A pilot study of fish stranding on the South Fork Boise River, 2012

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Table of Contents

Background

The South Fork Boise River below Anderson Ranch Dam downstream to Neal Bridge is a premiere rainbow [redband] trout (*Oncorhynchus mykiss*) fishery in southwest Idaho. It is managed with "Quality Trout" regulations by the Idaho Fish and Game Department (IDFG) that restrict terminal tackle to no live bait and barbless hooks, and bag and length limits of 2 fish over 20-inches in length (Butts et al. 2011).

Flows released from Anderson Ranch Dam are managed by the U.S. Bureau of Reclamation (Reclamation) to fulfill irrigation, flood control, and fish and wildlife needs (USFWS 2005). To support fish habitat and spawning, minimum flows from April 1 to September 15 are 600 cubic feet per second (cfs). From September 16 to March 31, minimum flows are 300 cfs. Ramping rates to decrease flows from 1,000 to 600 cfs from April 1 to September 15 are a maximum of 35 cfs per 10 minutes for 1 hour, and ramping rates to decrease flows from 600 to 300 cfs from September 16 to March 31 are a maximum of 35 cfs per 10 minutes (USFWS 2005). In practice, these guidelines typically result in two periods of rapid downrampings on the South Fork Boise River. For example, in 2011 flows were decreased from 1,600 to 600 cfs over 1.5 days in mid-August, and flows were again reduced from 600 to 300 cfs overnight on September 15.

Anglers have reported that the rapid reductions in flow from Anderson Ranch Dam during these two periods result in age-0 rainbow trout being stranded in dewatered portions of the channel (A. Brunelle, Ted Trueblood Chapter of Trout Unlimited (TU), personal comm.; Ed Dunn, Westfly.org, personal comm.). Stranding also occurs in larger pools and side channels that become disconnected from the main river channel. Besides these occasional observations, the extent, frequency, and magnitude of fish stranding and impacts on recruitment to the rainbow trout fishery have not been studied in detail.

Despite documented occurrences of fish stranding, other information suggests a healthy rainbow trout population. The abundance of rainbow trout over 254-mm TL (10 inches) have been relatively stable during the last three sampling years (2006, 2009, and 2012) and have averaged approximately 300 per km. Rainbow trout fry surveys conducted by IDFG (1996 and 2009) after downramping show average of 3 fry per meter of streambank electrofished (Butts et al. 2011). Furthermore, the condition factors of rainbow trout longer than 76-mm TL (3 in.) suggests that prey is also not limited (Butts et al. 2011); the diet of rainbow trout is largely macro-invertebrates. Other studies have shown Anderson Ranch Dam operations and changes in streamflows to alter macroinvertebrate drift patterns and displace mountain whitefish (*Prosopium williamsoni*) eggs (White and Wade 1980), but population-level impacts for macroinvertebrates, mountain whitefish, and other fishes have not been evaluated.

Fish Stranding Literature Review

Fish stranding has been documented in reservoirs during drawdowns and below dams when flows are reduced, and most studies to date have focused on quantifying mortality of salmonids below dams as a result of hydropeaking operations (Nagrodski et al. 2012). During drawdowns in Trail Bridge Reservoir (Oregon), more Chinook salmon (*O. tshawytscha*) and brook trout (*Salvelinus fontinalis*) were stranded in low gradient shorelines (versus high gradient shorelines) in the interstitial spaces in cobble substrates and in potholes (i.e., stranding pools) (Bell et al. 2008). The likelihood of fish being stranded was not associated with the rate of water elevation change (range: 12 – 46 cm/hr). In the Bear River below Grace Dam (Idaho), fish were over two-times more likely to be stranded when flows were downramped at a slower rate (0.25ft/hr versus 0.5 and 1.0 ft/hr; CES, 2010). The study authors speculated that rapid down ramping rates startled fish, causing them to seek deeper water more quickly than when downramping rates were slower. Cyprinids and sculpin were stranded most often, and no trout were stranded during the study (cutthroat trout *O. clarkii* and rainbow trout are present in that section of river). Bradford (1997) used an experimental stream to assess the effects of time of day, dewatering rate, and temperature on stranding of Chinook and coho (*O. kisutch*) salmon fry on gravel bars and in side channels. He found that more juvenile Chinook salmon were stranded on gravel bars when water temperature was 6°C compared to 12°C, but the rate at which water levels were lowered did not affect the amount of stranding on gravel bars; 2% of fish were stranded on average. However, in a second experiment more chinook and coho salmon fry became stranded in side-channels when water levels dropped faster (range: 6 to 60 cm/h), and more coho salmon were trapped when flows were decreased at night as opposed to during the day. Halleraker et al. (2003) found that decreasing the down ramping rate from >60 cm/h to <10 cm/h reduced the stranding of brown trout (*Salmo trutta*) fry in an experimental stream. Other studies have shown more stranding with faster ramping rates (Phinney 1974; Bauersfeld 1978), whereas other studies have shown no effect of ramping rate on fish stranding (Woodin 1984; Higgins and Bradford 1996; Bradford 1997). The effects of rate of water level change on fish stranding appears to be specific to each waterbody, fish species, and water-temperature, therefore prohibiting broad generalizations across systems.

Coordination

Two meetings were conducted with TU, IDFG, and Reclamation in early 2012 to discuss concerns regarding fish stranding on the South Fork Boise River below Anderson Ranch Dam. During the first meeting on April 3, 2012 TU conveyed angler concerns about how normal down ramping rates at Anderson Ranch Dam could affect the fishery in a negative way. Also, TU expressed interest in working together to better understand the problem with an aim toward potential solutions (letter to Jerry Gregg May 4 with response on June 6). This meeting was followed with a second meeting on June 27 to discuss how IDFG and Reclamation might assess the extent of stranding. IDFG expressed little concern, at the time, regarding population-level effects to either fish or macro-invertebrate populations resulting from current down-ramping rates on the South Fork Boise River. However, they were interested in working with partners to conduct a pilot study to determine the extent, magnitude, and frequency of stranding. IDFG did express concern regarding occasional down ramping rates that were of high magnitude (exceeding 30 cm/hr) and/or proceeded by a sharp rise in river level, which occur on the South Fork Boise River periodically. Reclamation expressed a need to follow existing bull trout (*Salvelinus confluentus*) study plans that focus on addressing Terms and Conditions in the 2005 FWS Opinion, but was also interested in participating in a pilot effort during the fall of 2012 to collect baseline data for future habitat mapping of stranding pools.

At the conclusion of the July 27th meeting the partners defined the study area, timing, and involvement by each partner for a pilot study of fish stranding in fall 2012. The study area was defined as Anderson Ranch Dam downstream to Pierce Creek because of observed fish stranding in the past and the presence of geomorphic conditions conducive to stranding. It was decided that the timing of the effort was to focus on two downramping events: 1) irrigation flow (summer flows) to 600 cfs and 2) 600 to 300 cfs (winter flows). IDFG and

Reclamation would lead on sampling the stranding pools and other habitats where stranding is likely to occur and TU would assist as needed. TU would lead the streambank surveys, and help identify additional stranding pools on other river segments where stranding pools are not targeted for sampling (see below).

Goal

The goal of this pilot study was to determine the extent of fish stranding and habitats generally associated with stranding during downramping on the South Fork Boise River below Anderson Ranch Dam downstream to Pierce Creek in the fall of 2012.

Methods

Downramping - Reclamation decreased streamflows on the South Fork Boise River below Anderson Ranch Dam from 1,800 cubic feet per second (cfs) to 900 cfs (in 300 cfs increments at 08:00, 10:00, and 13:00 Mountain Daylight Time [MDT]) on September 4th and again from 900 to 600 cfs (at 09:00 MDT) on September 5th, 2012 (Figure 1). On September 17th, flows were decreased again from 600 to 300 cfs (09:00 MDT) (Figure 1).

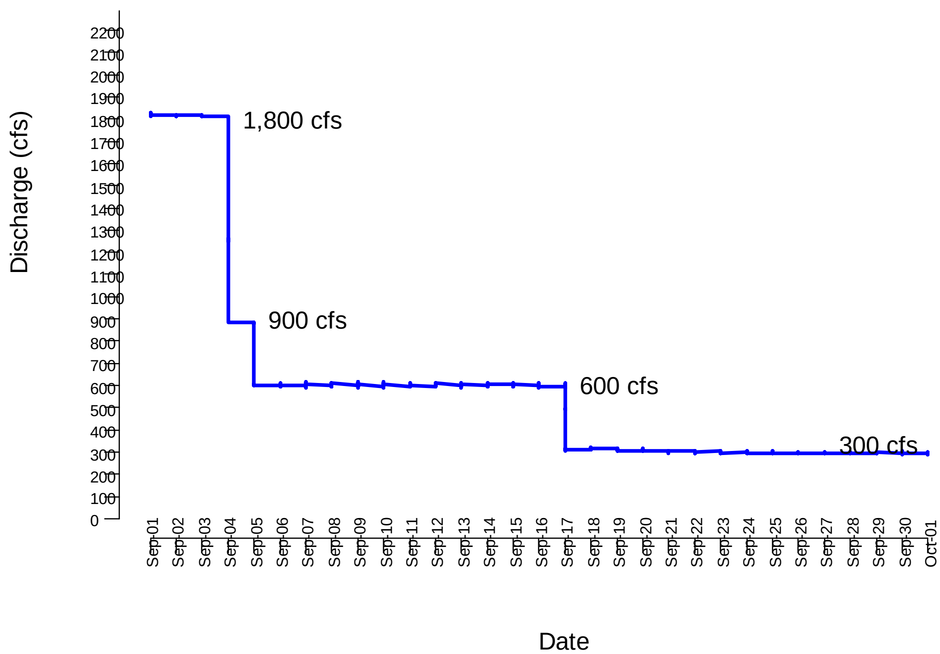

Figure 1. Streamflows on South Fork Boise River at Anderson Ranch Dam in September, 2012. Data from USGS gage 13190500 (SF Boise River 1.8 miles downstream of Anderson Ranch Dam ID).

Visual Surveys - To assess fish stranding along streambanks, visual surveys were conducted jointly by TU, IDFG, Reclamation, and volunteers[1] along 5 transects to estimate the number of stranded fishes during downramping on September 4th, 5th, and 17th (Figure 2). Transects represented dewatered sections of streambank and channel bed (including stranding pools and side channels) ranging from 600 to 2147-m in length along the bank, and the

[1] Four biologists (IDFG and TU) and five volunteers conducted visual surveys on September 4th and 5th. Eight biologists (IDFG, BOR, and TU) and approximately 12 volunteers conducted visual surveys on September 17th.

same transects were re-surveyed each downramping period. During the surveys 1-4 observers slowly walked the streambank on river right (roaded side) and counted the number of fishes stranded in exposed streambed substrates and vegetation. They visually estimated the number of fish in larger stranding pools and side channels. At least one TU, IDFG, or Reclamation biologist was present during each transect survey.

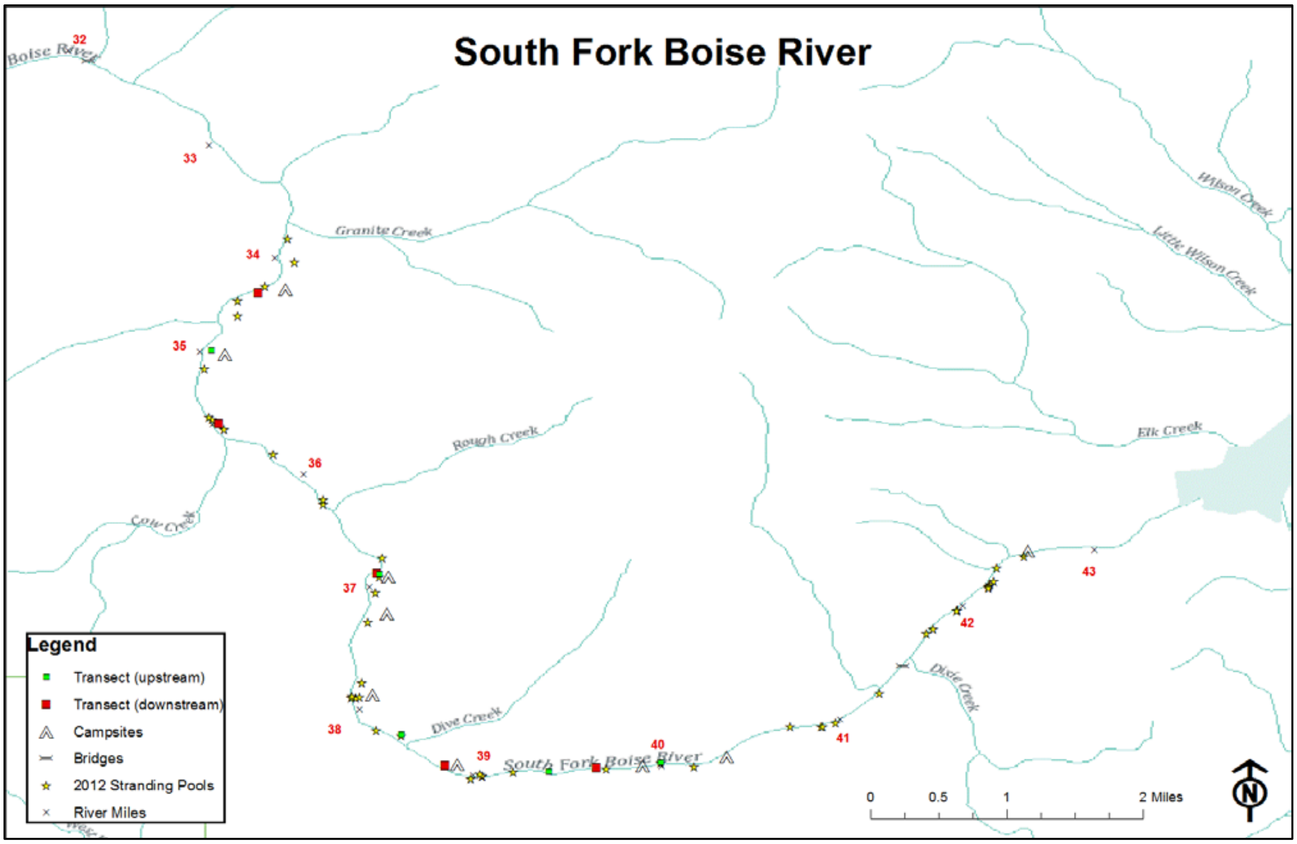

Figure 2. Location of upstream and downstream end of transects surveyed for stranded fish on September 4th, 5th, and 17th, 2012. Additional stranding pools were identified during surveys on September 18th and 20th.

Stranding Pool Surveys - In addition to the visual surveys, on September 18th and 20th Reclamation kayaked the river from Anderson Ranch Dam downstream to Danskin Bridge to identify additional areas with the potential to strand large numbers of fish. These locations represented potential and observed main-channel stranding pools. Stranded fish were not enumerated during this effort to avoid duplication of counts from previous sampling.

Electrofishing of Stranding Pools - On September 19th, IDFG backpack electrofished two side channel pools containing stranded fishes identified during the September 17th downramping; three electrofishing passes were made in each side channel with two electrofishers and two netters. Abundance of each species was estimated using the removal model m_{bh} in Program CAPTURE (Otis et al. 1978; Rexstad and Burnham 1991). Habitat measurements were used to estimate fish densities. Subsamples of stranded rainbow trout and mountain whitefish were measured for total length to estimate length frequencies for each species.

Results

Visual Surveys – Downramping occurred on September 4th, 5th, and 17th, and five transects totaling 8.6 km (range: 600 to 2147-m each) of streambank were visually surveyed for stranded fish during each downramping period. Across transects, steep and gradual sections of exposed channel bed, stranding pools, and disconnected side channels were encountered and visually surveyed for stranded fishes (Figure 3).

Figure 3. Habitat types surveyed on the South Fork Boise River for stranded fish comprised steep (A) and gradual (B) dewatered banks, stranding pools (C), and disconnected side channels (D).

Across all dates and transects, almost 14,000 fish were observed to be stranded (Table 1; Figure 4). More fish were observed to be stranded during the 1800 to 900 cfs (Sept. 4th) and 600 to 300 cfs (Sept. 17th) downramping periods. Age-0 rainbow trout were most frequently stranded during all three days, and sculpin (*Cottus* spp.) were the second-most frequently stranded species (Figure 5; Figure 6). Kokanee salmon (migrating adults from Arrowrock Reservoir) were also observed to be stranded. There was large variation in number of fishes stranded among transects (see error bars in Figure 5), which was driven by large numbers of fish observed in two disconnected side-channels that had high estimated numbers of stranded fish versus those stranded in small stranding pools or dewatered sections of streambank. While most rainbow trout encountered were age-0, on September 17th there were about 100 rainbow trout 10-15 cm in length that were observed in one stranding pool (Turnout #3; RM 38). Another rainbow trout greater than 15-cm was observed in another stranding pool (Turnout #3; RM 38).

Figure 4. Examples of stranded rainbow trout (A), sculpin (B), kokanee (C), and macroinvertebrates (D; Tricoptera) during visual streamside surveys on September 4th, 5th, and 17th during flow downramping on the South Fork Boise River, 2012.

On September 17th, data were collected for individual stranding pools in addition to being summarized across entire transects. More rainbow trout were stranded in 5 pools in River mile 38 than were observed in other river segments, with an average of 1,260 fish (1 SE = 1,161) per pool (Figure 7; top panel); river mile 41 had only one stranding pool with few fish. The average number of sculpin spp. observed per pool was consistent across river mile sections, although fewer sculpin were observed in River miles 37 and 38 (Figure 7 bottom panel). Again, the estimated number of fish per pool was highly variable because while most pools had few or no stranded fish there were a few pools with a large number of fish.

Table 1. Number of stranded fish observed (number per meter in parentheses) during visual streamside surveys on September 4th, 5th, and 17th during downrampings on the South Fork Boise River, 2012.

SiteID	Date	Start cfs	End cfs	Reach length (m)	Age-0 Rainbow Trout	Age-1+ Rainbow Trout	Sculpin spp.	Kokanee
Turnout 2	9/4/2012	1800	900	600	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
(River mile 39-40)	9/5/2012	900	600	600	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	9/17/2012	600	300	600	98 (0.2)	0 (0.0)	62 (0.1)	0 (0.0)
Turnout 3	9/4/2012	1800	900	1400	3494 (2.5)	16 (0.01)	144 (0.1)	13 (0.01)
(RM 38-39)	9/5/2012	900	600	1400	42 (0.03)	0 (0.0)	4 (0.01)	0 (0.0)
	9/17/2012	600	300	1650	570 (0.3)	0 (0.0)	1 (<0.01)	0 (0.0)
Indian Rock upstream	9/4/2012	1800	900	2147	3 (<0.01)	0 (0.0)	0 (0.0)	0 (0.0)
(RM 36-38)	9/5/2012	900	600	2147	15 (0.01)	4 (0.01)	8 (0.01)	0 (0.0)
	9/17/2012	600	300	2147	7364 (3.4)	900 (0.4)	73 (0.03)	~5 (<0.01)
Indian Rock to Cow	9/4/2012	1800	900	2413	300 (0.1)	0 (0.0)	16 (<0.01)	0 (0.0)
(RM 35-36)	9/5/2012	900	600	2413	25 (0.01)	0 (0.0)	42 (0.02)	0 (0.0)
	9/17/2012	600	300	2413	254 (0.1)	0 (0.0)	3 (<0.01)	0 (0.0)
Cow Creek Down	9/4/2012	1800	900	1812	48 (0.03)	0 (0.0)	5 (<0.01)	0 (0.0)
(RM 34)	9/5/2012	900	600	1812	250 (0.1)	2 (<0.01)	15 (0.01)	0 (0.0)
	9/17/2012	600	300	1812	200 (0.1)	0 (0.0)	12 (0.01)	0 (0.0)
Total				8372	12363 (1.5)	922 (0.1)	385 (0.05)	18 (<0.01)

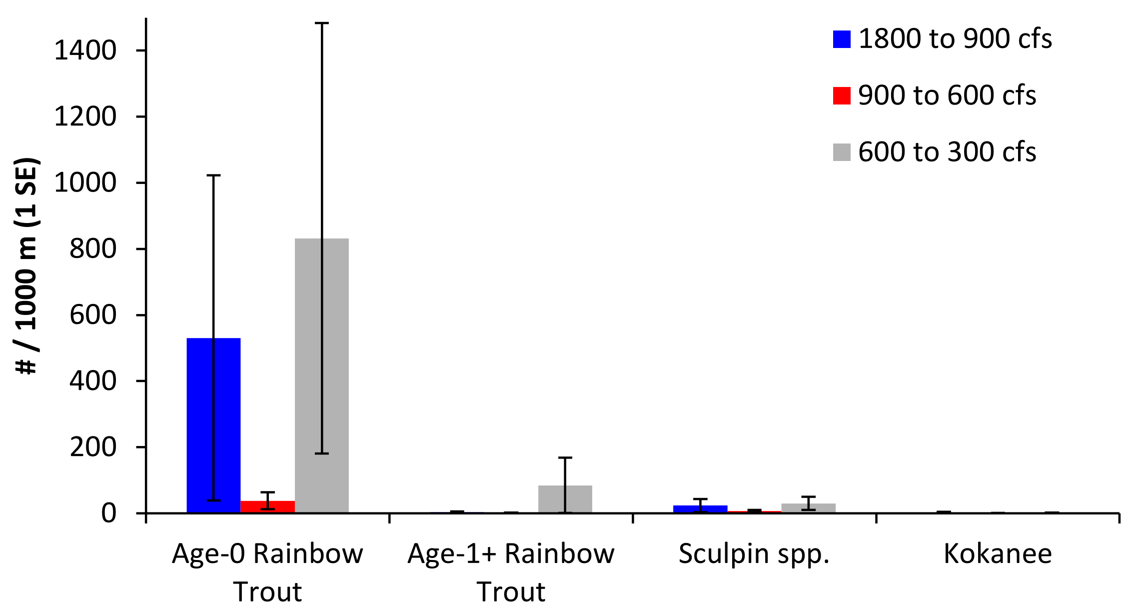

Figure 5. Mean (± 1 SE) number of observed fish stranded per 1000 meters by species and age class at 5 transects surveyed on the South Fork Boise River during three downramping periods on September 4th (1800 to 900 cfs), 5th (900 to 600 cfs), and 17th (600 to 300 cfs), 2012.

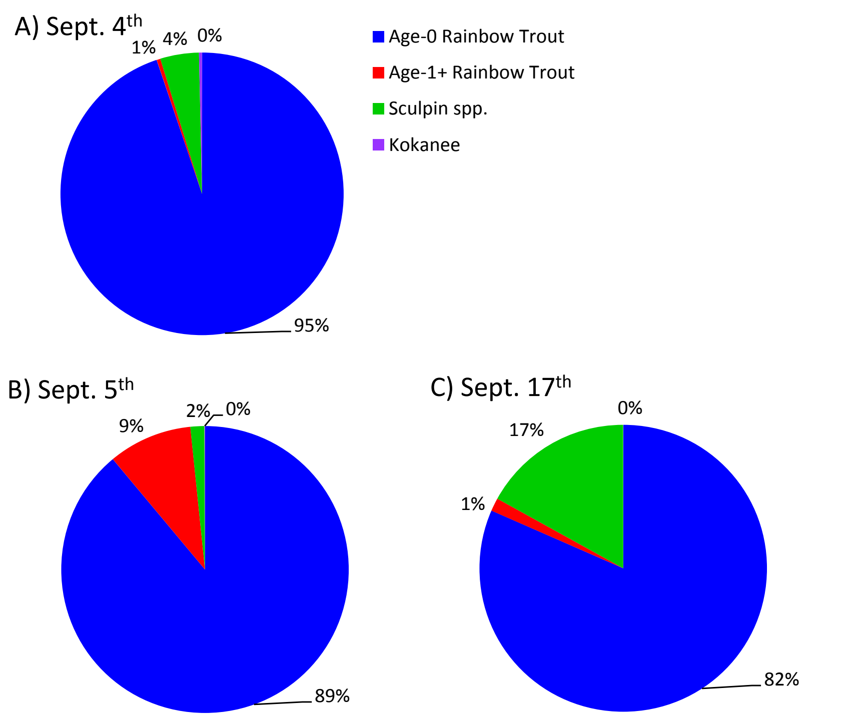

Figure 6. Percent composition of observed fish stranded by species and age class at 5 transects (8.4 km total) on the South Fork Boise River during three downramping periods on September 4th (A; 1800 to 900 cfs) , 5th (B; 900 to 600 cfs), and 17th (C; 600 to 300 cfs), 2012.

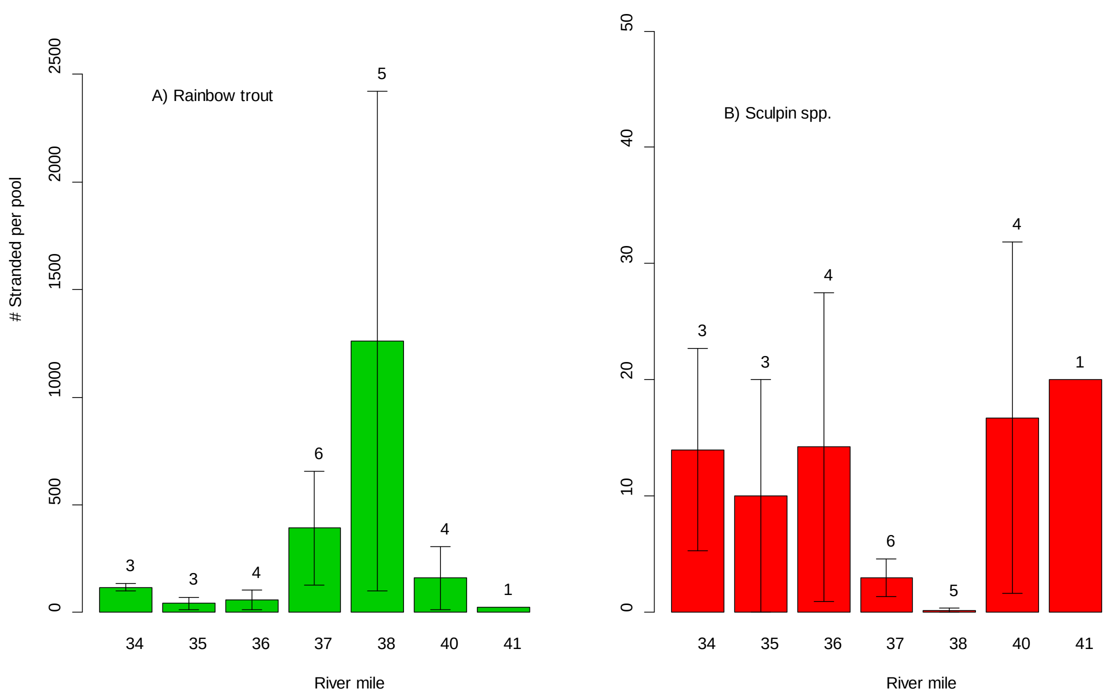

Figure 7.Mean (1 SE) number of observed rainbow trout (A) and sculpin spp.(B) stranded per pool by river mile on September 17th, 2013. Numbers represent number of pools surveyed (sample size, n) by river mile. See Figure 1 South Fork Boise River river mile locations.

Stranding Pool Surveys - Twelve additional potential and observed stranding pools were identified during Reclamation's additional surveys on September 18th and 20th (Figure 2). These observed pools were all located along the main channel. In total, 51 individual stranding pools (ranging in size from 0.12 to 1081.5 m^2) were located from September 4th-20th. These potential and observed pools consisted of side channels, backwaters, and dewatered streambed contours.

Electrofishing of Stranding Pools – On September 19th depletion electrofishing was used to estimate the abundance of fishes in two stranding pools located in a single side channel that became disconnected from the main channel on September 17th. Rainbow trout were the most abundant species in both pools; 727 trout were estimated to be stranded in one pool and 2,843 were stranded in the second pool (Table 2). The stranded rainbow trout ranged in total length from 27 to 208 mm TL (Figure 8); most were around 100 mm TL. A few mountain whitefish, sculpin spp., and sucker spp. were also collected from the two pools. The mountain whitefish stranded ranged in size from 55 to 76 mm TL.

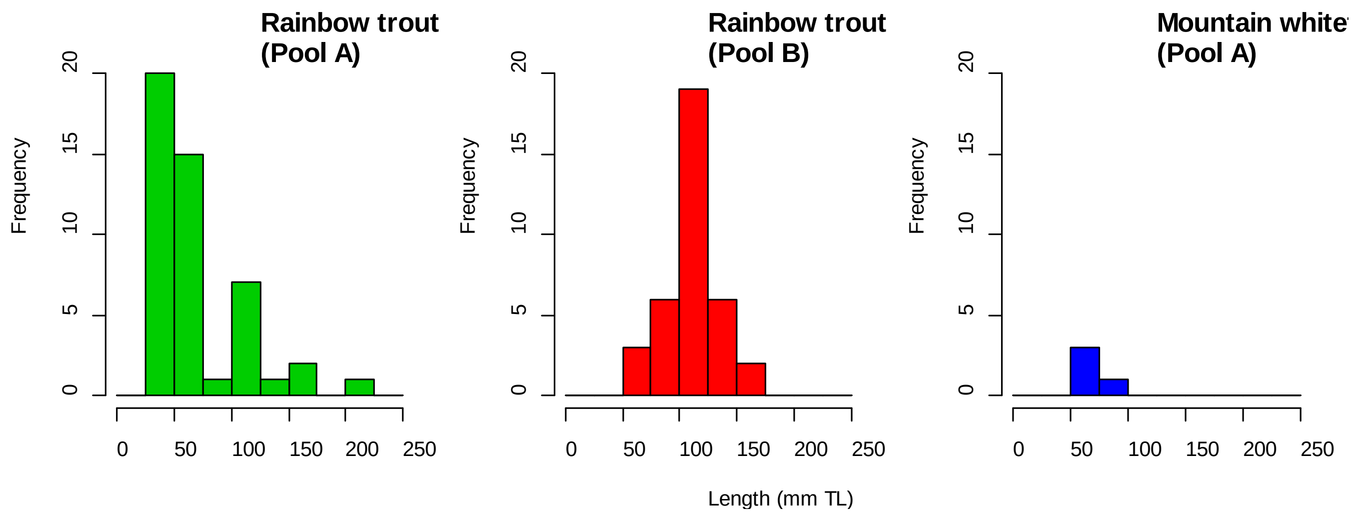

Figure 8. Length frequency histogram of rainbow trout and mountain whitefish collected by electrofishing from two stranding pools, South Fork Boise River, September 19th, 2012. No mountain whitefish were collected from pool B.

Table 2.Estimated number and density of observed fishes stranded in two stranding pools, South Fork Boise River, September 19th, 2012. Numbers were estimated using 3-pass depletion electrofishing.

Section	Species	N_{est}	1 SE	Length (m)	Area (m^2)	Linear Density (N / m)	Areal Density (N / m^2)
Pool A	Rainbow trout	727	20.1	15.2	115.5	47.8	6.3
	Mountain whitefish	4	0.97	15.2	115.5	0.3	0.03
	Sculpin spp.	8	0.77	15.2	115.5	0.5	0.07
Pool B	Rainbow trout	2843	39.5	36.4	121.6	78.1	23.4
	Mountain whitefish	0	0	36.4	121.6	0.0	0.0
	Sculpin spp.	32	0	36.4	121.6	0.9	0.26
	Sucker spp.	1	0	36.4	121.6	0.03	0.008

Discussion

This collaborative pilot study was the first attempt to gain a rough understanding of the scope of fish stranding on the South Fork Boise River when streamflows are ramped down from irrigation flows in summer to winter flows (i.e., 300 cfs), which typically occurs during a few days in late-August or September of each year. The downramping of flows on the South Fork Boise River below Anderson Ranch Dam in 2012 were similar in rate to past years but time of day was different. In past years, downramping has typically occurred during nighttime hours but in 2012 downramping occurred throughout the day, to accommodate survey crews, in September 4^{th}, and at 9:00am on September 5^{th} and 17^{th}. While only rough estimates fish stranding were obtained, the pilot study yielded valuable information that will be useful in informing future stranding studies on the South Fork Boise River (Noble et al. 2007).

The visual surveys represent rough approximations of the fish that were stranded. For example, the accuracy of visual estimates of stranded fish in large stranding pools is not known, and it is also not known how easily fish are detected in stream substrates during visual surveys; for example, many sculpin were found underneath large cobbles, apparently infiltrating into the substrates following water down, and it is impossible to search the entire river channel thoroughly for stranded fishes. Future studies could estimate detection probabilities of trout and sculpin in certain habitats for use in correcting counts to obtain unbiased abundance estimates, such as using depletion electrofishing estimates to assess the bias of visual estimates in stranding pools. Such comparisons on a subset of pools could be used to calibrate visual estimates in the future.

Despite the rough estimates, age-0 rainbow trout were observed to be stranded more often than any other species during downramping on the South Fork Boise River. While downramping tends to impact small fishes the most, the species-specific impacts tend to be variable across systems; for example in the Bear River below Grace Dam, most of the stranded fishes observed were newly hatched non-game fishes and not trout (CES 2010). In contrast, high but equal numbers of coho salmon, rainbow trout/steelhead, Chinook salmon, and redside shiners (*Richardsonius balteatus*) were observed to be stranded in the Bridge River, Canada (Higgins and Bradford 1996). This contrast between the South Fork Boise River and the Bear River highlights how stranding can differ across species and river system.

Fishes were observed to be stranded across various habitat types across all surveyed transects in the South Fork Boise River. Most stranded fishes were associated with a few side channels – two to be exact - that became disconnected from the main channel during downramping. However, fishes were also in stranding pools associated with gradually sloping banks, which have been identified as having high fish stranding risk in other studies (Tuhtan et al. 2012). Other stranding habitats included the interstitial spaces of exposed streambank substrates (both trout and sculpin) and small rivulets flowing through stands of willow (*Salix* spp.; D. Dauwalter, personal observation). These latter habitats stranded fewer fish, on average, than the large stranding pools or side channels and they were patchily distributed across the surveyed transects. Future surveys should differentiate fish stranding by habitat type (e.g., streambank, stranding pool, disconnected side channel).

The large side channels where many fish were observed to be stranded were identified as stranding pools if surface connectivity was not observed with the main river channel. A lack of surface connectivity would prohibit immigration or emigration from those disconnected side channels. While Reclamation fish crews tracked bull trout throughout the winter they observed live fish in side channels that were not connected to the main channel (T. Watson, BOR, personal communication). Ground water exchanges with side channels were not measured, but disconnected side channels with sufficient ground water connectivity, depth and surface ice cover could be used as overwintering habitat by juvenile fishes. Thus, future studies should evaluate how these disconnected side channels impact the fishes stranded within them.

It is not known whether the age-0 rainbow trout stranding observed during this study was extensive enough to impact fish populations in the South Fork Boise River. Across all downramping periods, approximately 1.5 age-0 trout per m were stranded during transect surveys. Juvenile trout surveys conducted by IDFG in fall – after downramping – typically yield approximately 3 age-0 trout per m of streambank that is electrofished. These estimates suggest that stranded trout could represent a moderate proportion of the fry population going into winter. However, this is a rough comparison, as the proportion of the age-0 trout stranded during downramping was not estimated directly. Winter mortality in north-temperature trout populations can be substantial (~50% over-winter juvenile mortality; Gresswell and Vondracek 2010) but is not always more than mortality observed in other seasons (Meyer and Griffin 1997; Sogard 1997; Carlson et al. 2008), and it is not known whether density dependent processes might affect recruitment into the population. For example, high densities of age-0 trout could result in intraspecific competition for food resources, reduce the condition (i.e., lipid reserves) of individuals prior to winter, and increase overwintering mortality. As such, stranding could reduce competition among age-0 trout and, therefore, decrease overwintering mortality. In addition, it is not known how much bull trout rely on age-0 rainbow trout as a prey resource, and whether any reduction in age-0 rainbow trout negatively affects bull trout that use the South Fork Boise River. A more thorough study would need to be designed to assess the proportion of age-0 rainbow trout that are stranded during downramping, how this relates to compensatory winter survival and recruitment into the rainbow trout population, and determine whether bull trout rely on age-0 rainbow trout as prey base and are affected by rainbow trout stranding.

Relation to Reclamation's Bull Trout Study

This pilot study was just the first part of a much larger study plan that Reclamation has developed for the South Fork Boise River to investigate measures to minimize the effect and /or amount of take of bull trout associated with operations of Anderson Ranch Dam.

The stranding pool and habitat surveys will help Reclamation make assertions as to how the drawdowns and potential stranding affects the system, therefore giving Reclamation sound guidance as how to best manage these potential losses. Estimates of stranding pool occurrence and whether fish use these areas will help validate whether the stranding pools are deemed necessary worries or not.

To better understand the physical conditions that lead to stranding pools within the study area, crews will continue to survey the study area from boat and by wading and will geo reference the location of all observed stranding pools during future sampling efforts. All future stranding pool inventories will also occur during both downramping events (irrigation flows to 600cfs and 600 to 300 cfs) immediately preceding and following the drawdown events. Mapping of stranding pools will be used with habitat surveys similar to work performed by Reclamation on the Deadwood River (Reclamation 2012). Then the geographic position of observed stranding pools will be layered with bathemetry maps (created with EAARL and green LiDar data) and used to select sampling sites during habitat work in subsequent years.

Full stranding pool and habitat surveys will provide information on annual occurrence of stranding pools and to determine how stable the river channel is year to year. Those surveys will also help determine how quickly the stranding pools become too warm and anoxic to fish. Answers to these questions are likely to be very important in designing management plans to possibly modify the seasonality of flow releases and ramping rates. It is the intent of Reclamation to manage flows from Anderson Ranch Dam in a way that reduces take of all fishes in the South Fork Boise River while meeting their ESA, irrigation and flood control obligations.

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