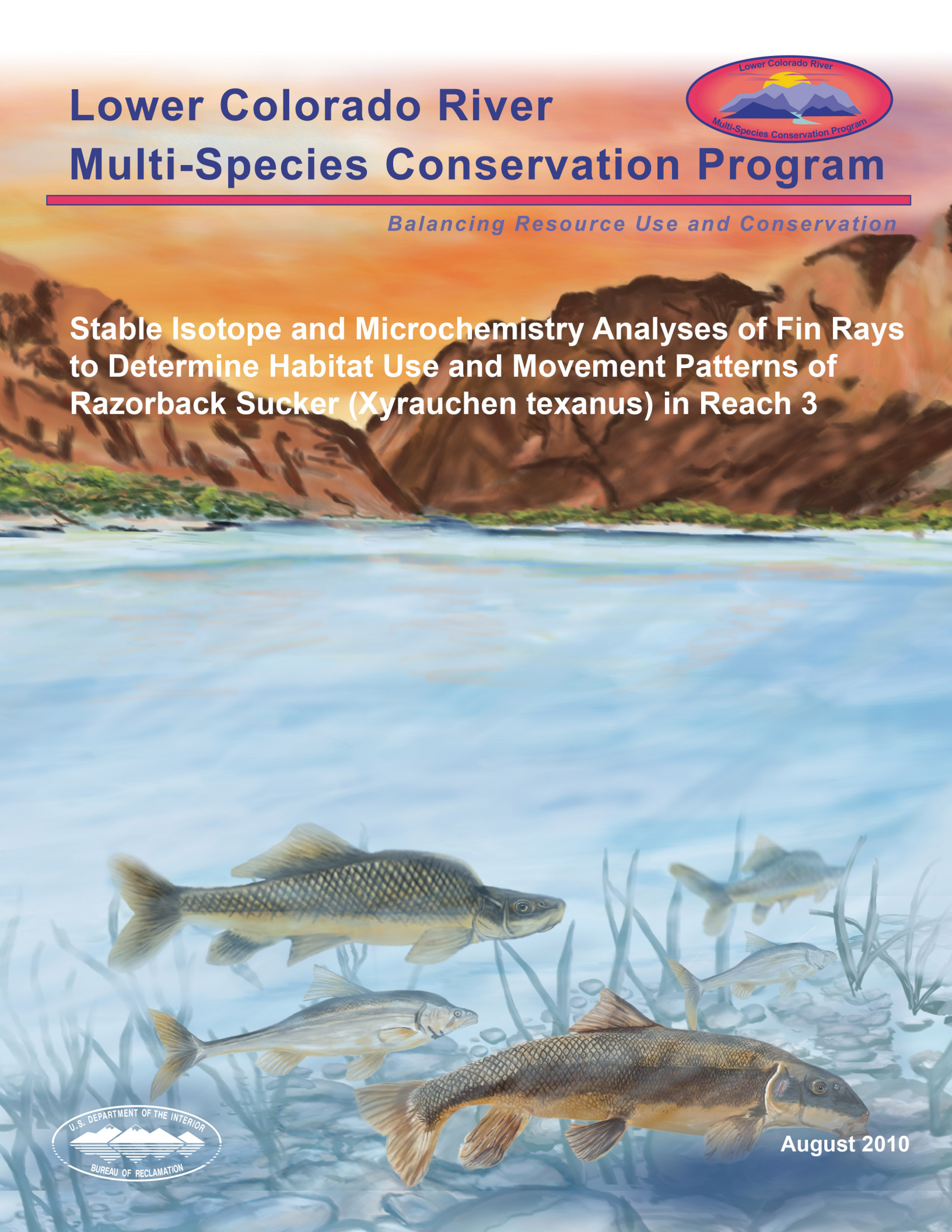
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Stable Isotope and Microchemistry Analyses of Fin Rays to Determine Habitat Use and Movement Patterns of Razorback Sucker (Xyrauchen texanus) in Reach 3



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Stable Isotope and Microchemistry Analyses of Fin Rays to Determine Habitat Use and Movement Patterns of Razorback Sucker (*Xyrauchen texanus*) in Reach 3

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TABLE OF CONTENTS

Page

Introduction 1

Methods 2

Data analyses 4

Results 4

Geology 4

Establishment and validation of hatchery strontium isotopes signatures 5

Classification of field collected fish to hatchery origins 7

Discussion 11

Acknowledgments 12

References 13

TABLES

Page

1 Mean strontium isotope ratios (two to five replicate fish) of the four razorback sucker hatcheries. 6

2 Mean strontium isotope ratios ±2 SE for PIT tagged known hatchery fish 6

3 Summary of PIT tag known hatchery origin and unknown counts from the 2008–2009 sample periods 8

FIGURES

Page

1 Sampling a razorback sucker pectoral fin ray 2

2 Cross-section of a razorback sucker fin ray. 3

3 Geological map of study region. 5

4 Strontium isotope ratios (95% confidence intervals) for PIT tag recovered fish with known hatchery origins 7

5 Bar plot of strontium isotope ratios for juvenile hatchery fish collected from two hatcheries 8

6 2009–2009 field caught fish with PIT tags. 9

7 2008–2009 field caught fish without PIT tags.. 10

8 Hatchery origins of all fish collected in 2008–2009 determined by strontium isotope ratios. 10

Introduction

Stable isotopic and microchemistry analyses have recently proven useful in studies of fish origins and environmental history within freshwater systems (Martinez *et al.* 2001, Kennedy *et al*. 2002, Hobbs *et al*. 2005, Whitledge *et al*. 2007). The use of stable isotopes and microchemistry analyses of bony structures that utilize naturally occurring chemical compounds from the fish's environment throughout its lifetime is a promising measure of its origin and habitat use (Campana 1999). A new geochemical tracer of stream origins is the isotopic composition of strontium (Sr) as measured by the ^{87}Sr:^{86}Sr ratio within the calcium carbonate derived hard parts (*e.g.*, otoliths, bones, fin rays) of fishes. Otolith ^{87}Sr:^{86}Sr has been shown to be positively correlated with ^{87}Sr:^{86}Sr in rearing waters (Hobbs *et al.* 2005, Kennedy *et al.* 2000, Kennedy *et al.* 2002, Weber 2002, Weber *et al.* 2005). ^{87}Sr is produced over geologic time by radiogenic decay of ^{87}Rb (Rubidium; half life = 48.8×10^9 years), and the stable ^{86}Sr isotope. Therefore, ^{87}Sr:^{86}Sr within rivers largely reflect the age (Rb decay) and mineralogy (Rb concentration) of the surrounding bedrock (Bacon *et al.* 2004, Palmer and Edmond 1989). Given the direct incorporation of ^{87}Sr:^{86}Sr from water into bony structures ^{87}Sr:^{86}Sr ratios provide an accurate marker of natal habitats.

Strontium isotope ratios in otoliths have been used to determine natal origins of a wide range of taxa from around the world, including the barramundi (*Latus calcarifer*) and galaxiids smelt from Australia; the Dolly Varden (*Salvilinus malma malma*) from Alaska; Atlantic salmon (*Salmo salar*) from Vermont; and in the California Central Valley, Chinook salmon (*Oncorhynchus tshawytscha*), the Sacramento splittail (*Pogonichthys macrolepidotus*), and the endangered delta smelt (*Hypomesus transpacificus* (Barnett-Johnson *et al.* 2008, Feyrer *et al.* 2007, Hobbs *et al.* 2005, Woodhead *et al.* 2005, Outridge *et al.* 2002, and Kennedy *et al.* 2000). Strontium isotope ratios (^{87}Sr:^{86}Sr) have also been validated with pectoral fin rays and applied to determine natal river origins and out-migration timing in green sturgeon (*Acipenser medirostris*) in the Klamath River system (Allen *et al.* 2008, Hobbs *et al.* in prep).

Information of natal origins of repatriated razorback suckers (*Xyrauchen texanus*), successfully introduced under the Lower Colorado River Multi-Species Conservation Program, a long-term, multi-agency effort to conserve and work towards the recovery of endangered species, will be helpful in understanding the composition and history of razorback suckers in the Colorado River. In this study, we initially attempted to use strontium isotope ratios to reconstruct the life history of razorback sucker habitat use in the lower Colorado River between Davis Dam and Parker Dam (Lake Mohave to Lake Havasu). However, preliminary analysis of 25 wild caught individuals and 10 hatchery reared juveniles from Willow Beach National Fish Hatchery (NFS) and Achii Hanyo Native Fish Rearing Facility (NFRF) showed very little variation along this stretch of the Colorado River which would result in poor discrimination of habitats based on fin ray strontium isotope ratios. Therefore, due to the lack of isotope variation, we did not analyze collected water samples. However, we did observe considerable differences of strontium isotope ratios among fish with a known hatchery origin as recorded in the

passive integrated transponder (PIT) tag database suggesting we could identify the hatchery origin for fish with unknown or unrecorded origins. Thus we utilized the strontium isotope ratios in pectoral fin rays of razorback sucker in the lower Colorado River between Davis Dam below Lake Mohave and Lake Havasu to determine hatchery origins of all captured fish in the 2008–2009 sample period (Appendix 1).

Methods

Razorback suckers were trammel netted and electrofished from known sucker habitats (Park Moabi, Blankenship, Pulpit Rock, Golden Shores, Castle Rock backwaters, and North Needles) on the Colorado River (Reach 3) between Davis Dam and Lake Havasu Delta in 2008 and 2009. A small section of razorback sucker pectoral fin ray was collected from each fish caught by severing the second pectoral fin ray, perpendicularly to the ray, 1 cm from the base with specialized fin ray chisel clippers (Figure 1). Fish

Figure 1.—Sampling a razorback sucker pectoral fin ray by severing the second pectoral fin ray, perpendicularly to the ray, approximately 1 centimeter from the base with specialized fin ray chisel clippers.

were measured (TL), weighed, and scanned for PIT and wire-coded tags, and quickly returned to the water. Pectoral fin ray samples were dried and sent to Bio-West, Inc. (Logan, Utah) for aging. Once the samples were aged, they were shipped to the University of California, Davis Interdisciplinary Center for Plasma Mass Spectrometry (Davis, California, http://icpms.ucdavis.edu) for quantifying ^{86}Sr:^{88}Sr isotopic ratios.

Fin rays from the initial 38 samples collected in 2008 and 25 juvenile samples collected from 4 hatcheries (Willow Beach and Dexter National Fish Hatcheries, Achii Hanyo Native Fish Rearing Facility, and Bubbling Ponds State Fish Hatchery; FH) were sectioned at the base of the ray with a low speed saw creating a thin section 1 mm in thickness (Figure 2). Thin sections were then polished with silicon carbide lapidary film and alumina paste, mounted on petrographic microscope slides, sonicated for 5 minutes in milli-Q ultra pure water and rinsed with 3M nitric acid. The remaining 296 samples from field collections in 2009 were previously sectioned and mounted by BioWest, Inc. The samples were removed from standard microscope slides and remounted onto petrographic slides, 12 samples per slide. Additional polishing was necessary to prepare a clean surface for micro-chemistry analyses as above. Strontium isotopes were measured using a multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS; Nu Plasma HR, Nu Instrument, Inc., Newburyport, Massachusetts) and was interfaced with an Nd: YAG 213-nm laser (New Wave Research, Inc., Fremont, California) for strontium isotope measurement by laser ablation (LA-MC-ICP-MS technique). Seven of the 12 Faraday cups were employed to collect ion currents on masses 82, 83, 84, 85, 86, 87, and 88. A 60-µm laser beam traversed across the thin fin ray section from the core (natal regions) to the edge (just prior to capture) at 10 µm per second, with the laser pulsing at 10 Hz and at 75% power output. Helium carrier gas was used to maximize sensitivity and minimize sample deposition at the ablation site, and was mixed with Argon gas between the laser sample cell and the plasma source. Gas blank and background signals were monitored until ^{84}Kr and ^{86}Kr (krypton) stabilized after the sample change (*i.e.*, exposing sample cell to the air) and were measured for 30 seconds. The laser was typically fired for 90–120 seconds, and background signals were subtracted from the measured signals automatically. Strontium ^{87}Sr:^{86}Sr ratios were normalized relative to ^{86}Sr:$^{88}Sr = 0.1194$ to correct for instrumental mass fractionation using an exponential mass bias law. Mass 85 was monitored to correct for any ^{87}Rb interference on ^{87}Sr. The analytical precision has been determined by using the results of a replicate analyses of a modern marine mollusk at the beginning and end of several analytical sessions. Replicate analyses of this mollusk have yielded ^{87}Sr:$^{86}Sr = 0.70919 \pm 0.000096$

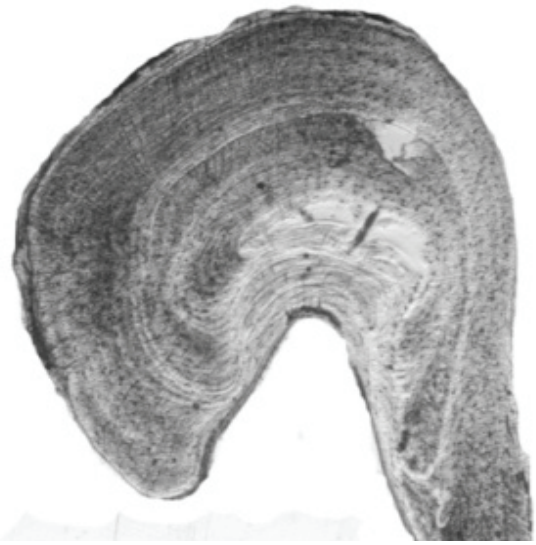

Figure 2.—Cross-section of a razorback sucker fin ray.

(n = 28), consistent with modern seawater values of 0.70918. To validate the technique among sampled fin rays, hatchery origin information from PIT tagged fish and fin ray samples from several hatcheries were used to associate ^{87}Sr:^{86}Sr ratios with hatchery location. Strontium voltage was monitored and when necessary corrected for with least squares analysis and bias correction. Corrected strontium ^{87}Sr:^{86}Sr ratios were rendered time resolved with a 5 point average, (as data were collected every 0.2 seconds), then smoothed with a 6 point (equivalent to the spot diameter) centered running mean. Time resolved profiles of strontium ^{87}Sr:^{86}Sr ratios were then translated to micron distance from the core to the edge of the profile scan. All data reduction and isotope ratio calculations were conducted using Matlab 9.0 (The MathWorks, Inc., Natick, Massachusetts).

To assess the spatial variation of the lithology of the lower Colorado River watershed, a GIS map of geological age using data from the U.S. Geological Survey for geological formations of the United States in Arc GIS Explorer was created. Data for geologic period are graphically displayed.

Data analyses

To validate the use of strontium isotope ratios to identify hatchery origins in razorback sucker fin rays, paired t-tests were conducted between the strontium isotope ratios of two to five individual juvenile fish collected from four different hatcheries with the strontium isotope ratios of fish with their respective hatchery origins recorded in the Native Fish Work Group Lower Colorado River database. To examine strontium isotope ratio differences among the four hatcheries, comparisons were conducted using a one-way analysis of variance (ANOVA) with the two to five individual juvenile fish as replicates. Hatcheries with indistinguishable strontium isotope ratios were combined to minimize classification error when identifying hatchery origins for unknown origin fish. Grouped hatchery origins with 95% confidence intervals from all hatchery collected fish, and PIT tag recovered fish with known hatchery origins were used to establish a strontium isotope signature for each hatchery for classifying field collected razorback suckers with previously unknown origins to their hatchery origins based on the 95% bootstrapped confidence rule (values within the 95% confidence interval have an equivalent assignment probability). The inclusion of PIT tag recovered fish in creating the 95% confidence rule was done to account for differences in hatchery practices (*i.e.*, fish from a hatchery being reared in isotopically dissimilar pond habitats at different ages, etc.). Thus, the resulting strontium isotope ratio would be different than the hatchery collected samples, but would more closely reflect a signature from an unknown sample that belonged to that particular hatchery group. Lastly, the proportion of fish from each hatchery group based on the PIT tag data was compared to the strontium isotope classification using a chi-square distribution, with the PIT tag data as expected values.

Results

Geology

The geological age and lithology of the bedrock along the lower Colorado River varied significantly, with primarily young Neogene granitic bedrock upstream of Lake Mead to

the northeast, and very old Paleozoic sedimentary rocks above the Grand Canyon. From Lake Mead to Davis Dam, the lithology varied with a mix of young Neogene volcanics and Quaternary sedimentary rock. From Davis Dam to Lake Havasu, a mix of older Proterozoic granite and Quaternary sedimentary rock prevailed. The Willow Beach NFH and Achii Hanyo NFRF were located in the Quaternary sedimentary bedrock, while the Bubbling Ponds FH occurred in Neogene volcanic rock, and the Hualapai Tribal Hatchery occurred in older Paleozoic sedimentary rock (Figure 3). The Willow Beach NFH and Achii Hanyo NFRF are located adjacent to the Colorado River and thus are likely to be influenced by the mixed river water incorporating both the local lithology and the water coming from the upstream dams, while the Hualapai Tribal Hatchery, Bubbling Ponds FH and Dexter NFH are isolated facilities located at great distance off the lower Colorado River and rely on well water reflecting the lithology of those regions.

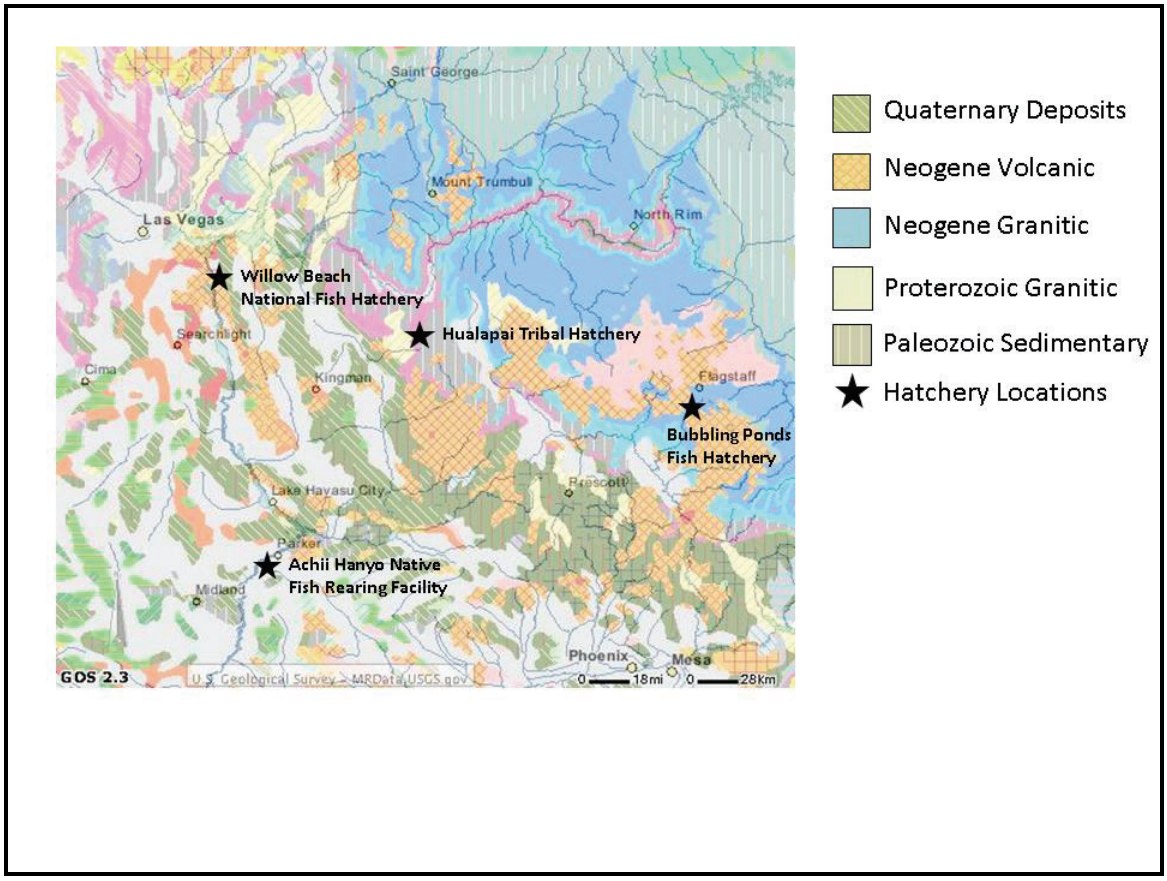

Figure 3.—Geological map of study region. Stars denote the location of hatchery facilities for razorback sucker.

Establishment and validation of hatchery strontium isotopes signatures

Fin ray strontium isotope ratios for juvenile fish collected at three of the four hatcheries (Willow Beach NFH, Achii Hanyo NFRF, and Bubbling Ponds FH) differed ($F = 698$, d.f. = 21, $p = <0.001$). The Willow Beach NFH and Achii Hanyo NFRF had a higher strontium isotope ratio (0.7106 and 0.7103, respectively) and were statistically different from each other (Tukey's test $p = <0.001$) and different than Bubbling Ponds FH and

Dexter NFH (Tukey's test p = <0.001). Bubbling Ponds FH and Dexter NFH had similar strontium isotope ratios of 0.7077 and 0.7076, respectively (Table 1).

Table 1.—Mean strontium isotope ratios (two to five replicate fish) of the four razorback sucker hatcheries. Error bars are 2 sigma SE.

Hatchery	$^{87}Sr:^{86}Sr$	±2SE
Willow Beach National Fish Hatchery	0.7107	0.00014
Bubbling Ponds Fish Hatchery	0.7077	0.00012
Achii Hanyo Native Fish Rearing Facility	0.7103	0.00013
Dexter National Fish Hatchery	0.7076	0.00005

Strontium isotope ratios for PIT tag recovered fish with recorded hatchery origins varied from a low of 0.7078 for Dexter NFH to a high of 0.7114 for the Hualapai Tribal Hatchery (Table 2). Significant overlap of 95% bootstrapped confidence intervals occurred for Willow Beach NFH, Bulkhead Cove, and Emerald Canyon Golf Course, while statistically significant differences occurred between Dexter NFH, Bubbling Ponds FH, Achii Hanyo NFRF, North Chemehuevi Cove, and Hualapai Tribal Hatchery, and Willow Beach NFH, Bulkhead Cove, and Emerald Canyon Golf Course fish (Figure 4).

Table 2.—Mean strontium isotope ratios ±2 SE for PIT tagged known hatchery fish.

Hatchery	$^{87}Sr:^{86}Sr$	±2SE
Dexter National Fish Hatchery	0.7078	0.00004
Bubbling Ponds Fish Hatchery	0.7102	0.00010
Achii Hanyo Native Fish Rearing Facility	0.7104	0.00003
Willow Beach National Fish Hatchery	0.7106	0.00005
Bulkhead Cove	0.7105	0.00007
Emerald Canyon Golf Course Ponds	0.7107	0.00004
North Chemehuevi Cove	0.7111	0.00008
Hualapai Tribal Hatchery	0.7114	0.00008

Fin ray strontium isotope ratios of Willow Beach NFH juvenile fish were slightly higher (0.7106) compared to values for adult fish collected which were PIT tag recorded as Willow Beach NFH fish (0.7105), however due to the extreme precision of the Nu Plasma instrument, these differences were statistically significant with a paired t-test (separate variance: t = 3.1, d.f. = 14, p = 0.01) but both are similar to the natural variation of the lower Colorado River between Davis and Parker Dams (0.7104–0.7108); as determined by longitudinal analysis of strontium isotopes across the whole fin ray during the time period of river residence. Meanwhile, Bubbling Ponds FH juvenile fish were

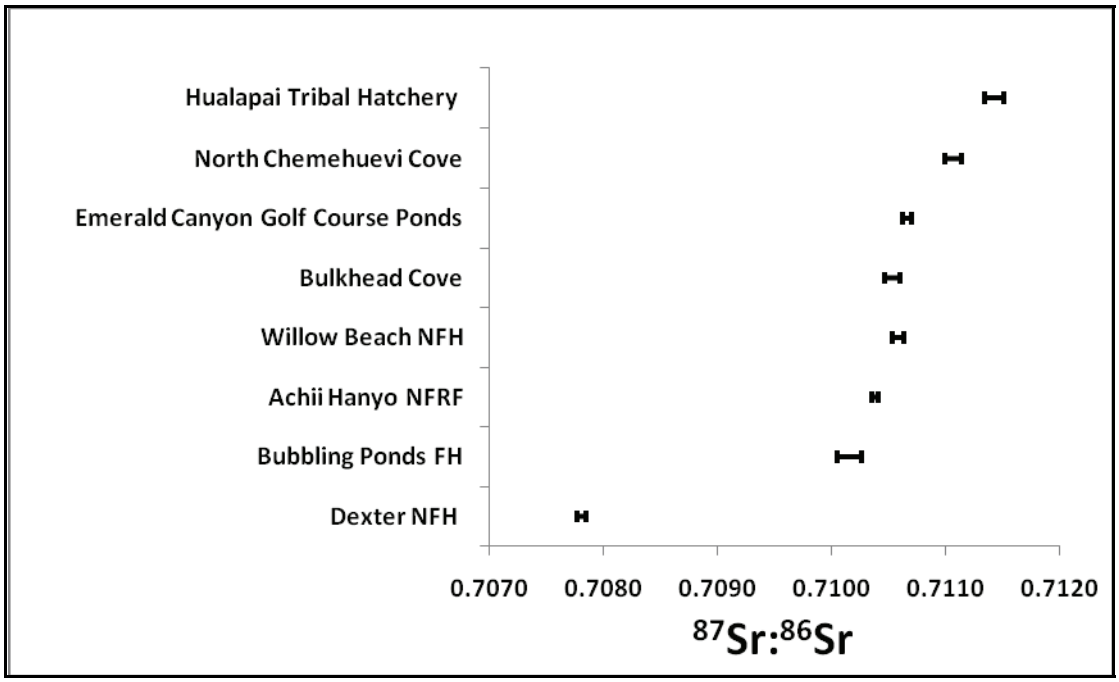

Figure 4.—Strontium isotope ratios (95% confidence intervals) for PIT tag recovered fish with known hatchery origins. Vertical bars depict the natural strontium isotope ratios for the lower Colorado River between Davis and Parker Dams.

highly significantly different (0.7077) than PIT tag recorded hatchery origins (0.7105) with a paired t-test, which was also similar to the natural river variation (separate variance: $t = 13.1$, d.f. = 5, $p < 0.001$; Figure 5).

Classification of field collected fish to hatchery origins

In total, we examined 311 individual fin ray samples from fall 2008 and spring 2009 field collections; of those, 123 fish had PIT tags (Table 3). Willow Beach NFH originating fish made up the majority (62%) of the 123 PIT tagged fish, while fish with a strontium isotope signature of an unknown origin made up 34% of the PIT tagged fish and the remaining 4% were from Bubbling Ponds FH and Dexter NFH (Figure 6). To test the efficacy of strontium isotope ratios to determine hatchery origins for a known origin subset of the data, those fish with Willow Beach NFH origin designations from PIT tag records were classified to hatchery origins using the strontium isotope 95% bootstrap confidence interval approach (*i.e.*,100% should be classified to Willow Beach NFH). Only 56% of the test fish had strontium isotope signatures that correctly matched the validated Willow Beach NFH value. Of the fish not classified to the correct hatchery, 33% were classified as Achii Hanyo NFRF fish, 6% were classified to the Emerald Canyon Golf Course, and the remaining 5% had isotopic signatures of an unknown origin (0.7090–0.7099; Figure 6). Since Willow Beach NFH and Achii Hanyo hatcheries occurred in similar bedrock, were both located adjacent to the river, and had strontium isotope ratios that were close to each other, we combined Willow Beach and Achii Hanyo data.

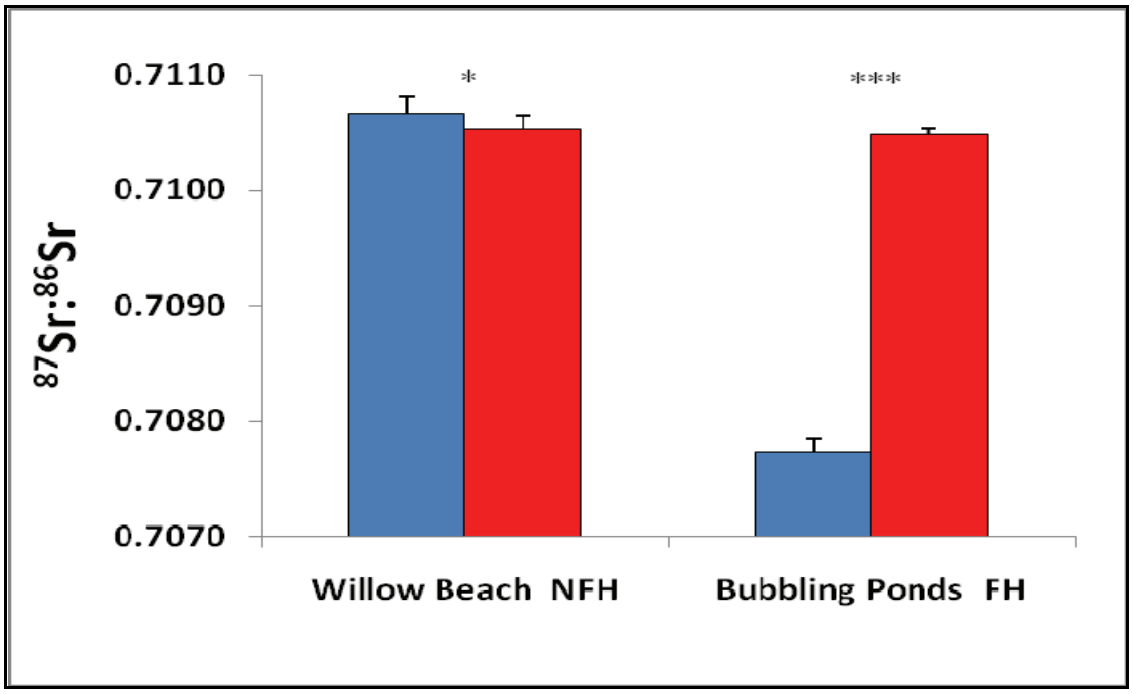

Figure 5.—Bar plot of strontium isotope ratios for juvenile hatchery fish collected from two hatcheries (Willow Beach National Fish Hatchery and Bubbling Ponds Fish Hatchery; blue bars) and PIT tag recovered fish with hatchery origins corresponding to each hatch (hatchery (red bars). Note Bubbling Ponds' value is the result of three individual fish. Error bars are 2 sigma SE, * = $p < 0.05$, and *** = $p < 0.001$.

Table 3.—Summary of PIT tag known hatchery origin and unknown counts from the 2008–2009 sample periods.

Hatchery	Count
Achii Hanyo Native Fish Rearing Facility	1
Bulkhead Cove	1
Hualapai Tribal Hatchery	1
North Chemehuevi Cove	1
Dexter National Fish Hatchery	2
Bubbling Ponds State Fish Hatchery	3
Emerald Canyon Golf Course Ponds	4
Willow Beach National Fish Hatchery	110
Unknown	188
Total	311

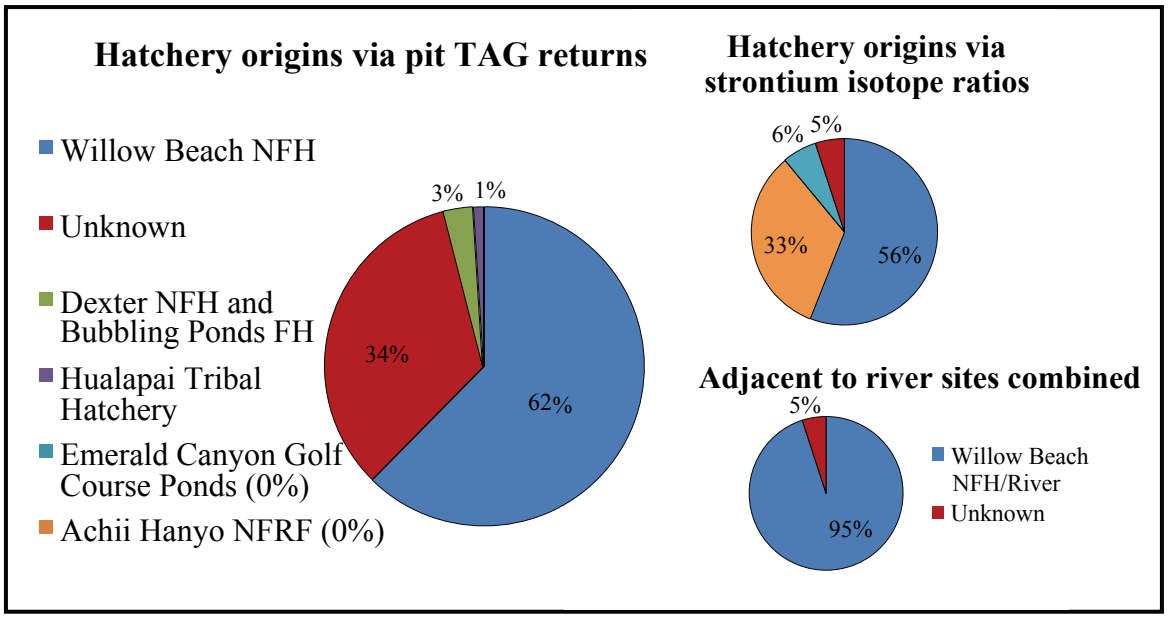

Figure 6.—2009–2009 field caught fish with PIT tags, large chart on left. Unknown fish did not have hatchery origin information recorded in the Native Fish Work Group Lower Colorado River database. Small top chart; Willow Beach fish (62%) assigned to hatchery origin based on strontium isotope ratios signatures. Small bottom chart are sites along the river with similar strontium isotope signatures combined. Unknowns are strontium isotope ratios (0.7090–0.7099).

Combining the Achii Hanyo NFRF value (0.7103) with the Willow Beach NFH and other origins with strontium isotope ratios within the natural variation (0.7104–0.7108) of the river, results in a 95% correct classification for fish with origins for hatcheries that occur directly adjacent to the river (Figure 3).

The PIT tagged fish lacking origin information (34% of the total collected in 2009) were then classified to hatchery origin using the strontium isotope signatures from juvenile hatchery validation collections, and for hatcheries not sampled for juveniles, values for PIT tag recovered fish were supplemented. The majority of those fish (54%) had strontium isotope ratios of an unknown origin (0.7090–0.7099). Willow Beach NFH and Achii Hanyo NFRF comprised the majority of the remaining portion of fish, 23% and 19% (42% combined), while the Dexter NFH and Bubbling Ponds FH made up 3%, and Hualapai Tribal Hatchery contributed 1% to the population (Figure 7).

Using the strontium isotope ratio approach on all fish collected in 2009 (311), fish with strontium isotope ratios of an unknown origin (0.7090–0.7099) made up the greatest proportion (35%), while the Willow Beach NFH (34%) and Achii Hanyo NFRF (23%), and fish from the Emerald Canyon Golf Course Ponds made up 6% (63% combined river sites), and Dexter NFH, Bubbling Ponds FH, and Hualapai Tribal Hatchery made up less than 3% of the population (Figure 8).

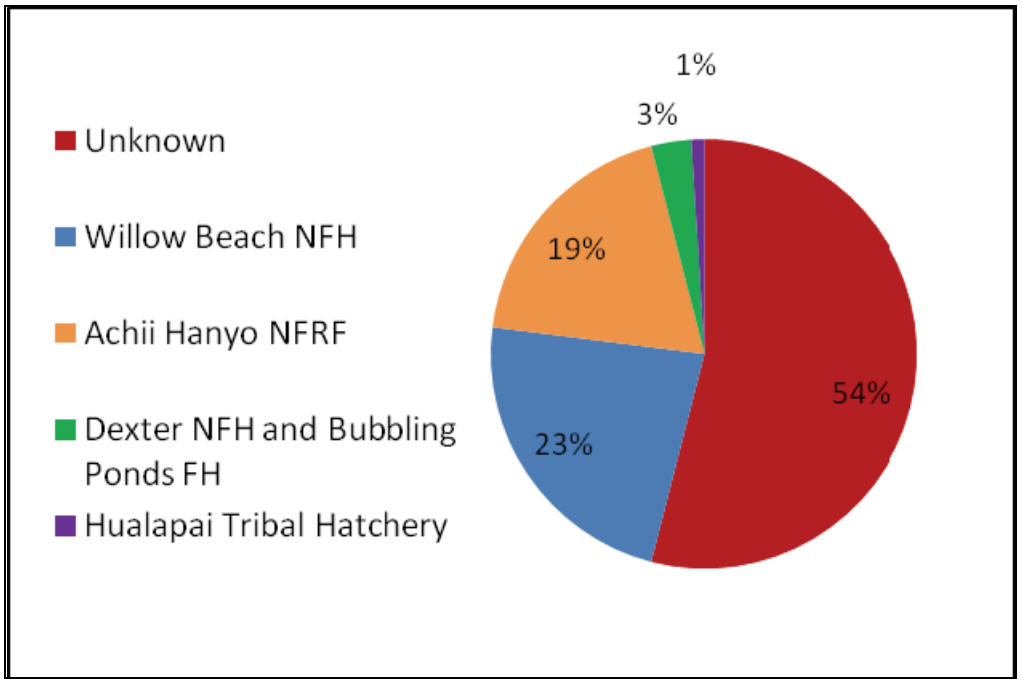

Figure 7.—2008–2009 field caught fish without PIT tags. Hatchery origins based on strontium isotope ratios.

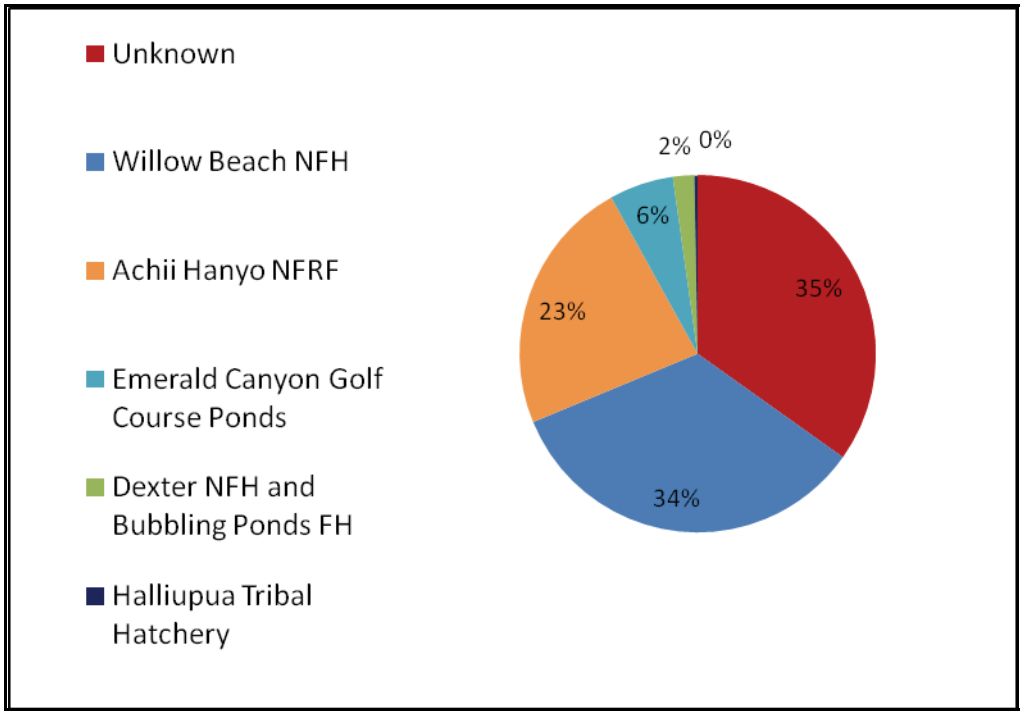

Figure 8.—Hatchery origins of all fish collected in 2008–2009 determined by strontium isotope ratios.

Discussion

The results presented in this study demonstrate the limited utility of fin ray strontium isotope ratios to determine hatchery origins in razorback sucker. Fish collected from the Willow Beach NFH had strontium isotope ratios that where similar with signatures from PIT tag recovered fish, providing validation for the technique. However, a large discrepancy occurred between fish collected from the Bubbling Ponds FH and the PIT tag recovered fish that the Native Fish Work Group Lower Colorado River database had indicated as Bubbling Ponds FH origin. We feel the discrepancy is due, in some degree, to the two different water sources at Bubbling Ponds FH (*i.e.*, spring-fed aquifer and well water) which is likely to have different strontium ratios resulting in conflicting fin ray strontium signatures in repatriated razorbacks. Another plausible theory is the transfer of some Bubbling Ponds' fish to grow-out ponds, which do not use mainstem Colorado River water and thus provide a different strontium signature. Lastly, the Bubbling Ponds' fish may be undergoing fin ray re-absorption following release in the river, altering the chemical composition. We cannot rule out that the strontium isotope ratios of PIT tag recovered fish reflected re-absorption of the fin ray during pond grow-out residence, which would result in similar signature to those environments and not reflect their natal origins. Similarly, fish spawned at Dexter and Willow Beach NFHs are reared for a short period of time and distributed to various grow-out ponds along the lower Colorado River, resulting in a strontium isotope signature similar to the natural variation within the geological province.

Geologic age of bedrock of the region can likely explain the variation in strontium isotope ratios of hatchery collected fish. Willow Beach NFH and Achii Hanyo NFRF had similar strontium isotope ratios and occurred in similar bedrock lithology along this stretch of the lower Colorado River. However the more radiogenic signature of strontium isotopes for these hatcheries likely reflects mixing of very old bedrock from the upstream region of the system, with the very young bedrock where Willow Beach NFH and Achii Hanyo NFRF occur. The remaining hatcheries, Bubbling Ponds FH and Dexter NFH occur in very young, less radiogenic rock and were located far from the river and used primarily ground water.

The most compelling result was that overall, 54% of the population consisted of fish with a strontium isotope signature of an unknown source (values 0.709–0.7099). Given the conservative mixing properties of strontium isotope ratios, the *likely* source would be either north of the Willow Beach NFH or east of Lake Havasu where younger bedrock occurs. Alternatively these fish could originate from the Bill Williams River, which flows into Lake Havasu and lies within slightly different lithology. Another possible source of unknown fish may be the downstream passage of razorback suckers through Davis Dam from Lake Mohave. A third possibility is that these isotope values reflect fish with a Dexter NFH origin (0.7076) or Bubbling Ponds FH (0.7077) and placed in the river (0.7107), followed by chemical reworking or re-absorption of fin rays, that would result in a more radiogenic signature (~0.709). Further studies are needed to determine strontium isotope microchemistry from hatchery sources that supply fish upstream of

Davis Dam and grow-out ponds in River Reaches 3 and 4 to further pinpoint the source of fish that could not be thus far attributed to a razorback sucker hatchery.

Hatcheries that use mainstem Colorado River water (Willow Beach NFH and Achii Hanyo NFRF) appear to have supplied most of the fish to the population, with only a few individuals from other locations such as the Emerald Canyon Golf Course Ponds and the Hualapai Tribal Hatchery based on PIT tag recorded origins. Proportions of fish stocked from hatcheries and grow-out ponds other than Willow Beach NFH and Achii Hanyo NFRF were underrepresented. Hatchery records indicate that a large number of Bubbling Ponds FH fish have been repatriated in the last 10 years, however only a small fraction of these fish were identified using our methods. These fish may not have been caught for fin ray sampling, re-absorbed their fin ray and have a new strontium signature (*i.e.*, classified as our unknown), or perished after stocking. These results suggest a reevaluation of the hatchery practices of those hatcheries that did not make significant contributions to the population. Since the sampling protocol employed in this study was focused on a relatively localized area during what is thought to be spawning migrations, it is possible that fish from other hatcheries may reside in areas not sampled or may not exhibit a migratory spawning behavior. However, this may not be likely based on unpublished data (R. Wydoski) which has shown that fish captured/stocked at numerous locations in reach 3 have all keyed on the spawning population in Needles, and there has been little evidence of other groups based on netting and telemetry.

This study provides a novel approach to supplement a successful PIT tagging program and provides rearing location information for the endangered razorback sucker in the lower Colorado River. We were able to successfully validate the use of fin ray strontium isotope ratios to identify source populations using hatchery collections and known hatchery origins with PIT tag recovered individuals for some hatchery populations. Importantly, we found a significant portion of the population were derived from a currently unknown origin, and found that mainly two of the razorback sucker hatcheries are successfully supplementing the population in the region of the river that was sampled. This study highlights future research needs regarding hatchery operations and the continued efforts to map the spatial variation of strontium isotope ratios throughout the region including in-river spatial and temporal variation with freshwater flow, additional sources of hatchery fish, and potential sources outside the immediate study area.

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Achii Hanyo NFRF, and Bubbling Ponds FH. Jeff Lantow, Eric Best, and two anonymous reviewers provided insightful reviews of the manuscript. Funding for this research was provided by the Lower Colorado River Multi-Species Conservation Program.

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Appendix 1

Collection, Fish Identification, Rearing, and ^{87}Sr:^{86}Sr Ratio Information for Razorback Suckers Analyzed in 2007–2009

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-001	257c60dbb0	RBS	521	1725	m	N. Needles	27-Jan-09	Shocker	0.71041	0.0001		Willow Beach	1
09-002	1c2d05bf90	RBS	671	3705	f	N. Needles	27-Jan-09	Shocker	0.71046	0.0001		Unknown	
09-003	257c630835	RBS	524	1720	m	Needles Bridge	26-Jan-09	Shocker	0.71048	0.0001		Willow Beach	
09-004	1c2d05ae51	RBS	615	2425	m	N. Needles	27-Jan-09	Shocker	0.71001	0.0001	42526f763d	Unknown	
09-005	257c61d90f	RBS	643	3430	f	N. Needles	27-Jan-09	Shocker	0.70941	0.0001		Unknown	
09-006	257c612413	RBS	674	3959	f	N. Needles	27-Jan-09	Shocker	0.71051	0.0001	4255125e62	Unknown	
09-007	1c2d061b78	RBS	671	3365	f	?	27-Jan-09	?	0.71001	0.0001		Unknown	
09-008	257c60beb8	RBS	620	2530	m	Needles Bridge	26-Jan-09	Shocker	0.71038	0.0001		Unknown	2
09-009	257c620dc8	RBS	592	2320	m	Needles Bridge	26-Jan-09	Shocker	0.71026	0.0001		Unknown	
09-010	257c610d1c	RBS	692	3620	f	Needles Bridge	26-Jan-09	Shocker	0.71029	0.0001		Unknown	
09-011	1c2c3369ec	RBS	694	4030	f	Needles Bridge	26-Jan-09	Shocker	0.70995	0.0001		Unknown	3
09-012	257c62b905	RBS	535	1485	m	Needles Bridge	26-Jan-09	Shocker	0.71047	0.0001		Willow Beach	4
09-013	257c60d503	RBS	564	1905	m	Needles Bridge	26-Jan-09	Shocker	0.71043	0.0001		Unknown	5
09-014	257c608373	RBS	535	1725	m	Needles Bridge	26-Jan-09	Shocker	0.71056	0.0001		Willow Beach	6
09-015	257c609683	RBS	585	1985	f	Needles Bridge	26-Jan-09	Shocker	0.71143	0.0002	4440661b78	Hualapai Tribe Hatchery	
09-016	1c2d05acf0	RBS	648	3445	f	N. Needles	27-Jan-09	Shocker	0.71001	0.0001		Unknown	
09-017	257c5b2e31	RBS	631	3135	f	Needles Bridge	26-Jan-09	Shocker	0.71048	0.0001		Unknown	7
09-018	257c613669	RBS	492	1250	m	Needles Bridge	26-Jan-09	Shocker	0.71006	0.0001		Willow Beach	8
09-019	1c2d06f8a5	RBS	552	1855	m	N. Needles	27-Jan-09	Shocker	*sample Error*			Unknown	
09-020	1c2d061956	RBS	590	2365	m	N. Needles	27-Jan-09	Shocker	0.70998	0.0001		Unknown	
09-021	1c2d061a4d	RBS	626	2855	f	N. Needles	27-Jan-09	Shocker	0.71008	0.0001		Unknown	
09-022	1c2d061d3e	RBS	588	2500	m	N. Needles	27-Jan-09	Shocker	0.71052	0.0001		Unknown	
09-023	1c2d0621f4	RBS	655	3400	f	N. Needles	27-Jan-09	Shocker	0.71049	0.0001	521e75025d	Bubbling Ponds	
09-024	257c62fc32	RBS	541	1650	m	Needles Bridge	26-Jan-09	Shocker	0.71047	0.0001		Willow Beach	
09-025	1c2d05bb0a	RBS	633	3340	f	N. Needles	27-Jan-09	Shocker	0.70780	0.0001		Unknown	
09-026	257c60cbfa	RBS	646	3100	f	N. Needles	27-Jan-09	Shocker	0.70987	0.0001	42522a4f5c	Unknown	
09-027	257c61c612	RBS	651	2475	f	N. Needles	27-Jan-09	Shocker	0.71079	0.0001	407f4d6055	Emerald Canyon Golf Course Ponds	
09-028	1c2d05ab3d	RBS	668	3210	f	N. Needles	27-Jan-09	Shocker	0.71037	0.0001		Unknown	
09-029	257c62faf8	RBS	667	3045	f	N. Needles	27-Jan-09	Shocker	0.70980	0.0001		Unknown	9

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	^{87}Sr:^{86}Sr	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-030	257c60e853	RBS	588	2470	m	Needles Bridge	26-Jan-09	Shocker	*sample Error*		425c64682e	Unknown	
09-031	1c2c2f9a25	RBS	621	3350	f	N. Needles	27-Jan-09	Shocker	0.71027	0.0001		Unknown	
09-032	257c60e195	RBS	690	3835	f	Needles Bridge	26-Jan-09	Shocker	0.71006	0.0001		Unknown	10
09-033	257c6095bd	RBS	666	2840	f	Needles	26-Jan-09	Shocker	0.70975	0.0001		Unknown	11
09-034	1c2d06149e	RBS	623	2310	m	N. Needles	27-Jan-09	Shocker	0.71015	0.0001		Unknown	
09-035	1c2c333833	RBS	619	2620	m	Needles Bridge	26-Jan-09	Shocker	0.71047	0.0001	42543e0940	Unknown	
09-036	1c2c333e9e	RBS	610	3050	m	Needles Bridge	26-Jan-09	Shocker	0.70998	0.0001		Unknown	
09-037	1c2c2fdcd0	RBS	589	2235	m	N. Needles	27-Jan-09	Shocker	0.70998	0.0001		Unknown	
09-038	1c2d05ad0b	RBS	644	3520	f	N. Needles	27-Jan-09	Shocker	0.70978	0.0002	4254427559	Unknown	
09-039	257c60f0ad	RBS	565	1905	m	Needles Bridge	26-Jan-09	Shocker	0.70992	0.0001		Unknown	12
09-040	257c6121ea	RBS	612	1925	f	Needles Bridge	26-Jan-09	Shocker	0.71054	0.0001		Willow Beach	
09-041	257c60cbd8	RBS	544	1620	m	Needles Bridge	26-Jan-09	Shocker	0.70988	0.0001		Unknown	
09-042	257c609c93	RBS	676	4365	f	Needles Bridge	26-Jan-09	Shocker	0.71062	0.0001		Unknown	13
09-043	257c60cec2	RBS	582	1990	m	Needles Bridge	26-Jan-09	Shocker	0.71037	0.0001		Unknown	14
09-044	257c60e88a	RBS	572	2056	m	Needles Bridge	26-Jan-09	Shocker	0.71013	0.0001		Unknown	15
09-045	257c60d533	RBS	578	2105	m	Needles Bridge	26-Jan-09	Shocker	0.70997	0.0001	4255094959	Unknown	
09-046	257c646e8f	RBS	515	1470	m	Needles Bridge	26-Jan-09	Shocker	0.71044	0.0001		Willow Beach	16
09-047	1c2c388987	RBS	620	2100	f	Needles Bridge	26-Jan-09	Shocker	0.70996	0.0001		Unknown	
09-048	257c60ef0c	RBS	593	2165	f	Needles Bridge	26-Jan-09	Shocker	0.71057	0.0001		Unknown	17
09-049	257c609373	RBS	581	2020	m	Needles Bridge	26-Jan-09	Shocker	0.71034	0.0001		Unknown	18
09-050	257c5ff9bd	RBS	574	1810	m	N. Needles	27-Jan-09	Shocker	0.70996	0.0001		Unknown	
09-051	257c60f087	RBS	602	2135	?	Needles Bridge	26-Jan-09	Shocker	0.71007	0.0001		Unknown	19
09-052	257c60d9b5	RBS	568	1945	m	Needles Bridge	26-Jan-09	Shocker	0.71015	0.0001	42531a0c2d	Unknown	
09-053	257c60cc9d	RBS	577	2245	m	Needles Bridge	26-Jan-09	Shocker	0.71016	0.0001	4456174020	Unknown	
09-054	257c610f57	RBS	650	3370	f	N. Needles	27-Jan-09	Shocker	0.70996	0.0001		Unknown	20
09-055	257c60e3e9	RBS	575	1945	m	Needles Bridge	26-Jan-09	Shocker	0.70998	0.0002		Unknown	21
09-056	257c60f442	RBS	710	4160	f	N. Needles	27-Jan-09	Shocker	0.71042	0.0001		Unknown	
09-057	1c2c85796d	RBS	665	3435	f	N. Needles	27-Jan-09	Shocker	0.70978	0.0002		Unknown	
09-058	257c60e0bf	RBS	633	3115	f	Needles Bridge	26-Jan-09	Shocker	0.71010	0.0001	20281d514a	Unknown	
09-059	257c60da62	RBS	618	2995	f	Needles Bridge	26-Jan-09	Shocker	0.71026	0.0002	4520473063	Unknown	
09-060	1c2d061a32	RBS	672	3535	f	N. Needles	27-Jan-09	Shocker	0.71018	0.0001		Unknown	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-061	1c2d0620f8	RBS	690	3365	f	N. Needles	27-Jan-09	Shocker	0.71031	0.0002		Unknown	
09-062	1c2d061347	RBS	595	2290	f	N. Needles	27-Jan-09	Shocker	0.71116	0.0001		Unknown	
09-063	257c60f9cd	RBS	572	2200	f	N. Needles	27-Jan-09	Shocker	0.71050	0.0001		Unknown	
09-064	1c2c84132f	RBS	628	2175	f	N. Needles	27-Jan-09	Shocker	0.70997	0.0002		Unknown	
09-065	257c60bac4	RBS	605	2925	m	N. Needles	27-Jan-09	Shocker	0.71050	0.0001		Unknown	
09-066	1c2c33329f	RBS	583	2380	m	N. Needles	27-Jan-09	Shocker	0.71007	0.0001		Unknown	
09-067	257c60ad46	RBS	616	2470	f	N. Needles	27-Jan-09	Shocker	0.71053	0.0001		Unknown	
09-068	1c2c32141b	RBS	470	1070	m	N. Needles	27-Jan-09	Shocker	0.71055	0.0001		Willow Beach	22
09-069	1c2d061c06	RBS	591	2170	m	N. Needles	27-Jan-09	Shocker	0.71023	0.0001		Unknown	
09-070	1c2d0609f0	RBS	665	3475	f	N. Needles	27-Jan-09	Shocker	0.71002	0.0001		Unknown	
09-071	1c2c33a69f	RBS	545	1710	m	N. Needles	27-Jan-09	Shocker	0.71044	0.0001		Unknown	
09-072	257c608b44	RBS	655	3615	f	N. Needles	27-Jan-09	Shocker	0.71020	0.0001		Unknown	
09-073	257c60c8a5	RBS	631	2835	f	Needles	26-Jan-09	Shocker	0.71008	0.0001		Unknown	23
09-074	257c609d60	RBS	602	2310	m	Needles Bridge	26-Jan-09	Shocker	0.70956	0.0001	42534a2839	Unknown	
09-075	257c62f313	RBS	522	1735	m	Needles Bridge	26-Jan-09	Shocker	0.71075	0.0001		Willow Beach	24
09-076	1c2c33691c	RBS	564	2015	m	?	26-Jan-09	Shocker	0.70980	0.0001		Unknown	25
09-077	257c60f0f8	RBS	569	2045	f	Needles Bridge	26-Jan-09	Shocker	0.71042	0.0001		Willow Beach	26
09-078	257c612174	RBS	630	2695	f	Needles Bridge	26-Jan-09	Shocker	0.70999	0.0001		Unknown	27
09-079	257c60c90e	RBS	520	1710	m	Needles Bridge	26-Jan-09	Shocker	0.71033	0.0001		Willow Beach	28
09-080	257c601877	RBS	503	1245	m	Needles Bridge	26-Jan-09	Shocker	0.71042	0.0001		Willow Beach	
09-081	257c60c86d	RBS	521	1490	m	Needles Bridge	26-Jan-09	Shocker	0.71069	0.0001		Willow Beach	29
09-082	257c61238c	RBS	516	1675	m	Needles Bridge	26-Jan-09	Shocker	0.71074	0.0001		Willow Beach	
09-083	257c60f4a8	RBS	634	2990	f	N. Needles	27-Jan-09	Shocker	0.71001	0.0001		Unknown	
09-084	1c2c388fbe	RBS	602	2245	m	Needles Bridge	26-Jan-09	Shocker	0.70990	0.0001		Unknown	30
09-085	257c612052	RBS	636	2935	f	Needles Bridge	26-Jan-09	Shocker	0.70997	0.0001		Unknown	31
09-086	1c2c83e40f	RBS	562	2300	m	N. Needles	27-Jan-09	Shocker	0.70979	0.0002		Unknown	
09-087	257c60d823	RBS	500	1710	?	Needles Bridge	26-Jan-09	Shocker	0.71054	0.0001	46473d7b6d	Willow Beach	
09-088	1c2d05c5d6	RBS	652	3125	f	N. Needles	27-Jan-09	Shocker	0.70944	0.0001		Unknown	
09-089	1c2c2f9920	RBS	683	3825	f	N. Needles	27-Jan-09	Shocker	0.71068	0.0001	4079791700	Emerald Canyon Golf Course Ponds	32
09-090	1c2d05ca25	RBS	588	2330	f	N. Needles	27-Jan-09	Shocker	0.70773	0.0001		Unknown	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-091	257c60d007	RBS	630	2450	f	Needles Bridge	26-Jan-09	Shocker	0.71004	0.0001		Unknown	33
09-092	257c62bdcd	RBS	500	1620	m	N. Needles	27-Jan-09	Shocker	0.71049	0.0000		Willow Beach	
09-093	1c2d06e416	RBS	658	3140	f	N. Needles	27-Jan-09	Shocker	0.71047	0.0001		Unknown	
09-094	257c60def3	RBS	619	2500	m	Needles Bridge	26-Jan-09	Shocker	0.71029	0.0001	4255086b7a	Unknown	
09-095	257c60c349	RBS	720	3675	f	Needles Bridge	26-Jan-09	Shocker	0.71000	0.0001		Unknown	34
09-096	257c60dc61	RBS	660	3215	f	Needles Bridge	26-Jan-09	Shocker	0.71007	0.0001		Unknown	35
09-097	257c6108ac	RBS	638	2545	f	Needles Bridge	26-Jan-09	Shocker	0.71026	0.0001		Unknown	
09-098	257c60e4c0	RBS	592	2160	m	Needles Bridge	26-Jan-09	Shocker	0.71013	0.0001		Unknown	36
09-099	257c60ac68	RBS	533	1560	m	Needles Bridge	26-Jan-09	Shocker	0.71044	0.0001		Willow Beach	37
09-100	257c611a16	RBS	547	1665	m	Needles Bridge	26-Jan-09	Shocker	0.71046	0.0001		Willow Beach	38
09-101	257c60e5cc	RBS	523	1545	m	Needles Bridge	26-Jan-09	Shocker	0.71048	0.0001		Willow Beach	39
09-102	257c60f334	RBS	645	3280	f	N. Needles	27-Jan-09	Shocker	0.71001	0.0001		Unknown	
09-103	1c2d05ad5b	RBS	621	2445	f	N. Needles	27-Jan-09	Shocker	0.70995	0.0001		Unknown	
09-104	1c2d060cdc	RBS	681	3210	f	N. Needles	27-Jan-09	Shocker	0.70964	0.0001		Unknown	
09-105	257c60d145	RBS	652	3505	f	N. Needles	27-Jan-09	Shocker	0.70984	0.0001		Unknown	40
09-106	1c2c83c3c0	RBS	663	3340	f	N. Needles	27-Jan-09	Shocker	0.71003	0.0001		Unknown	
09-107	257c618f90	RBS	690	3760	f	Needles Bridge	26-Jan-09	Shocker	0.70995	0.0001		Unknown	41
09-108	257c60dc1b	RBS	591	2350	m	Needles Bridge	26-Jan-09	Shocker	0.70775	0.0001		Unknown	42
09-109	257c6105be	RBS	618	2365	f	Needles Bridge	26-Jan-09	Shocker	0.71010	0.0001		Unknown	
09-110	1c2d06168f	RBS	516	1300	m	N. Needles	27-Jan-09	Shocker	0.71047	0.0001	4647742714	Willow Beach	
09-111	257c60d281	RBS	597	2500	m	Needles Bridge	26-Jan-09	Shocker	0.71054	0.0001	407f4a694f	Bulkhead Cove	
09-112	1c2d05be35	RBS	670	2655	f	N. Needles	27-Jan-09	Shocker	0.70992	0.0000		Unknown	
09-113	257c5fe358	RBS	486	1340	m	Needles Bridge	26-Jan-09	Shocker	0.71051	0.0001		Willow Beach	43
09-114	257c60d325	RBS	670	3520	f	Needles Bridge	26-Jan-09	Shocker	0.70984	0.0001		Unknown	44
09-115	1c2d059cfa	RBS	659	3190	f	Needles Bridge	26-Jan-09	Shocker	0.71046	0.0001	42536a352f	Unknown	
09-116	257c6004cc	RBS	676	3445	f	Needles Bridge	26-Jan-09	Shocker	0.70997	0.0001		Unknown	
09-117	257c608372	RBS	681	3590	f	Needles Bridge	26-Jan-09	Shocker	0.71051	0.0001	410f120c3a	Achii Hanyo	
09-118	257c608ae0	RBS	574	1855	f	Needles Bridge	26-Jan-09	Shocker	0.70815	0.0001	4637436d17	Dexter NFH	
09-119	257c60d732	RBS	582	2170	m	Needles Bridge	26-Jan-09	Shocker	0.71015	0.0001	425507783b	Unknown	
09-120	257c618311	RBS	549	1775	m	Needles Bridge	26-Jan-09	Shocker	0.70977	0.0001		Unknown	45
09-121	257c611713	RBS	519	1410	m	Needles Bridge	26-Jan-09	Shocker	0.71051	0.0001		Willow Beach	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-122	1c2c83b807	RBS	636	3300	f	N. Needles	27-Jan-09	Shocker	0.71065	0.0001	407f3e1501	Emerald Canyon Golf Course Ponds	
09-123	257c60ca78	RBS	600	2355	f	Needles Bridge	26-Jan-09	Shocker	0.71044	0.0001		Unknown	46
09-124	257c60c2ef	RBS	496	1495	m	N. Needles	27-Jan-09	Shocker	0.71048	0.0001		Unknown	
09-125	1c2c337bb4	RBS	642	2740	f	Needles Bridge	26-Jan-09	Shocker	0.70938	0.0001		Unknown	
09-126	257c60850f	RBS	545	1850	m	Needles Bridge	26-Jan-09	Shocker	0.70951	0.0001		Unknown	47
09-127	1c2c3378ee	RBS	670	3165	?	Needles Bridge	26-Jan-09	Shocker	0.70927	0.0001		Unknown	
09-128	257c60f474	RBS	633	3105	f	Needles Bridge	26-Jan-09	Shocker	0.71057	0.0001		Unknown	48
09-129	1c2d05bf34	RBS	540	1895	m	N. Needles	27-Jan-09	Shocker	0.71055	0.0001		Unknown	49
09-130	1c2c83b7b5	RBS	641	3105	f	N. Needles	27-Jan-09	Shocker	0.71042	0.0001	501955732b	Unknown	50
09-131	257c60e2a1	RBS	555	240	m	Needles Bridge	26-Jan-09	Shocker	0.71005	0.0001		Willow Beach	51
09-132	257c60da33	RBS	539	1650	m	Needles Bridge	26-Jan-09	Shocker	0.71055	0.0001		Willow Beach	52
09-133	1c2c8572bd	RBS	468	1000	f	N. Needles	27-Jan-09	Shocker	0.71057	0.0001		Willow Beach	
09-134	1c2c850a7d	RBS	576	1870	m	N. Needles	27-Jan-09	Shocker	0.71055	0.0001		Unknown	
09-135	257c621f44	RBS	510	1620	m	N. Needles	27-Jan-09	Shocker	0.70776	0.0001		Unknown	
09-136	1c2d06f185	RBS	656	3300	f	N. Needles	27-Jan-09	Shocker	0.71005	0.0001		Unknown	
09-137	257c60ce7f	RBS	529	1605	m	Needles Bridge	26-Jan-09	Shocker	0.71050	0.0001		Willow Beach	53
09-138	257c672b36	RBS	530	1700	m	Needles Bridge	26-Jan-09	Shocker	0.71055	0.0001		Willow Beach	
09-139	257c60ea3f	RBS	630	2825	f	Needles Bridge	26-Jan-09	Shocker	0.71023	0.0001		Unknown	54
09-140	257c60da2d	RBS	683	4285	f	Needles Bridge	26-Jan-09	Shocker	0.71019	0.0001		Unknown	55
09-141	257c60dfa5	RBS	631	2790	f	Needles	26-Jan-09	Shocker	0.71022	0.0001		Unknown	56
09-142	1c2c3369ca	RBS	642	3380	f	Needles Bridge	26-Jan-09	Shocker	0.71005	0.0001		Unknown	
09-143	257c60dc19	RBS	557	1825	m	Needles Bridge	26-Jan-09	Shocker	0.70997	0.0001		Unknown	57
09-144	257c5fe31d	RBS	595	2515	f	Needles Bridge	26-Jan-09	Shocker	0.71057	0.0001		willow Beach	
09-145	257c611c07	RBS	576	2065	?	Needles Bridge	26-Jan-09	Shocker	0.70998	0.0001		Unknown	58
09-146	257c60f5e3	RBS	650	3260	f	N. Needles	27-Jan-09	Shocker	0.71034	0.0001		Unknown	59
09-147	257c60d2a5	RBS	602	?	?	?	26-Jan-09	Shocker	0.70987	0.0001		Unknown	60
09-148	257c60e470	RBS	633	2835	f	?	26-Jan-09	Shocker	0.71022	0.0001		Unknown	61
09-149	257c60d750	RBS	575	2105	m	Needles Bridge	26-Jan-09	Shocker	0.70978	0.0001		Unknown	62
09-150	257c60953b	RBS	670	3615	f	Needles Bridge	26-Jan-09	Shocker	0.71039	0.0001		Unknown	
09-151	1c2c333edc	RBS	590	2305	m	Needles Bridge	26-Jan-09	Shocker	0.70942	0.0001		Unknown	63

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-152	257c611575	RBS	570	2100	f	N. Needles	27-Jan-09	Shocker	0.71058	0.0001		Willow Beach	
09-153	257c62fba5	RBS	515	1660	m	Needles Bridge	26-Jan-09	Shocker	0.71047	0.0001		Willow Beach	
09-154	1c2d06192e	RBS	655	2525	f	N. Needles	27-Jan-09	Shocker	0.71043	0.0001		Unknown	
09-155	257c60b903	RBS	564	2120	m	Needles Bridge	26-Jan-09	Shocker	0.70991	0.0001	425339414f1	Unknown	
09-156	1c2c844d8f	RBS	620	2900	f	Laughlin	28-Jan-09	Shocker	0.71043	0.0001		Unknown	
09-157	1c2c2f9631	RBS	679	3914	f	Laughlin	28-Jan-09	Shocker	0.71056	0.0001		Unknown	
09-158	257c60b246	RBS	558	2250	m	Laughlin	28-Jan-09	Shocker	0.71020	0.0001		Unknown	64
09-159	1c2d05bf37	RBS	661	2960	f	Laughlin	28-Jan-09	Shocker	0.71006	0.0001		Unknown	
09-160	257c60e50d	RBS	505	1520	m	Laughlin	28-Jan-09	Shocker	0.71055	0.0001		Willow Beach	
09-161	1c2d05c063	RBS	647	3710	f	Laughlin	28-Jan-09	Shocker	0.71050	0.0001		Unknown	
09-162	1c2d060cb5	RBS	491	1542	m	Laughlin	28-Jan-09	Shocker	0.71052	0.0001		Unknown	
09-163	257c60c401	RBS	608	2400	m	Laughlin	28-Jan-09	Shocker	0.70975	0.0002		Unknown	
09-164	257c60d5cf	RBS	525	1654	m	Laughlin	28-Jan-09	Shocker	0.71082	0.0001		Willow Beach	
09-165	257c611a02	RBS	615	2768	m	Laughlin	28-Jan-09	Shocker	0.71047	0.0001		Unknown	
09-166	1c2d05b1bf	RBS	600	2288	m	Laughlin	28-Jan-09	Shocker	0.71043	0.0001		Unknown	
09-167	257c6117ab	RBS	481	1205	m	Laughlin	28-Jan-09	Shocker	0.71065	0.0001		Willow Beach	
09-168	1c2d06c3bd	RBS	658	3075	f	Laughlin	28-Jan-09	Shocker	0.71013	0.0002		Unknown	
09-169	42536d5a61	RBS	686	3505	f	Laughlin	28-Jan-09	Shocker	0.70966	0.0002		Unknown	65
09-170	1c2d06176e	RBS	662	3540	f	Laughlin	28-Jan-09	Shocker	0.71011	0.0001		Unknown	
09-171	257c61ed79	RBS	529	1535	m	Laughlin	28-Jan-09	Shocker	0.71046	0.0001		Willow Beach	
09-172	1c2c841d98	RBS	677	3480	f	Laughlin	28-Jan-09	Shocker	0.71034	0.0001		Unknown	66
09-173	257c61221e	RBS	504	1330	m	Laughlin	28-Jan-09	Shocker	0.71063	0.0001		Willow Beach	
09-174	257c61b9c1	RBS	519	1630	m	Laughlin	28-Jan-09	Shocker	0.71050	0.0001		Willow Beach	
09-175	4456432678	RBS	606	2466	m	Laughlin	28-Jan-09	Shocker	0.71048	0.0001		Unknown	67
09-176	1c2d061294	RBS	609	275	f	Laughlin	28-Jan-09	Shocker	0.70987	0.0002		Unknown	
09-177	1c2c7f46f7	RBS	527	1735	m	Laughlin	28-Jan-09	Shocker	0.71073	0.0001		Unknown	
09-178	257c6097ef	RBS	574	2170	?	Laughlin	28-Jan-09	Shocker	0.70975	0.0001		Unknown	
09-179	1c2d05a9d0	RBS	684	3910	f	Laughlin	28-Jan-09	Shocker	0.71050	0.0001		Unknown	
09-180	1c2c84515f	RBS	666	3135	f	AVI	28-Jan-09	Shocker	0.70984	0.0001		Unknown	
09-181	257c625930	RBS	566	2270	f	AVI	28-Jan-09	Shocker	0.71066	0.0001		Willow Beach	
09-182	1c2c83bea4	RBS	620	2970	f	AVI	28-Jan-09	Shocker	0.71004	0.0001		Unknown	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-183	1c2c841d15	RBS	623	2615	f	AVI	28-Jan-09	Shocker	0.71047	0.0002		Unknown	
09-184	1c2c83cb58	RBS	685	3540	f	AVI	28-Jan-09	Shocker	0.71060	0.0001		Unknown	
09-185	1c2c83c1c1	RBS	650	3430	f	AVI	28-Jan-09	Shocker	0.70999	0.0003		Unknown	
09-186	1c2c83c066	RBS	657	3595	f	AVI	28-Jan-09	Shocker	0.70976	0.0002		Unknown	
09-187	1c2c8442be	RBS	646	3420	f	AVI	28-Jan-09	Shocker	0.71056	0.0001	407f6c1a20	Emerald Canyon Golf Course Ponds	68
09-188	1c2c841026	RBS	529	?	?	AVI	28-Jan-09	Shocker	0.71042	0.0001	464804557b	Willow Beach	
09-189	1c2c83be04	RBS	647	3655	f	AVI	28-Jan-09	Shocker	0.70955	0.0002	424f2e4f44	Unknown	
09-190	1c2c38c693	RBS	430	862	m	Pulpit Rock	12-Feb-09	Trammel	0.71057	0.0002		Willow Beach	69
09-191	1c2c856b17	RBS	545	1512	f	Pulpit Rock	12-Feb-09	Trammel	0.71067	0.0001		Willow Beach	
09-192	1c2c7f4aa0	RBS	455	950	u	Park Moabi	12-Feb-09	Trammel	0.71046	0.0002		Willow Beach	
09-193	1c2c83c38f	RBS	425	781	m	Park Moabi	12-Feb-09	Trammel	0.71062	0.0002		Willow Beach	
09-194	1c2d0612ce	RBS	355	453	u	Blankenship Bend	11-Feb-09	Trammel	0.71077	0.0001		Willow Beach	
09-195	257c61e75b	RBS	605	2210	u	Blankenship Bend	11-Feb-09	Trammel	0.71059	0.0001		Willow Beach	70
09-196	1c2d060ce4	RBS	560	2017	f	Blankenship Bend	10-Feb-09	Shocker	0.70787	0.0001	4637666649	Unknown	71
09-197	257c60db65	RBS	540	1626	m	Pulpit Rock	12-Feb-09	Trammel	0.71074	0.0001	46461c7b0a	Willow Beach	72
09-198	257c60f621	RBS	500	1289	m	Park Moabi	12-Feb-09	Trammel	0.71045	0.0001		Unknown	73
09-199	257c6196bf	RBS	560	2121	m	Park Moabi	12-Feb-09	Trammel	0.71033	0.0001		Willow Beach	74
09-200	1c2c8409c9	RBS	445	1025	m	Park Moabi	12-Feb-09	Trammel	0.71038	0.0001		Willow Beach	
09-201	1c2c8304e5	RBS	505	1501	m	Park Moabi	12-Feb-09	Trammel	0.71060	0.0001		no info	
09-202	1c2c856d5e	RBS	505	1332	m	Park Moabi	12-Feb-09	Trammel	0.71059	0.0001		Willow Beach	
09-203	1c2c857d19	RBS	450	817	u	Park Moabi	12-Feb-09	Trammel	0.71070	0.0001		Willow Beach	
09-204	1c2c2fd6a4	RBS	430	876	m	Park Moabi	12-Feb-09	Trammel	0.71052	0.0001		Willow Beach	
09-205	1c2c7ef220	RBS	455	878	m	Park Moabi	12-Feb-09	Trammel	0.71058	0.0001		Willow Beach	
09-206	257c60e186	RBS	480	1282	m	Park Moabi	12-Feb-09	Trammel	0.71057	0.0001		Willow Beach	75
09-207	1c2c7f4d4e	RBS	457	1100	u	Park Moabi	12-Feb-09	Trammel	0.71061	0.0001		Willow Beach	
09-208	1c2c840b55	RBS	455	1081	u	Park Moabi	12-Feb-09	Trammel	0.71055	0.0002		Willow Beach	
09-209	1c2c84136d	RBS	455	1163	m	Pulpit Rock	12-Feb-09	Trammel	0.71028	0.0002		Willow Beach	
09-210	257c63257f	RBS	510	?	m	Pulpit Rock	30-Oct-08	?	0.71056	0.0001		Willow Beach	
09-211	1c2c83bef9	RBS	488	?	?	Pulpit Rock	30-Oct-08	?	0.71070	0.0001		Willow Beach	
09-212	1c2c83c4e5	RBS	494	?	m	Pulpit Rock	30-Oct-08	?	0.71066	0.0001		Unknown	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-213	1c2c7f493a	RBS	445	?	m	Pulpit Rock	30-Oct-08	?	0.71065	0.0001		Willow Beach	
09-214	1c2c857b5a	RBS	464	?	?	Pulpit Rock	30-Oct-08	?	0.71057	0.0001		Willow Beach	
09-215	1c2c83be9d	RBS	430	?	?	Park Moabi	29-Oct-08	?	0.71070	0.0001		Willow Beach	
09-216	463778161d	RBS	509	?	?	Park Moabi	29-Oct-08	?	0.71057	0.0001		Willow Beach	
09-217	46476a461d	RBS	532	?	f	Park Moabi	29-Oct-08	?	0.71030	0.0001		Willow Beach	
09-218	46377f4c17	RBS	498	?	m	Park Moabi	29-Oct-08	?	0.71072	0.0001		Willow Beach	
09-219	1c2c7f4b2e	RBS	479	?	m	Park Moabi	29-Oct-08	?	0.71065	0.0001		Willow Beach	
09-220	1c2c857cd8	RBS	441	?	?	Park Moabi	29-Oct-08	?	0.71059	0.0001		Willow Beach	
09-221	1c2c857498	RBS	420	?	?	Park Moabi	29-Oct-08	?	0.71064	0.0001		Willow Beach	
09-222	1c2c7eeb98	RBS	406	?	m	Park Moabi	29-Oct-08	?	0.71060	0.0001		Willow Beach	
09-223	1c2c3687a9	RBS	431	?	m	Park Moabi	29-Oct-08	?	0.71061	0.0001		Willow Beach	
09-224	1c2c320808	RBS	423	?	m	Park Moabi	29-Oct-08	?	0.71048	0.0001		Willow Beach	
09-225	1c2c84118d	RBS	438	?	?	Park Moabi	29-Oct-08	?	0.71066	0.0001		Willow Beach	
09-226	1c2c83c213	RBS	415	?	m	Park Moabi	29-Oct-08	?	0.71060	0.0001		Willow Beach	
09-227	1c2c8409b3	RBS	432	?	m	Park Moabi	29-Oct-08	?	0.71044	0.0001		Willow Beach	
09-228	1c2c84097a	RBS	453	?	?	Park Moabi	29-Oct-08	?	0.71046	0.0001		Willow Beach	
09-229	1c2c857585	RBS	481	?	?	Blankenship Bend	28-Oct-08	Trammel	0.71049	0.0001		Willow Beach	
09-230	1c2c83bff1	RBS	471	?	?	Blankenship Bend	28-Oct-08	Trammel	0.71052	0.0001		Willow Beach	
09-231	1c2c83c0e0	RBS	427	?	?	Blankenship Bend	28-Oct-08	Trammel	0.71052	0.0001		Willow Beach	
09-232	1c2c83c058	RBS	411	?	m	Park Moabi	30-Oct-08	Trammel	0.71062	0.0001		no info	
09-233	1c2c83c519	RBS	485	?	f	Park Moabi	30-Oct-08	Trammel	0.71049	0.0001		Willow Beach	
09-234	4648124421	RBS	495	?	f	Park Moabi	30-Oct-08	Trammel	0.71054	0.0001		Willow Beach	
09-235	1c2c80e2b6	RBS	412	?	m	Park Moabi	30-Oct-08	Trammel	0.71066	0.0001		Willow Beach	
09-236	1c2c83c79f	RBS	437	?	m	Park Moabi	30-Oct-08	Trammel	0.71055	0.0001		Willow Beach	
09-237	257c6122a8	RBS	496	?	u	Park Moabi	30-Oct-08	Trammel	0.71047	0.0001		Willow Beach	
09-238	463744340a	RBS	544	?	f	Park Moabi	30-Oct-08	Trammel	0.71052	0.0001		Willow Beach	76
09-239	1c2c840993	RBS	442	?	m	Park Moabi	30-Oct-08	Trammel	0.71042	0.0001		Willow Beach	
09-240	1c2c83c9da	RBS	445	?	u	Park Moabi	30-Oct-08	Trammel	0.71061	0.0001		Willow Beach	
09-241	1c2c2f3ae9	RBS	469	?	f	Park Moabi	30-Oct-08	Trammel	0.71053	0.0001		Willow Beach	
09-242	1c2c841432	RBS	428	?	m	Pulpit Rock	30-Oct-08	Trammel	0.71052	0.0001		Willow Beach	
09-243	257c60ada7	RBS	535	?	?	Park Moabi	29-Oct-08	Trammel	0.71047	0.0001		Willow Beach	77

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-244	1c2c83bd51	RBS	440	?	m	Park Moabi	29-Oct-08	?	0.71028	0.0001		Willow Beach	
09-245	1c2c840690	RBS	424	?	?	Park Moabi	29-Oct-08	?	0.71048	0.0001		Willow Beach	
09-246	1c2c83bca3	RBS	415	?	?	Park Moabi	29-Oct-08	?	0.71051	0.0001		Willow Beach	
09-247	257c6109a1	RBS	489	?	?	Park Moabi	29-Oct-08	?	0.70778	0.0001		Dexter NFH	
09-248	1c2c8416e6	RBS	427	?	m	Park Moabi	29-Oct-08	?	0.71063	0.0001		Willow Beach	
09-249	257c632481	RBS	480	?	m	Park Moabi	29-Oct-08	?	0.71047	0.0001		Willow Beach	78
09-250	1c2c840fcc	RBS	401	?	?	Park Moabi	29-Oct-08	?	0.71053	0.0001		Willow Beach	
09-251	46466f2d4a	RBS	525	?	f	Park Moabi	29-Oct-08	?	0.71049	0.0001		Willow Beach	
09-252	1c2c33bcb8	RBS	463	?	m	Pulpit Rock	30-Oct-08	?	0.71046	0.0001		Willow Beach	79
09-253	1c2c83bfa8	RBS	484	?	f	Pulpit Rock	30-Oct-08	?	0.71044	0.0001		Willow Beach	
09-254	1c2c83e4c3	RBS	550	?	u	Pulpit Rock	30-Oct-08	Trammel	0.71047	0.0001		Unknown	
09-255	1c2c840933	RBS	446	?	u	Pulpit Rock	30-Oct-08	Trammel	0.71053	0.0001		Willow Beach	
09-256	1c2c856cc1	RBS	477	?	m	Pulpit Rock	30-Oct-08	Trammel	0.71048	0.0001		Willow Beach	
09-257	257c60ca7d	RBS	521	?	m	Pulpit Rock	30-Oct-08	Trammel	0.71043	0.0001		Willow Beach	
09-258	1c2c856d66	RBS	459	?	m	Pulpit Rock	30-Oct-08	Trammel	0.71053	0.0001		Willow Beach	
09-259	1c2c851732	RBS	614	?	m	Needles	26-Jan-09	?	0.71047	0.0001		Unknown	
09-260	1c2c83c550	RBS	543	?	m	Needles	26-Jan-09	?	0.71002	0.0001		Unknown	
09-261	257c612587	RBS	586	?	f	Needles	26-Jan-09	?	0.71040	0.0001		Willow Beach	80
09-262	257c6111d4	RBS	591	?	m	Needles	26-Jan-09	?	0.70972	0.0001		Unknown	81
09-263	257c61205c	RBS	627	?	f	Needles	26-Jan-09	?	0.71041	0.0001		Unknown	82
09-264	1c2c84132f	RBS	624	?	f	Needles	26-Jan-09	?	0.71052	0.0001		Unknown	
09-265	257c61c1d5	RBS	555	?	m	Needles	26-Jan-09	?	0.71053	0.0001		Willow Beach	83
09-266	257c60f046	RBS	474	?	m	Needles	26-Jan-09	?	0.71050	0.0001		Willow Beach	
09-267	257c60d446	RBS	642	?	f	Needles	26-Jan-09	?	0.71039	0.0001		Unknown	84
09-268	1c2c7f4bf0	RBS	721	?	f	Needles	26-Jan-09	?	0.71052	0.0001		Unknown	
09-269	1c2c84122a	RBS	685	?	f	Needles	26-Jan-09	?	0.71051	0.0001		Unknown	
09-270	257c60d753	RBS	595	?	f	Needles	26-Jan-09	?	0.71053	0.0001		Willow Beach	85
09-271	1c2c840a0d	RBS	625	?	?	?	26-Jan-09	?	0.71027	0.0001	52207c7674	Unknown	
09-272	257c60f224	RBS	521	?	m	Needles	26-Jan-09	?	0.71055	0.0001		Willow Beach	86
09-273	257c60ff03	RBS	514	?	m	Needles	26-Jan-09	?	0.71058	0.0001		Willow Beach	87
09-274	257c60c932	RBS	578	?	m	Needles	26-Jan-09	?	0.71052	0.0001		Unknown	

FIN_ID	PIT Tag	Species	Length (cm)	Weight (g)	Sex	Collection Site	Collection Date	Gear	$^{87}Sr:^{86}Sr$	2 Sigma Error	Old PIT Tag Number	Rearing Location	Note Code
09-275	1c2c2f928f	RBS	636	?	f	Needles	26-Jan-09	?	0.71005	0.0001		Willow Beach	88
09-276	1c2c856eb8	RBS	583	?	m	Needles	26-Jan-09	?	0.71040	0.0001	451f3a081d	Unknown	
09-277	1c2c857cf4	RBS	545	?	m	Needles	26-Jan-09	?	0.71039	0.0001		Unknown	

Note Code	Note
1	C2 raceway
2	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
3	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
4	B2L raceway
5	Fin ray sample taken, no capture data
6	B2L raceway
7	Found WT LDF
8	C2 raceway
9	Found WT LDF
10	No capture data
11	No capture data
12	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
13	No WT found
14	Found WT RP1
15	Found WT LP1
16	C2 raceway
17	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
18	Found WT LDF
19	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
20	No capture data
21	No capture data
22	Reared in D6 upper raceway
23	No capture data
24	C2 raceway
25	No capture data, recap column was blank in data file, unknown if recap
26	B2L raceway
27	No capture data, recap column was blank in data file, unknown if recap
28	B2L raceway

Note Code	Note
29	B2L raceway
30	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
31	No capture data
32	No capture data
33	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
34	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
35	no capture data
36	Fin ray sample taken, no capture data, recap column was blank in data file, unknown if recap
37	C2 raceway
38	C2 raceway
39	C2 raceway
40	No capture data
41	Found WT LDF
42	No WT found
43	From D4 raceway
44	No capture data
45	Dexter NFH
46	No capture data, recap column was blank in data file, unknown if recap
47	No WT found
48	No capture data
49	No capture data
50	Found WT LDF
51	C2 raceway
52	C2 raceway
53	C2 raceway
54	Found WT LDF
55	No capture data
56	No capture data
57	Found WT RDF
58	WT RP1
59	Found WT LDF
60	Found WT RDF
61	No WT
62	Found WT LDF

Note Code	Note
63	WT LDF
64	Found WT RDF, sonic tag 365
65	WT LDF
66	No capture data
67	WT LDF
68	Double tagged with 134 tag
69	Reared in B10 lower raceway
70	Dexter NFH
71	Undetected 400 khz tag or suspected tag loss so marked as repatriate
72	Tagged wth 134 tag
73	Undetected 400 khz tag or suspected tag loss so marked as repatriate
74	C2 raceway
75	C2 raceway
76	Double tag with 134 tag
77	C2 raceway
78	B2L raceway
79	Reared in D6 upper raceway
80	C2 raceway
81	Found WT RP1
82	Found WT RDF
83	From D4 raceway
84	No capture data
85	C2 raceway
86	B2L raceway
87	C2 raceway
88	B2L raceway