San Juan River Arm of Lake Powell Razorback Sucker (*Xyrauchen texanus*) Survey: 2011

Interim Progress Report

(Final)

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Submitted by:

Travis A. Francis
Dale W. Ryden
Benjamin J. Schleicher
Fish Biologist
U. S. Fish and Wildlife Service
Colorado River Fishery Project
764 Horizon Drive, Building B
Grand Junction, Colorado 81506

-and-

Darek S. Elverud
Fish Biologist
Utah Division of Wildlife Resources
1165 S. Hwy 191 Suite 4
Moab, UT 84532

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Executive Summary

Trammel Netting Sampling

1. 315 net sets (3199 net hours) produced 5,042 fish
   A. 1.9% of total catch was made up of four native species
      a. Flannelmouth sucker (n=49)
      b. Razorback sucker (n=38)
      c. Colorado pikeminnow (n=8)
      d. Razorback X flannelmouth sucker hybrids (n=2)
   B. 98.1% of total catch was made up of non-native species (listed in decreasing order of abundance)
      a. Gizzard shad
      b. Common carp
      c. Channel catfish
      d. Bluegill
      e. Yellow bullhead
      f. Smallmouth bass
      g. Striped bass
      h. Largemouth bass
      i. Green sunfish
      j. Black crappie
      k. Black bullhead
      l. Walleye
      m. Threadfin shad

Electrofishing Sampling

1. Only native species were collected during electrofishing
2. Observed species composition was similar to that observed in the trammel net catch
3. > 41.2 hours of electrofishing effort expended
   A. Some electrofishing effort was not recorded in the field
   B. Native species collected included:
      n. Flannelmouth sucker (n=54)
      o. Razorback sucker (n=42)
      p. Colorado pikeminnow (n=16)

Larval Fish Sampling

1. 28 larval samples collected (7 total hours sampling)
   A. Total native fish catch consisted of one fish
      1) Razorback sucker metalarvae (20.7 mm TL)
   B. Non-native catch included (listed in decreasing order of abundance) – shad species (gizzard and threadfin), black crappie, largemouth bass, and common carp

Razorback Sucker

1. 75 individual razorback sucker (all adults) were collected with both electrofishing and Trammel Netting
   A. Mean TL = 503 mm (range = 429-619 mm TL)
   B. Mean relative condition was 102 (range = 99)

C. 80 total capture events with these 75 fish
    1) Only 1 recapture occurred between trips
    2) 20 were captured within a few miles of the waterfall
    3) 16 were captured near Spencer's Camp
    4) 44 were captured around Piute and Neskahi Canyons
D. 47 razorback sucker had PIT tags when captured, 28 did not have PIT tags
    1. Original tagging found for 45 of the 47 razorback sucker with PIT tags
        a. 41 were stocked into the San Juan River with a PIT tag
        b. 3 were tagged after being captured in the San Juan River without a PIT tag
        c. 1 was stocked in Lake Powell at Piute Farms in 1995
        d. 2 PIT tags were not found in the SJRIP PIT tag database
    2. 26 of 28 fish without PIT tags (i.e., unknown year-class) had fin clips collected for aging, 13 were analyzed
        a. Mean age = 9 years (range = 6-16 years)
E. 40 individuals had sexually dimorphic traits
    1. 18 were female (identified 26 April through 14 June)
    2. 22 were male (identified 11 May through 15 June)

Colorado Pikeminnow

1. 24 individual Colorado pikeminnow collected
    A. Mean TL = 327 mm (range = 228-519 mm TL)
    B. Mean relative condition was 92 (range = 85-100)
    C. 24 total capture events
        1) 13 were captured within a few miles of the waterfall
        2) 3 were captured between Noki and Copper Canyons
        3) 8 were captured near Spencer's Camp
    D. 12 Colorado pikeminnow had PIT tags when captured, 12 did not
        1. 6 were stocked into the San Juan River with PIT tags
            a. 1 in 2006
            b. 3 in 2007
            c. 2 in 2009
        2. 6 were tagged after being captured in the San Juan River without a PIT tag

Flannelmouth Sucker

1. 103 individual flannelmouth sucker were collected
    A. Mean TL = 327 mm (range = 228-519 mm TL)
    B. Of 103 capture events
        1) 43 were captured within a few miles of the waterfall
        2) 3 were captured between Noki and Copper Canyons
        3) 41 were captured near Spencer's Camp
        4) 16 were captured around Piute and Neskahi Canyons

Other Native Fish

1. Two razorback X flannelmouth sucker hybrids were collected

Introduction

Razorback sucker (*Xyrauchen texanus*) is one of three San Juan River native fish species (the Colorado pikeminnow, *Ptychocheilus lucius*, and the roundtail chub, *Gila robusta* being the other two) that have become greatly reduced in numbers and range since the mid 1900's (Minckley 1973, Bestgen 1990). Physical alterations of riverine habitats, water impoundment in the form of Navajo Reservoir and Lake Powell and their associated effects on flow and thermal regimes, introduction of nonnative fish species, and contaminants have probably all contributed to the decline of these native species (Platania 1990, Brooks et al. 1993, Ryden and Pfeifer 1994a). Extremely small numbers of wild razorback sucker and the long-term lack of recruitment led to this species being listed as endangered under the Endangered Species Act on 22 November 1991 (U.S. Fish and Wildlife Service {USFWS} 1991). The razorback sucker is also currently protected by state laws in Arizona (AZ), California (CA), Colorado (CO), Nevada (NV), New Mexico (NM), Utah (UT), and by the Navajo Nation. Critical Habitat in the San Juan River has been designated from the Hogback irrigation diversion in New Mexico downstream to Neskahi Canyon (UT) in Lake Powell (Maddux et al. 1993, USFWS 1994).

Populations of razorback sucker occupied several large reservoirs in the lower Colorado River Basin (LCRB) after their construction, including Lake Havasu, Lake Mojave and Lake Mead. These populations were originally composed of adult fish that were thought to have recruited within the first few years of reservoir formation (Albrecht et al. 2008b). These populations of long-lived adult fish began disappearing 40-50 years after the creation of these reservoirs (Minckley 1983). In the most dramatic case, the Lake Mojave razorback sucker population (estimated at 75,000 individuals in the 1980s) had dropped to just 218 individuals by March 2007 (Albrecht et al. 2008b). It has long been known that razorback sucker successfully spawn in large reservoirs. In fact, the main management strategy for the LCRB to augment their populations of razorback sucker is to collect wild-produced larval razorback sucker being produced in these reservoirs, rear them in predator-free environments, and then stock these fish back into the reservoirs and rivers once they have reached sub-adult or adult size (Albrecht et al. 2008b). This management approach was adopted because natural recruitment in most LCRB reservoirs was either very rare or non-existent and it is thought that stocking razorback sucker of larger size (minimum of 8.5 inches) gives them a higher likelihood of avoiding predation, thus increasing their chances of recruiting (Albrecht et al. 2008b). In contrast, the Lake Mead population of razorback sucker is generally young, is naturallyreproducing, and has increased over time (Albrecht et al. 2008b).

Likewise, wild razorback sucker occupied the San Juan River arm of Lake Powell, roughly 25 years after its construction. The Lake Powell razorback sucker population has been undergoing regular, if unintentional, augmentation since 1994, as razorback sucker stocked into the San Juan River have moved downstream into Lake Powell. Razorback sucker occupying the San Juan River arm of Lake Powell are part of the San Juan River razorback sucker population and contribute towards the demographic recovery criteria.

One of the two goals of the San Juan River Recovery Implementation Program (SJRIP) is to recover endangered fishes in the San Juan River Basin with the ultimate goal of establishing self-sustaining populations of razorback sucker and Colorado pikeminnow (SJRIP 2011). Due to the paucity of historic and recent collections of this species, including the failure to collect any wild razorback sucker during three years (1991-1993) of intensive studies on all life stages of the San Juan River fish community (Buntjer et al. 1993, 1994, Lashmett 1993, 1994, Ryden and Pfeifer 1993, 1994b, Gido and Propst 1994) the SJRIP initiated a stocking program for razorback sucker in the San Juan River (Ryden and Pfeifer 1994a).

The numbers of razorback sucker stocked annually between 1994 and 2010 have varied greatly (from 16 fish in 1995 to >28,000 fish in 2010). However, with the exception of 1999, some level of stocking has occurred in 16 of the last 17 years (Furr 2011). Post-stocking monitoring of these fish has occurred annually each fall since 1994. The number of sub-adult and adult razorback sucker collected during any given fall monitoring trip fluctuates in direct relation to the number of fish that were recently stocked into the river (Ryden 2009). In other words, the more fish stocked in the recent past, the greater the number of razorback sucker collected during fall sampling. Thus, most of the fish being collected during fall monitoring efforts have been in the river less than one overwinter period post-stocking and are not a good indicator of the whether the riverine population is increasing or decreasing in number.

Based on the large number of razorback sucker stocked over the last 16 years and the documented persistence of a few individual razorback sucker from 6 to 14 overwinter periods post-stocking (Ryden 2011), one would expect that this population was increasing over time. Comparisons of capture data for razorback sucker that were in the river for 1+ overwinter periods showed that the number of older fish being collected during Adult Monitoring trips had changed little over the last eight-year period from 2002-2009 (range = 16-36 fish; Ryden 2009). However, in 2010, this number increased to 70 fish (Ryden 2011). In addition, between-year comparisons of scaled CPE for all razorback sucker that were in the river 1+ overwinter periods showed no significant difference from 2003-2009 (Ryden 2009). Again this trend changed in 2010, with scaled CPE for all razorback sucker that were in the river 1+ overwinter periods was significantly higher in 2010 than in each of the previous three years (Ryden 2011).

Analysis of razorback stocking data in the San Juan River from 1994 to 2007 by Bestgen et al. (2009) indicated 1st interval apparent survival of < 2% in most years. Apparent survival cannot distinguish between mortality and departure from the study area. So fish moving any place out of the study area are considered mortality as well. Therefore, some unknown rate of loss of stocked razorback sucker over the waterfall and into Lake Powell is considered mortality in these models. Captures of PIT-tagged razorback sucker in Lake Powell or below the waterfall confirm some level of loss of stocked fish over the waterfall and into Lake Powell. By increasing the study area to Lake Powell, future attempts at this analysis will result in a better informed model.

The numbers of Colorado Pikeminnow stocked annually between 1996 and 2010 have fluctuated widely (from 148 adults in 2001 to 500,000 age-0 "larvae" in 1999) as have the ranges of sizes and year-classes. Over 3.3 million age-0 and over 37,000 age-1+ (range 1+ to 16 year old) Colorado pikeminnow have been stocked (Furr 2011). Post-stocking monitoring of these fish has occurred annually each fall since 1996. Although hundreds of Colorado pikeminnow recaptures have occurred, recruitment of stocked fish into the adult population has been minimal. Colorado pikeminnow loss over the waterfall and into Lake Powell versus mortality is unknown. Captures of pikeminnow in Lake Powell should help provide some information on loss of stocked fish from the river.

The area now inundated by the San Juan River arm of Lake Powell is extremely isolated and remote and this area has received the least survey and research effort among the UCRB sub-basins, and the historic status of rare fish species, including the razorback sucker, is largely unknown (Bestgen 1990). Yet despite limited sampling, razorback sucker are known to have inhabitated the San Juan River arm of Lake Powell for many years. In 1987 and 1988, 16 different wild adult razorback sucker were collected from the south shore of Lake Powell near the concrete boat ramp at Piute Farms Marina (Platania 1990). These fish were collected in March and April each year and the presence of a large number of ripe males as well as gravid females indicated a possible spawning aggregation. In addition, gill net surveys performed by crews from Utah Division of Wildlife Resources Wahweap Hatchery (UDWR-Wahweap) collected six wild razorback sucker in Piute Farms Wash in April 1982 and another three wild razorback sucker from Neskahi Wash, one each in November 1983, 1984, and 1989 (UDWR unpublished data, Figure 2). In

April 1990, a multi-agency effort to collect and remove wild adult razorback sucker for use as future broodstock collected a total of 14 adult fish between Mike's Canyon and Copper Canyon (McKay 1990). These fish ranged in size from 557-682 mm TL. Eleven of these fish were removed and transported to Ouray NFH for use as broodstock (two were mortalities and one escaped back into the lake). Four of these fish (including one of the mortalities) were recaptures from the 1987-1988 collections. While he did not collect any razorback sucker during his 1991-1992 collections in the San Juan River arm of Lake Powell, Lashmett (1993) mentions that "Within the same study area, three adult razorback sucker (Xyrauchen texanus) were sampled from Lake Powell in April 1992 during a separate study in the extreme upper San Juan River arm of Lake Powell." However, the data for the fish to which this reference pertains is unknown. In the spring of 1993 (i.e., one year prior to the initiation of stocking razorback sucker in the riverine portion of the San Juan River), three weeks of sampling between the waterfall and Zahn Bay failed to locate any more wild adult razorback sucker in the San Juan River arm of Lake Powell. In August 1995, UDWR-Wahweap stocked 130 razorback sucker (mean TL = 407 mm) into the San Juan River arm of Lake Powell at Piute Farms (Ryden 2000). Only one of these fish has been recaptured and that was in the San Juan River upstream of Mexican Hat, UT (at RM 58.0 on 21 May 1996). Since 2001, UDWR-Wahweap personnel have conducted the only sampling in the San Juan River arm of Lake Powell. From 2006 to 2009, UDWR-Wahweap annual monitoring near Neskahi Wash has shown a catch rate of razorback sucker from 0.05 to 0.2 razorback sucker per net night. While the catch rates are low, they are similar to the lower end of catch rates of razorback sucker observed in Lake Mead from studies specifically targeting razorback sucker (Albrecht et al. 2008a).

Once stocking of razorback sucker into the riverine portion of the San Juan River began (i.e., March 1994), razorback sucker began to once again be collected in the San Juan River arm of Lake Powell. Between March 1995 and November 2009, a total of 49 razorback sucker were collected from the San Juan River arm of Lake Powell by various agencies and researchers (Appendix 3). While the origin of many of these fish could not be determined, at least 25 of them were known to have been stocked upstream in the San Juan River. Collections of razorback sucker ranged from just downsteam of Clay Hills take-out (in the mainstem San Juan River) downstream to Neskahi Canyon (in Lake Powell). Sizes of these razorback sucker indicate that almost all were large, adult fish capable of spawning. At present, the presence of a large waterfall precludes the movement of these fish back upstream into the main stem San Juan River.

The SJRIP has instituted many management actions to recover the listed fish species. While a fish community monitoring program has been instituted since 1999 in the main stem river, "peripheral" habitats haven't been subject to the same level of monitoring effort. Considering that all razorback sucker occupying the San Juan River arm of Lake Powell downstream as far as Neskahi Canyon would contribute to meeting target numbers set forth in the Recovery Goals (USFWS 1994, 2002), the SJRIP initiated a full scale monitoring effort in this section of Lake Powell in 2011. This study is the joint responsibility of the U. S. Fish and Wildlife Service (USFWS) Colorado River Fishery Project (CRFP) office in Grand Junction, CO and the Utah Division of Wildlife Resources (UDWR) office in Moab, UT. However, numerous other partners supplied personnel, equipment, laboratory and logistical support.

2011 Objectives

1) Sample and document the overall make-up of the fish community in the San Juan River arm of Lake Powell, with emphasis being placed on collecting the following types of data on endangered razorback sucker: a. Presence/absence

b. Distribution and abundance

c. Population size structure

d. Point of origin (based on PIT tag data)

2) Attempt to identify possible spawning aggregations of razorback sucker in the San Juan River arm of Lake Powell.

Relationship to the Recovery Program

While the razorback sucker survey in Lake Powell took place outside of the riverine portion of the San Juan River, it is still directly applicable to tasks 3.3.2.1 and 3.3.2.2 of the SJRIP Long Range Plan (dated March 2009). It also has the potential to yield data that, when combined with information from other studies and monitoring efforts, is applicable to the following tasks in the Long Range Plan: 2.2.1.2, 2.2.1.3, 2.2.3.1, 2.2.4.1, 2.2.4.2, 2.2.5.1, 2.2.5.2, 4.1.1.1, 5.1.1.1, 5.1.1.2, 5.1.2.3, 5.1.3.3, and 5.1.4.1.

Study Area

This study was conducted on the San Juan River arm of Lake Powell, in Utah (Figure 1). The study area for the Lake Powell razorback sucker survey began immediately downstream of the waterfall (RM -1.1) and extended downstream to approximately Piute Canyon (RM -33.1) -- a distance of approximately 32 miles (Figure 2). See Appendix 4 for river mile (RM) to lake mile (LM) conversions.

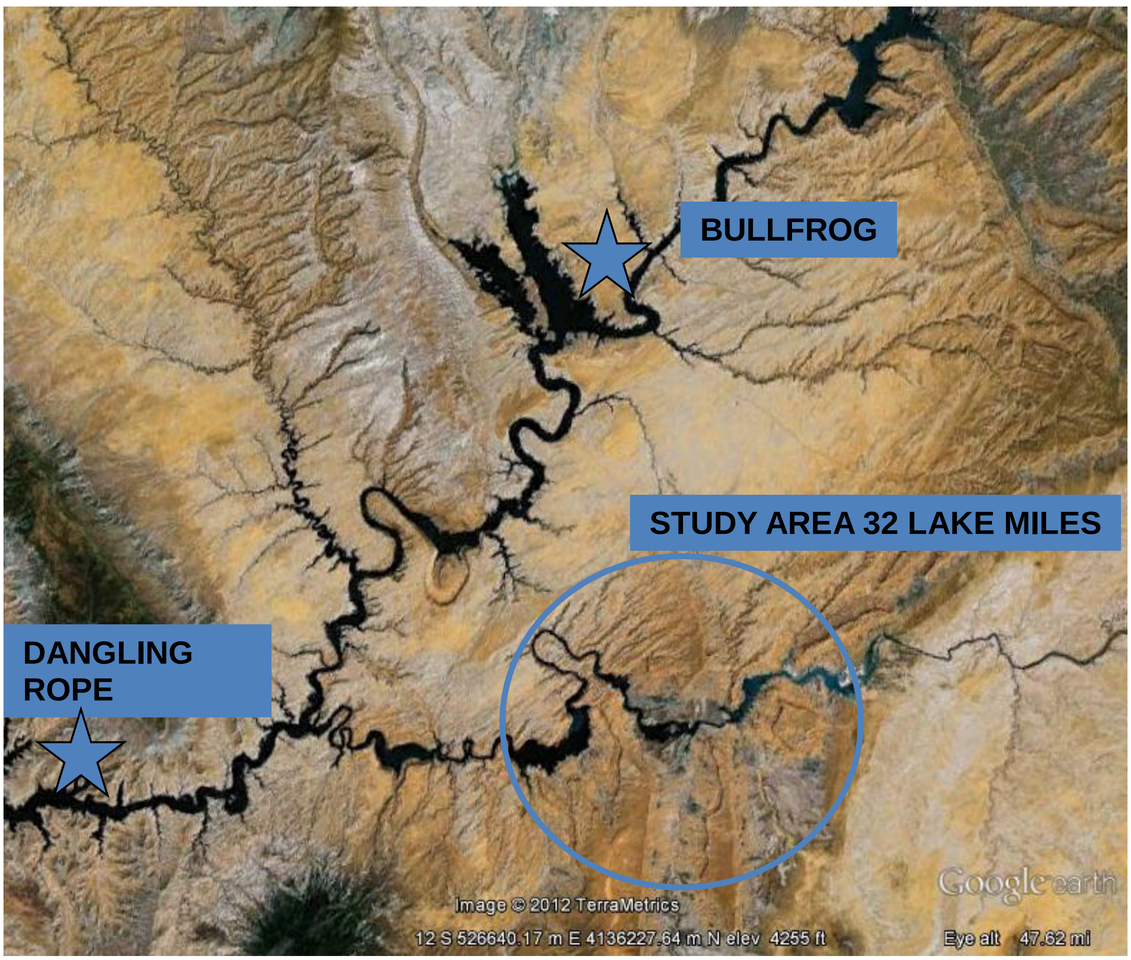

Figure 1. Google earth image of the confluence of the Colorado and San Juan Rivers in Lake Powell, UT referencing the location of the study area.

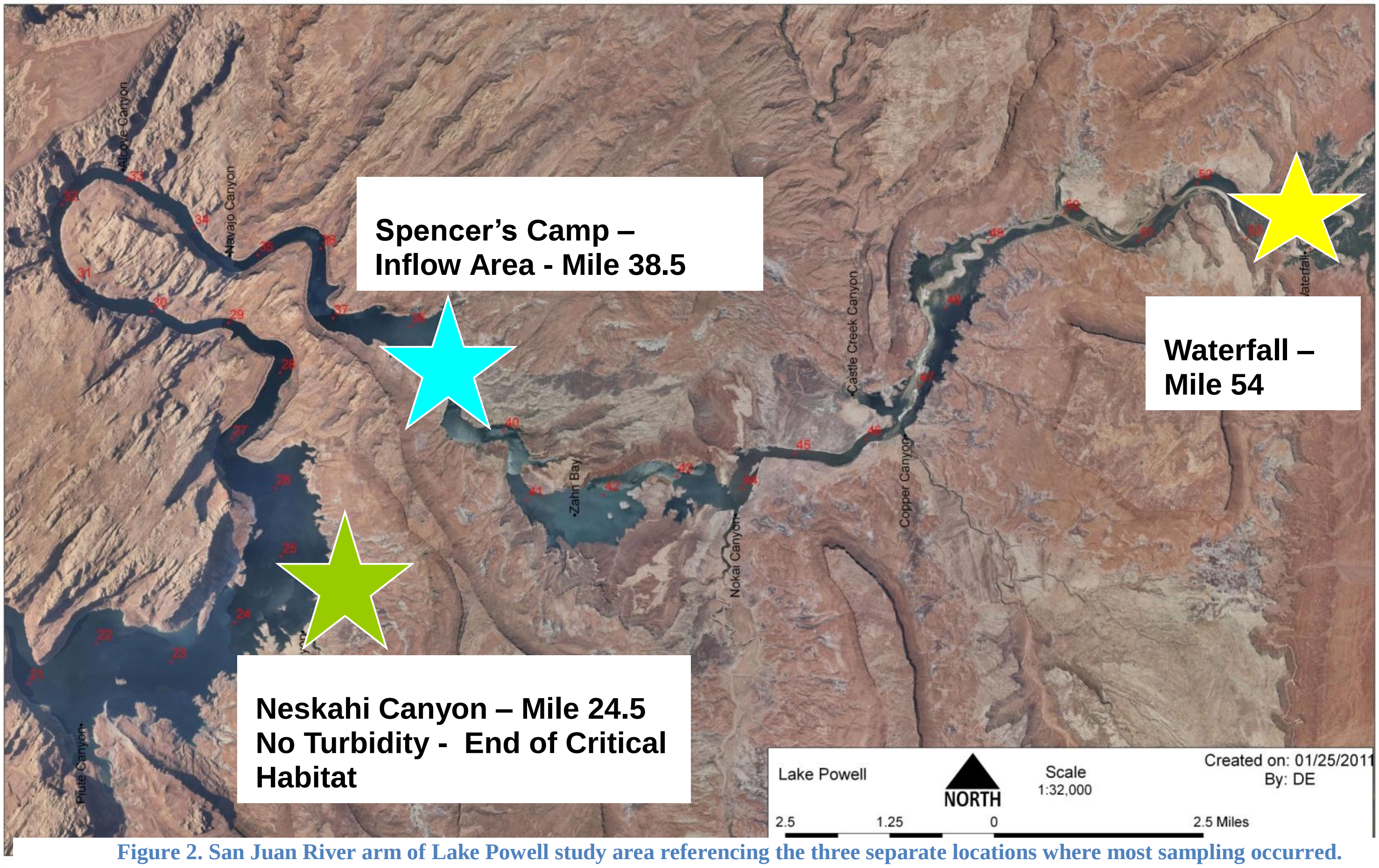

Figure 2. San Juan River arm of Lake Powell study area referencing the three separate locations where most sampling occurred.

Data Integration

Work performed in the early 1990's through 2009 conducted by Utah Division of Wildlife Resources, Bureau of Reclamation, U.S. Fish and Wildlife, and U.S. Geological Survey provided information on historical captures of razorback sucker in the San Juan arm of Lake Powell and provided the impetus for this project. PIT tag data collected in the lake from the onset of the SJRIP propagation program in 1994 confirmed that razorback sucker stocked in the river were ending up in Lake Powell (Appendix 3). Preliminary planning for this project required consulting LCRB razorback sucker work in Lake Mead. Predicting spawning dates was made possible by the work completed by the SJRIP larval fish surveys.

Larval fish identification for this project was provided by the SJRIP larval fish crew (Brandenburg and Farrington, 2008-2010). Pectoral fin ray aging for this project was provided by the LCRB Lake Mead crew (Albrecht et al, 2008b).

PIT tag histories for the endangered fish handled during this project was made available by all of the SJRIP large-bodied fish sampling in the San Juan River (including non-native fish removal and large-bodied fish community monitoring) and the SJRIP propagation work. PIT tag data were utilized to run relative condition indices for razorback sucker and Colorado pikeminnow in the San Juan River for this project.

We anticipate that the number and origin of razorback sucker (and Colorado pikeminnow) being collected in Lake Powell will help shed light on a number of questions that are either directly or peripherally related to our stated study objectives. Some of these include: Are all of the razorback sucker in Lake Powell originating from riverine stockings of this species? Can the loss of stocked fish from the San Juan River into Lake Powell be quantified? If the waterfall were inundated, would endangered fish residing in Lake Powell return upstream to the river, or would they continue to be geographically isolated populations? Are razorback sucker successfully spawning in Lake Powell? If so, are they recruiting in the face of a plethora of nonnative fishes? Is there any interchange of razorback sucker between the San Juan River and the Colorado River through Lake Powell?

The answers to these questions could help the SJRIP refine future endangered fish augmentation strategies and get a better idea of how endangered fish in habitats adjacent to the main stem San Juan River are contributing (or not) to the overall recovery efforts for these species. Ultimately, the razorback sucker residing in the San Juan arm of Lake Powell could help the SJRIP meet the demographic downlist and delist criteria specified for this species in the razorback sucker Recovery Goals (USFWS 2002).

Methods

The USFWS's Colorado River Fishery Project (USFWS-CRFP) office from Grand Junction, CO and the UDWR Moab Field Station (UDWR-Moab) had joint responsibility for all field aspects of this study. Sampling crews consisted of six to eight people to run trammel nets, do sonic telemetry work, collect larvae, and perform electrofishing. All boats and sampling equipment used on this project were decontaminated (following National Park Service protocols) prior to launching and after take-out to insure that no invasive aquatic nuisance species are being transported either to or from Lake Powell.

Predicting Spawning Season

Sampling in Lake Mead from 1996-2007 determined that spawning season is the most efficient time to successfully sample razorback sucker due to the movement and location of fish associated with spawning activity (Albrecht et al. 2008b). Thus sampling for razorback sucker in the San Juan River arm of Lake Powell took place during the predicted spawning period. Studies in Lake Mead also determined that the return rate of razorback sucker captured during spawning was similar to that of fish captured during the remainder of the year; thus sampling during spawning season did not appear to have an adverse effect on adult survival (Albrecht et al. 2008b).

Larval razorback sucker collections in Lake Mead increase when surface temperatures reach approximately 55˚F (12.8˚C) and peak at surface temperatures in the high 50's to middle 60's (Albrecht et al. 2006). Historical data from Lake Powell indicate surface water temperatures typically reach 55˚F (12.8˚C) during early to late April. In addition, data obtained from collections of larval razorback in the mainstem San Juan River indicated that over the last five-year period (2005-2009) first hatching dates for larval razorback sucker began between 26 March and 30 April (at water temperatures ranging from 12.9-15.3˚C) and last hatching dates ended between 24 May and 2 July (at water temperatures ranging 14.4-

21.8˚C; Brandenburg and Farrington 2009, 2010). Examination of water temperatures (from the Bluff USGS gage) in the 15-day window prior to first and last hatching dates, compared to known razorback sucker egg incubation times (Bozek et al. 1984, Snyder and Muth 1990, USFWS 2002) indicated that, over this same five-year period, date of spawning likely began between 11 March and 14 April (at water temperatures from 10.1-12.5˚C) and spawning likely ended between 18 May and 26 June (at temperatures from 15.0-21.5˚C). Using the two most extreme values to bracket the entire spawning season window, this yields a period of 107 days (roughly 15 weeks), from 11 March to 26 June, with three of five years having spawning beginning in late March. Brandenburg and Farrington (2008) stated that the mean temperature during hatching was usually just over 15˚C. In addition, the distribution of razorback sucker protolarvae in the San Juan River was significantly higher in May than in any other month (Brandenburg and Farrington 2010). It was anticipated that spawning season of razorback sucker in the San Juan River arm of Lake Powell should not vary greatly from those of fish in the main stem river. Thus, the timing and duration of razorback sucker spawning in the main stem San Juan River can likely be used as a reasonable surrogate to predict when spawning of this species is likely to occur in the San Juan River arm of Lake Powell.

Timing and Location of Field Sampling

Given the predicted 15-week spawning window discussed earlier, field sampling in 2011 was spread out to cover as much of the predicted spawning season as possible. The relative isolation of the San Juan River arm of Lake Powell, difficulty in accessing this portion of the lake, and the need to stay in contact with sonic-telemetered fish required keeping sampling trips relatively close together. Thus, 2011 field sampling occurred on the following dates: 22-27 March, 13-28 April, 8-25 May, and 6-16 June 2011. This 51-day sampling effort covered approximately 50% of the predicted spawning season. Sampling occurred in 8 of the 13 calendar weeks that encompass the core of the predicted 2011 spawning period.

In Lake Mead, placement of trammel nets is determined by a combination of factors. Nets are set in locations where adult razorback sucker have been successfully captured in the past, in close proximity to locations where sonic-tagged individuals were found, and near confirmed or suspected spawning areas (Albrecht et al. 2008b). We followed these guidelines, but also had many exploratory (blind) net sets in promising habitats.

Sonic Telemetry

Work done in Lake Mead from 1996-2007 indicated that one the most efficient ways to locate a natural population of razorback sucker in a reservoir was through the use of sonic telemetry (Albrecht et al. 2008b). They found that artificially-reared razorback sucker that were implanted with sonic tags and stocked into a reservoir would quickly integrate into natural population of razorback sucker (Albrecht et al. 2008).

In early February, twenty five large sub-adult or adult razorback sucker (> 400 mm TL) were obtained from USFWS's Uvalde National Fish Hatchery (NFH). Seven of these fish were surgically implanted with Sonotronics Model CHP-87-L sonic tags with an 18-month battery life (following Albrecht et al. 2008). All 25 fish were held at the Uvalde NFH while those that had undergone surgery recovered and healed. The remaining eighteen fish were held in case any of the sonic-tagged fish died following surgery. In all instances of tag insertion, the transmitter did not exceed 2% of the fish's body weight. While at Uvalde NFH, these fish were fed and monitored daily by USFWS fish culturists. On March 9th 2011, all of the razorback sucker were transported, tempered, and stocked in Lake Powell (following appropriate USFWS protocols) just downstream of the waterfall. Stocking efforts were coordinated with the Utah Department of Natural Resources. All appropriate importation permits and health certifications were acquired prior to stocking. It was anticipated that stocking in this time frame should have preceded any potential spawning by several weeks to a month, thus allowing newly stocked fish several weeks to acclimate to reservoir conditions and locate resident fish before field sampling commences (B. Albrecht, pers. comm.).

Once field sampling began (22 March through 15 June, 2011) sonic telemetering occurred on a weekly basis (or daily basis during sampling trips). An additional eight lake caught razorback sucker were surgically implanted with tags and released. These 15 sonic tagged fish and intensive sonic telemetering helped guide researchers to areas in which to set trammel nets. Data collected for each sonic telemetry contact included date, time, temperature (water and ambient), Global Positioning System (GPS) coordinates, and water depth. Two submersible ultrasonic receivers (SURS) were deployed to passively collect data on a tagged fish's movement within the study area.

Trammel Netting

The main sampling technique utilized was trammel-netting, which has been identified as the most effective method for collecting razorback sucker in Lake Powell (Mueller et al. 2000) and Lake Mead (Albrecht et al. 2006). Trammel nets were 45.75 meters (150 feet) long by 1.83 meters (6 feet) deep. Inner mesh sizes of the trammel nets were 2.54 cm (1 inch) and the outer panels were 30.5 cm (12 inches). Nets were set perpendicularly to shorelines in the late afternoon/evening before sunset and pulled the following morning shortly after sunrise around the Neskahi and Spencer's sites (following Albrecht et al. 2008b). Nets were set at 2-4 hour intervals in the upstream sample site (around Spencer's Camp below Zahn Bay to the waterfall) after we experienced some Colorado pikeminnow mortality. The total number of nets set each day as well as the total number of hours each net is set were recorded in order to allow CPE comparisons to be made between sites and sampling efforts. Global Positioning System (GPS) coordinates, substrate type, and any additional pertinent habitat information (e.g., the presence/absence of emergent or submergent cover, water turbidity) was recorded for each net set.

All endangered fishes were weighed using Pesola spring scales (g), measured (mm TL and SL), and checked for presence of a PIT tag. Fish lacking a PIT tag, or having an older (400 kHz tag), received a new (134 kHz) tag. Somatic and sexually dimorphic condition was recorded for all endangered species, when evident. A small number of razorback sucker (including both fish with and without a PIT tags) had a 6.4 millimeter (a quarter inch squared) fin ray section removed from the left pelvic fin for aging (following Albrecht 2008b). All non-native fishes collected were recorded by species and life stage. A representative sub-sample of each non-native fish species encountered were weighed and measured.

Boat Electrofishing

Due to low lake levels, there was a large amount of riverine habitat downstream of the current waterfall. Sampling this portion of the San Juan River arm of Lake Powell required the use of electrofishing. Although an unexpected result, 2011 sampling proved that electrofishing in shallow clear water, even in the most downstream sections of lacustrine critical habitat, was successful in collecting razorback sucker. Electrofishing took place from a motorized, aluminum jon boat. The electrofishing crew consisted of two netters and one boat operator. Mueller et al. (2000) stated that electrofishing was the best viable option for sampling flooded tamarisk habitats at the inflow areas of Lake Powell. Building on this, electrofishing crews sampled along shorelines, in coves and embayments, in and around sunken obstacles, and in flooded tamarisk, emergent vegetation and in other areas that are generally hard to sample with trammel nets. Data for native fish species encountered during electrofishing operations was collected in the same manner as for trammel-netting. Sampling effort (seconds) data were collected for CPE comparisons among sites and sampling efforts.

Larval Sampling

When adult razorback sucker were handled in ripe condition, larval samples were collected during the night near the adult fish capture sites. A sample consisted of suspending an Optronics Fish-N-Lite ® over the gunwale of a boat, submerging the light and collecting larval fish with aquaria dip-nets for fifteen minutes. G.P.S coordinates were recorded, as was effort to determine CPE. Larvae were preserved in 100% ethanol and sent to American Southwest Ichthyological Researcher's L.L.C. (ASIR) for identification.

Data Analysis

After two incidental Colorado pikeminnow mortalities near Spencer's camp, the original standard operation procedure (SOP), from the approved 2011 scope of work, for setting over-night net sets was changed to day only net sets in the Spencer's camp sampling area. Considering the change in SOP, comparisons of CPE among locations and type of net set (day versus night) was necessary.

Mean log transformed (LN, natural log) catch per unit effort for trammel netting (CPE, fish per net-hour) was calculated for razorback sucker, Colorado pikeminnow and flannelmouth sucker for each trip, location and net set type (night versus day sets). Mean CPE was compared among trips, locations and set type using Analysis of Variance; pairwise comparisons were made using Tukey's Honestly-Significant-Difference Test ($P<0.05$; SYSTAT13).

Mean log transformed (LN, natural log) catch per effort for electrofishing (CPE, fish per hour) was calculated for razorback sucker, Colorado Pikeminnow and flannelmouth sucker for each trip and location. Mean CPE was compared among trips and locations using Analysis of Variance; pairwise comparisons were made using Tukey's Honestly-Significant-Difference Test ($P<0.05$; SYSTAT13).

Length frequency distributions were calculated for razorback sucker, Colorado pikeminnow and flannelmouth sucker.

Consistent with methods used to track body condition of Colorado pikeminnow and humpback chub (*Gila cypha*) in the upper Colorado River, relative condition was calculated for razorback sucker and Colorado pikeminnow caught in the San Juan (Osmundson and White 2009, Francis and McAda 2011). Relative condition accounts for allometric growth and makes the measurement comparable between species and between different units of measure (Le Cren 1951). The standard average body condition is represented by 100 (x 100). Relative body condition (K_n) is the observed mass (M_o) of a given fish divided by the expected mass for a fish of its length:

$$K_n = (M_o \div M_e) \times 100$$

The expected mass or standard weight (M_e) is calculated using constants derived from mass-length regressions:

$$\log_{10}Me = ((\log_{10}\text{length})\ \text{slope}) + \text{y intercept}$$

The constants for these time-of-year-specific mass-length regressions were derived from razorback sucker and Colorado pikeminnow captured from the San Juan River (including Lake Powell) from 1995 through 2011. Wege and Anderson (1978) suggest using samples from the mid-to-late growing season when tissue accumulation is neither high nor low (pre-or-post spawning). However, timing for this project did not allow for this suggestion and tissue accumulation (regardless of being high or low) should be fairly similar throughout the entire San Juan during the possible spawning period when normalized by robust data sets through a period of 16 years. Relative condition of each animal was calculated using the constant specific to animals captured from the first week of April through the last week of June. Mean K_n was compared among passes using Analysis of Variance; pairwise comparisons were made using Tukey's Honestly-Significant-Difference Test (P<0.05; SYSTAT13).

Results

Throughout the sample season the lake elevation changed drastically. According to lakepowell.water-data.com, the lowest lake elevation (taken at the Glenn Canyon Dam) was on the first study day, March 22nd, with an elevation (from sea level) of 3612.06 ft. The lake elevation increased 24.77 ft. to an elevation of 3636.83 ft. on the last day of the study June 15th. The waterfall at river mile (RM) -1.1 (the uppermost portion of the study area) became inundated the last week of July as the lake elevation reached its peak for 2011, on August 1st, at an elevation 3660.81 ft. (48.75 ft. higher than the March 22nd elevation). The lowest lake level (and a resultant sandbar) made sampling above Spencer's camp not possible until the third trip (May 8th – May 25th). During the third sampling trip work was done in Zahn Bay (above Spencer's); however, a sand bar precluded any upstream work until the fourth sampling trip (June 6th – June 16th) and then sampling was completed below the waterfall. The sandbars that prevented upstream sampling may have also prevented the Uvalde NFH sonic tagged fish (stocked at the waterfall near Piute Farms) from reaching the sampling areas at both Spencer's camp and Neskahi canyon. By the end of the second trip (April 27th) two of the Uvalde NFH sonic-tagged fish were located near Spencer's Camp in areas where other razorback sucker were being captured providing evidence that the sandbar was then passible by fish.

The 2011 catch included three native species, one native hybrid species and 13 non-native species. In order of abundance the native fish catch included flannelmouth sucker, razorback sucker, Colorado pikeminnow and razorback X flannelmouth sucker hybrids (Table 1). All fishes represented in the trammel net catch were also observed by the electrofishing crews (Table 2, Figure 3). Trammel net catch for the 13 non-native species in order of abundance were gizzard shad, common carp, channel catfish, bluegill, yellow bullhead, smallmouth bass, striped bass, largemouth bass, green sunfish, black crappie, black bullhead, walleye, and threadfin shad. Only 1.9% (n = 97) of the total trammel net catch (n = 5,042) was comprised of native species and the top three non-native species (gizzard shad, common carp, and channel catfish) composed of 72% of the total catch (Figure 3).

Table 1. 2011 native fish catch (trammel net and electrofishing) by trip on the San Juan River arm of Lake Powell.

TRIP	Flannelmouth Sucker	Colorado Pikeminnow	Razorback Sucker	Razorback X Flannelmouth Hybrid
1	0	0	0	0
2	14	6	11	0
3	36	1	20	0
4	53	17	44	2
TOTAL	103	24	75	2

Table 2. Scientific and common names, status, and database codes for fish species collected from the San Juan River arm of Lake Powell during the 2011 sampling effort.

Scientific Name	Common Name	Status	Database Code
Family Catostomidae – suckers			
Catostomus latipinnis	flannelmouth sucker	Native	Catlat
Xyrauchen texanus	razorback sucker	Native	Xyrtex
X.texanus X C.latipinnis	hybrid	Native	texXlat
Family Cyprinidae – carps and minnows			
Cyprinus carpio	common carp	Introduced	Cypcar
Pimephales promelas	fathead minnow	Introduced	Pimpro
Ptychocheilus lucius	Colorado pikeminnow	Native	Ptyluc
Family Centrarchidae – sunfishes			
Lepomis cyanellus	green sunfish	Introduced	Lepcya
Lepomis macrochirus	bluegill	Introduced	Lepmac
Micropterus dolomieu	smallmouth bass	Introduced	Micdol
Micropterus salmoides	largemouth bass	Introduced	Micsal
Pomoxis nigromaculatus	black crappie	Introduced	Pomnig
Family Clupeidae – shad			
Dorosoma cepedianum	gizzard shad	Introduced	Dorcep
Dorosoma petenense	threadfin shad	Introduced	Dorpet
Family Ictaluridae – bullhead catfishes			
Ameiurus melas	black bullhead	Introduced	Amemel
Ameiurus natalis	yellow bullhead	Introduced	Amenat
Ictalurus punctatus	channel catfish	Introduced	Ictpun
Family Percidae – perches			
Sander vitreus	walleye	Introduced	Stivit
Family Moronidae – temperate basses			
Morone saxatilis	striped bass	Introduced	Morsax

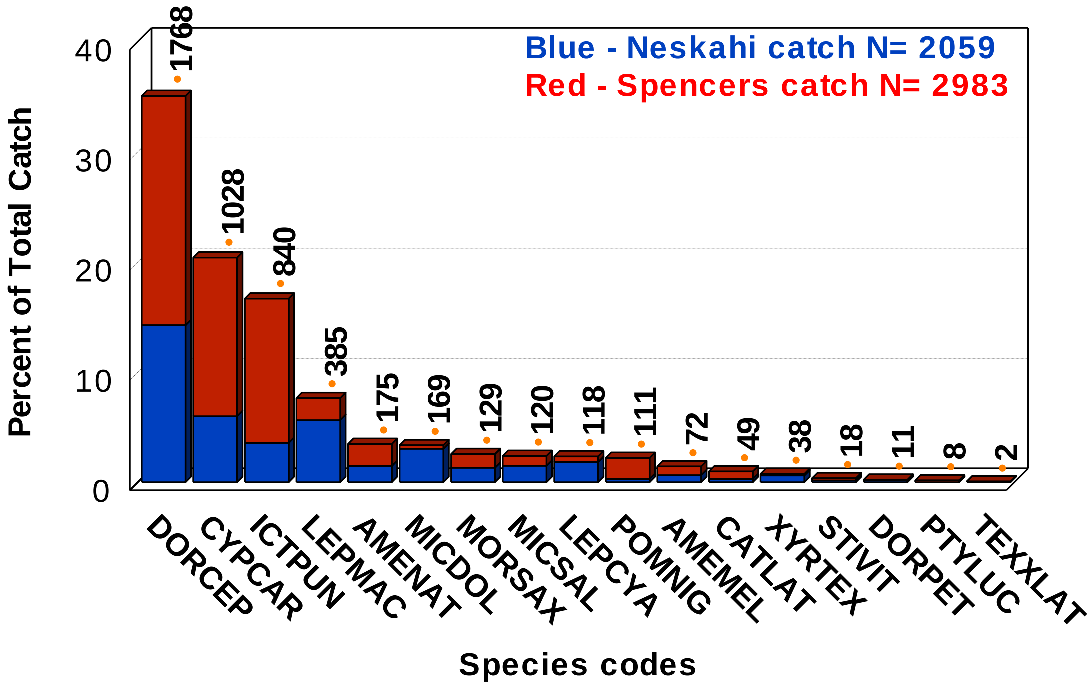

Figure 3. San Juan River arm of Lake Powell trammel net percent of total catch, 2011.

Razorback sucker

In 2011, sampling conducted for this project resulted in the capture of 75 individual razorback sucker in the San Juan River arm of Lake Powell. Razorback sucker captured in 2011 were large, mature adult fish with total lengths ranging from 429-619 mm (Figure 4). Twenty eight (37%) of the 75 razorbacks captured did not have a PIT tag when captured. In 2010, approximately 12% of the razorback sucker captured in the San Juan River upstream of the waterfall did not have a PIT tag. As only one of the 75 razorback sucker captured in 2011 was recaptured during another sampling trip, data from 2011 are insufficient for calculating a reliable population estimate. However, 75 individuals captured in 2011 with just a single recapture may indicate that a large number of razorback sucker occupy the San Juan River arm of Lake Powell.

Of the 47 razorback sucker captured with a PIT tag, 41 were stocked in the San Juan River and three were tagged after being captured in the river in 2007 and 2008. The 41 that were stocked in the river included one each from 1994, 2001, 2002 and 2008; three from 2005; four from 2006; fourteen from 2004; and sixteen from 2007 stocking events. One fish captured with a PIT tag was stocked at Piute Farms (in the lake) in 1995 (Table 3, Appendix 1). Two tags were not found in the SJRIP database.

Table 3. Number of razorback sucker stocked in the San Juan River by year and number of those fish captured in Lake Powell during 2011.

Year	Number Stocked in San Juan (Sizes of Fish Stocked)	2011 Lake Powell Captures
1994	687 (Mean TL = 251 mm; Range = 100-446 mm TL)	1
1995	146 (Mean TL = 424 mm; Range = 397-482 mm TL)	1
1996	237 (Mean TL = 336 mm; Range = 204-434 mm TL)	0
1997	2,883 (Mean TL = 192 mm; Range = 104-412 mm TL)	0
1998	1,275 (Mean TL = 250 mm; Range = 185-470 mm TL)	0
1999	0 N/A	0
2000	1,044 (Mean TL = 214 mm; Range = 111-523 mm TL)	0
2001	688 (Mean TL = 410 mm; Range = 288-560 mm TL)	1
2002	140 (Mean TL = 319 mm; Range = 110-470 mm TL)	1
2003	887 (Mean TL = 327 mm; Range = 100-495 mm TL)	0
2004	2,972 (Mean TL = 353 mm; Range = 225-559 mm TL)	14
2005	1,993 (Mean TL = 355 mm; Range = 223-534 mm TL)	3
2006	13,764 (Mean TL = 265 mm; Range = 68-537 mm TL)	4
2007	16,906 (Mean TL = 268 mm; Range = 110-573 mm TL)	16
2008	4,424 (Mean TL = 297 mm; Range = 225–390 mm TL)	1
2009	8,316 (Mean TL = 375 mm; Range = 136-511 mm TL)	0
2010	28,419 (Mean TL = 391 mm; Range = 222-575mm TL)	0

Forty of the razorback sucker captured had sexually dimorphic traits (tubercles, leathery peduncles, gravidity) 18 were female and 22 were male. Female traits were identified from the 26th of April through the 14th of June. Three of the females were ripe and expressing eggs; one was captured near Spencer's camp (27th of April), and two were captured near Neskahi Canyon (22nd and 23rd of May). Male traits were identified from the 11th of May through the 15th of June. Two of the males were ripe and expressing milt; both were captured near Neskahi Canyon (23rd of May).

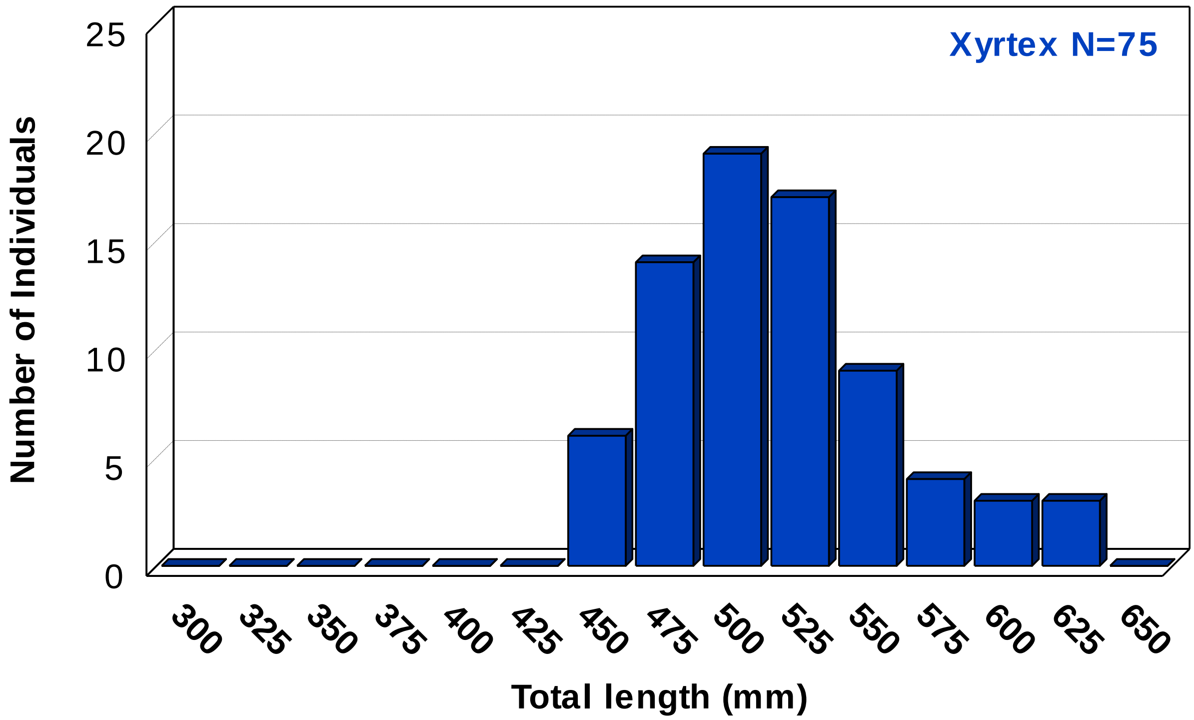

Figure 4. Size structure of razorback sucker captured in the San Juan River arm of Lake Powell, 2011.

Condition—The Me (mass-length regression) equation derived from razorback sucker captured in the San Juan River Basin from April through June in the years 1995 through 2011 (n = 1,823) is

$$\log_{10}Me = ((\log_{10}length)\ 3.0538) + (-5.1221)$$

Mean *Kn* (relative body condition) for razorback sucker captured in the San Juan River arm of Lake Powell from April to June 2011 is similar to razorback sucker captured river wide during the same time period (Figure 5).

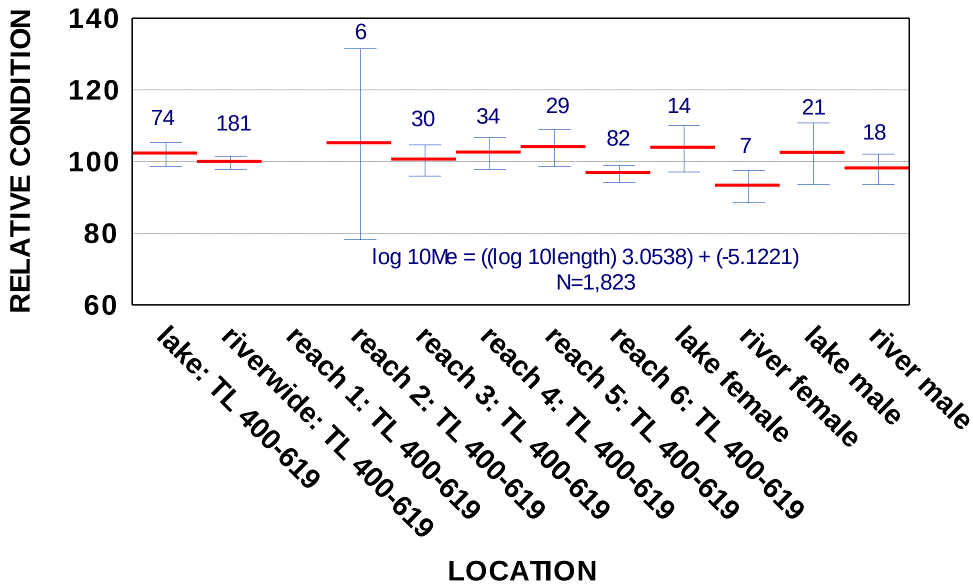

Figure 5. Mean relative body condition (Kn) of razorback sucker captured in the San Juan River basin, April – June 2011. Upper and lower bars represent 95% confidence intervals.

Ages based on fin-ray samples generally agreed with known ages. Twenty-six fin ray samples were collected from razorback sucker and two samples were collected from flannelmouth x razorback (hybrid) sucker in 2011 (Table 4). Nine of the razorback sucker samples were from SJRIP propagation activities and were PIT tag recaptures; these fish had a known age and were a control group. The remaining 17 razorback sucker and two hybrids had no PIT tags and were of an unknown year class. Fin rays from five razorback sucker and one hybrid were unreadable, and all but one of these samples were from fish without PIT tags. Of the 13 razorback sucker samples of an unknown year class, ages ranged from 6-16 years (mean – 9). Of the eight razorback sucker samples of a known year class, actual ages ranged from 9-19 (mean – 12). Only one known aged razorback sucker (19 years) had an incorrect age assigned (15 years) from the fin ray sample. The one hybrid sample aged was nine years.

Table 4. San Juan River arm of Lake Powell, razorback sucker pectoral fin ray ageing results for 2011. Those cells highlighted in blue were a sub-sample of known age fish from SJRIP propagation activities.

# of samples	Species	Recapture	Known Yearclass from PIT tag	Known Age	Year Class from Fin ray ageing	Fin ray Age
1	XYRTEX	No			1995	16
1	XYRTEX	No			1998	13
2	XYRTEX	No			2001	10
3	XYRTEX	No			2002	9
2	XYRTEX	No			2003	8
3	XYRTEX	No			2004	7
1	XYRTEX	No			2005	6
4	XYRTEX	No			Poor sample no age	
1	XYRTEX	Yes	1992	19	1996	15
1	XYRTEX	Yes	1992	19	1992	19
5	XYRTEX	Yes	2001	10	2001	10
1	XYRTEX	Yes	2001	10	Poor sample no age	
1	XYRTEX	Yes	2002	9	2002	9
1	TEX x LAT	No			2002	9
1	TEX x LAT	No			Poor sample no age	

Razorback sucker were captured in both primary sampling locations around: 1. Piute and Neskahi Canyons , and 2. Spencer’s camp in trammel nets. Total trammel net effort expended included 207 sets for 2,660 net hours around Piute and Neskahi Canyons and 108 sets for 539 net hours around Spencer’s camp (Figures6 and 7). The disparity between the two efforts was a result of overnight net sets near Spencer’s being discontinued after the second trip because of incidental Colorado pikeminnow mortality.

Razorback sucker were also captured by boat mounted electrofishing in both locations and near the waterfall at the upstream terminus of the study area (RM -1.1). Total electrofishing effort expended was 29.8 hours near Spencer’s camp and 11.4 + hours (one collection of two razorback sucker didn’t have effort recorded) near Piute and Neskahi Canyons.

In total, there were 80 captures of 75 individual razorback sucker. Five individuals were recaptured, four were handled within the same trip and one was first captured during the second trip and was recaptured during the third trip. Of the 80 captures, 38(47.5%) were the result of trammel netting; 31 were captured near Piute and Neskahi Canyons and seven were captured near Spencer’s camp (Figures 6 and 7). Electrofishing accounted for 42(52.5%) of the 80 captures; 13 were captured near Piute and Neskahi Canyons, nine were captured near Spencer’s camp, and 20 were captured during the fourth trip near the waterfall (Figure 8).

Sonic tagged razorback sucker included seven Uvalde NFH fish stocked an RM -1.1 just below the waterfall, and eight fish tagged from the lake (five from near Spencer's camp, and three from near Neskahi Canyon). Last contact for three of the hatchery fish was near Spencer’s camp; fish #50 the 27th of April, fish #’s 48 and 47 the 10th and 12th of June. Last contact with the other four hatchery fish (#’s 51, 52, 62 and 63) was the day of stocking (9th of March). Last contact with seven of the lake fish implanted with sonic tags was within two to three miles of their capture sites: Spencer’s camp tagged fish #’s 49, 64 and 66 12th of June and fish # 68 the 9th of June; Neskahi Canyon tagged fish # 53 the 20th of

April, fish # 65 (most likely a mort) and fish # 54 the 14th of June. One fish (#67) tagged near Neskahi Canyon was last contacted in western Zahn Bay the 9th of June. Fish #54 was the only fish recaptured during separate trips. 54 was re-sutured and released near Neskahi Canyon and subsequently was contacted two days later near Spencer's camp (a 12 mile movement). As previously noted, last contact with 54 was back near Neskahi Canyon on the 14th of June (Appendix 6).

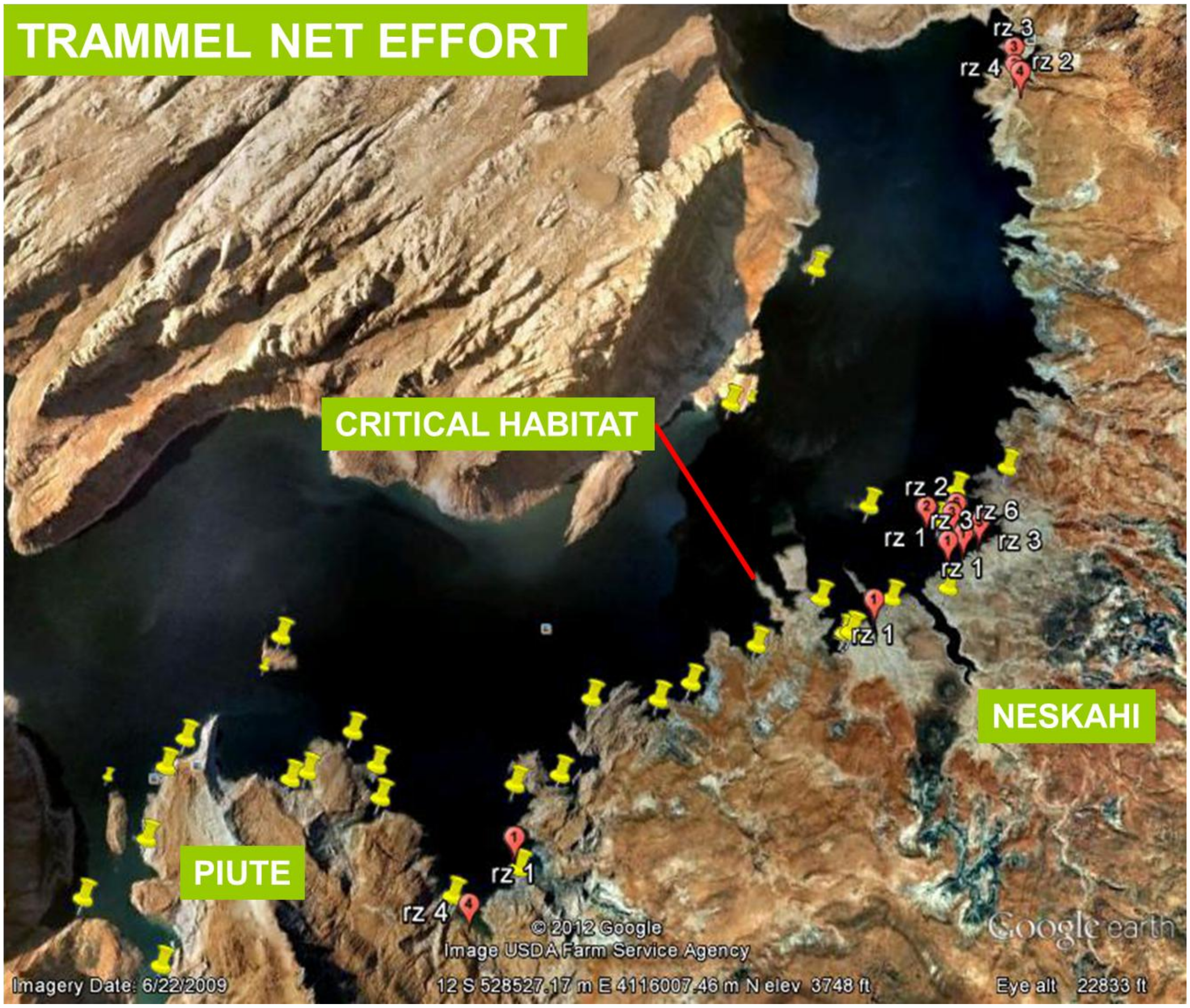

Figure 6. A Google earth image of the San Juan River arm of Lake Powell (RM -29.1 to -34.1) with trammel net set locations (depicted by yellow push pins, large pins are for two or more sets) and razorback sucker capture locations (as depicted by red balloons) near Piute and Neskahi Canyons. The red line approximates the location of the bottom end of critical habitat for razorback sucker in the San Juan River system.

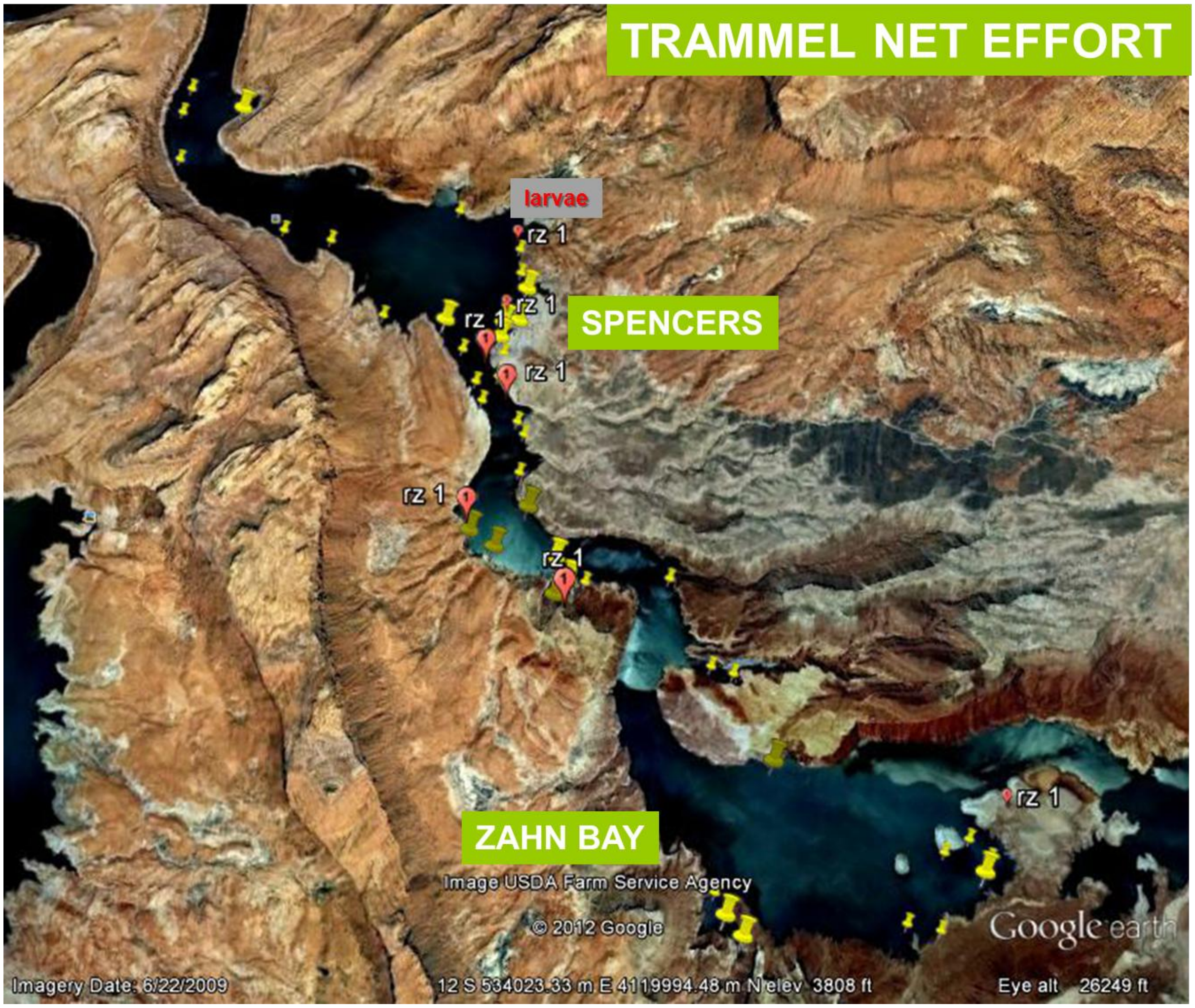

Figure 7. A Google earth image of the San Juan River arm of Lake Powell (RM -13.1 to -18.1) with trammel net set locations (depicted by yellow push pins, large pins are for two or more sets) and razorback sucker capture locations (as depicted by red balloons) near Spencer's camp and Zahn Bay.

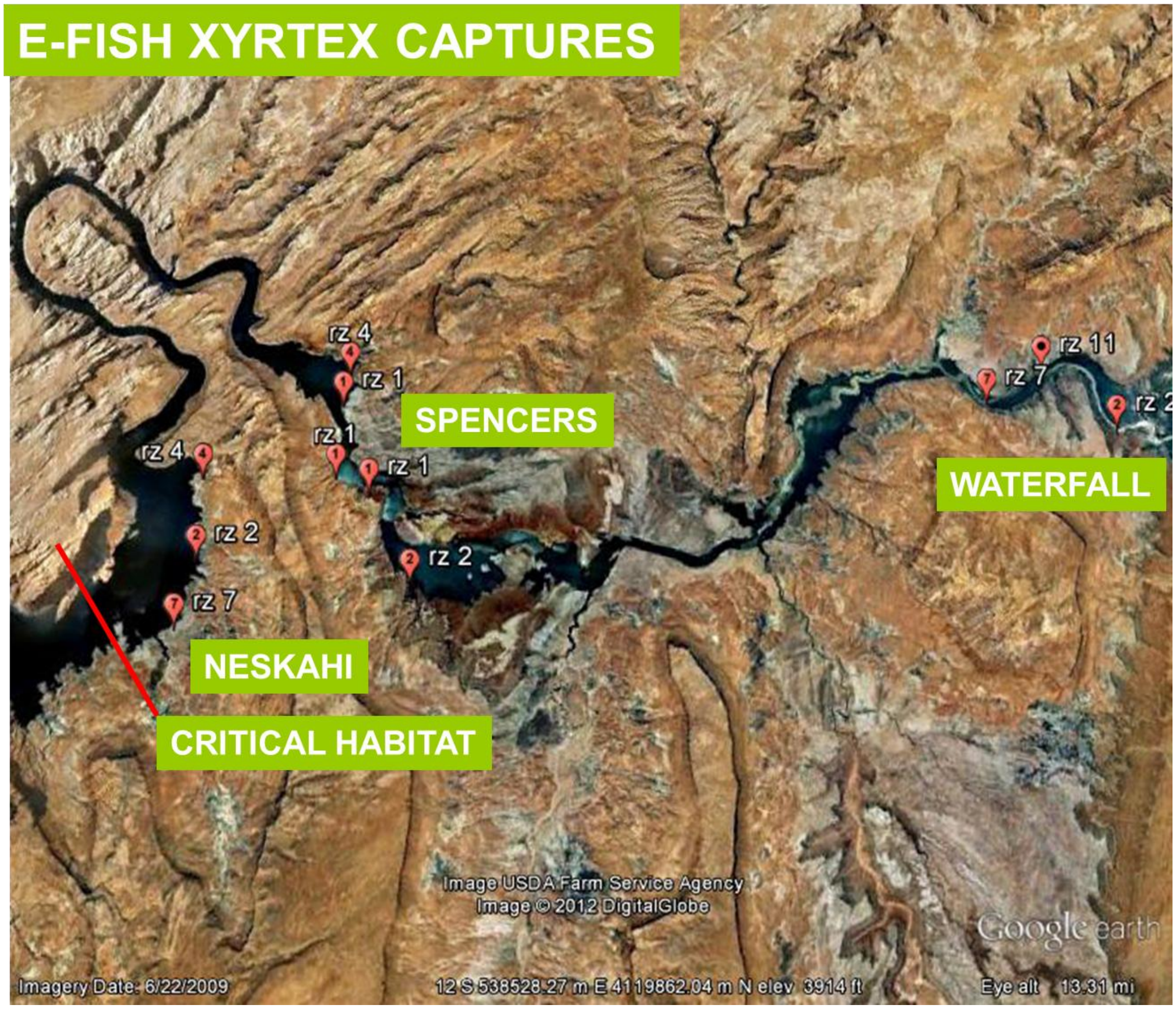

Figure 8. A Google earth image of the entire San Juan River arm of Lake Powell study area with razorback sucker electrofishing capture locations (as depicted by red balloons). The red line approximates the location of the bottom end of critical habitat for razorback sucker in the San Juan River system.

Spencer's camp was not sampled during trip one. For razorback sucker, there were no significant differences ($P > 0.1$) for LN transformed CPE among locations and types of net set (day or night; Figure 9). Comparisons of trammel net LN transformed CPE among locations and trips provided no significant differences (Figure 10). Averaged mean trammel net CPE for the entire study (regardless of trip or location) was 0.016 razorback sucker per net hour in 2011.

LN transformed electrofishing CPE did not vary significantly among locatons or trips (Figure 11). Two razorback sucker were captured with electrofishing near Neskahi Canyon during the fourth trip and the crew neglected to record effort. Inflated LN transformed CPE values with large confidence intervals at the Spencer's camp location during the fourth trip prompted separating the work done near the waterfall from the rest of Spencer's camp work (Figure 11). Averaged mean electrofishing CPE for the entire study (regardless of trip or location) was 1.28 razorback sucker per hour in 2011.

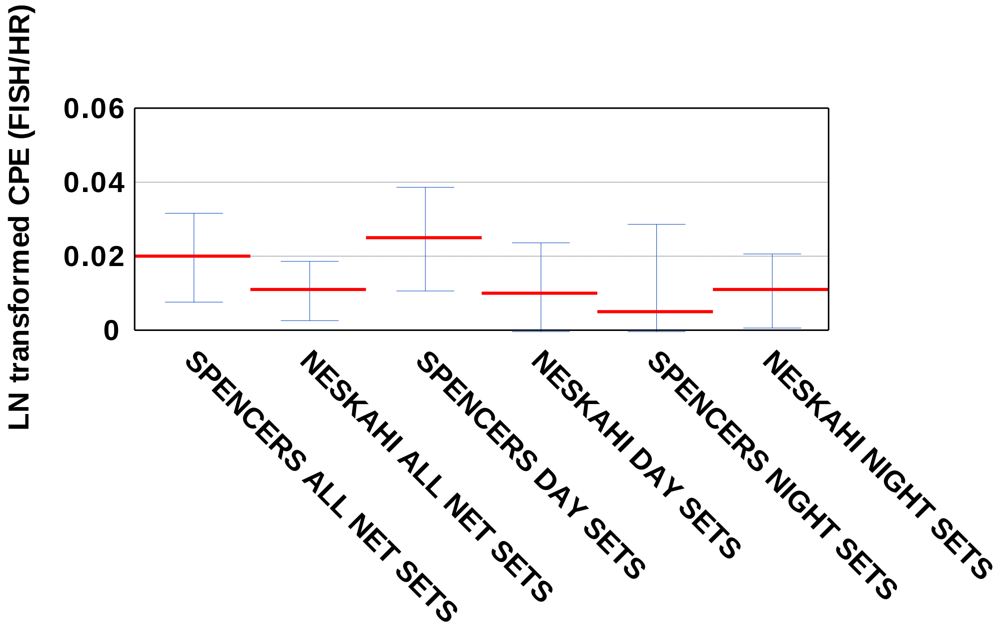

Figure 9. Razorback sucker LN transformed trammel net catch per unit effort (number of fish per net hour, bounded by 95% confidence intervals) comparing sampling locations and day versus night sets.

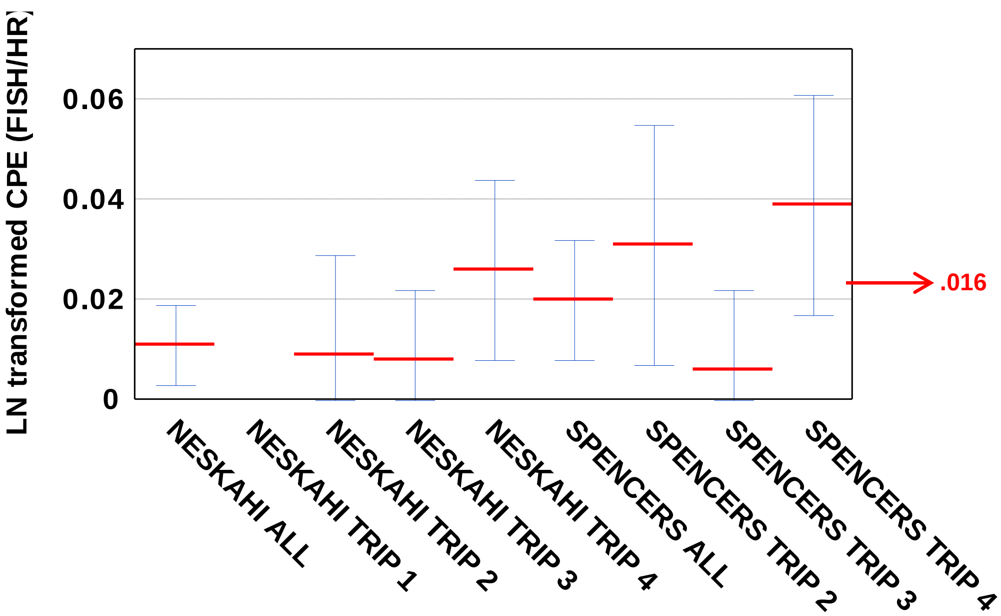

Figure 10. Razorback sucker LN transformed trammel net catch per unit effort (number of fish per net hour, bounded by 95% confidence intervals) comparing sampling locations and trips. Mean catch per unit effort for the entire study (regardless of trip or location) was .016 razorback sucker per net hour.

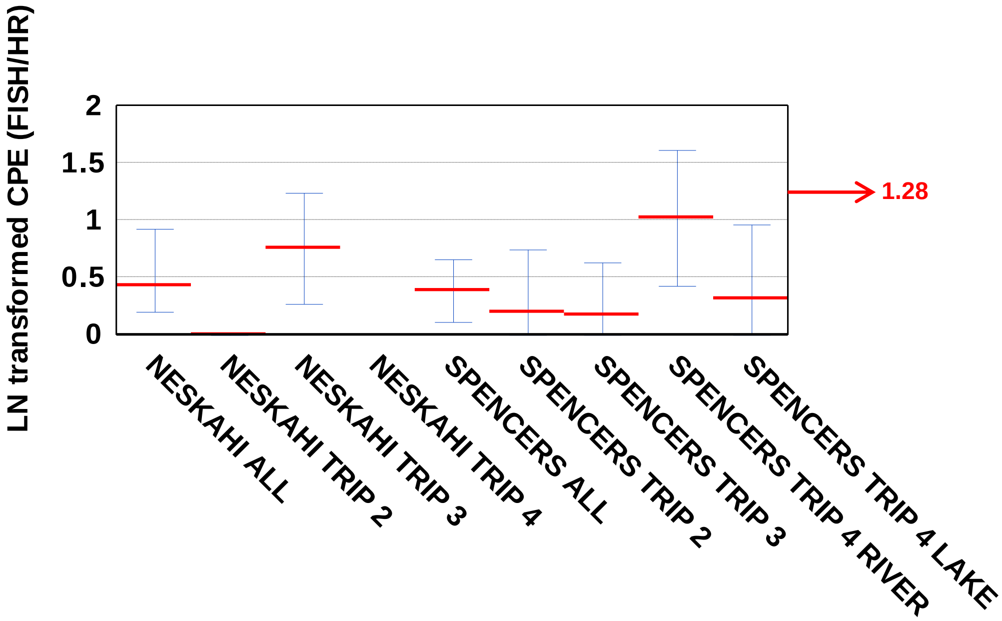

Figure 11. Razorback sucker LN transformed electrofishing mean catch per unit effort (number of fish per electrofishing hour, bounded by 95% confidence intervals) comparing sampling locations and trips. Mean catch per unit effort for the entire study (regardless of trip or location) was 1.28 razorback sucker per hour.

Seven hours of larval sampling (in total from both the Neskahi Canyon and Spencer's camp sample areas) produced one razorback sucker metalarvae (TL 20.7mm) collected on the 9th of June near Spencer's camp at RM -17.1 (Figure 12). Razorback sucker larvae accounted for less than 1% of our total catch. Larval sampling CPE is .143 razorback sucker per hour in 2011. Using Bestgen et al. (2002) back dating hatch calculation for razorback sucker larvae, the metalarvae was hatched approximately 42.3 days prior to capture or on the 27th of April.

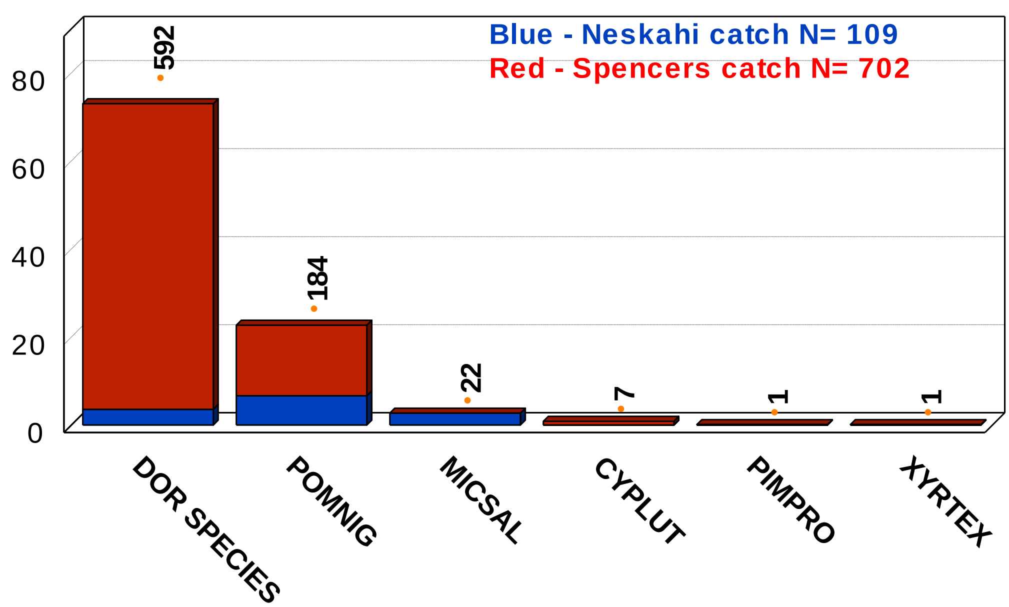

Figure 12. San Juan River arm of Lake Powell larval sampling percent of total catch, 2011.

Colorado pikeminnow

In 2011, sampling conducted for this project resulted in the capture of 24 individual Colorado pikeminnow in the San Juan River arm of Lake Powell. Eight Colorado pikeminnow were captured near Spencer's camp, three were captured in between Noki and Copper Canyons, and 13 were captured one to three miles below the waterfall. No (0) Colorado pikeminnow were captured downstream near Neskahi and Piute Canyons (Appendix 2). Colorado pikeminnow captured in 2011 had total lengths ranging from 228-519 mm with a mean of 327 mm (Figure 13). Five (21%) of the Colorado pikeminnow captured were adults, the remaining 19 (79%) were juveniles.

Twelve (50%) of the 24 Colorado pikeminnow captured did not have a PIT tag when captured (Appendix 2). Of the 12 Colorado pikeminnow captured with a PIT tag, six were stocked in the San Juan River with PIT tags and four were tagged after being captured in the river in 2010. The six that were stocked in the river with PIT tags included one from 2006; three from 2007; and two from 2009 stocking events (Table 3). Two recaptured PIT tags were not found in the SJRIP database; however, (determined by TL) these fish were most likely from the 2009 year class. Of the twelve captured without a PIT tag, it is a reasonable assumption to believe that these fish are the result of the SJRIP propagation program. Determined by total length, seven are most likely from the 2009 year class and five from the 2008 year class. One fish captured without a PIT tag was large enough (TL 458 mm) to confound ageing by TL.

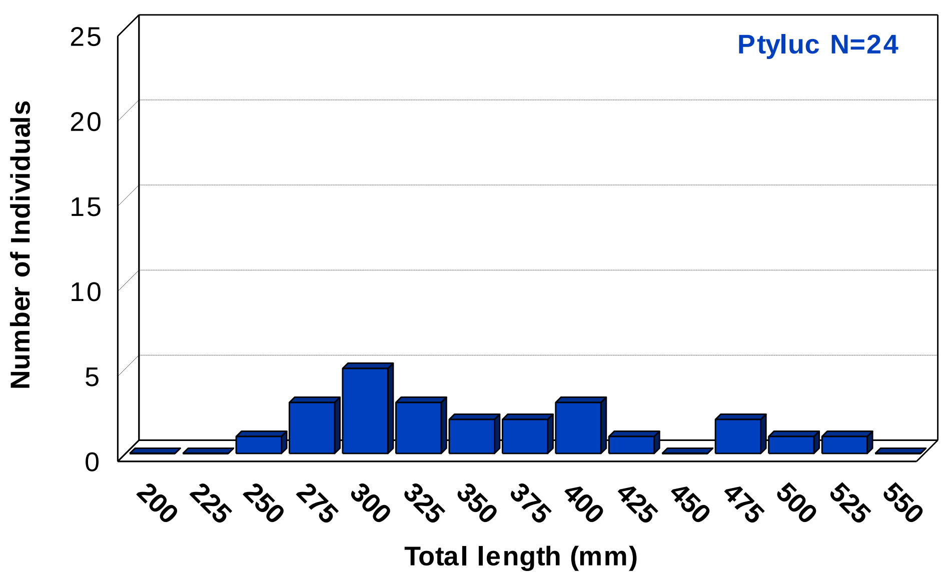

Figure 13. Size structure of Colorado pikeminnow captured in the San Juan River arm of Lake Powell, 2011.

Condition—The Me (mass-length regression) equation derived from Colorado pikeminnow captured in the San Juan River Basin from April through June in the years 1998 through 2011 (n = 2,518) is

$$\log_{10}Me = ((\log_{10}length)\ 3.0444) + (-5.2744)$$

Mean *Kn* (relative body condition) for Colorado pikeminnow captured in the San Juan River arm of Lake Powell from April to June 2011 is similar to Colorado pikeminnow captured river wide during the same time period (Figure 14). As you move upstream through the SJRIP defined geomorphological reaches, mean *Kn* is significantly higher in geomorphic reaches four and six when compared to geomorphic reaches two and three (Figure 14). Both juvenile and adult Colorado pikeminnow were captured; thus, mean *Kn* was compared among location and size class and there were no significant differences (Figure 15).

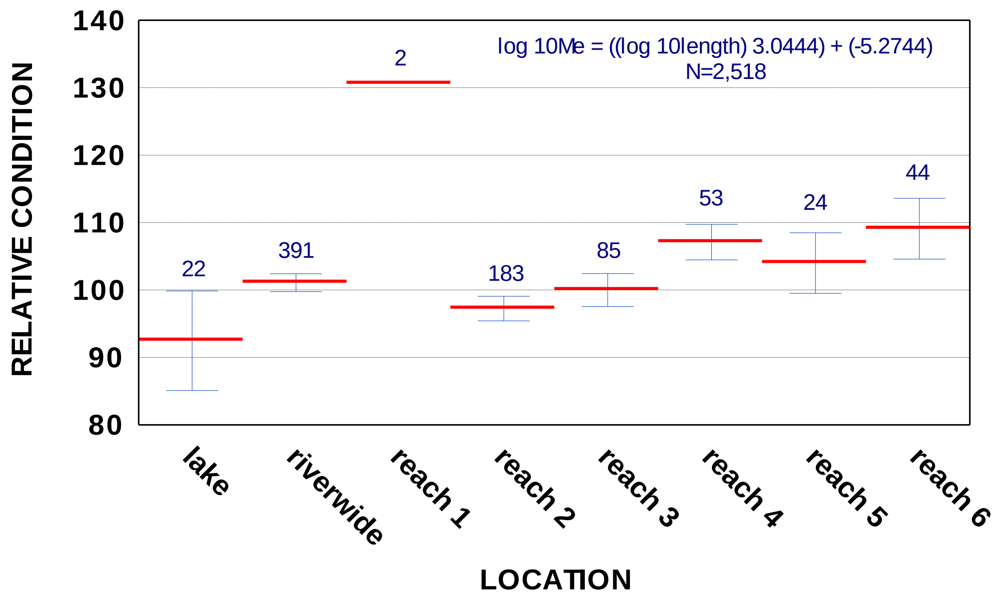

Figure 14. Mean relative body condition (Kn) of Colorado pikeminnow captured in the San Juan River basin, April – June 2011 illustrating (Kn) by capture location. Upper and lower bars represent 95% confidence intervals.

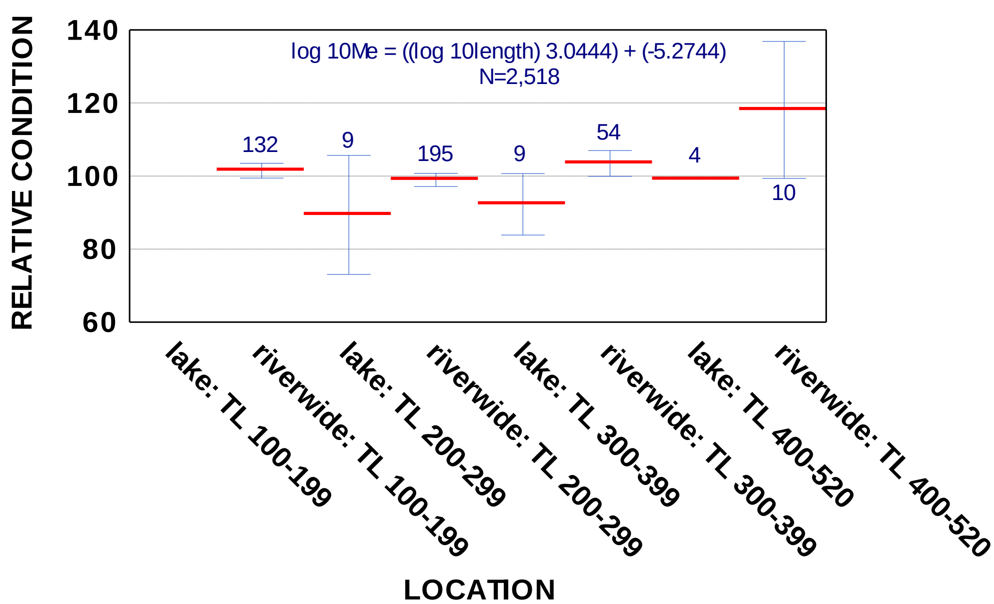

Figure 15. Mean relative body condition (Kn) of Colorado pikeminnow captured in the San Juan River basin, April – June 2011 illustrating (Kn) by capture location and size class. Upper and lower bars represent 95% confidence intervals.

All Colorado pikeminnow were captured around and upstream of Spencer's camp; therefore, LN transformed CPE comparisons among locations (Piute and Neskahi vs. Spencers) were unnecessary. Spencer's camp was not sampled during trip one. For Colorado pikeminnow, there were no significant differences ($P > 0.1$) for LN transformed CPE between trips and types of net set (day or night; Figure 16). Averaged mean trammel net CPE for the entire study (regardless of trip or net set type) was .024 Colorado pikeminnow per net hour in 2011.

Comparisons of Colorado pikeminnnow electrofishing LN transformed CPE among trips was unnecessary considering that all Colorado pikeminnow captured with electrofishing were caught near the waterfall during the fourth trip (Figure 17). Averaged mean electrofishing CPE for the entire study period from near Spencer's camp and upstream to the waterfall was 1.53 Colorado pikeminnow per hour in 2011.

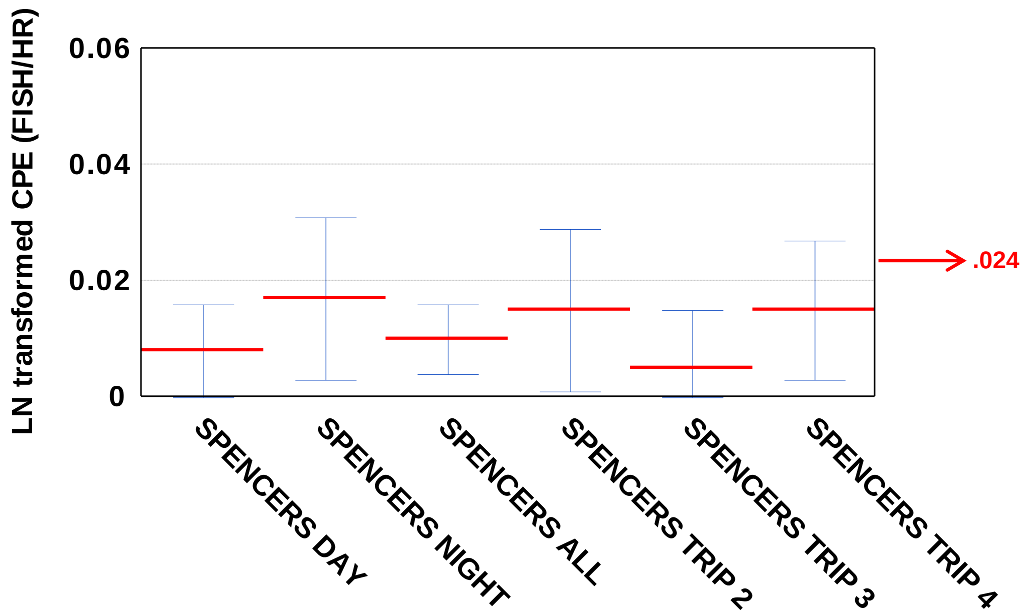

Figure 16. Colorado pikeminnow LN transformed trammel net catch per unit effort (number of fish per net hour, bounded by 95% confidence intervals) comparing day versus night sets and trips. Average catch per unit effort for the entire study (regardless of trip or net set type) was .024 Colorado pikeminnow per net hour.

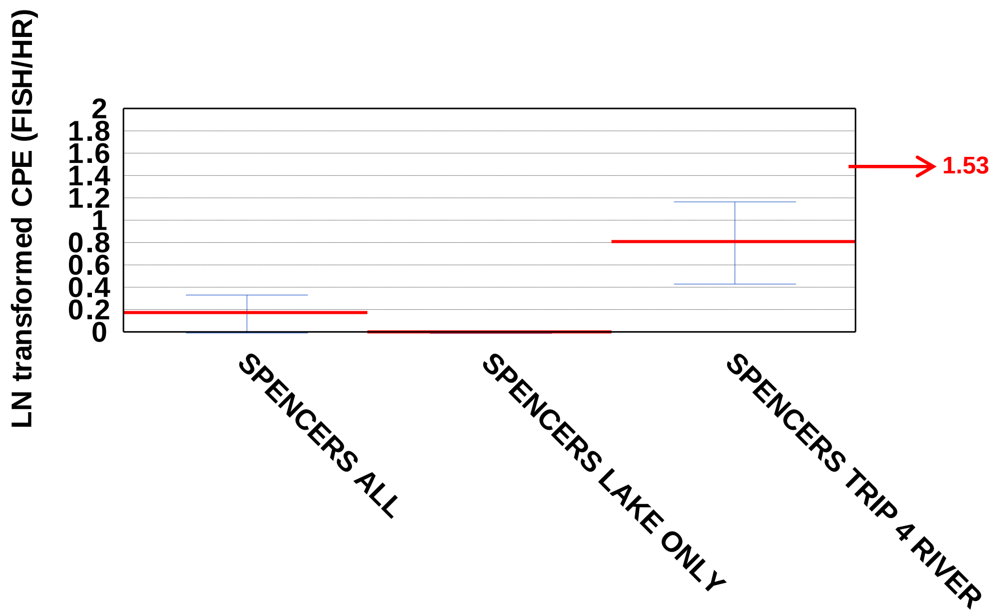

Figure 17. Colorado pikeminnow LN transformed electrofishing catch per unit effort (number of fish per electrofishing hour, bounded by 95% confidence intervals). Mean catch per unit effort for the entire study (from near Spencer's camp and upstream to the waterfall) was 1.53 Colorado pikeminnow per hour.

Flannelmouth sucker

In 2011, sampling conducted for this project resulted in 103 captures of flannelmouth sucker in the San Juan River arm of Lake Powell. Sixteen flannelmouth sucker were captured near Piute and Neskahi Canyons, 41 were captured near Spencer's camp, three were captured in between Noki and Copper Canyons, and 43 were captured one to four miles below the waterfall.

Flannelmouth sucker captured in 2011 had total lengths ranging from 220-510 mm with a mean of 330 mm (Figure 18). Six (6%) of the flannelmouth sucker captured were adults, the remaining 97 (94%) were juveniles.

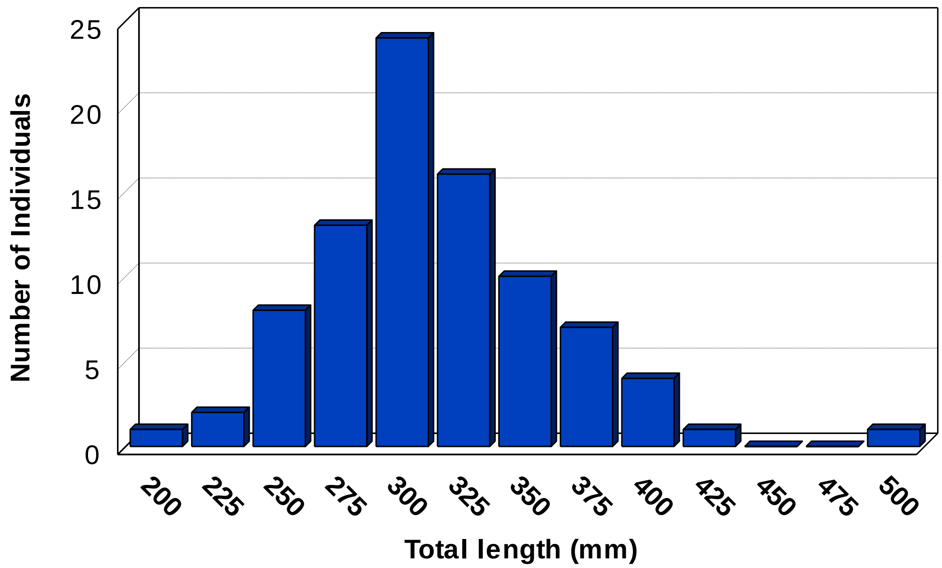

Figure 18. Size structure of Flannelmouth sucker captured in the San Juan River arm of Lake Powell, 2011.

Spencer's camp was not sampled during trip one. For flannelmouth sucker, there were significant differences ($P < 0.1$) in LN transformed trammel net CPE between Spencer's camp and Neskahi; however there were no differences in day sets LN transformed CPE when compared to night sets at either location (Figure 19). LN transformed catch rates of flannelmouth sucker were significantly higher at Spencer's Camp compared to Neskahi Canyon during trip 3. (Figure 20). Averaged mean trammel net CPE for the entire study (regardless of trip or location) was .043 flannelmouth sucker per net hour in 2011.

Comparisons of flannelmouth sucker electrofishing LN transformed CPE among locations and trips provided no significant differences (Figure 21). Inflated mean CPE values with large confidence intervals at the Spencer's camp location during the fourth trip prompted separating the work done near the waterfall from the rest of Spencer's camp work and there was a significant increase ($P < 0.1$) in LN transformed electrofishing CPE in flannelmouth sucker captured in the river near the waterfall when compared to all other trips and locations (Figure 21). Averaged mean electrofishing CPE for the entire study (regardless of trip or location) was 1.62 flannelmouth sucker per hour in 2011.

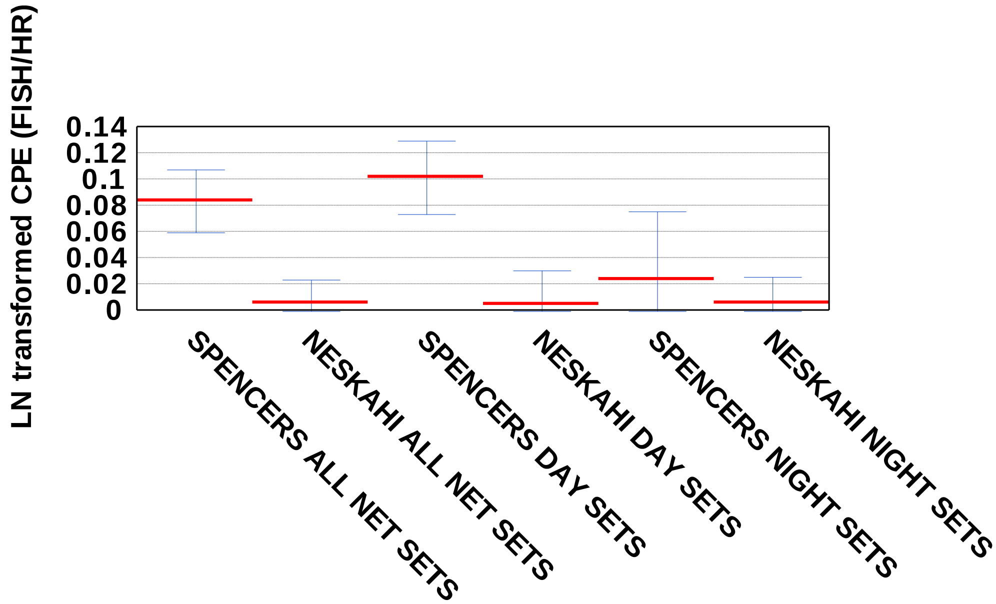

Figure 19. Flannelmouth sucker LN transformed trammel net catch per unit effort (number of fish per net hour, bounded by 95% confidence intervals) comparing sampling locations and day versus night sets.

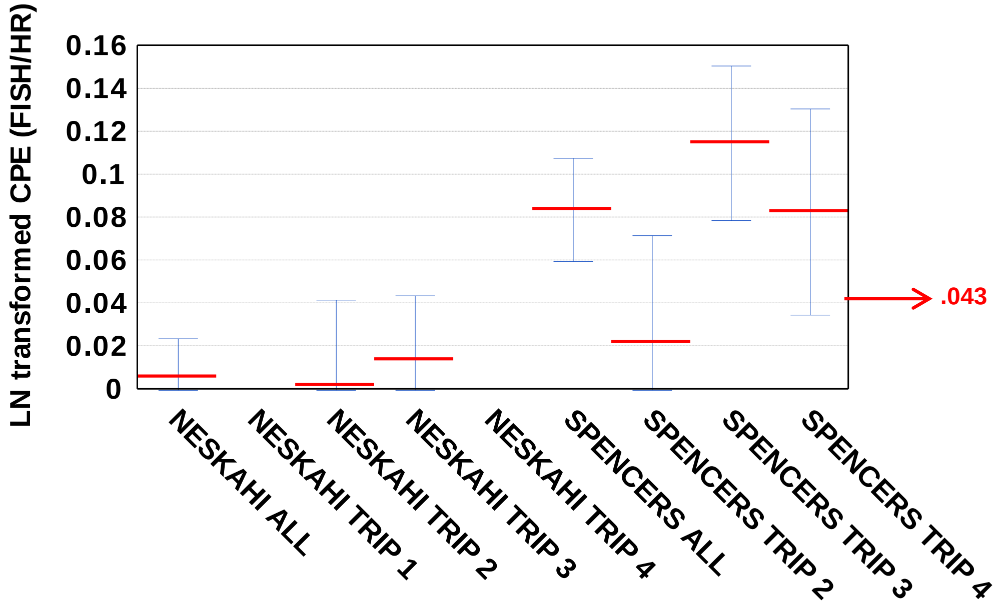

Figure 20. Flannelmouth sucker LN transformed trammel net mean catch per unit effort (number of fish per net hour, bounded by 95% confidence intervals) comparing sampling locations and trips. Mean catch per unit effort for the entire study (regardless of trip or location) was .043 flannelmouth sucker per net hour.

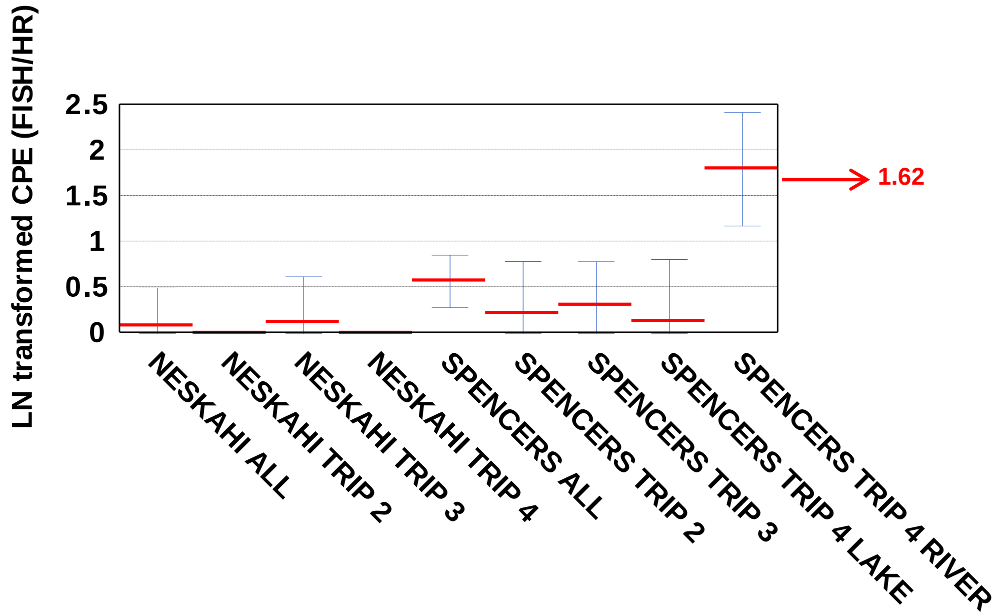

Figure 21. Flannelmouth sucker LN transformed electrofishing mean catch per unit effort (number of fish per electrofishing hour, bounded by 95% confidence intervals). Mean catch per unit effort for the entire study was 1.62 flannelmouth sucker per hour.

Discussion

The first (sample year 2011) intensive multi-life stage razorback sucker survey in the San Juan arm of Lake Powell provided important insights on razorback sucker habitat use, spawning behavior, movement, and native and non-native fish composition. Sonic telemetry, trammel netting, electrofishing, and larval sampling provided information on the importance of the 33 LM below the waterfall, and in particular the importance of Spencer's Camp and Neskahi Canyon to spawning fish. Twenty eight (37% of total catch) razorback sucker were without a PIT tag suggesting potential recruitment. Fin ray aging data on 13 of these fish provided insight on potential successful years (1992-2005) for wild recruitment. Incidental to the original objectives of the study was the catch of Colorado pikeminnow and flannelmouth sucker. Albeit, native fishes represent a very small proportion of the trammel net total catch (1.9%), there is a detectable native fish community present in the San Juan arm of Lake Powell.

Sonic Telemetry

Sonic telemetered razorback sucker provided important insights on movement within the 33 lake miles sampled during the 2011 study period. While the original seven Uvalde NFH sonic tagged fish were unable to move into our sampling locations (due to a sandbar reaching across the lake) until late in the second trip, when two were located they grouped with fish we were already catching near Spencer's camp and would have directed our adult sampling to locations with other razorback sucker. Seven of the eight razorback sucker sonic tagged in the lake did direct the adult sampling to other areas where razorback sucker were captured and to one of the biggest aggregations of spawning fish located near Neskahi Canyon. Additionally, the movement of one individual tagged near Piute Canyon to Spencer's camp and back again provides evidence of large movements and mixing during the spawning season. Considering the highly variable lake elevations and sedimentation it is anticipated that spawning locations will vary in future years and adds impetus to the use of sonic telemetry in future Lake Powell razorback sucker work.

Adult and Larval Sampling

As a first year effort, many assumptions were made to try to schedule work in accordance to suspected razorback sucker spawning time. As may be expected, there is a big difference in water temperature during the spring between the San Juan River inflow (warmer; Spencer's camp and above) and the lacustrine sampling site near the end of critical habitat (cooler; Neskahi and Piute Canyons). Therefore, spawning times were nearly a month apart (determined by handling ripe individuals). Our sampling period was ideal for handling adults in both areas; however, the earliest trips were less productive as fish were probably in deeper water beyond our sampling techniques and less active. A larger aggregate of spawning fish was handled near Neskahi Canyon, while fish expressing sexually dimorphic traits near Spencer's camp were captured in smaller numbers covering a larger geographic area. A multi-year study will allow for CPE comparisons and may shed light on abundance of razorback sucker in the San Juan arm of Lake Powell.

Relative condition of these individuals (n=74; one fish lacked a weight measurement) when compared to individuals (n=181) captured in the river, during the same time period, suggest that the fish found in the lake are in good condition. In fact, the rare event that occurred the 1st of August, when the waterfall was inundated allowing fish passage proved these fish were capable of large upstream movements. Four fish captured in the San Juan arm of Lake Powell were handled again in the river traveling 47-180 miles upstream in 57-107 days (SJRIP database).

While we are unable to conclusively say that some of the 28 fish captured without PIT tags were wild recruits, there is evidence to suggest the possibility of a few of them being wild. According to fin aging results, one fish was from a 1995 year class and no fish were stocked in the San Juan River from that year class. Another fish was aged to be from a 1998 year class and only ten fish from that year class were stocked into the river; thus, the odds that we handled one of these fish and it slipped a tag seems unlikely. The higher percent of untagged fish in the lake compared to the river (37% versus 14%) suggests that some might have been wild recruits. Promising results from a trial experiment on the middle San Juan River to identify natal origins of razorback sucker with isotopic signatures collected from razorback sucker scales, and a plan to collect scales in Lake Powell, should provide more clarity on wild recruitment in the 2012 data (Steve Platania, pers. comm.).

Fourty-two of the razorback sucker captured were the result of the SJRIP propagation activities. When comparing the percentage of stocked fish found in the lake's catch to that of the river's catch, an equal representation of each stocking was found in each location through the 2007 stocking event (Appendix 5). The 2008 through 2010 stockings may not be available for capture in the lake, yet. This provides strong evidence that fish stocked in the river are not disproportionately being swept down to the lake, making them unavailable to the river population.

While the predicted spawning season and associated field season was ideal for catching adults, it may have left us short on time to collect larvae. One confirmed a larva captured near Spencer's camp provides evidence of successful spawning in the lake. Because of the one month separation in spawning times when comparing Spencer's (earlier) and Neskahi (later) the larvae potentially produced at Neskahi may not have been available to catch during our sample season. Very little effort was devoted to larval sampling in 2011 and more is anticipated to occur in 2012.

Conclusions and Recommendations

A recent finding of razorback sucker recruitment in wetlands on the Green River (Bestgen and Webber, 2011) and the ongoing work and findings of natural recruitment and a self-sustaining population of razorback sucker on Lake Mead (Albrecht et al. 2008b) indicates that non-moving (slack) water may be very important for the species to successfully recruit. Considering limited slack water or back water habitats on the San Juan River, Lake Powell may be essential to recruitment and potential recovery of the species in this basin. One year's worth of sampling answered some critical questions for the program in regards to presence of the species in the lake, distribution of the species, if they are spawning, the ages and size structure of the fish available to our sampling techniques, will the fish return to the river if given the opportunity, and the composition of the fish community. However, many more questions need to be answered including:

1. Are the fish recruiting to the adult stage?
2. Is there successful reproduction occurring outside of critical habitat?
3. In the face of ever changing lake elevations, will the species continue to persist in the lake?
4. Will it be possible to estimate abundance?
5. Is there mixing of propagated fish from the UCRRP and the SJRIP?

In light of all these new questions, we recommend continued work on the San Juan arm of Lake Powell placing an emphasis on sampling downstream of critical habitat and an increased effort collecting larval fish.

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Affiliation of Individuals Cited as Personal Communication

Steve Platania. American Southwest Ichthyological Researcher's L.L.C.

Appendices

Appendix 1. 2011 San Juan River arm of Lake Powell razorback sucker stock and capture histories.

Capture Information from Lake Powell Project									Additional Capture Information					
Capture Date	Capture Location Lake Mile / (River Mile)	Gear Type	TL	WT	400 kHz PIT Tag Number	134 kHz PIT Tag Number	134 kHz PIT Tag Recapture	Sex	Contact Type	Stock/Tag Date	River Mile	TL	Year Class	Age
4/13/2011	38.4(-17.1)	EL	521			3D9257C69BF6B[c]	YES	I	STOCK	7/27/2007	158.6	273	2006	
4/14/2011	39.7(-15.8)	EL	449	1090		3D91C2D572324[c]	NO	I						
4/14/2011	39.4(-16.1)	TN	485	1015		3D91C2D995B32[c]	NO	I						
4/19/2011	23.0(-32.5)	TN	490	1042	4365351723	3D91C2C2D7689[b,c]	NO	I	STOCK	8/23/2004	158.6	296	2002	
4/19/2011	23.0(-32.5)	TN	491	1590		3D9257C6BA6E3[c]	YES	I	STOCK	8/1/2007	158.6	276	2006	
4/20/2011	23.0(-32.5)	TN	485	1490		3D91C2D996516	NO	I						
4/20/2011	22.9(-32.6)	TN	481	1240		3D9257C6BAC7E[c]	YES	I	STOCK	4/23/2007	158.6	430	NA	
4/21/2011	23.0(-32.5)	TN	577	2200		3D91C2D99C889	NO	I						
4/26/2011	39.7(-15.8)	TN	619	2300		3D91C2D19DC21[c]	NO	F					2001	10
4/27/2011	38.4(-17.1)	TN	478	1320		3D91C2D585250[c]	NO	F						
4/27/2011	39.4(-16.1)	EL	525	1400	426A362A77	3D91C2D999F38	NO	F	STOCK	4/15/2004	158.6	346	2001	
5/11/2011	24.5(-31.0)	TN	510	1540		3D91BF1A0265B	YES	F	STOCK	5/19/2005	158.6	316	2002	
5/11/2011	24.5(-31.0)	EL	510	1250		3D9257C6B9D41[a]	YES	M	STOCK	6/28/2007	158.6	462	2003	
5/12/2011	24.5(-31.0)	EL	536	1750	5324573949	3D91C2D999B26	NO	I	STOCK	4/18/2007	158.6	389	2006	
5/15/2011	24.5(-31.0)	TN	557	1760		3D91C2D584B00	NO	M						
5/18/2011	41.2(-14.3)	EL	458	1030	441B03143B*	3D91C2D998377	NO	I	CAPTURE	9/2/2011	130.0	461		
5/19/2011	38.7(-16.8)	TN	451	900		3D9257C691E99	YES	I	STOCK	6/6/2007	158.6	270	NA	
									CAPTURE	9/21/2011	166.6	466		
5/19/2011	41.2(-14.3)	EL	466	970		3D9257C69D05E	YES	I	STOCK	6/5/2007	158.6	256	NA	
5/22/2011	24.5(-31.0)	TN	495	1250		3D91BF1D86C72	YES	M	STOCK	5/18/2005	158.6	358	2002	
5/22/2011	24.5(-31.0)	EL	560		4504356E5E	3D91C2D99B8FC	NO	F	STOCK	7/13/2004	158.6	386	2001	
5/22/2011	24.5(-31.0)	EL	512	1900	53256E4B25	3D91C2D99C89C	NO	M	STOCK	4/18/2007	158.6	389	2006	

Capture Information from Lake Powell Project									Additional Capture Information					
Capture Date	**Capture Location Lake Mile / (River Mile)**	**Gear Type**	**TL**	**WT**	**400 kHz PIT Tag Number**	**134 kHz PIT Tag Number**	**134 kHz PIT Tag Recapture**	**Sex**	**Contact Type**	**Stock/Tag Date**	**River Mile**	**TL**	**Year Class**	**Age**
5/22/2011	24.7(-30.8)	TN	532	1600		3D9257C69C541	YES	F						
5/22/2011	24.5(-31.0)	EL	487	1700		3D9257C6B7A54	YES	M	STOCK	8/20/2007	158.6	246	2006	
5/23/2011	26.1(-29.4)	EL	524	1800		3D91C2D997683	NO	M					2002	9
5/23/2011	26.1(-29.4)	EL	492	1250	4269785742	3D91C2D99A8B7	NO	M	STOCK	4/14/2004	158.6	332	2001	
5/23/2011	24.5(-31.0)	TN	503	1350		3D91C2D99CB24	NO	I						
5/23/2011	24.5(-31.0)	TN	530	1850		3D9257C69BA9A	YES	I	STOCK	8/14/2007	158.6	265	2006	
5/23/2011	26.1(-29.4)	EL	517	1550		3D9257C6ACC3E	YES	F	STOCK	6/13/2007	158.6	455	NA	
5/24/2011	26.0(-29.5)	TN	530	1450	4364441B15	3D91C2D584900	NO	M	STOCK	8/24/2004	158.6	330	2002	
5/24/2011	26.1(-29.4)	EL	495	1495	426A2B4939	3D91C2D592A16	NO	I	STOCK	4/13/2004	158.6	345	2001	
5/25/2011	26.0(-29.5)	TN	511	1400		3D91C2D580F53	NO	I					2004	7
6/7/2011	41.7(-13.8)	TN	516	1310	4240070F2C	3D91C2D588E38	NO	I	STOCK	10/30/2001	158.6	375	2000	
6/7/2011	39.0(-16.5)	TN	464	1090		3D9257C6BB8B3	YES	I	STOCK	6/5/2007	158.6	243	NA	
6/8/2011	50.9(-4.6)	EL	451	750		3D91C2D56FF7D	NO	M						
6/8/2011	50.9(-4.6)	EL	498	1340	522A1A3277	3D91C2D5728CF	NO	M	STOCK	4/22/2002	158.6	285	2001	
6/8/2011	50.9(-4.6)	EL	524	1320		3D91C2D58BFBD	NO	M	CAPTURE	8/4/2011	42.5	520		
6/8/2011	50.9(-4.6)	EL	536	1700	425C1E1A34	3D91C2D58C54C	NO	M	STOCK	4/14/2004	158.6	315	2001	
6/8/2011	50.9(-4.6)	EL	444	900		3D91C2D58F36B	NO	M						
6/8/2011	50.9(-4.6)	EL	477	890		3D9257C6B1552	YES	M	STOCK	6/11/2007	158.6	221	NA	
6/8/2011	50.9(-4.6)	EL	440	840		3D9257C6B25F1	YES	I	STOCK	5/22/2007	158.6	191	NA	
6/9/2011	38.2(-17.3)	EL	541	1800	447B28395E	3D91C2D591DFF	NO	I	STOCK	7/13/2004	158.6	395	2001	
6/10/2011	38.2(-17.3)	EL	448	1080		3D91C2D58EC8B	NO	I						
6/10/2011	38.2(-17.3)	EL	472	990	426A406E65	3D91C2D592613	NO	I	STOCK	4/13/2004	158.6	343	2001	
6/10/2011	38.2(-17.3)	EL	449	890		3D9257C6B2CB5	YES	I	STOCK	11/13/2008	166.6	300	2006	
6/10/2011	38.1(-17.4)	TN	481	1080		3D9257C6B81FF	YES	I	TAG	4/9/2008	148.0	430		
6/12/2011	53.0(-2.5)	EL	473	1100		3D91BF1CD4AD8	YES	I	STOCK	8/30/2005	158.6	292	2004	
6/12/2011	51.5(-4.0)	EL	469	1000		3D91C2D580B13	NO	I					2005	6
6/12/2011	51.5(-4.0)	EL	462	800		3D91C2D588325	NO	M						
6/12/2011	51.5(-4.0)	EL	491	1200		3D91C2D58C081	NO	I					2004	7
6/12/2011	51.5(-4.0)	EL	485	1100		3D91C2D58EA62	NO	M					2003	8

Capture Information from Lake Powell Project									Additional Capture Information					
Capture Date	Capture Location Lake Mile / (River Mile)	Gear Type	TL	WT	400 kHz PIT Tag Number	134 kHz PIT Tag Number	134 kHz PIT Tag Recapture	Sex	Contact Type	Stock/Tag Date	River Mile	TL	Year Class	Age
6/12/2011	51.5(-4.0)	EL	490	1100		3D91C2D58FACE	NO	I					2004	7
6/12/2011	53.0(-2.5)	EL	522	1400		3D91C2D5934F0	NO	I					2003	8
6/12/2011	51.5(-4.0)	EL	473	900		3D9257C690DF8	YES	I	TAG	6/27/2007	38.9	200		
6/12/2011	51.5(-4.0)	EL	489	1100		3D9257C69CE1F	YES	I	STOCK	8/14/2006	158.6	253	NA	
6/12/2011	51.5(-4.0)	EL	462	1000		3D9257C6ACB06	YES	M	STOCK	5/16/2007	158.6	305	NA	
6/12/2011	51.5(-4.0)	EL	429	1000		3D9257C6B2A17	YES	I	STOCK	5/15/2007	158.6	239	NA	
6/12/2011	51.5(-4.0)	EL	460	1300		3D9257C6BA814	YES	I	STOCK	8/15/2006	158.6	243	2005	
6/12/2011	51.5(-4.0)	EL	452	1050		3D9257C6BC90E	YES	I	TAG	10/3/2007	101.0	290		
6/13/2011	24.6(-30.9)	TN	498	1520		3D91BF18E66D0	YES	I	STOCK	6/27/2006	158.6	420	2002	
						3D91BF18E66D0		I	CAPTURE	8/17/2011	30.0	503		
						3D91BF18E66D0		I	CAPTURE	9/6/2011	83.0	505		
6/13/2011	24.4(-31.1)	TN	510	1750	4269033A79	3D91C2D571C3F	NO	F	STOCK	4/14/2004	158.6	300	2001	
6/13/2011	24.6(-30.9)	TN	510	1410		3D91C2D599BC1[a]	NO	F					1998	13
6/13/2011	24.6(-30.9)	TN	530	1590		3D91C2D59C551	NO	F					2002	9
6/13/2011	26.1(-29.4)	TN	486	1400		3D91C2D59D24D	NO	F					2002	9
6/13/2011	24.6(-30.9)	TN	519	1320	44737D6100	3D91C2D5A6618	NO	F	STOCK	7/13/2004	158.6	340	2001	
6/13/2011	26.1(-29.4)	TN	546	2140	1F435D1C25	3D91C2D5A66CE	NO	M	STOCK	11/18/1994	117.5	422	1992	
						3D91C2D5A66CE		M	CAPTURE	5/14/1995	82.0	422		
						3D91C2D5A66CE		M	CAPTURE	4/16/1999	100.2	509		
6/13/2011	26.1(-29.4)	TN	525	1840	1F40171674	3D91C2D5A6DD6	NO	M	STOCK	8/15/1995	0.0	389	1992	
6/13/2011	26.1(-29.4)	TN	597	2460		3D91C2D5AA0AB	NO	F					2001	10
6/13/2011	24.6(-30.9)	TN	465	1000	425C524158	3D91C2D5AC99F	NO	M	STOCK	4/13/2004	158.6	325	2001	
6/13/2011	26.1(-29.4)	TN	517	1645		3D9257C69B689[a]	YES	F	STOCK	7/27/2006	158.6	432	2001	
6/14/2011	25.4(-30.1)	EL	605	2100		3D91C2D58BC8E	NO	F					1995	16
6/14/2011	24.6(-30.9)	TN	557	1860	42692B492A	3D91C2D59C43B	NO	I	STOCK	4/13/2004	158.6	332	2001	
6/14/2011	24.5(-31.0)	TN	536	1690	447D763F6A	3D91C2D5A0492	NO	F	STOCK	7/13/2004	158.6	385	2001	
6/14/2011	24.6(-30.9)	TN	605	2080		3D91C2D5A059D	NO	I						
6/15/2011	24.6(-30.9)	TN	570	2140			NO	M						
6/15/2011	26.1(-29.4)	TN						I						

Capture Information from Lake Powell Project									Additional Capture Information					
Capture Date	**Capture Location Lake Mile / (River Mile)**	**Gear Type**	**TL**	**WT**	**400 kHz PIT Tag Number**	**134 kHz PIT Tag Number**	**134 kHz PIT Tag Recapture**	**Sex**	**Contact Type**	**Stock/Tag Date**	**River Mile**	**TL**	**Year Class**	**Age**
Razorback Sucker / Flannelmouth Sucker Hybrids														
6/13/2011	24.6(-30.9)	TN	511	1300		3D91C2D58F764[a]	YES	I					2002	9
6/14/2011	24.6(-30.9)	TN	516	1400		3D91C2D5A687C	NO	I						
[a] Fish captured twice during a single sampling trip in Lake Powell														
[b] Fish captured during two separate sampling trips in Lake Powell														
[c] Fish sonic tagged														
*** Fish captured with a PIT tag, but no record of the fish being tagged was found in the database.**														

Appendix 2. 2011 San Juan River arm of Lake Powell Colorado pikeminnow stock and capture histories.

2011 CAPTURE DATA FROM LAKE POWELL PROJECT							STOCKING AND CAPTURE DATA FROM SAN JUAN RIVER					
Capture Date	**Lake Mile / (River Mile) of Capture**	**Gear**	**TL**	**SL**	**WT**	**134 Khz PIT#**	**Contact Type**	**Stock/Tag Date**	**Stock/Tag RM**	**Stock / Tag TL**	**Year Class**	
4/15/2011	38.1(-17.4)	TN	484	409	985	3D9257C698466	STOCK	7/20/2006	180.2	NA	2004	
4/15/2011	39.4(-16.1)	TN	470	395	710	3D9257C69EBD5	STOCK	4/18/2007	134.9	NA	2006	
4/15/2011	39.8(-15.7)	TN	276	235	170	3D91C2D1651A2*						
4/15/2011	39.8(-15.7)	TN	386	315	315	3D91C2D996879						
4/25/2011	39.4(-16.1)	TN	391	320	400	3D91C2C43ABF6	STOCK	3/17/2009	133.7	NA	2006	
4/26/2011	37.3(-18.2)	TN	308	250	190							
5/18/2011	38.4(-17.1)	TN	366	310	365	3D91C2C40AFC7	STOCK	3/17/2009	133.7	NA	2006	
6/8/2011	50.9(-4.6)	EL	272	224	150	3D91C2C2D895A*						
6/8/2011	50.9(-4.6)	EL	365	310	345	3D91C2D5480AE						
6/8/2011	50.9(-4.6)	EL	458	390	535	3D91C2D58187B						
6/8/2011	50.9(-4.6)	EL	323	270	190	3D91C2D581915						
6/8/2011	50.9(-4.6)	EL	285	238	138	3D91C2D58C79C						
6/8/2011	50.9(-4.6)	EL	298	250	153	3D91C2D58E907						
6/8/2011	50.9(-4.6)	EL	228	190	80	3D91C2D591DE3						
6/8/2011	50.9(-4.6)	EL	285	237	139	3D91C2D59C590	TAG	9/9/2010	124	258	2008	
6/8/2011	50.9(-4.6)	EL	261	217	118	3D91C2D59D1D8	TAG	9/10/2010	121.0	230	2009	
6/8/2011	50.9(-4.6)	EL	309	254	155	3D91C2D59D2CD	TAG	9/9/2010	128.0	288	2008	
6/8/2011	50.9(-4.6)	EL	332	280	251	3D9257C697AA8	TAG	3/14/2010	33.7	199	2008	
6/9/2011	41.8(-13.7)	TN	423	349		3D9257C6B9732	STOCK	10/3/2007	134.9	NA	2006	
6/9/2011	46.3(-9.2)	EL	389	327	390	3D91C2D43B16C						
6/9/2011	46.3(-9.2)	EL	349	285	275	3D91C2D5A69E4						
6/9/2011	46.3(-9.2)	EL	519	440	940	3D9257C69DD39	STOCK	4/18/2007	134.9	NA	2006	
6/12/2011	53.0(-2.5)	EL	265	210	100	3D91C2D571A41						
6/12/2011	53.0(-2.5)	EL	285	235	70	3D91C2D58F6CE						

*** Fish captured with a PIT tag, but no record of the fish being tagged was found in the database.**

Appendix 3. All known collections of razorback sucker from the San Juan River arm of Lake Powell after stocking began in the riverine portion of the San Juan River (i.e., March 1994).

Collection Date	Collection Site	Number Of Fish	Gear	Agency & (Collector)	Pit Tag Number	TL (mm)	Stocking Date & (RM Stocked At)	Year-Class
03/16/1995	RM -8.5	1	Trammel Net	NPS	1F43686353	427	10/27/1994 (79.6)	1992
07/13/1999	RM 2.0	1	Trammel Net	USGS – Denver (Gordon Mueller)	5220551C28	489	Unknown	?
08/17/1999	RM 1.1	1	Trammel Net	USGS – Denver (Gordon Mueller)	7F7B1B5402	467	04/22/1998 (158.6)	1993
10/05/1999	RM 1.1 & RM 0.7	2	Trammel Net	USGS – Denver (Gordon Mueller)	1F75115803 7F7B18014B	532 490	08/15/1995 (0.0) 05/28/1998 (158.6)	1992 1993
10/07/1999	RM 1.1	1	Trammel Net	USGS – Denver (Gordon Mueller)	7F7B12155F	459	05/28/1998 (158.6)	1993
06/06/2000	RM 0.0	3	Trammel Net	USGS – Denver (Gordon Mueller)	1F41482038 1F6B2B7356 7F7B11352B	492 472 485	11/18/1994 (158.6) 08/15/1995 (0.0) 04/22/1998 (158.6)	1992 1992 1993
06/07/2000	RM -4.0	1	Trammel Net	USGS – Denver (Gordon Mueller)	1F732D724F	505	11/18/1994 (136.6)	1992
06/27/2000	RM 0.7	1	Electrofishing	USGS – Denver (Gordon Mueller)	1F412A2D49	505	11/18/1994 (117.5)	1992
06/28/2000	RM 1.1	1	Trammel Net	USGS – Denver (Gordon Mueller)	1F4E594773	495	Unknown	
07/18/2000	RM -2.4	1	Electrofishing	USGS – Denver (Gordon Mueller)	1F43686353	522	10/27/1994 (79.6)	1992
06/03/2003	San Juan River arm of Lake Powell	2	Unknown	USGS Coop. Unit at Utah State Univ. (Gary Thiede)	Unknown	~ 530 (21”) ~ 530 (21”)	Unknown (no PIT tag reader)	? ?
07/30/2003	San Juan River arm of Lake Powell	1	Unknown	USGS Coop. Unit at Utah State Univ. (Gary Thiede)	Unknown	495	Unknown (no PIT tag reader)	?

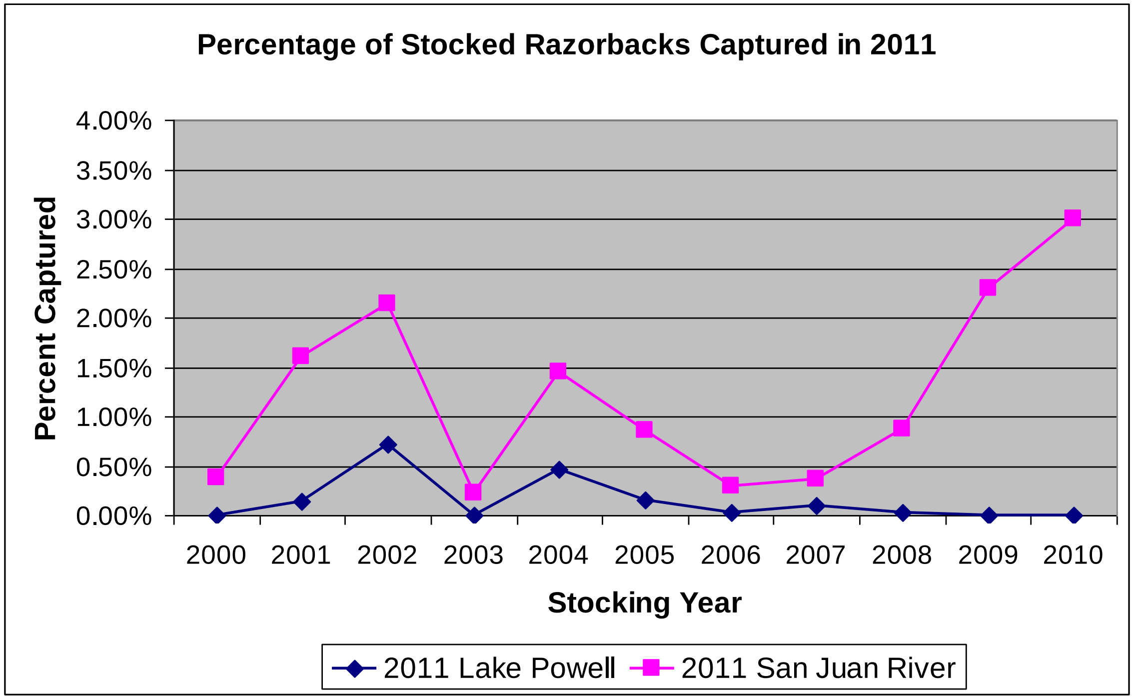
Collection Date	Collection Site	Number Of Fish	Gear	Agency & (Collector)	Pit Tag Number	TL (mm)	Stocking Date & (RM Stocked At)	Year-Class
08/28/2003 exact dates unknown	"One point upstream of Neskahai Wash"	4	Gill Net	UDWR - Wahweap (Georg Blommer) (Quent Bradwisch)			08/08/1995 (0.0) 3 Unknown (no PIT tag reader)	1992 ? ?
Collection Date	Collection Site	Number Of Fish	Gear	Agency & (Collector)	Pit Tag Number	TL (mm)	Stocking Date & (RM Stocked At)	Year-Class
May 2004	San Juan River arm of Lake Powell	1	Unknown	USGS Coop. Unit at Utah State Univ. (Shane Vatland – grad student of Phaedra Budy's)	?	?	Unknown (no PIT tag reader)	?
11/04/2004	Neskahai Wash (~ RM -35.0)	3	Gill Net	UDWR - Wahweap (Georg Blommer)	425B763D54 425C1F0E44 4268686119	411 448 470	04/13/2004 (158.6) 04/14/2004 (158.6) 04/13/2004 (158.6)	2001 2001 2001
07/28/2005	RM -1.1	1	Cast Net	UDWR - Moab (Julie Jackson)	7F7B142B34	~ 450	05/28/1998 (158.6)	1993
08/24/2005	RM -1.1 RM -1.1	2	Cast Net	UDWR - Moab (Julie Jackson)	3D91BF1E9BE0B (4220700E12 & 3D91BF1D8B884)	482 458	Unknown Unknown	?
8/14/06	RM -1.1	1	Cast Net	UDWR – Moab (Darek Elverud)	(426B1D7261 & 3D91BF18BFEE3)	514	4/13/04 (158.6)	2001
10/30/2006	Neskahai Wash (~ RM -35.0)	4	Gill Net	UDWR - Wahweap	441E215133 423E581A63 425B083239 44742C1776	485 535 437 500	Unknown 10/30/01 (158.6) 4/14/04 (158.6) Unknown	? 1999 2001 ?
7/12/07	RM -1.1	1	Angling	UDWR – Moab (Darek Elverud)	3D91BF1E89192	460	5/17/05 (158.6)	2002
8/13/07	RM -1.1	1	Cast Net	UDWR – Moab (Darek Elverud)	(426B370B27 & 3D9257C69341E)	424	4/13/2004 (158.6)	2001
11/07/2007	Neskahai Wash (~ RM -35.0)	2	Gill Net	UDWR - Wahweap		508 501	Unknown (no PIT tag reader)	? ?

Collection Date	Collection Site	Number Of Fish	Gear	Agency & (Collector)	Pit Tag Number	TL (mm)	Stocking Date & (RM Stocked At)	Year-Class
06/10/2008	RM -3.8	7	Electrofishing	UDWR - Moab (Darek Elverud)	3D9257C697544	411	Unknown	?
	RM -5.5				3D9257C69C6D0	309	Unknown	?
	RM -9.5				3D9257C6AE6A1	245	Unknown	?
	RM -11.5				(425A3A4B20 & 3D9257C6B90ED)	495	4/14/04 (158.6)	2001
	RM -3.8				(5229117968 & 3D9257C6BA328)	464	4/26/04 (158.6)	2002
	RM -6.5				3D9257C69B976	405	7/26/2006 (158.6)	2001
	RM -9.5				(52283D1348 & 3D9257C6BC079)	510	4/14/2003 (158.6)	2001
7/22/08	RM -1.1	3	Cast Net	UDWR - Moab (Darek Elverud)	3D91BF1CD424C	439	5/18/05 (158.6)	2002
					(43650A4B2B & 3D9257698598)	524	8/24/04 (158.6)	2000
					3D91BF1CD3F61	444	5/19/05 (158.6)	2002
11/05/2008	Neskahai Wash (~ RM -35.0)	1	Gill Net	UDWR - Wahweap		412	Unknown (no PIT tag reader)	?
11/17/2009	Neskahai Wash (~ RM -35.0)	2	Gill Net	UDWR - Wahweap		513	Unknown (no PIT tag reader)	?
						415		?

Appendix 4. San Juan River negative river miles (RM) converted to the San Juan River arm of Lake Powell's lake miles (LM).

River Mile (RM)	Lake Mile (LM)	River Mile (RM)	Lake Mile (LM)
-1.1	54	-18.1	37
-2.1	53	-19.1	36
-3.1	52	-20.1	35
-4.1	51	-21.1	34
-5.1	50	-22.1	33
-6.1	49	-23.1	32
-7.1	48	-24.1	31
-8.1	47	-25.1	30
-9.1	46	-26.1	29
-10.1	45	-27.1	28
-11.1	44	-28.1	27
-12.1	43	-29.1	26
-13.1	42	-30.1	25
-14.1	41	-31.1	24
-15.1	40	-32.1	23
-16.1	39	-33.1	22
-17.1	38		

Appendix 5. Percentage of stocked razorback sucker captured in the San Juan River and the San Juan Arm of Lake Powell in 2011.



Appendix 6. **2011 San Juan River arm of Lake Powell razorback sucker sonic tracking data**

SONIC TAG TRACKING DATA 2011						
Trip	**Date**	**Tag ID**	**Lake Mile**	**River Mile**	**Movement**	**Comments**
0	3/9/2011	47	54	-1.5		Stocking date
2	4/27/2011	47	39.9	-15.6	-14.1	
3	5/17/2011	47	39.5	-16.0	-0.4	
4	6/10/2011	47	39.6	-15.9	0.1	
4	6/12/2011	47	39.6	-15.9	0.0	
0	3/9/2011	48	54.0	-1.5		Stocking date
4	6/10/2011	48	40.6	-14.9	-13.4	
2	4/14/2011	49	39.7	-15.8		Tagging Date
2	4/24/2011	49	38.5	-17.0	-1.2	
2	4/27/2011	49	38.5	-17.0	0.0	
3	5/17/2011	49	38.5	-17.0	0.0	
3	5/19/2011	49	38.5	-17.0	0.0	
4	6/7/2011	49	38.5	-17.0	0.0	
4	6/12/2011	49	38.5	-17.0	0.0	
0	3/9/2011	50	54.0	-1.5		Stocking date
2	4/27/2011	50	38.5	-17.0	-15.5	
2	4/19/2011	53	23	-32.5		Tagging Date
2	4/20/2011	53	21.2	-34.3	-1.8	
2	4/19/2011	54	23	-32.5		Tagging Date
2	4/20/2011	54	21.2	-34.3	-1.8	
3	5/22/2011	54	24.5	-31.0	3.3	E-fishing recap
3	5/24/2011	54	36.5	-19.0	12.0	
4	6/14/2011	54	24.2	-31.3	-12.3	
2	4/27/2011	64	38.4	-17.1		Tagging Date
3	5/17/2011	64	39.3	-16.2	0.9	
3	5/19/2011	64	39.3	-16.2	0.0	

4	6/7/2011	64	39.0	-16.5	-0.3	
4	6/12/2011	64	38.8	-16.7	-0.2	
2	4/20/2011	65	22.9	-32.6		Tagging Date
2	4/20/2011	65	21.2	-34.3	-1.7	
3	5/14/2011	65	21.2	-34.3	0.0	
3	5/22/2011	65	21.2	-34.3	0.0	
4	6/14/2011	65	21.2	-34.3	0.0	
2	4/13/2011	66	38.4	-17.1		Tagging Date
2	4/24/2011	66	38.5	-17.0	0.1	
3	5/17/2011	66	39.3	-16.2	0.8	
4	6/7/2011	66	39.0	-16.5	-0.3	
4	6/12/2011	66	38.8	-16.7	-0.2	
2	4/14/2011	67	39.4	-16.1		Tagging Date
2	4/24/2011	67	39.5	-16.0	0.1	
2	4/27/2011	67	38.5	-17.0	-1.0	
3	5/16/2011	67	41.6	-13.9	3.1	
4	6/9/2011	67	42.0	-13.5	0.4	
2	4/26/2011	68	39.7	-15.8		Tagging Date
3	5/24/2011	68	36.9	-18.6	-2.8	
4	6/9/2011	68	36.9	-18.6	0.0	
0	3/9/2011	51	54.0	-1.5		Stocking date
0	3/9/2011	52	54.0	-1.5		Stocking date
0	3/9/2011	62	54.0	-1.5		Stocking date
0	3/9/2011	63	54.0	-1.5		Stocking date