Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Distribution and Post-Stocking Survival of Bonytail in Lake Havasu

2014 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

December 2014

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Lower Colorado River Multi-Species Conservation Program

Distribution and Post-Stocking Survival of Bonytail in Lake Havasu

2014 Annual Report

Prepared by:

Kristen G. Humphrey, Brian R. Kesner, and Paul C. Marsh

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

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ACRONYMS AND ABBREVIATIONS

ABS	acrylonitrile butadiene styrene
Achii Hanyo	Achii Hanyo Native Fish Rearing Facility
amp-hr	ampere-hour(s)
ASU	Arizona State University
Bill Williams River NWR	Bill Williams River National Wildlife Refuge
BLM	Bureau of Land Management
CAP	Central Arizona Project
cm	centimeter(s)
CPUE	catch per unit effort
FIP	Fishery Improvement Project
g	gram(s)
kHz	kilohertz
km	kilometer(s)
km/day	kilometer(s) per day
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
M	gram(s)
M&A	Marsh & Associates, LLC
mg/L	milligrams per liter
mm	millimeter(s)
NTU	nephelometric turbidity unit
PIT	passive integrated transponder
PVC	polyvinyl chloride
Reclamation	Bureau of Reclamation
SNARCC	Southwest Native Aquatic Resources & Recovery Center
SUR	submersible ultrasonic receiver
TL	total length
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Symbols

°C	degrees Celsius
%	percent

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2 Individual Fish Narratives for April – May 2014 Bonytail Telemetry

EXECUTIVE SUMMARY

Bonytail (*Gila elegans*) is federally listed as endangered and considered functionally extirpated from its historical range, and its presence in the Colorado River Basin now relies entirely on stocking programs. Lake Havasu, Arizona, California, and Nevada, is one of the few release locations for hatchery fish and sites where stocked individuals are occasionally captured. Information regarding the basic ecology of this species is limited to past field observations and a small number of telemetry projects in the basin. The result is a lack of knowledge regarding how to better inform managers of the post-stocking fate and habitat use of hatchery-reared bonytail.

We completed the second and third iterations of an acoustic telemetry study, and a first iteration of remote passive integrated transponder (PIT) scanning within Lake Havasu, this year. Bonytail were surgically implanted with acoustic tags and released near Blankenship Bend on two occasions. Ten tagged bonytail were released in October 2013 and 12 were released in April 2014. A directional hydrophone and receiver were used to actively track study fish, and multiple submersible ultrasonic receivers (SURs) were placed throughout the study area for passive tracking. Fish were tracked intensively for 4 weeks and then periodically for the following 60 days in the autumn study and intensively for 6 weeks during the spring study. Additionally, from January to February 2014, remote PIT scanners were deployed to monitor PIT-tagged bonytail released in Blankenship Bend. In February 2014, Marsh & Associates, LLC, participated in the week-long multi-agency Native Fish Netting "Roundup" at Lake Havasu. During this event, fish sampling was conducted predominately through trammel netting efforts.

During the autumn telemetry study, three bonytail were determined dead within 13 weeks post-release, contact was lost with six study fish, and one tag was still active by the end of the study (N = 10). Study fish released into the main channel in autumn 2013 were the only fish to disperse out of Blankenship Bend, as fish released into the backwater remained in the vicinity of Blankenship Bend throughout the study. Autumn 2013 main channel released fish were contacted farther up- and downstream (difference in mean up- and downstream dispersal of 4.6 kilometers [km] from the release site) than backwater released fish. Autumn 2013 passive contacts between sunset and sunrise comprised 57 percent (%) of total passive contacts.

During the spring telemetry study, only one fish was determined dead, contact was lost with six study fish, and five fish were still active 6 weeks post-stocking (N = 12). Backwater released fish from spring 2014 spent 64% of days tracked in Blankenship Bend compared to main channel released fish spending only 40% of days tracked in Blankenship Bend. Total number of days tracked was adjusted for each fish depending on study season and time of determined mortality. Spring 2014 main channel released fish were also contacted farther upstream (difference

in mean upstream dispersal of 5.7 km from the release site) but less downstream (difference in mean downstream dispersal of 3.0 km) than backwater released fish. During the spring 2014 telemetry tracking, passive contacts between sunset and sunrise comprised 84% of total passive contacts.

Out of a total of 22 telemetry tagged bonytail for the year, 12 were permanently lost to the study within the first 5 weeks after release. The majority of these fish (67%) were last located within the study area and were not contacted by SURs specifically placed in locations to detect fish leaving the study area. Loss of contact with these tags may have been due to removal from the system (for example, by an avian predator), tag failure, or a result of our inability to detect a signal even though the tag was present and functioning properly.

Over the course of PIT scanning, 124 unique bonytail were contacted, 10 of which were released in October 2013. Most contacts occurred during the week of release and within 2 km of the release location, after which contacts steeply declined. Besides release location, 11 PIT-tagged bonytail were contacted in Trampas Cove, and one was contacted in Clear Bay. Trammel netting efforts in February 2014 during the multi-agency Native Fish Netting “Roundup” captured eight bonytail, one of which was inside the digestive tract of a largemouth bass.

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 river is designated as Reach 3 of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) 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 reservoir portion of this reach extends from Parker Dam upstream to Lake Havasu City, approximately 45 river km, and upstream of 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 endemic to the region and federally listed as endangered (U.S. Fish and Wildlife Service [USFWS] 1980, 1991). Additionally, bonytail is considered functionally extirpated from its historical range (Marsh 2004), and its persistence in the Colorado River Basin now relies entirely on stocking (Bureau of Reclamation [Reclamation] 2004; Minckley and Thorson 2007).

Since 1981 when augmentation began, approximately 209,502 bonytail have been stocked into Lake Havasu, of which 305 have been recaptured during routine monitoring (Pacey 2014, personal communication). Capture events are an indirect result of the Lake Havasu Fishery Improvement Project (FIP), which was initiated in 1993 in part to help re-establish bonytail and razorback sucker populations within the reservoir (Doelker 1994). The stocking goal of 30,000 bonytail greater than 250 millimeters (mm) total length (TL) established by FIP was achieved in 2003 (Minckley and Thorson 2007). Since 2006 and for the next 42 years, the LCR MSCP will stock 4,000 bonytail per year greater than 300 mm TL into Reach 3 (Reclamation 2004). To date, the program has stocked approximately 37,600 bonytail in the reservoir, of which approximately 16,400 were passive integrated transponder (PIT) tagged prior to release.

Bonytail monitoring in the reservoir is accomplished through combined efforts of the USFWS, U.S. Geological Survey (USGS), Reclamation, Bureau of Land Management (BLM), California Department of Wildlife, Arizona Game and Fish Department and public volunteers. Surveys are performed in February and involve trammel netting between the Bill Williams River National Wildlife Refuge (Bill Williams River NWR) and Moabi Regional Park near Needles, California, and extensive boat electroshocking between Needles and Laughlin,

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

Nevada. Out of the 305 bonytail encountered during monitoring, 80 were PIT tagged upon release (unpublished data), and only three of these were recaptured more than a year after stocking, suggesting that stocking in the reach has failed to establish a persistent population.

Previous telemetry studies in the Lower Colorado River Basin have involved examining habitat use of bonytail. A telemetry study on Lake Mohave tracked bonytail into deeper portions of the lake during the day and shallower shoreline habitat at night (Marsh and Mueller 1999). A separate study at Cibola High Levee Pond documented bonytail use of riprap shoreline during daylight and movement into open waters at night (Mueller et al. 2003; Marsh et al. 2013a). In a study completed on 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 NWR, concluding that (1) PIT-tagged bonytail could be reliably contacted by remote PIT scanners 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; Schooley 2010).

We are in the process of implementing a multi-year research project on Lake Havasu in which we will continue to document the post-stocking distribution, habitat use, and mortality of bonytail. For all of our investigations, inferences regarding post-stocking habitat use are based on where study fish are contacted over time. No analysis was conducted on the availability of habitat in the release area, so individual or third order habitat selection is not implied or investigated (*sensu* Martin et al. 2009). The goal of this research is to document post-stocking distribution and survival and guide future stocking endeavors in the reservoir. 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. Up to three release sites may be chosen: 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. Each release site requires a minimum of 1 month of monitoring.

4. Identifying specific habitat types used or preferred by this species within each release site.

5. 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 by this project in addition to other Federal and non-Federal entities.

Secondary Objectives

1. Participation 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

Passive and active remote sensing technologies were applied to each of our study sites to meet primary objectives 1 and 2. Passive sampling was achieved using an array of submersible ultrasonic receivers (SURs) and PIT scanning units, while active sampling was conducted by boat using a directional or towable omnidirectional hydrophone. During the autumn and spring studies, acoustic tags were surgically implanted into 10 and 12 bonytail, respectively. Intensive active sampling began immediately following spring and autumn releases. Remote PIT scanning systems were deployed in the winter. 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).

Study Area

Lake Havasu (see figure 1) is impounded by Parker Dam, which was completed by Reclamation in 1938. The dam creates a 7.98×10^8 cubic meter storage capacity reservoir and generates hydroelectric power for the Metropolitan Water District of Southern California and for utilities in Arizona, California, and Nevada. The Bill Williams River NWR occupies the southeast terminus of

Lake Havasu (figure 2). The Lake Havasu Basin extends to the northern reach of Windsor Basin at the Colorado River inflow near Lake Havasu City. Upstream of Windsor Basin, the Colorado River forms a braided channel for approximately 10 km, much of which is within the boundaries of Lake Havasu National Wildlife Refuge and filled with an extensive network of backwaters that continue through Topock Gorge. Between Topock Gorge and Davis Dam, the Colorado River is sinuous and channelized, flowing through urban areas and farmlands surrounding Laughlin, Nevada, Mohave Valley, and Needles, California (figure 3).

Telemetry studies were conducted near Blankenship Bend in autumn 2013 and spring 2014 in an attempt to compare seasonal variability (figure 4). The termini of the study area were determined by the most up- and downstream SURs, from the sand dunes and the USGS gaging station to Castle Rock and the basin. Blankenship Bend is composed of an upper and lower bend and was bound by SURs deployed at the refuge's no boater zone and Rearing Cove (figure 5). A previous telemetry study was completed in the Bill Williams River NWR in spring 2013. At the conclusion of 2015, both the Blankenship Bend and Bill Williams River NWR study areas will have been sampled during both spring and autumn seasons. The separate study areas were chosen to represent different habitats within Lake Havasu, focusing on 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.

Bonytail Surgeries

Prior to the stocking of bonytail within Lake Havasu, ten (mean TL=305.9 mm, range= 285 – 325 mm) and twelve (mean TL=346.4 mm, range= 268 – 486 mm) study fish were implanted in autumn 2013 and spring 2014, respectively with PT-4 acoustic transmitters (Sonotronics, Inc.). 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. Fish were identified by the unique tag number assigned by Sonotronics, Inc. A shaded area near the Windsor Beach State Park boat ramp was utilized as the surgery station. Two aerated "recovery" tanks were filled with a 50:50 mixture of lake and hatchery water and placed on the transport boat located near the surgical station. Dissolved oxygen (milligrams per liter [mg/L]) and water temperature (degrees Celsius [°C]) were monitored with a hand-held Hannah Instrument® 9829 multi-parameter water quality probe.

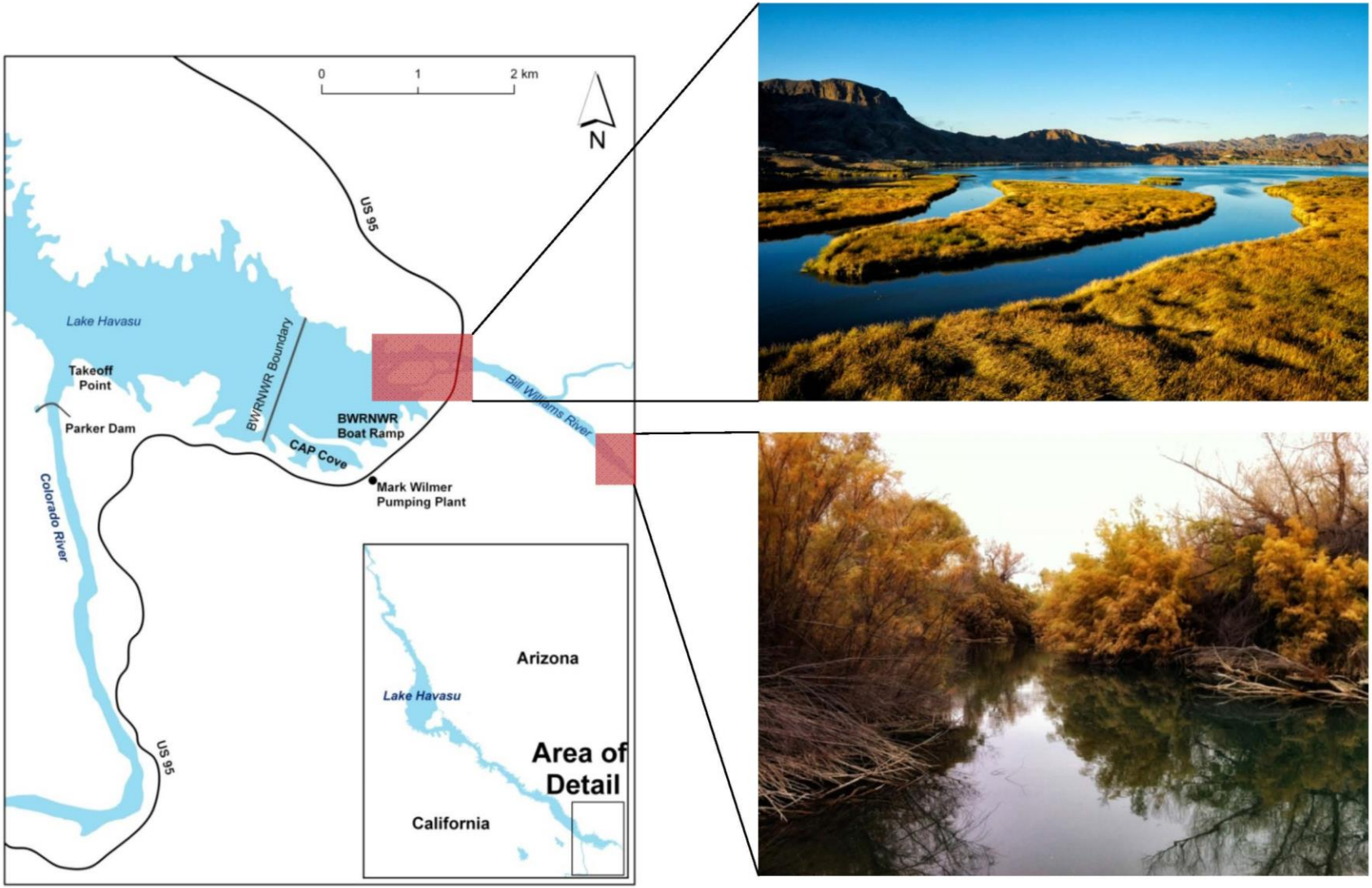

Figure 2.—Map of the watercraft-accessible portion of the Bill Williams River National Wildlife Refuge at the southeast terminus of Lake Havasu, Arizona and California, and photographs of the reach.

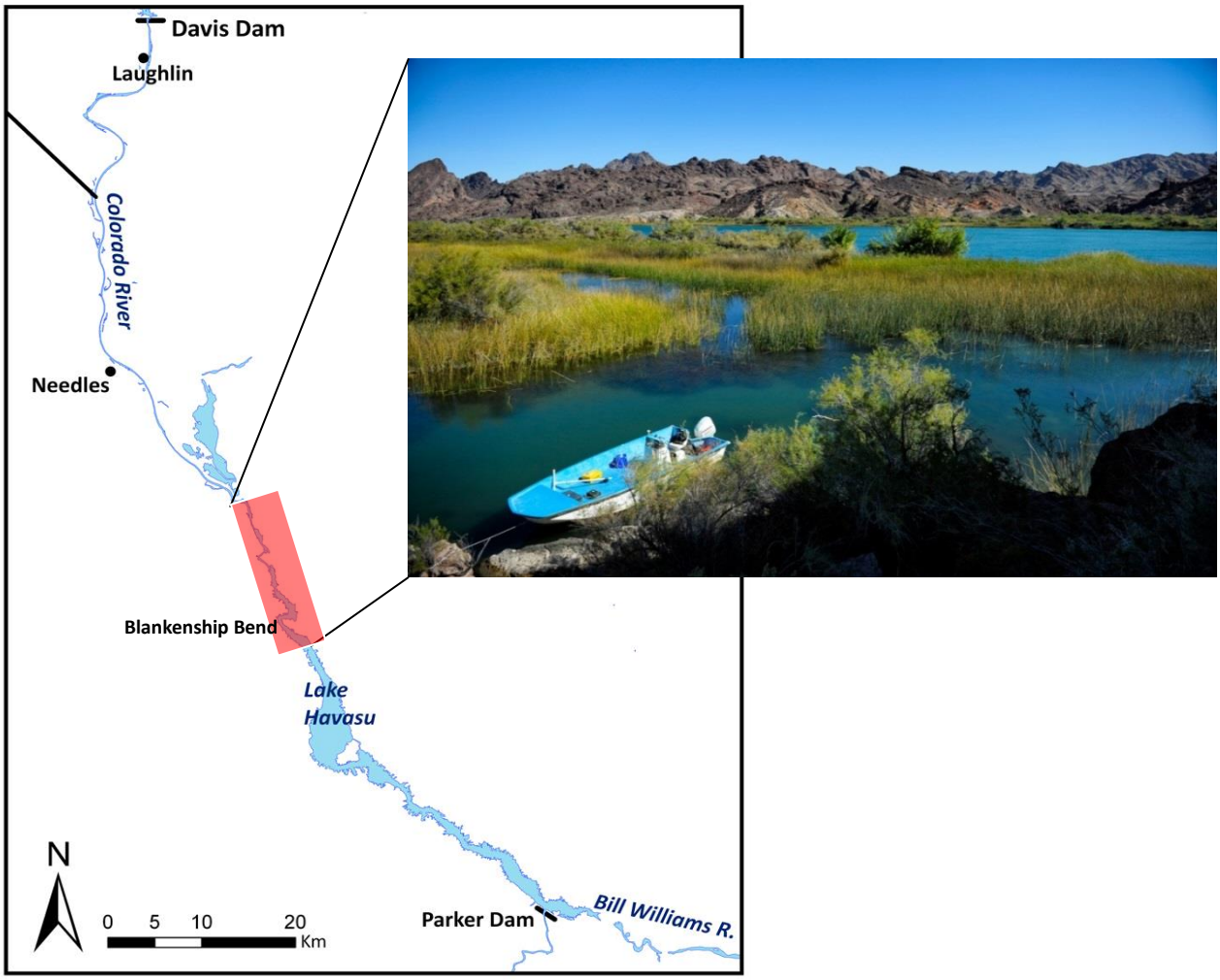

Figure 3.—Map of the Colorado River delta and Topock Gorge near Blankenship Bend, Lake Havasu, Arizona and California, and a photograph of a typical off-channel backwater (foreground) in the reach.

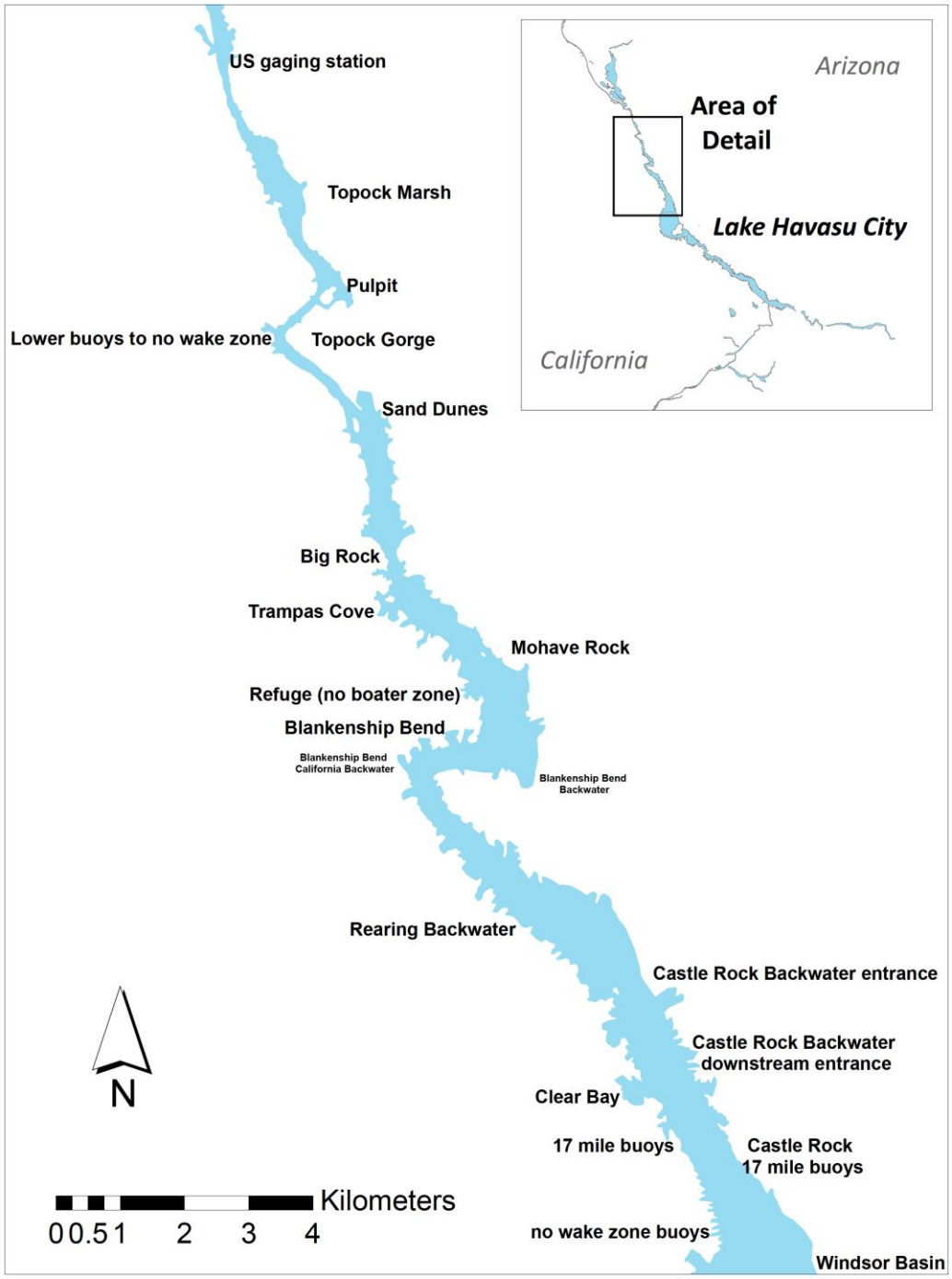

Figure 4.—Map of the Colorado River delta and Topock Gorge near Blankenship Bend, Lake Havasu, Arizona and California, with place names mentioned in text.

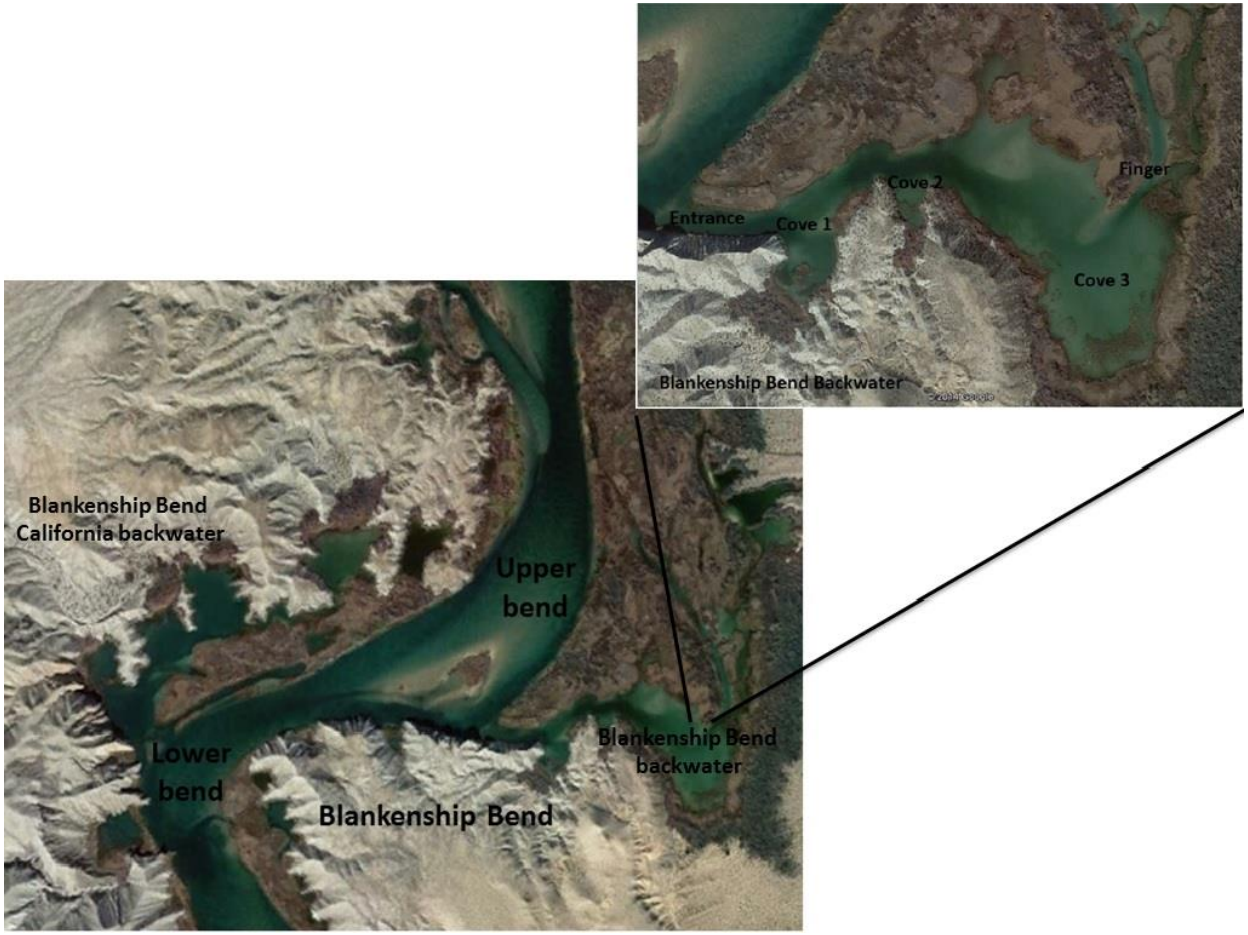

Figure 5.—Map of Blankenship Bend, Colorado River, Arizona and California, with place names mentioned in text.

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 mg/L) 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 millimeter [mm]), weighed (nearest gram [g]), and scanned for a 134-kilohertz (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 solution (125 mg/L) into its mouth and gills. A short (< 2 centimeter [cm]) incision was made slightly anterior and dorsal to the left pelvic fin where a sanitized acoustic tag was then inserted into the abdominal cavity. The incision was sutured with three knots using CP Medical 4/0 Polypro blue monofilament and a NRB-1 cutting needle. Betadine was then swabbed over the incision site, and the antibiotic Baytril was injected using a 10 milligram 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.

Telemetry

Prior to stocking of bonytail, SURs were deployed at different locations throughout the study area. Sites were selected to ensure detection of movement up- or downstream and to determine if fish entered or exited major backwaters. All SURs deployed throughout the study area were attached to a camouflage rope and connected to a 6-meter (m) piece of galvanized cable that was connected to secure on-shore habitat (e.g., 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. The placement of weights ensured 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 was programmed to scan continuously. SURs were positioned throughout the study area targeting passageways of fish movement. Additionally, SURs were placed within backwaters to obtain data on fish entering and exiting these locations. There was no set distance between SUR locations, and deployment relied heavily on availability of secure on-shore habitat. SURs were downloaded routinely or as needed throughout both studies, and confidence values, as defined by the number of detections within a timed window, were calculated using Sonotronics SURsoft Stand Alone Data Processing Center software. Only records from SURs with a confidence of 5 were included in analysis. Data were imported into a Microsoft Access® database used for managing fish contact histories and SUR locations.

Table 1.—Data collected from 10 bonytail surgically implanted with telemetry tags on October 22, 2013, Lake Havasu, Arizona and California.

("Determined dead" is the first date of contact with a sedentary tag, BW is the backwater near Blankenship Bend, and MC is the Colorado River main channel at Blankenship Bend [figure 4]. All fish were released at approximately 14:00 on October 22, 2013.)

Tag ID	TL (mm)	Weight (g)	PIT tag No.	Release location	Easting	Northing	Determined dead
3	315	215	003BA6A6E2	BW	736517	3831393	
4	287	240	003BA6D23D	BW	736517	3831393	11/17/2013
5	285	188	003BA6D365	MC	735515	3831321	
7	306	188	003BA93A5A	MC	735515	3831321	12/18/2013
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	

Table 2.—Data collected from 12 bonytail surgically implanted with telemetry tags on April 8, 2014, Lake Havasu, Arizona and California.

("Determined dead" is the date of first contact with a sedentary tag, BW is the backwater near Blankenship Bend, and MC the Colorado River main channel at Blankenship Bend [figure 4]. All fish were released at approximately 14:24 on April 8, 2014.)

Tag ID	TL (mm)	Weight (g)	PIT tag No.	Release location	Easting	Northing	Determined dead
122	355	302	000B0DA8DE	MC	735760	3831317	
123	362	358	000B0DA8C3	MC	735760	3831317	5/4/2014
124	357	346	1C2D6D1785	MC	735760	3831317	
125	360	363	1C2D6D1707	MC	735760	3831317	
126	337	256	1C2D6D0A0D	MC	735760	3831317	
127	268	132	36F2B26D84	MC	735760	3831317	
137	310	210	1C2D6C07A1	BW	736589	3831463	
138	376	351	1C2D6BF6D8	BW	736589	3831463	
139	340	260	1C2D6B892F	BW	736589	3831463	
140	304	180	1C2D6C3CBB	BW	736589	3831463	
141	302	196	1C2D6C38F0	BW	736589	3831463	
142	486	915	1C2D6BF6DA	BW	736589	3831463	

Active tracking was conducted with a directional (Model DH-4, Sonotronics, Inc.) or omnidirectional towable (Model TH-2, Sonotronics, Inc.) 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 a grid system of 1-km spaced waypoints mimicked from previous acoustic telemetry studies (Mueller et al. 2000; Karam et al. 2008). When the towable hydrophone was used, boat speed was maintained at about 10 km per hour or less to reduce noise interference from the engine and to allow the device to scan for multiple frequencies. Once a fish was detected using the towable hydrophone, the directional hydrophone was used to triangulate its location. Mesohabitat measurements, including turbidity (nephelometric turbidity units [NTUs]), secchi depth (m), surface water temperature (°C), and depth (m), were taken at each point of active tracking triangulation. If individual bonytail displayed continued inhabitance within the same site on a repeated basis during the study, additional fine-scale habitat variables were measured and recorded, including substrate size and type, shoreline type, vegetation, and topography. The first date of three consecutive active tracking events that a fish was found at the same location was determined as its time of death. The time of the last recorded active or passive (SUR) contact with a fish whose signal was permanently lost during the 45 days was determined as the time the fish was lost to the study.

Patterns of dispersal and displacement were assessed for individual fish using Esri® ArcMAP™ Version 10.1. Farthest up- and downstream dispersal was calculated by measuring the river distance between the release site and farthest up- or downstream point of contact by active or passive efforts. Results were within 200 m based on the SUR nominal detection radius. Total straight line displacement was assessed in ArcGIS by creating paths between tracking events for each fish. The total distance of these paths was calculated to provide minimum (straight line) total distance displaced between contacts for each fish and does not account for river sinuosity. Inhabitance in Blankenship Bend was represented by the percentage of days tracked in this area over the total number of days tracked per fish.

Autumn 2013

During autumn 2013, 12 SURs were initially placed throughout Lake Havasu, and 3 SURs were added a few weeks post-stocking (figure 6). SURs were deployed from October 22, 2013 to January 19, 2014. Study fish were propagated and reared at the USFWS Dexter National Fish Hatchery (now Southwest Native Aquatic Resources & Recovery Center [SNARRC], Dexter, New Mexico) and released into Blankenship Bend on October 22, 2013. Acoustic transmitters had a

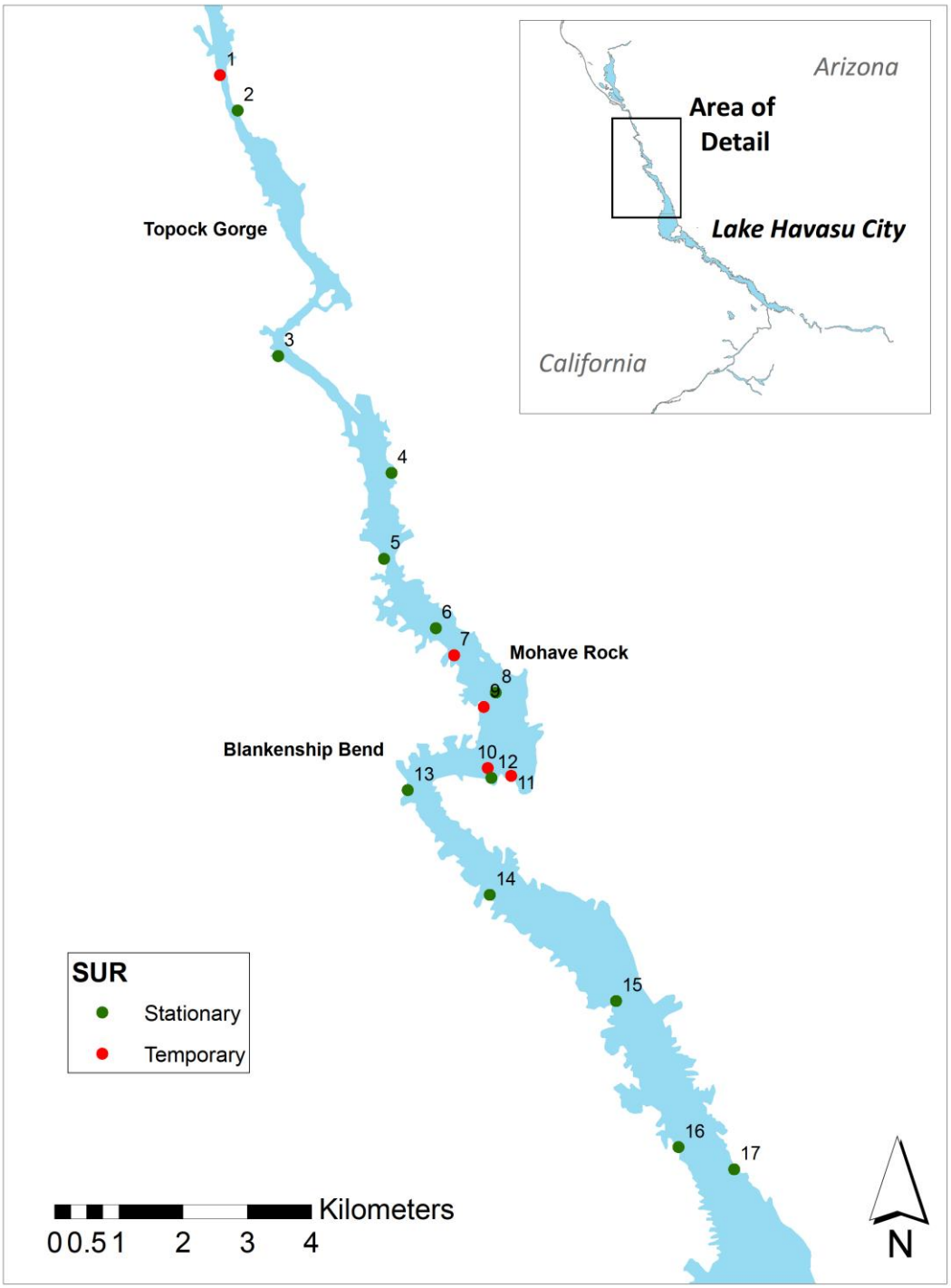

Figure 6.—Locations of submersible ultrasonic receivers deployed on October 21, 2013 (green; stationary), and November 11, 2013, or November 13, 2013 (red; temporary); Lake Havasu, Arizona and California.

standard battery life of three months. Fish were actively tracked by boat each day for the first 4 weeks and once a month within the following 60 days of the autumn 2013 study. Sampling schedules remained flexible to combat weather unpredictability and to adapt to behavioral observations of tracked fish. The majority of sampling was conducted during daylight hours, with one period of night tracking occurring biweekly in the autumn 2013 study.

Spring 2014

Twenty five SURs were deployed in spring 2014, composing 21 permanent sites and 4 temporary sites (figure 7). SURs were deployed from April 8, 2014, to May 21, 2014. Due to an unavailability of hatchery bonytail, spring 2014 study fish were captured from Cibola High Levee Pond and held until release on April 7, 2014. To combat signal detection issues in the complex and highly vegetated backwater systems, acoustic transmitters used were programed with increased power, which decreased nominal battery life to approximately 45 days. Fish were therefore actively tracked by boat each day for 6 weeks during the spring 2014 study. Sampling schedules remained flexible to combat weather unpredictability and to adapt to behavioral observations of tracked fish. Most tracking in the spring 2014 study occurred between sunset and sunrise due to the expectation that bonytail are more active in the evening hours (Marsh et al. 2013a).

Remote PIT Scanning

Remote PIT scanning systems, developed in-house at Marsh & Associates, LLC (M&A), were deployed throughout the Lake Havasu study area following the release of stocked bonytail. Two models of PIT scanners were utilized: shore based and submersible. The shore-based units (e.g., Kesner et al. 2010) were comprised of an antenna and scanner housed in a 2.3 x 0.7 m polyvinyl chloride (PVC) frame connected by 45.7 m of cable to a waterproof box that protects the logger and battery (55 ampere-hours [amp-hr]) and was secured to shore.
The battery provided power to the scanner to run continuously for 72 hours, eliminating the need for manually removing and charging the batteries. Each submersible unit was made of a 0.8 x 0.8 m or 0.7 x 1.3 m PVC frame antenna attached to a scanner, logger, and a 10.4 amp-hr battery contained in watertight PVC and acrylonitrile butadiene styrene (ABS) piping. The unit was completely submerged and tied to a secure object to prevent movement while in use. Scanning was continuous up to 60 hours per deployment. Scanning and recorded data were downloaded, entered, and imported into the M&A online remote sensing database (http://www.nativefishlab.net/?page_id = 479) at the conclusion of the trip.

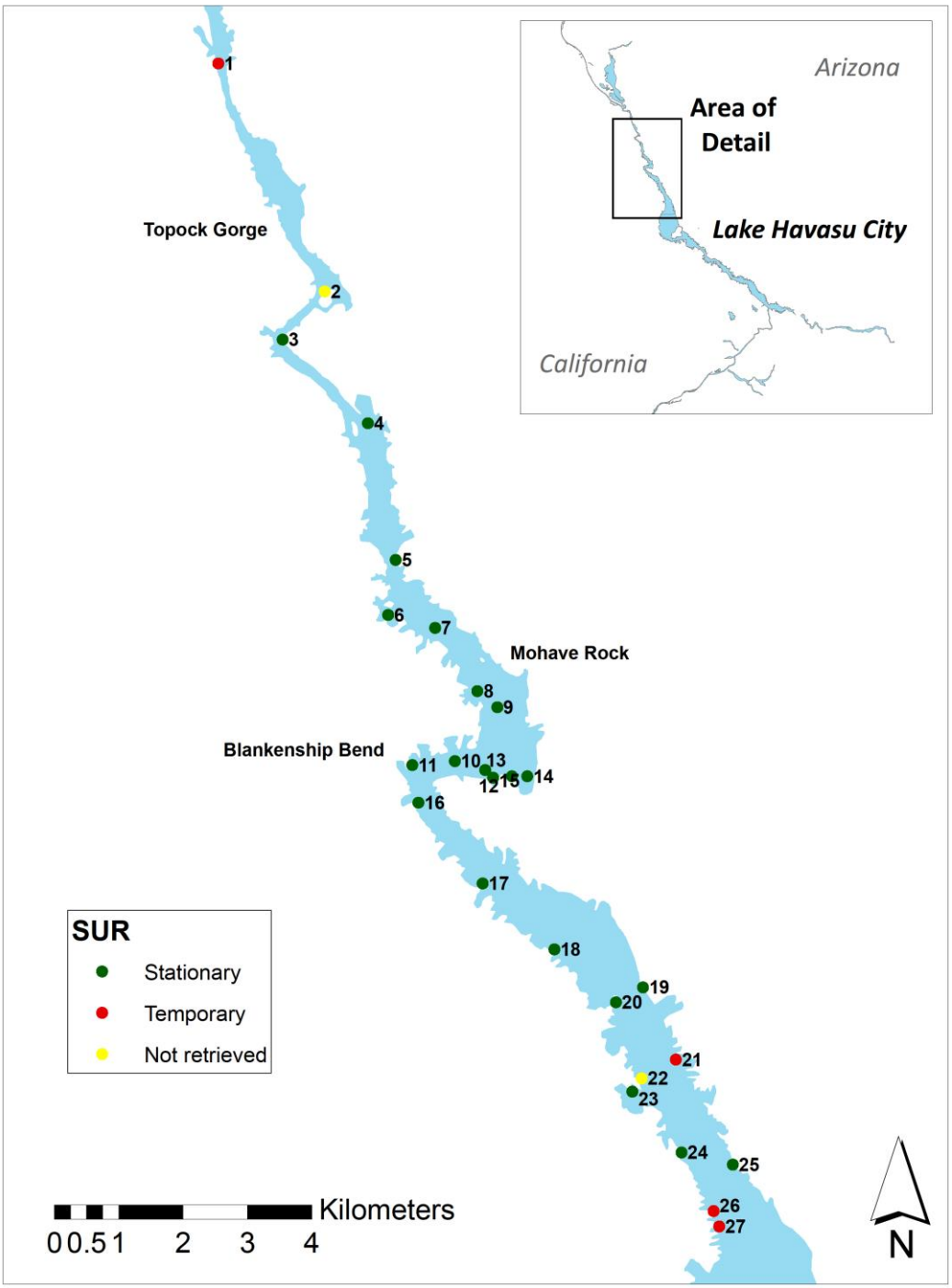

Figure 7.—Locations of submersible ultrasonic receivers deployed on April 7, 2014 (green; stationary), later through the study (red; temporary), and not retrieved (yellow); Lake Havasu, Arizona and California.

Remote PIT scanners were placed at selected locations throughout the Blankenship Bend area multiple times during the autumn 2013 telemetry study (figure 8). 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 (bottom flat), while the other was oriented vertically with only the bottom edge contacting the substrate (bottom long). Locations for PIT scanners were in backwaters surrounding Blankenship Bend and other sites bonytail were suspected to occupy. Deployments were generally near shore in water less than about 3 m deep.

Bonytail harvested in December 2014 from the USFWS Achii Hanyo Native Fish Rearing Facility (Achii Hanyo), Parker, Arizona, and held at Lake Mead Fish Hatchery, Boulder City, Nevada, were released into Blankenship Bend on January 14, 2014. From January 13 to February 28, 2014, submersible and shore-based units were tethered to the shoreline and deployed in Reach 3. Units were deployed within backwaters and in the main channel of the river at up to 297 different sites within nine different locations, including Blankenship Bend, Castle Rock, Clear Bay, Golden Shores, Pulpit, Rearing Cove, Topock Marina Boat Launch, Trampas Cove, and Two Lobe Cove (figure 9). Depth among sites ranged from 0.3 – 9.6 m. During four isolated sampling events, beginning the week of stocking and continuing every other week after for 7 weeks, remote PIT scanners were deployed for up to five consecutive days. PIT scanners were moved to different sites each day if they did not record contacts. Because the area is a popular recreation site, deployments were limited to locations where PIT scanners were inconspicuous and water depth was adequate to avoid collisions with boats. Unlike autumn PIT scanning in which scanners were deployed in pairs to compare orientation effectiveness, winter PIT scanning was designed to track post-stocking dispersal and survival; therefore deployment locations were given priority by habitat type, targeting shallow areas within backwaters, eddies within the main channel, and areas with extensive cover.

2014 Lake Havasu Native Fish Netting “Roundup”

From February 10 – 12, 2014, M&A participated in the multi-agency Native Fish Netting “Roundup” on Lake Havasu. Eleven fixed reaches, including Blankenship Bend and south of Blankenship Bend, Clear Bay and north of Clear Bay, Mohave Rock, Park Moabi, Picture Rock, Pulpit, Rearing Cove, Trampas Cove, and Two Lobe Cove were sampled using trammel nets. Forty-eight trammel nets (45.7 x 1.8 m, 3.8-cm stretch mesh, 30.5-cm bar outer wall) were deployed in overnight sets along the shore of Lake Havasu. Nets were set in the late afternoon, checked and retrieved the following morning, and then re-deployed in a new location later that afternoon for three consecutive nights. All fish were

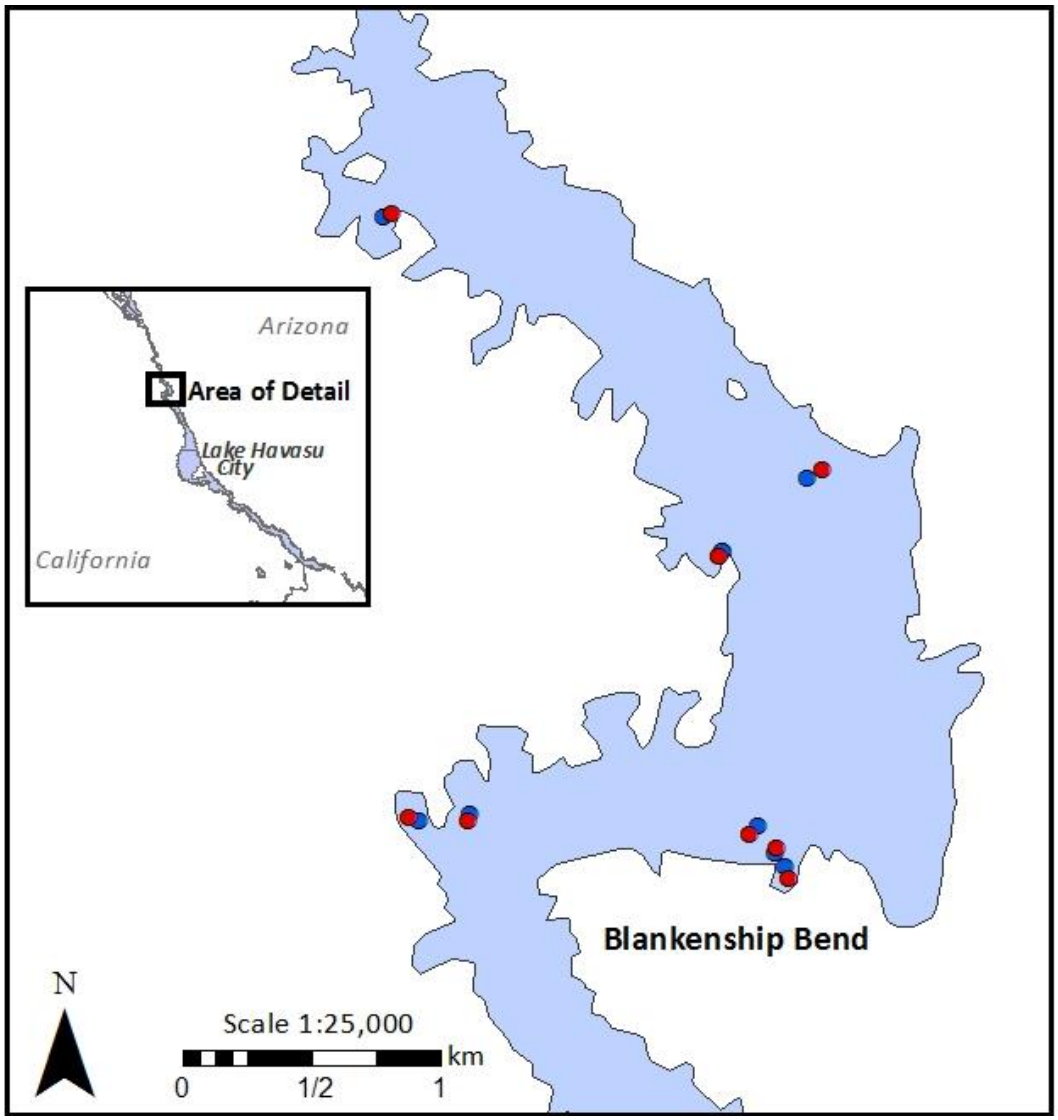

Figure 8.—Locations of remote passive integrated transponder scanning antennas deployed either vertically (blue) or horizontally (red) during the October 2013 – January 2014 telemetry study, Lake Havasu, Arizona and California.

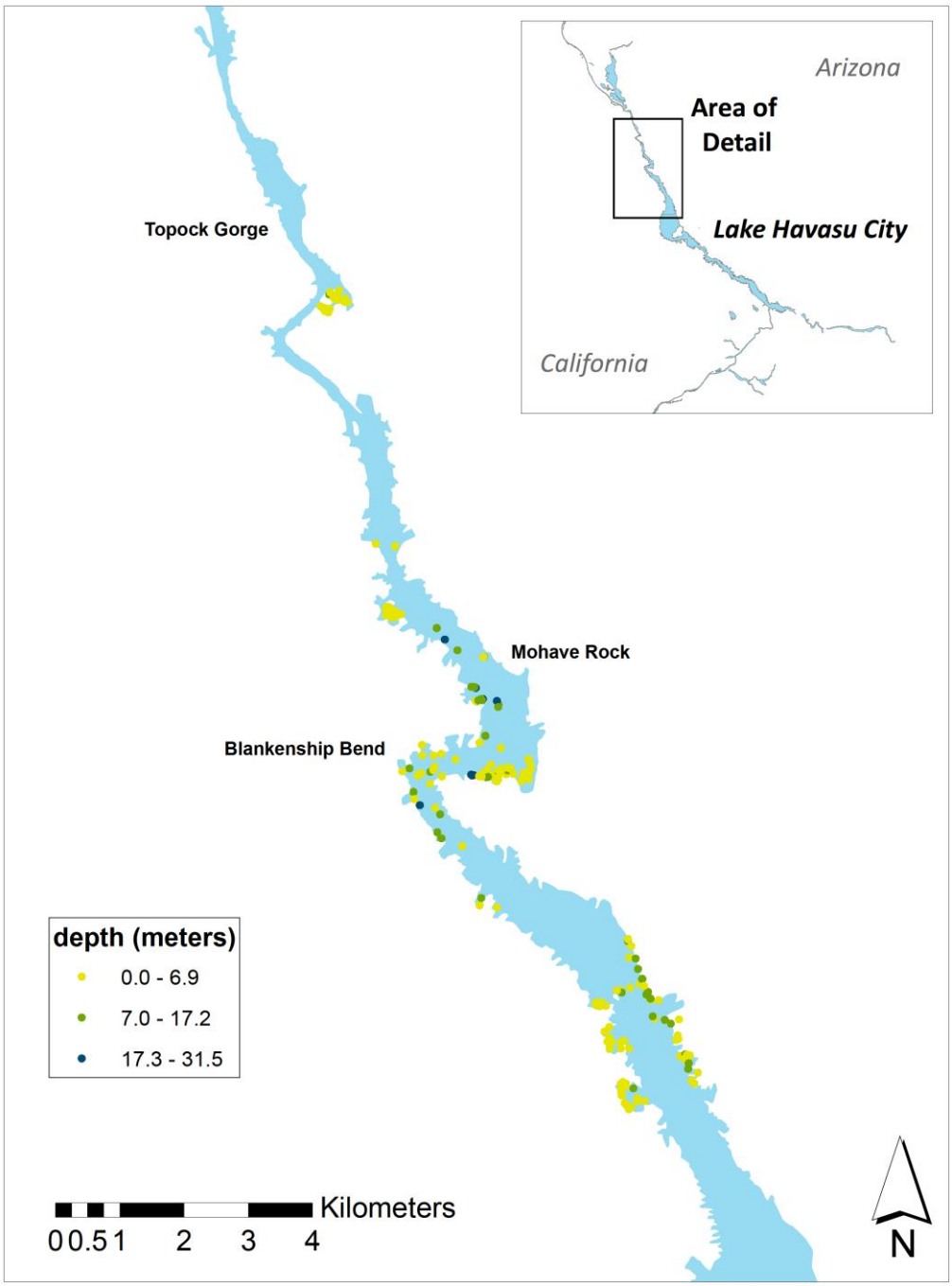

Figure 9.—Locations of remote passive integrated transponder scanning antennas deployed from January – February 2014, Lake Havasu, Arizona and California. PIT scanners deployed at greater depths are represented by darker colors.

removed and processed daily, and if a native species, enumerated, measured for TL (mm), weighed (g), sexed, scanned for a wire or 134-kHz PIT tag, and tagged if none was present.

RESULTS

Autumn 2013 Telemetry

Ten fish were released near Blankenship Bend in autumn 2013 and over the course of the study, 98,873 contacts were recorded by active and passive tracking. Of those contacts, 100 were recorded by active tracking, and 98,773 (99.9%) were recorded by passive tracking (figure 10). Passive contacts between sunset and sunrise comprised 57% of total passive contacts. All bonytail were located during the first week post-stocking; however, contacts per week declined following the first week (figure 11). Study fish were tracked for a mean of 28.4 days (range 0 – 86 days) (table 3). Mean number of contacts per fish was 10 (range 1 – 20, median 9.5) active contacts and 9,877 (range 0 – 50,172, median 3,449) passive contacts.

Post-Stocking Mortality and Transmitter Recovery

The majority of actively tracked bonytail within the study area were contacted on a weekly basis (figure 12), and only one fish that was actively tracked (fish 262) had more than a 1-week gap between contacts. However, losses to the study were high. Five of 10 fish (50%) were lost to the study (never contacted again, two backwater released fish and three main channel released fish), and two others were confirmed mortalities (tags 4 [backwater released fish] and 257 [main channel released fish], recovered by SCUBA) within a month post-release. Of the five fish lost to the study, fish 260 was last contacted upstream of the sand dunes near Topock Gorge, and fish 261 was last contacted at the Castle Rock backwater entrance (attachment 1). Both of these locations are sites that are near the termini of the study area's up- and downstream boundaries and, therefore, may indicate that the study fish swam out of the study detection reach. Both of these lost fish were contacted within several 24-hour periods at least once at all SURs between Blankenship Bend and the most up- or downstream SUR gate of the last recorded contact; therefore, it is unlikely that these fish returned to the study area undetected. The remaining three lost study fish (fish 3, 5, and 259) were last contacted in Blankenship Bend. Of the three bonytail actively tracked after the first month, fish 7 perished (a determined mortality not recovered by SCUBA) by week 9, fish 258 was lost to the study by week 10, and fish 262 was actively tracked into the final week (week 13).

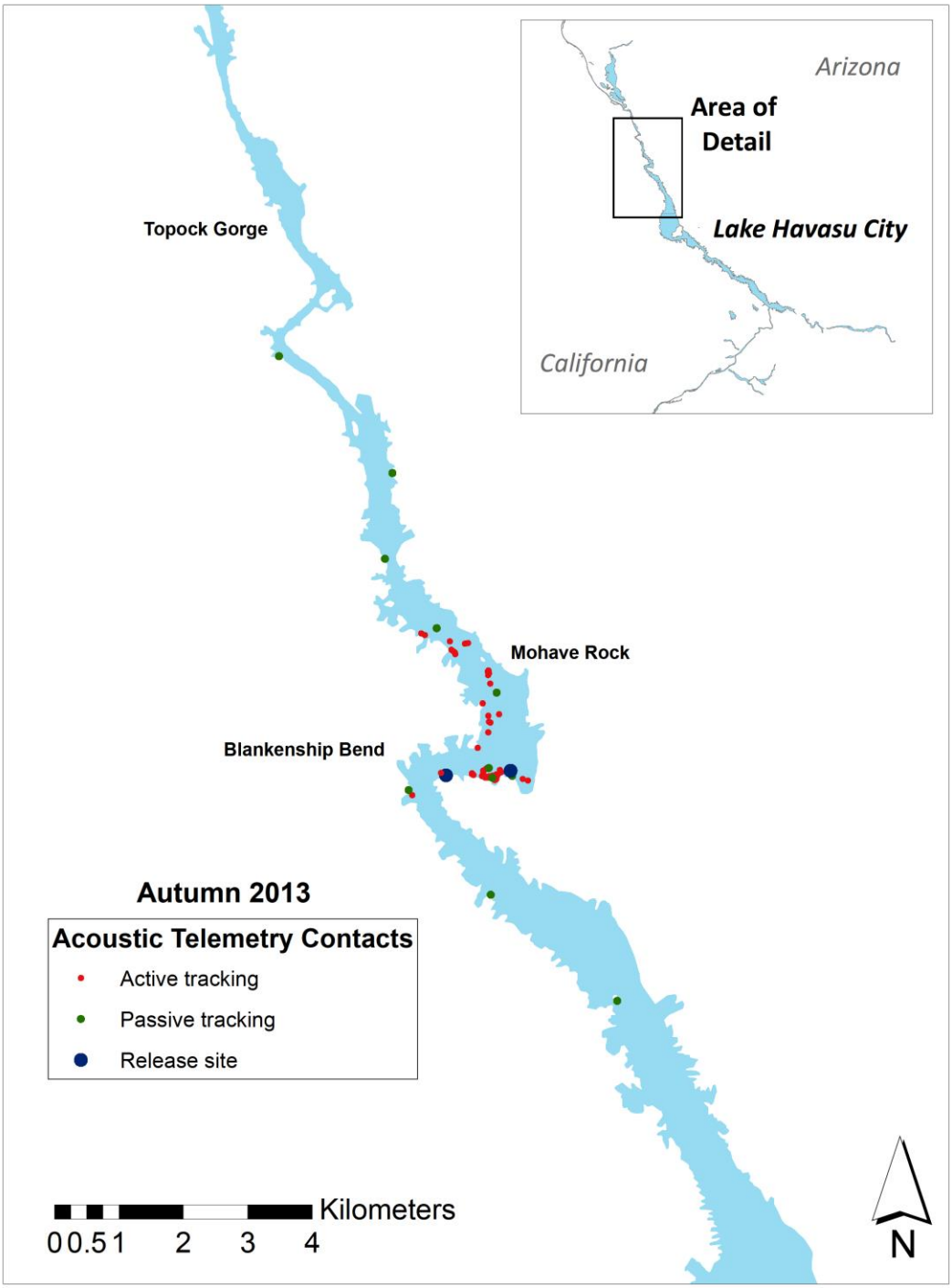

Figure 10.—Active (red) and passive (green) telemetry contacts and bonytail release sites (blue) during the October 2013 – January 2014 study; Lake Havasu, Arizona and California.

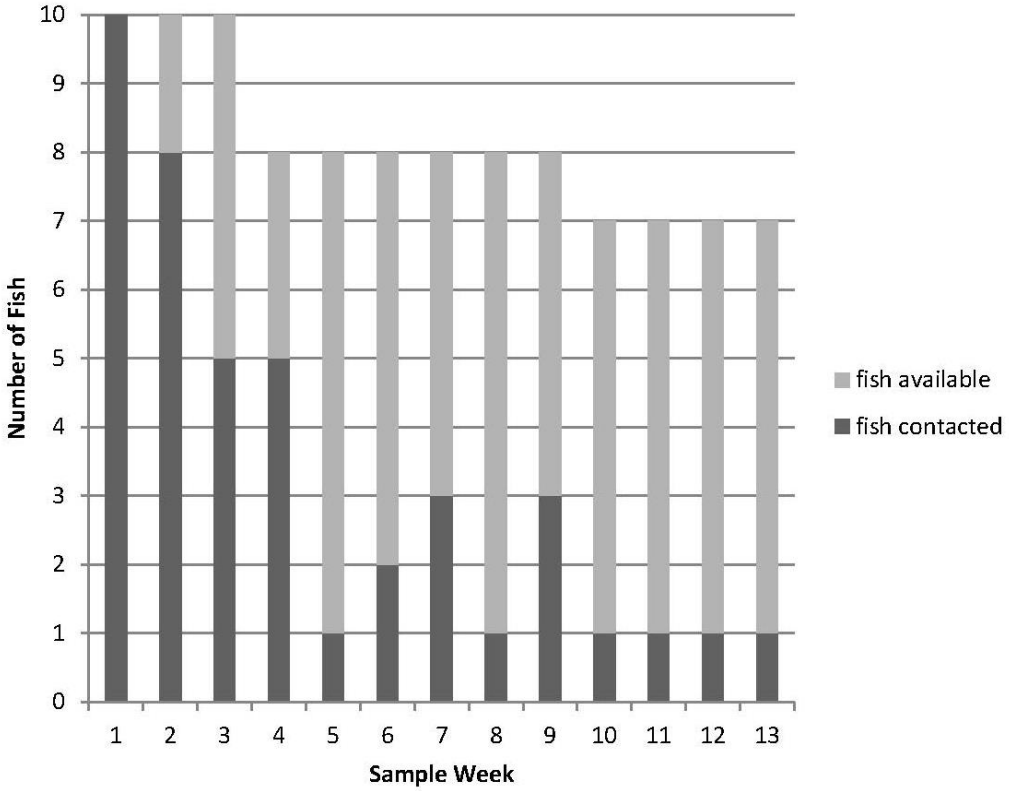

Figure 11.—Total number of 10 acoustic-tagged bonytail potentially available for contact (light gray box) and those actually contacted (dark gray box) each week during the October 2013 – January 2014 telemetry study, Lake Havasu, Arizona and California.

Movement Patterns and Inhabitance

Mean dispersal from release sites along the channel thalweg (i.e., accounting for river sinuosity), was 2.0 km upstream (range 0 – 8.3 km) and 1.3 km downstream (0 – 5.0 km) (table 3). Fish released in the main channel dispersed farther up- and downstream than fish released in the backwater. Summed mean up- and downstream dispersal was 5.6 km for main channel released fish and 1.1 km for backwater released fish. Mean total minimum (straight line) displacement was 9.0 km (range 0 – 20 km; 13.4 and 4.7 km for main channel and backwater released fish, respectively) with a mean displacement of 0.50 kilometer per day (km/day) (range 0 – 2.6 km/day; 0.8 and 0.2 km/day for main channel and backwater released fish, respectively). Bonytail released within backwater habitat continued to be contacted exclusively within the area of their release, never leaving Blankenship Bend (figure 13). Of the bonytail released in the main channel, the farthest upstream site of contact was recorded passively by a SUR upstream of the sand dunes and at the downstream buoys of the no wake zone of Topock Gorge (figure 14, see figure 4). The most downstream site of contact

Table 3.—Dispersal and displacement data collected for acoustic-tagged bonytail in October 2013 – January 2014, Lake Havasu, Arizona and California

Tag	Release site	Dispersal (km)		Displacement (km)	Days at large	Displacement per day (km/day)
		Upstream	Downstream			
3	Backwater	0.3	0.4	2.2	9	0.24
4	Backwater	1.6	0.4	6.1	20	0.31
5	Main channel	0.0	0.1	0	0	0.00
7	Main channel	2.7	0.7	20	57	0.35
257	Backwater	0.9	0.6	4	18	0.22
258	Backwater	0.0	0.4	9	58	0.16
259	Backwater	0.0	0.5	2	9	0.22
260	Main channel	8.3	0.1	16	22	0.73
261	Main channel	3.1	5.0	13	5	2.60
262	Main channel	3.2	5.0	18	86	0.21
Average all fish		2.0	1.3	9.0	28.4	0.50
Averages by release site						
Main channel		3.4	2.2	13.4	34.0	0.8
Backwater		0.6	0.5	4.7	22.8	0.2

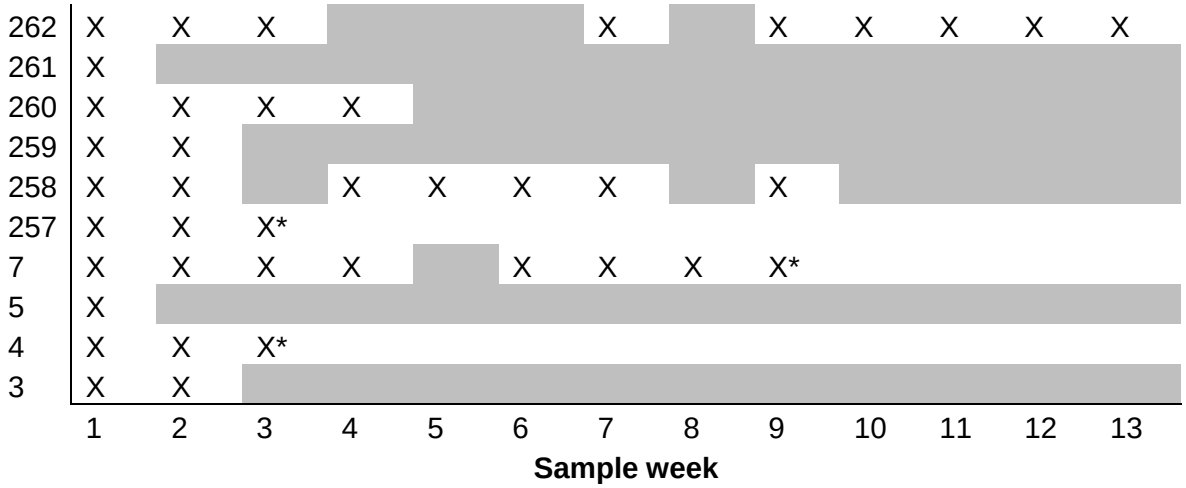

Figure 12.—Weekly contacts (X) and non-contacts (gray boxes) for all 10 fish during the October 2013 – January 2014 bonytail telemetry study, Lake Havasu, Arizona and California. (* Denotes a mortality.)

was also recorded passively by a SUR at the main entrance to the Castle Rock backwater. Fish 260, 261, and 262 from the main channel release group displayed the greatest total minimum (straight line) displacement.

Habitat Assessment

Mean secchi depth was 1.30 m (range 0.50 – 2.25 m), surface water temperature was 15.7°C (range 9.00 – 19.0°C), and depth was 5.70 m (range 0.30 – 5.85 m) across all points of active triangulation. Active tracking contacts occurring in riverine mesohabitats accounted for 51%, contacts in backwater mesohabitats accounted for 44%, and contacts located in the peripheral channels accounted for 5% of active contacts.

Remote PIT Scanners

During the October 2013 study, remote PIT scanners deployed in Blankenship Bend scanned for a total of 1,072.25 hours and contacted six unique bonytail. PIT scanners were placed in sets of two with different orientations (see figure 8). PIT scanners that were deployed horizontally with all sides contacting the substrate resulted in six bonytail contacts, more than those oriented vertically with the bottom edge contacting the substrate (two contacts).

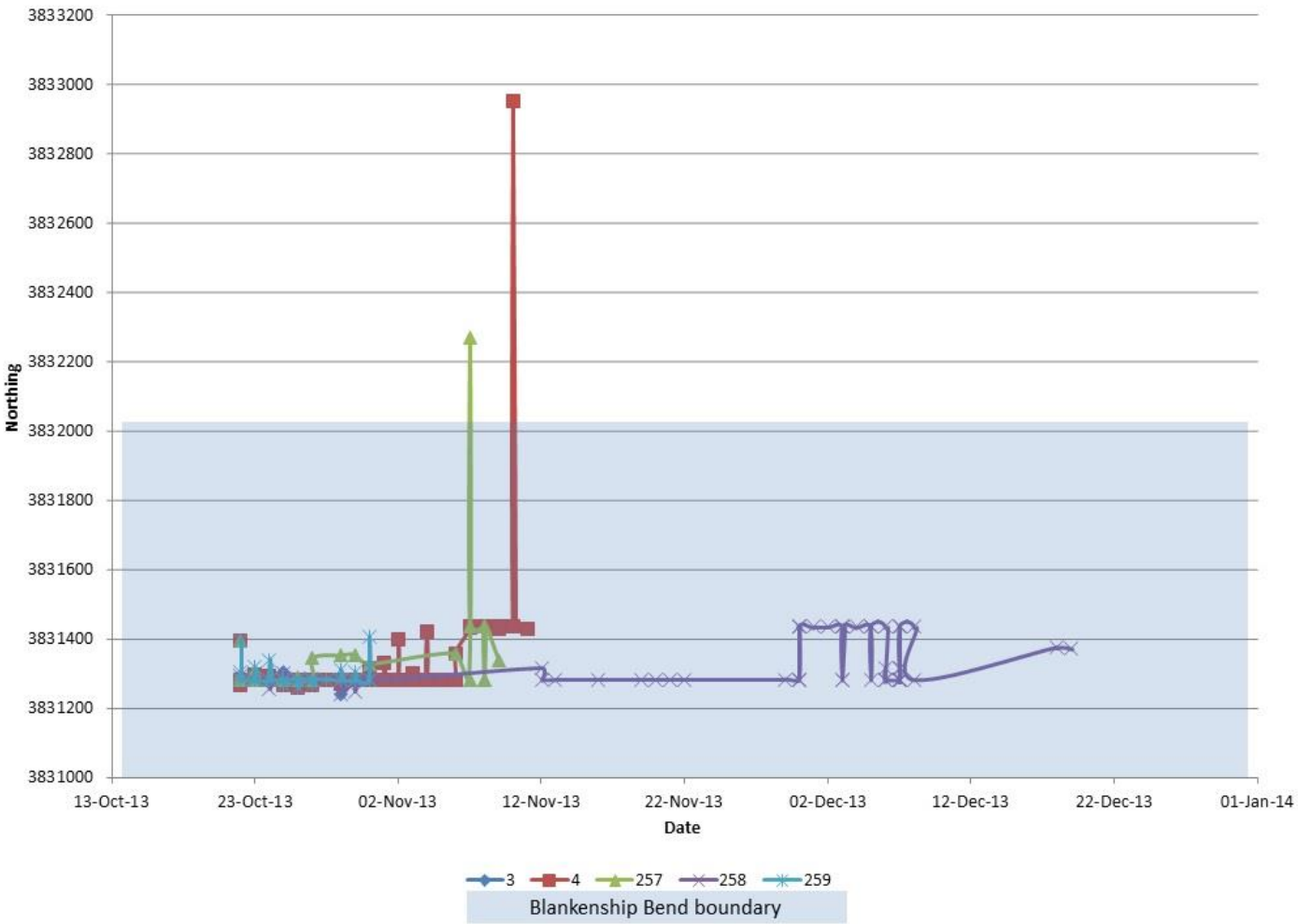

Figure 13.—Up- and downstream displacement represented by distance north and south in meters displayed as Universal Transverse Mercator northing over time of backwater released bonytail over time during the October 2013 – January 2014 telemetry study, Lake Havasu, Arizona and California.

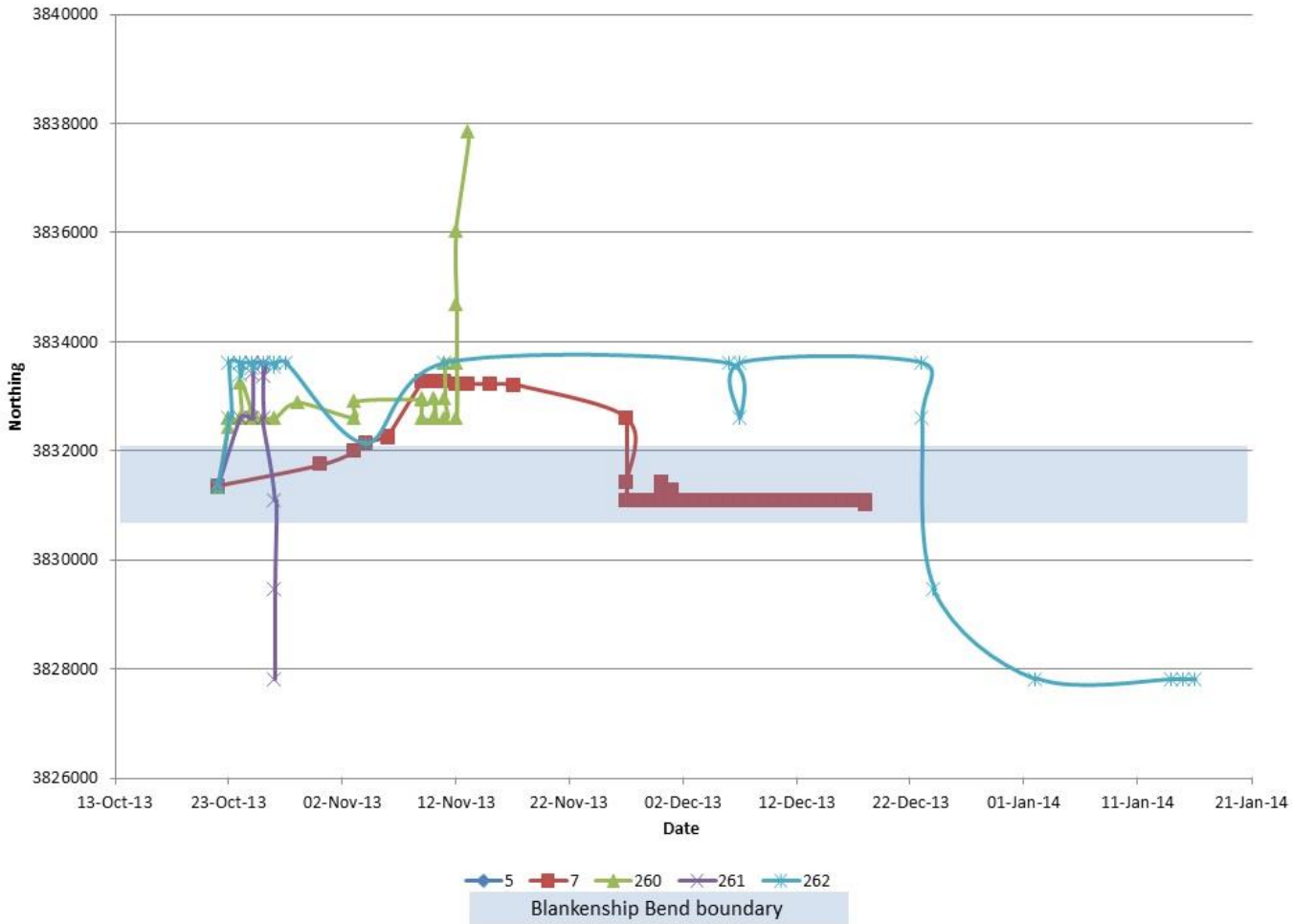

Figure 14.—Up- and downstream displacement represented by distance north and south in meters displayed as Universal Transverse Mercator northing over time of main channel released bonytail over time during the October 2013 – January 2014 telemetry study, Lake Havasu, Arizona and California.

Winter 2014 PIT Scanning

Remote PIT scanners deployed in Reach 3 scanned for a total of 7,085.1 hours, contacting 321 unique fish, of which 124 were bonytail, 194 were razorback, and three were unknown (no record of release or capture). Of the 124 unique bonytail contacted over the course of the study, 10 fish had been released on October 22, 2013, and 114 fish were released on January 1, 2014, all at Blankenship Bend (figure 15). Most contacts (89%) occurred within 3 weeks of the second stocking from January 13 – 17, 2014 (figure 16). Eleven contacts were recorded at Trampas Cove (across three isolated sampling weeks), and one contact was in Clear Bay. All other contacts (193) were within Blankenship Bend. An additional 26 bonytail were contacted during the study period through other LCR MSCP Reach 3 study efforts: 23 released from Blankenship Bend in January 2014 and three in October 2013. Although scanners were deployed disproportionately across habitat types, catch per unit effort (CPUE) for bonytail was highest among submersible 0.8 x 0.8 m PIT scanners oriented horizontally compared to 0.7 x 1.3 m PIT scanners oriented vertically. Contact per unit time scanned was highest at a PIT scanner deployment of 4 m, followed by deployments at depths between 1.2 and 1.8 m.

2014 Lake Havasu Native Fish Netting "Roundup"

Efforts during the 2014 Lake Havasu Native Fish Netting "Roundup" resulted in 638 fishes being captured, representing 11 non-native and two native species (bonytail and razorback sucker). Eight bonytail were captured, one of which was deceased. Five of the captured bonytail had been released in October 2013, and three had been released in January 2014. One bonytail was captured in Trampas Cove, one in Blankenship Bend, and six were captured in or near Clear Bay. During the week of the "Roundup," a total of four bonytail were contacted, all of which were recorded by PIT scanners deployed simultaneously to a net set in Trampas Cove. Despite PIT scanners set in conjunction with trammel nets in Clear Bay, bonytail were only contacted by nets. The one bonytail mortality was found inside the throat of a netted largemouth bass (505 mm TL; figure 17). Mean TL of captured bonytail was 303 mm (range 290 – 322 mm), and mean weight was 207.8 g (range 136 – 305 g). Additionally, electrofishing was conducted as part of supplemental efforts on January 27, 2014, resulting in one captured bonytail, also released into Blankenship Bend in 2012 from Achii Hanyo.

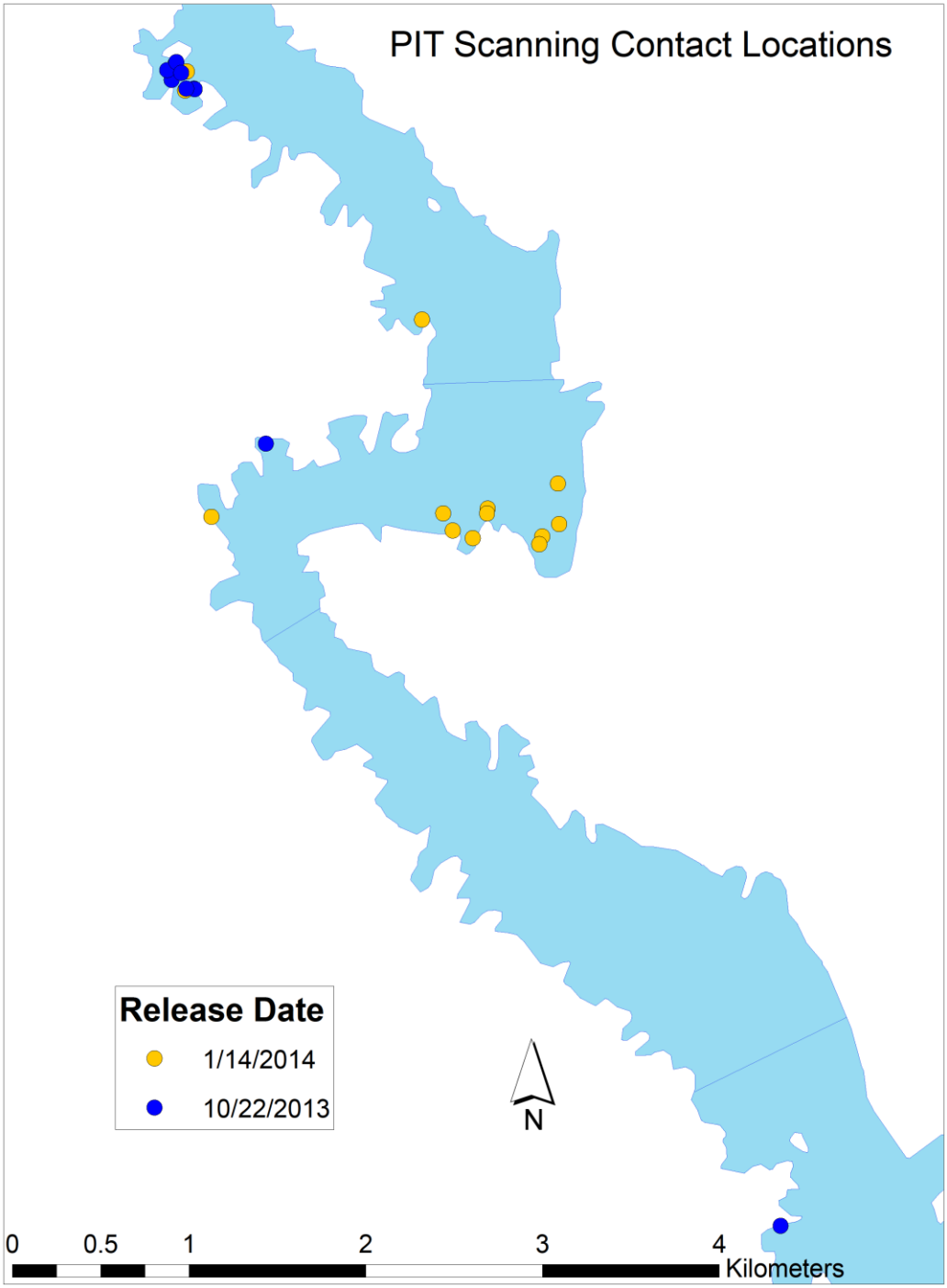

Figure 15.—Contacts of bonytail released January 14, 2014 (yellow), and October 22, 2013 (blue), at remote passive integrated transponder scanning locations from January – February 2014, Lake Havasu, Arizona and California.

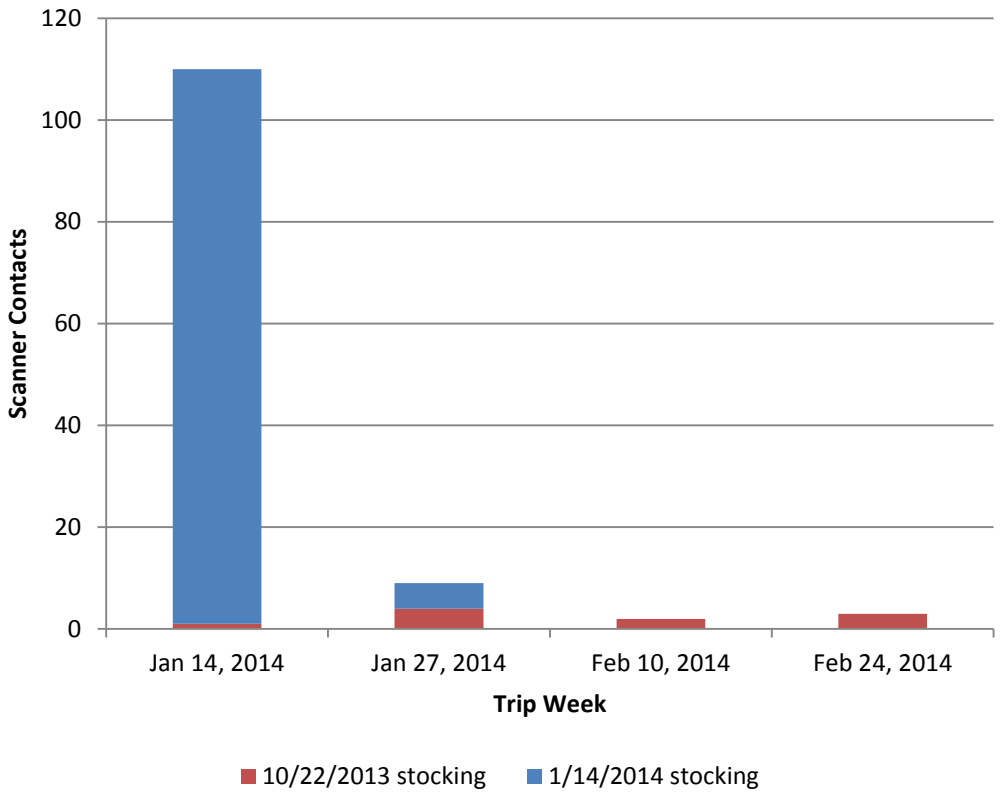

Figure 16.—Contacts of bonytail released January 14, 2014 (blue), and October 22, 2013 (red), over time by remote PIT scanning from January – February 2014, Lake Havasu, Arizona and California.

Spring 2014 Telemetry

Twelve bonytail were released near Blankenship Bend in spring 2014, and over the course of the study, 52,909 contacts were recorded by active and passive tracking. Of those contacts, 123 were recorded by active tracking, and 52,786 (99.8%) of all contacts, were recorded by passive tracking (figure 18). Passive contacts between sunset and sunrise comprised 84% of total passive contacts. Stationary SURs contacted tagged bonytail at 20 of 21 deployment sites. There were no records from one stationary SUR located in Topock Gorge just upstream of the no wake zone buoys. The SUR site at the Mile 17 sign inside the Castle Rock backwater did not have a SUR from April 28, 2014, to May 4, 2014. Several SURs were buried due to shifting sediment for part of the study period, which may have compromised their detection radius. Fish were contacted at two sites with temporary SURs. Two SURs were not retrieved (one SUR was apparently stolen from the main channel near the delta, and one SUR's line was

Figure 17.—Photos captured largemouth bass that have consumed bonytail, Lake Havasu, Arizona and California.
1. Bonytail can be seen in mouth of a largemouth bass captured by trammel net by Reclamation in November 2013. 2. Bonytail from 1. was removed from largemouth bass and can be seen partially digested with a small largemouth bass in its mouth. 3. Close up of the throat of a largemouth bass captured by trammel net during the February "Roundup" in Clear Bay on February 12, 2014, with the tail of a bonytail visible toward the bottom of the throat. 4. Unidentified prey in throat of largemouth bass.
(Photo credit: Julia Mueller and Rick Wydoski)

cut in Topock Gorge near the Pulpit Rock backwater entrance). Eleven records from a SUR upstream of Trampas Cove recorded after May 6, 2014, were excluded from analyses due to improper time formatting.

Study fish were tracked for a mean of 23.6 days (range 3 – 42 days) (table 4). Mean total active contacts per fish was 10 (range 4 – 26, median 9), and mean total passive contacts per fish was 4,399 (range 213 – 22,435, median 2,828). Contacts greatly decreased from the first to second week and increased into the fourth week before gradually declining for the remainder of the study (figure 19). All tagged fish were contacted in the first week of the study post-release, but the number of tagged fish contacts declined in the following weeks (figure 20). Six tagged fish were contacted within the first month of the study but were then lost.

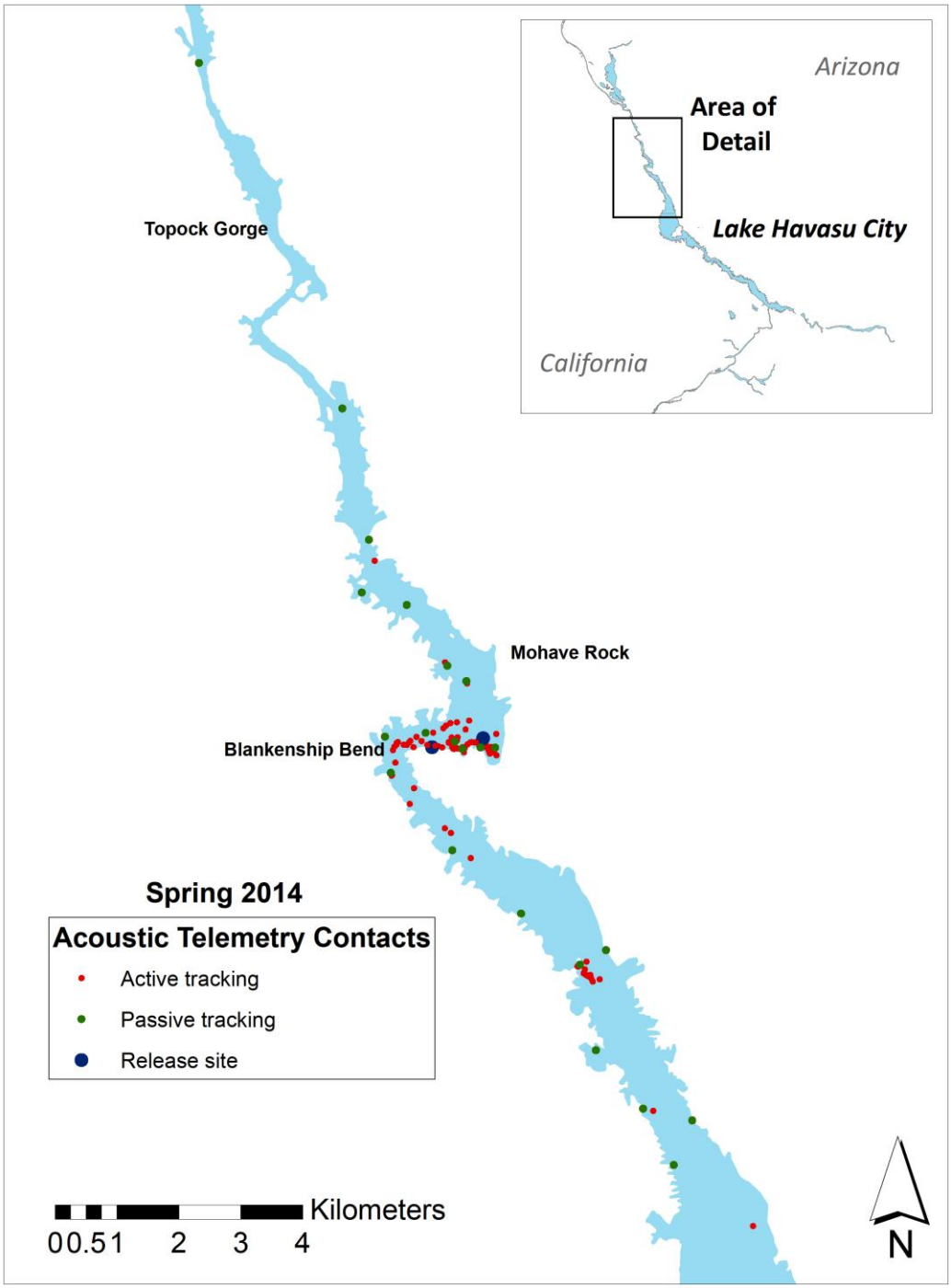

Figure 18.—Active (red) and passive (green) telemetry contacts and bonytail release sites (blue) during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

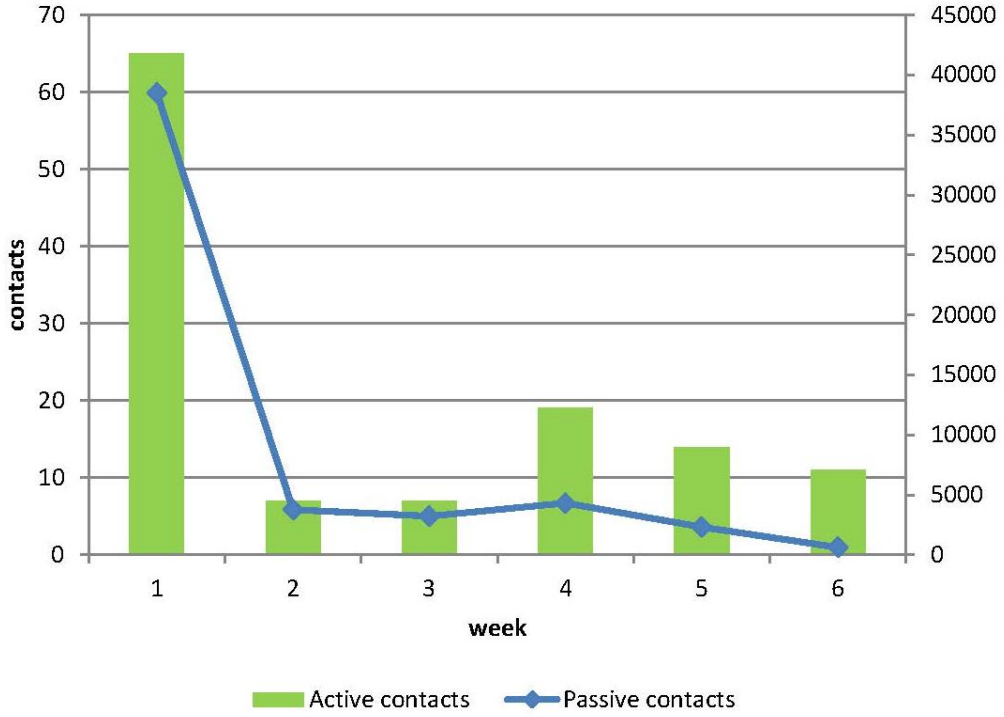

Figure 19.—Total active and passive acoustic bonytail tracking contacts per week during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

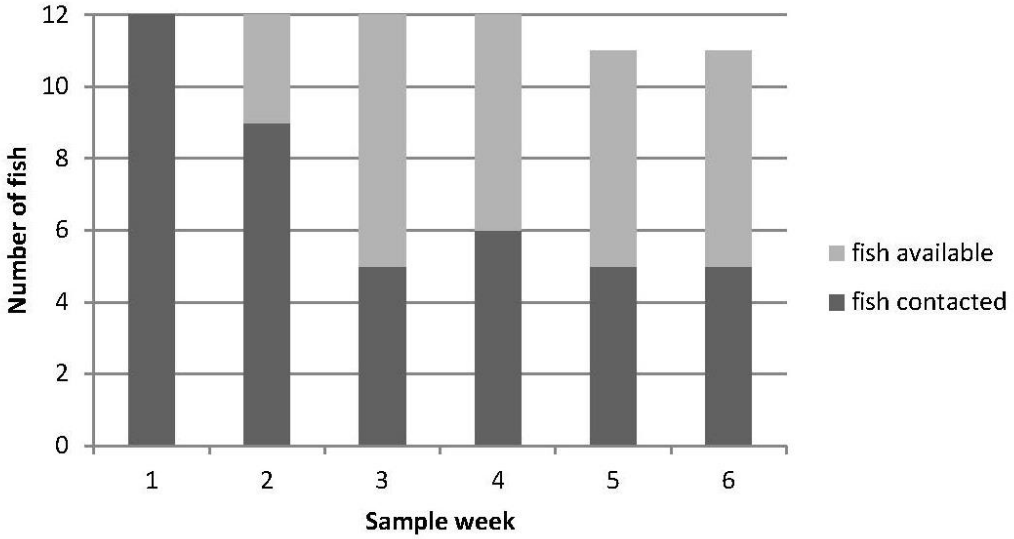

Figure 20.—Total number of 12 acoustic-tagged bonytail potentially available for contact (light gray box) and those actually contacted (dark gray box) each week during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

Three tagged fish were tracked initially, followed by a period of non-detection by either active or passive efforts, and then contacted again prior to the end of the study. Two fish (fish 125 and 140) were tracked every week of the study, and one tagged fish (fish 123) was determined a mortality based on a sedentary tag (see table 2).

Post-Stocking Mortality and Transmitter Recovery

During the final week of the study (week six), five fish (42%) were active (figure 21). This included one fish from the main channel release and four fish from the backwater release group. Mean TL at release of the remaining active study fish (373 mm) was greater than those that were lost or determined a mortality (327 mm). Contact was lost with three fish (two main channel released fish and one backwater released fish) within the first week, and three additional fish (two main channel released fish and one backwater released fish) were lost in the middle of the study between weeks three and five. Of these six lost study fish, two (fish 126 and 127) were last contacted by the most upstream SUR at the sand dunes and were determined to have moved out of the study reach (attachment 2). Five out of five study fish contacted at the upstream SUR gate at the sand dunes were contacted within several days prior by two SURs between Blankenship Bend and the sand dunes. Therefore, it is unlikely that lost fish returned into the study reach undetected. The remaining four study fish (fish 122, 124, 137, and 141) were last contacted near Blankenship Bend between the SUR upstream of Rearing Cove and the sandbar island in the bend. Each of the three fish (fish 138, 139, and 142) that were not contacted for a period of at least a week later re-emerged within the same area. Only one (fish 142) of these three fish was out of contact for a period longer than a week. There was one determined mortality, fish 123, at the beginning of week five at 28 days post-release.

Movement Patterns and Inhabitance

Mean dispersal from release sites along the channel thalweg was 3.8 km upstream (range 0 – 13 km) and 6.1 km downstream (range 0 – 11 km) (table 4). Fish released in the main channel dispersed farther upstream and less downstream than fish released in the backwater. Summed mean up- and downstream dispersal was 11.2 km for main channel released fish and 8.5 km for backwater released fish. Mean total minimum (straight line) displacement was 36 km (range 2 – 65 km; 34.8 and 37.3 km for main channel and backwater released fish, respectively) with a mean displacement of 2.0 km/day (range 0.5 – 4.7 km/day; 2.0 and 2.1 km/day for main channel and backwater released fish, respectively). The farthest upstream site of contact was recorded passively by a SUR upstream of Topock Gorge by the USGS gauging station. The most downstream site of contact was recorded actively within the basin at the southeast exit of the Castle Rock backwater. Fish 123 and 125 from the main channel release group displayed the greatest total minimum (straight line) displacement.

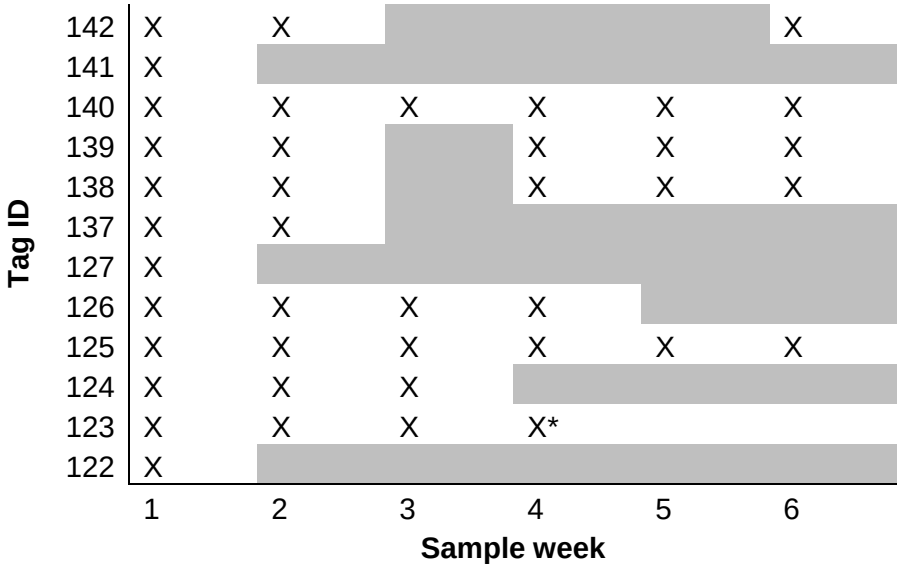

Figure 21.—Weekly contacts (X) and non-contacts (gray boxes) for all 12 study bonytail during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.
(* Denotes a mortality.)

Individual main channel released fish were contacted farther upstream than individual backwater released fish, while contacts with backwater released fish had more consistency in distance and time of up- and downstream dispersal, exhibiting less variability in distance, farther downstream displacement, and early dispersal in the study time frame (figure 22). By the end of the first week and the beginning of the second, five out of six fish (tag numbers 137, 138, 139, 141, and 142) released in the backwater dispersed at least approximately 9 km downstream (figure 23), ranging between the SUR placed downstream from Rearing Cove (fish 141) to downstream from the Mile 17 buoys (fish 137). All five fish reversed course and dispersed upstream within 1 day. Fish 137 dispersed upstream before contact was lost. Fish 142 dispersed to near Rearing Cove where contact was lost until the end of the study at the same location. Two fish (fish 138 and 139) returned to Blankenship Bend where they were contacted for the remainder of the tracking period along with fish 140, which never left Blankenship Bend. The dispersal pattern for fish released in the main channel (figure 24) was less consistent. All six fish dispersed upstream at different times during the study. Five of the six fish were tracked as far upstream as the SUR at the sand dunes where contact was lost with three of these five (fish 125, 126, and 127), before which fish 125 was tracked upstream to the SUR at the USGS gauging station. Four of the six main channel released fish also dispersed downstream, ranging from the SUR deployed upstream of Rearing Cove to the northeast shore of the basin, though there was no observed consistency in time or distance traveled.

Table 4.—Dispersal and displacement data collected for acoustic-tagged bonytail in April – May 2014, Lake Havasu, Arizona and California

Tag	Release site	Dispersal (km)		Displacement (km)	Days at large	Displacement per day (km/day)
		Upstream	Downstream			
122	Main channel	0.7	0.0	2	4	0.5
123	Main channel	6.4	10.7	65	28	2.3
124	Main channel	6.4	4.3	31	20	1.6
125	Main channel	13.4	3.1	49	37	1.3
126	Main channel	6.4	8.3	48	27	1.8
127	Main channel	6.4	1.2	14	3	4.7
137	Backwater	1.3	10.0	34	9	3.8
138	Backwater	1.3	10.0	65	37	1.8
139	Backwater	1.7	9.5	42	35	1.2
140	Backwater	0.0	2.0	30	42	0.7
141	Backwater	1.3	5.1	20	5	4.0
142	Backwater	0.2	8.9	33	38	0.9
Average all fish		3.8	6.1	36.1	23.8	2.0
Averages by release site						
Main channel		6.6	4.6	34.8	19.8	2.0
Backwater		0.9	7.6	37.3	27.7	2.1

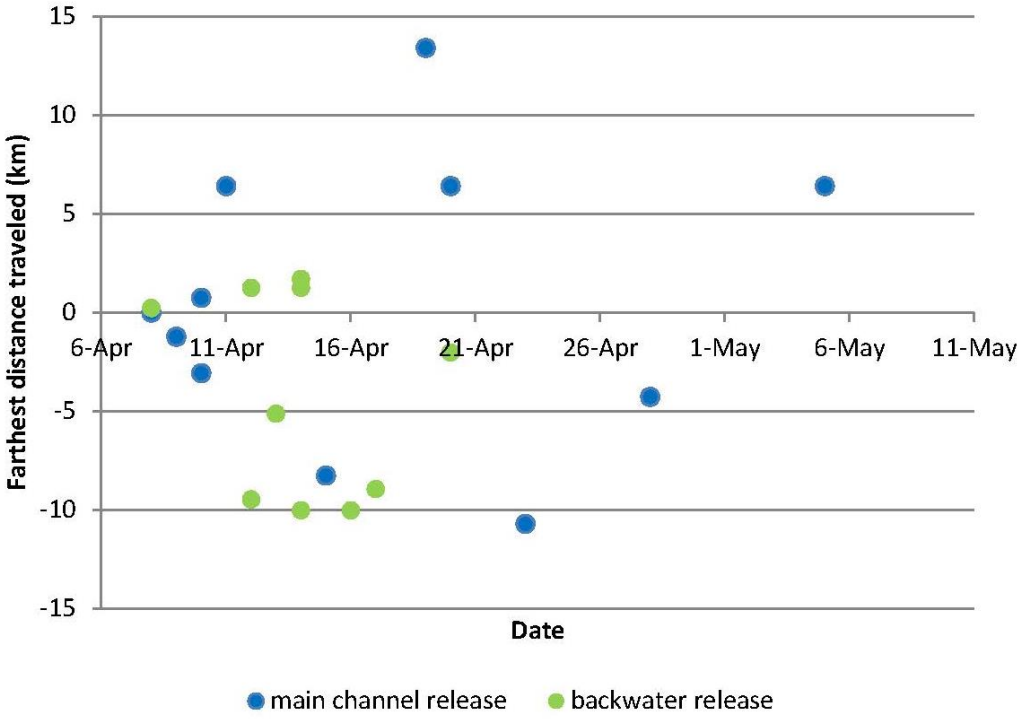

Figure 22.—Farthest distance dispersed up- and downstream from main channel (blue) and backwater (green) released bonytail during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

Study fish were consistently contacted in Blankenship Bend at a greater rate than other portions of the study area each week (figure 25). Mean percentage of days tagged fish were tracked in Blankenship Bend out of total days tracked was 52.2% (range 14.3 – 100%). Study fish released in the backwater spent more tracked days on average (64.4%) in Blankenship Bend than study fish released in the main channel (40.1%). Two tagged fish were never contacted outside of Blankenship Bend. Of the 10 tagged fish that left, 20% never returned. Often, study fish went through short periods of non-detection before re-emerging at the same SUR. Fish 140 most consistently displayed patterns of non-detection and re-emergence.

Habitat Assessment

Mean turbidity was 1.65 NTU (range 0.53 – 4.63 NTU), surface water temperature was 17.3 °C (range 12.0 – 22.8 °C), and depth was 3.42 m (range 0.52 – 10.6 m) across all points of active triangulation. Active tracking contacts occurring in backwater mesohabitats accounted for 42.6% of all active contacts, and contacts in the main channel or riverine mesohabitats accounted for 57.4%. Contacts made by active tracking located mid-channel accounted for 41.5% of all active contacts while triangulations located at the river's periphery accounted for 58.5%.

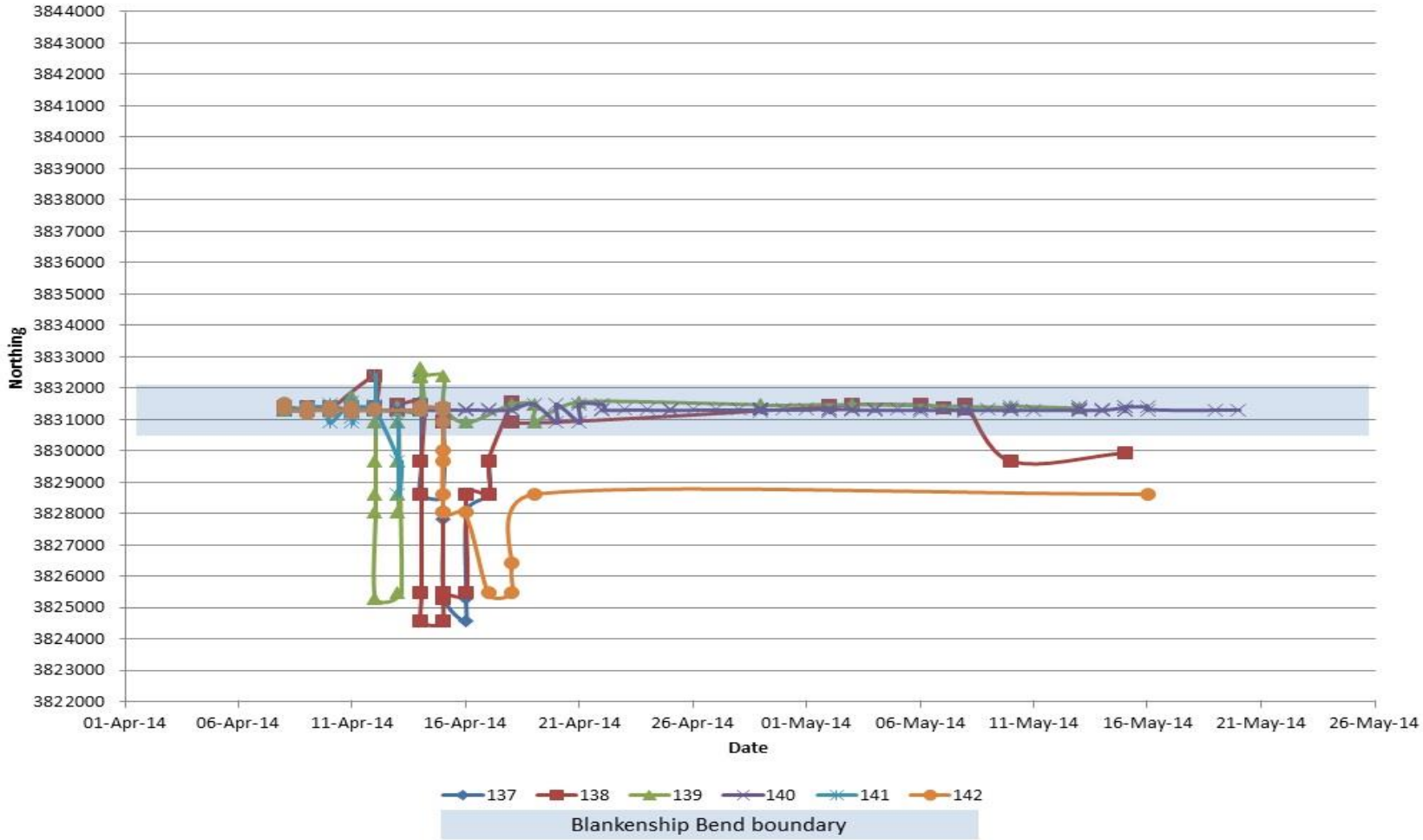

Figure 23.—Up- and downstream displacement represented by distance north and south in meters displayed as Universal Transverse Mercator northing over time of six individual backwater released bonytail during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

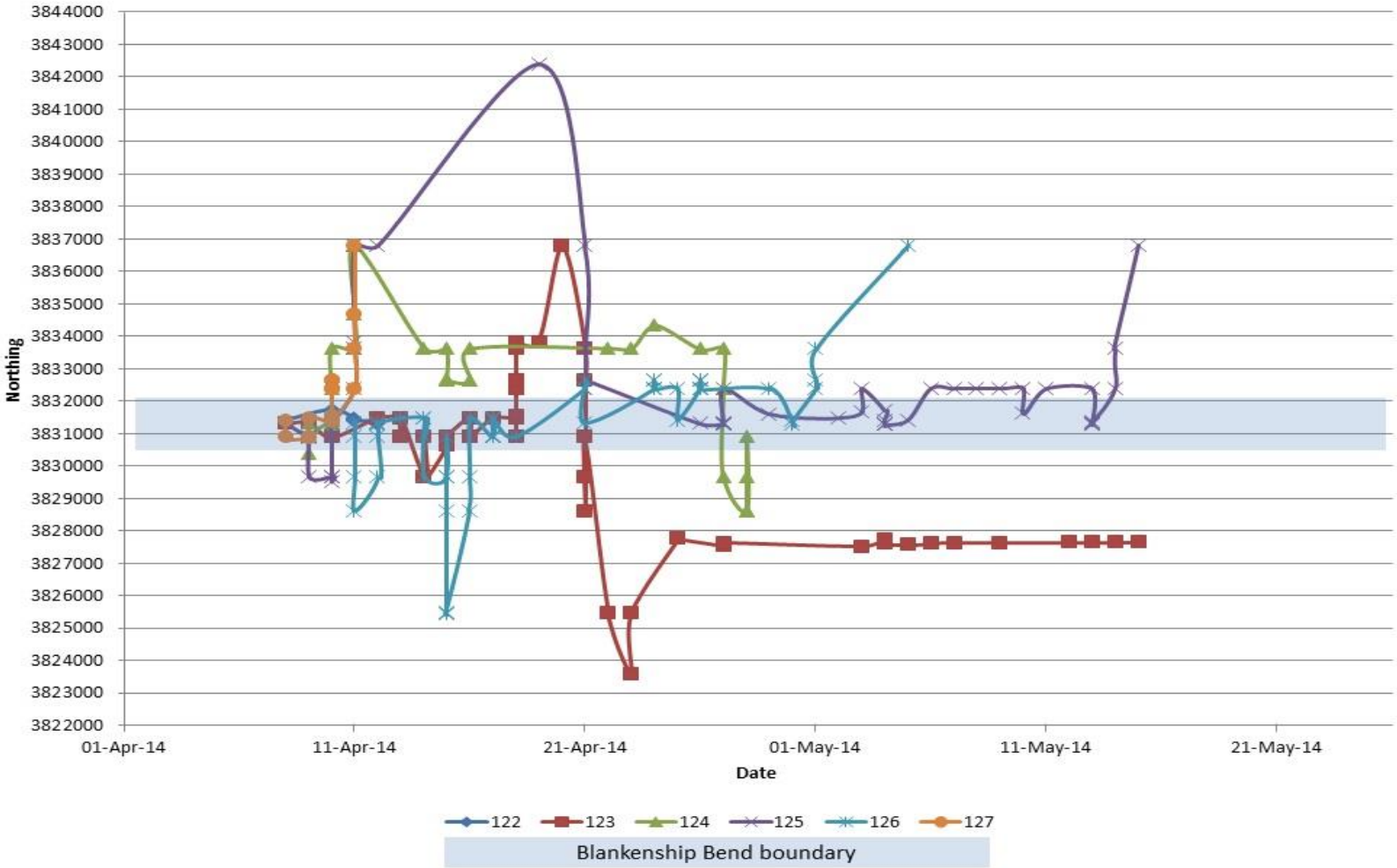

Figure 24.—Up- and downstream displacement represented by distance north and south in meters displayed as Universal Transverse Mercator northing over time of six individual main channel released bonytail during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.

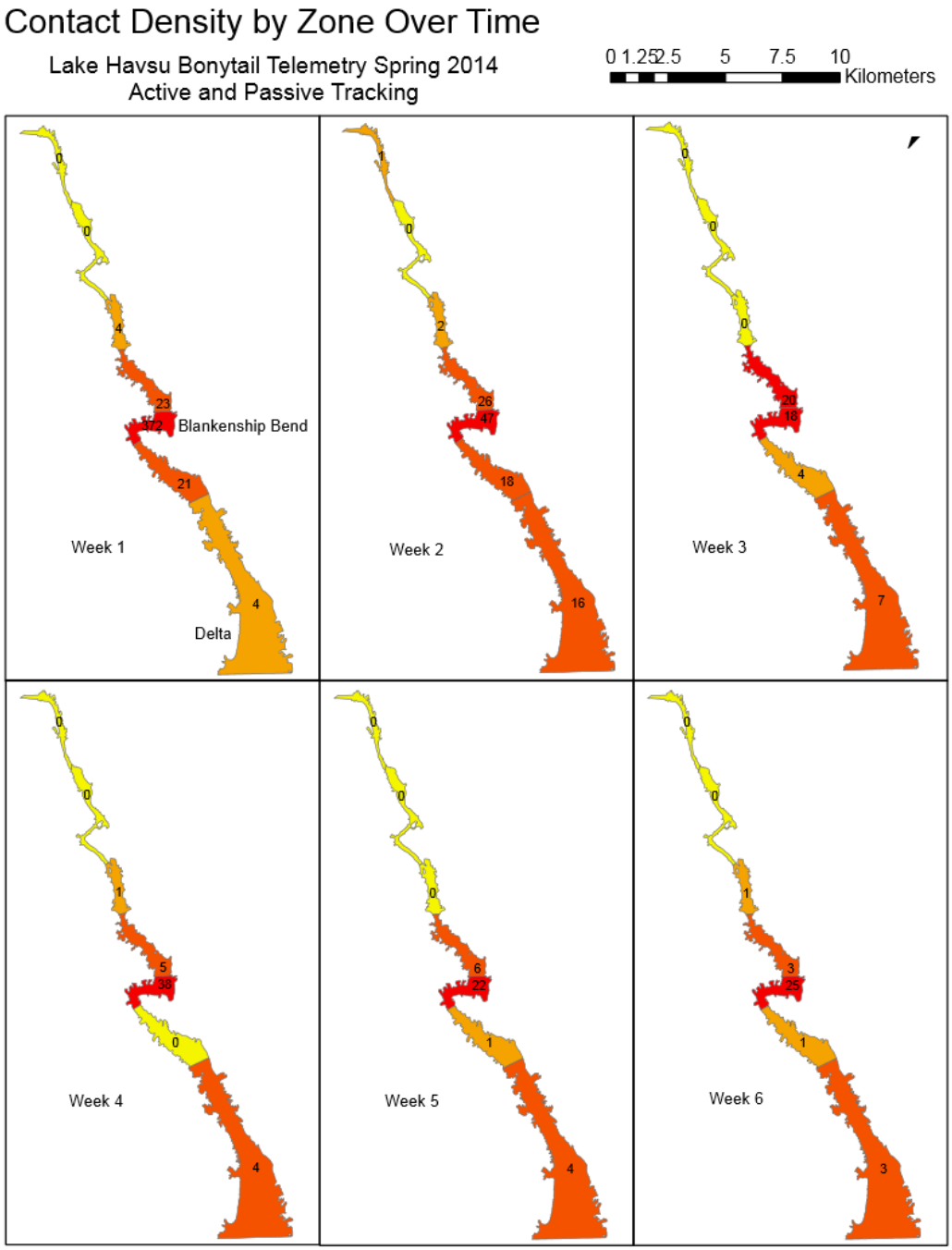

Figure 1.—Contact density of tracked bonytail over time during the April – May 2014 telemetry study, Lake Havasu, Arizona and California.
Lowest densities are yellow, intermediate densities are orange, and highest densities are red; numerals are actual number of contacts.

Microhabitats were measured at five locations for four tagged fish that continuously inhabited the same site on a repeated basis during the study (table 5; figure 26). Fish with tag number 140 was contacted twice in the third cove of Blankenship Bend backwater where current was nil and turbidity was 1.03 and 1.10 NTU, surface water temperature was 25.2 and 25.1 °C, and depth was 1.00 and 2.30 m at times of successive contacts. Pool habitat within this cove was recorded as having a silt substrate with little submerged cover (vegetation or large debris). Shoreline vegetation was predominately bulrush (*Scirpus*) with a small amount of common reed (*Phragmites australis*) near the finger of the cove.

Fish 125 was consistently tracked in a glide of the main channel in Blankenship Bend near an area of sandy substrate. Cliffs were to the south, while an adjacent sandbar was lined with bulrush near-shore and common reed and cattail (*Typha*) further up the shoreface. The shoreline along river left was bulrush and salt cedar (*Tamarix*) with a large amount of submerged woody debris. Current was perceptible and turbidity was 0.93 NTU, surface water temperature was 21.2 °C, and depth was 1.80 m.

Fish 138 was consistently tracked upstream of the Blankenship Bend California backwater in a run of the main channel at a depth of 5.60 m, surface water temperature of 21.6 °C, and turbidity of 1.29 NTU. Current was present and substrate was fine sand with no submerged cover. Cliffs were located along river left, and bulrush was along river right near a sandbar.

In addition to fish 138, fish 139 was also tracked upstream of the Blankenship Bend California backwater in a run of the main channel with perceptible current over an area of fine sand. Cliffs were toward river left, and river right was lined with bulrush near a sandbar. Turbidity was 1.29 NTU, surface water temperature was 21.6 °C, and depth was 5.60 m.

DISCUSSION

Only six (27%) of 22 bonytail implanted with telemetry tags were actively tracked into the final week of tracking. Four study fish likely swam out of the detection area as evidenced by their contact by SURs at the study area's termini, but eight fish were lost to the study near or within Blankenship Bend with no indication of dispersal beyond the immediate stocking site. Lost fish may be a consequence of the densely vegetated and complex habitat; however, equipment and techniques ultimately proved effective in re-establishing contact with six temporarily lost fish. Considering this success in re-establishing contact with four of six fish in less than 2 weeks and given the broad spatial coverage of SURs and the extensive and intensive active tracking, it is less likely that most of these eight permanently

Table 5.—Microhabitat measurements from active tracking in April – May 2014 of tagged bonytail displaying continued inhabitance, Lake Havasu, Arizona and California

BW is the backwater near Blankenship Bend and MC is the Colorado River main channel at Blankenship Bend.

Fish tag	Location	Mesohabitat	Depth (m)	SWT[1]	Turbidity (NTU)	Topography	Shoreline	Shoreline vegetation	Substrate	Submerged cover
140	Blankenship Bend backwater Cove 3	BW	1.00	25.2	1.03	Pool	Vegetation	Predominately *Scirpus*, small amount of *Phragmites* near finger	Silt	Little
140	Blankenship Bend backwater Cove 3	BW	2.30	25.1	1.10	Pool	Vegetation	Predominately *Scirpus*, small amount of *Phragmites* near finger	Silt	Little
138, 139	Blankenship Bend upstream of the California backwater	MC	5.60	21.6	1.29	Run	Vegetation	Cliffs toward river left, *Scirpus* along river right near sandbar	Fine sand	None
125	Blankenship Bend east of island	MC	1.80	21.2	0.93	Glide	Vegetation	Cliffs to south, sandbar with *Scirpus* along shore, and *Phragmites* behind *Scirpus* and small amount of *Typha;* river left was *Scirpus* and salt cedar with a lot of woody debris	Sand	Little

[1] SWT = surface water temperature.

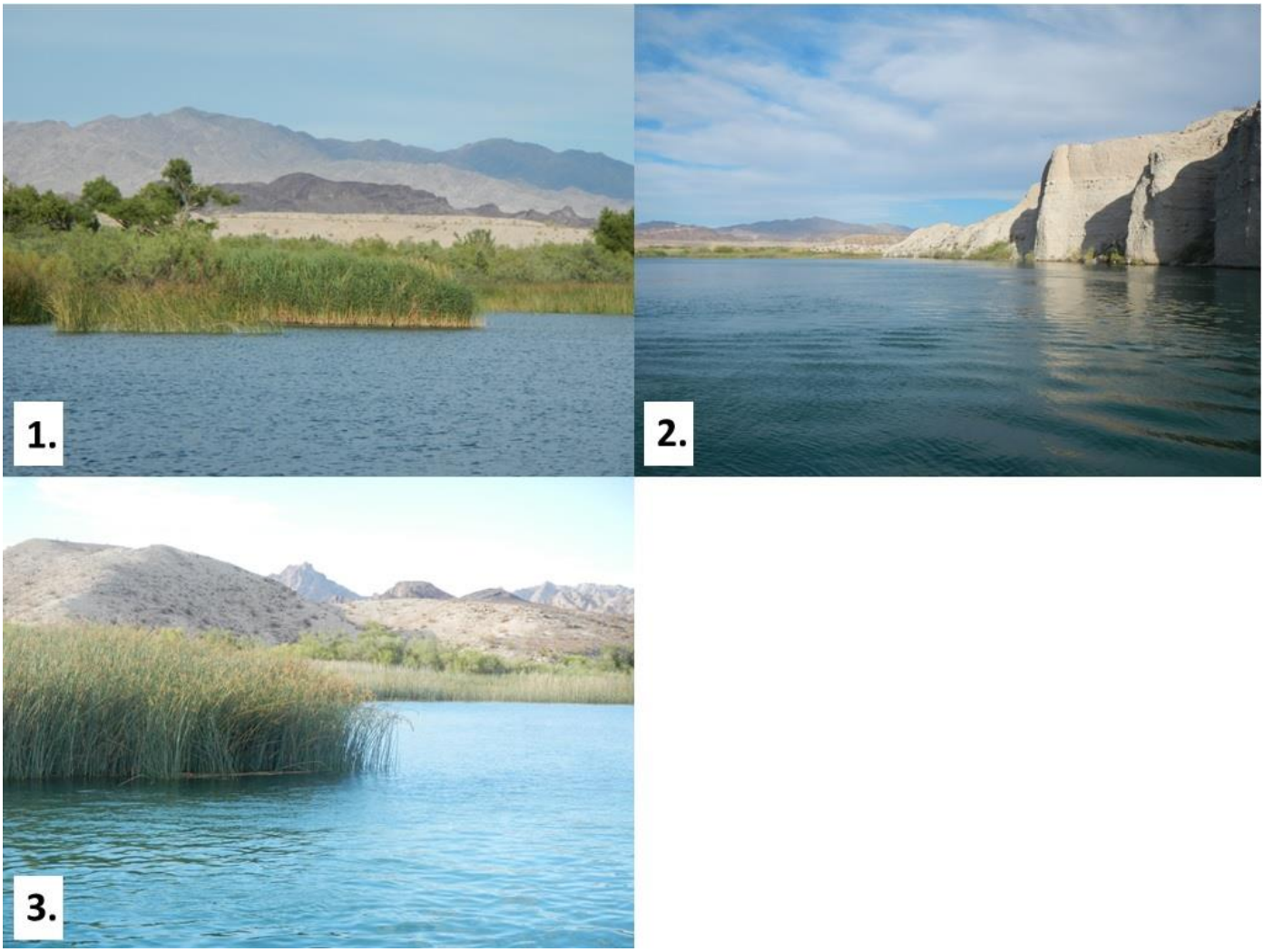

Figure 26.—Photos of microhabitat locations, Lake Havasu, Arizona and California.
1. Location of continued inhabitance of fish 140 in Blankenship Bend Backwater. 2. Location of continued inhabitance of fish 125 in the main channel of Blankenship Bend outside of Blankenship Bend Backwater.
3. Location of continued inhabitance of fish 138 and 139 upstream of the Blankenship Bend California backwater.

lost fish were "missed." Spontaneous acoustic tag failure is another possibility, but in our experience this is rare. It is possible that these fish were removed from the water by a predator or scavenger, and thus mortality of tagged bonytail during this study may have been as high as 55%.

Avian predation of stocked fish can decimate stocked rainbow trout (*Oncorhynchus mykiss*) (Modde et al. 1996) and wild populations of cui-ui (*Chasmistes cujus*) (Scoppettone et al. 2014). Blankenship Bend lies within the boundary of Lake Havasu National Wildlife Refuge where piscivorous birds such as American white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), and osprey (*Pandion haliaetus*) are abundant. Any bonytail consumed by avian predators would be lost to acoustic telemetry studies unless the tag was shed over water, as was the case during telemetry at the Bill Williams River NWR in spring 2013, where an acoustic tag was recovered at a known roosting site of double-crested cormorant (Mueller et al. 2014). PIT scanning at this location also resulted in 11 contacted PIT tags, and similar scanning implemented on a known seabird breeding site has successfully estimated avian predation of juvenile salmonids (Frechette et al. 2012). PIT scanning known roosting sites at Pulpit Rock has resulted in contacts with expelled razorback PIT tags (R. Wydoski 2014). PIT scanning beneath double-crested cormorant roosting sites may therefore provide contacts with PIT tags shed from consumed bonytail and should be incorporated into future studies.

Bonytail consumed by piscivorous fish may also result in a loss of contact with study fish if tags were evacuated under heavy cover. Direct observation of a bonytail in the digestive tract of a largemouth bass (*Micropterus salmoides*) (see figure 17) illustrates the threat piscivorous fishes pose to bonytail survival. Data from the February "Roundup" suggest relatively high numbers of largemouth bass (CPUE = 1.2) in Blankenship Bend. In addition, some acoustic-tagged fish in the spring telemetry study dispersed multiple kilometers in several days after previous periods of relatively little movement. For example, after remaining within relatively close proximity to Blankenship Bend through the first week of tracking and part of the second, fish 123 traveled a reach of 17 km in 3 days, a movement rate not exhibited by other study fish. A higher rate of movement is consistent with that of striped bass (*Morone saxatilis*; Ng et al. 2007; Wilkerson and Fisher 1997), a large pelagic piscivore that is common in Lake Havasu. Recent data suggest that striped bass can take up to 20 days to evacuate a consumed tag (Friedl et al. 2013), which makes mortality estimates and habitat preference assessments from a 60-day study suspect, considering a tag may be tracked for up to a third of the study period before it is evacuated, during which time it is unknown if it was representative of the behavior of a bonytail or predator. If a tagged bonytail is consumed toward the end of the study, it may never be determined a mortality or casualty of predation. Telemetry tags with a dissolvable "trigger" to detect consumption by a predator are currently being tested (Hydroacoustic Technology, Inc. 2014) and could provide an important tool to further examine the impact of piscivory on bonytail.

Despite the losses, new and corroborating data on post-stocking behavior of bonytail were collected. Eighty-four percent of passive contacts during spring 2014 occurred between sunset and sunrise. Tracking data support that bonytail are most active at night (Marsh and Mueller 1999, Marsh et al. 2013a) presumably to feed (Marsh et al. 2013b). Marsh et al. (2013a) observed bonytail establishing fidelity toward selective territory during the day while emerging into an isolated backwater at night. Bonytail may behave similarly at Blankenship Bend in the spring as observed through the lack of detection during the day and re-emergence of study fish in the same areas at night. Fish 140 displayed this described pattern most obviously and consistently (attachment 2). Study fish from the autumn 2013 telemetry did not exhibit these trends as strongly. The backwater released fish tended to move out of contact range in the late evenings and re-emerge at the same SUR in the early mornings. It is unclear if shorter periods of non-detection followed by a re-emergence at the same SUR occurring during the evening hours represent fish that simply swam out of detection range or fish that had moved into some type of heavy cover. Although fish were intensely tracked in both studies, some of the attention was focused on finding bonytail for which contact was lost. Future studies will focus on contacted fish within the study area and rely on SURs to discern the fate of lost fish. Non-detection periods in the evenings exhibited by autumn 2013 study fish may represent an increase in activity away from the backwater containing the SUR. Adapting tracking efforts to focus more intensively on identifying sites of disappearance and re-emergence may provide clues to preferred habitat cover.

Autumn study fish dispersed half as far upstream and one-fifth as far downstream compared to spring study fish. The difference may be related to season, as mean surface water temperatures were higher in spring, and bonytail begin spawning in late spring (Wagner 1955; Minckley 1973). However, fish origin may have also played a role. Study fish from the autumn 2013 study were transported directly from the hatchery, whereas spring 2014 study fish were captured from Cibola High Levee Pond and held at the hatchery for 13 days prior to surgeries and release. The difference in rearing facility (hatchery versus a “natural” pond), method of capture prior to transport (hatchery collection versus trammel netting), and transport time likely resulted in differing levels of stress in study fish and may account for the difference in post-stocking behavior (Portz 2009).

Both seasons of telemetry had a slightly higher percentage of active contacts in riverine mesohabitats compared to backwater mesohabitats (56 – 57% riverine and 43– 44% backwater). This result was similar to a bonytail study in Green River, Utah where main channel contacts made up 59% (102 of 174 contacts) of the total contacts (Chart 1990). The difference was minor and also may represent methodological bias due to difficulty tracking in complex backwaters where signals could be deflected or attenuated by obstructions, including debris and aquatic vegetation.

Backwater released acoustic-tagged fish displayed more consistency in behavior to each other than study fish released in the main channel. These fish appeared more likely to remain in Blankenship Bend and its backwaters. Furthermore, backwater released study fish in spring were more likely than those released in autumn to travel downstream and then return toward Blankenship Bend (five out of six study fish). Patterns in dispersal were not observed by acoustic-tagged fish released in the main channel, although in both studies, these fish travelled farther distances both up- and downstream than backwater released fish. It is unclear why fish released in the backwaters were more likely to remain within the Blankenship Bend boundaries that include both backwaters and the main channel.

All four identified microhabitat locations that were continuously inhabited by acoustic- tagged bonytail in spring 2014 were located in Blankenship Bend near the release sites. One fish was continuously tracked in the third cove of Blankenship Bend backwater while the other three sites, occupied by four different fish, were in the main channel within the Blankenship Bend area. Substrate of the backwater site was silt, while other sites were either fine sand or sand. All sites were less than 6 m in depth and in close proximity to sandbars, or shallow sandy areas. In Lake Mohave, Wagner (1955) also found bonytail over clean, sandy bottoms in eddying currents, which coincides with PIT scanning data in which contacts with bonytail were greatest at depths between 1.2 and 1.8 m. Surface water temperatures of the main channel sites were within less than 1 degree of each other and several degrees cooler than the backwater site. All sites had little to no submerged vegetation. Bulrush was observed at all sites but does occur in high densities universally throughout the study area; therefore, it cannot be determined if it is preferred vegetation.

Only one study fish was actively tracked throughout the autumn 2013 telemetry study, providing only one microhabitat data sample prior to the winter 2014 PIT scanner study. PIT scanner deployment locations were therefore based on the few locations recorded during the telemetry study and recorded captures from netting activities. Regardless, the deployment locations were consistent with observed habitat preference during the subsequent spring 2014 telemetry. PIT scanner arrays contacted multiple bonytail in Trampas Cove during three isolated sampling trips, suggesting some preference to that area. Both PIT scanning and trammel netting identified bonytail in Trampas Cove and Clear Bay, though contacts were inconsistent as to which method of sampling may be more effective. These sites will be targeted in future efforts.

PIT scanning during autumn 2013 was conducted to establish antenna orientation guidelines. Due to limited bonytail contacts, the effect of orientation on contact rate could not be determined. However, 0.8 x 0.8 m PIT scanner deployments oriented horizontally had greater contact rates of bonytail than 0.7 x 1.3 m PIT scanners orientated vertically during winter 2014, though scanners were not set equally across habitat types. These PIT scanners also had greater contacts at depths between 1.2 and 1.8 m. Marsh and Mueller (1999) in Lake Mohave,

Arizona and Nevada and Chart (1990) in the Green River, Utah also reported bonytail to be commonly found in shallow waters (less than 3 m), although Karam et al. (2013) in Lake Havasu, Arizona and California contacted bonytail at mean depths of 5 – 8 m.

We continue to assess the question of whether lack of captures by traditional sampling methods was due to behavior or methodological bias. During the February "Roundup," captures of bonytail (CPUE = 0.1) were low compared to netting efforts of non-native predators such as redear sunfish (*Lepomis microlophus*) (CPUE = 1.7) and largemouth bass (CPUE = 1.2), consistent with results of the fate of acoustic and PIT-tagged bonytail. Based on overall few contacts and captures across several approaches, it is unlikely that methodological bias is the key culprit. Additional efforts should be applied to the gorge where six of the total 22 study fish were passively contacted.

Fewer acoustic-tagged fish were used in this study than earlier ones so tracking effort could be more concentrated and intensive. However, losses during telemetry appear to not be due to too many fish to track but to high mortality. During previous telemetry studies in 2010 (Karam et al. 2011; Karam et al. 2012), study fish were stocked with mean TL of at least 400 mm, and more than 80% of study fish were active after 1-month post-release compared to less than 50% in the current study when a mean TL of fish at stocking was less than 350 mm. While this was not the case in autumn, spring released study fish still active by the end of the study had a greater mean TL than those lost or determined a mortality. Tagging additional bonytail (20 – 30 fish) at a larger size (greater than 400 mm TL) would increase the number of available fish to assess post-stocking habitat preferences beyond 1-month post-release and may result in increased PIT scanning contacts rates and increased precision of post-stocking survival estimates. Despite the limitations of monitoring equipment, combined sampling methods strengthen conclusions.

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. Increase the size of study fish if possible

3. Experimentally study the role of turbidity on bonytail survival

4. Continue yearly net monitoring of bonytail and outreach to the general public

5. Use remote PIT scanning in conjunction with small-scale acoustic telemetry to better evaluate and understand bonytail habitat use

6. Study the use by bonytail of backwater habitats near Blankenship Bend, specifically Trampas Cove and Clear Bay

7. Investigate the role of aviary predation on bonytail survival

8. Implement the use of predation detection tags during telemetry

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LITERATURE CITED

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

Chart, T. 1990. Radio-telemetered monitoring of stocked bonytail chub (*Gila elegans*) in the Green River, Utah 1988–1989. Utah Division of Wildlife Resources Final Report to the Bureau of Reclamation.

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. Bureau of Land Management, Lake Havasu City, Arizona. 23 p.

Friedl, S.E., J.E. Hightower, F.S. Scharf, and K.H. Pollock. 2013. Telemetry-based mortality estimates of juvenile spot in two North Carolina estuarine creeks. Transactions of the American Fisheries Society 142:399–415.

Frechette D., A.K. Osterback, S.A. Hayes, M.H. Bond, J.W. Moore, S.A. Shaffer, and J.T. Harvey. 2012. Assessing avian predation on juvenile salmonids using Passive Integrated Transponder Tag Recoveries and Mark-Recapture methods. North American Journal of Fisheries Management 32:1237–1250.

Hydroacoustic Technology, Inc. 2014. HTI's Predation Tag. Retrieved from http://www.slideshare.net/htisonar/efficacy-of-a-new-acoustic-tag-designed-to-indicate-occurrence-of-a-predation-event.

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. 2011. Distribution and post-stocking survival of bonytail in Lake Havasu. 2010 Annual Report. Reclamation Agreement No. R10PC30171, Boulder City, Nevada. Marsh & Associates, Tempe, Arizona. 58 p.

_____. 2012. Distribution and post-stocking survival of bonytail in Lake Havasu. 2011 Annual Report. Reclamation Agreement No. R10PC30171, Boulder City, Nevada. Marsh & Associates, LLC, Tempe, Arizona. 75 p.

Karam, A.P., C.M. Adelsberger, K.A. Patterson, J.E. Warmbold, and P.C. Marsh. 2013. Distribution and post-stocking survival of bonytail in Lake Havasu. 2013 Final Report. Reclamation Agreement No. R10PC30171, Boulder City, Nevada. Marsh & Associates, Tempe, Arizona. 83 p.

Kesner, B. R., J. R. Nelson, M. K. Fell, G. Ley, and P. C. Marsh. 2010. The development of two portable remote (PIT) scanning systems. Colorado River Basin Science and Resource Management Symposium. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Marsh, P.C. 1997. Sonic telemetry of bonytail in Lake Mohave, Arizona and Nevada. Final Report, U.S. Geological Biological Resources Division Agreement No. 1445-0009-94-1108. Arizona State University, Tempe, Arizona. 18 p. + figures.

_____. 2004. Threatened fishes of the world: *Gila elegans* Baird and Girard 1853 (Cyprinidae). Environmental Biology of Fishes 70:144.

Marsh, P.C. and G. Mueller. 1999. Spring-summer movements of Bonytail in a Colorado River reservoir, Lake Mohave, Arizona and Nevada. U.S. Geological Survey Open File Report 99-103. 26 p.

Marsh P.C., B.R. Kesner, and C.A. Pacey. 2005. Repatriation as a management strategy to conserve a critically imperiled fish species. North American Journal of Fisheries Management 25:547–556.

Marsh, P.C., G.A. Mueller, and M.R. Schwemm. 2013a. 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.

Marsh, P.C., G.A. Mueller, and J.D. Schooley. 2013b. Springtime foods of bonytail (Cyprinidae: *Gila elegans*) in a lower Colorado River backwater. The Southwestern Naturalist 58:512–516.

Martin, J., V. Tolon, B.V. Moorter, M. Basille, C. Calenge. 2009. On the use of telemetry in habitat selection studies. Pages 37–55 In Telemetry: Research, Technology and Applications (D. Barculo D. and J. Daniels, editors), Nova Science Publishers Inc.

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 °C. 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, Arizona. 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. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix. 293 p.

Minckley, W.L. 1979. Aquatic habitats and fishes of the lower Colorado River, Southwestern United States. Final Report, Bureau of Reclamation, Boulder City, Nevada. Contract Number 194-06-300-2529. Arizona State University, Tempe.

Minckley, W.L. and J.E. Deacon. 1991. Battle against extinction: native fish management in the American West. University of Arizona Press, Tucson.

Modde, T., A.F. Wasowicz, and D.K. Hepworth. 1996. Cormorant and grebe predation on rainbow trout stocked in a southern Utah reservoir. North American Journal of Fisheries Management 16:388–394.

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

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. 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, Colorado. 43 p.

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, Colorado. 69 p.

Mueller, G.A., J. Carpenter, P.C. Marsh, and C.O. Minckley. 2003. Cibola High Levee Pond Annual Report 2003. U.S. Geological Survey, Denver, Colorado. 26 p.

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. Marsh & Associates, LLC. Tempe, Arizona. 24 p.

Ng C.L., K.W. Able, and T.M. Grothues. 2007. Habitat use, site fidelity, and movement of adult striped bass in a southern New Jersey estuary based on mobile acoustic telemetry. Transactions of the American Fisheries Society 136:1344–1355.

Pacey, C. 2014. Marsh & Associates, LLC., Tempe, Arizona, personal communication.

Patterson, K.A., B.R. Kesner, A.P. Karam, and P.C. Marsh. 2013. Comparative survival of repatriated razorback sucker in Lower Colorado River Reach 3. 2013 Final Report. Marsh & Associates, LLC, Tempe, Arizona. 36 p.

Portz, D.E. 2009. Stress inducing factors of bonytail hatchery and stocking practices. Bureau of Reclamation, Technical Service Center, Denver, Colorado. 50 p.

Reisner, M. 1986. Cadillac desert: The American West and its disappearing water. Penguin Books, New York. 582 p.

Schooley, J. D. 2010. Avian predation on razorback sucker *Xyrauchen texanus* in the lower Colorado River. Master of Science Thesis, Arizona State University, Tempe. 153 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, Reclamation Agreement No. 06-FC-30-0002. Arizona State University, Tempe. 30 p. + figures, tables.

Scoppettone G.G., P.H. Rissler, M.C. Fabes, and D. Withers. 2014. American white pelican predation on Cui-ui in Pyramid Lake, Nevada. North American Journal of Fisheries Management 34:57–67.

U.S. Fish and Wildlife Service. 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.

Wagner, R.A. 1955. Basic survey of Lake Mohave. Completion Report, Project F-2-R-1, Wildlife Restoration Division, Arizona Game and Fish Department, Phoenix.

Wilkerson M.L. and W.L. Fisher. 1997. Striped bass distribution, movements, and site fidelity in Robert S. Kerr Reservoir, Oklahoma. North American Journal of Fisheries Management 17:677–686.

Wydoski, R. 2014. Bureau of Reclamation, Denver, Colorado, personal communication.

ATTACHMENT 1

Individual Fish Narratives for October 2013 – January 2014
Bonytail Telemetry

The following provides a detailed narrative of post-stocking tracking efforts for all telemetered fish during the October 2013 – January 2014 bonytail study.

FISH 3

Fish 3 (total length [TL] = 315 millimeters [mm] and mass [M] = 215 grams [g]) was released into the Blankenship Bend backwater on October 22, 2013. The fish remained in the backwater continuously until contact was lost into the second week of tracking. Active tracking from the 22nd – 27th confirmed the fish's location in the backwater. On the evening of the 22nd, 23rd, and 24th, fish 3 moved out of submersible ultrasonic receiver (SUR) detection range and re-emerged in the same area several hours later. The fish exhibited similar behavior on the evening of the 25th, except the fish remained out of contact until the morning of the 26th. The same pattern occurred in the evening of the 26th, 27th, and 28th, though the fish moved out of detection at a later hour on the 28th. On the 29th, fish 3 moved out of detection range in the early afternoon but was contacted actively that evening in the third cove before re-emerging at the same SUR the early morning of the 30th. Fish 3 moved out of detection range of the SUR in the Blankenship Bend backwater in the afternoon of the 30th and was last contacted actively in the late morning of the 31st near the entrance to the backwater in vegetation.

FISH 4

Fish 4 (TL = 287 mm and M = 240 g) was released into the Blankenship Bend backwater on October 22, 2013, and never left the area for the duration of tracking. Active tracking triangulated the fish in the third cove of the backwater after release (see figure 4). The SUR deployed in the backwater then tracked the fish for the remainder of the 22nd and through the 23rd. The fish moved out of detection range in the evening of the 23rd for multiple hours before re-emerging at the same SUR. Similar behavior occurred on the evening of the 24th, 25th, 26th, 27th, 28th, and 29th. Active tracking confirmed the fish's location in the first cove. The pattern of behavior deviated on the 30th when fish 4 moved out of contact range for most of the daylight hours and then again in the late evening through the morning of the 31st, both times re-emerging at the same SUR. Fish 4 again moved out of detection range through most of the daylight hours on the 1st of November until re-emerging in the evening at the same SUR, though it was actively tracked near the entrance to the backwater in vegetation. Similar behavior occurred on the 2nd, 3rd, 4th, and the 5th when the fish again moved out of detection range through most of the daylight hours but was actively tracked during the day on the 2nd and 4th outside of the backwater entrance and on the 3rd back in vegetation in the first cove. When fish 4 moved out of detection range in the morning of the 6th, it did not re-emerge near that SUR. Active

tracking that afternoon and the following afternoon found the fish near vegetation in the main channel on river left upstream of the backwater entrance. Shortly later in the afternoon of the 7th, the fish was passively tracked by the SUR just upstream of the backwater release site where the fish remained through the evening of the 10th, being occasionally actively tracked outside of the backwater on river left just downstream from Mohave Rock. Active tracking continued to triangulate the fish at this location, and it was determined deceased on November 11, 2013.

FISH 5

Fish 5 (TL = 285 mm and M = 188 g) was released into the main channel of Blankenship Bend on October 22, 2013, and immediately disappeared from detection. The fish was only tracked once actively in the afternoon after release near the release site moving upstream.

FISH 7

Fish 7 (TL = 306 mm and M = 188 g) was released into the main channel of Blankenship Bend on October 22, 2013. The fish was only actively tracked from the time of release until the 17th of November. On the 22nd of October, the fish was actively tracked near the release site. In the morning of the 31st, the fish was upstream of the sand bar island of Blankenship Bend near the north bank. The fish was next tracked upstream of this location, upstream of the upper bend of Blankenship Bend in the evening of the 3rd of November. In the morning of the 4th, the fish was further upstream on river right near vegetation and in the afternoon of the 6th, fish 7 was slightly further upstream, tucked back in vegetation, but moved out toward mid-channel an hour later. Next, fish 7 moved upstream of Mohave Rock where it was contacted manually on river right in the late afternoon of the 9th. The fish was in the same location according to active efforts on the 10th and 11th but did move slightly downstream on the 12th, 13th, and 15th. The fish was still actively tracked in the same area on the 17th but appeared to be swimming. The fish was not contacted again until the morning of the 27th by passive efforts near Mohave Rock, and later near the entrance to Blankenship Bend backwater, and then at the lower bend of Blankenship Bend. In the afternoon of the 27th, fish 7 was back upstream near Mohave Rock but again swam downstream past the backwater entrance to the lower bend where it remained into the early morning of the 28th. The fish moved in and out of detection range at times but continuously re-emerged at the same SUR through the 28th, 29th, and 30th. In the evening of the 30th, fish 7 quickly entered and exited Blankenship Bend backwater before returning to the lower bend of Blankenship Bend. The fish did the same in the morning of the 1st of December but then remained at the lower bend through the 2nd of November – 16th of

January and was actively triangulated during this time near vegetation on river right. The fish was determined a mortality beginning the 18th of December, though this may be a conservative estimate.

FISH 257

Fish 257 (TL = 315 mm and M = 210) was released into Blankenship Bend backwater on October 22, 2013, and was actively and passively tracked in the first cove of Blankenship Bend backwater in the afternoon and evening of the 22nd and morning of the 23rd. The fish remained in the first cove of the backwater through the 27th but did move out of detection range and then re-emerge at the same SUR in the late evening and early morning each night except for the last. Active tracking on the 23rd placed the fish near phragmites. On the 25th and 26th, the fish was tracked outside of the backwater entrance. Fish 257 was not tracked on the 28th but on the 27th, 29th, 30th, and 31st, it was actively triangulated at the same location outside of the backwater near submerged vegetation. On the 6th and 7th of November, the fish was triangulated in the main channel on river left approximately 25 meters from Blankenship Bend backwater entrance. The fish was determined deceased on the 9th of November after continuously being actively triangulated downstream from the backwater entrance in the described general area.

FISH 258

Fish 258 (TL = 293 mm and M = 211) was released into Blankenship Bend backwater on October 22, 2013, where it remained through the duration of the study. Passive tracking from the 22nd to the 31st placed the fish in the first cove of Blankenship Bend backwater. Active tracking during this time complemented passive data, except for on the 29th when manual efforts triangulated fish 258 in the third cove of the backwater. Fish 258 had moved out of detection range for multiple hours in the evening of the 24th but re-emerged in the morning of the 25th at the same SUR and did the same on the evening of the 25th, 26th, 27th, and 28th. Fish 258 went out of contact range earlier than previous days on the 29th, in the early afternoon. At this time, active tracking located the fish in the third cove of Blankenship Bend backwater. The fish re-emerged briefly at the SUR in the first cove in the early morning of the 30th, moved back out of contact range, and then re-emerged again in the first cove where it remained through the afternoon and evening before returning to its normal behavior, disappearing from detection in the evening and re-emerging in the morning of the 31st. That evening when the fish moved out of contact range, it did not emerge until days later in the early morning of the 12th of November near a SUR placed in the third cove of the backwater but quickly returned to the first cove before moving out of detection range. The fish was next contacted in the evening of the 13th again in the first

cove where it appeared to remain until the 30th, though moving out of detection range more frequently, typically during daylight hours. In the morning of the 30th, the fish moved out of the backwater to be contacted by the SUR deployed near the backwater entrance. The fish was continuously passively tracked here through the evening of the 3rd of December when fish 258 moved in range of the SUR in the first cove for a brief amount of time before returning to the SUR outside of the entrance. Again, the fish was continuously tracked here through the evening of the 5th when it briefly visited the first cove before moving out of detection range and re-emerging outside of the backwater in the early morning of the 6th. In the evening of the 6th and morning of the 7th, the fish moved back and forth between the SURs in the first cove and outside of the backwater. The same behavior occurred in the evening of the 7th after much of the daylight hours were spent outside of the backwater. The same pattern occurred on the 8th before the fish moved out of contact. Fish 258 was not contacted again until the 18th and 19th of December by active efforts in the second cove of Blankenship Bend backwater, its last contact.

FISH 259

Fish 259 (TL = 325 mm and M = 218 g) was released into Blankenship Bend backwater on October 22, 2013, and never appeared to leave through the duration of the study according to passive and active tracking. The fish moved out of detection range for multiple hours in the evening of the 22nd, 23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, and a couple of hours in the early evening of the 22nd and morning of the 27th, each time re-emerging at the same location. Fish 259 was last contacted by passive efforts in the evening of the 31st in the first cove of Blankenship Bend backwater.

FISH 260

Fish 260 (TL = 311 mm and M = 198 g) was released into the main channel of Blankenship Bend on October 22, 2013, and then immediately moved upstream. Active tracking on the 22nd triangulated the fish near the release site and observed it swimming upstream. On the 23rd, the SUR at Mohave Rock contacted the fish, and active tracking located the fish near Mohave Rock river right near phragmites. On the 24th, active tracking triangulated the fish approximately 150 meters upstream of Mohave Rock near cattails. Fish 260 was contacted sporadically, usually for several hours in the evenings and early mornings, by the SUR at Mohave Rock on the 23rd – 27th. Active tracking from the 25th of October to the 11th of November continued to locate fish 260 close to Mohave Rock on river left near a backwater entrance. No detection occurred on the 28th of October or the 30th of October to the 9th of November. From the 9th to the 11th, the fish returned to its pattern of moving into detection range of the

SUR at Mohave Rock for short periods of time in the late evenings and early mornings. In the late evening of the 11th, the fish's behavior changed when it was contacted by the SUR downstream from Trampas Cove and upstream of Mohave Rock, but in the early morning of the 12th, the fish returned downstream from Mohave Rock according to passive efforts. That evening, the fish returned upstream, passed the SUR downstream from Trampas Cove, passed the SUR at the big rock upstream of Trampas Cove, and arrived to the SUR downstream from the sand dunes. By the morning of the 13th, fish 160 moved farther upstream of the sand dunes to the SUR at the downstream buoys of the no wake zone of Topock Gorge. This was the last site of contact for fish 160.

FISH 261

Fish 261 (TL = 312 mm and M = 202 g) was released into the main channel of Blankenship Bend on October 22, 2013, and after being actively tracked near the release site that afternoon, it was observed moving upstream. The SUR at Mohave Rock tracked the fish moving upstream in the mornings of the 24th and 25th. Active tracking in the evening of the 25th triangulated the fish approximately 150 meters upstream of Mohave Rock mid-channel as the fish moved into range of the SUR upstream of Mohave Rock and downstream from Trampas Cove. Here, the fish remained through the 26th, though it moved out of detection range and re-emerged at the same location in the early morning and through most of the daylight hours, although active tracking during the day did triangulate the fish in the late morning hiding in submerged vegetation river left approximately 100 meters upstream of Mohave Rock. By the early morning of the 27th, the fish had traveled downstream all the way to the lower bend of Blankenship Bend as described by SUR data. The fish continued to travel downstream that morning past the SUR upstream of Rearing Cove to the SUR deployed near the main entrance of the Castle Rock backwater. The morning of the 27th, outside of the Castle Rock backwater, was the last contact with fish 261.

FISH 262

Fish 262 (TL = 310 mm and M = 187 g) was released into the main channel of Blankenship Bend on October 22, 2013, and quickly traveled upstream as confirmed by active tracking. In the morning of the 23rd, the fish was first contacted by the SUR at Mohave Rock and then by the SUR upstream of Mohave Rock and downstream from Trampas Cove. It moved in and out of contact through most of the later morning and daylight hours of the 24th but was contacted actively in the afternoon approximately 100 meters upstream of Mohave Rock on river left near a patch of cattails. After re-emerging in the evening of the 24th at the SUR downstream from Trampas Cove, fish 262 again went through a short period of non-detection in the early morning of the 25th and

again through most of the daylight hours of the 25th. Active tracking that evening, as well as on the 27th, placed the fish on river right farther upstream but still downstream from Trampas Cove. The SUR downstream from Trampas Cove continued to track the fish through the evening of the 25th and morning of the 26th before it underwent non-detection through most of the daylight hours of the 26th and re-emerged very briefly in the evening still in the same location. Fish 262 re-emerged again mid-morning of the 27th very briefly before moving out of detection range and re-emerging that evening near the SUR downstream from Trampas Cove. The fish was still at this SUR in the very early morning of the 28th but was not contacted again until the 4th of November by active efforts downstream from Mohave Rock on river right in vegetation. Next, fish 262 was tracked passively in the evening of the 11th back upstream at the same SUR upstream of Mohave Rock and downstream from Trampas Cove. No contacts were recorded again until the evening of the 6th of December, still at the same SUR where it remained for a short period of time. Fish 262 emerged next downstream at the SUR deployed near the no boater zone by Mohave Rock in the early morning of the 7th but quickly moved back to the SUR between Mohave Rock and Trampas Cove. No contacts were recorded through most of the daylight hours of the 7th, but the fish did re-emerge that evening at the same location. The next contact was in the evening of the 23rd at the same location. Later that evening, the fish moved back downstream to the SUR at the no boater zone near Mohave Rock. In the evening of the 19th, the fish was contacted farther downstream below Blankenship Bend at the SUR upstream of Rearing Cove. On the 2nd of January, the fish was recorded by the SUR at the Castle Rock main entrance. The fish was not contacted again until the 14th at the same SUR near Castle Rock, where it appears to have remained through the 16th, though it went through a period of non-detection and re-emergence in the evening of the 14th and morning of the 15th. The last contact of fish 262 was on the 16th at the Castle Rock entrance.

ATTACHMENT 2

Individual Fish Narratives for April – May 2014 Bonytail Telemetry

The following provides a detailed narrative of post-stocking tracking efforts for all telemetered fish during the April – May 2014 bonytail study.

FISH 122

Fish 122 (total length [TL] = 355 millimeters [mm] and mass [M] = 302 grams [g]) was released into the main channel of Blankenship Bend on April 8, 2014, where it was contacted consistently into the late evening by the submersible ultrasonic receiver (SUR) outside of Blankenship Bend backwater east of the sandbar island, except for several hours in the early evening, in which it moved out of detection range and re-emerged at the same SUR. Active triangulation placed the fish near the cliff just upstream of the release site that evening. It was not contacted on the 9th; however, active tracking did locate the fish in the early morning of the 10th upstream of Blankenship Bend backwater in a pocket of bulrush on river left. Fish 122 was also actively tracked in the early morning of the 11th in the main channel just south of the sandbar island in Blankenship Bend after which it moved within range of the SUR outside of Blankenship Bend backwater across from the sandbar island where it remained through most of the morning. It was not contacted again until the early evening of the 11th by active tracking just upstream of the Blankenship Bend backwater entrance in an eddy near submerged woody debris and again later that evening in the main channel between the sandbar island and the backwater entrance, during which time it was also in range of the SUR near the backwater entrance east of the sandbar island, and remained so consistently until the morning of the 12th. Fish 122 then moved into the first cove of Blankenship Bend backwater for a short amount of time before returning to the SUR at the entrance to the backwater. Contact was lost through much of the day until the late afternoon of the 12th when the fish re-emerged at the same location. The last contact of fish 122 was on the 12th by the SUR just upstream of the Blankenship Bend backwater entrance.

FISH 123

Fish 123 (TL = 362 mm and M = 358 g) was released into the main channel of Blankenship Bend on April 8, 2014, and was actively contacted that evening in bulrush near the release location and on the 9th just downstream from the release location on river left at the downstream bend of Blankenship Bend. Through the first week and the beginning of the second, fish 123 remained in the lower portion of Blankenship Bend down to Rearing Cove. Fish 123 remained in range of a SUR at the lower bend of Blankenship Bend in the very early morning of the 10th for approximately an hour before moving out of contact range through most of the day and re-emerging in the evening of the 10th at the same location where it resided for over an hour. The fish was not contacted on the 11th but was recorded by SUR in the very early morning of the 12th in the Blankenship Bend California

backwater where it remained consistently through the morning, except for several hours of the early morning, during which time it disappeared from detection and re-emerged at the same location. The fish was not recorded through the rest of the 12th but did re-emerge again at the same location in the early morning of the 13th and remained in the area for a couple hours. Mid-morning, the fish moved back near the SUR at the lower bend of Blankenship Bend, out of detection through the day, and by the evening of the 13th, fish 123 returned to the Blankenship Bend California backwater for a brief amount of time. Through most of the early morning of the 14th, except for a few hours, fish 123 was within detection range of the SUR placed upstream of Rearing Cove. Later that morning, fish 123 was contacted by the SUR in the lower bend of Blankenship Bend where it remained for a couple of hours before moving out of contact range for much of the daylight hours. Late in the evening of the 14th, the fish had returned to the SUR placed upstream of Rearing Cove, and in the early morning of the 15th, the fish was actively tracked just south of Blankenship Bend in an eddy near bulrush.
Fish 123 was passively tracked back in the lower bend of Blankenship Bend through the late morning of the 15th, and disappeared until the early morning of the 16th at the Blankenship Bend California backwater but quickly returned to the lower bend of Blankenship Bend. That morning, the fish moved out of range for a couple hours, re-emerging at the same SUR before moving out of detection range for most of the daylight hours. Fish 123 spent the late evening of the 17th and the early morning of the 18th in the Blankenship Bend California backwater before moving upstream past the giant reed (*Arundo donax*) in Blankenship Bend to the downstream no boater zone entrance, through the refuge area, and up to the SUR between Mohave Rock and Trampas Cove. Fish 123 remained consistently at the SUR from the morning throughout most of the day until it entered Trampas Cove in the evening of the 18th. The fish disappeared through the late night of the 18th and throughout the 19th until the early evening of the 19th when it re-emerged in Trampas Cove for a couple hours. Fish 123 then began to deviate from its previously observed behavior as it traveled a 73 km distance in 3 days. This fish moved upstream to the sand dunes very early on the 20th before moving out of range throughout most of the 20th and re-emerging at the sand dunes late on the evening of the 20th. Early on the 21st, fish 123 began swimming downstream past the SUR between Mohave Rock and Trampas Cove and through the refuge. Later in the morning, it swam past the SUR placed upstream of Rearing Cove and then the SUR placed downstream from Rearing Cove but ended up back upstream at the lower bend of Blankenship Bend by later in the morning. In the early morning of the 22nd, the fish was at the Mile 17 buoys. The most downstream recorded site of all tagged fish was located between the delta and basin on the morning of the 23rd by active tracking, but the fish had returned within range of the Mile 17 buoys SUR by the evening of the 23rd. Beginning on the 25th, fish 123 was continuously actively tracked in the same area just downstream from the main Castle Rock entrance on river right where it was determined a mortality.

FISH 124

Fish 124 (TL = 357 mm and M = 346 g) was released into the main channel of Blankenship Bend on April 8, 2014. Active tracking mapped fish 124 near the release site early in the morning of the 9th and downstream from the Blankenship Bend California backwater in the evening of the 9th. The SUR at the lower bend of Blankenship Bend also contacted fish 124 in the area for a couple of hours that evening. In the early morning of the 10th, the fish moved near the entrance to the Blankenship Bend backwater, being contacted between the SUR outside of the entrance across from the sandbar island and by the SUR in the first cove of the backwater until mid-morning, though there was an occasion the fish disappeared and re-emerged in the area. The fish also moved out of detection range through most of the daylight hours of the 10th and again re-emerged that evening at the same location near the SUR placed in the first cove of Blankenship Bend backwater. Fish 124 did swim upstream later that evening past the no boater zone and the SUR between Trampas Cove and Mohave Rock to Big Rock. It swam to the SUR at the big rock upstream of Trampas Cove by the early morning of the 11th. Later in the morning of the 11th, fish 124 arrived at the sand dunes, but contact was lost until the evening of the 14th when the fish was tracked by the SUR between Trampas Cove and Mohave Rock where it remained until the early morning of the 15th. Mid-morning of the 15th, fish 124 was contacted passively in the refuge. It then moved out of contact range through most of the daylight hours and re-emerged in the refuge where it was tracked actively and passively in the evening of the 15th and remained through the morning of the 16th. The fish moved further upstream that morning to the SUR between Trampas Cove and Mohave Rock but remained out of contact from the morning of the 16th to the evening of the 22nd, though re-emerging at the same SUR as previously recorded. Fish 124 remained at this location throughout the evening of the 22nd and early morning of the 23rd, disappearing during the day of the 23rd, and re-emerging in the evening of the 23rd still at the SUR between Trampas Cove and Mohave Rock. SURs did not contact fish 124 on the 24th or 25th; however, active tracking did find the fish on the 24th in the evening at the entrance of Trampas Cove near a large patch of bulrush where it was potentially disturbed by the tracking boat but was inevitably followed upstream to Picture Rock. When fish 124 returned downstream, it still remained in range of the SUR between Trampas Cove and Mohave Rock in the evening of the 26th and early morning of the 27th. The fish then traveled downstream to the no boater zone entrance later in the morning of the 27th and then to the SURs up- and downstream from Rearing Cove in the evening of the 27th and early morning of the 28th but arrived back upstream at the lower bend of Blankenship Bend later in the morning of the 28th. By the evening of the 28th, the fish moved back down to the SUR downstream from Rearing Cove where it remained for several hours before moving up to the SUR upstream of Rearing Cove. Fish 124 was last contacted in the late evening of the 28th upstream of Rearing Cove.

FISH 125

Fish 125 (TL = 360 mm and M = 363 g) was released into the main channel of Blankenship Bend on April 8, 2014, and was actively tracked approximately 200 meters downstream from the release site on the evening of the 8th and was passively tracked at the lower bend in Blankenship Bend for approximately an hour in the evening of the 9th. Fish 125 was then tracked by active efforts downstream from Blankenship Bend, near the SUR at the lower bend, followed by passive efforts at the SUR upstream of Rearing Cove where it consistently remained through the night of the 9th and into the morning of the 10th, with the exception of a couple hours in the very early morning of the 10th, though it re-emerged at the same SUR. Active tracking that morning also identified the tag in this area near pampas grass. After no contacts through most of the daylight hours, in the evening of the 10th, the fish briefly returned upstream to the lower bend of Blankenship Bend and was also contacted actively in the lower bend of Blankenship Bend. Early in the morning of the 11th, fish 125 was within range of the SUR in the refuge for several hours before moving upstream past Mohave Rock and Trampas Cove and into Trampas Cove where it remained through the morning, except for several hours, though the fish re-emerged near the same SUR. The fish disappeared again in the late morning until the late afternoon, still re-emerging in Trampas Cove. In the very late evening of the 11th, fish 125 was recorded at the sand dunes where it remained into the very early morning of the 12th. Not until the 19th was fish 125 contacted at the SUR at the USGS gage station. The next tracking event occurred by SUR in the early morning of the 21st back at the sand dunes. Later that morning, the fish was contacted at the SUR between Trampas Cove and Mohave Rock, the entrance to the no boater zone, and within the refuge. Fish 125 was not contacted from the 21st to the 26th. In the late evening of the 26th through the morning of the 27th, it was passively tracked at the finger of the third cove of Blankenship Bend backwater and briefly in the first cove. The SUR at the downstream entrance to the no boater zone recorded fish 125 in the evening of the 27th. From the 29th of April through the 3rd of May, only active tracking could account for fish 125. In the early morning of the 29th, fish 125 was triangulated twice in bulrush just upstream of the sand bar island in Blankenship Bend. On the evening of the 2nd, fish 125 was in the main channel upstream of the backwater entrance east of the sand bar island, and on the 3rd, it was across from the sandbar island. Later on the 3rd, SUR data indicate that the fish returned to the no boater zone for several hours but eventually came back downstream to be contacted actively in the evening of the 4th in Blankenship Bend near the sandbar island. SUR data suggest that the fish was near the entrance to the backwater shortly after this time and then traveled into the first cove of Blankenship Bend backwater where it remained into the late evening. Further active tracking complements these data, triangulating the fish near the backwater entrance just downstream from the buoys. In the mid-morning of the 5th, the fish had exited the backwater and was tracked by the SUR across from the sandbar island near the backwater entrance. For approximately 5 hours in the morning, and during most of the daylight hours, fish 125 was out of contact range

but did re-emerge at the same SUR. By the evening of the 6th and early morning of the 7th, fish 125 was recorded by the SUR near the no boater zone entrance, disappeared through most of the 7th, and re-emerged at the same SUR in the evening of the 8th. The fish went out of contact range until the evening of the 9th, still re-emerging at the same SUR. Similar behavior occurred the following 2 days, when fish 125 disappeared late in the evening of the 9th and 10th and reappeared in the evenings of the 10th and 11th. Active tracking confirmed the fish's location upstream of Blankenship Bend in the evening of the 10th. Fish 125 was not contacted at all on the 12th but did re-emerge on the 13th in the evening briefly before entering Blankenship Bend backwater and was contacted by the SUR in the first cove of the backwater, then at the finger in the third cove, and back to the first cove. Active tracking also triangulated fish 125 in the first cove near the second cove moving toward the exit of the backwater. Early on the 14th, fish 125 was contacted again at the entrance to the no boater zone, disappearing during much of the day and re-emerging in the same area that evening, and then moving upstream near the SUR between Trampas Cove and Mohave Rock. Fish 125 traveled further upstream to the sand dunes in the morning of the 15th, disappearing for a few hours and emerging in the same area, as well as throughout most of the day. Fish 125 was last contacted on the 15th by the SUR stationed at the sand dunes.

FISH 126

Fish 126 (TL = 337 mm and M = 256 g) was released into the main channel of Blankenship Bend on April 8, 2014, and was first actively tracked in the evening of the 11th near the release site and then passively tracked by the SUR at the lower bend of Blankenship Bend. Shortly later that evening, fish 126 swam downstream past the SURs placed up- and downstream from Rearing Cove, returning to the upstream SUR in the early morning of the 12th and then back up to the lower bend of Blankenship Bend. Later in the morning of the 12th, the fish moved through the first cove of Blankenship Bend backwater to the third cove and back to the first cove where it consistently remained into the evening before being actively triangulated near the cliffs south of the sandbar island in Blankenship Bend. Fish 126 arrived in the Blankenship Bend California backwater in the early morning of the 13th, moved out of contact range for a couple hours in the morning, through most of the daylight hours of the 13th, and for a couple of hours in the early morning of the 14th but re-emerged each time still in the Blankenship Bend California backwater. Later in the morning of the 14th, fish 126 was passively tracked briefly at the lower bend of Blankenship Bend, moved out of detection range for most of the daylight hours, and then returned to the Blankenship Bend California backwater that evening. Late in the evening of the 14th and early morning of the 15th, fish 126 briefly moved within range of the SUR upstream of Rearing Cove. The fish swam upstream to the lower bend of Blankenship Bend mid-morning of the 15th where it was very briefly recorded by SUR. By the evening of the 15th, fish 126 had moved

downstream past the upstream and downstream SURs near Rearing Cove to the SUR upstream of the Mile 17 buoys where it remained through the evening, during which time it was actively triangulated near the lower Castle Rock backwater entrance. In the morning of the 16th, fish 126 returned upstream past both SURs near Rearing Cove, moved out of contact range during the daylight hours, and swam into the Blankenship Bend California backwater by the evening. Beginning in the morning of the 17th for a short amount of time, fish 126 was contacted back and forth between the SUR at the lower bend of Blankenship Bend and in the California backwater and was next contacted in the morning of the 18th, again at the lower bend. Fish 126 was not tracked again until the 21st, first by SURs near the entrance to the no boater zone and in the refuge area that morning, and then at the finger of the third cove of Blankenship Bend backwater that evening. The fish was out of any contact range two more days before being passively tracked through the morning of the 24th back at the entrance to the no boater zone, occasionally being recorded by the SUR in the refuge area, during which time it received no contact for several hours but re-emerged back in the same area. Fish 126 then disappeared through most of the 24th, though it again re-emerged in the same area near the no boater zone in the evening of the 26th. Shortly afterward, the fish moved down into Blankenship Bend, contacted by the SUR across from the sandbar island near the backwater entrance for a very brief amount of time. Fish 126 was next contacted at the entrance of the no boater zone with brief contacts by the SUR in the refuge in the evening of the 26th, during which time it moved out of contact for a couple of hours but re-emerged in the same area. The fish was not tracked again for several days but did re-emerge for a brief period in the same area at the entrance to the no boater zone on the 29th. In the morning of the 30th, fish 126 was in the first cove of Blankenship Bend backwater, moved out of SUR range through much of the day, and then back into range that evening, still in the first cove before traveling near the SUR across from the sandbar island in Blankenship Bend. Later in the evening of the 1st of May, the fish had returned back upstream to the no boater entrance, into the refuge, and then upstream to the SUR between Trampas Cove and Mohave Rock. Fish 126 was not contacted again until the evening of the 5th at the sand dunes, the last record of contact.

FISH 127

Fish 127 (TL = 268 mm and M = 132 g) was released into the main channel of Blankenship Bend on April 8, 2014, and was actively tracked that evening near the release site in slower moving water west of the sandbar island. Through the late evening, the SUR at the lower bend of Blankenship Bend recorded fish 127 where it remained through most of the 9th. Very early on the 9th, fish 127 was again actively tracked, this time in a large eddy near the SUR at the lower bend of Blankenship Bend on river right. For several hours later into the morning, the fish had moved out of contact range of the SUR but did re-emerge in the same area. After being consistently passively contacted through much of the 9th at the lower

bend, in the evening of the 9th, fish 127 swam into the Blankenship Bend California backwater where it remained for a couple of hours. The next contact was not until the morning of the 10th by active tracking just downstream from the release site. In the evening of the 10th, the SUR placed at the giant reed in Blankenship Bend briefly recorded the tag, shortly after which the SUR at the entrance to the no boater zone upstream of Blankenship Bend recorded the fish for several hours, with occasional contacts inside the refuge. Later that evening, the fish moved back downstream to near the giant reed in Blankenship Bend and was actively triangulated just upstream of Blankenship Bend's lower bend on river left. Early on the 11th, fish 127 had moved back upstream to the no boater entrance and then to the SUR between Trampas Cove and Mohave Rock. The fish continued to swim upstream, being contacted by the SUR at the big rock upstream of Trampas Cove and then at the sand dunes. The afternoon of the 11th at the sand dunes was the last contact with fish 127.

FISH 137

Fish 137 (TL = 310 mm and M = 210 g) was released into the backwater of Blankenship Bend on April 8, 2014, where it remained for most of its contacts for the first few days of the study. Through the 8th, the fish sporadically traveled around the backwater, being recorded initially in the afternoon by the SUR in the third cove of Blankenship Bend backwater before disappearing from detection for several hours and re-emerging in the third cove where it continued to be contacted by SURs at the south end of the third cove and in the finger. Next, it was recorded by the SUR in the first cove. Active tracking during this time triangulated the fish approximately 15 meters from bulrush in the main channel before it returned to the third cove, with occasional contacts in the finger, as recorded by passive equipment. Beginning in the late evening of the 8th and then early morning of the 9th, fish 137 moved from the first cove of the backwater to outside of the backwater near the entrance, where it was recorded by the SUR east of the sandbar island, and briefly moved back and forth between the two SURs in the morning and evening of the 9th. That morning, active tracking recorded the fish in this area on the edge of bulrush, and that evening, the fish was actively tracked near the entrance to the backwater in bulrush. Similar behavior was recorded beginning on the morning of the 10th as the fish continued to move back and forth between the SURs in the first cove of Blankenship Bend backwater and outside of the backwater entrance east of the sandbar island. The fish was suspected to be in the same location as the previous day based on active tracking. The fish did move out of contact range from the SUR east of the sandbar island through the daylight hours of the 10th and emerged that evening at the first cove of the backwater. Fish 137 disappeared for a few hours that evening, this time re-emerging at the same SUR in the first cove. Active tracking placed it near the entrance to the backwater moving into bulrush just as it was re-emerging in range of the SUR. In the early morning of the 11th, the fish had moved into the third cove of the backwater where its location was confirmed by active tracking. It was

soon contacted by the SUR in the finger for a short period and then returned in range of the SUR at the south end of the third cove. Later that morning, the fish moved into the first cove before again traveling out of SUR detection range for approximately 12 hours and before being contacted in the evening briefly by the SUR outside of the backwater entrance east of the sandbar island, back in the first cove, and then in the third cove. Again, active tracking confirmed fish 137's location in the third cove that evening. The fish traveled back out of the backwater later in the evening as it was contacted in the first cove and outside of the entrance by SUR. The fish was not contacted in the late evening of the 11th, only briefly passively at the finger in the morning of the 12th, and not at all on the 13th but was recorded again at the finger of the third cove of Blankenship Bend backwater early in the morning of the 14th. Its behavior then changed as it traveled out through the first cove, past the backwater entrance, to the no boater zone entrance, and then back downstream to the SUR at the giant reed in Blankenship Bend. In the evening of the 14th, the fish continued to travel downstream past the up- and downstream SURs of Rearing Cove and then back up to the lower bend of Blankenship Bend by the morning of the 15th. Fish 137 was not recorded during the daylight hours of the 15th but was contacted in the evening of the 15th at the Castle Rock backwater upstream entrance and then at the SUR upstream of the Mile 17 buoys. In the morning of the 16th, the fish was contacted further downstream at the SUR downstream from the Mile 17 buoys in the main channel. Later that morning, the fish moved near the Mile 17 sign in the Castle Rock backwater. The fish then moved out of the Castle Rock backwater, being recorded at the Castle Rock backwater main entrance that evening after being out of SUR detection range throughout most of the daylight hours. Fish 137 swam upstream the morning of the 17th, past the SUR downstream from Rearing Cove to the SUR upstream of Rearing Cove, moving out of detection range through the daylight hours and re-emerging at the same SUR in the evening. The last record of fish 137 occurred at the SUR upstream of Rearing Cove on the evening of the 17th.

FISH 138

Fish 138 (TL = 376 mm and M = 351 g) was released into the backwater of Blankenship Bend on April 8, 2014. It was subsequently contacted by the SUR in the third cove and the SUR in the finger of the third cove of Blankenship Bend backwater in the afternoon. That evening, the SUR in the first cove of the backwater recorded the fish, followed by the SUR outside of the backwater entrance east of the sandbar island, but the fish did move back past the first and third cove to the finger. Active tracking that evening triangulated the fish near the release site. The fish was still near the finger of the third cove in the early morning of the 9th, though it was out of SUR detection range through most of the early morning before re-emerging at the same SUR, and was briefly contacted by the SUR of the third cove. The fish was out of contact range through most of the daylight hours but re-emerged at the same SUR that evening. Contacts that

evening were similar to the previous night, shifting between the third cove and finger before moving out and shifting between the first cove and outside of the backwater entrance. Fish 138 eventually settled on the SUR outside of the backwater entrance through most of the late evening and early morning of the 10th. Fish 138 then passed the first cove and swam between the finger and the third cove. The fish was tracked actively at the entrance to the back bay. Later in the morning, the fish exited the third cove and swam back and forth between the first cove and out near the SUR east of the sandbar island outside of the backwater. For the remainder of the morning, it traveled within range of the third cove and finger before disappearing by the late morning. In the afternoon, the fish re-emerged near the same location near the finger where it remained, also within detection radius of the SUR of the third cove, for less than an hour. The fish was not tracked for the rest of the afternoon but again re-emerged in the evening at the same location where it remained for over an hour, again with contacts in the third cove. No tracking data exist for the 11th, but the fish was passively tracked near the no boater zone in the evening of the 12th before returning downstream past the SUR east of the sandbar island, into the first cove of Blankenship Bend backwater, and into the third cove and near the finger of the backwater for a brief period early in the morning of the 13th. Fish 138 then swam back out past the first cove to outside of the backwater to the SUR east of the sandbar island before disappearing from detection through most of the daylight hours and re-emerging at the same SUR in the evening. The fish quickly traveled to the SUR at the Blankenship Bend California backwater in the evening of the 13th. Interestingly, fish 138 was not contacted through almost all of the morning of the 14th but did re-emerge still at the Blankenship Bend California backwater SUR in the late morning, again moving out of contact range through the rest of the afternoon and re-emerging at the same SUR in the early evening. Later that evening, the fish swam downstream past the SURs up- and downstream from Rearing Cove as well as the SUR upstream of the Mile 17 buoys. The fish remained near the SUR downstream from the Mile 17 buoys into the early morning of the 15th and then returned upstream to the lower bend of Blankenship Bend but then back down to the Mile 17 sign in the Castle Rock backwater still before sunrise. On the evening of the 15th, the fish emerged at the SUR upstream of the Mile 17 buoys where it remained into the morning of the 16th, though it disappeared and re-emerged at the same SUR for several hours that morning. Late that evening, the fish traveled upstream past the SUR downstream from Rearing Cove to the SUR upstream of the backwater. Fish 138 was next passively tracked in Blankenship Bend near the giant reed and actively tracked north of the small sandbar before traveling to the lower bend of Blankenship Bend before late morning. The fish was not tracked at all during the third week of the study. On the 2nd of May, fish 138 was only tracked actively in the late evening upstream of the Blankenship Bend California backwater entrance but then tracked passively in the evening of the 3rd in the California backwater. Again, the fish was out of any detection until the 6th, re-emerging still in the California backwater that afternoon for a short amount of time. On the 7th, the fish was only tracked actively in vegetation around a sandy area outside of the Blankenship

Bend California backwater in the late evening and then again at the same location in the early morning on the 8th. In the evening of the 8th, fish 138 moved back into the Blankenship Bend California backwater. The fish was not tracked on the 9th but was on the 10th in the morning passively at the SUR upstream of Rearing Cove. The fish was not tracked again until the morning of the 15th only by active efforts in an eddy just downstream from the lower bend of Blankenship Bend. Fish 138 was last contacted at this location on the 15th.

FISH 139

Fish 139 (TL = 340 mm and M = 260 g) was released into the backwater of Blankenship Bend on April 8, 2014, where it was contacted by the SUR in the third cove and the finger of the backwater through the afternoon. It was predominately contacted by the SUR at the finger in the mid-evening, returned back in range of the SUR in the third cove, and then ventured into the first cove by late evening. The fish was also actively tracked that evening in the backwater 10 meters from the edge of cattails. By the early morning of the 9th, the fish moved from the first cove back into the third cove, into the finger, and then out back out through the third cove to the first cove. Later in the morning, the fish was contacted back and forth between the first cove and outside of the backwater to be contacted by the SUR east of the sandbar island. For a couple of hours in the morning, fish 139 moved out of detection range but re-emerged near the same SUR east of the sandbar island in Blankenship Bend. The fish disappeared again through much of the daylight hours and re-emerged in the early evening of the 9th, also outside of the backwater entrance east of the sandbar island. Through the evening, the fish exhibited similar behavior, traveling back and forth in and out of the backwater. Fish 139 disappeared in the morning of the 10th for several hours and re-emerged again in the same area near the SUR east of the sandbar. The fish was not contacted for the remainder of the day but did re-emerge in the first cove of the backwater in the morning of the 11th before swimming into the third cove and near the finger and then back out through the first cove to east of the sandbar island. Again, the fish was out of detection range during the day but did re-emerge in the evening of the 11th at the same SUR east of the sandbar island. Active tracking that evening triangulated the fish first north of a brush patch at the corner of the sandbar island and a couple hours later south of the sandbar island. In the late evening of the 11th, fish 139 disappeared but re-emerged a couple hours later at the same SUR east of the sandbar island in the early morning of the 12th before moving into the first cove. Passive tracking suggests that the fish then swam downstream to the lower bend of Blankenship Bend where it remained through the early morning. In the evening of the 12th, the fish swam downstream and was recorded by SURs up- and downstream from Rearing Cove, the SUR at the main upstream entrance to the Castle Rock backwater, and to the SUR at the Mile 17 sign in the Castle Rock backwater. By the early morning of the 13th, fish 139 was recorded at the SUR upstream of the Mile 17 buoys in the main channel. It then briefly returned to the lower bend of

Blankenship Bend before traveling back down to the Castle Rock backwater upstream entrance and then back up to the SUR downstream from Rearing Cove where it moved out of range for most of the morning before re-emerging at the same SUR in the late afternoon of the 13th. By evening, fish 139 traveled further upstream past the SUR upstream of Rearing Cove to the first cove of Blankenship Bend backwater, outside of the backwater entrance east of the sandbar island, and back into the first cove by the morning of the 14th. The fish was actively triangulated in bulrush with submerged woody debris north of the upper bend. Later in the morning, the fish was passively tracked in the finger of the backwater, after which it swam through the third cove into the first cove, where it was briefly recorded by the SUR outside of the entrance east of the sandbar island. For 5 hours the fish was not contacted in the late morning, for 1 hour in the afternoon, a couple hours in the late afternoon, and 1 hour in the early evening but re-emerged each time at the same SUR in the first cove of the backwater on the 14th. Later, fish 139 moved into range of the SUR at the finger and then back through the first cove to move upstream to the entrance to the no boater zone where it was occasionally contacted by the SUR in the refuge. The fish remained at the no boater zone entrance into the morning of the 15th. Later in the morning, passive tracking recorded the fish in the Blankenship Bend California backwater where it disappeared for most of the day and re-emerged briefly that evening at the same location. Fish 139 was next contacted in the morning of the 16th at the lower bend of Blankenship Bend where it remained for a couple hours. There were no contacts on the 17th, but the fish was tracked in the evening of the 18th in the Blankenship Bend California backwater. Again, contact was lost with fish 139 for the remainder of the evening and did not re-emerge until several hours later in the morning of the 19th at the same SUR in the Blankenship Bend California backwater. The fish later swam downstream to the lower bend of Blankenship Bend. Fish 139 was not contacted again until the evening of the 21st at the giant reed in Blankenship Bend. Again, the fish moved out of contact range. Active efforts triangulated the fish in the morning of the 29th in a cattail pocket upstream of the entrance to the Blankenship Bend California backwater. The last passive contact was not until the 3rd of May inside of the Blankenship Bend California backwater. Active tracking in the evening of the 10th of May triangulated the fish twice upstream of the Blankenship Bend California backwater entrance in a cattail pocket. In the early morning of the 13th, the fish was actively tracked on river left at the lower bend of Blankenship Bend. This was the last contact of fish 139.

FISH 140

Fish 140 (TL = 304 mm and M = 180 g) was released into the backwater of Blankenship Bend on April 8, 2014. The fish remained in the third cove of Blankenship Bend backwater for much of the duration of the study beginning on the afternoon of the 8th as confirmed by passive tracking. The fish was out of detection range for several hours in the late afternoon of the 8th but re-emerged at the same SUR in the third cove before moving into the first cove and then out of

the backwater to be recorded by the SUR east of the sandbar island. Active tracking during this time triangulated the fish near the cliff south of the sandbar island. Fish 140 then moved in and out of the backwater, being recorded by the SUR east of the sandbar island and the SUR in the first cove but remained in the first cove through the morning of the 9th. Later that morning, the fish briefly swam back into the third cove where it was passively and actively tracked west of the release site near bulrush before revisiting the first cove and then moving out of contact through much of the day until the evening of the 9th when it was passively tracked by SURs in the third cove and finger of Blankenship Bend backwater. Active efforts that evening also tracked the fish near the finger. In the morning of the 10th, the fish remained near the backwater finger, and active tracking placed the fish in the back bay of the backwater. During the later morning and much of the day, the fish again disappeared and re-emerged at the same SUR in the third cove that evening. Fish 140 remained predominately near the SUR in the third cove, with occasional contacts by the SUR at the finger through the evening and into the morning of the 11th. Active tracking continued to find the fish in the third cove during this time and recorded the fish more south in the morning of the 11th. Later that morning, the fish visited the first cove before moving out of contact for much of the day. In the evening of the 11th, fish 140 was back in the third cove and near the finger of Blankenship Bend backwater. The fish was triangulated again in the third cove in a similar area, causing suspicion of a potential mortality. However, data from active efforts triangulated the fish near the mouth of the finger, and passive tracking recorded the fish more consistently at the SUR in the finger through the remainder of the evening of the 11th. It may be possible that fish 140 swam into the finger at this time. The fish remained at this location through much of the morning of the 12th, receiving consistent contacts at the SUR at the finger and occasional contacts by the SUR in the third cove. Again, the fish disappeared during the day and re-emerged at the same SUR in the third cove in evening of the 12th. Most passive tracking data indicated that the fish was closer to the SUR at the finger through the evening, and active tracking again placed the fish in the third cove. Similar behavior occurred on the 13th, as the fish remained in the third cove and near the finger through the morning, was briefly contacted passively in the first cove, disappeared through the day, and emerged in the third cove in the evening. Fish 140 did move out of detection range for a couple of hours in the evening of the 13th, as well as several hours in the late evening and into the morning of the 14th, re-emerging both times at the same SUR in the finger of the backwater. Later in the morning, the fish visited the first cove, disappearing through the day, and re-emerged in the early evening at the same SUR before returning to the finger of the backwater later in the evening. Active tracking again confirmed the location of the fish in the third cove where it was stationary into the morning of the 15th. On the 15th, fish 140 exhibited similar behavior to the previous day, moving to the first cove, disappearing through the day, re-emerging at the same SUR in the first cove in the evening, and returning to the finger. The 16th displayed the same pattern, as did the 17th, with the exception of the fact that while the fish did disappear and re-emerge around the same time, it did so near the finger and not in

the first cove, though it did visit the first cove late in the evening of the 17th. The fish mimicked its behavior from the 17th on the 18th, remaining stationary at the finger through the morning, disappearing during the day, re-emerging in the evening at the same SUR, and visiting the first cove later in the evening. The 19th is significant because fish 140 deviated from its behavior pattern exhibited through the first and much of the second week as it was contacted in the Blankenship Bend California backwater that morning, though it still disappeared and re-emerged in the evening at the same SUR. The fish moved to the lower bend of the Blankenship Bend in the morning of the 20th until the early afternoon before returning to the Blankenship Bend California backwater that evening. In the morning of the 21st, the fish was again at Blankenship Bend's lower bend and then it's California backwater that evening. After 5 hours of non-detection, fish 140 re-emerged at the same SUR in the Blankenship Bend California backwater in the morning of the 22nd. In the evening of the 22nd, the fish returned to the first cove of Blankenship Bend backwater and then the finger where it was passively tracked into the morning of the 23rd before moving out of detection range through the remainder of the morning and most of the day only to re-emerge at the same SUR in the finger that evening, just as was observed the following day of the 24th. After spending the morning of the 25th near the finger and moving out of detection range, fish 140 emerged in the first cove in the evening of the 25th, instead of at the same location, though it quickly returned to the finger. The fish displayed behavior similar to the 23rd and 24th everyday on the 26th of April through the 10th of May. For over an hour in the early morning of the 10th, fish 140 was not contacted but did re-emerge at the same SUR at the finger. During this time, active tracking triangulated the fish in the evenings and early mornings throughout the third cove, often moving around. Behavior finally deviated the evening of the 10th when the fish swam into the first cove. Here, it disappeared for several hours into the early morning of the 11th and a couple of hours shortly later in the morning, re-emerging in both cases at the same SUR in the first cove. As consistent with its activity, fish 140 disappeared from the first cove through most of the day of the 11th and was not contacted at all on the 12th. However, the fish re-emerged back at the finger briefly in the evening of the 13th before traveling to the first cove. In the evening of the 13th, active tracking followed the fish as it moved toward the first cove. Later, the fish was triangulated in the second cove of Blankenship Bend, after which it was recorded passively at the finger. It quickly returned to the first cove where it remained into the morning of the 14th, again being actively triangulated in the morning of the 15th in the second cove. The SUR in the first cove recorded the fish through the evening of the 15th, while active tracking recorded the fish to be near the entrance of the backwater, moving toward the main channel along the cliffs. Shortly after, fish 140 was recorded by the SUR outside of the backwater east of the sandbar island. The fish was not contacted through most of the morning of the 16th but did re-emerge at the same location east of the sandbar before moving back into the backwater to the first cove. Fish 140 was not contacted on the 17th or 18th,

and only once passively very late on the 19th, still in the first cove. Through the early morning of the 20th, fish 140 remained in the first cove. The 20th of May was the last contact for fish 140 in Blankenship Bend backwater.

FISH 141

Fish 141 (TL = 302 mm and M = 196 g) was released into the backwater of Blankenship Bend on April 8, 2014, did not travel far from Blankenship Bend, and was quickly lost. The fish remained in the third cove of the backwater, receiving occasional contacts at the finger, until the late evening of the 8th, although it did move out of detection range for several hours but re-emerged at the same SUR. The fish was recorded actively in the second cove near a line of cattail before returning back to the third cove and near the finger where it remained into the morning of the 9th. Later in the morning of the 9th, fish 141 again swam into the first cove and out of the backwater where it was contacted by the SUR outside of the entrance to Blankenship Bend backwater east of the sandbar island. After no contacts during the day, the fish swam back through the first cove to return to the third cove and near the finger in the evening of the 9th. Later in the evening, the fish revisited the first cove to swim out within range of the SUR east of the sandbar island and continued to travel back and forth between the two SURs through the morning of the 10th. The fish was out of contact range for over an hour during this morning but re-emerged at the same SUR before moving back out of contact range through most of the day. In the evening of the 10th, fish 141 began between the SURs in the first cove of Blankenship Bend backwater and outside of the backwater east of the sandbar island. It later traveled downstream to the California backwater, was briefly contacted by the SUR at the giant reed, and then traveled to the lower bend of Blankenship Bend by the early morning of the 11th. The fish was out of detection range through part of the day but re-emerged at the same SUR at the lower bend of Blankenship Bend on the afternoon of the 11th. Active tracking also recorded the fish in the lower bend in the evening, but fish 141 later returned to Blankenship Bend backwater through the first cove to the third cove and near the finger according to passive data. Later in the evening, the fish revisited the first cove and exited the backwater to be recorded by the SUR east of the sandbar island. Active tracking at this time triangulated the fish near the entrance of the backwater at the buoy. The fish was not recorded through the late evening of the 11th and early morning of the 12th but re-emerged at the same SUR and then disappeared again through most of the day, still re-emerging in the evening at the same SUR east of the sandbar island before returning back into the first cove. Active tracking triangulated the fish in the main channel east of the sandbar during the time the SUR in the first cove was contacting the fish. In the evening of the 12th, fish 141 moved upstream, past the SUR east of the sandbar island, and within range of the no boater zone entrance; however, the fish quickly returned downstream to near the Blankenship Bend backwater entrance as it was contacted by the SUR east of the sandbar island and the SUR in the first cove. In the early morning of the 13th,

the fish traveled further downstream to the SURs up- and downstream from Rearing Cove. The last contact with fish 141 was later in the morning of the 13th at the lower bend of Blankenship Bend by the SUR.

FISH 142

Fish 142 (TL = 486 mm and M = 915 g) was released into the backwater of Blankenship Bend on April 8, 2014. The fish remained in the third cove of the backwater through the afternoon and evening of the 8th and morning of the 9th as confirmed by SURs in the third cove and finger of the backwater and active tracking. The fish moved out of detection range through most of the day of the 9th but re-emerged in the evening at the same location by the SUR in the finger. Later in the evening of the 9th, the fish traveled through the first cove to very briefly be contacted by the SUR placed outside of the backwater entrance east of the sandbar island. Active tracking at this time triangulated the fish approximately 100 meters downstream from the backwater entrance near the cliffs and later in the center of the first cove. By the late evening, the fish swam back into the third cove, occasionally contacted by the SUR in the finger. In the very early morning of the 10th, the fish took a similar path through the first cove to outside of the entrance of the backwater, remaining in this area through much of the morning. The location of fish 142 was confirmed visually during active tracking upstream of Blankenship Bend backwater along the sandbar island that morning. Fish 142 then moved to the SUR in the first cove and further to the SUR in the third cove and then the finger before sunrise. Again, the fish disappeared through the day but re-emerged in the evening of the 10th and then traveled to the first cove, briefly being contacted by the SUR outside of the backwater east of the sandbar. Active tracking found fish 142 at the south end of the first cove in bulrush. Very late in the evening of the 10th and into the morning of the 11th, the fish moved from the SUR in the third cove to the SUR in the finger, while active tracking identified the fish to be at the south end of the third cove. As expected, contact was lost through the day, but the fish re-emerged in the evening at the same SUR at the finger of the backwater. Later in the evening, right before the fish was contacted in the first cove, active tracking triangulated the fish as swimming from the third cove toward the first where it remained for a short amount of time before returning back to the third cove where it moved back and forth between the two SURs in the cove and finger through the evening. By the morning of the 12th, fish 142 again visited the first cove for a few hours and then swam through the third cove to return closer to the finger. Contact was lost through the remainder of the 12th and completely on the 13th before re-emerging still at the finger in the evening of the 14th. Consistently, the fish entered the first cove and exited the backwater to be recorded by the SUR east of the sandbar island. Active tracking placed the fish south of the large sandbar island where it had previously been observed visually. By the morning of the 15th, the SUR in the first cove briefly recorded the fish, while active tracking triangulated the fish in an eddy in Blankenship Bend at the edge of bulrush,

swimming downstream. Atypical of behavior thus far, fish 142 did travel downstream in the morning of the 15th past the SURs up- and downstream from Rearing Cove to the main upstream entrance to the Castle Rock backwater, before returning upstream to the lower bend of Blankenship Bend and then moving out of SUR detection range. In the afternoon of the 15th, fish 142 was passively tracked near the main entrance of the Castle Rock backwater where it disappeared for a large portion of the day but re-emerged at the same SUR in the later evening. Briefly, in the morning of the 17th and 18th, passive tracking recorded the fish at the SUR upstream of the Mile 17 buoys. In the evening of the 18th, for a short amount of time, the fish was near the SUR in the Castle Rock backwater. Fish 142 returned upstream early in the morning of the 19th to the SUR downstream from Rearing Cove. Fish 142 was not tracked again until the 16th of May, re-emerging at the same location. This SUR downstream from Rearing Cove on the 16th of May was the last contact for fish 142.