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RAZORBACK SUCKER MOVEMENTS AND HABITAT USE IN THE SAN JUAN RIVER INFLOW, LAKE POWELL, UTAH, 1995–1997

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ABSTRACT.—Seventeen subadult, hatchery-reared razorback suckers (*Xyrauchen texanus;* ($\bar{x}$ = 456 mm total length) were implanted with sonic transmitters and tracked for 23 months in the lower 89.6 km of the San Juan River (San Juan arm of Lake Powell, Utah). Fish were released at 2 sites, and 9 made extensive up- and downstream movements ($\bar{x}$ = 47.8 km; contact was lost with 4, and 4 others presumably died or lost their transmitters). The San Juan arm is primarily inundated canyon; however, most fish contacts occurred in shallow coves and shoreline with thick stands of flooded salt cedar in the upper inflow area. Eight fish frequented the Piute Farms river/lake mixing zone, and at least 4 moved upstream into the San Juan River. Seven fish were found in 2 aggregations in spring (3 fish in Neskahi Bay in 1996 and 4 fish just downstream of Piute Farms in 1997), and these may have been associated with spawning activity. Continued presence of razorback suckers in the Piute Farms area and lower San Juan River suggests the San Juan inflow to Lake Powell could be used as an alternate stocking site for reintroduction efforts.

Key words: razorback sucker, Xyrauchen texanus, *San Juan River inflow.*

The razorback sucker (*Xyrauchen texanus*) is endemic to the Colorado River and is considered to be in danger of extinction (USFWS 1991). Although the fish was once abundant and widespread in the larger river systems, remnant populations occur only in isolated reaches of the Green, Colorado, and San Juan rivers and in several lower basin reservoirs in Arizona, Nevada, and California (USFWS 1998). Extant razorback sucker populations consist mostly of older adults with little or no recruitment (Minckley et al. 1991, reviewed in USFWS 1998). The razorback sucker was given federal protection in 1991, and critical habitat was designated in 1994 (USFWS 1991, 1994).

Razorback sucker movements and habitat use have been studied in rivers and reservoirs throughout the Colorado River basin (summarized in USFWS 1998), but few studies have been done in river inflows to reservoirs (see Minckley et al. 1991 for summary). Distribution and abundance of razorback sucker in the San Juan River and inflow to Lake Powell (San Juan arm) are not well known. The first documented razorback sucker capture occurred in 1976 in a gravel pit adjacent to the river near Bluff, Utah (USBLM 1981). Since then, fewer than 25 wild fish have been captured, and the majority of these were found in the upper inflow area (Minckley et al. 1991, Platania et al. 1991). In 1995 we developed a biotelemetry study to track a group of subadult hatchery razorback sucker stocked into the upper San Juan River inflow (i.e., the inundated lower 89.6 km of the San Juan River; Fig. 1). Our objectives were to evaluate movements and habitat use to help guide future stocking efforts.

METHODS

We used sonic rather than radio telemetry to track the fish because much of the study area is deep, inundated canyon (to 100 m). Tracking equipment (receiver and directional hydrophones) and transmitters (theoretical life of 14 months; 22 g in air, 65 mm × 16 mm; 72–79 kHz) were obtained from Sonotronics, Tucson, Arizona.

Three-year-old razorback suckers of San Juan River stock were provided by Wahweap Warmwater Fish Hatchery, Page, Arizona. On 1 November 1995 fish were transported by truck (14.4°C water) to Piute Farms Wash and immediately taken downstream by boat to the release sites where they were tempered to river water (16.1°C) and placed in holding pens. Surgical procedures were similar to

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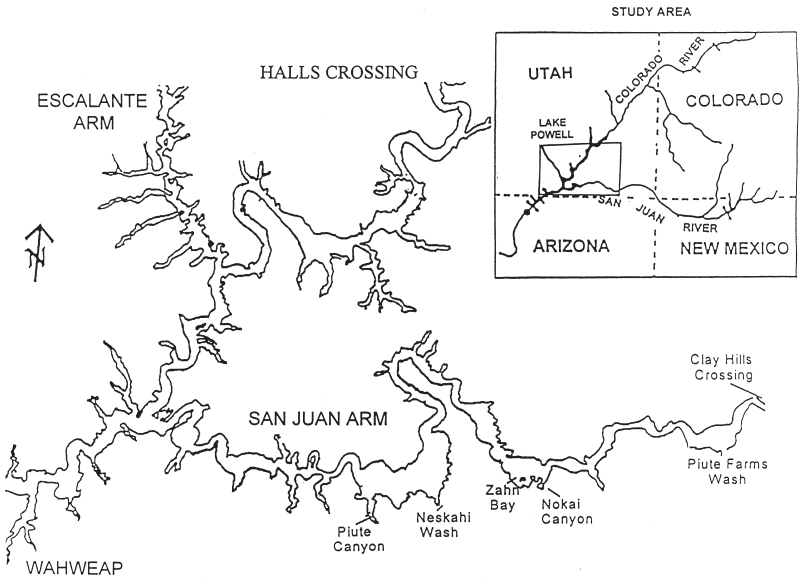

Fig. 1. Map of Lake Powell, Utah, showing San Juan arm study area.

those of Winter (1983) and Tyus (1987). Fish were anesthetized using MS222 (tricaine methanesulfonate, 80–100 mg · L^{-1}), weighed (to the nearest 10 g), measured (total length, TL), and placed in the tagging cradle for abdominal tag implantation. Following surgery, fish were held for 30 minutes before being released. We checked each transmitter prior to and immediately following release. Seventeen fish ($\bar{x}$ = 456 mm TL) were implanted and released (Table 1). Two release sites in the upper inflow area, Neskahi Wash (river kilometer, RK 38.4) and Zahn Bay (RK 68.5), were selected because they offered some sheltered side canyon and cove habitat (Fig. 1).

Portable and fixed tracking systems were used to monitor fish movements. The fixed listening station was installed upstream of the Zahn Bay release site to detect upstream movements. This system was checked and data downloaded monthly until March 1996, when the station was vandalized and not replaced.

Tracking efforts focused on the lower 89.6 km of the San Juan arm (i.e., from Clayhills Crossing to the confluence). We searched for tagged fish the first 2 days following release and approximately monthly for the next 2 years. Surveys were conducted by boat using a directional hydrophone, and we listened for fish in mid-channel and along both shorelines where possible. Transmitter signals that could not be moved were presumed to be either expelled tags or dead fish. Tracking in 1997 occurred in association with another study (Mueller and Marsh 1998) wherein effort was concentrated in and above Piute Farms. The main body of Lake Powell (from Friendship Cove area upstream to Hite Marina including the Escalante River and all side canyons) was extensively surveyed (about 500 locations) in April 1996. The San Juan River above Clayhills Crossing was surveyed in June (Mexican Hat, Utah, to the Clayhills Crossing) and October (Bluff, Utah, to Piute Farms Wash) 1996. Our fish location estimates were based on RK 0 being the buoy marker at the historic mouth of the San Juan River. Thus, for example, Neskahi Wash, RK 38.4, was 38.4 km upstream of the confluence.

RESULTS

Movements

Nine of the 17 study fish were contacted 59 times over the 23-month study period (contact was lost with 4 fish, and another 4 fish either died or expelled the transmitters; Table 2). The nine fish averaged 47.8 km, up- and downstream movements combined (range 20.5–103.5 km; Table 1). All contacts occurred in or upstream of Neskahi Bay (Fig. 1), including Piute Canyon (RK 33.6), Neskahi Wash (RK 38.4),

TABLE 1. Summary of razorback suckers released with sonic transmitters in the inflow area of the lower San Juan River, November 1995. Weight is to the nearest 10 g.

Transmitter	Total length (mm)	Weight (gm)	Distance moved[a] (km)
NESKAHI WASH RELEASE SITE[a]			
2246	457	1050	0.3
2273	471	1050	6.4
2336	464	1000	0
2354	445	1000	103.5
2363	449	1000	0
2453	457	1100	12.8
2525	458	1100	3.6
3335	454	1100	4.8
ZAHN BAY RELEASE SITE[b]			
2237	442	900	76
2255	463	1100	38.7
2264	440	940	20.5
2327	495	1240	39.7
2345	463	1050	23.3
2426	444	1020	76.5
2435	467	1020	1.1
2543	434	960	25.3
2633	448	1000	26.7

[a]Distance moved is the sum of up- and downstream movements.
[b]Neskahi Wash is about 38.4 km and Zahn Bay about 68.8 km upstream of the San Juan River buoy marker in Lake Powell.

Nokai Canyon (RK 69.6), and the Piute Farms to Clayhills Crossing reach (RK 81.6–89.6). In addition, 3 fish were detected 16–40 km upstream of Clayhills Crossing in the San Juan River.

Seven fish left the Neskahi Wash site during the first few days following release (Table 2). Three fish moved downstream 4.8 km into Piute Canyon the first winter, 1 moved into Neskahi Bay and later died or lost its transmitter, and 3 fish quickly disappeared. One of the Piute Canyon fish overwintered and then moved 16 km above Clayhills Crossing (RK 105.6) by June 1996. This fish was later contacted in the Piute Farms area (RK 83.2–84.8). A second fish also overwintered in Piute Canyon and then was found on the southeast shore of Neskahi Bay in April 1996 (about RK 41.6). This fish and another razorback sucker (no sonic signal) were observed swimming together in flooded salt cedar (1.5–4 m depth) for several minutes. We had no further contact with the study fish after this sighting. One fish that moved into Piute Canyon either died or lost its transmitter. Total distance moved by the Neskahi fish ranged from zero to about 103.5 km (Table 1).

Of the fish released at Zahn Bay (RK 68.5), one was detected 20 km downstream 10 days after release but not encountered again. Two fish moved downstream 30.1 km to Neskahi Wash during the first winter–spring (Table 2). One of these fish was contacted at several locations within Neskahi Bay, then lost for several months, and later found upstream in Piute Farms during summer 1997. After the downstream movement during winter–spring 1996, the second fish moved upstream to Piute Farms where it was contacted several times in stands of flooded salt cedar. Four Zahn Bay releases moved 1 km upstream into Nokai Canyon (RK 69.6) during winter and spring 1996 (Table 2). One fish was presumed dead (or tag expelled). Two fish remained in the canyon for a short time and later were located in the Piute Farms/Clayhills Crossing reach. The fourth fish moved back and forth between Nokai Canyon and Piute Farms, but contact was lost after January 1997. The remaining 2 fish left the release site after the first week. One was found in the Piute Farms area throughout the study, but the other was not detected for 1.5 years, when it was also located in Piute Farms. Total distance moved by the Zahn Bay fish ranged from 1.1 to about 77 km (Table 1).

Habitat Use

Razorback suckers were most often located in shallow, flooded stands of salt cedar and, in some cases, cobbled shorelines. We rarely contacted any fish in the main channel and

TABLE 2. Summary of razorback sucker contacts in the San Juan River inflow November 1995–September 1997. Data are fish locations in river kilometer, RK (RK 0 is the San Juan River buoy marker in Lake Powell).

Tag #	11/95	12/95	1/96	2/96	3/96	4/96	5/96	6/96	8/96	10/96	11/96	1/97	3/97	5/97	6/97	7/97	8/97	9/97
Neskahi Wash release site (RK 38.4)																		
2246	38.4	38.1																
2273	38.4	44.8																
2336	38.4		38.4	38.4	38.4	38.4	38.4	38.4	38.4	37.3		38.4	38.4					
2354	38.4			33.6	33.6	33.6	33.6	105.6						81.2		83.2–84.8	83.5–84.2	83.5
2363	38.4																	
2453	38.4			33.6	33.6	41.6												
2525	38.4–40		41	40	40	39.2	40	40	40	40		40						
3335	38.4			33.6	33.6	33.6	33.6		33.6									
Zahn Bay release site (RK 68.5)																		
2237	68.5–41.6			40.5	40–41.6	38.4						68.8			83	81.6		
2255	68.5–75.2	78.4					69.6									85.3–86.4	85.1	89.6
2264	68.5	48																
2327	65.6–70.4		69.6	69.6				84.8	84.8	69.3	69.3	67.2						
2345	68.5							84.8		84.8				81.2		84.8	83.8–84.6	
2426	68.5–68.2		38.4					84.8	84.8							84.8	84.5	
2435	68.5–68.8		69.6	69.6	69.6	69.6	69.6		69.6	69.6	69.6							
2543	68.5														89.6	86.4	85.4	
2633	68.5					69.6	77.6	84.8	84.8	84.8				81.2		85.1	84.3–85.3	88

located none during the April 1996 reservoir survey. The tagged fish frequented 3 locations: Neskahi Bay, Nokai Canyon, and the Piute Farms to Clayhills Crossing reach. These areas are unique in that they contain some shallow shorelines with large expanses of flooded and emergent salt cedar.

DISCUSSION

At least 9 fish exhibited relatively long-distance movements over the 23-month study period (i.e., over 20 km). Long-distance movements by adult razorback sucker have also been reported in other river and reservoir systems and often are associated with spawning migrations (Tyus 1987, Tyus and Karp 1990, Modde and Irving 1998, Mueller et al. 2000, Ryden 2000). Our fish generally moved upstream above the upper release site and remained upstream (3 fish moved downstream shortly after release; of these, 1 was lost, and the remaining 2 moved back upstream for the duration of the study). However, other studies have noted a general downstream movement after release, followed by fish sometimes returning at least to the release site (Burdick and Bonar 1997, Foster and Mueller 1999, Irving 2000). We cannot explain why our fish moved up while similar-sized, hatchery-raised fish in other studies moved down, except perhaps our fish were released in sheltered, protected areas and therefore had more time to acclimate to lake/river conditions.

All contacts with known study fish occurred from Neskahi Bay (including Piute Canyon) upstream to Whirlwind Draw (16 km upstream of Clayhills Crossing). The fish primarily used shallow (up to 5 m), vegetated habitats in side canyons and open bays (Piute Farms) in the upper arm. These unique areas represent a small portion of available habitat in Lake Powell (<1%) but are similar to habitats used by adult razorback sucker in the Colorado River basin (USFWS 1998, Bradford and Gurtin 2000). No fish were located downstream of Neskahi Bay where there is no shallow vegetated or cobbled shoreline.

Eight fish used the Piute Farms area during the study; of these, we were in contact with at least 7 fish for 23 months (Table 2). Contact was lost with 1 fish after 15 months, presumably to tag failure. The Piute Farms to Clayhills Crossing reach is the transition zone between river and lake influences, although we observed muddy inflows 15 km downstream. The upper end of Piute Farms includes a natural sandstone dam (and waterfall) that at times may be a barrier to fish moving up into the river (Ryden and Ahlm 1996). However, at least 4 of our fish (including the 2 unidentified sonic transmitter signals detected 30–40 km upstream of Clayhills Crossing) moved above the falls, indicating that the sandstone dam is not a barrier to subadult/adult razorback sucker.

We had no contact with 4 transmitters after the first few weeks. We presume that these missing fish either quickly left the release area and moved down into Lake Powell (the transmitters were not detected by the remote listening station situated above the release sites) or died and washed up on shore. Alternatively, the transmitters may have failed. Large fluctuations in lake level (9.1 m) significantly altered the shallow habitats, and we believe some of the lost transmitters may have been fish that moved into the shallows, became stranded, and died. The shoreline of Lake Powell is mostly steep-walled and barren of shallow, vegetated areas, unlike other large reservoirs in the system, and we believe few if any fish successfully acclimated to the deep, flooded canyons in the main body of the lake. However, tracking conditions were not ideal and some fish may have moved into Lake Powell beyond the San Juan arm.

We looked for tagged fish in the spring of both years in an attempt to locate spawning habitat. Three razorback suckers (2 implanted and 1 probable Wahweap release) were observed in a shoreline cove in Neskahi Bay (RK 41.6) in March–April 1996, and 4 implanted fish were located above a gravel bar in the upper inflow (RK 81.2) in May 1997. Although we did not try to confirm spawning activity, it is possible that these fish were either staging or seeking suitable spawning habitat. Ripe razorback suckers have been captured in the Piute Farms area in the past (Platania et al. 1991), but we were unable to successfully track there in the spring because of high flows and associated turbulence from San Juan River runoff.

At least 8 of 17 released hatchery-reared razorback suckers survived handling and transportation and successfully acclimated to river inflow conditions. Their concentration in the Piute Farms–Clayhills Crossing area for 23

months suggests this area was the most preferred razorback sucker habitat. Although historic records are scant, captures of wild fish (Platania et al. 1991) and recent captures of hatchery fish in the same area support our findings. Razorback sucker recruitment is suffering basin-wide, suggesting that optimal habitats may no longer exist in the presently altered system. Thus, suboptimal habitats such as the San Juan River inflow (and possibly other reservoir inflow areas) may be needed for recovery and should be considered useable habitat for razorback sucker reintroduction efforts. River inflow areas may allow stocked fish an opportunity to acclimate to the wild system without flow forcing them downstream.

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