Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Distribution and Post-Stocking Survival of Bonytail in Lake Havasu

2013 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

January 2014

Lower Colorado River Multi-Species Conservation Program
Steering Committee Members

Federal Participant Group

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

Arizona Participant Group

Arizona Department of Water Resources
Arizona Electric Power Cooperative, Inc.
Arizona Game and Fish Department
Arizona Power Authority
Central Arizona Water Conservation District
Cibola Valley Irrigation and Drainage District
City of Bullhead City
City of Lake Havasu City
City of Mesa
City of Somerton
City of Yuma
Electrical District No. 3, Pinal County, Arizona
Golden Shores Water Conservation District
Mohave County Water Authority
Mohave Valley Irrigation and Drainage District
Mohave Water Conservation District
North Gila Valley Irrigation and Drainage District
Town of Fredonia
Town of Thatcher
Town of Wickenburg
Salt River Project Agricultural Improvement and Power District
Unit “B” Irrigation and Drainage District
Wellton-Mohawk Irrigation and Drainage District
Yuma County Water Users’ Association
Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

Other Interested Parties Participant Group

QuadState Local Governments Authority
Desert Wildlife Unlimited

California Participant Group

California Department of Fish and Wildlife
City of Needles
Coachella Valley Water District
Colorado River Board of California
Bard Water District
Imperial Irrigation District
Los Angeles Department of Water and Power
Palo Verde Irrigation District
San Diego County Water Authority
Southern California Edison Company
Southern California Public Power Authority
The Metropolitan Water District of Southern California

Nevada Participant Group

Colorado River Commission of Nevada
Nevada Department of Wildlife
Southern Nevada Water Authority
Colorado River Commission Power Users
Basic Water Company

Native American Participant Group

Hualapai Tribe
Colorado River Indian Tribes
Chemehuevi Indian Tribe

Conservation Participant Group

Ducks Unlimited
Lower Colorado River RC&D Area, Inc.
The Nature Conservancy

Lower Colorado River Multi-Species Conservation Program

Distribution and Post-Stocking Survival of Bonytail in Lake Havasu

2013 Annual Report

Prepared by:

Julia S. Mueller, Brian R. Kesner, Paul C. Marsh, and Schannon H. Gehrke

Marsh & Associates, LLC
5016 South Ash Avenue, Suite 108
Tempe, Arizona 85282

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

January 2014

Mueller, J.S., B.R. Kesner, P.C. Marsh, and S.H. Gehrke. 2014. Distribution and Post-Stocking Survival of Bonytail in Lake Havasu, 2013 Annual Report. Submitted to the Bureau of Reclamation, Boulder City, Nevada, by Marsh & Associates, LLC, Tempe, Arizona.

ACRONYMS AND ABBREVIATIONS

ASU	Arizona State University
Bill Williams River NWR	Bill Williams River National Wildlife Refuge
FIP	Lake Havasu Fisheries Improvement Program
km	kilometer(s)
m	meter(s)
mm	millimeter(s)
PIT	passive integrated transponder
PVC	polyvinyl chloride
Reclamation	Bureau of Reclamation
SUR	submersible ultrasonic receivers
TL	total length
USFWS	U.S. Fish and Wildlife Service

Symbols

>	greater than
<	less than

CONTENTS

Page

Executive Summary ES-1

Introduction 1
    Primary Objectives 3
    Secondary Objectives 4
Methods 4
    Study Area 4
    Submersible Ultrasonic Receiver Deployment 7
    Bonytail Surgeries 7
    Tracking Tagged Fish 10
    PIT Scanning 10
Results 14
    Spring 2013 14
    Autumn 2013 14
Discussion 18
Recommendations 18
Acknowledgments 19
Literature Cited 21

Tables

Table Page

1 Data collected from six bonytail that were surgically implanted with tags on April 17, 2013 8
2 Data collected from 10 bonytail that were surgically implanted with tags on October 22, 2013 9
3 Data associated with 11 bonytail tags recovered at a known roosting site of double-crested cormorant during May and June 2013 17

Figures

Figure Page

1 Map of Lake Havasu, Arizona, California, and Nevada. 2
2 Map of the watercraft-accessible portion of the Bill Williams River NWR at the southeast terminus of Lake Havasu, Arizona and California, and photographs of the reach. 5
3 Map of the Colorado River delta and Topock Gorge near Blankenship Bend, Lake Havasu, Arizona and California, and a photograph of a typical off-channel backwater (foreground) in the reach. 6
4 Location of SURs deployed on April 11, 2013. 11
5 Location of SURs deployed on October 21, 2013 (red), November 11, 2013 (blue), and November 13, 2013 (green). 12
6 Locations of PIT scanning antennas deployed either vertically (blue) or horizontally (red) during the autumn study. 13
7 Days at large for bonytail released in Bill Williams River NWR on April 17, 2013. 15
8 Map of release (pink) and final (blue) fate locations for six bonytail released in Bill Williams River NWR on April 17, 2013. 15
9 Photograph of woody debris occupied by double-crested cormorant at a site where 1 acoustic tag from this study and 11 PIT tags were later scanned via snorkelers. 16
10 Map of release (pink) and contact (blue) locations for 10 bonytail the day they were released near Blankenship Bend on October 22, 2013. 16

EXECUTIVE SUMMARY

Lake Havasu, Arizona, California, and Nevada, is one of the few locations where critically endangered bonytail (*Gila elegans*) have been captured. Since wild populations have been extirpated, the presence of this species relies entirely on stocking programs. Very little is known about the basic ecology of these stocked fish because most data are limited to past field observations of the now-extirpated wild population. Further, no conclusions could be made on the basis of previous telemetry studies conducted within the reservoir due to possible transmitter loss, premature mortality, and loss of contact with tagged fish. Therefore, minimal information exists on post-stocking fate and habitat use of hatchery-reared bonytail.

We are in the process of completing the second part of an acoustic telemetry study within Lake Havasu that will attempt to describe and characterize the inhabitance and dispersal of hatchery-reared bonytail. Fish were surgically implanted with sonic tags and released into two distinct locations in April and October 2013. Six implanted fish were released within the Bill Williams River National Wildlife Refuge in April, and 10 were released near Blankenship Bend in October. A directional hydrophone and receiver were used to actively track fish, and multiple submersible ultrasonic receivers that continuously scanned for tags were placed throughout the study area for passive tracking.

In the spring study, all bonytail were determined dead within 2 weeks post-release, and all six tags were recovered via diver. As a result, we were unable to draw any conclusions about post-stocking habitat preference within the reservoir.

We are in the process of completing the autumn study. To date, with the use of active tracking, at least half of the original 10 bonytail have been contacted; with the use of passive tracking, that number has further increased. The study now is transitioning to a biweekly sampling schedule. Both sampling methods will be utilized for a complete 3 months of tracking or until all tags are recovered.

INTRODUCTION

Lake Havasu, a main stem lower Colorado River reservoir, extends approximately 132 kilometers (km) along the Arizona-California and Arizona-Nevada borders (figure 1). This portion of the reservoir is designated as Reach 3 of the Lower Colorado River Multi-Species Conservation Program and provides water to the Metropolitan Water District of Southern California and the Central Arizona Project (CAP) through the Colorado River Aqueduct and the CAP Canal, respectively. The lake portion of this reservoir extends from Parker Dam upstream to Lake Havasu City, approximately 45 river km, and upstream from this point, the river portion extends another 87 km through Topock Gorge to Davis Dam.

Introductions of non-native fish species to support recreational angling have drastically altered the native fish community within the reservoir (Moffett 1942; Dill 1944; Minckley 1979; Minckley and Deacon 1991; Mueller and Marsh 2002). Physical modifications that promote agriculture and urbanization throughout the Southwest have also exacerbated these changes (Reisner 1986; Mueller and Marsh 2002). Bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*) are two fish species that are endemic to the region and are federally listed as endangered (U.S. Fish and Wildlife Service [USFWS] 1980, 1991). Additionally, bonytail is considered functionally extirpated from its former range (Marsh 1996, 2004), and its persistence in the wild now relies entirely on stocking programs (Bureau of Reclamation [Reclamation] 2004; Minckley and Thorson 2007).

Since 1981 when augmentation began, approximately 204,300 bonytail have been stocked into Lake Havasu, of which, 285 individuals (0.1 percent) have been recaptured through routine monitoring of the lake (C. Pacey 2013, personal communication). These results have been an indirect outcome from the Lake Havasu Fisheries Improvement Program (FIP). The FIP was created in 1993 in part to help re-establish bonytail and razorback sucker populations within the reservoir (Doelker 1994). The stocking goal established by the FIP was achieved in 2003 (30,000 bonytail greater than 250-millimeter (mm) total length (TL) (Minckley and Thorson 2007). For the next 42 years, the Lower Colorado River Multi-Species Conservation Program will be directing Reach 3 stocking (4,000 bonytail per year greater than 300-mm TL) (Reclamation 2004), and the FIP will continue to conduct annual monitoring of bonytail.

Bonytail monitoring in the reservoir is accomplished through the combined efforts of the USFWS, U.S. Geological Survey, Reclamation, Bureau of Land Management, California Department of Wildlife, and public volunteers. Surveys are performed in February and involve trammel netting between the Bill Williams River and Moabi Regional Park near Needles, California, and extensive boat electroshocking between Needles and Laughlin, Nevada. To date, recovery and conservation of bonytail in Lake Havasu have been unsuccessful due to infrequent recaptures during surveys (19 recaptures between 1994 and 2007)

Figure 1.—Map of Lake Havasu, Arizona, California, and Nevada.

(Minckley and Thorson 2007), lack of reproduction and recruitment (Pacey and Marsh 1998), and the lack of knowledge on the basic ecology of the species.

Several telemetry studies in the lower Colorado River basin have involved examining habitat use of bonytail. A study at Lake Mohave suggested that bonytail utilize cover in the deeper portions of the lake during the day and move into shallower shoreline habitat at night (Marsh 1997). A separate study at Cibola High Levee Pond documented bonytail use of riprap shoreline along the banks during the day and migration into open waters at night (Mueller et al. 2003; Marsh et al. 2013). In another study completed at Lake Havasu, bonytail were contacted along shorelines or in coves, suggesting near-shore habitat use (Minckley 2006). More recently, Karam et al. (2012) conducted four telemetry studies within the Bill Williams River National Wildlife Refuge (Bill Williams River NWR). They concluded that: (1) passive integrated transponder (PIT)-tagged bonytail could be reliably contacted by remote-PIT scanning antennas up to 3 months post-stocking and (2) water clarity, stocking site, and time of year may influence bonytail post-stocking mortality and dispersal. It has been concluded from multiple studies that predation by birds and non-native fishes are likely causes for mortality of native fish within the lower Colorado River (Doelker 1994; Mueller 2003; Schooley et al. 2008; Karam and Marsh 2010).

We are in the process of implementing a multi-year research project in Lake Havasu, which will continue to document the post-stocking distribution, habitat use, and mortality of bonytail in Lake Havasu. For all of our investigations, inferences regarding habitat use are based on where fish are contacted over time because occupancy is a coarse descriptor of inhabitance by stocked fish. The goal of this research is to better understand stocking implications and guide future stocking endeavors in the reservoir. Ultimately, this work will aid in long-term survival of this critically imperiled species. A list of objectives, as specified in the Statement of Work for the current study period, is provided below.

Primary Objectives

1. Continue investigations across multiple release sites and variable habitat conditions within Reach 3.
2. Choose up to three release sites: one release site must be near the Bill Williams River NWR, and other proposed sites should be upstream of Lake Havasu. Releases and subsequent monitoring could be accomplished simultaneously or successively.
3. Monitor each release site for a minimum of 1 month.
4. Identify specific habitat types used or preferred by this species within each release site.

5. Compare short-term survival estimates (minimum of 1–3 months) for bonytail at each release site.
6. Monitor movements and/or movement patterns of individual bonytail within Reach 3.
7. Summarize all annual bonytail contact/collection data for Reach 3 that was collected during this project in addition to other data collected by Federal and non-Federal entities.

Secondary Objectives

1. Participate in at least one annual, week-long, multi-agency survey event held in February and November each year.
2. Compare or assess environmental conditions at survey sites that may influence survival (i.e., turbidity and vegetation).

METHODS

Both passive and active sampling remote sensing technologies were applied to each of our study sites to meet primary objectives 1 and 2. Passive sampling was achieved using submersible ultrasonic receivers (SURs), and active sampling was conducted by boat using a directional or towable omnidirectional hydrophone. During our spring and autumn studies, acoustic tags were surgically implanted into 6 and 10 bonytail, respectively. Month-long, intensive acoustic telemetry began immediately following each release. Collaboratively, these data will be used to evaluate bonytail post-stocking movement, habitat preference, and differential survival among the stocking locations and seasons (primary objectives 3, 4, 5, and 6). A more detailed description of the study is provided below.

Study Area

A separate study area within Lake Havasu was chosen for each of the two study periods. The location of the spring study was in the Bill Williams River and its delta (figure 2), and the autumn study area was located near Blankenship Bend (figure 3). These locations were chosen to represent different habitats within Lake Havasu and to represent both its lake and river portions. Further, two separate release sites were chosen within each study area. Bonytail were released in both backwater and main channel areas to represent different mesohabitats within each study area. At the conclusion of 2015, both study areas will have been sampled during both spring and autumn seasons to account for possible seasonal differences in study areas.

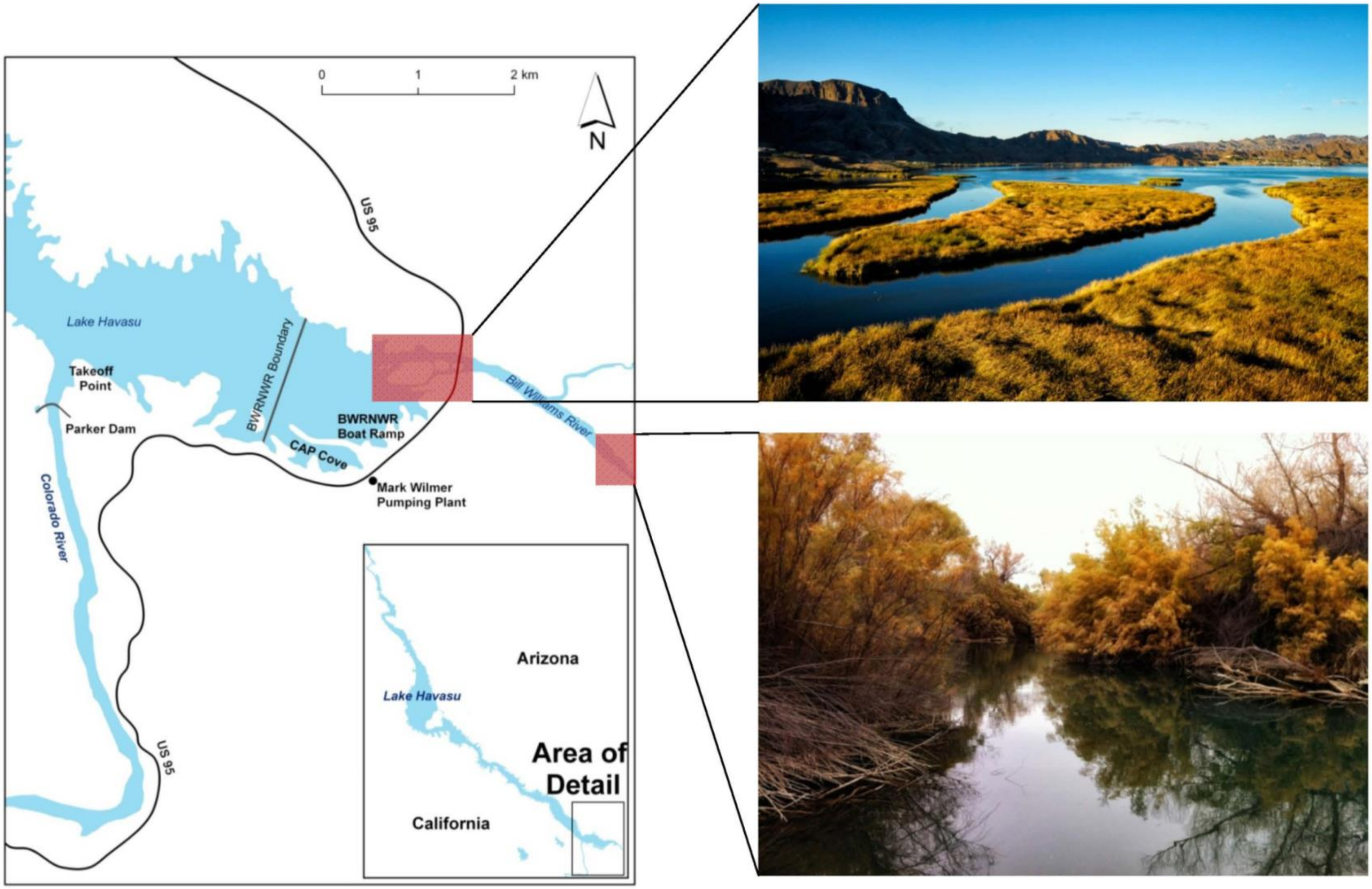

Figure 2.—Map of the watercraft-accessible portion of the Bill Williams River NWR at the southeast terminus of Lake Havasu, Arizona and California, and photographs of the reach.

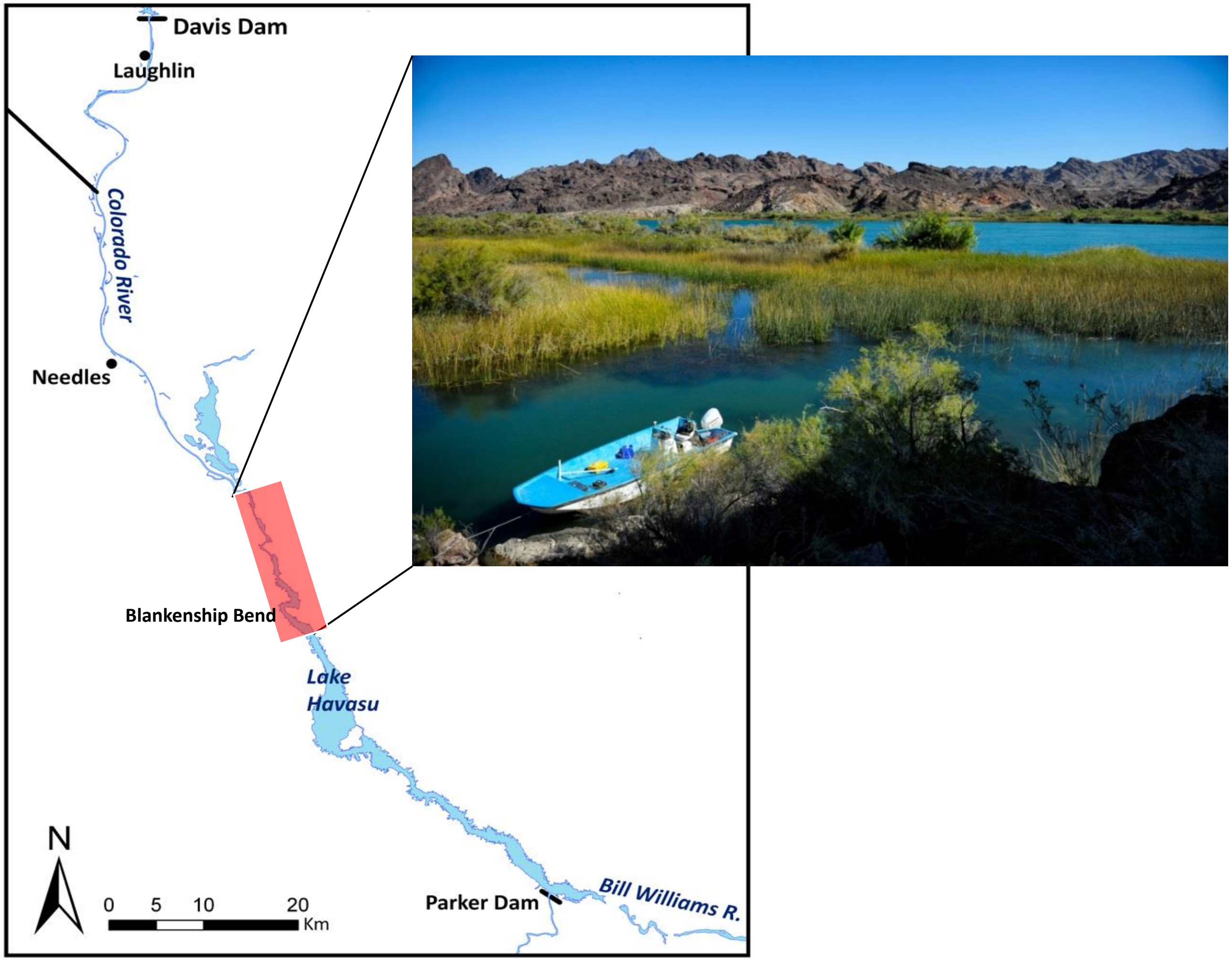

Figure 3.—Map of the Colorado River delta and Topock Gorge near Blankenship Bend, Lake Havasu, Arizona and California, and a photograph of a typical off-channel backwater (foreground) in the reach.

Submersible Ultrasonic Receiver Deployment

All SURs utilized during the studies were attached to a camouflaged rope and connected to a 6-meter (m) piece of galvanized cable that was then connected to secure on-shore habitat (usually a tree root). The cable was used in order to avoid rope abrasion caused by waves and rocks within the lake. Weights were tied near each SUR and to a central location on the rope to ensure that each unit was completely submerged within the water column. Each SUR had a battery life expectancy of 8 months, a nominal detection radius of 200 m, and scanned continuously for the duration of the studies. SURs were randomly positioned throughout the study area to act as passageways for fish movement. Additionally, SURs were placed near entrances to backwaters in order to obtain data on fish entering and exiting these locations. There was no set distance among SUR locations, and deployment relied heavily on the availability of secure on-shore habitat.

Bonytail Surgeries

Prior to the stocking of bonytail within Lake Havasu, a selected number were implanted with PT-4 acoustic transmitters with a 3-month battery life (Sonotronics, Inc.). The tags were activated with an external magnet and tested for functionality using a directional hydrophone (DH-4; Sonotronics, Inc.) and receiver (USR-08; Sonotronics, Inc.) prior to implantation. A shaded area near the transport trucks was utilized as the surgery station. Two aerated “recovery” tanks were filled with 50:50 mixture of lake:hatchery water and placed on the transport boat located near the surgical station. Dissolved oxygen (milligrams per liter) and water temperature (degrees Celsius) levels were monitored with a hand-held Hannah Instrument® 9829 multi-parameter water quality probe.

Surgeries generally followed the outline described by Marsh (1997) and Karam et al. (2008). Fish were placed into a solution containing tricaine methanesulphonate (MS-222; 125 milligrams per liter) until equilibrium was lost. Anesthesia progress was determined by cessation of all fin and muscular movements and weak operculation. Once the desired depth of anesthesia was reached, the fish was removed from the container, measured (TL; nearest mm), weighed (nearest gram), and scanned for a 134-kHz PIT tag (tables 1 and 2). The fish was then placed on its dorsum in a cradle specifically made for surgeries with a wet towel wrapped around its body. Once in place, a turkey baster was used to continually pump MS-222 into its mouth and gills. A short (< 2-centimeter) incision was made slightly anterior and dorsal to the left pelvic fin where a sterilized acoustic tag was then inserted into the abdominal cavity. The incision was sutured with three knots using USSC 3-0 Monosof black monofilament and a C-14 cutting needle. Betadine was then swabbed over

Table 1.—Data collected from six bonytail that were surgically implanted with tags on April 17, 2013 (All fish were released at approximately 13:00 on April 17, 2013.)

Sonic tag ID	TL (mm)	Weight (g)	PIT tag number	Release location	Easting	Northing	Determined dead
2	307	216	1C2DE1E9C3	Bill Williams River NWR launch[1]	766544	3798398	4/27/2013
3	309	227	1C2DD78901	Bill Williams River NWR launch	766544	3798398	4/22/2013
4	343	307	1C2DE1EB34	Bill Williams River NWR launch	766544	3798398	4/28/2013
5	334	282	1C2DE1F824	Bill Williams River log jam[2]	769476	3797837	4/25/2013
6	318	227	1C2DE1DD08	Bill Williams River log jam	769476	3797837	4/25/2013
7	336	262	1C2DE1B70B	Bill Williams River log jam	769476	3797837	4/26/2013

[1] Bill Williams River NWR launch refers to a boat launch in the Bill Williams River NWR.
[2] Bill Williams River log jam log jam refers to a log jam upstream in the Bill Williams River.

Table 2.—Data collected from 10 bonytail that were surgically implanted with tags on October 22, 2013 (All fish were released at approximately 14:00 on October 22, 2013.)

Sonic tag ID	TL (mm)	Weight (g)	PIT tag number	Release location	Easting	Northing	Determined dead
3	315	215	003BA6A6E2	BW[1]	736517	3831393	
4	287	240	003BA6D23D	BW	736517	3831393	11/17/2013
5	285	188	003BA6D365	MC[2]	735515	3831321	
7	306	188	003BA93A5A	MC	735515	3831321	
257	315	210	003BA6A6AA	BW	736517	3831393	11/17/2013
258	293	211	003BA6D269	BW	736517	3831393	
259	325	218	003BA6D278	BW	736517	3831393	
260	311	198	003BA6D3EA	MC	735515	3831321	
261	312	202	003BA6D397	MC	735515	3831321	
262	310	187	003BA6A717	MC	735515	3797837	

[1] BW refers to those fish released within the backwater near Blankenship Bend.
[2] MC refers to those released within the main channel of Blankenship Bend.

the incision site, and the antibiotic Baytril was injected using a 10 milligrams per kilogram dosage into the dorsal-lateral musculature to prevent infection (Martinsen and Horsberg 1995). The fish was then placed into a freshwater recovery tank and closely watched to ensure complete recovery.

Tracking Tagged Fish

Prior to stocking bonytail, SURs were deployed at different locations throughout the study area. Fourteen SURs were utilized for the duration of the spring study (figure 4). Sites were selected to ensure detection of movement up- or downstream and to determine if fish entered or exited major backwaters. During autumn, 12 SURs were initially placed throughout Lake Havasu, and 3 SURs were added a few weeks post-stocking (figure 5). SURs were downloaded routinely or as needed throughout both studies, and data were imported into a Microsoft Access® database used for managing fish contact histories and SUR locations.

During the first 4 weeks of both studies, fish were actively tracked by boat each day. There were no set times when sampling was to occur, but the majority of sampling was conducted between 08:00 and 18:00. At least 1 day out of every 2-week period was designated for night sampling (between sunset and sunrise).

Active tracking was conducted with a directional hydrophone and receiver. The receiver was manually set to specific tag frequencies corresponding to each tagged fish. Active tracking initially began at each release site but later varied depending on recorded fish movement. If all bonytail were not contacted by active tracking, SURs were downloaded and the data reviewed for the missing fish. Active tracking locations were moved based on the most recent encounter or most recent SUR record for each fish. If fish could not be located, active tracking resumed at the location of the most recent encounter, continuing along the grid system of 1-km spaced waypoints used in previous acoustic telemetry studies (Mueller et al. 2000; Karam et al. 2008). In spatially restricted environments, a towable hydrophone (Model TH-2, Sonotronics Inc.) was used. Boat speed was maintained at about 10 km per hour or less to reduce noise interference from the engine and allow the device to scan for multiple frequencies. Once a fish was detected using the towable, the directional hydrophone was used to pinpoint its exact location.

PIT Scanning

Four PIT scanning antennas were placed at selected locations throughout the Blankenship Bend area multiple times during our autumn telemetry study (figure 6). PIT scanners were deployed in backwaters surrounding

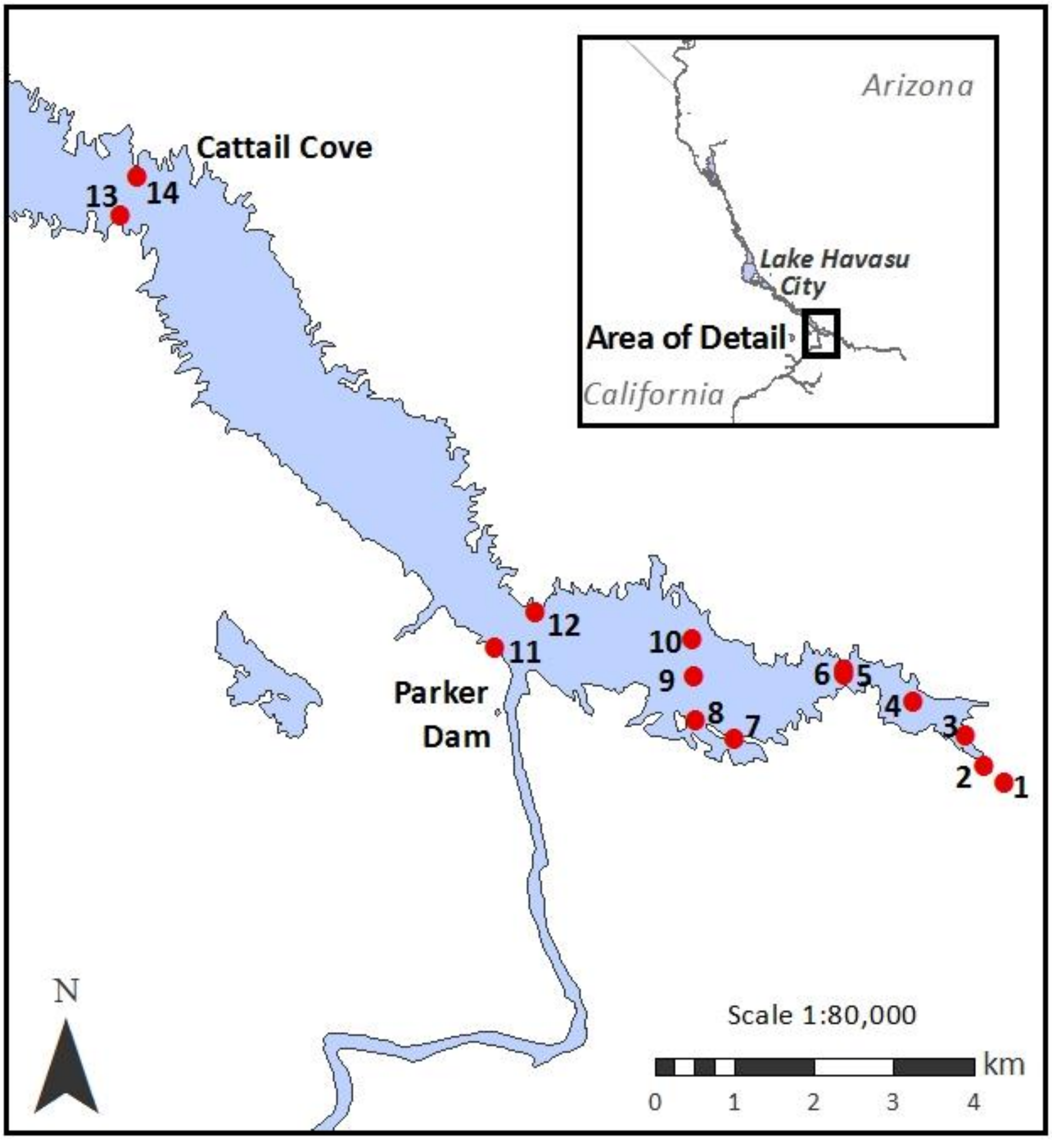

Figure 4.—Location of SURs deployed on April 11, 2013.

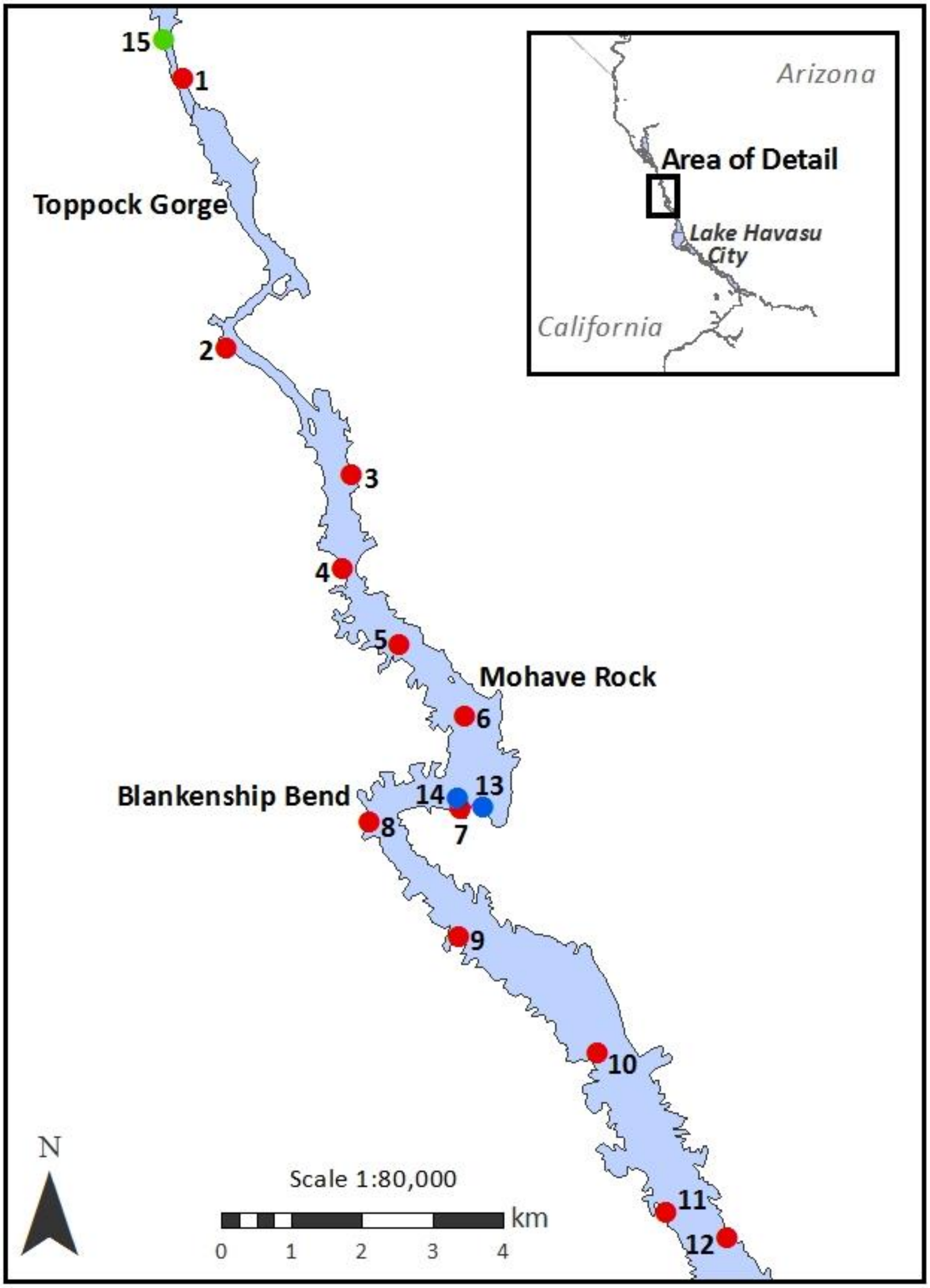

Figure 5.—Location of SURs deployed on October 21, 2013 (red), November 11, 2013 (blue), and November 13, 2013 (green).

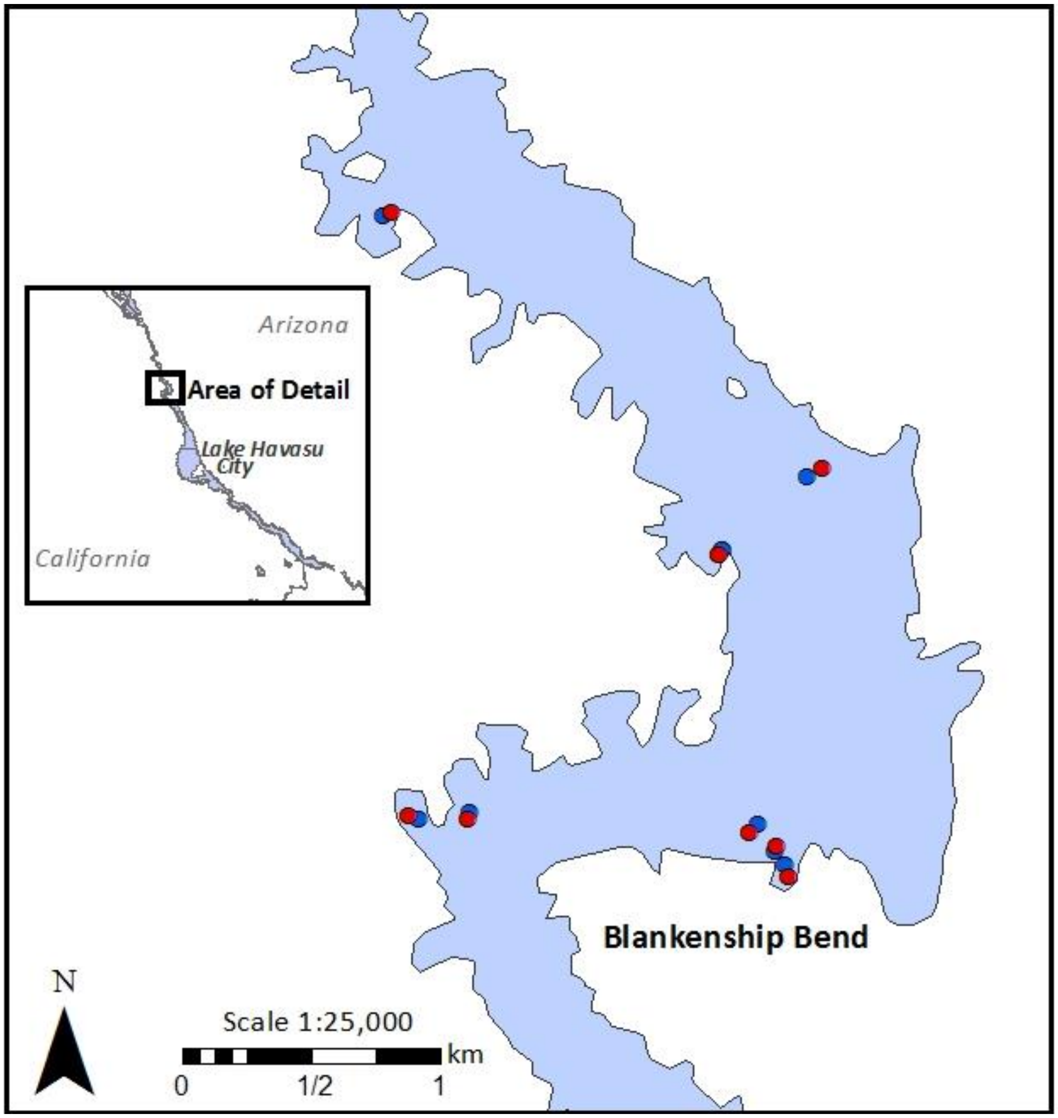

Figure 6.—Locations of PIT scanning antennas deployed either vertically (blue) or horizontally (red) during the autumn study.

Blankenship Bend and other sites bonytail were expected to occupy. Deployments were generally near shore in water less than about 3 m.

Each submersible unit was made of a 0.8 x 1.4 m polyvinyl chloride (PVC) frame antenna attached to a scanner, logger, and a 10.4 amp-hour battery contained in watertight PVC and acrylonitrile butadiene styrene piping.

The unit was completely submerged during use and tied to a secure object to prevent movement while in use. Scanning was continuous for up to 60 hours per deployment. Two PIT scanners were placed within close proximity to one another in different orientations to compare effectiveness in contacting PIT-tagged bonytail. One antenna was deployed horizontally with all sides contacting the substrate, and the other was oriented vertically with only the bottom edge contacting the substrate.

RESULTS

Spring 2013

All six bonytail released on April 17 were confirmed mortalities (transmitters recovered via diver) by April 29, 2013, less than 2 weeks after release (figure 7). All fish were contacted and recovered within 3,000 m of release site.[1] All fish were first contacted at the site of tag recovery within the first week post-release (figure 8). One tag (Tag ID 3) was recovered at a known roosting site of double-crested cormorant (*Phalacrocorax auritus*) (figure 9). This site was scanned by snorkeling for PIT tags in May and June 2013, and 11 PIT tags were contacted (table 3). None of these tags were from telemetered fish.

Autumn 2013

All 10 fish were contacted the day of release, October 21, 2013, within 1,000 m of their release site (figure 10). Bonytail released within backwater habitat continued to be contacted exclusively within the area of their release for 9 days post-release. Bonytail released in the river were contacted as far upstream as SUR 5 (2,202 m from the release site) (see figure 5) within the first week post-release. No fish moved downstream from the release site until October 27, 2013, when fish 261 was contacted on SUR 10 (4,478 m from the release site) (see figure 5).

[1] Tag #4 had several passive contacts on a SUR deployed at Black Meadow Landing (> 9 km from the release site) on April 24, 2013, but the fish was never contacted via active tracking outside of the Bill Williams River NWR. It was recovered near the Bill Williams River NWR buoy line on April 29, 2013.

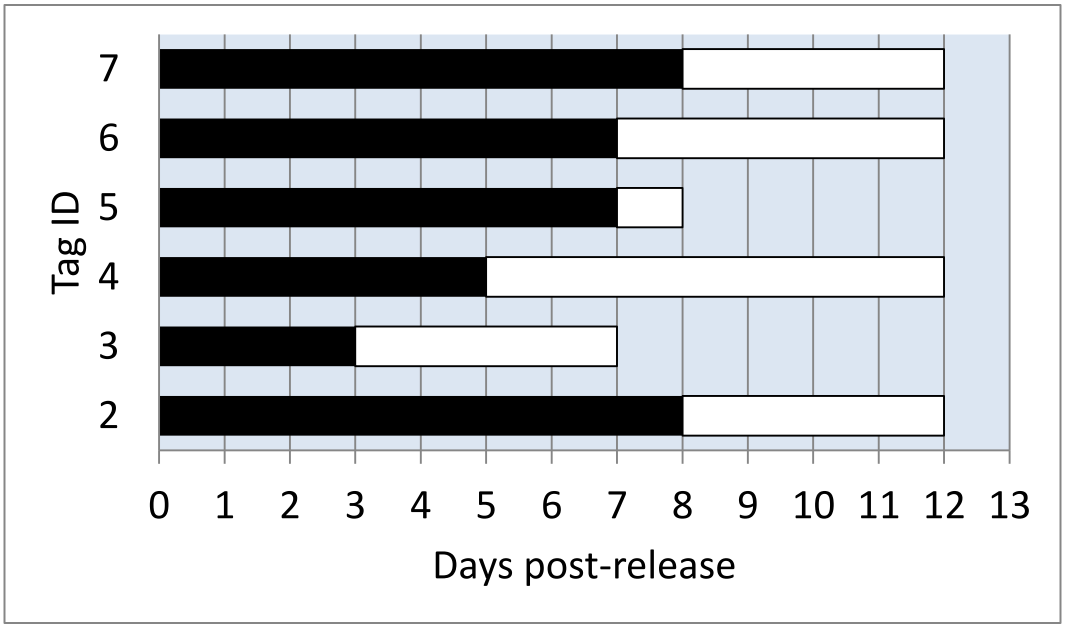

Figure 7.—Days at large for bonytail released in Bill Williams River NWR on April 17, 2013.
Black bars indicate the number of days the tag was active and presumed alive. White bars indicate the number of days the tag was sessile and presumed dead until its eventual recovery.

Figure 8.—Map of release (pink) and final (blue) fate locations for six bonytail released in Bill Williams River NWR on April 17, 2013.

Figure 9.—Photograph of woody debris occupied by double-crested cormorant at a site where 1 acoustic tag from this study and 11 PIT tags were later scanned via snorkelers.

Figure 10.—Map of release (pink) and contact (blue) locations for 10 bonytail the day they were released near Blankenship Bend on October 22, 2013.

Table 3.—Data associated with 11 bonytail tags recovered at a known roosting site of double-crested cormorant during May and June 2013 (All fish were released on the Bill Williams River NWR.)

PIT tag number	Release date	Sex	TL (mm)	Number stocked	Comments
1C2D9AA594	11/29/2011	U[1]	376	2113	TL is from the average of the subset measured at the USFWS's Southwestern Native Aquatic Resources & Recovery Center, Dexter, New Mexico
1C2DD7C075	4/17/2013	J[2]	305	2314	TL is the average from the batch
1C2DDB91A5	4/17/2013	J	305	2314	TL is the average from the batch
1C2DDBF6B4	4/17/2013	J	305	2314	TL is the average from the batch
1C2DE195B1	4/17/2013	J	305	2314	TL is the average from the batch
1C2DE1C20D	4/17/2013	J	305	2314	TL is the average from the batch
1C2DE1C887	4/17/2013	J	305	2314	TL is the average from the batch
36F2B261FE	4/17/2013	J	305	2314	TL is the average from the batch
36F2B272E8	10/8/2012	J	320	1998	TL is the mean TL provided by the hatchery on the stocking slip
36F2B27E59	10/8/2012	J	320	1998	TL is the mean TL provided by the hatchery on the stocking slip
36F2B27F0E	10/8/2012	J	320	1998	TL is the mean TL provided by the hatchery on the stocking slip

[1] Undetermined.
[2] Juvenile.

Test deployments of PIT scanners in the Blankenship Bend area during the October 2013 telemetry study resulted in 1648.6 hours of scanning and contact with 33 razorback sucker and 166 unknown contacts; the last presumed but yet to be confirmed as bonytail released during this study. Additionally, deploying PIT scanners vertically with only the bottom edge contacting the substrate resulted in more contact than those oriented flat with all sides contacting the substrate.

DISCUSSION

The complete loss of bonytail released in the Bill Williams River NWR within 2 weeks post-release was likely not representative of the mortality schedule of a typical stocking. Previous telemetry studies have documented significant post-stocking mortalities (Karam et al. 2012; Minckley 2006) but not at the rate experienced in April 2013. These fish were likely consumed by a fish or bird after being released (no carcasses were recovered), and there is at least equivocal evidence that these fish may have been more vulnerable to predation due to poor health or other conditions upon release.[2]

Given the short duration of the spring study and the autumn study not concluding until January 17, 2014, no conclusions can be drawn from the first year of data on habitat use. However, the first year's data have confirmed that intensive acoustic tracking can provide estimates of post-release survival and guide PIT scanning efforts to locations of bonytail concentrations.

RECOMMENDATIONS

The following recommendations are suggested to improve survival of bonytail stocked into Lake Havasu:

1. Continue to PIT tag a proportion of bonytail stocked into Lake Havasu
2. Experimentally study the role of turbidity on bonytail survival
3. Continue yearly net monitoring of bonytail
4. Continue outreach to the general public

[2] Approximately 450 bonytail from the same shipment as the telemetry fish were transported to the USFWS Achii Hanyo Native Fish Rearing Facility at Parker, Arizona. About 300 of these were redistributed on April 14 to Davis Cove on Lake Mohave, where they had 66 percent survival through June 2014. However, all of the 150 fish that remained at Achii Hanyo were dead within a few weeks (J. Lantow 2013, personal communication).

ACKNOWLEDGMENTS

Collections were permitted under the authorization of USFWS and the States of Arizona and California. The care and use of fish in this study were approved under Arizona State University (ASU) Institutional Animal Care and Use Committee Protocol Numbers 05-767R and 08-959R. This project was made possible with cooperation from M. Ulibarri, W. Knight, and other staff (Southwestern Native Aquatic Resources & Recovery Center, Dexter, New Mexico), M. Thorson, T. Knecht, and R. Randall (Arizona Fish and Wildlife Conservation Office, Parker, Arizona), D. Gilbert and staff (Bill Williams River NWR, Parker, Arizona), J. Lantow, J. Anderson, and A. Finnegan (Lower Colorado River Multi-Species Conservation Office – Boulder City, Nevada), D. Gray (Central Arizona Project, Phoenix, Arizona), K. Koch (Bureau of Land Management, Lake Havasu, Arizona), J. Guthrie (Arizona State Parks, Lake Havasu, Arizona), C. Ehlo and W. Massure (Marsh and Associates, LLC), and T. Dowling and M. Saltzgiver (ASU, Tempe [now with Wayne State University, Detroit, Michigan]). This work was supported under Reclamation Agreement Number R13PD30019.

LITERATURE CITED

Bureau of Reclamation (Reclamation). 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Final. Sacramento, CA.

Dill, W.A. 1944. The fishery of the lower Colorado River. California Fish and Game 30:109–211.

Doelker, A. 1994. Lake Havasu Fisheries Improvement Program Native Fish Management Plan Summary of Activities, May 1993 through December 1994. U.S. Bureau of Land Management, Lake Havasu City, AZ. 23 p.

Karam, A.P., B.R. Kesner, and P.C. Marsh. 2008. Acoustic telemetry to assess post-stocking dispersal and mortality of razorback sucker *Xyrauchen texanus*. Journal of Fish Biology 73:719–727.

Karam A.P. and P.C. Marsh. 2010. Predation of adult razorback sucker and bonytail by striped bass in Lake Mohave, Arizona-Nevada. Western North American Naturalist 70:117–120.

Karam, A.P., C.M. Adelsberger, and P.C. Marsh. 2012. Distribution and Post-Stocking Survival of Bonytail in Lake Havasu, 2011 Annual Report. Prepared under Reclamation Agreement No. R10PC30171 for the Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, NV, by Marsh & Associates, LLC, Tempe, AZ. 75 p.

Lantow, J.C. 2013. Bureau of Reclamation, Boulder City, NV.

Marsh, P.C. 1996. Threatened fishes of the world: *Xyrauchen texanus* (Abbott, 1860) (Catostomidae). Environmental Biology of Fishes 45:258.

Marsh, P.C. 2004. Threatened fishes of the world: *Gila elegans* (Baird and Girard 1953) (Cyprinidae). Environmental Biology of Fishes 70:144.

Marsh, P.C. and G.A. Mueller. 1997. Sonic Telemetry of Bonytail in Lake Mohave, Arizona and Nevada, Final Report. Prepared under U.S. Geological Survey Biological Resources Division Agreement No. 1445-0009-94-1108, Denver, CO, by Arizona State University, Tempe. 18 p. + figures.

Marsh, P.C., G.A. Mueller, and M.R. Schwemm. 2013. Diel cover use and local site fidelity of a large southwestern cyprinid, Bonytail *Gila elegans* in a lower Colorado River backwater. Western North American Naturalist 73:211–218.

Martinsen, B. and T.E. Horsberg. 1995. Comparative single-dose pharmacokinetics of four quinolones, oxolinic acid, flumequine, sarafloxacin, and enrofloxacin in Atlantic salmon (*Salmo salar*) held in seawater at 10 ºC. Antimicrobial Agents and Chemotherapy 39(5):1059–1064.

Minckley, C.O. 2006. Sonic Telemetry of Bonytail in Lake Havasu, AZ-CA. USFWS-AZFROPA-06-011. U.S. Fish and Wildlife Service, Parker, AZ. 18 p.

Minckley, C.O. and M.S. Thorson. 2007. A review of the distribution and management of bonytail in the Lower Colorado River Basin. American Fisheries Society Symposium 53:129–134.

Minckley, W.L. 1979. Aquatic Habitats and Fishes of the Lower Colorado River, Southwestern United States, Final Report. Prepared under Contract Number 194-06-300-2529 for the Bureau of Reclamation, Boulder City, NV, by Arizona State University, Tempe, AZ.

Minckley, W.L. and J.E. Deacon. 1991. Battle Against Extinction: Native Fish Management in the American West. University of Arizona Press, Tucson, AZ.

Moffett, J.W. 1942. A fishery survey of the Colorado River below Boulder Dam. California Fish and Game 28:76–86.

Mueller, G.A. 2003. The Role of Stocking in the Reestablishment and Augmentation of Native Fish in the Lower Colorado River Mainstem (1998–2002). Open-File Report 03-288. U.S. Geological Survey, Denver, CO. 43 p.

Mueller, G.A., P.C. Marsh, G. Knowles, and T. Wolters. 2000. Distribution, movements, and habitat use of razorback sucker (*Xyrauchen texanus*) in a lower Colorado River reservoir, Arizona-Nevada. Western North American Naturalist 60:180–187.

Mueller, G.A. and P.C. Marsh. 2002. Lost, A Desert River and its Native Fishes: A Historical Perspective of the Lower Colorado River. Information and Technology Report USGS/BRD/ITR–2002–0010: U.S. Government Printing Office, Denver, CO. 69 p.

Pacey, C.A. 2013. Marsh & Associates, LLC, Tempe, AZ, personal communication.

Pacey, C.A. and P.C. Marsh. 1998. Resource Use by Native and Non-native Fishes of the Lower Colorado River – Literature Review, Summary, and Assessment of Relative Roles of Biotic and Abiotic Factors in Management of an Imperiled Indigenous Ichthyofauna, Final Report. Prepared under Agreement No. 7-MT-30-R0012 for the Bureau of Reclamation, Boulder City, NV, by Arizona State University, Tempe. 70 p. + tables, appendices.

Reisner, M. 1986. Cadillac Desert: The American West and its Disappearing Water. Penguin Books, New York. 582 p.

Schooley, J.D., B.R. Kesner, J.R. Campbell, J.M. Barkstedt, and P.C. Marsh. 2008. Survival of Razorback Sucker in the Lower Colorado River, Final Report. Prepared under Reclamation Agreement No. 06-FC-30-0002 for the Lower Colorado River Multi-Species Conservation Program, Boulder City, NV, by Arizona State University, Tempe. 30 p. + figures, tables.

U.S. Fish and Wildlife Service (USFWS). 1980. Bonytail Chub; Determination as an Endangered Species. Federal Register 44:27710–27713.

______. 1991. Endangered and Threatened Wildlife and Plants; the Razorback Sucker (*Xyrauchen texanus*) Determined to be an Endangered Species; Final Rule. Federal Register 56:54957–54967.