Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Demographics and Post-stocking Survival of Repatriated Razorback Sucker in Lake Mohave 2010 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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Table of Contents

Figures

Summary

Three general areas of inquiry were pursued relative to razorback sucker *Xyrauchen texanus* in Lake Mohave, Arizona and Nevada, during the period covered by this report: (1) post-stocking dispersal and fate assessed by acoustic telemetry, (2) routine monitoring and (3) ecological modeling. Creel census data was not collected by either state agency (Arizona and Nevada) in the current year (2010) as of the reporting date. Additional sources for large striper catch data are being sought in 2011.

An acoustic telemetry study initiated in autumn 2009 was completed in spring 2010. Ten adult razorback sucker collected from Lake Mohave between river mile (RM) 60-62 near Hoover Dam and 14 adults (2005 year-class) reared at Bubbling Ponds Fish Hatchery (BPFH) were implanted with acoustic transmitters and released near RM 62 and at the Willow Beach boat ramp, respectively, on 4 November 2009. Two fish from the BPFH group were removed from analysis: one because it was never contacted and another because it died two hours after surgery at the site of release. At the conclusion of the study, all other fish (100%) from both groups remained active. Average total distances traveled by river fish and BPFH fish were 71 and 128 km, respectively.

We handled 23 razorback suckers (21 captures, two short-term recaptures) in 2010. Ninety-six percent of captures occurred in March (4% during December). All of the individuals were PIT-tagged repatriates. Based on monitoring data from 2009 and 2010, we estimate the current wild razorback sucker population Lake Mohave is 24 fish (9 – 480, 95% confidence interval [CI]). The repatriated razorback sucker population is estimated to number 1,439 (753 - 2,805 95% CI) with a 1% estimated survival of all repatriates released as of 1 March 2009. The current total population estimate for razorback sucker in Lake Mohave is 1,463.

A total of 12,278 scanning contacts and 711 unique individuals were reported since remote sensing began in Lake Mohave in 2008; 1,733 from 2008, 3,083 from 2009 and 7,462 from 2010. In 2010 the number of unique remote scanning contacts with razorback sucker exceeded the total razorback sucker catch during the March roundup in 2010 (389 scans compared to 286 captured), but most fish were contacted only at one location; 5 of 18 fish contacted in both the Half Way Wash and Tequila sampling sites for fish released prior to March 1, 2010 and 9 of 39 fish for fish released after March 1, 2009. In addition, one fish released prior to March 1, 2010 and six fish released after March 1, 2010 were contacted at Half Way Wash and Yuma Cove.

Introduction

Lake Mohave once was home to the largest known population of wild razorback sucker *Xyrauchen texanus*. Historically, this population contained more than one hundred thousand fish, but numbers have dwindled dramatically in recent years and it currently is made up of fewer than 100 individuals (Marsh et al. 2003, Turner et al. 2007, this report). A repatriation program for restoring razorback sucker in Lake Mohave was begun in the early 1990s (Mueller 1995). The program utilizes wild-produced larvae that are reared in protective captivity and then repatriated to the reservoir after growing to a nominal size of 30 cm or more. There have been a number of adjustments to the program that incorporate new information in an attempt to increase survival of stocked fish, but results thus far have not met expectations (Marsh et al. 2005). The current recommended minimum size for stocking is 50 cm, but even fish of this size are subject to predation (Karam and Marsh 2010).

Razorback sucker like many other native fishes of the region is on a trajectory that soon will lead to its extirpation in the wild in the lower Colorado River. Conservation plans for big-river fishes in the lower Colorado River (Minckley et al. 2003, U.S. Fish and Wildlife Service 2005) incorporate a population component that will occupy the main stream, but it may be impractical or impossible to accommodate that plan. If main channel populations cannot be developed and maintained, conservation of razorback sucker in the lower river may depend entirely on populations in off-channel habitats that are free of non-native fishes. It is an objective of this research to provide information needed to determine how such a strategy should contribute to maintenance of razorback sucker in Lake Mohave and throughout the lower Colorado River. Moreover, our results provide critical demographic information and management recommendations to help ensure the long-term persistence of a genetically viable stock of adult razorback sucker in Lake Mohave.

This report summarizes our findings for the fifth year (2010) of an ongoing study on post-stocking dispersal and mortality. The first three years were conducted under contract between Reclamation and Arizona State University (ASU); the current agreement is with Marsh & Associates (M&A). This reflects only a change in association and not a change in researcher participation. A fourth round of acoustic telemetry has provided comparative mortality estimates between repatriated fish immediately after stocking and repatriated fish at large for more than a year. Population and survival estimates for wild and repatriate populations were updated based on results from standard monitoring, and ecological modeling focused on comparing remote sensing data to netting data for use in mark-recapture models.

Methods

Post-stocking Dispersal and Fate

2009-10 Acoustic Telemetry

Adult razorback suckers (n = 24) were implanted with acoustic transmitters and stocked into Lake Mohave. Ten fish, average total length (TL) 61 cm, were collected between river mile (RM) 60-62 using a boat electrofisher and 14 fish, average TL 53 cm (2005 year class), reared in outdoor ponds at BPFH were implanted with acoustic transmitters, stocked at separate locations in Lake Mohave, and telemetered bi-monthly between 4 November 2009 and 3 May 2010.

River fish were chosen for a number of reasons. First, there is a known population of adult razorback sucker residing between RM 60-62 in Lake Mohave. These fish are present year-round, but their movement patterns are poorly understood. The previous year's study (2008-09) indicated 50% of fish stocked at Fortune Cove moved between downstream locations near the stocking site and the zone Above Willow Beach. It is unknown if the reciprocal is true; whether fish that reside in this upstream stretch of river remain exclusively there, or if they move to downriver portions of the reservoir where larvae of spawning fish are captured for the repatriation program.

Adult razorback sucker reared at BPFH were chosen because no other hatchery reared adults > 50 cm TL were available in quantities needed for this study. Additionally, since large batch stockings of adult razorback sucker from Dexter National Fish Hatchery & Technology Center (Dexter; 2006 year-class) and BPFH (2005 year-class) occurred on 13 and 22 October, 2009, respectively, we were interested to learn more about post-stocking mortality and distribution of these repatriates, given their stocking location at Willow Beach boat ramp.

On 14 October 2009, Reclamation staff (Jon Nelson, Andi Montony, and Trish Del Rose) and Marsh & Associates (M&A) staff (Abraham Karam) used a boat electrofisher to collect adult razorback sucker from Lake Mohave between RM 60-62 near Hoover Dam. Four adults were captured (Table 1) and transported to Willow Beach National Fish Hatchery (WBNFH) where fish were placed in a circular raceway and treated with salt and formalin.

On 29 October 2009, Reclamation staff (Jon Nelson), NPS staff (Mitch Urban), and M&A staff (Abraham Karam) used a boat electrofisher to collect seven additional adult razorback sucker from

Lake Mohave between RM 60-62 near Hoover Dam (Table 1). These fish were transported to WBNFH where they were placed in a circular raceway and treated with salt and formalin.

On 30 October 2009, 25 adult razorback sucker were collected from BPFH, placed in two, 189-L fish transport tanks filled with local water (salted and aerated) and transported to WBNFH where fish were placed in circular raceway and treated with salt and formalin.

On 2 November 2009, four of eight total Submersible Ultrasonic Receivers (SURs) were deployed in strategic locations between Willow Beach and Hoover Dam (Fig. 1). Locations included SUR 10206 Hoover Dam (11S 703462 3986464), SUR 315 Pt 3 (11S 703596 3985230), SUR 317 Pt 13 (11S 706819 3976903), SUR 316 Hatchery (11S 710815 3972450).

On 3 November 2009, 10 river fish and 14 BPFH fish were implanted with acoustic transmitters (six of the acoustic transmitters, which did not properly activate prior to surgery were sent back to Sonotronics and were deemed to have faulty circuitry). Surgeries followed protocol from Karam et al. (2008). All individuals had previously received a 134 kHz full-duplex PIT tag for individual identification. Each fish was anesthetized, weighed, measured (TL), scanned for a PIT tag, and surgically implanted with an acoustic transmitter (IBT 96-6-I; Sonotronics, Inc.). To maintain a proper level of anesthesia, MS-222 water was continually flushed over each fish's gills for the duration of the surgery. A small mediolateral incision was made slightly anterior and dorsal to the left pelvic fin and an acoustic transmitter sanitized in 70% ethanol was inserted into the abdominal cavity. The incision was sutured with 2-3 knots using USSC 3-0 Monosof black monofilament and a C-14 cutting needle. The closed wound was swabbed with Betadine and the broad spectrum antibiotic Baytril® (Enrofloxacin; 23 mg/ml solution) was injected into dorsal-lateral musculature of each fish as a preventative measure for post-surgery infection (Martinsen and Horsberg, 1995). Individual injections ranged from 0.4-1.4 ml and were based on a categorical chart that identified appropriate dosage based on each fish's weight. Following surgery, both groups of razorback sucker were placed in separate recovery raceways and monitored for 24-h to ensure proper health and tag retention.

On 4 November 2009, the remaining four SURs were deployed in strategic locations between Painted Canyon Lights and Willow Beach (Fig. 1). Locations included SUR 10119 Chalk Cliffs (11S 708198 3959277), SUR 10205 Fire Mountain (11S 709482 3951864), SUR 416 Painted Canyon AZ (11S 710809 3933111), and SUR 595 Painted Canyon NV (11S 711229 3933030).

All 14 study fish from BPFH were loaded in a two-chambered live well filled with river water and transported by truck to the Willow Beach boat ramp and released. Approximately 30 minutes thereafter, the live well was drained, placed inside a 21 ft boat and refilled with river water, and all 10 study fish from the river were loaded inside. Fish were boated upstream and released approximately 3 km downstream of Hoover Dam 11S 703596 3985230.

Acoustic tagged razorback sucker from BPFH were stocked at the Willow Beach boat ramp because 4,822 adult razorback sucker (2,234 individuals from BPFH, average TL 422 mm and 2,588 individuals from Dexter, average TL 416 mm) were stocked at the same location during the three week period prior to the release of study fish.

Manual and SUR tracking techniques and database management all followed methods previously reported (Karam et al. 2008). All contacts for SURs Painted Canyon AZ and SUR Painted Canyon NV were combined under the name SUR Painted Canyon because each unit was deployed on opposite sides of the reservoir channel to ensure complete coverage near the entrance to Cottonwood Basin. Average number of monthly SUR contacts for both groups of fish was determined by determining the average number of contacts per day during each month, then interpolating that number to a standardized 30 d month.

Routine Monitoring

M&A personnel routinely occupy a field camp on Lake Mohave at Carp Cove, Arizona, near River Mile (RM) 20. Trammel netting and other program-related activities such as razorback sucker larval collections are implemented from that site. From 30 November to 4 December 2009 as many as four trammel nets (91.4 x 1.8 m, 3.8-cm stretch mesh) were fished continuously along the Arizona shoreline from Pot Cove upstream to Carp Cove. Three additional trammel nets were fished continuously in Arizona Bay from 1-3 December 2009. In a similar effort, seven trammel nets were fished continuously along the Arizona shoreline from Pot Cove upstream to Carp Cove during the March roundup (15-19 March 2010).

Native fishes encountered were processed (measured, sexed, scanned for a PIT tag and tagged if none was present, and examined for general health and condition) and released. A fin clip was taken from a sub-sample of razorback suckers, placed in 1 ml of 95% ethanol in a snap-cap tube, and returned to the Dowling laboratory at Arizona State University for genetic analysis (reported

elsewhere). All relevant data are entered into the comprehensive lower Colorado River native fishes PIT tag database maintained by M&A. Population estimates are based on the modified Peterson method (Ricker 1975).

Creel Census Data

No creel census data were collected by either state agency (Arizona Game and Fish Department and Nevada Department of Wildlife [NVDOW]). Creel census data may be collected in late 2010 by NVDOW (Mike Burrell personal communication), but additional sources of large striped bass will be sought in 2011.

Ecological modeling

In 2010, remote PIT scanning data from Lake Mohave were collected and provided by Jon Nelson (USBR), and these data were explored and incorporated into catch data for future modeling that will use both catch and scanning data. Although repeated handling of razorback sucker has not been shown to significantly impact mortality rates (Kesner et al. 2010), remote PIT scanning is still a viable alternative or supplement to the capture and handling of razorback sucker when only tag encounters are needed (e.g., for mark-recapture analysis). Nearly every razorback sucker repatriated to Lake Mohave was PIT tagged prior to release, but only fish released or captured within the last four years contain a 134 kHz PIT tag, which dramatically increases the ability of remote scanning equipment to detect the tag. In addition, double tagging of 400 kHz fish with a 134 kHz tag has complicated the capture histories of many fish (e.g., two or more 134 kHz tags in one fish, mismatches of 400 and 135 kHz tags), and so the focus of data analysis was restricted to fish stocked with a 134 kHz PIT tag. Data analysis was focused on summarizing contact data for a given sampling period and sampling location. For site and time specific scanning summaries the total number of unique fish scanned in 2010 was split between razorback sucker released before and after March 1, 2009 because the 2010 population estimate is considered valid as of March 1, 2009 and fish released after this time are not included in the estimate calculations.

Results

Post-stocking Dispersal and Fate

2009-10 Sonic Telemetry

All ten river fish were contacted for a total of 652 contacts. The highest concentration of contacts occurred in the zone Above Willow Beach (Fig. 2). Of total contacts, 601 (92%) were made remotely with SURs. SUR Pt 3 recorded the largest number of contacts (422 [70%]), while SUR Painted Canyon recorded the least (8[1%]) (Table 2).

All ten river fish (100%) remained active throughout the study (Fig. 3). Average total distance traveled by active adults was 70.5 km. Fish dispersed between Painted Canyon Lights and 2 km downstream of Hoover Dam. Average distance traveled per fish was the highest in November (29.1 km, ± 6.6 SE) and the lowest in May (1.0 km, ± 0.7 SE) (Fig. 4).

Twelve of 14 BPFH fish were contacted for a total of 832 contacts. The highest concentration of contacts occurred in the zone Above Willow Beach (Fig. 5). Of total contacts, 761 (91%) were made remotely with SURs. SUR Pt 3 recorded the highest number of contacts (333 [44%]), while SUR Painted Canyon recorded the least (9 [1%]) (Table 2).

A small amount of green digestive fluid was noted during surgery at the incision site of one BPFH fish. That individual never swam away from the boat ramp after its release. Another BPFH fish was never contacted over the course of the study, despite intensive active and passive tracking efforts in the immediate vicinity of the Willow Beach boat ramp. Both individuals were therefore removed from further analysis.

All twelve BPFH fish (100%) remained active throughout the study (Fig. 3). Average total distance traveled by active adults was 128.1 km. Fish dispersed between Painted Canyon Lights and 2 km downstream of Hoover Dam. Average distance traveled per fish was the highest in February (37.6 km, ± 11.2 SE) and the lowest in May (2.3 km, ± 1.0 SE) (Fig. 4).

Routine Monitoring

We handled 23 razorback suckers during autumn (December) 2009 and spring (March) 2010 monitoring events, with December and March monitoring activities accounting for 4% (n=1) and 96% (n=22) of the captures respectively (Table 1). Two fish captured in March were short-term recaptures and omitted from Table 1 and any further analysis. All of the individuals had PIT tags and all fish were repatriates. The majority of fish captured were female (57%) and nine were male.

Twenty-one fish were captured during 2009/2010 monitoring for the first time since their release into the lake (unpublished data, NFWG database; Table 3). One fish was tagged and released in the late 1990s, while the 20 remaining fish were tagged since 2000. Two fish were at large six and thirteen years while the remaining 19 fish were at large less than a year. Nineteen fish with year class information were approximately one to five years old at stocking.

Gender was determined for all fish at the time of capture (Table 4). Females appeared to exhibit more growth over their time at large, ranging from 0.1 to 0.8 cm/month while males appeared to have less growth, ranging from less than zero to 0.6 cm/month. Seven fish were less than or equal to 35.0 cm TL at release, 14 fish were greater than 35.0 cm TL at release. Eleven fish were less than 40.0 cm at capture. Nineteen fish were at large for one year or less, their growth ranged from less than 0.0 to 8.0 cm TL/month. Growth for the two fish at large six and 13 years was 0.3 cm and 0.2 cm TL/month, respectively.

Nine percent of total fish (n=2) captured originated from lakeside backwaters (Table 5). North Arizona Juvenile and Dandy Cove contributed one fish each. Off-site rearing facilities contributed more than 90% of the total fish captured; fish were reared at Achii Hanyo Fish Hatchery and BPFH, AZ, and WBNFH.

Two fish moved from the Arizona Bay Zone (AZ side of the river near Wrong Cove) and four fish moved from the River Zone (three from AZ side of the river near WBNFH and one from NV side of the river near Painted 8 Cove), all were captured in the Basin Zone (comprised of Tequila + Nine Mile zones; see Fig. 2, Table 6) on the AZ side of the reservoir, which was our general monitoring location. One fish released in the River Zone traveled to the Arizona Bay Zone. Fourteen fish never left the Basin Zone. One fish released at WBNFH traveled the furthest, approximately 53 km downstream to

our monitoring area. Others traveled one to 52 km from their release sites on both sides of the reservoir.

Based on monitoring data from 2008 and 2009, we estimate the current wild razorback sucker population Lake Mohave is 24 fish (9 - 480 95% CI; Table 7). We estimate the repatriated razorback sucker population is 1,439 (753-2,805 95% CI; Table 8) with a 1% estimated survival of all repatriates released as of 1 March 2008. The current population estimate for razorback sucker in Lake Mohave is 1,463.

Creel Census Data

Creel census was conducted once a week at Willow Beach by NVDOW from 11 January 2009 to 5 August 2009. During that time, ten large (greater than 80 cm TL) striped bass were documented. Six of the ten were scanned for PIT tags, but none were detected. Since NVDOW began providing creel census data in 2006, 18 large striped bass and two large channel catfish *Ictalurus punctatus* have been scanned for PIT tags. No tags have been detected.

Ecological Modeling

A total of 12,278 scanning contacts and 711 unique individuals were reported since remote sensing began in Lake Mohave in 2008; 1,733 from 2008, 3,083 from 2009, and 7,462 from 2010. There were 176, 194, and 477 unique PIT tags contacted in 2008, 2009, and 2010 respectively. Of these contacts 70, 90, and 389 were tagged with a 134 kHz tag upon release, respectively. For 2010 scanning, the number of unique contacts with razorback sucker tagged at release with a 134 kHz tag (389 razorback sucker) exceeded the total razorback sucker catch during the March roundup in 2010 (286 razorback sucker, NFWG database).

There was only one unique contact of 134 kHz PIT tagged razorback sucker released prior to March 1, 2009 during the last 3 sampling trips, despite 12 PIT contacts unique to the location and trip made over the same period (Table 9). Scanning on the last trip at an additional site (Liberty Cove) resulted in no new contacts with fish released prior to March 1, 2009. However, the accumulation of unique contacts with razorback sucker released with a 134 kHz tag after March 1, 2009 was continuous through the sampling period in 2010, and all 13 fish contacted on the last sampling trip (Liberty Cove) were unique.

Few fish were contacted in more than one location during the 2010 sample season regardless of when they were released (Table 10), indicating some site fidelity for individual razorback sucker. Still, 5 of 18 fish were contacted in both the Half Way Wash and Tequila sampling sites for fish released prior to March 1, 2010 and 9 of 39 fish for fish released after March 1, 2009. In addition, one fish released prior to March 1, 2010 and six fish released after March 1, 2010 were contacted at Half Way Wash and Yuma Cove within the short three month sampling period in 2010.

Discussion

Post-stocking Dispersal and Fate

2009-10 Sonic Telemetry

In contrast to results from three previous studies that used acoustic telemetry to determine post-stocking mortality of razorback sucker in Lake Mohave (Kesner et al. 2007, 2008, and 2009), all fish from the 2009-10 study survived the entire six-month post-stocking period. During the previous two studies, which compared post-stocking survival of subadults to adults, mortality was high but variable between years; with larger fish always surviving better than small ones (see Kesner et al. 2008 and 2009). Mortality in all previous studies was attributed to predation by striped bass (Karam et al. 2008, Karam and Marsh 2010) and was not a result of our surgical techniques or fish handling (Karam et al. 2008).

Adult river fish utilized in this year's study were the largest razorback sucker used in any of our acoustic telemetry studies to date (average TL = 61 cm). Average size of the BPFH adults (53 cm) was similar to last year's study (54 cm); however only 80% of individuals from the 2008-09 study survived the six-month post-stocking period. Lack of mortality from the 2009-10 study suggests a few possible reasons for 100% survival: 1) stocking location affected post-stocking survival, 2) large striped bass may not have been abundant during this study, and 3) repatriate size-at-release affects post-stocking survival.

The stocking site for previous studies was Fortune Cove, which for years was utilized as a release location for subadult razorback sucker repatriates. However, poor long-term survivorship during the preceding decade was an important factor for stocking fish elsewhere and was a fundamental reason for revisiting this location during the past three studies to learn more about post-stocking mortality and to gain a better understanding of stocked fish dispersal. The predation event of a 50

cm razorback sucker described in Karam and Marsh (2010), and the recovery of acoustic transmitters during previous telemetry studies (Kesner et al. 2007, 2008, and 2009), many of which were retrieved from the bottom of the reservoir in the vicinity of Fortune Cove, is definitive evidence of striped bass predation of recently repatriated razorback sucker. Six-month survival of subadults in all three previous studies was consistent with poor returns on batch stocking at Fortune Cove and provides insight as to why the overall population of razorback sucker in Lake Mohave has not increased during the years following.

Willow Beach in the recent past has been perceived as a poor stocking location for razorback sucker because a robust and abundant striped bass population inhabits that portion of Lake Mohave (Pelle and Paulson 1993). Stomach contents from striped bass caught near Willow Beach often contain hatchery reared rainbow trout, which are stocked by the thousands every week by WBNFH and NDOW personnel. Further, striped bass caught in the vicinity of Willow Beach have also been shown to feed on other stocked fish such as native bonytail (Karam and Marsh 2010). The observation of bonytail in the stomach of striped bass was the first time in five years any bonytail have been observed in the reservoir. Stocked trout and bonytail are a catalyst for striped bass growth: 35+ kg individuals are commonly caught by anglers in this reach of Lake Mohave, and present a critical hazard for post-stocking survival of razorback sucker repatriates.

Considering the hostile environment created when striped bass are present, 100% survival of acoustic tagged BPFH razorback sucker stocked at the Willow Beach boat ramp was unexpected. Creel census data were not available, but based on the lack of postings in an online fishing board (www.acplugs.com/forum/index.html), the number of large striped bass captured by anglers near Willow Beach during this telemetry study was considerably less than during the previous three years. Large striped move into upriver portions of Lake Mohave during summer months (Mike Burrell, personal communication), which in theory would place them in close proximity to stocked fish. However, all four telemetry studies ended in late spring and did not take into account summer survivorship. It is possible that BPFH study fish distributed to areas of the reservoir with lower striped bass abundance. Seventy two percent of all SUR contacts for BPFH acoustic tagged fish occurred upstream of RM 62 near Hoover Dam where the USBR Dive team has documented an abundant year-round population of razorback sucker (Montony and Ulepic 2010).

Size-at-release undoubtedly played a factor because fish were contacted in areas where large striped bass are traditionally harvested, despite their apparent low abundance during this study. Results

from the previous three studies (Kesner et al. 2007, 2008, and 2009) provided stepwise comparison of how razorback sucker repatriates with a larger TL improves post-stocking survival. While the comparison of similar size classes between years was difficult to assess due to yearly variation, larger repatriates always survived better than smaller ones during any given year. It is therefore reasonable to conclude size played an important role in this year's survival, since telemetry tagged razorback sucker in the 2009-2010 study were the largest on average compared to previous years.

Over the course of the study, 60% of river fish remained exclusively in the zone Above Willow Beach. However, 40% of the fish ventured to zones downstream of Willow Beach, all of which are areas of the lake where spring larval collections have been made in the past. Further, one of the adult fish was captured in a net at Yuma Cove during the March 2010 Razorback Sucker Roundup signifying the individual was likely spawning in an area common for larval collections. This individual was captured nearly fours months after a lack of contacts by passive or active tracking signifying that acoustic tagged fish can evade detection for months.

BPFH fish distribution followed a similar trend. Despite being released at the Willow Beach boat ramp (17 km downstream of the stocking location for the river fish), 62% remained exclusively in the zone Above Willow Beach while 38% of individuals also ventured to zones downstream of Willow Beach.

The vast majority of all contacts (both groups of study fish) took place in the zone Above Willow Beach, and more precisely above RM 62 (Figs. 2 & 5). Recapture data from two recent (13 July and 17 August) Reclamation-led electrofishing trips that took place between RM 60-62 confirm these observations: 77% of all fish captured were stocked either at the Willow Beach boat ramp or at WBNFH in the months during or the month preceding the onset of the telemetry work. Further, 43% of the 17 Aug 2010 collection and 50% of the 13 July 2010 collection consisted of 2005 year-class BPFH stock, which were the same fish used for the telemetry study. The abundance of BPFH recaptures confirms the excellent survivorship of BPFH tagged fish during the 2009-10 telemetry study.

Routine Monitoring

The wild population at less than 50 fish is nearing functional extirpation, while the repatriate population has been maintained around 1,500 fish for years by continued stocking. Without this stocking the genetic legacy of the razorback sucker would already have been lost, but the optimistic initial goal of 50,000 razorback sucker appears unattainable given current constraints. Although size at release appears to have a significant impact on post-release survival (Kesner et al. 2009, 2010, this report), the gains may be offset by the losses in stocking numbers due to hatchery space limitations. The unusually high survivorship of telemetry tagged fish, and the large number of recently released fish appearing in capture and remote sensing data may indicate an anomalously low year for razorback sucker mortality, but reasons for such a lull in mortality factors can only be hypothesized and cannot be counted on in the future. Population dynamics of striped bass in Lake Mohave are poorly understood, and yet they may play an important role in optimizing razorback sucker survival. Creel census data have been inconsistent and inadequate to asses the population dynamics of striped bass, and so alternative approaches are being pursued in 2011.

Creel Census Data

No data were collected as of September 1, 2010 and alternative sources are being considered in 2011.

Ecological Modeling

Unique contacts with razorback sucker using remote PIT scanning exceeded contacts with razorback sucker by netting in 2010 in spite of the fact that the majority of the population is still implanted with 400 kHz PIT tags. This indicates that remote PIT scanning is markedly more effective in contacting individuals than netting. As 134 kHz fish begin to dominate the tagged population, recapture rate (the proportion of the population contacted in a given year) will increase even with a reduction in netting if the level of remote sensing effort remains constant. For the current applicable population estimate (2009) the contacted 134 kHz population remains small (64 unique fish), but this number may increase dramatically for the 2010 estimate given the 325 unique contacts in 2010 with razorback sucker that were released after March 1, 2009.

Continuing Studies

In 2011, remote PIT scanners will be utilized in the zone Above Willow Beach during the coming winter/spring to augment continued scanning in the basin and Arizona Bay area, and these data will help gain a further understanding of reservoir-wide distribution of razorback sucker. Routine netting of repatriate and remnant wild stocks will continue annually during March and November/December and as necessary at other times. A website will be launched that gives striped bass anglers the opportunity to claim a monetary based prize for photo documentation confirming native fish in the stomach contents of striped bass. Development of a population dynamic model for razorback sucker in Lake Mohave incorporating size at release data from mark-recapture (netting and remote sensing data) and acoustic telemetry studies will be finalized, which will help direct species conservation and management.

Acknowledgements

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Table 1. Recapture histories for river fish captured on 14 and 29 October 2009 between RM 60-62 on Lake Mohave near Hoover Dam.

Fish	Date	Tag #	History	Location	Collector	Sex	TL (mm)	Weight (g)	Rearing	Comments
154	10/29/09	1C2D05C87E	Repatriate Capture	62 RM (both sides of river)	BR, NPS and M&A	M	530	1668	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
157	11/9/2001	1C2D06192B	Repatriate Release	Placer Cove	BR	J	385	0	Boulder City Wetlands Park	
157	10/14/2009	1C2D06192B	Repatriate Capture	62 RM (both sides of river)	M&A and BR	F	630	3500	Boulder City Wetlands Park	Sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
171	10/14/2009	1C2D05A6D7	Repatriate Capture	62 RM (both sides of river)	M&A and BR	U	610	4000	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, released 11/4/2009 at RM 62
181	10/29/2009	1C2D066FAF	Repatriate Capture	62 RM (both sides of river)	BR, NPS and M&A	F	665	3460	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
156	10/29/200	1C2D061E58	Repatriate Capture	62 RM (both sides of river)	BR, NPS and M&A	F	590	2020	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
182	06/08/2006	257C60DC87	Wild Capture	62 RM	BR	F	535	0	Not applicable	
182	10/29/2009	257C60DC87	Wild Capture	62 RM (both sides of river)	BR, NPS and M&A	M	550	1779	Not applicable	Sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
166	10/29/2009	1C2C2F7A8E	Repatriate Capture	62 RM (both sides of river)	BR, NPS and M&A	F	585	2385	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
185	10/29/2009	1C2D061DE1	Repatriate Capture	62 RM (both sides of river)	BR, NPS and M&A	F	585	2385	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
167	10/14/2009	1C2D06B715	Repatriate Capture	62 RM (both sides of river)	M&A and BR	F	600	3700	Unknown	Undetected 400 khz tag, suspected tag loss and marked as repatriate, sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
199	5/12/1999	1C2D05A6CA	Repatriate Release	30 RM	BR	J	290	0	Willow Beach NFH	
199	3/13/2001	1C2D05A6CA	Repatriate Capture	Basalt Cove	FWS	U	547	1771	Willow Beach NFH	
199	10/14/2009	1C2D05A6CA	Repatriate Capture	62 RM (both sides of river)	M&A and BR	U	650	4040	Willow Beach NFH	Sent to WBNFH, sonic tag, released 11/4/2009 at RM 62
199	3/19/2010	1C2D05A6CA	Repatriate Capture	Yuma and Owl Point Coves	AZGFD and FWS	F	646	0	Willow Beach NFH	Acoustic tag

Table 2. Percentage of total contacts made by each SUR during the 2009-10 acoustic telemetry study.

	Percentage of SUR contacts	
	BPFH fish	**River fish**
Hoover Dam	28	15
SUR pt 3	44	70
SUR pt 13	20	9
SUR Hatchery	2	0
SUR Chalk Cliffs	2	1
SUR Fire Mountain	2	3
SUR Painted Canyon	1	1

Table 3. Adult razorback sucker monitoring summary by capture month, total number of fish, PIT tag, history, and gender during December 2009 and March 2010 monitoring events, Lake Mohave, Arizona and Nevada. Two fish captured in March were short-term recaptures and omitted from analysis.

Capture month	Total N fish (% of total)	PIT tag? (% of total)		History (% of total)		Gender (% of total)		
		Yes	No	Repatriate	Wild	Female	Male	Unknown
December (2009)	1 (4)	1 (4)	0	1 (4)	0	12 (57)	8 (38)	0
March (2010)	20 (96)	20 (96)	0	20 (96)	0	0 (0)	1 (5)	0
Total (% of total N fish)	21	21 100)	0	21 (100)	0	12 (57)	9 (43)	0)

Table 4. Adult razorback sucker monitoring summary for 21 paired release-capture data per fish PIT tag number with calculated time at large (capture date minus release date then divided by 30 d for months at large or 365 d for years at large) and capture history. Data are in order by number of captures and also include year class information where available. Release date is when fish, generally juveniles, were stocked into Lake Mohave.

PIT tag	Release date	Capture date	Days at large	Months at large	Years at large	Capture history	
						Captures	Comments
1C2D05A544[a]	10/23/2009	12/2/2009	40	1	0	1	First capture in 2009
1C2D639BE3[b]	1/5/2010	3/16/2010	70	2	0	1	First capture in 2010
1C2D695C4D[b]	1/5/2010	3/16/2010	70	2	0	1	First capture in 2010
1C2D676D61[c]	1/5/2010	3/16/2010	70	2	0	1	First capture in 2010
1C2D70F78B[d]	1/7/2010	3/19/2010	71	2	0	1	First capture in 2010
1C2D67C42F[c]	1/5/2010	3/17/2010	71	2	0	1	First capture in 2010
1C2D69774C[b]	1/5/2010	3/18/2010	72	2	0	1	First capture in 2010
1C2D677362[c]	1/5/2010	3/18/2010	72	2	0	1	First capture in 2010
1C2D683A73[c]	1/5/2010	3/18/2010	72	2	0	1	First capture in 2010
1C2D74797A[c]	1/5/2010	3/18/2010	72	2	0	1	First capture in 2010
1C2D63A441[b]	1/5/2010	3/19/2010	73	2	0	1	First capture in 2010
1C2D696B8B[b]	1/5/2010	3/19/2010	73	2	0	1	First capture in 2010
1C2D7490C0[c]	1/5/2010	3/19/2010	73	2	0	1	First capture in 2010
1C2D683175[b]	12/18/2009	3/16/2010	88	3	0	1	First capture in 2010
1C2D697064[b]	12/17/2009	3/17/2010	90	3	0	1	First capture in 2010
1C2D64370C[e]	12/3/2009	3/16/2010	103	3	0	1	First capture in 2010
1C2D643869[a]	10/23/2009	3/18/2010	146	5	0	1	First capture in 2010
1C2C36F04C[a]	10/23/2009	3/19/2010	147	5	0	1	First capture in 2010
1C2C38C46D[f]	9/13/2009	3/18/2010	186	6	0	1	First capture in 2010
533277004B	6/18/2004	3/19/2010	2,100	70	6	1	First capture in 2010
7F7A075250	10/9/1996	3/19/2010	4,909	164	13	1	First capture in 2010

[a]2005 year class, reared at Bubbling Ponds Fish Hatchery
[b]2006 year class, reared at Willow Beach NFH
[c]2005 and 2006 mix of year class, reared at Willow Beach NFH
[d]2005 year class, reared at Willow Beach NFH
[e]2008 year class, reared at Achii Hanyo Fish Hatchery
[f]2006 year class, reared at Dandy Cove, Lake Mohave

Table 5. Adult razorback sucker monitoring summary for 21 paired release-capture data per fish PIT tag number with growth rate (capture total length (TL) in cm minus release TL then divided by months at large). Data are in order of years at large. Release date is when fish, generally juveniles, were stocked into Lake Mohave.

PIT tag	TL (cm)			Months at large	Years at large	Gender
	Release	Capture	Growth rate/month			
1C2D05A544	47.5	47.4	-0.1[a]	1	0	M
1C2D67C42F	31.0	31.0	0.0	2	0	M
1C2D69774C	37.0	37.0	0.0	2	0	M
1C2D70F78B	46.5	46.8	0.1	2	0	F
1C2D63A441	39.0	39.5	0.2	2	0	M
1C2D7490C0	35.0	35.5	0.2	2	0	M
1C2D677362	31.5	32.0	0.2	2	0	M
1C2D74797A	35.5	36.0	0.2	2	0	F
1C2D683A73	35.0	36.0	0.4	2	0	F
1C2D695C4D	41.0	42.2	0.5	2	0	F
1C2D639BE3	36.5	38.0	0.6	2	0	M
1C2D676D61	32.5	33.8	0.6	2	0	M
1C2D696B8B	42.0	44.0	0.8	2	0	F
1C2D697064	39.0	39.4	0.1	3	0	F
1C2D64370C	46.5	47.5	0.3	3	0	F
1C2D683175	34.5	35.9	0.6	3	0	M
1C2D643869	47.0	47.7	0.1	5	0	F
1C2C36F04C	49.0	52.2	0.7	5	0	F
1C2C38C46D	45.5	48.8	0.5	6	0	F
533277004B	36.5	59.1	0.3	70	6	F
7F7A075250	33.1	63.7	0.2	164	13	F

[a]Any negative growth rate is likely due to measurement error when time at large is less than six months

Table 6. Adult razorback sucker monitoring summary for 21 paired release-capture data with rearing type and location, and release and capture sites. Data are in alphabetical order of rearing type and rearing location. Release site is where fish were stocked into Lake Mohave.

Rearing Type	Rearing Location	Release Location	Release State	Release River km	Release Zone	Capture Location	Capture State	Capture River km	Capture Zone	Distance Traveled (change km)	n fish
Lakeside backwater	North Arizona Juvenile	Chemehuevi Cove	NV	19	Basin	Cottonwood Cove East and Carp Cove	AZ	33	Basin	13	1
	Dandy Cove	Dandy Cove	NV	26	Basin	Cottonwood Cove East and Carp Cove	AZ	33	Basin	7	1
Off-site facility	Achii Hanyo	Cottonwood Cove	NV	37	Basin	Carp Cove (inside)	AZ	33	Basin	4	1
	Bubbling Ponds FH	Willow Beach boat ramp	AZ	84	River	Carp Cove (inside)	AZ	33	Basin	52	1
						Carp Cove (north point)	AZ	33	Basin	51	1
						Yuma Cove (south of)	AZ	39	Arizona Bay	45	1
	Willow Beach NFH	Nine Mile Coves	NV	26	Basin	Cottonwood Cove East (161 km inside, north shore)	AZ	32	Basin	6	4
						Cottonwood Cove East (1st point south of north point)	AZ	32	Basin	6	1
		Painted 8 Cove	NV	75	River	Cottonwood Cove East (161 km inside, north shore)	AZ	32	Basin	43	1
		Six Mile Coves	NV	31	Basin	Carp Cove (inside)	AZ	33	Basin	2	1
						Cottonwood Cove East (161 km inside, north shore)	AZ	32	Basin	1	5
		Willow Beach NFH	AZ	85	River	Cottonwood Cove East (1st point south of north point)	AZ	32	Basin	53	1
		Wrong Cove	AZ	50	Arizona Bay	Carp Cove (inside)	AZ	33	Basin	17	1
						Cottonwood Cove East (161 km inside, north shore)	AZ	32	Basin	18	1

Table 7. Wild adult razorback sucker population estimate, based on field data from all of March, 2009 and 2010, and using annual single-census population estimate, *N** (Chapman modification of the Peterson Method, Ricker 1975).

Data years	*N**	95% Confidence limit	
		Lower	Upper
2009 and 2010	24	9	480

Table 8. Repatriate razorback sucker population estimate, based on field data from all of March, 2009 and 2010, and using annual single-census population estimate, *N** (Chapman modification of the Peterson Method, Seber 1973). This year's estimate is adjusted to exclude fish capture in March 2009 that were released in March 2009 (*N*=1) as well as fish released after March 1, 2009 and captured in March 2010 (*N*=171).

Data years	*N**	95% Confidence limit		*N* repatriated released (as of March 1, 2009)	Estimated % survival
		Lower	Upper		
2009 and 2010	1,439	753	2,805	128,695	1

Table 9. Unique PIT tag contacts for each location during a sampling trip (Contacts) and cumulative unique PIT tag contacts (Cumulative) through the 2010 sample year from remote sensing data for razorback sucker on Lake Mohave.

		Release before March 2009		Release after March 2009	
Date	**Location**	**Contacts**	**Cumulative**	**Contacts**	**Cumulative**
02/09/2010	Yuma	11	11	55	55
	Tequila	6	17	5	60
	1/2 W WASH,9M	4	21	7	65
02/16/2010	Yuma	4	23	21	81
	Tequila	5	28	21	101
	1/2 W WASH,9M	13	39	26	126
03/02/2010	Yuma	4	42	13	135
	Tequila	9	50	62	184
	1/2 W WASH,9M	3	52	3	186
03/09/2010	Yuma	12	58	70	231
	Tequila	8	62	62	256
	1/2 W WASH,9M	0	62	1	257
04/07/2010	Yuma	2	63	13	268
	Tequila	4	64	27	287
	1/2 W WASH,9M	1	64	1	287
04/14/2010	Yuma	1	64	20	296
	Tequila	4	64	28	309
	1/2 W WASH,9M	0	64	3	312
04/19/2010	LCSB	0	64	13	325

Table 10. Unique razorback sucker contacts for fish released before March 1, 2010 (top) and after (bottom) made during the 2010 sampling year (February to April) in 2010 using remote PIT scanners among three locations. The diagonal represents unique contacts per location, whereas the cells below the diagonal represent contacts in common between locations.

Location	Half Way Wash	Tequila	Yuma
Half Way Wash	18		
Tequila	5	28	
Yuma	1	3	27

Location	Half Way Wash	Tequila	Yuma
Half Way Wash	39		
Tequila	9	148	
Yuma	6	18	156

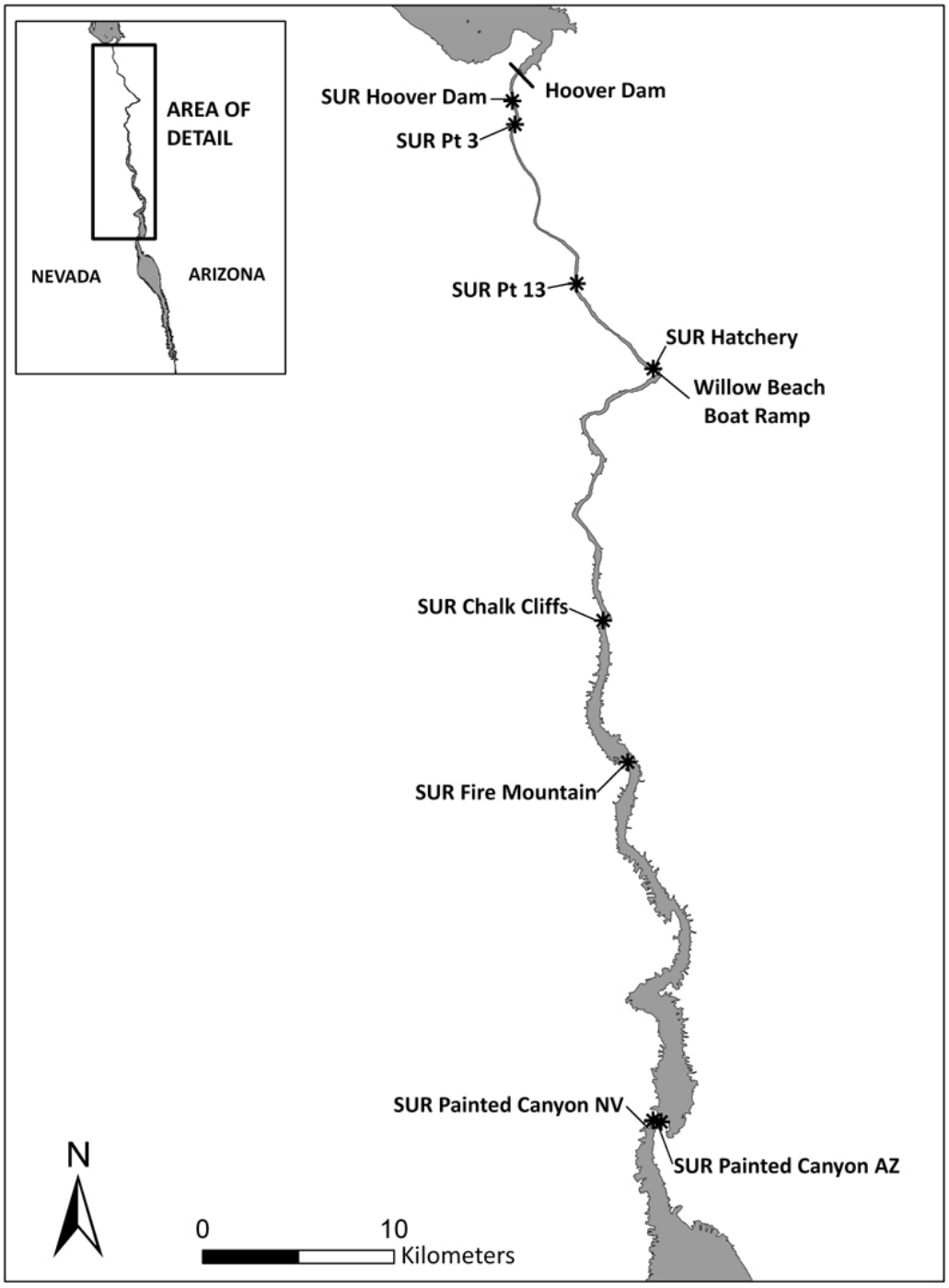

Figure 1. Sketch map of Lake Mohave Arizona-Nevada depicting the locations of all Submersible Ultrasonic Receivers (SURs) used in this study along with the stocking locations (SUR Pt 3 for river fish and Willow Beach Boat Ramp for Bubbling Ponds fish) for all acoustic tagged razorback sucker released on 4 November 2009.

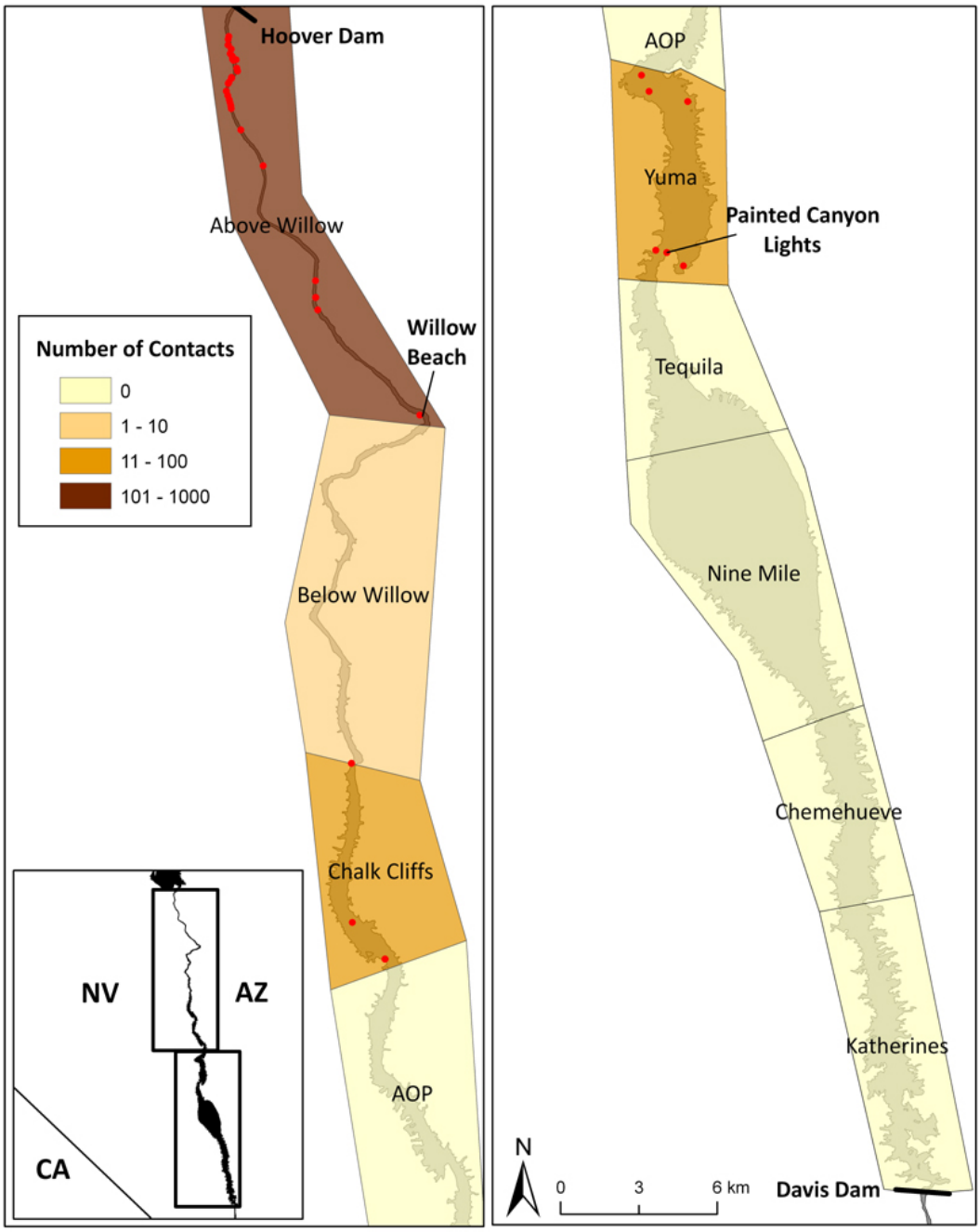

Figure 2. Contact densities by zone for all acoustic tagged river caught razorback sucker (n=10) over the course of the six month study (4 November 2009 and 5 May 2010).

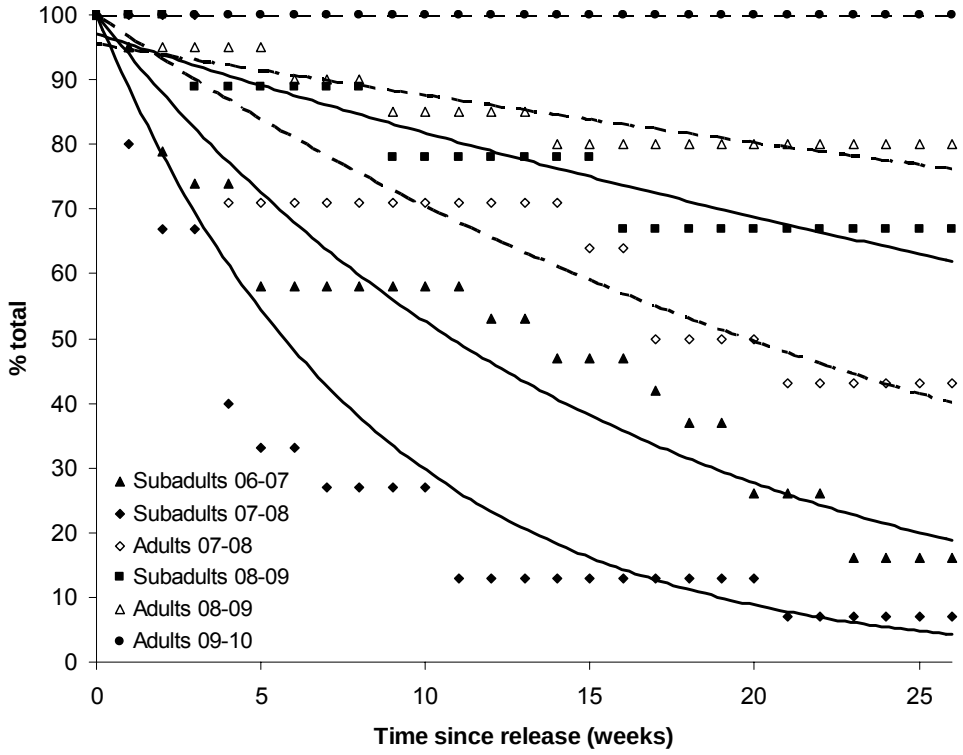

Figure 3. Six month post-stocking survivorship for subadult (solid lines) and adult (dashed lines) razorback sucker during the past four telemetry studies in Lake Mohave (2006-07, 2007-08, 2008-09, and 2009-10). Adults from 2009-10 represent both groups of telemetry-tag implanted razorback sucker (BPFH and River adults).

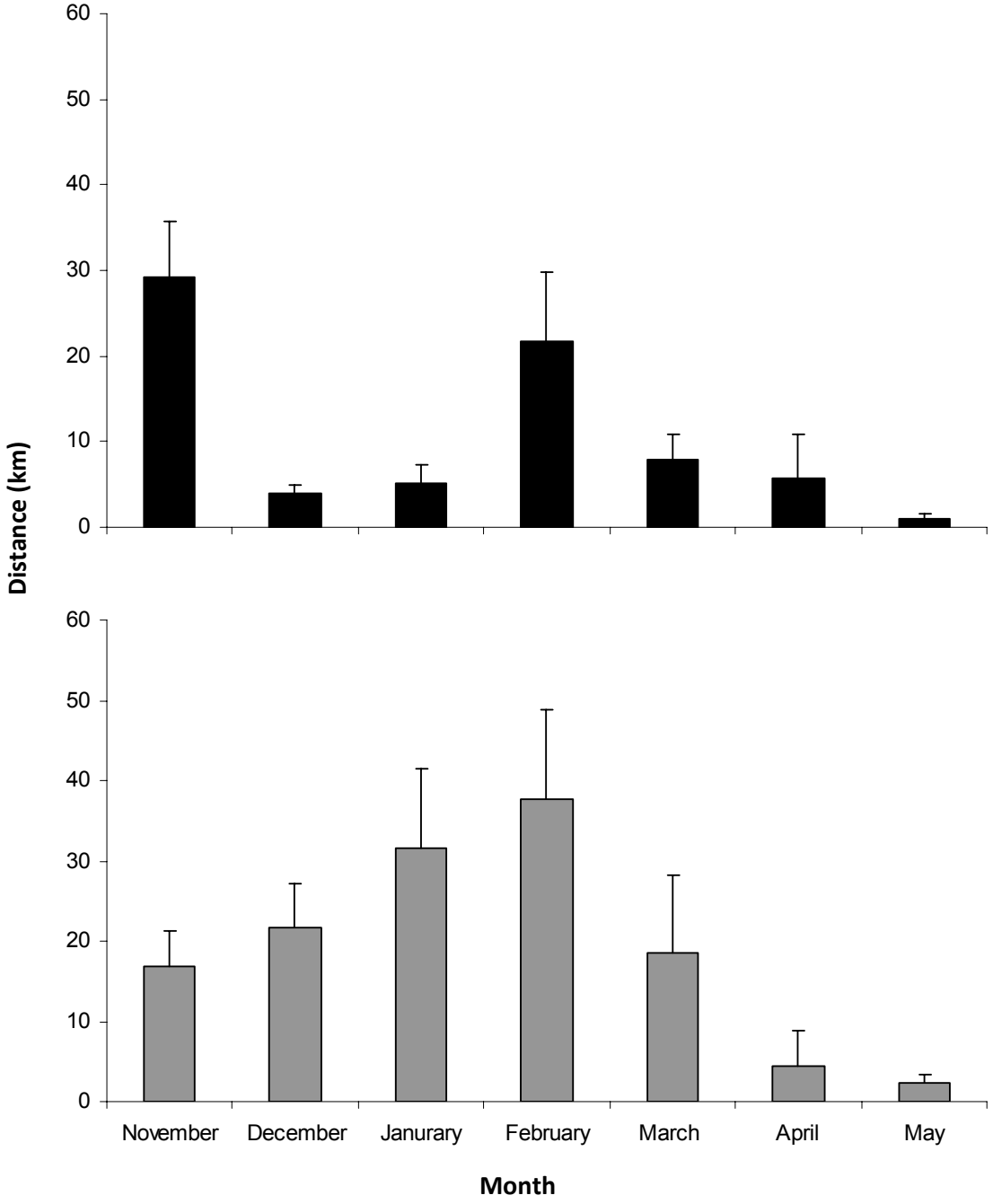

Figure 4. Average distance traveled per month for acoustic tagged river fish (top) and BPFH fish (bottom) during the 2009-10 acoustic telemetry study.

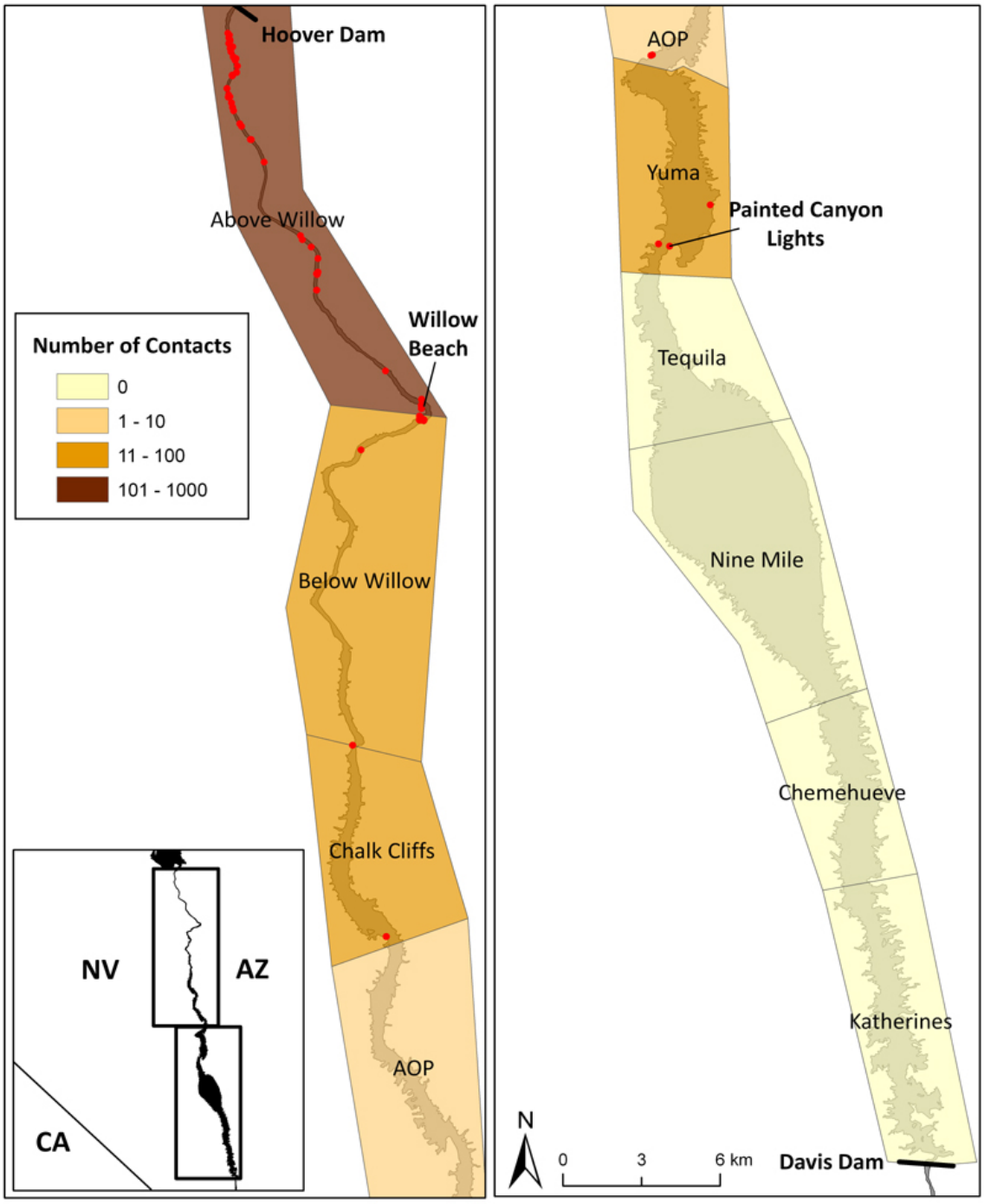

Figure 5. Contact densities by zone for all acoustic tagged BPFH reared razorback sucker over the course of the six month study (4 November 2009 and 5 May 2010)