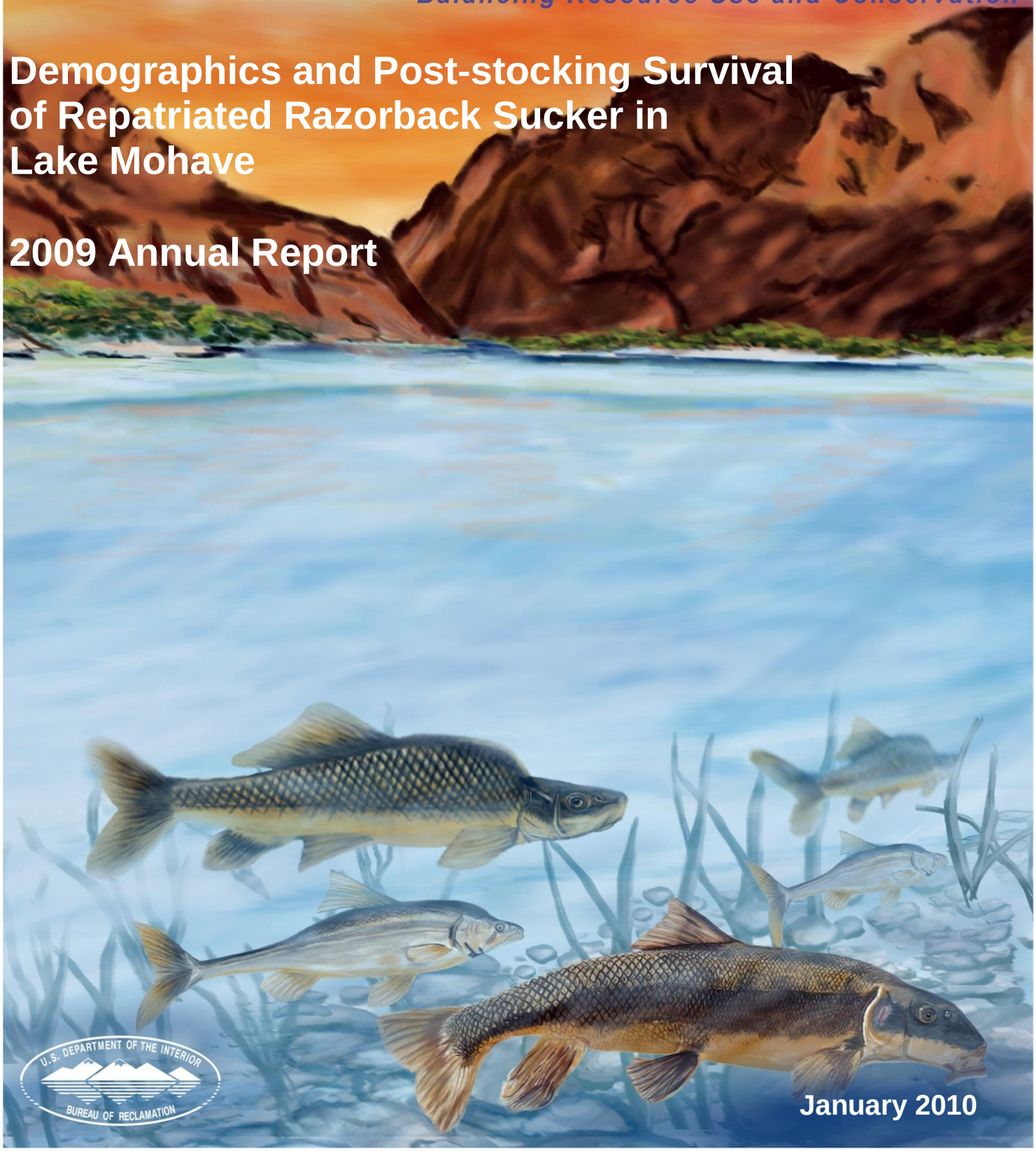
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

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

2009 Annual Report



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Lower Colorado River Multi-Species Conservation Program

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

2009 Annual Report

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January 2010

B.R. Kesner, A.P. Karam, C.A. Pacey, and P.C. Marsh. 2010. Demographics and Post-Stocking Survival of Repatriated Razorback Sucker in Lake Mohave, 2009 Annual Report. Annual report submitted to the Bureau of Reclamation, Lower Colorado Region, Boulder City, Nevada, by Marsh & Associates, LLC, Tempe, Arizona.

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Summary

Four general areas of inquiry were pursued relative to razorback sucker *Xyrauchen texanus* in Lake Mohave during the period covered by this report: (1) post-stocking dispersal and fate determined by acoustic telemetry, (2) routine monitoring, (3) creel census, and (4) ecological modeling. Studies that were initiated prior to but completed during current reporting period are presented first in the summary that follows.

The acoustic telemetry study initiated in autumn 2008 was completed in 2009. Twenty adult and ten subadult razorback sucker were implanted with acoustic transmitters and released at Fortune Cove on 6 November 2008. One fish was removed from analysis because it was contacted only once, immediately after release. At the conclusion of the study, six of nine (67%) subadult and sixteen of twenty (80%) adult razorback sucker remained active. Average total distances traveled by active subadults and adults were 44 and 116 km, respectively. Five transmitters were recovered from the bottom of the reservoir by a SCUBA diver. No fish remains were observed near any recovered transmitters. One transmitter was recovered from the stomach of a striped bass *Morone saxatilis* and another transmitter remained in the same location until the conclusion of the study but was never recovered.

We handled 20 razorback suckers (20 captures, no short-term recaptures) in 2009. Seventy-five percent of captures occurred in March (25% during December). Fourteen individuals were PIT tagged repatriates, one was a wild PIT tagged fish, and five were untagged fish. Based on monitoring data from 2008 and 2009, we estimate that the current wild razorback sucker population Lake Mohave is 70 fish (32 - 467 95% confidence interval [CI]). The repatriated razorback sucker population is estimated to number 1,502 (949-2,384 95% CI) with a 1% estimated survival of all repatriates released as of 1 March 2008. The current total population estimate for razorback sucker in Lake Mohave is 1,572.

Ten large striped bass (greater than 80 cm total length) were processed by the NVDOW creel census clerk in 2009 (six were scanned for PIT tags), and none contained a PIT tag.

No decreasing trend in survival was evident for fish released prior to 2002, captured in 2004-2009, and categorized by previous capture history, and the resulting statistical test was insignificant. Prior capture and handling thus did not have a measureable effect on razorback sucker mortality.

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.

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 fourth year (2009) 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 third round of acoustic telemetry has provided further evidence of post-repatriation mortality as well as comparative mortality estimates between two size classes of released fish. Population and survival estimates for wild and repatriate populations were updated based on results from standard monitoring. Creel census data on large striped bass *Morone saxatilis* abundance and impact on

razorback sucker stockings are currently being provided through collaboration with Nevada Department of Wildlife (NVDOW).

Methods

Post-stocking Dispersal and Fate

2008-09 Acoustic Telemetry

For this study, 30 razorback sucker (10 subadults, average total length [TL] 38 cm and 20 adults, average TL 54 cm) were implanted with acoustic transmitters, stocked in Lake Mohave, and telemetered twice each month between 6 November 2008 and 5 May 2009.

On 22-23 October 2008, Reclamation staff harvested adult razorback sucker from Yuma Cove backwater (11S 712763 3933461; Fig. 1) using overnight sets of trammel nets. Captured fish were held in net pens for 24 h due to inclement weather. On 24 October, the 30 largest individuals were removed from net pens, placed in aerated holding tanks filled with local water, and transported by boat to Willow Beach National Fish Hatchery (Willow Beach NFH). At the hatchery, fish were transferred into two indoor circular raceways treated with salt to reduce fish stress and held for a period of seven days.

On 31 October, 10 subadult razorback sucker were collected from an outdoor raceway, transferred to a separate indoor circular raceway. All adult and subadult individuals had previously received a 134 kHz 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.). In order 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 sterilized in isopropanol 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 0.2-0.9 ml and were based on a categorical chart that identified appropriate dosage based on each fish's weight. Following surgery, adult and

subadult razorback sucker were placed in separate recovery raceways and monitored to ensure proper health and tag retention.

On 5 November, six SURs were deployed at various locations throughout the northern half of Lake Mohave (Fig. 1); Fortune Cove (11S 707708 3956019), Chalk Cliffs (11S 708198 3959277), Windy Canyon (11S 707342 3964180), Fire Mountain Lights (11S 707904 3951864), Painted Canyon Lights (11S 711229 3933030), and the entrance to Klondike Cove (11S 710911 3933226). The SUR deployed at Windy Canyon was relocated on 2 February 2009 to the upper river (11S 706881 3977619) between Big Sand Bar and Horseshoe Rapids, where it remained until the conclusion of the study.

On 6 November, all study fish were placed in two, 1893-L aerated tanks, transported by boat downriver from Willow Beach NFH, and released into Fortune Cove. Manual and SUR tracking techniques and database management all followed methods previously reported (Karam et al. 2008). All SCUBA observations and transmitter recovery took place on 29-90 April 2009.

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 1-5 December 2008 as many as eight 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 Levi Cove. In a similar effort, four to six trammel nets were fished continuously along the Arizona shoreline from Pot Cove upstream to Carp during the March roundup (16-20 March 2009).

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 laboratory for genetic analysis (reported elsewhere). All relevant data are entered into the comprehensive lower river PIT tag database maintained by M&A. Population estimates are based on the modified Peterson method (Ricker 1975).

Creel Census Data

Creel census data were collected periodically by a NVDOW biologist at Cottonwood Landing, Nevada and Willow Beach, Arizona. A majority of striped bass greater than 80 cm in total length encountered by the biologist were scanned for PIT tags. If a PIT tag was found, the stomach was to be removed and sent to M&A.

Ecological modeling

Previous modeling work has shown statistically significant site fidelity for both wild and repatriate razorback sucker in Lake Mohave (Kesner et al. 2007), but incorporating location into models had little to no effect on estimates of survival and recapture rates (Kesner et al. 2008). In 2009, capture frequency analysis was used to determine if fish handling in Lake Mohave resulted in a reduction in survivorship. To do this, release and contact data from the NFWG database were queried and sorted for three discreet time periods. Razorback sucker stocked into Lake Mohave before January 1, 2002 were initially targeted. These fish were given two years to grow to adult size and were assumed to have similar mortality and capture rates by January 1, 2004. The number of captures between January 1, 2004 and December 31, 2006 for these individual fish were then tallied so that each released fish was identified as being not captured at all, captured once, captured twice, etc. Subsequent captures of these fish between January 1, 2007 and September 1, 2009 were grouped based on the capture tallies calculated between 2004 and 2006. Fish that were not captured at all between 2004 and 2006 were excluded from the final table since the number not captured between 2004 and 2006 but alive is unknown and therefore could not be compared to future captures in 2007 to 2009. The resulting data were tabulated in a contingency table and a chi-square test was used to determine if capture proportions differed significantly among the previous capture tallies. If repeated handling affected survival, then capture proportion (period 2007 to 2009) would significantly decline with an increase in handling occasions (period 2004-2006).

Results

Post-stocking Dispersal and Fate

2008-09 Acoustic Telemetry

All ten subadult razorback sucker were contacted post-release for a total of 343 contacts. Of the 343 contacts, 307 (90%) were made remotely with SURs. One subadult razorback sucker was contacted immediately following its release, but was not contacted again for the remainder of the study. Therefore it is excluded from further analysis.

Subadult survival remained high throughout the study, and at the conclusion of the study, six of nine (67%) fish were active. Contact density for these fish was highest in the Chalk Cliffs zone (Fig. 2), and diminished with distance from the release zone. Average total distance traveled by active subadults was 44 km. Active fish dispersed between Painted Canyon Lights ~ 3 km upstream of Cottonwood Cove and 49 Mile Light (11S 707635 3970098) ~ 5 km downstream of Willow Beach (Figs.1 & 2), approximately 17 and 8 km down- and upstream of the release site, respectively.

All three subadults that died during this study were dead within 35 days post-stocking (Fig. 3). Corresponding transmitters were located and retrieved by a SCUBA diver. Transmitter 110 was recovered from the main river channel (11S 707543 3970126) ~ 3 km upstream of Monkey Hole, transmitter 124 was recovered near the Arizona shore (11S 708018 3955403) near Oro Cove, and transmitter 141 was recovered from Camp Therman Coves (11S 717335 3913860) ~ 3 km downstream of Chemehueve Cove. No fish remains were observed in the vicinity of the transmitters.

All 20 adult razorback sucker were contacted for a total of 1,375 contacts. Of the 1,375 contacts, 1,206 (88%) were made remotely with SURs.

Adult survival was exceptionally high throughout the study, and after six months, 16 of 20 (80%) fish were active. Contact density for these fish was highest in the Chalk Cliffs zone and diminished with distance from the release zone, but dispersal was across a greater proportion of the reservoir than for subadult fish (Fig. 2). Average total distance traveled by active adults was 116 km. Active fish dispersed between the Arizona shore opposite Cottonwood Cove (11S 711085 3930488) and Nevada Hot Springs (11S 703466 3984640) ~2 km downstream of Hoover Dam (Fig 4), approximately 30 and

35 km down- and upstream of the release site, respectively. Eight of 16 (50%) active adult fish migrated to shallow alluvial gravel bars located between Willow Beach and Hoover Dam where they were observed among large groups of additional razorback sucker (Fig. 5). Seven of those telemetered fish made repeated migrations between Painted Canyon Lights and gravel bars located upstream of Willow Beach.

All four adults that died during this study were dead within 96 days post-stocking (Fig. 3). Two of four transmitters from were located and retrieved by a SCUBA diver. Transmitter 108 was recovered from the littoral zone of the Arizona shoreline (11S 708250 3956743) near Oil Pan Cove and transmitter 129 was recovered near Nine Mile (11S 710788 3922310). No fish remains were observed in the vicinity of either transmitter. Transmitter 123 was recovered on 12 November 2008 from the stomach of a 30 kg striped bass by an angler fishing near Liberty Cove (11S 708503 3953249). Transmitter 114 stayed in the same location for 85 days near Yuma Cove (11S 712586 3933712) but was never recovered.

Routine Monitoring

We handled 20 razorback suckers during autumn (December) 2008 and spring (March) 2009 monitoring events, with December and March monitoring activities accounting for 25% (n=5) and 75% (n=15) of the captures respectively (Table 1). Fifteen individuals had PIT tags while five did not. Of the five fish without PIT tags, all were suspected repatriates due to their overall healthy condition, and noted as such in the database as well as included in this summary for a total of 19 repatriated and one wild fish. The majority of fish captured were female (70%) with five males and one of unknown gender. The single known wild fish was a male initially captured sixteen years earlier in 1993 near RM 24.5, on an unknown side of the reservoir in the Arizona Bay zone (comprised of Yuma + AOP zones; Fig. 2), approximately three river miles (4.8 km) south from the M&A monitoring area and then captured six more times over the years (unpublished data, NFWG database). For purposes of this report, only the 14 repatriated fish with paired release-capture data will be discussed further; data from the five suspected repatriates captured without a tag were omitted.

Twelve fish were captured during 2008/2009 monitoring for the first time since their release into the lake while two fish each had one prior capture (unpublished data, NFWG database; Table 2). Three fish were tagged in the 1990s, with the oldest tag from 1995 while the eleven remaining fish were

tagged since 2000. Six fish were at large four years or less while eight were at large for seven years or more with three of these fish at large for 11 or more years. Two fish with year class information were approximately three years old at stocking and at large from three to four years at time of capture during our monitoring period.

With the exception of one individual, gender was determined for each fish at the time of capture (Table 3). Females appeared to exhibit more growth over their time at large, ranging from 0.2 to 0.7 cm/month while males appeared to have less growth, ranging from less than zero[1] to 0.1 cm/month. Six fish were less than or equal to 35.0 cm TL at release, 8 fish were greater than 35.0 cm TL at release, and all fish were greater than 41.5 cm TL upon capture. Of the fish at large for one year or less, growth ranged from less than 0 to 0.1 cm TL/month. Growth for fish at large three to four years and seven or more years ranged from 0.3 to 0.6 cm and 0.1 to 0.4 cm TL/month, respectively.

Sixty-four percent of total fish captured originated from lakeside backwaters (Table 4). Yuma Cove and North Arizona Juvenile contributed three fish each from lakeside backwaters, totaling 43% of the total fish captured. Off-site rearing facilities contributed 36% of the total fish captured; these were reared at Willow Beach NFH and Boulder City Wetlands Park, NV.

Six fish moved from the Arizona Bay zone and seven fish moved from the NV side of the reservoir; all fish were captured in the Basin Zone (comprised of Tequila + Nine Mile zones; Fig. 2) on the AZ side of the reservoir, which was our general monitoring location. One fish released at Road Runner Cove, NV traveled the furthest, approximately 19 km upstream to the our monitoring area. Others traveled three to 17 km from their release sites on both sides of the reservoir.

Based on monitoring data from 2008 and 2009, we estimate that the current wild razorback sucker population Lake Mohave is 70 fish (32-467 95% CI). We estimate that the repatriated razorback sucker population is 1,502 (949-2,384 95% CI) 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 1,572.

Creel Census Data

Creel censusing was conducted once a week at Willow Beach by NVDOW from 11 January 20009 to 5 August 2009. During that time, ten large (greater than 80 cm TL) striped bass were documented. Six

[1] Fish reported as -0.8 cm growth. We confirmed measurements from field notes and they are correct in the database.

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

There are records of 57,920 repatriate releases into Lake Mohave prior to January 1, 2002. Out of this total, 363 were captured between January 1, 2004 and December 31, 2006; 324 were captured once, 31 twice, and 8 three times. Seventy-one razorback sucker released before January 1, 2002, and captured between 2004 and 2006 were captured again between January 1, 2007 and September 1, 2009. When these fish are categorized by their previous capture history, no decreasing trend is evident (Fig. 6), and the resulting statistical test was insignificant ($p = 0.157$, $df = 2$). This result indicates that repeated capture and handling of razorback sucker does not have a measureable effect on razorback sucker mortality, and that these processes are not likely to contribute significantly to mortality estimates as currently construed.

Discussion

Post-stocking Dispersal and Fate

2008-09 Acoustic Telemetry

Results from this study are significant because they confirm our conclusion from the previous two telemetry studies (2006-07 and 2007-08): striped bass are responsible for post-stocking mortality of repatriated razorback sucker in Lake Mohave (Karam and Marsh in press). During all three studies we collected a broad array of data that support this conclusion: 1) in 2006-07 data from our captive fish experiment confirmed our surgical techniques had no affect on implanted fish health or survival, 2) visual observations of 36 immobile transmitters (from 2006-09) using SCUBA indicated no razorback sucker remains were located in the vicinity transmitters, and 3) all telemetered fish that entered Cottonwood Basin (2006-09) were subsequently located in the reservoir, rejecting the hypothesis that study fish were exiting Lake Mohave via Davis Dam. Further, we received photo documentation from anglers which depicted razorback suckers in the stomach contents of striped bass, but none of the photos were taken during the timeframe of previous studies. However, during 2008-09 a fisherman who caught a 30 kg striped bass in the vicinity of Fortune Cove found an acoustic transmitter in its stomach which belonged to a 50 cm razorback sucker. Questions

remained as to whether adult repatriates of the current recommended socking size (≥ 50 cm TL) were immune to predation by striped bass, which is the only piscivore in the reservoir with a gape large enough to ingest fish of that size (Dennerline and Van Den Avyle 2000). The predation scenario described clearly rejects that assertion. Further photo documentation was provided by anglers which depicted bonytail *Gila elegans* in the stomach contents of striped bass on two separate occasions in 2007. Those striped bass were caught near Willow Beach where thousands of bonytail had been stocked during the previous week. These predation scenarios confirm recently stocked fish were consumed by striped bass (Karam and Marsh in press).

Average total distance traveled by active adults was over 2.6 times greater than active subadults during the same period. It is important to note that prior to their release, adults spent months in Yuma Cove backwater where they were exposed to environmental conditions that were vastly different than those found in a hatchery raceway. Razorback sucker that spend time in these semi-natural conditions are likely better suited for repatriation into the reservoir. This assertion is strengthened by the fact that half of active adults routinely dispersed into the zone Above Willow and were observed interacting with other large groups of spawning razorback sucker (Fig. 5). This pattern of activity contrasts with that of subadult fish which were dispersed shorter distances and never entered into the Above Willow Zone (Figs. 2 and 4). This upriver aggregation of razorback sucker is well documented—boat electrofishing surveys conducted by Reclamation routinely contact a considerable number of razorback sucker in this reach, most of which contain older, 400 kHz PIT tags, which generally have not been used since 2006 . Further research should be conducted to determine the frequency of exchange between the razorback sucker aggregation in the Above Willow zone and other portions of reservoir. Our data suggest mixing is likely. Dispersal behavior exhibited by adult telemetered fish in this study is encouraging since it is hoped that repatriated fish will interact with other razorback sucker in Lake Mohave and ultimately make contributions to the overall genetic variation in the reservoir's population.

Dispersal into Cottonwood Basin by active adults was rare, and absent for active subadults. When fish were contacted by the SURs located near Painted Canyon Lights, it is possible fish swam into the basin during the interim period between manual surveys, but those fish were always located upstream of the Painted Canyon SURs during subsequent surveys. With the exception of one active adult who was contacted in the Tequila Zone (Fig. 4) during a manual survey, transmitters of fish that moved downstream of Painted Canyon were located on subsequent manual surveys and never moved locations again. Those transmitters were recovered at the conclusion of the study.

Subadult mortality peaked during the fifth week post stocking, yet survivorship was 9% higher than what subadults experienced during the same time period in 2006-07 and twice as high as that experience by subadults in 2006-07. After the fifth week, survivorship unexpectedly leveled off and all remaining six subadults survived through the end of the study. Six month survivorship was over 4 times greater than 2007-08 subadults and 9.5 times greater than that experience by 2006-07 subadults.

While the erratic subadult survivorship estimates from this and the previous two seasons makes comparison between years difficult, it is still important to note that adult survivorship in 2008-09 was the highest of the three studies. Adult survivorship declined during the first three months post-stocking. Thereafter, all fish remained alive during the latter half of the study. Large yearly fluctuations in subadult survivorship experienced during the past three studies (2006-07, 2007-08, and 2008-09) creates a challenging scenario for comparing subadult and adult survivorship between respective years (Fig. 7). This is due in part to the small number of fish utilized in the studies (total numbers of subadults released during all studies to date were 20, 15, and 10 individuals, respectively), but estimates nonetheless fall within the range of predictions based on mark-recapture data of post stocking mortality. Comparison of adult and subadult survivorship within years is warranted since mortality factors similarly affect both size classes of fish during that time period. Other explanations of variable mortality rates between years include reservoir community dynamics such as variation in striped bass predation pressure.

Routine Monitoring

Population estimates for wild razorback sucker in Lake Mohave had hovered near 500 fish for several years (Marsh et al. 2003 & 2005, Turner et al. 2007). This number was possibly artificially maintained by repatriate razorback suckers that had lost their PIT tags and consequently been mislabeled upon capture as wild. The most recent population estimate excludes all tag-less fish, and therefore more accurately reflects the decline in population of previously tagged wild fish (excluding wild fish that lose their PIT tag).

Repatriates in Lake Mohave now outnumber wild adults by more than an order of magnitude. The new protocol which recommends a minimum stocking size of 50 cm is expected to increase survivorship dramatically, but to date less than 200 razorback sucker have been at large at this size

for more than 2 years. Results from telemetry studies continue to support this conclusion, but the actual difference appears quite variable from year to year (Kesner et al. 2008; this report) and resolution must await the availability of additional capture data.

Creel Census Data

Although no PIT tags have been detected by NVDOW staff in striped bass or channel catfish stomachs in the last four years, few small razorback suckers have been released in that time, and creel census data that were collected at Cottonwood Cove in 2009 resulted in only 6 large striped bass scanned. The lack of tag detections is at least partially due to bad timing. Since the increase in target release size to 50 cm, few razorback suckers have achieved this size and have been released. In addition, the fish that have been released from Willow Beach have been large, close to 50 cm, fish. This size has been targeted to avoid predation by striped bass, and therefore they are expected to be rarely ingested. However, cooperation with NVDOW is expected to continue and additional data should accrue.

Ecological Modeling

Additional mark-recapture modeling in the last three years has demonstrated a significant spatial component to the Lake Mohave mark-recapture data, but this was also shown to have little impact on survival estimates (Kesner et al. 2008). Current levels of sampling effort also do not appear to have an impact on razorback sucker survival (this report). Together these results indicate that current and previous estimates of population size and survival are accurate. At the same time, acoustic telemetry studies have provided further support for the hypothesis that an increase in size at release from 35 to 50 cm TL results in a multi-fold increase in survival, but there is significant temporal variation (year to year) in post-release survival for either size class. This variation must be accounted for in any predictive model, and may be due to variation in large striped bass abundance, a decrease in other striped bass food resources, or additional unknown factors. Creel census data although instructive, has been neither consistent nor large scale enough to estimate large striped bass abundance. If large striped bass abundance could be estimated accurately, this may reduce the amount of uncertainty in predictions of future population size and help direct conservation measures.

The number of razorback sucker released at 50 cm TL or longer has dramatically increased in the last two years, with 665 records total as of December 10, 2009, 418 of which were released in 2008 and 2009 (NFWG database). Within the next few years survival estimates from these releases will be compared with the acoustic telemetry survival estimates, and make predictions of long-term population status feasible.

Continuing Studies

A telemetry study using target length (50 cm) fish will be performed during autumn-winter 2009-10 to assess and further evaluate variation in post-stocking mortality and dispersal. Routine monitoring of repatriate and wild stocks will continue annually during March, May, and November and as necessary at other times. Available creel census data will be evaluated relative to piscivory on razorback suckers. Development of a population dynamic model for razorback sucker in Lake Mohave incorporating size at release data from mark-recapture and acoustic studies will continue which will help direct species conservation and management.

Acknowledgements

Collections were under permit authorization of U.S. Fish and Wildlife Service, National Park Service (Lake Mead National Recreation Area) and the states of Arizona and Nevada. Animal use was under IACUC protocol nos. 05-767R and 08-959R to the principal investigator. Individuals who contributed their time and energy to this project in various capacities include T. Burke, B. Contreras, T. Delrose, J. Lantow, J. Nelson, M. Burrell, J. Campbell, M. Fell, G. Ley, J. Schooley, M. Schwemm, A. Baran, M. Olson, J. Scott, T. Stephens, T. Wolters, and the Reclamation dive team, J. Burke, G. Clune, R. Tang, and W. White under the leadership of C. Ulepic. All, plus others not named, are thanked for their time and effort in behalf of the fish.

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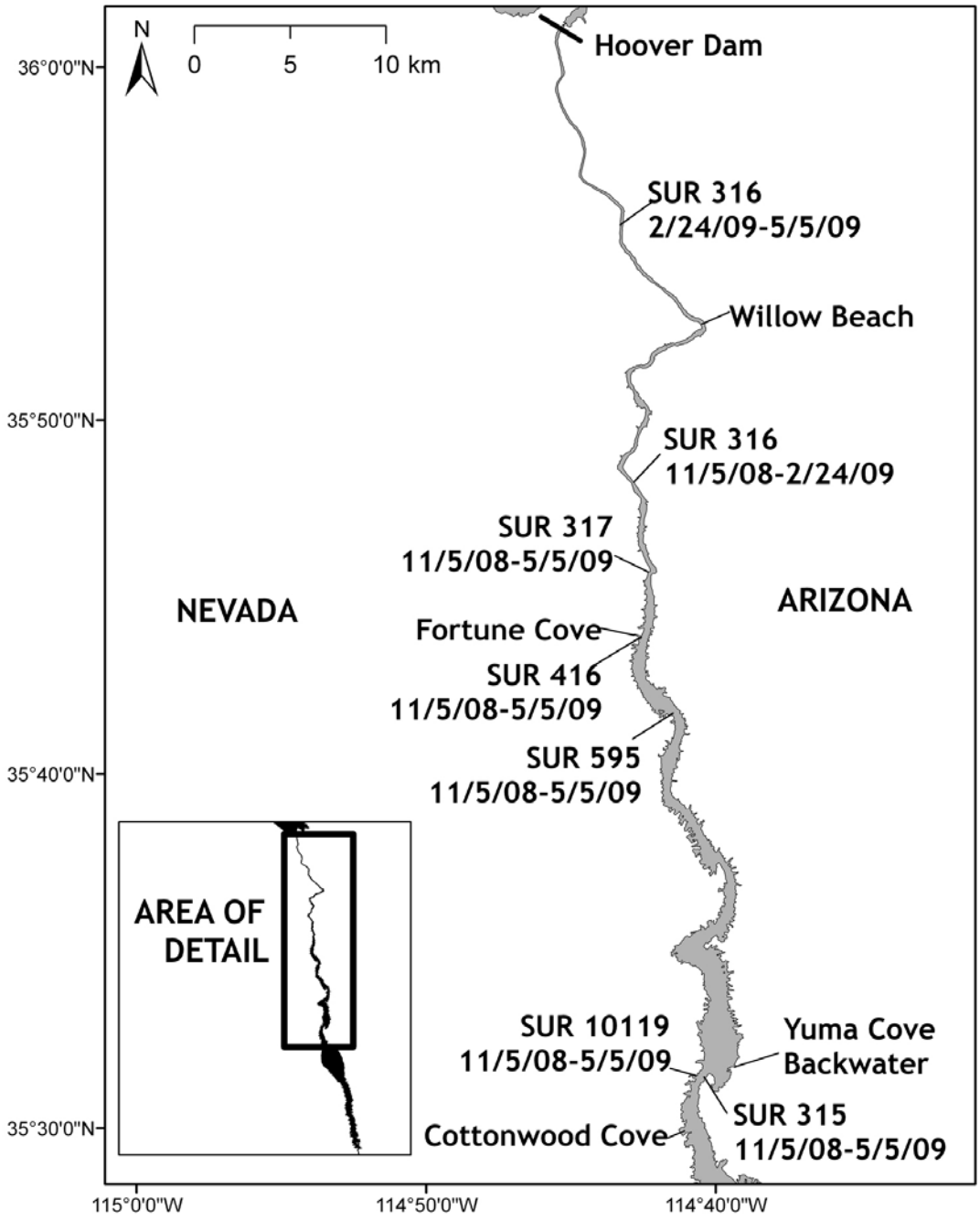

Figure 1. Sketch map of Lake Mohave Arizona/Nevada showing place names and SUR locations between 5 November 2008 and 5 May 2009.

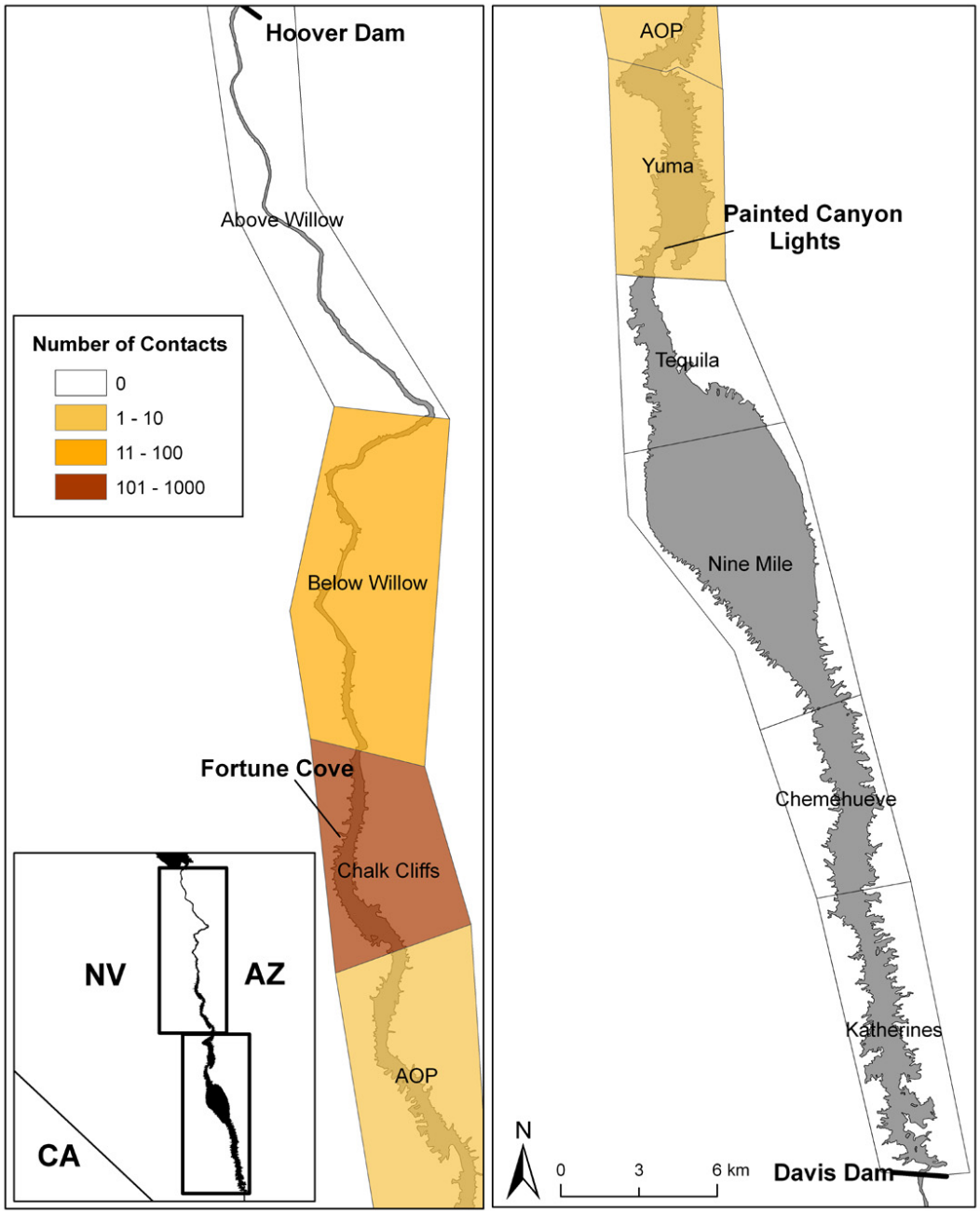

Figure 2. Contact densities by zone for all subadult razorback suckers still living (n = 6) at the end of the six month study (5 November 2008 and 5 May 2009).

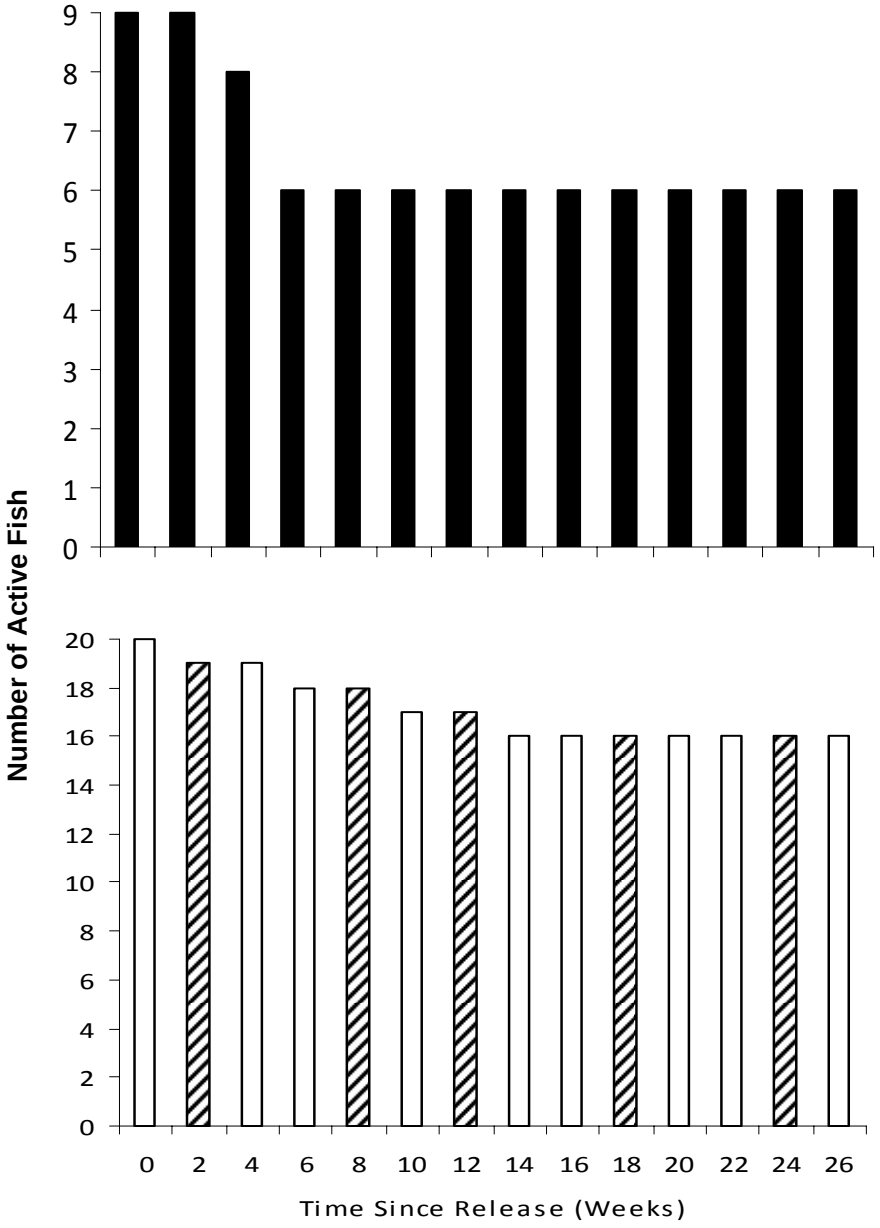

Figure 3. Summary of active tagged razorback sucker subadults (solid bars) and adults (striped bars) contacted over the six month study. Number of active fish is the total number of razorback sucker without a documented dead contact for a given bimonthly survey.

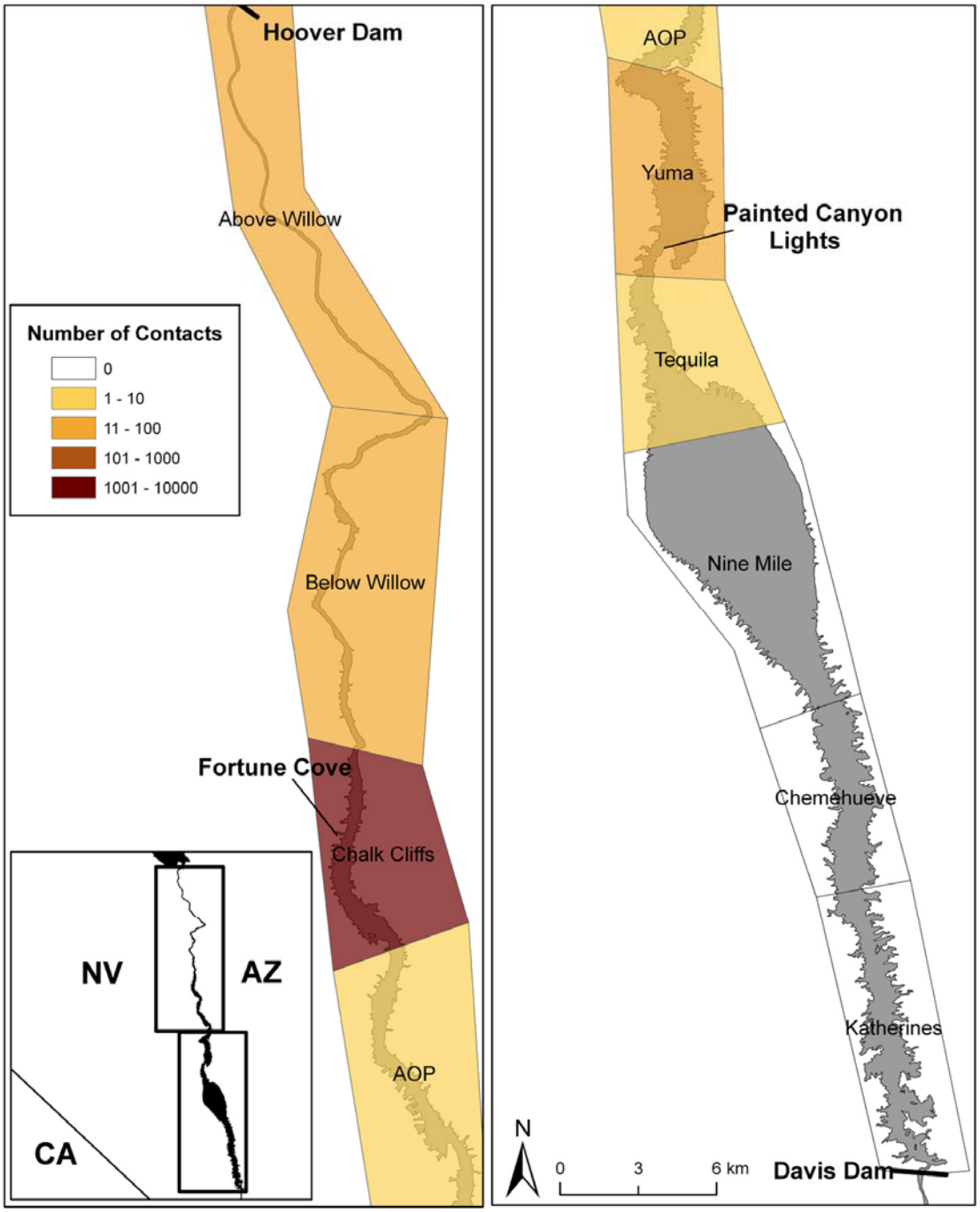

Figure 4. Contact densities by zone for all adult razorback suckers still living (n = 16) at the end of the six month study (5 November 2008 and 5 May 2009).

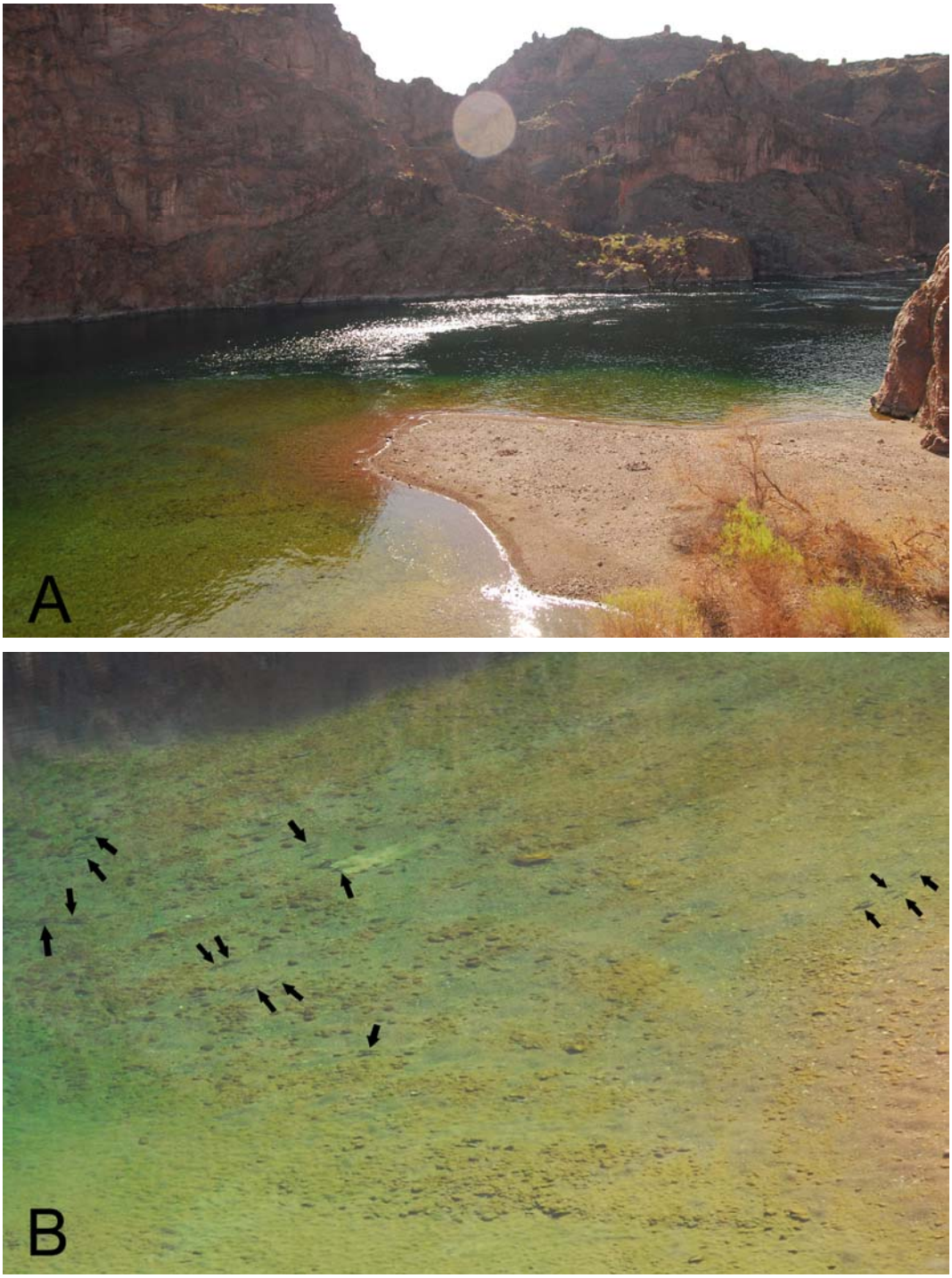

Figure 5. Gravel bar extending into the main channel of the Colorado River upstream of Willow Beach (A), where adult telemetered razorback suckers were located during the course of the six month study. Razorback suckers shown congregating and spawning on the gravel bar are depicted by black arrows (B).

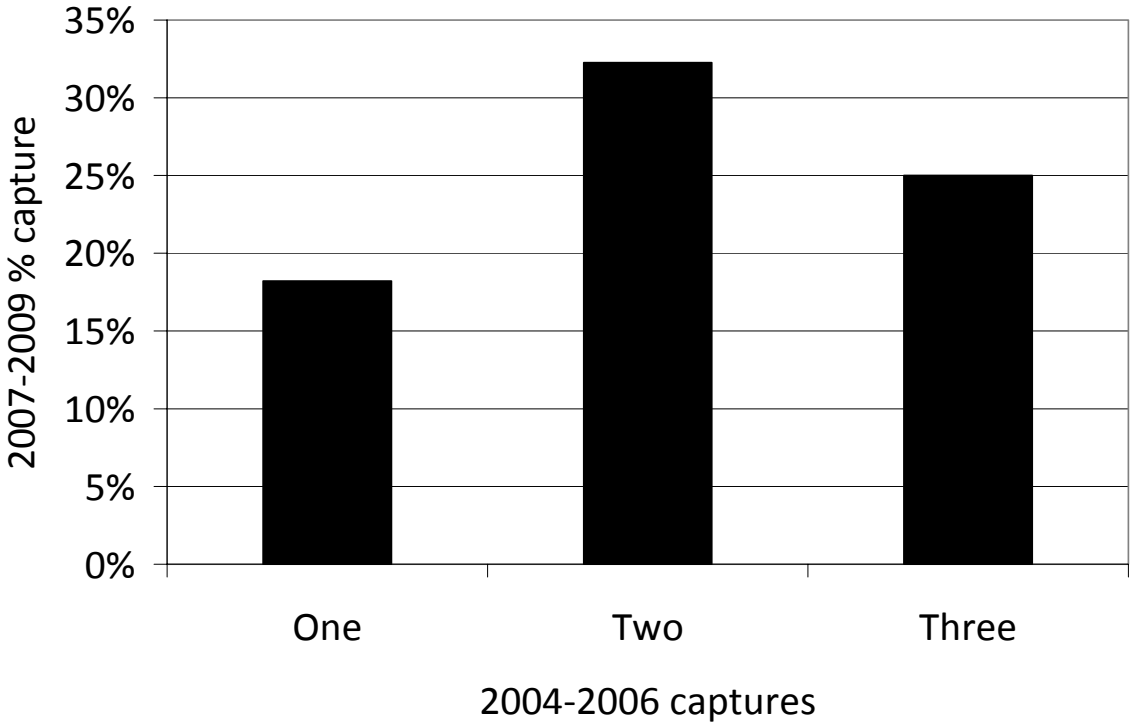

Figure 6. Capture rates of repatriate razorback sucker from 2007 to 2009 in Lake Mohave (y-axis) do not decrease with increasing prior captures (x-axis), indicating a lack of handling mortality.

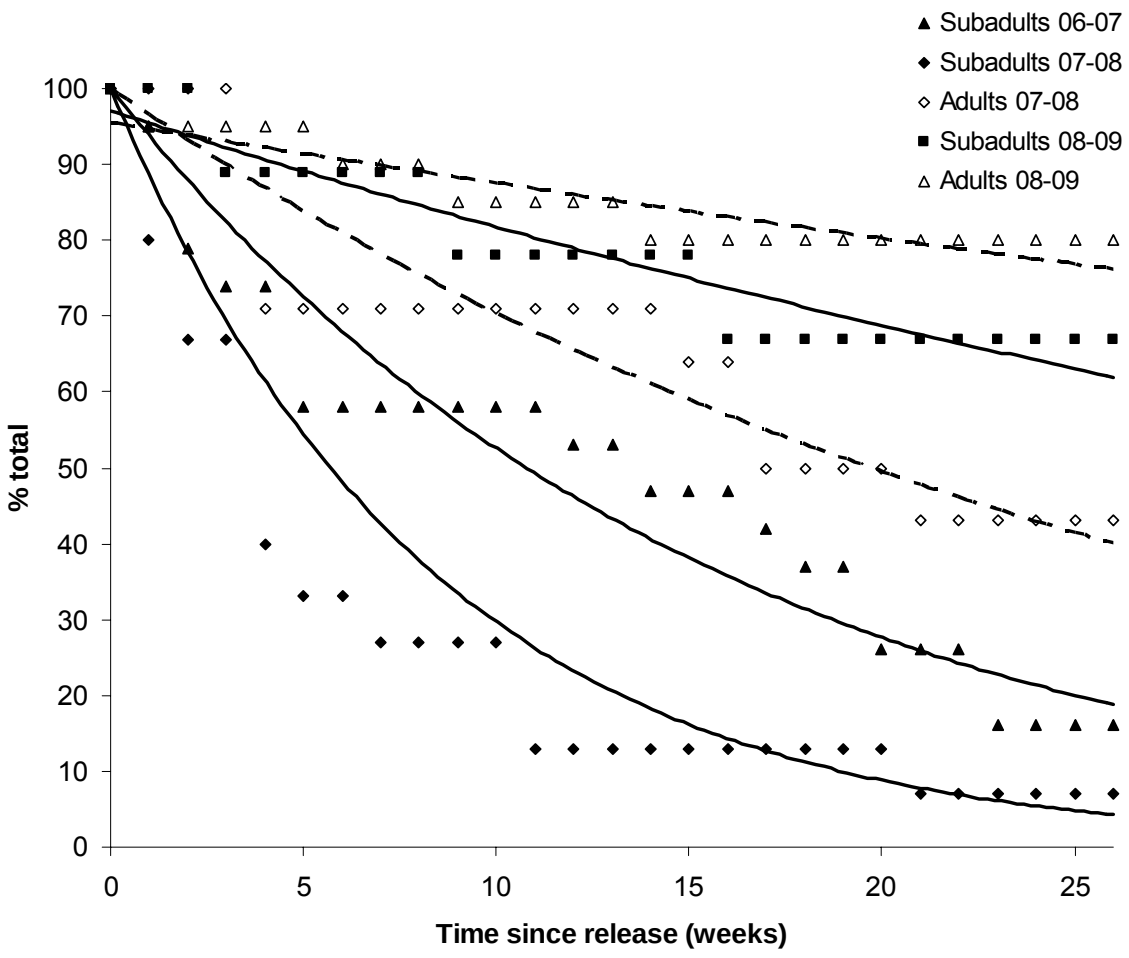

Figure 7. Six month post-stocking survivorship for subadult (solid lines) and adult (dashed lines) razorback sucker during the past three telemetry studies in Lake Mohave (2006-07, 2007-08, and 2008-09).

Table 1. Adult razorback sucker monitoring summary by capture month, total number of fish, gender, PIT tag, and history during March and December monitoring events, Lake Mohave, Arizona and Nevada.

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 (2008)	5 (25)	5 (25)	0	5 (25)	0	2 (10)	3 (15)	
March (2009)	15 (75)	10 (50)	5[a] (25)	14 (70)	1 (5)	12 (60)	2 (10)	1 (5)
Total (% of total N fish)	20	15 (75)	5 (25)	19 (95)	1 (5)	14 (70)	5 (25)	1 (5)

[a]Five fish captured without PIT tags were suspected to be repatriates and their histories were marked as such in the database.

Table 2. Adult razorback sucker monitoring summary for fourteen 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	
						Number of captures	Comments
4647776409[a]	4/1/05	3/17/09	1,446	48	4	1	First capture in 2009
4637701373[b]	1/25/06	3/18/09	1,148	38	3	1	First capture in 2009
1C2C33ACE1	11/20/07	3/17/09	483	16	1	1	First capture in 2009
1C2D012FF9	10/6/08	12/4/08	59	2	0	1	First capture in 2008
201D603C27	11/20/95	12/3/08	4,762	159	13	1	First capture in 2008
2037213454	11/20/95	12/2/08	4,761	159	13	1	First capture in 2008
257C60E10E	6/13/07	12/4/08	540	18	1	1	First capture in 2008
257C611F6B	10/8/08	3/17/09	160	5	0	1	First capture in 2009
42016D2D60	3/11/98	3/18/09	4,025	134	11	1	First capture in 2009
520E524F15	9/26/00	3/18/09	3,095	103	8	1	First capture in 2009
5325721921	6/20/01	3/18/09	2,828	94	8	1	First capture in 2009
5326044B70	5/30/01	3/18/09	2,849	95	8	1	First capture in 2009
42407B0943	6/27/01	12/4/08	2,717	91	7	2	First capture in 2006, second capture in 2008
532623435E	9/22/00	3/17/09	3,098	103	8	2	First capture in 2008, second capture in 2008

[a]2002 year class, reared at Willow Beach NFH
[b]2003 year class, reared at Willow Beach NFH

Table 3. Adult razorback sucker monitoring summary for fourteen paired release-capture data per fish PIT tag number with growth rate (capture total length (TL) in mm 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 (mm)			Months at large	Years at large	Gender
	Release	Capture	Growth rate/month			
1C2D012FF9	430	415	-0.8[a]	2	0.16	M
257C611F6B	455	490	0.7	5	0.44	U
1C2C33ACE1	530	594	0.4	16	1.32	F
257C60E10E	430	549	0.7	18	1.48	F
4637701373	350	582	0.6	38	3.15	F
4647776409	370	540	0.3	48	3.96	F
42407B0943	290	586	0.3	91	7.44	F
5325721921	295	556	0.3	94	7.75	F
5326044B70	315	655	0.4	95	7.81	F
520E524F15	370	610	0.2	103	8.48	F
532623435E	380	570	0.2	103	8.49	F
42016D2D60	350	650	0.2	134	11.03	F
2037213454	341	585	0.1	159	13.04	M
201D603C27	365	607	0.1	159	13.05	M

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

Table 4. Adult razorback sucker monitoring summary for fourteen 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. Data from two repatriates were omitted, one fish suspected as a repatriate captured without a tag and from the one fish released seven days prior to its capture.

Rearing Type	Rearing Location	Release Location	Capture Location	Release Zone	Release State	Release River km	Capture River km	Distance Traveled (change km)
Lakeside backwater	Arizona Juvenile	Arizona Juvenile	Pot Cove	Basin	AZ	25	31	6
			Carp Cove (north point)	Basin	AZ	25	33	8
			Carp Cove (inside)	Basin	AZ	25	33	8
	Dandy Cove	Dandy Cove	Carp Cove (inside)	Basin	NV	26	33	7
	Nevada Larvae	Nevada Larvae	Pot Cove (north of)	Basin	NV	24	31	7
	Nine Mile Cove	Nine Mile Coves	Waterwheel and Carp Coves	Basin	NV	26	33	7
	Yuma Cove	Yuma Cove	Pot Cove	Arizona Bay	AZ	39	31	9
				Arizona Bay	AZ	39	31	9
			Carp Cove (north point)	Arizona Bay	AZ	39	33	6
Off-site facility	Boulder City Wetlands Park	Cottonwood Cove	Pot Cove (north of, cove)	Basin	NV	37	31	5
			Carp Cove (north point)	Basin	NV	37	33	3
			Waterwheel Cove	Basin	NV	37	32	4
	Willow Beach NFH	Catclaw to Great West Cove	Carp Cove (inside)	Arizona Bay	AZ	50	33	17
		Road Runner Cove	Carp Cove (north point)	Arizona Bay	NV	52	33	19