645	F
3/5/2013	RS	384.36F2B25F66		3/5/2013	NO (WILD)	215	197	175	90	I
3/6/2013	RS	384.36F2B25F66		3/5/2013	YES (WILD)	–[e]	–[e]	–[e]	–[e]	I
3/27/2013	RS	384.1B796EE7EF	367	3/8/2012	YES (WILD)	560	516	475	1,865	M
4/9/2013	RS	3D9.1C2D6356E1	5557	4/9/2013	NO (STOCKED)	479	438	397	1,204	M
4/9/2013	RS	384.36F2B25F1A	4448	4/9/2013	NO (STOCKED)	475	436	402	1,118	F
4/9/2013	RS	384.36F2B25F73	4666	4/9/2013	NO (STOCKED)	479	441	400	1,278	M
4/9/2013	RS	384.36F2B25F67	4455	4/9/2013	NO (STOCKED)	484	451	418	1,307	F
4/9/2013	RS	384.1B796EE8D5	5668	4/9/2013	NO (STOCKED)	532	494	451	1,632	F
4/9/2013	RS	384.36F2B239AA	4555	4/9/2013	NO (STOCKED)	453	418	384	923	F
4/9/2013	RS	384.36F2B25F36	3338	4/9/2013	NO (STOCKED)	464	430	400	1,004	F
4/9/2013	RS	3D9.1C2D6C799B	4658	4/9/2013	NO (STOCKED)	510	473	441	1,791	F
4/9/2013	RS	3DD.003BA2F9FB	3747	4/9/2013	NO (STOCKED)	521	490	455	1,482	F
4/9/2013	RS	384.36F2B25F13	5556	4/9/2013	NO (STOCKED)	500	462	430	1,302	F
3/21/2013	H	3DD.003BA2FAFA		3/21/2013	NO (WILD)	337	313	285	394	I
4/25/2013	H	3DD.003BA2F9B1		4/25/2013	NO (WILD)	429	395	360	869	F
4/30/2013	H	3DD.003BA2FA2B		4/30/2013	NO (WILD)	390	370	335	–[e]	I
4/30/2013	H	384.36F2B25F24		4/30/2013	NO (WILD)	435	407	370	–[e]	I

[a] Species: RS = razorback sucker, and H = hybrid.
[b] Date originally stocked or originally captured.
[c] WT = weight in grams.
[d] Sex: F = female, I = immature, and M = male.
[e] Not recorded, typically to avoid excessive handling stress.

For the 2013 field season, razorback sucker catch per unit effort (CPUE), based on four total captures in overnight net sets, was 0.06 fish per net-night compared to 0.10, 0.08, and 0.18 fish per net-night in 2010, 2011, and 2012, respectively (figure 6). Catch rates have varied over the past four study years and were found to differ significantly (analysis of variance [ANOVA], $F_{3,463} = 2.63$, $p = 0.0498$), although a post hoc pair-wise comparison was not able to identify differences among sampling means. In comparison, the CPUE for razorback suckers captured at the CRI in 2013 was slightly lower than the CPUE at the Muddy River/Virgin River inflow area in 2005 and 2006 (0.07 and 0.08, respectively), when that spawning aggregate was first identified and adult sampling was initiated, and lower than Las Vegas Bay in 2012 (0.08) (figure 6) (Albrecht et al. 2013).

The first wild razorback sucker captured in 2013 was a female with a TL of 610 mm. This fish showed slight spawning coloration but was not expressing eggs on February 27, 2013. The first razorback sucker expressing gametes was a tuberculated, wild male captured on March 27, 2013, expressing milt (see table 3). This fish measured 560 mm TL and was implanted with an acoustic transmitter and released at the point of capture.

Four new, wild razorback sucker x flannelmouth sucker hybrids were captured at the CRI in 2013, resulting in an overall CPUE of 0.06 hybrid fish per overnight net set (table 3 and figure 6). Since 2010, a total of 17 hybrids have been captured at the CRI with a sex ratio of 1.0:2.5 (male:female), with adults of both sexes typically exhibiting signs of sexual maturity at time of capture.

Additionally, 271 flannelmouth suckers were captured (22 were recaptured fish, and 249 were new, wild fish), resulting in an overall CPUE of 3.16 flannelmouth suckers per overnight net-night for the 2013 field season (figure 6 and attachment 1). Since 2010, 636 flannelmouth suckers have been captured at the CRI. Catch rates have varied by year but have remained higher than catch rates of razorback or hybrid suckers. Many of these fish were immature, or their sex was not readily identifiable at the time of capture; thus, sex ratios are not included.

Finally, a single bluehead sucker measuring 273 mm TL and of undetermined sex was captured during the 2013 field season (attachment 1). This is only the second time that a bluehead sucker has been collected during razorback sucker research and monitoring efforts on Lake Mead (the first was in 2011during this study).

Length and Growth Information

Although four razorback suckers were captured at the CRI in 2012, annual growth rate analyses were performed using data from two of the three recaptured individuals (tables 3 and 4). One individual captured in 2013 was a new fish subsequently recaptured the following day; therefore, growth could not be calculated for that individual. The estimated mean annual growth, as determined

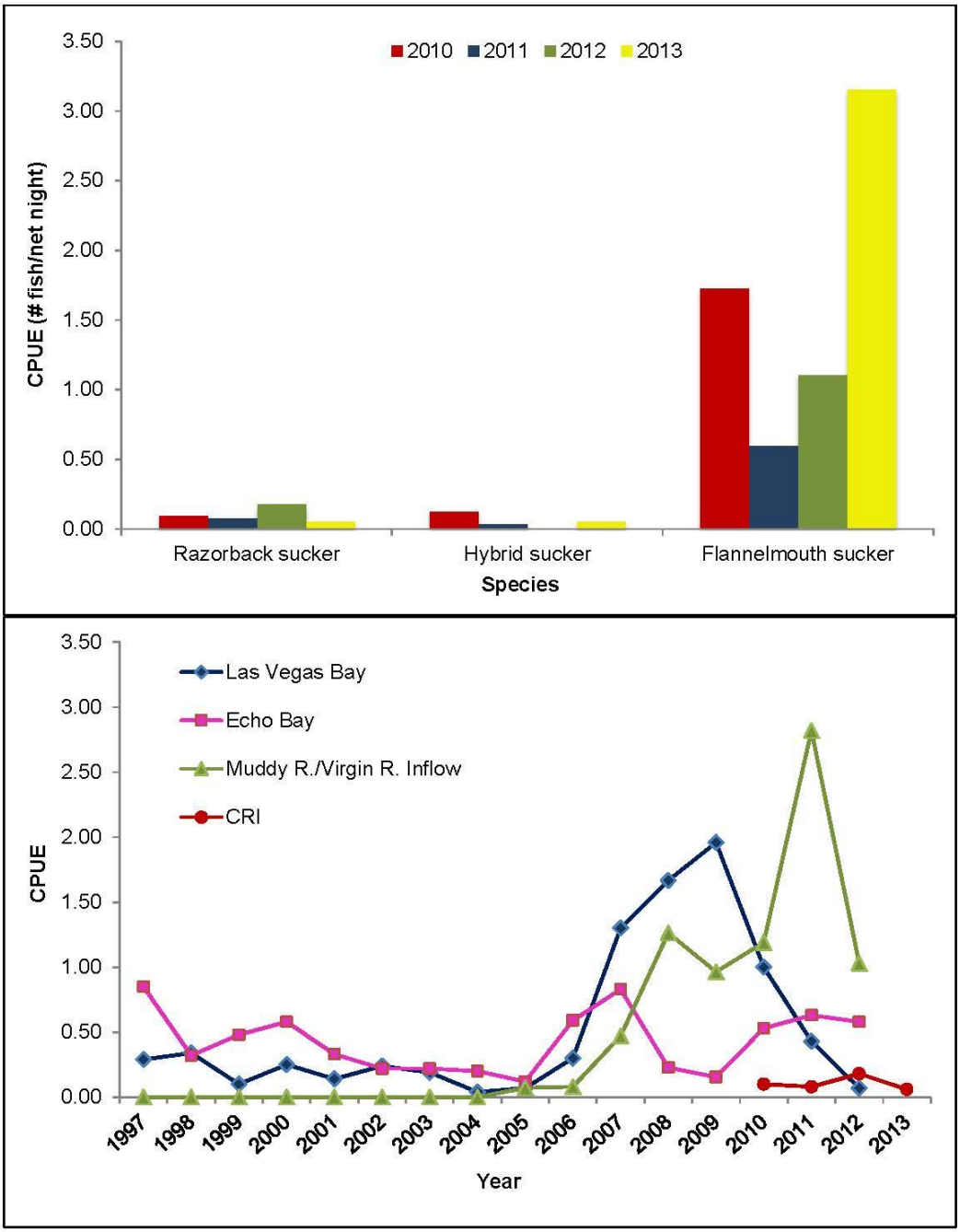

Figure 6.—Trammel netting CPUE values from the CRI, 2010–13 (top) and comparison in razorback sucker CPUE among all sampling locations on Lake Mead (bottom).

from recaptured razorback suckers from the CRI in 2013, was 20.8 mm (±17.9 mm) per year (table 4). For comparison, the mean annual growth of all razorback suckers captured from the CRI and other locations in Lake Mead during 2012 was 15.8 and 16.8 mm, respectively (Albrecht et al. 2013, Kegerries and

Table 4.—Growth histories for razorback sucker recaptured at the CRI during the 2013 field season

PIT tag number	Date stocked[a]	TL (mm)	Last date recaptured	TL (mm)	Total growth (mm)	Days between measurements	Growth/year (mm/365 days)
Colorado River – wild fish							
384.1B796EF482	3/6/2012	572	2/27/2013	610	38.0	358	38.7
384.1B796EE7EF	3/8/2012	557	3/27/2013	560	3.0	384	2.9
						Mean annual growth	**20.8 ± 17.9**

[a] The date a fish was stocked into Lake Mead, or the date a wild fish was originally captured.

Albrecht 2013). It should be noted that the mean annual growth calculated for razorback suckers at the CRI in 2013 is only based on two recaptured individuals. With a large standard error, these data should not be used to assume typical average growth; rather, they should be used in conjunction with growth reported in past field efforts on Lake Mead.

Razorback suckers captured at the CRI in 2013 ranged in TL from 215 to 610 mm. The hybrid suckers (razorback x flannelmouth) captured at the CRI in 2013 ranged from 337 to 435 mm TL. Finally, the more numerous flannelmouth suckers captured in 2013 at the CRI ranged in size from 238 to 495 mm TL (figure 7).

Larval Sampling

Sampling for razorback sucker larvae was initiated at the CRI on February 27, 2013, and continued through May 2, 2013. No native sucker larvae were collected via active crappie light or passive larval light trap sampling in 2013. Larval sampling was conducted near areas where sonic-tagged fish were contacted and in association with the 2012 spawning areas (figure 8). Much of the effort was focused in and around Devil's Cove and along the western shoreline south of Iceberg Canyon. Due to the presence of sonic-tagged fish 485 late in the season, larval fishing was also conducted around North Bay (figure 8).

A total of 11,540 minutes was spent larval sampling via boat sampling using crappie lights and passive larval light trap sampling combined. Catch-per-minute values of razorback sucker larvae collected at the CRI from 2010 to 2013 compared to other sampling areas on Lake Mead are depicted in table 5. Although the CPUE for larval razorback sucker at the CRI in 2013 was 0.0, there are no significant differences among catch rates for sampling years dating back to 2010 due to overall low larval razorback sucker collections (ANOVA,

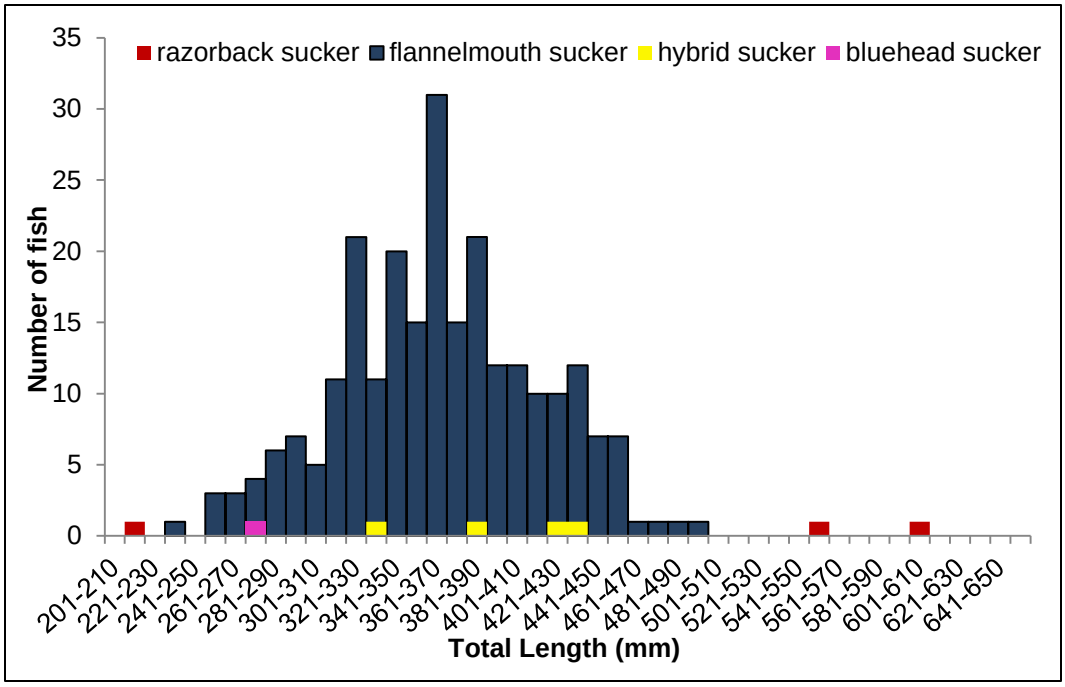

Figure 7.—Length-frequency distributions for native suckers captured at the CRI, 2013.

$F_{3,637} = 2.13$, $p = 0.0957$) (table 5). Although other larval sucker species (flannelmouth and razorback x flannelmouth sucker) were collected in 2010 and 2011, none were collected in 2013.

Spawning Site Identification and Observations

Due to the limited number of spawning adults and lack of larval razorback sucker captured at the CRI in 2013, a spawning site could not be determined. In 2012, the primary CRI spawning sites were along the western shoreline of Lake Mead, below the mouth of Iceberg Canyon (figure 8) or, more specifically, Devil's Cove, and the second cove to the south and west of Devil's Cove. Although all four of the razorback suckers captured in 2013 came from these areas, and the two adults captured were displaying spawning conditions, the validation of these habitats as spawning areas is weak, at best, due to the lack of larval fish collected. Fluctuating lake levels over the last 10 years (the majority in decline) have influenced habitat conditions in all areas where razorback sucker sampling activities have occurred during studies on Lake Mead (Albrecht et al. 2010b). Typical habitat shifts at the previously known razorback sucker spawning areas are characterized by fish following shoreline configurations as needed, apparently to accommodate fluctuating lake levels and changing conditions (Albrecht et al.

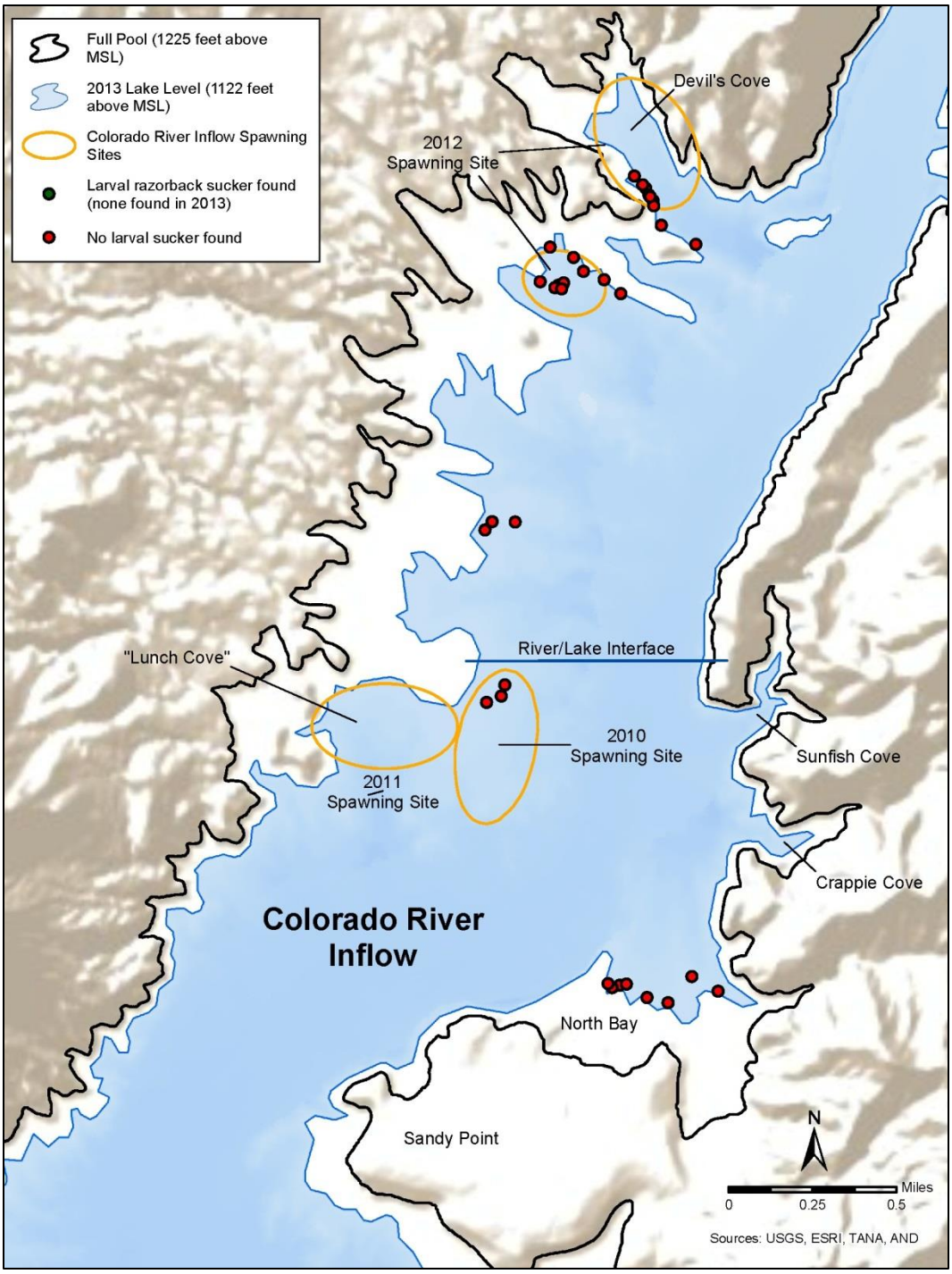

Figure 8.—Larval razorback sucker sample and capture locations at the CRI, 2013.

Table 5.—Larval razorback sucker catch-per-minute comparisons by primary sampling location on Lake Mead for 2007–13 (modified from Albrecht et al. 2013)

Primary sampling location	2007	2008	2009	2010	2011	2012	2013
CRI	–	–	–	0.002	0.007	0.0014	0.0000
Las Vegas Bay	0.39	0.43	0.342	0.093	0.282	0.1791	NA[a]
Echo Bay	0.43	0.024	0.021	0.269	1.482	0.2197	NA[a]
Muddy River/Virgin River inflow	0.001	0.116	0.107	0.011	0.013	0.0036	NA[a]

[a] Had not been calculated or reported at time of reporting.

2010b). As of April 30, 2013, the lake elevation was approximately 339 m (1,113 ft) asl, compared with approximately 343 m (1,124 ft) asl recorded the previous year on this same date (figure 9).

Razorback Sucker Aging

At the CRI in 2013, only one new, wild razorback sucker had a fin ray section surgically removed for age determination. This fish was determined to be a 2-year-old fish, spawned in 2011 (cover photo, attachment 2, and figure 10).

In addition to presenting information on the razorback suckers captured and aged at the CRI in 2013, figure 10 presents cumulative Lake Mead razorback sucker recruitment data as reported by Albrecht et al. (2013) and the Lake Mead Long-term Monitoring Report (forthcoming). The rationale for presenting the larger aging and recruitment dataset from Lake Mead with the CRI aging data is to continue putting razorback sucker recruitment events into a more holistic dataset. It is our hope that continued efforts in all study areas will add to the body of knowledge pertaining to the unique razorback sucker recruitment occurring within Lake Mead.

To date, all aged fish were spawned between 1972–2011, with the exception of one fish that was spawned around 1966 (attachment 2). Until recent years, the majority of fish aged were spawned during high lake elevations between 1978–89 and 1997–99 (figure 10). However, recent data—now including aging data from CRI specimens—show Lake Mead razorback sucker recruitment occurring beyond 1999, which coincides with the steady decline in lake levels through 2010. With the inclusion of this year's data, 2001–2006 still appears to be one of the better periods for Lake Mead razorback sucker recruitment despite dropping lake levels (figure 10). When combined with the long-term data, fish aged from the CRI coincide with strong cohorts observed from other areas of the lake (figure 10).

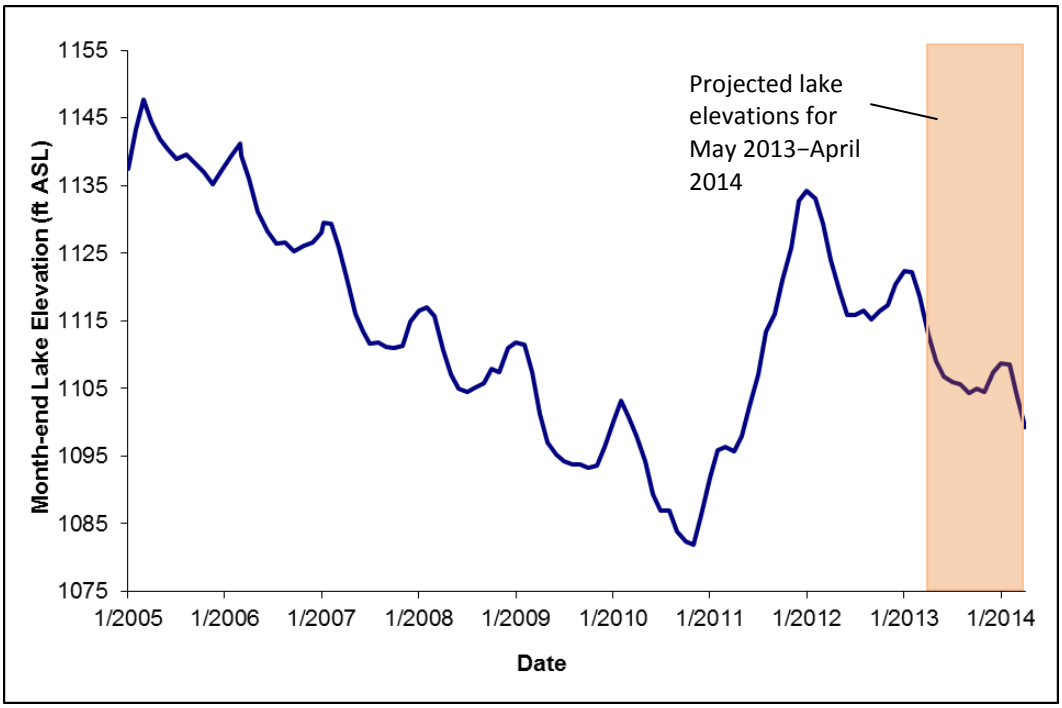

Figure 9.—Lake Mead elevations using a combination of actual, recorded, and historical lake elevation data as well as projected lake elevations (Reclamation 2013).

Fin ray specimens from flannelmouth, hybrid, and bluehead suckers were obtained using the methodologies described for razorback suckers. Flannelmouth suckers were not aged for purposes of this report and are not reported on herein. All four hybrid suckers captured in 2013 were aged, which resulted in two year-classes. Two of these fish were determined to be 5 years old (2007 year-class), while the other two were determined to be 7 years old (2005 year-class). The single bluehead sucker captured was also aged at 5 years, corresponding to a 2007 year-class for that species. Depending on project scope and overall interest, recruitment patterns of flannelmouth suckers and hybrid suckers could also be investigated as more data are collected on these native species during future efforts at the CRI.

Population Estimation

Using data from 2010–2013, the population of razorback suckers at the CRI was estimated at 44 individuals and bounded with a 95% confidence interval (CI) of 36 and 63 individuals (table 6). Although it is feasible to estimate the population of razorback suckers at the CRI as a standalone population, movement data suggest that wild and stocked individuals do move and occupy other spawning locations within Lake Mead. Thus, a lake-wide estimate could be a useful tool in

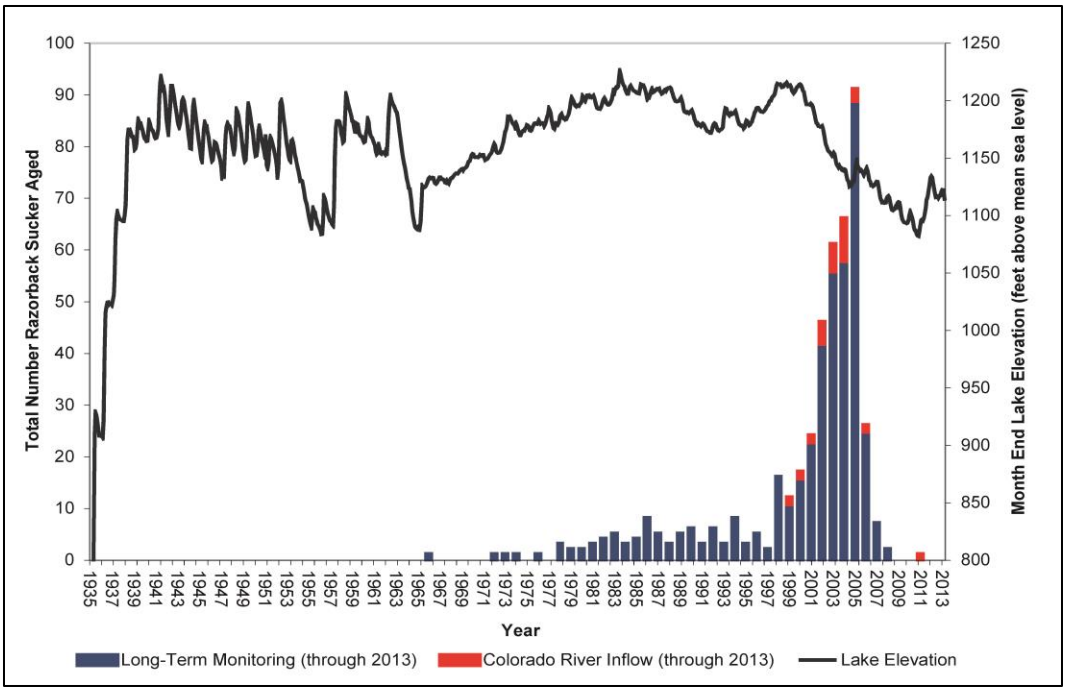

Figure 10.—Lake Mead hydrograph from January 1935 to April 2013, with the number of aged razorback suckers spawned each year.
Red bars denote the number of razorback suckers captured at the CRI through 2013, while blue bars denote recruitment and aging data from the cumulative long-term monitoring and aging efforts (modified from Albrecht et al. 2013 and the Lake Mead Long-term Monitoring Report [forthcoming]).

Table 6.—Population estimates for razorback suckers at the CRI using mark-recapture data from 2010 to 2013 from the program MARK

Population estimate	95% CI	Capture histories	Capture probability
44	36–63	52	0.0228

assessing the razorback sucker population within Lake Mead. The lake-wide estimate calculated in 2012 was 596 individuals (CI = 468–786) (Albrecht et al. 2013). Model ranking according to AICc weights and model likelihoods for estimates produced in the program MARK can be found in attachment 3.

DISCUSSION AND CONCLUSIONS

Information collected since 2010 at the CRI has expanded the knowledge of spawning behavior, habitat use, growth, and age of razorback sucker populations in Lake Mead. Combined evidence from sonic telemetry, trammel netting, and

larval collection data confirms that razorback suckers occupied CRI habitats and successfully spawned there in 2010, 2011, and 2012. It is still unclear how consistently razorback sucker spawning occurs, as spawning activity was not verified in 2013. It is also unclear to what degree razorback sucker recruitment occurs within this area; however, data presented in this report documented the presence of a juvenile razorback sucker occupying habitat within the CRI in 2013. Although sonic-tagged fish were documented moving upstream of the Pearce Ferry Rapid as far as Quartermaster Canyon in 2012 and Spencer Creek in 2013, it is still a bit unclear (based on the data collected to date) if, when, and why wild razorback suckers utilize the Colorado River proper. Tracking fish movement upstream is a substantial link to razorback sucker habitat use of the lower Grand Canyon. In fact, in October 2012, Arizona Game and Fish Department personnel captured an unmarked adult razorback sucker near Spencer Creek (A. Bunch 2012, personal communication). This finding, combined with documentation of sonic-tagged fish moving into the lower Grand Canyon to the same location at which the wild fish was captured in 2012, is significant considering razorback suckers have not been collected in the Grand Canyon in approximately two decades (Valdez et al. 2012a). Given these data, there is a strong possibility of a razorback sucker spawning location existing within the lower Grand Canyon. This said, subsequent sampling would need to be conducted within the lower Grand Canyon to capture spawning individuals and confirm successful spawning via larval sampling for validation. There remains much to be learned regarding razorback sucker habitat use and what functions the lower Grand Canyon may serve in promoting natural, wild recruitment of this unique species. These recent findings continue to identify linkages between Lake Mead and the lower Grand Canyon and support the need for additional and comprehensive studies to fully understand razorback sucker use of the lower Grand Canyon and the CRI (Valdez et al. 2012b).

Sonic Telemetry

Sonic telemetry proved to be a valuable tool during the 2013 field season. We were able to maintain contact with fish from the January 2011 and February 2010 stocking and sonic-tagging efforts as well as with one wild fish tagged during the 2013 sampling efforts. Considering the size of the CRI, its dynamic nature, the apparent ties to the lower Grand Canyon, and the previously unknown status of razorback suckers using its habitats (before this study), the success of using pond-reared fish to locate new, wild individuals exceeded expectations for the first 4 years of this study. Additionally, we confirmed that wild fish can be captured, implanted, and released back into the lake to provide data related to movement and habitat use. Sonic-tagged fish provided crucial information regarding the general location of the razorback sucker population, greatly enhancing the ability to capture new, wild razorback suckers at the CRI.

The implantation and release of sonic-tagged fish into the lower Grand Canyon has already provided useful data regarding the feasibility of techniques and the effectiveness of tracking these individuals post-release. The adaptability of these individuals stocked into the river system and their proximity to other stocked, sonic-tagged fish indicates that they are able to incorporate themselves among conspecifics and seek out habitat preferable for razorback suckers. Although two of the stocked fish were not contacted through May 10, 2013, we postulate that these individuals traveled upstream above Separation Canyon outside of our permitted sampling area. We are hopeful that further investigation and data collected by SURs above this location will confirm this assumption. It is anticipated that much will be learned regarding habitat suitability for razorback suckers in the lower Grand Canyon based on the data provided by tracking these fish. It would also be of interest to sample locations frequented by these individuals to determine if other wild razorback suckers are using the same habitats and if successful spawning is occurring within the lower Grand Canyon.

Observations from the CRI reinforce the importance of inflow areas to razorback suckers. Large inflow areas have been documented to contain increased fish species diversity and reproduction and allow for recruitment in a variety of systems (Kaemingk et al. 2007; Albrecht et al. 2010c; Schreck 2010). It was important to further investigate razorback sucker use of shallow, riverine areas within the Colorado River proper in 2013 because annual patterns and variations in movement seemed to be dictated by differing water levels and changes in habitat. For example, despite receding water levels and increased velocities and turbulence at the Pearce Ferry Rapid, sonic-tagged fish were able to navigate above the rapid and into the lower Grand Canyon. It is unknown whether this rapid is a barrier to upstream fish movement during even lower water elevations than those observed during 2013, but perhaps upstream movement above the rapid will continue, as it appears that the rapid has become less violent as it is likely scouring and cutting. Likewise, it will be important to continue searching for sonic-tagged fish to see whether they return to previously utilized spawning areas during similar water years or shift spawning locations based on water levels as was documented in 2012.

In addition to illustrating movement patterns and providing habitat use data, sonic-tagged fish helped determine the placement of trammel nets for the successful capture of wild razorback suckers at the CRI in 2013. Perhaps the most exciting find was the capture of a single juvenile razorback sucker. As water levels fluctuate, sonic-tagged fish will continue to provide valuable data on changes in razorback sucker movement patterns, habitat use, and spawning site selection regardless of whether study efforts occur within the lake, the interface, or the Colorado River proper in future years.

In 2012, one CRI-stocked, sonic-tagged fish (357) was located in Las Vegas Bay, where it remains to date (Albrecht et al. 2013). Additionally, wild, sonic-tagged

fish 367 was documented leaving Gregg Basin in May 2013. This integration with other spawning aggregates or movement to other areas of the lake from its original stocking location suggests that razorback suckers in Lake Mead navigate throughout the lake and potentially to other unknown spawning aggregates. This finding also suggests that we should refrain from citing tag failure or surgical complications when sonic-tagged fish are not immediately located during standard telemetry or monitoring efforts. We should also not be alarmed when sonic-tagged fish are not located for long periods of time, as the entire lake is not frequently tracked for these fish. This conclusion is further supported by contacts made during the 2011 season with sonic-tagged fish 267, which was originally thought to have experienced tag battery failure in 2010 (Kegerries and Albrecht 2011). Furthermore, fish from Las Vegas Bay and the Overton Arm that were undetected for long periods of time were contacted at the CRI during the 2012 study year and emphasizes the importance of lake-wide research and monitoring efforts (Kegerries and Albrecht 2013).

Finding fish that had been stocked in other parts of the lake at the CRI raises the question of whether wild fish from populations at the long-term monitoring locations display similar large-scale movements. Such evidence was discovered in 2012 when a wild, female razorback sucker originally captured at the Muddy River/Virgin River inflow area in 2009 was recaptured at the CRI near the confirmed spawning areas. In fact, this same fish was also recaptured in Echo Bay in 2009 shortly after being captured at the Muddy River/Virgin River inflow area (Kegerries and Albrecht 2013). The question of wild fish movement and utilization of multiple spawning locations could be answered by sonic tagging wild, Lake Mead razorback suckers of various size classes, similar to efforts conducted during the earlier years of this study (e.g., Holden et al. 1997). By sonic tagging wild razorback suckers, other questions posed in this report could also be addressed, such as do wild fish utilize the flowing portions of the Colorado River proper as we saw in 2012 and 2013 with stocked fish? Efforts to this end have begun with the capture and implantation of sonic-tagged fish 367 at the CRI this season and should continue through other razorback sucker studies on Lake Mead.

Anticipating that sonic-tagged fish stocked into the Nevada portions of the Colorado River would remain in the river, combination sonic/radio-tagged fish were stocked there in 2011. Although these fish did not provide data on upstream movement throughout the river proper, many tagged individuals used riverine habitats closer to the lake interface. For example, in 2011, we found that aggregates of sonic-tagged fish periodically occupied slower-moving slackwaters and eddies in this dynamic portion of the river. In 2012, this same pattern of riverine movement and habitat use was observed just downstream from the Pearce Ferry Rapid. Because water levels were higher, and the rapid did not appear to be a barrier for upstream movement (based on visual observations only), efforts to track sonic-tagged fish above the rapid into the lower Grand Canyon were conducted. Based on SUR data, it was determined that sonic-tagged fish did

travel up and down the river proper above Pearce Ferry Rapid. It was interesting that the majority of the sonic-tagged fish located at the CRI in 2012 occupied flowing portions of the river at some point. Two of these fish even traveled more than 48 km (30 miles [mi]) upstream. In 2013, it appears that some of these fish are continuing upstream movements and residing within the lower Grand Canyon. Although these are stocked fish, it is important to remember that they are likely functioning similarly to wild fish as suggested by their use for years to successfully find wild spawning populations during Lake Mead razorback sucker research and monitoring efforts. It is hypothesized that wild fish would exhibit similar behavior, and utilizing wild fish to test this hypothesis is still recommended.

Although sonic-tagged fish were detected utilizing flowing portions of the river proper in 2011, 2012, and 2013, the scale in which movement was documented was different. One explanation for this was the expansion of our geographic research area and ability to navigate further upstream in 2013. The reason for this movement is unclear, especially since four of these fish appeared to have taken longer-term residency in the lower Grand Canyon (longer than 3 months). In 2011 and 2012, fish that moved above the Pearce Ferry Rapid during the spawning season returned to the inflow area by July. It will be interesting to see if this same pattern holds true for fish that moved upstream in 2013. Perhaps the use of the river is related to habitat preference or availability and/or ease of passage depending on lake and river conditions. This gap in our understanding underscores the importance of tagging wild razorback suckers to determine if they use river habitats differently than stocked fish. Regardless of our lack of understanding at this time, the amount of time that stocked, sonic-tagged fish spend in the flowing portion of the Colorado River, and their frequent movement in and out of the area, suggests the habitat offered by the combination of lake and river may be critical for wild razorback suckers. It must also be considered that habitat changes occurring at the CRI with fluctuating water levels may change the quality of spawning habitat within the inflow area from year to year. The same could be said for the river proper as flows vary. In fact, a high-flow experiment was conducted in November 2012 (Reclamation 2011) that could have created habitat more suitable for razorback suckers within the lower Grand Canyon or prompted upstream movement patterns; a more detailed study would need to be conducted to investigate this hypothesis. As we continue to study this location, it will be important to holistically maintain the ability to track fish and sample in areas they frequent to answer questions regarding how they use the Colorado River and CRI.

Although maintaining contact with fish moving in and out of the flowing portions of the Colorado River is critical, this environment poses many difficulties and can reduce tracking effectiveness using standard methods. This observation led to an investigation into the most effective and efficient methods of tracking under these less than desirable conditions. It was found that it is feasible to effectively track sonic-tagged razorback suckers employing a combination of passive and active

telemetry using a variety of settings to capitalize on listening time while drifting downstream. This was validated by the success in contacting numerous sonic-tagged individuals within the flowing portions of the river in 2013.

Passive telemetry proved to be a valuable method for tracking sonic-tagged fish at the CRI. Because of limited knowledge of razorback sucker existence at the CRI, it remained important to track the movement of sonic-tagged fish to locate spawning aggregates. The SURs were placed strategically to try to capture any large-scale movements into or out of Gregg Basin and the Colorado River. This technology aided in tracking fish 367 as it made its way out of the CRI to an undetermined location, tracking stocked fish as they migrated upstream into the lower Grand Canyon, and tracking downstream movement of sonic-tagged fish released into the lower Grand Canyon. Fish not contacted for long periods via manual or passive methods may have been in areas of the river proper or the lake that are not conducive to active sonic telemetry detection. They may also have been at depths, distances, or in areas of underwater cover that did not allow for detection by the SUR. Although the SURs collected valuable data, maintaining them in the lake and deploying them in the river is an ongoing task, with challenges similar to those of any other new and developing methodologies. Issues with tampering and theft, as well as changing water levels and river conditions, mean the SURs demand fairly regular attention and monitoring. Despite these potential problems, the SURs collected data without field crews present, which increased the efficiency and effectiveness of the study, especially within the flowing portions of the Colorado River. The usefulness of stationary SUR technology can be limited by geographic placement. To obtain effective movement data, several SURs must be located within a given basin. Combining active and passive tracking methods allowed field crews to more efficiently and effectively locate spawning razorback suckers. The SUR data are also validated by manual tracking data. The SURs were valuable tools in the active search for sonic-tagged fish—we were able to narrow the search area based on the most recently logged data. The SUR data also provided insight into when razorback suckers move and how far they can potentially travel in a given period of time. As more data are collected on interbasin fish movements within Lake Mead, SURs may help determine whether Lake Mead razorback suckers should be managed as one population or as multiple, independent, and largely separate populations.

Adult Sampling- and Spawning-Related Observations

Of note was the lack of razorback spawning documented at the CRI in 2013; however, annual spawning did occur there in 2010, 2011, and 2012. The capture of razorback sucker x flannelmouth sucker hybrids and flannelmouth suckers has

been a fairly common occurrence at the CRI since 2010 (Albrecht et al. 2010a; Kegerries and Albrecht 2011, 2013). In fact, the numbers of flannelmouth suckers captured at the CRI has increased since 2010, which is similar to what researchers are finding within the Grand Canyon (A. Bunch 2012, personal communication). Although hybridization between flannelmouth suckers and razorback suckers is extensively documented and summarized by Bestgen (1990), the reasons for hybridization between these species at the CRI are not clearly understood. Hubbs and Miller (1953) hypothesized that chance mixing of eggs and sperm in flowing water may be the main cause when both species are present in the same habitats. Habitat alterations could also potentially reduce reproductive isolation, thereby increasing the likelihood of hybridization (Muhlfeld et al. 2009), which may be more likely the case at the CRI. Hybridization between these two species has also been documented on the San Juan River, where razorback suckers are stocked on top of large flannelmouth sucker populations (Ryden 2006). It is unclear whether hybridization will have a negative impact on the wild razorback sucker population at the CRI or whether the hybrids will contribute to reproduction and recruitment of razorback suckers. It appears the hybrids do produce viable gametes, which allows for backcrossing to either species (T. Dowling 2012, personal communication). Flannelmouth suckers and razorback suckers are both Lower Colorado River Multi-Species Conservation Program species of concern, highlighting the importance of the CRI for the sustainability and conservation of both species. With the presence of flannelmouth, razorback, hybrid, and bluehead suckers (Kegerries and Albrecht 2011), the CRI appears to provide key habitat for native suckers within the lower Colorado River system.

Compared to Echo Bay, Las Vegas Bay, and the Muddy River/Virgin River inflow area, very little is known regarding habitat use of spawning razorback suckers at the CRI. Similar to the original documentation of the Muddy River/ Virgin River inflow area as a spawning site for razorback suckers in 2006, sonic-tagged fish movement patterns within specific CRI habitats that appeared to be potential spawning areas lead to the collection of ripe, wild, adult razorback suckers. An important goal for investigation of the CRI was to ascertain whether recruitment was occurring there. Evidence was provided with the capture of a single, juvenile razorback sucker at the CRI this season, thereby accomplishing this goal. Questions such as how that recruitment is occurring and to what degree the recruitment impacts Lake Mead razorback sucker population dynamics as a whole still remain. Perhaps, like the Muddy River/Virgin River inflow area in 2005, our investigations at the CRI coincide with its early establishment as a spawning area. The data showing an increase in numbers of wild, adult razorback suckers, the expansion of the areas used to spawn, and lack of juvenile razorback suckers seem to support the hypothesis that, at this point, the CRI is a fairly new spawning area. This idea appears to be further supported by a generally

increasing population trend throughout Lake Mead (Albrecht et al. 2013). We suspect that documentation of successful recruitment at the CRI will continue with future studies as young individuals appear in subsequent sampling efforts by direct capture and through data obtained from aging techniques.

Lake levels are projected to fluctuate on Lake Mead over the next several years (see figure 9). If this occurs, razorback suckers at the CRI are likely to change spawning site locations to adapt to the highly variable conditions imposed by these fluctuations and Colorado River dynamics as they have done in preceding years. Given the relatively large inflow area and delta formed by the Colorado River proper, as well as the magnitude of change that has occurred at the CRI (kilometers of change rather than meters of change typical at the other, more thoroughly researched study areas), we hypothesize that shifts in spawning site location—should razorback suckers choose to spawn at the CRI—will continue to occur during future field seasons. These changes necessitate continued and careful monitoring of this relatively understudied razorback sucker spawning aggregate. How the potentially dramatic habitat changes will affect razorback sucker spawning success, and ultimately recruitment, at the CRI are unknown and must be tracked over time.

In summary, the trammel netting conducted at the CRI in 2013 yielded several interesting results.

1. Young, juvenile razorback suckers do occur at the CRI and can be captured by standard methods used to capture adult razorback suckers. The capture of a 215 mm TL razorback sucker near habitat frequented by other razorback suckers in 2012 suggests that the CRI may provide recruitment habitat. Further studies should be conducted to verify this and identify habitats at the CRI critical for razorback sucker recruitment.

2. Razorback suckers are present at the CRI and can be found in spawning condition on and near appropriate habitat during the spawning period. The number of razorback suckers at this location is rather nebulous, and the timing or intensity of spawning appears to be more variable than at other known spawning areas in Lake Mead (Albrecht et al. 2010b, 2010c; Kegerries and Albrecht 2011; Shattuck et al. 2011). Factors for this disparity may include annual river and lake conditions, inter- and intra-annual water level fluctuations (and the resulting gains or losses of littoral habitat types at the CRI), temperature differences and variability between the lake and river proper, and the interaction of these factors. A more holistic understanding of the importance of this unique location to razorback suckers may be attained through continued efforts at the CRI and the Colorado River proper.

3. Wild razorback suckers were captured at different locations for four consecutive field seasons at the CRI, demonstrating the possibility that unknown aggregates of razorback suckers exist at other locations in Lake Mead or the Colorado River. Sampling unexplored areas of the lake or within flowing portions of the river with suitable razorback sucker habitat may lead to documentation of new, unknown spawning aggregates. Such sampling would require increased field efforts; however, our current methodologies for finding new aggregates would ensure that field efforts would be efficient and effective.

4. The sonic telemetry techniques described in this report, as well as in other Lake Mead razorback sucker reports, can be used as an effective tool for trammel net placement to help document razorback sucker habitat use in understudied and unexplored areas of Lake Mead. Telemetry has also proved important for determining the extent of razorback sucker interaction within the lower Grand Canyon. Therefore, these techniques should be continued and improved though future efforts.

5. Razorback and flannelmouth sucker (likely even bluehead sucker) habitat use overlaps at the CRI, as throughout the upper basin. Hybridization of these native sucker species has been documented through direct capture of razorback sucker x flannelmouth sucker hybrids. Trammel netting, sonic telemetry, and larval sampling data from the CRI suggest that all sucker species and hybrids are using the more lentic portions of the CRI for spawning activities. Perhaps these species are also spawning upstream in the unsampled portion of the river.

As more research is conducted in Lake Mead, we anticipate that our understanding of conditions important for razorback sucker recruitment—despite lake level changes—will be clarified though the findings of this study and the long-term monitoring efforts described most recently by Albrecht et al. (2008b, 2010b, 2013) and Shattuck et al. (2011) during their comprehensive review of Lake Mead razorback sucker research. It remains key to monitor razorback suckers not only at the CRI but also at the long-term monitoring sites and the Colorado River proper in an integrated, holistic, and comparable manner.

Larval Sampling

No larval razorback suckers were captured at the CRI during the 2013 spawning period, although successful spawning was documented during 2010, 2011, and 2012. The numbers and catch rates of larval razorback suckers at the CRI from 2010 to 2013 have been similar to those during the first two field seasons of larval sampling in the Muddy River/Virgin River inflow area and Las Vegas Bay in 2012 (Albrecht et al. 2013). Capture rates of larvae, juveniles, and adults in the

Muddy River/Virgin River inflow area have increased over time (Albrecht et al. 2010b; Shattuck et al. 2011; Albrecht et al. 2013), and it will be interesting to evaluate whether similar trends occur at the CRI.

For the CRI in particular, river currents, high spring winds, and increased wave action could decrease the number of larvae captured as they drift into Lake Mead from a spawning area in the Colorado River. If in fact native suckers are spawning upstream in the river proper, it is possible that a portion of the larvae collected at the CRI is a result of downstream larval drift. Without current documentation of spawning occurring within the Colorado River upstream of Lake Mead, we can only assume that the natal origin for razorback suckers is Lake Mead, and we submit that additional effort in this regard is more than warranted. It should be noted, however, that larval light-trap sampling did occur in slackwater and eddy riverine habitats near Iceberg Canyon in 2012 and 2013, and no larval razorback suckers were collected.

Growth and Aging

Based on data collected from razorback suckers at the CRI to date, it appears that growth rates for razorback suckers captured in this area are similar to the relatively high growth rates observed in razorback suckers collected at the Las Vegas Bay, Echo Bay, and Muddy River/Virgin River study areas (Modde et al. 1996; Pacey and Marsh 1998; Albrecht et al. 2008a, 2010b). This finding makes sense considering the fairly young ages of razorback suckers (less than 10 years) recently reported in Lake Mead (Albrecht et al. 2010b, 2013; Shattuck et al. 2011). Future growth rate findings for razorback suckers captured at the CRI will allow for a more robust comparison to the overall size and age structure of all spawning aggregates across study areas. Similarly, it will be interesting to see whether future efforts result in the capture of smaller, juvenile razorback suckers, which would confirm recruitment at the CRI.

Determining the age of one wild CRI razorback sucker during the 2013 field season and incorporating the ages of 433 wild fish from previous studies helped verify that razorback sucker recruitment has occurred regularly in Lake Mead from 1973 to 2008, with the exception of one fish that was spawned around 1966 (Shattuck et al. 2011; Albrecht et al. 2013) (attachment 2). Based on lake-wide data collected to date, some of the most pronounced recruitment occurred from 2001 to 2006, with a total of 314 razorback sucker captures resulting from those spawning events alone. These data suggest a strong recruitment trend in recent years. This pulse of young fish indicates that successful spawning and recruitment are occurring at low and fluctuating lake levels. Lake-wide aging data confirm natural, wild recruitment within the Lake Mead razorback sucker population as recently as 2011. Fish spawned as recently as the 2012 season should become susceptible to sampling gear within the next year or two. This

assumes that recruitment is occurring and will continue for these age classes; we have no reason to suggest otherwise. Finally, as more specimens are obtained from all areas of Lake Mead, including the CRI, we hope to identify conditions that promote recruitment, and we remain optimistic that capturing additional razorback suckers at the CRI will help clarify results from study efforts throughout Lake Mead.

To date, we have collected and identified fish from nine year-classes (1999–2006 and 2011) at the CRI. Aging results from the 2013 field season alone identified one additional year-class (2011). Interestingly, eight of the nine year-classes found at the CRI correlate with relatively strong year-classes across Lake Mead (see figure 10). It will be interesting to capture and age additional razorback suckers from the CRI to ascertain whether years of strong recruitment at the CRI correlate with years of strong recruitment across the rest of Lake Mead.

Population Estimate

The 2013 field season marks the second year in which population estimates could be calculated for the CRI using consistent methods reported for the long-term razorback sucker studies (Albrecht et al. 2013). There are particular assumptions in a closed-population model (Albrecht et al. 2008a) that may not have been fully met. However, the assumption of natality and mortality are thought to have been somewhat mitigated by using 4 years of data for the estimate. Razorback suckers are a long-lived, slow-growing species, and turnover in the adult population likely occurs at a slow rate, which increases the probability of survival between sampling occasions (Minckley 1983). Additionally, by combining sites that have demonstrated connectivity, or by constructing a lake-wide model, immigration and emigration could be accounted for, and those assumptions are somewhat mitigated. Though we include the CRI standalone population estimate, current data support the inclusion of other spawning locations, as wild fish movement has been observed along with stocked fish movement within the lake proper and even up into the Colorado River (as reported herein).

Interestingly, the population estimate produced from the period of 2010–13 and those from the period of 2010–2012 (Kegerries and Albrecht 2013) are very similar (44 and 41 individuals, respectively). This may suggest that there is little variation within the number of razorback suckers at the CRI from year to year, but with only two estimates, it is impossible to discern a trend in population dynamics. Empirical field data from other long-term monitoring data on Lake Mead suggest the population abundance of razorback suckers is increasing with a linear regression, indicating a relatively high level of goodness of fit (Albrecht et al. 2013). Continued monitoring may provide a greater understanding of the

population dynamics and drivers of the CRI razorback sucker population, and additional data will help improve our ability to detect significant correlations between population estimates through time.

Conclusions and Future Considerations

In 2013, BIO-WEST documented razorback suckers at the CRI by capturing a wild, unmarked, juvenile fish and recaptured wild, adult fish in spawning condition. Larval razorback suckers were not captured, but evidence that the species spawned successfully in or near the CRI was documented in 2010, 2011, and 2012. Stocked, sonic-tagged razorback suckers demonstrated upstream movement in excess of 80 km (50 mi), in some cases into the Colorado River proper. BIO-WEST also captured a number of flannelmouth suckers, four flannelmouth sucker x razorback sucker hybrids, and one bluehead sucker at the CRI in 2013.

After 4 years of sampling, we have answered many questions, including whether a spawning razorback sucker population exists at the CRI. Additionally, we have determined that spawning activities appear to occur nearly every year and that spawning locations may shift depending on changes to habitat. We have also documented the presence of a juvenile razorback at the CRI, lending support for the hypothesis of recruitment in this area of Lake Mead. This is very similar to what occurs at other spawning areas throughout Lake Mead. Many questions have also resulted from our sampling over the last 4 years. For example, what role is the river playing in wild razorback sucker recruitment? What, if any, is the long-term use of the lower portions of the Colorado River proper during both the spawning and non-spawning periods of the year? Does the Pearce Ferry Rapid create a natural barrier to upstream movement of razorback suckers at specific water elevations? These questions may have never been asked had we not tracked razorback suckers into the flowing portions of the Colorado River. Hybridization with flannelmouth suckers is something that was undocumented in Lake Mead; however, based on our recent studies, hybridization is now known to occur. As such, the question becomes, what does this hybridization potential mean for razorback sucker recruitment and recovery? We have also discovered flannelmouth suckers to be common at the CRI, concluding that the habitat at the CRI is suitable for native suckers in general and is perhaps very important for flannelmouth suckers. However, several questions remain that extend beyond the scope of our initial study efforts – questions that continued research and monitoring could help answer. For example, will this area be a consistent spawning area beyond our initial 4-year study? How common are juvenile razorback suckers at the CRI as compared to documentation at other locations in Lake Mead? These are questions that could be answered with subsequent sampling. We have identified a fairly young population of razorback suckers at the CRI (less than 13 years old), but could enough fin ray specimens be collected

to better understand the age structure of the fish currently using the CRI, or could enough fin ray specimens be collected to extrapolate and predict the age structure of fish using the area in the future? With more sampling and a longer-term dataset, comparisons could be made regarding recruitment patterns with other Lake Mead locations used by razorback suckers. The last 4 years have demonstrated similarities in habitat characteristics utilized by razorback suckers compared to other Lake Mead spawning locations, but perhaps there are differences that have not been identified that could be critical for wild recruitment. The most important question might be: Can we learn from the apparent natural recruitment success of Lake Mead razorback suckers and apply the information to other areas throughout the Colorado River basin that are presently or were historically occupied by the species? This study at the CRI, combined with the long-term monitoring on Lake Mead, have brought us a lot closer to understanding, identifying, and perhaps establishing wild recruitment throughout the historic range of razorback suckers. At a minimum, these efforts have spurred research in other, similar areas (e.g., Lake Powell, perhaps soon within the lower Grand Canyon). At this time, it is important to consider where the razorback sucker population at the CRI (and Lake Mead in general) fits into recovery planning for both the Lower Colorado River Basin and the Grand Canyon. Decisions will need to be made by the LMWG (and others) to determine the importance of, and potential strategies for, monitoring this population. Determinations on the level and scope of continued research for razorback suckers, and perhaps flannelmouth suckers, will also need to be made at that time.

The information presented in this report, along with findings from the long-term monitoring areas (e.g., Albrecht et al. 2013), suggest the Lake Mead razorback sucker population is generally young, self-sustaining, and perhaps growing. This demonstrates the uniqueness of the Lake Mead razorback sucker population and provides one of the few positive stories for this endangered species.

2013–14 Colorado River Inflow Recommendations for Study

Given the findings from the CRI to date, maintaining sampling efforts comparable to the 2010–13 efforts at the CRI should be continued for this population of razorback suckers during the next and future calendar years. These efforts should include year-round sonic telemetry, trammel netting from February to May, sampling for larvae from February to May, aging adult and juvenile razorback suckers and razorback sucker x flannelmouth sucker hybrids that are captured, and year-round monitoring of razorback sucker activity and presence within the lower Grand Canyon for all life stages. Wild razorback suckers from Lake Mead should be sonic tagged as needed when contact is lost with the majority of the currently tagged fish. These efforts will help us to: (1) identify the 2014 (and

future) CRI spawning location(s); (2) better understand razorback sucker habitat use within the Colorado River proper; (3) potentially identify other, new spawning sites as dictated by tracking sonic-tagged fish; and (4) identify seasonal riverine habitat use patterns if they exist. Data stemming from sampling efforts can be used to assist in understanding the size and habitat use of razorback suckers at the CRI, help document the movement of tagged fish between sites, identify potential limitations or habitat shifts associated with the CRI spawning aggregates, identify lake-wide recruitment patterns, and help characterize the habitat use and relationship that Lake Mead razorback suckers have with the Colorado River proper.

Lastly, we recommend taking a comprehensive approach to synthesizing the data collected on Lake Mead razorback suckers over the past 17 years. It is apparent that the CRI population should not be viewed or managed independently from the other razorback sucker populations in Lake Mead. This is also true for any razorback suckers that may be present in the lower Grand Canyon, as this report suggests a strong linkage between razorback suckers that inhabit both the lake and the river. A holistic look at wild razorback sucker recruitment as it relates to Lake Mead, and the lower Grand Canyon as a continuum, may help to better characterize the conditions needed to establish and maintain a recruiting population not only in Lake Mead but also in other locations historically occupied by this species. Continued efforts may also help to address questions and objectives outlined in future recovery goals and plans.

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ATTACHMENT 1

Date, Passive Integrated Transponder (PIT) Tag, and Size Data for Flannelmouth and Bluehead Suckers Captured at the Colorado River Inflow Area in 2013

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
2/21/2013	FM	384.36F2B25F37	2/21/2013	NO	315	293	264	276	I
2/21/2013	FM	384.36F2B25F6D	2/21/2013	NO	325	303	272	326	I
2/21/2013	FM	384.1B796EE086	2/21/2013	NO	326	316	228	332	I
2/21/2013	FM	384.1B796EE28C	2/21/2013	NO	351	329	290	386	I
2/21/2013	FM	384.36F2B25F45	2/21/2013	NO	364	340	307	376	I
2/21/2013	FM	384.36F2B25F16	2/21/2013	NO	365	338	307	385	I
2/21/2013	FM	384.36F2B25F3D	2/21/2013	NO	365	338	305	415	I
2/21/2013	FM	384.36F2B25F4C	2/21/2013	NO	366	343	311	453	I
2/21/2013	FM	384.36F2B25F43	2/21/2013	NO	367	341	310	460	I
2/21/2013	FM	384.36F2B25F18	2/21/2013	NO	378	362	324	415	I
2/21/2013	FM	384.1B796EED14	2/21/2013	NO	380	355	320	486	I
2/21/2013	FM	384.36F2B25F4B	2/21/2013	NO	385	360	325	480	I
2/21/2013	FM	384.36F2B25F2B	2/21/2013	NO	390	366	327	520	I
2/21/2013	FM	384.36F2B25F56	2/21/2013	NO	390	361	332	565	I
2/21/2013	FM	384.1B796EDE43	2/21/2013	NO	391	357	318	528	I
2/21/2013	FM	384.36F2B25F5E	2/21/2013	NO	396	366	330	530	I
2/21/2013	FM	384.36F2B25F27	2/21/2013	NO	397	379	342	548	I
2/21/2013	FM	384.36F2B25F59	2/21/2013	NO	410	381	343	586	I
2/21/2013	FM	384.1B796EE213	2/21/2013	NO	422	395	353	630	I
2/21/2013	FM	384.1B796EE6FD	2/21/2013	NO	423	395	355	678	F
2/21/2013	FM	384.36F2B25F52	2/21/2013	NO	433	400	364	751	F
2/21/2013	FM	384.1B796EFBD7	2/2/2012	YES	440	415	380	776	F
2/21/2013	FM	3D9.1C2D266245	4/3/2012	YES	440	420	383	714	F
2/21/2013	FM	384.36F2B25F5B	2/21/2013	NO	445	413	367	757	F
2/21/2013	FM	3DD.003B9F3E61	1/29/2013	YES	450	430	395	586	F
2/21/2013	FM	384.36F2B25F47	2/21/2013	NO	452	425	380	782	F
2/21/2013	FM	384.36F2B25F64	2/21/2013	NO	453	430	392	752	F
2/21/2013	FM	384.1B796EE42F	4/28/2011	YES	490	458	410	980	M
2/21/2013	FM	384.36F2B25F75	2/21/2013	NO	495	465	430	990	F
2/26/2013	FM	384.36F2B25F22	2/26/2013	NO	312	291	265	270	I
2/26/2013	FM	384.36F2B25F4D	2/26/2013	NO	327	305	271	290	I
2/26/2013	FM	384.36F2B25F26	2/26/2013	NO	336	311	280	315	I
2/26/2013	FM	384.36F2B25F1C	2/26/2013	NO	341	317	286	342	I
2/26/2013	FM	384.36F2B25F6F	2/26/2013	NO	366	343	307	422	I

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
2/26/2013	FM	384.36F2B25F6A	2/26/2013	NO	371	342	309	437	I
2/26/2013	FM	384.36F2B25F14	2/26/2013	NO	373	350	312	439	I
2/26/2013	FM	384.36F2B25F53	2/26/2013	NO	390	365	330	525	I
2/26/2013	FM	384.36F2B25F5C	2/26/2013	NO	390	360	323	540	I
2/26/2013	FM	384.36F2B25F2C	2/26/2013	NO	394	372	339	540	I
2/26/2013	FM	384.36F2B25F40	2/26/2013	NO	395	368	335	536	I
2/26/2013	FM	384.36F2B25F65	2/26/2013	NO	405	376	340	574	I
2/26/2013	FM	384.36F2B25F20	2/26/2013	NO	410	386	348	524	I
2/26/2013	FM	384.36F2B25F74	2/26/2013	NO	410	389	345	634	F
2/26/2013	FM	384.36F2B25F51	2/26/2013	NO	415	390	353	590	I
2/26/2013	FM	384.36F2B25F33	2/26/2013	NO	417	392	355	614	I
2/26/2013	FM	384.36F2B25F6E	2/26/2013	NO	425	395	357	730	I
2/26/2013	FM	384.36F2B25F3B	2/26/2013	NO	435	402	365	662	F
2/26/2013	FM	384.36F2B25F5D	2/26/2013	NO	442	413	378	698	F
2/27/2013	FM	384.36F2B25F4E	2/27/2013	NO	276	259	234	175	I
2/27/2013	FM	384.36F2B25F25	2/27/2013	NO	345	324	295	368	I
2/27/2013	FM	384.36F2B25F15	2/27/2013	NO	349	323	295	395	I
2/27/2013	FM	384.36F2B25F17	2/27/2013	NO	364	339	312	405	I
2/27/2013	FM	384.36F2B25F28	2/27/2013	NO	370	346	316	485	I
2/27/2013	FM	384.36F2B25F4F	2/27/2013	NO	387	361	334	485	I
2/28/2013	FM	384.36F2B25F31	2/28/2013	NO	254	234	209	134	I
2/28/2013	FM	384.36F2B25F42	2/28/2013	NO	344	320	284	364	I
2/28/2013	FM	384.36F2B25F17	2/27/2013	YES					
3/5/2013	FM	3DD.003BA2FA24	3/5/2013	NO	268	236	222	174	I
3/5/2013	FM	384.36F2B25F70	3/5/2013	NO	270	250	220	162	I
3/5/2013	FM	3DD.003BA2FA13	3/5/2013	NO	321	302	276	302	I
3/6/2013	FM	384.36F2B25F71	3/6/2013	NO	285	260	235	168	I
3/6/2013	FM	384.36F2B25F66	3/5/2013	YES	–[g]	–[g]	–[g]	–[g]	–[g]
3/6/2013	FM	384.36F2B25F70	3/5/2013	YES	–[g]	–[g]	–[g]	–[g]	–[g]
3/7/2013	FM	384.36F2B25F69	3/7/2013	NO	350	336	301	381	I
3/7/2013	FM	384.36F2B25F2A	3/7/2013	NO	457	425	381	917	F
3/7/2013	FM	384.36F2B25F47	2/21/2013	YES	–[g]	–[g]	–[g]	–[g]	–[g]
3/12/2013	FM	3DD.003BA2FA03	3/12/2013	NO	260	244	221	137	I
3/12/2013	FM	384.36F2B25F44	3/12/2013	NO	308	286	259	230	I

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
3/12/2013	FM	3DD.003BA2FA08	3/12/2013	NO	390	366	335	494	F
3/13/2013	FM	384.36F2B25F50	3/13/2013	NO	321	311	271	291	I
3/13/2013	FM	384.36F2B25F58	3/13/2013	NO	342	319	295	338	I
3/13/2013	FM	384.36F2B25F12	3/13/2013	NO	381	355	319	415	I
3/13/2013	FM	384.36F2B25F23	3/13/2013	NO	389	375	344	520	I
3/13/2013	FM	384.1B796EE3FF	2/8/2012	YES	414	385	355	649	I
3/13/2013	FM	384.36F2B25F3F	3/13/2013	NO	415	391	354	648	I
3/13/2013	FM	384.36F2B25F46	3/13/2013	NO	431	404	371	667	U
3/19/2013	FM	3DD.003BA2FA2C	3/19/2013	NO	300	281	257	212	I
3/19/2013	FM	3DD.003BA2FA0F	3/19/2013	NO	315	294	267	250	I
3/19/2013	FM	3DD.003BA2FA2F	3/19/2013	NO	317	298	268	301	F
3/19/2013	FM	3DD.003BA2FA3F	3/19/2013	NO	360	339	303	402	F
3/19/2013	FM	3DD.003BA2FA37	3/19/2013	NO	364	342	310	447	F
3/19/2013	FM	3DD.003BA2F9FF	3/19/2013	NO	377	351	320	494	F
3/19/2013	FM	3DD.003BA2FA0D	3/19/2013	NO	415	390	356	601	F
3/19/2013	FM	3DD.003BA2FA3B	3/19/2013	NO	458	439	397	909	F
3/19/2013	BH	3DD.033BA2FA35	3/19/2013	NO	273	244	240	212	I
3/21/2013	FM	3DD.003BA2FA06	3/21/2013	NO	238	221	198	124	I
3/21/2013	FM	3DD.003BA2FA49	3/21/2013	NO	265	255	231	177	I
3/21/2013	FM	3DD.003BA2FA25	3/21/2013	NO	288	268	239	186	I
3/21/2013	FM	3DD.003BA2FA0A	3/21/2013	NO	296	275	249	232	I
3/21/2013	FM	3DD.003BA2FA4A	3/21/2013	NO	300	279	250	259	I
3/21/2013	FM	3DD.003BA2FA0B	3/21/2013	NO	314	292	260	256	F
3/21/2013	FM	3DD.003BA2FA01	3/21/2013	NO	322	300	272	308	I
3/21/2013	FM	3DD.003BA2FA5D	3/21/2013	NO	323	300	270	303	I
3/21/2013	FM	384.36F2B25F6D	2/21/2013	YES	329	300	274	333	I
3/21/2013	FM	3DD.003BA2FA4E	3/21/2013	NO	329	310	275	313	I
3/21/2013	FM	3DD.003BA2FA5C	3/21/2013	NO	329	301	270	303	I
3/21/2013	FM	3DD.003BA2FA26	3/21/2013	NO	331	310	281	305	I
3/21/2013	FM	3DD.003BA2FA20	3/21/2013	NO	341	321	287	364	F
3/21/2013	FM	3DD.003BA2FA57	3/21/2013	NO	341	320	290	344	I
3/21/2013	FM	384.36F2B25F1C	2/26/2013	YES	343	320	295	352	I
3/21/2013	FM	3DD.003BA2FA4F	3/21/2013	NO	346	324	294	393	F
3/21/2013	FM	384.36F2B25F4C	2/21/2013	YES	370	349	307	464	F

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
3/21/2013	FM	3DD.003BA2FA10	3/21/2013	NO	370	345	306	445	F
3/21/2013	FM	3DD.003BA2FA40	3/21/2013	NO	370	347	321	452	F
3/21/2013	FM	3DD.003BA2FA04	3/21/2013	NO	380	355	315	529	F
3/21/2013	FM	3DD.003BA2FA53	3/21/2013	NO	380	357	319	510	F
3/21/2013	FM	3DD.003BA2FA19	3/21/2013	NO	387	360	331	481	F
3/21/2013	FM	3DD.003BA2FA50	3/21/2013	NO	389	363	334	469	F
3/21/2013	FM	3DD.003BA2FA28	3/21/2013	NO	400	374	341	589	F
3/21/2013	FM	3DD.003BA2FA58	3/21/2013	NO	404	375	337	504	F
3/21/2013	FM	3DD.003BA2FA1D	3/21/2013	NO	421	390	360	639	F
3/21/2013	FM	384.1B796EDDFE	2/15/2012	YES	424	400	367	665	F
3/21/2013	FM	3DD.003BA2FA09	3/21/2013	NO	431	408	371	623	F
3/26/2013	FM	3DD.003BA2F99D	3/26/2013	NO	282	262	239	190	I
3/26/2013	FM	3DD.003BA2F9A8	3/26/2013	NO	311	289	263	276	I
3/26/2013	FM		3/26/2013	NO	323	300	277	299	I
3/26/2013	FM	3DD.003BA2F9AC	3/26/2013	NO	351	326	297	367	I
3/26/2013	FM	3DD.003BA2F9B5	3/26/2013	NO	359	337	305	386	I
3/26/2013	FM	3DD.003BA2F99A	3/26/2013	NO	363	340	310	431	I
3/26/2013	FM	3DD.003BA2F9C3	3/26/2013	NO	395	381	343	584	I
3/26/2013	FM	3DD.003BA2F9A6	3/26/2013	NO	425	400	365	641	U
3/26/2013	FM	3DD.003BA2F9D6	3/26/2013	NO	430	403	368	686	U
3/26/2013	FM	384.36F2B25F1B	3/26/2013	NO	480	450	412	745	F
3/26/2013	FM	384.1B796EE28C	2/21/2013	YES	–[g]	–[g]	–[g]	–[g]	–[g]
3/27/2013	FM	3DD.003BA2FA4C	3/27/2013	NO	279	259	236	174	I
3/27/2013	FM	3DD.003BA2FA41	3/27/2013	NO	354	328	298	364	I
3/28/2013	FM	3DD.003BA2F9CC	3/28/2013	NO	318	290	276	263	I
4/3/2013	FM	3DD.003BA2FA02	4/3/2013	NO	284	265	241	197	I
4/3/2013	FM	3DD.003BA2FA07	4/3/2013	NO	285	263	236	200	I
4/3/2013	FM	3DD.003BA2FA05	4/3/2013	NO	307	287	262	255	I
4/3/2013	FM	3DD.003BA2FA0E	4/3/2013	NO	320	298	271	261	I
4/3/2013	FM	3DD.003BA2FA2E	4/3/2013	NO	347	322	297	329	F
4/3/2013	FM	3DD.003BA2FA18	4/3/2013	NO	350	333	300	420	F
4/3/2013	FM	3DD.003BA2FA47	4/3/2013	NO	363	335	310	392	F
4/3/2013	FM	3DD.003BA2FA1E	4/3/2013	NO	370	343	313	424	F
4/3/2013	FM	3DD.003BA2FA39	4/3/2013	NO	370	347	315	471	F

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
4/3/2013	FM	3DD.003BA2FA42	4/3/2013	NO	382	354	325	469	F
4/3/2013	FM	3DD.003BA2FA5A	4/3/2013	NO	391	364	331	532	F
4/3/2013	FM	3DD.003BA2FA44	4/3/2013	NO	403	375	337	614	F
4/3/2013	FM	3DD.003BA2FA38	4/3/2013	NO	427	399	365	662	F
4/3/2013	FM	384.36F2B25F5B	2/21/2013	YES	445	415	375	760	F
4/11/2013	FM	3DD.003BA2F9FC	4/11/2013	NO	252	236	212	142	I
4/11/2013	FM	3DD.003BA2F9B2	4/11/2013	NO	326	304	275	323	I
4/11/2013	FM	3DD.003BA2F9E6	4/11/2013	NO	336	321	299	406	I
4/11/2013	FM	384.36F2B25F32	4/11/2013	NO	346	325	299	379	I
4/11/2013	FM	3DD.003BA2F9B6	4/11/2013	NO	354	330	303	412	I
4/11/2013	FM	3DD.003BA2FA3A	4/11/2013	NO	358	334	308	437	I
4/11/2013	FM	3DD.003BA2F9F0	4/11/2013	NO	369	343	313	439	I
4/11/2013	FM	3DD.003BA2FA2A	4/11/2013	NO	370	346	315	408	I
4/11/2013	FM	3DD.003BA2F9DC	4/11/2013	NO	389	365	336	486	I
4/11/2013	FM	3DD.003BA2FA15	4/11/2013	NO	392	371	340	618	I
4/11/2013	FM	384.36F2B25F2D	4/11/2013	NO	400	373	345	581	I
4/11/2013	FM	384.36F2B25F38	4/11/2013	NO	405	384	356	577	I
4/11/2013	FM	384.36F2B25F6C	4/11/2013	NO	409	389	364	612	I
4/11/2013	FM	384.36F2B25F55	4/11/2013	NO	414	391	358	593	I
4/11/2013	FM	3DD.003BA2F9F5	4/11/2013	NO	429	404	371	807	U
4/11/2013	FM	3DD.003BA2FA5B	4/11/2013	NO	434	405	376	743	U
4/11/2013	FM	3DD.003BA2F9C6	4/11/2013	NO	438	407	378	737	M
4/11/2013	FM	3D9.1C2D269180	2/8/2011	YES	442	421	398	872	M
4/11/2013	FM	3DD.003BA2F9ED	4/11/2013	NO	446	422	390	804	U
4/11/2013	FM	3D9.1C2D267CA9	2/10/2011	YES	459	442	402	1011	U
4/11/2013	FM	3DD.003BA2F997	4/11/2013	NO	466	435	405	829	U
4/11/2013	FM	QUICK RELEASE	4/11/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/11/2013	FM	QUICK RELEASE	4/11/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/17/2013	FM	384.36F2B25F6B	4/17/2013	NO	292	270	243	187	I
4/17/2013	FM	384.36F2B25F57	4/17/2013	NO	341	320	289	414	I
4/17/2013	FM	384.1B796EDB04	2/8/2012	YES	372	355	321	443	I
4/17/2013	FM	3DD.003BA2FA54	4/17/2013	NO	420	394	357	641	I
4/17/2013	FM	384.36F2B25F48	4/17/2013	NO	433	407	368	740	U
4/17/2013	FM	3DD.003BA2FA32	4/17/2013	NO	442	412	373	913	U

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
4/24/2013	FM	3DD.003BA2FA43	4/24/2013	NO	305	292	265	271	I
4/24/2013	FM	3DD.003BA2F9C5	4/24/2013	NO	395	372	340	586	F
4/24/2013	FM	3DD.003BA2FA51	4/24/2013	NO	416	392	362	633	F
4/25/2013	FM	3DD.003BA2F9BC	4/25/2013	NO	272	254	232	183	I
4/25/2013	FM		4/25/2013	NO	279	263	240	181	I
4/25/2013	FM	3DD.003BA2F996	4/25/2013	NO	286	261	242	190	I
4/25/2013	FM	3DD.003BA2FA1F	4/25/2013	NO	298	277	256	275	I
4/25/2013	FM	3DD.003BA2FA45	4/25/2013	NO	298	280	252	255	F
4/25/2013	FM	3DD.003BA2F9D2	4/25/2013	NO	300	280	253	217	I
4/25/2013	FM	3DD.003BA2F9F3	4/25/2013	NO	305	288	260	246	I
4/25/2013	FM	3DD.003BA2F9FD	4/25/2013	NO	310	295	270	306	F
4/25/2013	FM	3DD.003BA2F9B7	4/25/2013	NO	315	290	267	309	F
4/25/2013	FM	3DD.003BA2F9F2	4/25/2013	NO	319	300	272	325	F
4/25/2013	FM	384.36F2B25F3A	4/25/2013	NO	320	300	276	280	F
4/25/2013	FM	3DD.003BA2FA4B	4/25/2013	NO	321	305	276	300	F
4/25/2013	FM	3DD.003BA2F998	4/25/2013	NO	323	300	275	294	F
4/25/2013	FM	3DD.003BA2F9B9	4/25/2013	NO	324	298	273	313	I
4/25/2013	FM	3DD.003BA2F9F6	4/25/2013	NO	324	304	281	329	F
4/25/2013	FM	3DD.003BA2FA31	4/25/2013	NO	324	304	278	354	F
4/25/2013	FM	3DD.003BA2F9E5	4/25/2013	NO	325	304	280	318	F
4/25/2013	FM	384.36F2B25F3C	4/25/2013	NO	326	303	275	336	F
4/25/2013	FM	3DD.003BA2F9F4	4/25/2013	NO	328	307	280	316	F
4/25/2013	FM	3DD.003BA2FA2D	4/25/2013	NO	330	309	284	358	F
4/25/2013	FM	3DD.003BA2FA29	4/25/2013	NO	332	314	286	351	F
4/25/2013	FM	384.36F2B25F5A	4/25/2013	NO	335	320	290	333	F
4/25/2013	FM	384.36F2B25F62	4/25/2013	NO	335	310	285	353	F
4/25/2013	FM	3DD.003BA2F9C0	4/25/2013	NO	335	316	288	356	F
4/25/2013	FM	3DD.003BA2FA00	4/25/2013	NO	336	314	286	370	F
4/25/2013	FM	384.36F2B25F1F	4/25/2013	NO	338	317	290	337	F
4/25/2013	FM	3DD.003BA2FA4D	4/25/2013	NO	340	321	391	374	F
4/25/2013	FM	3DD.003BA2FA55	4/25/2013	NO	340	316	291	352	F
4/25/2013	FM	384.36F2B25F34	4/25/2013	NO	342	320	295	350	F
4/25/2013	FM	3DD.003BA2FA11	4/25/2013	NO	344	322	299	340	F
4/25/2013	FM	3DD.003BA2FA12	4/25/2013	NO	345	320	394	363	F

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
4/25/2013	FM	3DD.003BA2FA16	4/25/2013	NO	345	318	292	408	F
4/25/2013	FM	3DD.003BA2F9BB	4/25/2013	NO	346	326	297	372	F
4/25/2013	FM	384.36F2B25F68	4/25/2013	NO	347	321	290	464	F
4/25/2013	FM	3DD.003BA2F9B8	4/25/2013	NO	351	330	305	387	F
4/25/2013	FM	3DD.003BA2F9C4	4/25/2013	NO	351	329	300	411	F
4/25/2013	FM	3DD.003BA2F99F	4/25/2013	NO	355	335	305	435	F
4/25/2013	FM	3DD.003BA2FA3C	4/25/2013	NO	356	342	310	430	F
4/25/2013	FM	384.36F21B25F5F	4/25/2013	NO	358	338	311	380	F
4/25/2013	FM	3DD.003BA2FA3D	4/25/2013	NO	358	334	307	425	F
4/25/2013	FM	3DD.003BA2F9A2	4/25/2013	NO	359	340	305	414	F
4/25/2013	FM	384.36F2B25F2E	4/25/2013	NO	360	334	305	404	F
4/25/2013	FM	384.36F2B25F19	4/25/2013	NO	362	338	306	444	F
4/25/2013	FM	3DD.003BA2FA59	4/25/2013	NO	363	335	315	426	F
4/25/2013	FM	384.36F2B25F21	4/25/2013	NO	364	339	310	414	F
4/25/2013	FM	3DD.003BA2FA14	4/25/2013	NO	364	336	310	416	F
4/25/2013	FM	3DD.003BA2F9DA	4/25/2013	NO	365	345	315	399	F
4/25/2013	FM	3DD.003BA2FA56	4/25/2013	NO	365	344	315	468	F
4/25/2013	FM	384.36F2B25F41	4/25/2013	NO	366	344	315	448	F
4/25/2013	FM	3DD.003BA2FA04	3/21/2013	YES	366	345	322	525	F
4/25/2013	FM	3DD.003BA2FA34	4/25/2013	NO	366	342	315	407	F
4/25/2013	FM	384.36F2B25F1D	4/25/2013	NO	368	345	315	513	F
4/25/2013	FM	3DD.003BA2F99C	4/25/2013	NO	368	340	311	428	F
4/25/2013	FM	3DD.003BA2F9AF	4/25/2013	NO	370	349	321	413	F
4/25/2013	FM	3DD.003BA2F9D1	4/25/2013	NO	370	347	319	448	F
4/25/2013	FM	3DD.003BA2F9E9	4/25/2013	NO	371	369	320	430	F
4/25/2013	FM	384.36F2B25F39	4/25/2013	NO	372	353	326	503	F
4/25/2013	FM	384.36F2B25F54	4/25/2013	NO	372	346	316	483	F
4/25/2013	FM	3DD.003BA2FA22	4/25/2013	NO	372	347	316	505	F
4/25/2013	FM	3DD.003BA2FA17	4/25/2013	NO	375	350	320	447	F
4/25/2013	FM	384.36F2B25F63	4/25/2013	NO	378	360	324	583	F
4/25/2013	FM	3DD.003BA2F9EE	4/25/2013	NO	379	356	324	472	F
4/25/2013	FM	3DD.003BA2F9CB	4/25/2013	NO	381	358	325	484	F
4/25/2013	FM	384.36F2B25F3E	4/25/2013	NO	382	357	324	542	F
4/25/2013	FM	384.36F2B25F29	4/25/2013	NO	384	360	332	505	F

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]
4/25/2013	FM	3DD.003BA2F9A3	4/25/2013	NO	384	360	331	528	F
4/25/2013	FM	3DD.003BA2F9E2	4/25/2013	NO	387	363	335	460	M
4/25/2013	FM	3DD.003BA2F9E4	4/25/2013	NO	388	364	332	531	F
4/25/2013	FM	384.36F2B25F2B	2/21/2013	YES	390	366	340	532	F
4/25/2013	FM	3DD.003BA2FA33	4/25/2013	NO	390	362	330	625	M
4/25/2013	FM	3DD.003BA2FA46	4/25/2013	NO	397	370	340	539	F
4/25/2013	FM	3DD.003BA2F99B	4/25/2013	NO	401	379	345	629	F
4/25/2013	FM	3DD.003BA2F99E	4/25/2013	NO	401	375	342	591	F
4/25/2013	FM	3DD.003BA2F9BA	4/25/2013	NO	406	382	355	600	F
4/25/2013	FM	3DD.003BA2FA1C	4/25/2013	NO	406	388	352	595	F
4/25/2013	FM	3DD.003BA2F9A0	4/25/2013	NO	414	382	359	701	F
4/25/2013	FM	3DD.003BA2FA30	4/25/2013	NO	417	394	358	636	F
4/25/2013	FM	384.36F2B25F35	4/25/2013	NO	425	400	365	639	F
4/25/2013	FM	3DD.003BA2F9CD	4/25/2013	NO	432	402	370	662	F
4/25/2013	FM	3DD.003BA2FA27	4/25/2013	NO	434	404	368	870	F
4/25/2013	FM	3DD.003BA2FA3E	4/25/2013	NO	434	412	370	798	F
4/25/2013	FM	384.36F2B25F64	2/21/2013	YES	457	431	396	718	F
4/25/2013	FM	3DD.003BA2F9E7	4/25/2013	NO	458	425	395	880	F
4/25/2013	FM		4/25/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/25/2013	FM		4/25/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/25/2013	FM		4/25/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/25/2013	FM		4/25/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/25/2013	FM		4/25/2013	NO	–[g]	–[g]	–[g]	–[g]	–[g]
4/30/2013	FM		4/30/2013	NO	325	305	280	0	I
4/30/2013	FM	384.36F2B25F1E	4/30/2013	NO	343	319	285	346	I
4/30/2013	FM	384.36F2B25F2F	4/30/2013	NO	355	332	303	392	I
4/30/2013	FM	3DD.003BA2FA36	4/30/2013	NO	355	330	298	392	I
4/30/2013	FM	3DD.003BA2FA3F	4/30/2013	YES	365	345	315	0	I
4/30/2013	FM	3DD.003BA2F9DE	4/30/2013	NO	384	357	323	485	I
4/30/2013	FM	3DD.003BA2F9E1	4/30/2013	NO	394	370	330	0	I
5/2/2013	FM	3DD.003BA2FA21	5/2/2013	NO	328	307	278	300	I
5/2/2013	FM	3DD.033BA2FA23	5/2/2013	NO	328	303	274	303	I
5/2/2013	FM	3DD.003BA2F9B0	5/2/2013	NO	357	335	302	392	I
5/2/2013	FM	3DD.003BA2FA48	5/2/2013	NO	442	416	376	776	U

Table 1-1.—Date, PIT tag, and size data for flannelmouth and bluehead suckers captured at the Colorado River inflow area in 2013

Date	Species	PIT tag number	Date stocked[a]	Recapture	TL[b] (mm)	FL[c] (mm)	SL[d] (mm)	Wt[e] (g)	Sex[f]

[a] Date originally stocked or originally captured.
[b] Total length in millimeters.
[c] Fork length in millimeters.
[d] Standard length in millimeters.
[e] Weight in grams
[f] I = immature, F = female, M = male, and U = unidentified (sex not determined).
[g] Not recorded, typically to avoid excessive handling stress.

ATTACHMENT 2

Ages Determined from Razorback Sucker Pectoral Fin Ray Sections Collected from Lake Mead

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
Las Vegas Bay			
5/10/1998	588	10 [b]	1987
12/14/1999	539	13	1986
12/14/1999	606	17+	1979 – 1982
12/14/1999	705	19+	1977 – 1980
1/8/2000	650	18+	1978 – 1981
2/27/2000	628	17+	1979 – 1982
1/9/2001	378	6	1994
2/7/2001	543	11	1989
2/22/2001	585	13	1987
12/1/2001	576	8 – 10	1991 – 1993
12/1/2001	694	22	1979
12/1/2001	553	10	1991
2/2/2002	639	16	1985
3/25/2002	650	22	1979
3/25/2002	578	10 – 11	1990 – 1991
3/25/2002	583	22 – 24	1977 – 1979
3/25/2002	545	20 [b]	1982
3/25/2002	576	20	1982
5/7/2002	641	15	1986
6/7/2002	407	6	1995
6/7/2002	619	20[b]	1982
6/7/2002	642	20[b]	1982
12/3/2002	354	4	1998
12/6/2002	400	4	1998
12/6/2002	376	4	1998
12/19/2002	395	4	1998
1/7/2003	665	16	1986
1/22/2003	494	4	1998
2/5/2003	385	4	1998
2/18/2003	443	5	1997
3/4/2003	635	19	1983
3/20/2003	420	4	1998
4/8/2003	638	21 [b]	1982
4/17/2003	618	10	1992
4/22/2003	650	20 – 22	1980 – 1982
5/4/2003	415	3+[c]	1999

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
3/3/2004	370	5	1998
2/22/2005	529	6	1998
2/22/2005	546	6	1998
3/29/2005	656	16	1989
1/26/2006	740	15	1991
2/21/2006	621	23	1983
3/23/2006	461	5	2001
3/23/2006	718	16	1990
3/31/2006	635	7	1999
3/31/2006	605	6	2000
4/4/2006	629	6	2000
4/25/2006	452	4	2002
4/25/2006	463	4	2002
1/30/2007	514	5	2002
2/6/2007	519	5	2002
2/6/2007	574	8	1999
2/13/2007	526	5	2002
2/16/2007	530	5	2002
2/20/2007	534	6	2001
2/21/2007	358	3	2004
2/21/2007	511	5	2002
2/27/2007	645	13	1994
2/27/2007	586	15	1992
2/27/2007	603	13	1994
2/27/2007	650	17	1990
3/6/2007	515	4	2003
3/6/2007	611	13	1994
3/6/2007	565	6	2001
3/13/2007	586	7	2000
3/13/2007	636	25	1982
3/13/2007	524	5	2002
4/2/2007	704	9	1998
4/9/2007	644	11	1996
2/12/2008	425	5	2003
2/12/2008	390	3	2005
2/12/2008	490	3	2005
2/12/2008	430	4	2004

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
2/12/2008	379	4	2004
2/12/2008	399	4	2004
2/12/2008	430	4	2004
2/12/2008	413	4	2004
2/12/2008	554	9	1999
2/12/2008	426	9	1999
2/18/2008	385	3	2005
2/25/2008	605	6	2002
2/25/2008	655	36	1972
4/3/2008	468	4	2004
4/3/2008	619	7	2001
4/3/2008	640	10	1998
4/3/2008	560	11	1997
4/8/2008	423	3	2005
4/8/2008	535	6	2002
4/10/2008	422	3	2005
4/10/2008	375	3	2005
4/10/2008	452	4	2004
4/10/2008	472	4	2004
4/10/2008	467	4	2004
4/10/2008	429	5	2003
4/23/2008	430	4	2004
2/13/2009	395	5	2004
2/13/2009	528	11	1998
2/13/2009	630	15	1994
2/17/2009	510	8	2001
2/17/2009	440	5	2004
2/17/2009	420	5	2004
2/18/2009	376	4	2005
2/18/2009	411	4	2005
2/18/2009	427	4	2005
2/24/2009	438	5	2004
2/24/2009	403	6	2003
2/24/2009	446	6	2003
3/3/2009	416	4	2005
3/3/2009	565	8	2001
3/3/2009	431	5	2004

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
3/3/2009	340	5	2004
3/3/2009	539	8	2001
3/3/2009	521	8	2001
3/3/2009	419	6	2003
3/3/2009	535	6	2003
3/3/2009	748	17	1992
3/17/2009	377	3	2006
3/17/2009	458	4	2005
3/17/2009	421	4	2005
3/17/2009	369	3	2006
3/17/2009	440	5	2004
4/6/2009	546	8	2001
4/13/2009	536	7	2002
4/13/2009	510	7	2002
4/13/2009	451	4	2005
4/13/2009	578	13	1996
2/2/2010	531	5	2005
2/2/2010	391	5	2005
2/2/2010	342	5	2005
2/11/2010	351	3	2007
3/3/2010	485	5	2005
3/3/2010	553	6	2004
3/3/2010	621	9	2001
3/23/2010	395	3	2007
3/23/2010	500	5	2005
3/23/2010	514	6	2004
4/20/2010	560	7	2003
2/8/2011	587	8	2003
2/10/2011	574	12[c]	1999
3/3/2011	364	7	2004
3/3/2011	434	4	2007
3/24/2011	411	4	2007
3/24/2011	390	3	2008
3/29/2011	379	6	2005
3/29/2011	346	4	2007
3/29/2011	376	3	2008
2/5/2013	510	10	2003

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
2/19/2013	512	7	2006
2/26/2013	500	7	2006
4/16/2013	561	8	2005
Echo Bay			
1/22/1998	381	5	1993
1/9/2000	527	13	1987
1/9/2000	550	13	1987
1/9/2000	553	13	1987
1/9/2000	599	12 – 14	1986 – 1988
1/27/2000	557	13	1986
1/27/2000	710	19+	1979 – 1981
2/9/2001	641	13	1988
2/24/2001	577	18+	1980 – 1982
2/24/2001	570	8	1992
2/24/2001	576	15	1986
2/24/2001	553	18	1983
12/18/2001	672	13	1988
2/27/2002	610	18 – 20	1982 – 1984
3/26/2002	623	16	1986
4/2/2002	617	35+	1966 – 1968
4/17/2002	583	20[b]	1982
5/2/2002	568	18 – 19	1983 – 1984
11/18/2002	551	13	1989
12/4/2002	705	26	1976
1/21/2003	591	16	1986
2/3/2003	655	27 – 29	1974
2/3/2003	580	13	1989
4/2/2003	639	19 – 20	1982
4/2/2003	580	23 – 25	1978
4/23/2003	584	10	1992
5/6/2003	507	9+	1993
5/6/2003	594	20	1982
12/18/2003	522	20	1982
1/14/2004	683	14	1989
2/18/2004	613	10	1993
3/17/2004	616	19	1983
3/17/2004	666	17	1985

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
3/17/2004	618	9	1994
4/6/2004	755	17	1985
3/2/2005	608	15	1990
3/2/2005	624	8	1996
1/10/2006	630	12	1994
2/1/2006	705	16	1990
2/16/2006	601	22	1984
1/11/2007	535	5	2002
1/11/2007	493	5	2002
2/1/2007	637	7	2000
2/8/2007	609	12	1995
2/14/2007	501	4	2003
3/2/2007	590	11	1996
3/9/2007	660	12	1995
3/16/2007	691	21	1986
3/28/2007	564	13	1994
2/28/2008	640	25	1983
2/29/2008	635	8	2000
3/5/2008	653	24	1984
3/19/2008	532	6	2002
3/19/2008	510	7	2001
2/20/2009	602	7	2002
2/26/2009	662	16	1993
2/18/2010	520	7	2003
2/25/2010	465	5	2005
3/10/2010	535	7	2003
3/10/2010	530	9[c]	2001
3/24/2010	451	4	2006
3/24/2010	465	5	2005
3/24/2010	466	5	2005
4/8/2010	470	5	2005
4/8/2010	540	8	2002
4/22/2010	538	7	2003
4/22/2010	489	8	2002
4/22/2010	460	9	2001
2/9/2011	529	7	2004
2/9/2011	524	7	2004

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
2/24/2011	555	7	2004
3/2/2011	513	6	2005
4/7/2011	533	7	2004
4/7/2011	522	7	2004
4/19/2011	537	6	2005
4/19/2011	540	7	2004
4/19/2011	515	6	2005
2/9/2012	619	10	2002
2/9/2012	644	29	1983
2/16/2012	559	9	2003
2/16/2012	565	12	2000
2/22/2012	589	10	2002
2/22/2012	548	12	2000
3/1/2012	585	7	2005
3/7/2012	663	12	2000
3/29/2012	571	12	2000
3/29/2012	595	13	1999
4/12/2012	610	13	1999
4/12/2012	571	14	1998
2/7/2013	670	8	2005
2/7/2013	579	10	2003
2/7/2013	655	7	2006
2/14/2013	692	17	1996
Muddy River/Virgin River inflow area			
2/23/2005	608	6	1998
2/22/2006	687	33	1973
2/22/2007	452	4	2003
2/22/2007	542	5	2002
2/22/2007	476	5	2002
2/22/2007	459	4	2003
2/22/2007	494	5	2002
3/1/2007	477	5	2002
3/1/2007	512	4	2003
3/8/2007	463	5	2002
3/8/2007	455	4	2003
3/15/2007	516	4	2003
4/3/2007	508	4	2003

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
4/11/2007	498	7	2000
2/27/2008	465	4	2004
2/27/2008	670	20	1988
3/25/2008	530	6	2002
3/25/2008	271	2[d]	2006
3/26/2008	345	3	2005
3/26/2008	541	7	2001
3/26/2008	521	7	2001
3/26/2008	665	18	1990
4/1/2008	229	2	2006
4/1/2008	370	3	2005
4/1/2008	360	3	2005
4/1/2008	385	4	2004
4/1/2008	514	5	2003
4/1/2008	536	5	2003
4/1/2008	514	6	2002
4/1/2008	548	6	2002
4/1/2008	518	7	2001
4/1/2008	530	7	2001
4/1/2008	494	8	2000
4/1/2008	535	9	1999
4/1/2008	559	10	1998
4/22/2008	533	6	2002
4/22/2008	504	6	2002
2/4/2009	496	9	2000
2/12/2009	553	10	1999
2/12/2009	505	8	2001
2/19/2009	464	5	2004
2/25/2009	549	7	2002
3/11/2009	585	8	2001
3/11/2009	552	8	2001
3/24/2009	366	3	2006
3/24/2009	572	9	2000
4/8/2009	348	3	2006
4/8/2009	291	3	2006
4/15/2009	374	3	2006
4/15/2009	372	3	2006

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
4/15/2009	390	3	2006
4/15/2009	365	3	2006
4/15/2009	375	3	2006
4/15/2009	399	3	2006
4/15/2009	362	3	2006
4/15/2009	386	4	2005
4/15/2009	390	4	2005
2/3/2010	455	3	2007
2/3/2010	475	5	2005
2/3/2010	441	5	2005
2/3/2010	495	7	2003
2/3/2010	532	8	2002
2/9/2010	491	5	2005
2/9/2010	444	5	2005
2/9/2010	500	5	2005
2/9/2010	464	6	2004
2/9/2010	471	6	2004
2/17/2010	494	6	2004
2/17/2010	470	7	2003
2/17/2010	479	7	2003
2/17/2010	425	7	2003
2/17/2010	483	7	2003
2/24/2010	234	4	2006
3/17/2010	477	4	2006
3/17/2010	465	5	2005
3/17/2010	485	5	2005
3/17/2010	499	6	2004
3/17/2010	491	6	2004
3/17/2010	600	9	2001
3/18/2010	452	5	2005
3/18/2010	473	5	2005
3/24/2010	485	5	2005
2/1/2011	601	7	2004
2/1/2011	571	6	2005
2/1/2011	556	7	2004
2/1/2011	586	6	2005
2/1/2011	506	8	2003

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
2/1/2011	572	8	2003
2/1/2011	500	6	2005
2/22/2011	501	7	2004
2/22/2011	534	6	2005
2/22/2011	506	6	2005
2/22/2011	508	6	2005
2/22/2011	524	7	2004
2/22/2011	517	8	2003
2/22/2011	580	5	2006
2/22/2011	509	8	2003
2/22/2011	586	6	2005
2/22/2011	512	7	2004
2/22/2011	585	6	2005
2/23/2011	545	6	2005
2/23/2011	500	6	2005
2/23/2011	527	7	2004
2/23/2011	552	5	2006
3/1/2011	510	10	2001
3/1/2011	573	9	2002
3/1/2011	518	8	2003
3/1/2011	538	6	2005
3/1/2011	532	9	2002
3/1/2011	553	6	2005
3/1/2011	595	6	2005
3/1/2011	563	6	2005
3/1/2011	555	6	2005
3/1/2011	483	7	2004
3/1/2011	599	9	2002
3/1/2011	560	5	2006
3/9/2011	556	7	2004
3/9/2011	534	6	2005
3/9/2011	549	7	2004
3/9/2011	494	4	2007
3/9/2011	505	6	2005
3/15/2011	575	8	2003
3/15/2011	551	8	2003
3/15/2011	515	7	2004

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
3/15/2011	558	8	2003
3/15/2011	576	8	2003
3/15/2011	587	8	2003
3/15/2011	572	7	2004
3/15/2011	575	10	2001
3/15/2011	551	7	2004
3/15/2011	561	7	2004
3/15/2011	566	9	2002
3/15/2011	542	6	2005
3/15/2011	577	8	2003
4/5/2011	521	7	2004
4/5/2011	495	6	2005
4/12/2011	572	8	2003
1/31/2012	604	7	2005
1/31/2012	570	7	2005
2/1/2012	525	12	2000
2/7/2012	525	9	2003
2/8/2012	536	7	2005
2/8/2012	501	9	2003
2/8/2012	623	12	2000
2/21/2012	566	10	2002
2/21/2012	590	10	2002
3/13/2012	555	9	2003
3/13/2012	521	9	2003
3/13/2012	618	9	2003
3/13/2012	610	12	2000
3/14/2012	539	7	2005
3/14/2012	530	9	2003
3/15/2012	546	7	2005
3/15/2012	576	10	2002
3/15/2012	574	10	2002
3/21/2012	559	7	2005
3/28/2012	575	8	2004
4/4/2012	551	6	2006
4/4/2012	575	7	2005
4/11/2012	535	9	2003
2/6/2013	519	9	2004

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
2/13/2013	630	10	2003
2/21/2013	546	7	2006
2/21/2013	544	8	2005
2/21/2013	584	8	2005
2/21/2013	606	11	2002
2/21/2013	549	8	2005
3/5/2013	567	10	2003
3/5/2013	537	10	2003
3/5/2013	621	10	2003
3/5/2013	558	8	2005
3/5/2013	601	8	2005
3/14/2013	600	12	2001
3/14/2013	616	9	2004
3/21/2013	551	8	2005
3/21/2013	616	10	2003
3/21/2013	605	10	2003
3/21/2013	629	9	2004
3/21/2013	570	9	2004
3/21/2013	578	9	2004
3/21/2013	577	10	2003
3/21/2013	621	14	1999
3/21/2013	639	9	2004
3/27/2013	539	8	2005
3/27/2013	580	10	2003
4/3/2013	554	8	2005
4/3/2013	542	7	2006
4/10/2013	560	10	2003
4/10/2013	598	9	2004
Colorado River inflow area			
4/20/2010	563	6	2004
4/20/2010	508	6	2004
4/20/2010	568	11	1999
2/8/2011	594	8	2003
3/10/2011	659	11	2000
3/24/2011	584	9	2002
3/24/2011	530	7	2004
3/24/2011	545	6	2005

Table 2-1.—Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead

Date collected	Total length (mm[a])	Age	Presumptive year spawned
4/19/2011	636	9	2002
4/20/2011	570	10	2001
1/26/2012	602	8	2004
2/21/2012	604	10	2002
3/1/2012	546	8	2004
3/1/2012	559	9	2003
3/6/2012	535[g]	11	2001
3/6/2012	573	6	2006
3/6/2012	572	7	2005
3/8/2012	557	8	2004
3/20/2012	630	10	2002
3/20/2012	548	8	2004
3/21/2012	571	9	2003
3/28/2012	572	8	2004
4/3/2012	602	9	2003
4/24/2012	555[d]	9	2003
3/5/2013	215	2	2011

[a] mm = millimeters.
[b] Fish stocked from Echo Bay larval fish captured in 1999 and raised at Nevada Department of Wildlife Lake Mead Fish Hatchery.
[c] Fish stocked from Floyd Lamb Park ponds, sonic tagged.
[d] Fish was a mortality; found dead in net.

ATTACHMENT 3

Model Selection Summary Information for Closed-Capture Population and Survival Estimates for Razorback Suckers in Lake Mead Using Mark-Recapture Data from 2010–13 Generated in the Program Mark

Table 3-1.—Model selection summary information for closed-capture population and survival estimates for razorback suckers in Lake Mead using mark-recapture data from 2010–2013 and generated in the program MARK

Model[a]	AICc[b]	Delta AICc[c]	AICc weight[d]	Model likelihood[e]	Number of parameters	Deviance[f]
pi(t)p(.)N(.)	294.8417	0.0000	0.18295	1.0000	2	252.8401
pi(t)p(.)N(t)	294.8417	0.0000	0.18295	1.0000	2	252.8401
pi(.)p(t)N(.)	296.8492	2.0075	0.06705	0.3665	3	252.8401
pi(.)p(t)N(t)	296.8492	2.0075	0.06705	0.3665	3	252.8401
pi(t)p(t)N(.)	296.8492	2.0075	0.06705	0.3665	3	252.8401
pi(t)p(t)N(t)	296.8492	2.0075	0.06705	0.3665	3	252.8401

[a] pi = probability that the individual occurs in the mixture, (t) = parameter variable through time, ρ = capture probability, (.) = parameter consistent through time, and N = abundance estimate.
[b] Adjusted Akaike's information criterion (AICc) adjusted for small sample-size bias.
[c] AICc minus the minimum AICc.
[d] Ratio of delta AICc relative to entire set of candidate models.
[e] Ratio of AICc weight relative to AICc weight of best model.
[f] Log-likelihood of model minus log-likelihood of the saturated model (Zelasko et al. 2011).