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CULVERT ROUGHNESS ELEMENTS FOR NATIVE UTAH FISH PASSAGE: PHASE II

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16. Abstract

Native fishes have become an increasingly important concern when designing fish passable culverts. Many operational culverts constrict waterways which increase velocities and prevent upstream passage of small fish species. The current method to ensure fish passage is to match the average cross sectional velocity to the sustained swim speed of the fish. This study takes investigates the passage rates of leatherside chub (*Lepidomeda aliciae*) and speckled dace (*Rhinichthys osculus*) at three sites (an arch culvert with substrate bottom, box culvert with bare bottom, and a stream section with no culvert) located on Salina Creek near Salina, UT. It was found that fish were able to pass through all of the sites. However, fish were able to take advantage of the habitat within the culvert that had a substrate bottom more effectively than within the culvert that had no substrate within the barrel. This was reflected in population density estimates at each of the three test sites for each species. It was also found that the substrate at the arch culvert and stream sites scaled with the fish measured in this study. The D_{50} and D_{84} were 44 and 205 mm at the arch culvert site and 26 and 126 mm at the stream site. The average fish length was 76 mm for the chub and 64 mm for the dace. It is believed that placing substrate that scales with fish length within the culvert will provide enough velocity heterogeneity to allow the fish to successfully pass.

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1.0 EXECUTIVE SUMMARY

Fish passage has become an increasingly important concern when designing culverts. Previous design standards often produced constricted waterways, thereby increasing velocities and preventing upstream passage of many fishes. Native Utah fishes such as leatherside chub (*Lepidomeda aliciae*) and speckled dace (*Rhinichthys osculus*) are of special concern when designing fish-passable culverts since they are often weaker swimmers than the salmonids for which culverts are usually designed.

Current fish passage design procedures match the average cross sectional velocity to the sustained swim speed of the fish. This results in expensive projects and large culvert barrels because reduced velocity zones exist near boundaries within the culvert that fish can take advantage of when passing upstream. In previous research, it was concluded that these native Utah fishes perform the best in a natural substrate treatment in a laboratory setting and that substrate should scale with the size of the fish.

This study investigates these conclusions further by means of field testing at Salina Creek at two culverts and a comparable stream site. One of the culverts was an arch culvert filled with cobble-sized substrate and the other was a double-barrel concrete box culvert. All sites were of similar length (19-21 m). It was found that fish were able to move through all of the three sites. In order to better quantify the fishes' usage of the sites, population density estimates were made for each site to determine how many fish were inside each site at the time of recapture.

Elevated population density estimates for dace at the arch culvert lead to the conclusion that fish are able to use the culvert barrel similarly to the way they would a natural habitat. This may be due to the ability of dace, which are benthic swimmers, to take advantage of the reduced velocity zones near the substrate more effectively than the chub which are mid-column swimmers. Estimates of chub population densities were low at all sites since all were fast-water sections that chub do not prefer to use as habitat. The population density estimate at the stream site was approximately 76 fish higher than at the arch culvert site. It is believed that fish are able to take advantage of the reduced velocity zones created by the substrate within the arch culvert to pass through it and use it as habitat. Comparing fish swim speeds to velocities near the substrate may result in more appropriately sized and economical culvert designs. Substrate size is also an important factor and should be matched to the surrounding substrate and compared to the average fish length. Using substrate within the culvert would allow more culverts to be retrofitted or for new fish-passable culverts to be designed as it would be a more economical solution.

2.0 INTRODUCTION

Culvert design standards favor small barrels for economic reasons; this may result in restriction of the stream such that the average velocity presents a flow barrier for non-salmonid fish species. Some such species are southern leatherside chub (*Lepidomeda aliciae*) and speckled dace (*Rhinichthys osculus*). To counteract this, when considering fish passage, average velocities are matched to sustained fish speeds. This conservative practice may result in oversized culvert barrels and more expensive and invasive projects. Fish may be able to take advantage of decreased velocities near the boundary that would enable them to expend less energy and pass upstream successfully through culverts with an average velocity that exceeds their sustained swim speed. Results from Phase I of this project showed that fish do the best in a laboratory treatment that simulates a natural environment with substrate that scales with the size of the fish (D_{50} of the substrate is on the order of the length of the fish). Research in this Phase II project has been conducted to determine if this conclusion holds in the field and whether or not the results can be applied to retrofitting and designing new culverts in Utah.

Scope

Only native Utah non-salmonid fish were considered in this study. The results are for use in designing, retrofitting, and replacing of culverts managed by Utah Department of Transportation (UDOT). Results may have implications for other regions and fish species that were not studied, but would necessitate further research.

2.1 Objectives

This study takes advantage of the conclusions made in Phase I of this project and applies them to the field in order to test fish in their natural habitat. The results from Phase I and the methods used during this study focus on the way native non-game fishes in southern Utah take advantage of reduced velocity zones near boundaries specifically within culverts. The results provide useful insight into how fish are able to pass through excessive velocity barriers in their natural environment. These results may be applied to design standards for retrofitting and design of new culverts.

2.2 Document Organization

A literature review of background information and current design practices are set forth. Following, there are sections describing the research methods, data collection, and results, written such that the study should be easily replicable. Finally, a discussion of the results, conclusions, and recommendations are made. Appendices with additional information are also included.

2.3 Literature Review

The main consideration in culvert design is hydraulic conveyance and flood capacity. Other considerations, such as allowable headwater and tailwater elevations, are also taken into account. These design factors alone usually result in a structure that is smaller than the stream channel. This contracts flow, increases in-barrel velocities, and may result in scour downstream of the culvert. Concern for fish passage led to new culvert designs that adjusted mean design velocities to match swimming capabilities of fish. Recently, passage for other aquatic animals such as frogs and turtles have been highlighted. A culvert is defined as a barrier to passage when the capabilities of the species in question is exceeded (Norman et al. 2011).

Many culverts that exist today were designed without concern for animal movement. This caused fragmentation of the ecosystems and thereby fragmented populations of animals in the watershed (Trombulak and Frissell 2000). Disconnecting populations negatively affects biodiversity as smaller, disconnected populations are more prone to chance elimination (Farhig and Merriam 1985). In non-fragmented areas, after an event causes local extinction of a certain species, the area is often able to be repopulated by a nearby population that is larger and more stable (Allan and Castillo 2007). Population fragmentation must be considered when designing culverts. Culverts that allow for aquatic organism passage promote ecosystem health by allowing movement for seeking food, shelter, and mating partners, escaping predation, and moving in response to seasonal changes or natural disturbances (Jackson 2003).

Aquatic organism passage focuses primarily on fish at this time. The most common obstructions for fish at culverts are excessive water velocities, drops at inlets or outlets, physical barriers (e.g. weirs, baffles, debris), excessive turbulence, and insufficient water depth for fish to swim. Culverts should allow fish passage at a range of flow conditions, especially at times when movement is more likely such as during migratory seasons (Norman et al. 2011). However, fish likely will not move during high-flow events, so passage does not need to be ensured for storm events during which fish likely will not choose to move. Fish passable culverts should also be designed so that non-fish species will be able to pass through the culvert. Design procedures are not commonly tailored for a specific species except when an existing culvert is rehabilitated based on a species of interest. Many conservative designs suggest matching the culvert to the surrounding stream by sizing the culvert barrel so that it does not contract the stream at all, embedding the culvert or using an open bottom culvert, and using substrate similar to the surrounding streambed. By meeting these criteria, the engineer assumes that the culvert would present no more of a challenge than the animal’s natural habitat would (Norman et al. 2011).
A common design procedure to ensure specific species fish passage is to match the average cross-sectional velocity to the prolonged swim speed of the fish (Powers 1997). Average velocity

is recognized as a conservative parameter, but since little is known about how fish reduced velocity zones within a culvert, it is a safe and conservative predictor (Lang et al. 2004).
In order to more effectively design for fish passage, some basic fish biology should be known. Fish have two muscle systems for different swimming methods. The red muscle system is used when aerobic respiration is appropriate (during low-stress activities) and the white muscle system is used when anaerobic respiration is appropriate (during periods of high-intensity activities). For this reason, the white muscle system may only be used for a short time before the fish becomes fatigued (Behlke 1991). Fish have three movement types in a combination of these muscle systems: sustained, prolonged, and burst. Sustained movement is an aerobic exercise so it can be maintained for very long periods of times. Prolonged movement uses both red and white muscle systems, so it can be maintained for a maximum of 200 minutes. Burst movement uses only the white muscle system and can be maintained for only seconds. After reaching exhaustion by any of these types of movement, the fish requires a period of rest before continuing. Because of this, fish can fail to pass through a culvert for many reasons such as excessive length, high velocities, or the presence of an outlet drop (Kilgoreet al. 2010).

Considerations must also be made for a range of species and life stages of fish. Although some culverts may be passed by stronger, mature fish, the same culvert may not allow smaller or younger fish to pass (Norman et al. 2011). In some areas it is prudent to design for the "least species" of the area, or the weakest swimmer. By ensuring that the weakest swimmer is able to pass upstream, all other fish should also be able to pass upstream.

A distinction should also be made between groups of fish that have different methods of swimming. Many fish are classified as benthic fish, or those that regularly dwell at the bottom of a stream or lake. These fish generally have down-turned mouths to facilitate feeding, flat stomachs, and are well-equipped to take advantage of boundary layers. Some other fish are classified as mid-column swimmers, or those that regularly dwell within the water column. These fish are generally found in pools and deeper, slow-water sections of streams (Wilson and Belk 2001). Differences in dispersal, or how far a fish will normally move, are also important distinctions to be made since some fish will not choose to move through culverts, even if they are physically capable of passage.

In Phase I of this study, native Utah fishes were tested in a laboratory facility using three treatments: a bare Plexiglas flume, a bare flume with strategically-placed cylinders, and a natural substrate treatment. Fish were found to perform the best and most naturally in the substrate treatment tests and energetic calculations showed that fish expended the least amount of energy in the substrate treatment. These results and observations led to the conclusion that fish are able to pass upstream most easily in a substrate treatment and that the treatment should roughly scale with the size of the fish (Esplin and Hotchkiss 2011).

3.0 RESEARCH METHODS

3.1 Purpose

The goal of designing for fish passage is to create a system that allows for fish movement throughout the system, not necessarily to simply promote the movement of fish. Fish are more likely to move from habitats of a lower quality since they will search for better habitat. The objective of this study is to test the hypothesis that fish are able to move more easily through culverts with natural substrate in the bottom than through bare culverts. This hypothesis is based on Phase I results. We believe that the species of fish used in this experiment are representative of species of similar functional groups and that the tests may be applicable to culverts throughout Utah.

3.2 Experimental Design

This study is based on tests completed during Phase I that show that fish are most easily able to traverse a flume in a treatment where natural substrate is placed. This allows the fish to be able to move in a natural manner. It was decided that culverts would be chosen with three different substrate "treatments:" one was completely filled with natural substrate, one had no substrate, and the third was a natural section of the stream with no culvert.

3.3 Experimental Setup

All test sites were located within a 1 kilometer stretch of Salina Creek. Sites were chosen along Salina Creek because of the availability of appropriate, non-perched culverts and adequate populations of native Utah fishes.

The creek is part of the Sevier River drainage located in Fish Lake State Park in Southern Utah. The most upstream site (the arch culvert) is located at 38°54.898'N 111°44.038'W; the middle site (the stream section) is located at 38°54.901'N 111°44.204'W; and the downstream site (the box culvert) is located at 38°54.893'N 111°44.337'W. The relative locations of each site are shown in the figure below. The elevation is approximately 1755 meters (5758 feet).

Figure 1. Map of Salina Creek with test sites. Flow is from east to west. Site 1 is the box culvert, site 2 is the stream site, and site 3 is the arch culvert.

The stream segment tested has a variety of pools and riffles with depths from 0.25 to 1.5 m. The depth is approximately 0.48 m (ranging from 0.08 to 0.53 m) in the arch culvert and 0.24 m (ranging from 0.16 to 0.30 m) in the box culvert. The overall gradient is approximately 1.67 percent.

3.3.1 Fishes

Salina Creek has four main fish species: speckled dace (*Rhinichthys osculus*), mountain sucker (*Catostomus platyrhanchus*), mottled sculpin (*Cottus bairdi*) and southern leatherside chub (*Lepidomeda aliciae*). Only speckled dace and southern leatherside chub were included in the study because there were high densities of only chub and dace species in the area. Of the four species found, only the leatherside chub is a mid-column swimmer; the other three species are all benthic swimmers.

3.3.2 Culvert and stream description

The upstream culvert is a bottomless corrugated metal arch culvert that spans the entire stream. It is 21.45 m long and 7 m wide with cobble-sized substrate on the bottom. An upstream view of the culvert is shown in Figure 2.

Figure 2. View from upstream of the culvert (taken in 27 May 2011).

The stream section is located between the two culverts and is of similar length to the two culverts (21 m). It has relatively uniform substrate and depth. An upstream view of the site is shown in Figure 3.

Figure 3. View of the stream site from upstream (taken 26 July 2011).

The downstream culvert is a double barreled concrete box with a span of 6.40 m and rise of 3.19 m. The culvert is 19.1 m long and was completely clear of substrate for the entire length. There was a fair amount of woody debris caught on the upstream side of the culvert during the time of this study. An upstream view of the culvert is shown in Figure 4.

Figure 4. View of the box culvert from upstream (taken 24 September 2011).

Tests were performed in August rather than mid-summer due to a late spring runoff peak. Even so, during recapture flows had not returned to their normal base flow discharge. Despite this, fish should still be able to traverse through the culverts and testing had to be completed before the fall when the fish would no longer be moving.

A pygmy meter was used to measure velocities near the stream bed or culvert bottom at each site. The pygmy meter was useful for simplifying the data collection procedure. Measurements were taken at the depth above the substrate that corresponds to benthic species swimming position. Using an acoustic Doppler velocimeter (ADV) to take measurements was considered, but the idea was discarded since only the x-velocity measurement was needed and using the Pygmy meter was more suited to fieldwork.

4.0 DATA COLLECTION

4.1 Mark and Recapture

We used a short-term mark-recapture study to assess fish passage through each test site. Fish were marked on 26 July 2011 and the recapture event was 15-16 August 2011. At each test site, we captured approximately 60 southern leatherside chub and 60 speckled dace in 50 m reaches both downstream and upstream (total of 120 fish per species per test site) using a back-pack electroshocker. We divided the fish into four groups that represented the possible combinations of capture and release locations. Half of the fish from each capture location were released at the capture location (e.g. captured and released downstream of a test site), while the other half were released at the opposite capture location (e.g. captured downstream and released upstream). We released half of the fish in the opposite location of capture to act as a motivator or stimulant to encourage movement. Each group at each test site was uniquely batch marked using a one of four colors of visible elastomer tags (Northwest Marine Technology, Inc.; Shaw Island, Washington) at one of three locations on the fish (dorsal insertion of caudal fin, ventral insertion of caudal fin, and posterior insertion of anal fin). We measured the standard length (SL) of each fish to the nearest mm. Fish less than 40 mm SL represented young of year fish and could not be captured efficiently (Rasmussen and Belk 2011); therefore, we did not include these fish in the study. Southern leatherside chub were 40-119 mm SL, and did not significantly vary in size across test sites. Speckled dace were 40 – 80 mm SL, and were significantly larger at the box culvert. Fish were released approximately 10 m downstream or upstream of the test site.

For the recapture event, we completed two-pass depletions of 10-m stream segments by electroshocking. We started 250 m downstream of the box culvert, and completed the depletion effort in 88 segments, or 880 m of stream, ending 120 m upstream of the arch culvert. Included in these 88 segments were two 10-m segments within each of the test sites which were used to estimate the density of fish utilizing the test sites as habitat. For each 10-m segment, we recorded the total number of fish of each species captured for each pass, as well as the SL and batch mark for each recaptured fish.

4.2 Flow measurements

Flow was calculated by measuring velocity using a pygmy meter at a specific cross-section on the downstream end of the arch culvert at the conclusion of each field event: marking, recapture, and velocity testing. Measurements were taken approximately every foot from bank to bank using 30-second interval.

4.3 Pebble Count

A pebble count was completed at each test site after the recapture event. Samples were taken systematically at even-spaced marks along a measuring tape that was stretched between banks across each site. The tape made a zig-zag pattern across the area as shown in Figure 5. Particles were selected approximately 1 ft (0.3 m) apart. A yardstick was inserted at each point straight down from the tape and whatever the stick was touching was then measured, excepting biological material. Samples were measured with a gravelometer (also pictured below). Larger samples were measured with the yardstick in millimeters and smaller particles were classified as sand. A pebble count was not performed for the box culvert site since it was completely bare except for some sand that had deposited behind the debris dam.

Figure 5. Pebble count setup in the stream test site (taken 15 October 2011).

4.4 Velocity measurements

Near-boundary velocities were measured with a pygmy meter across the entire area of each test site. The pygmy meter was kept as near to the boundary as possible (approximately 2 cm from the boundary; Figure 6).

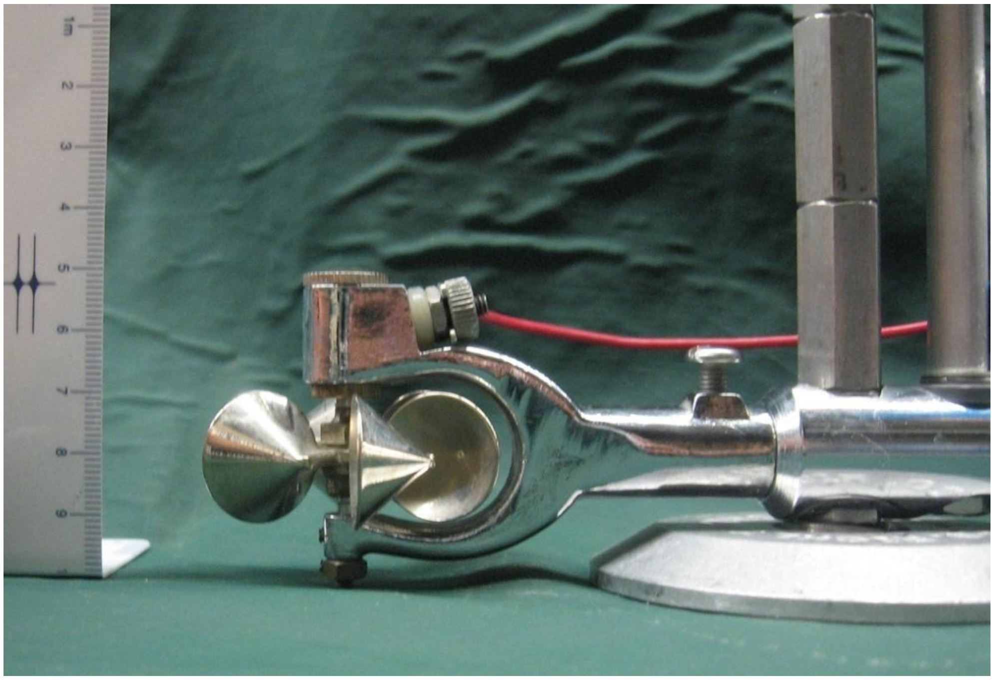

Figure 6. Pygmy meter in position used for taking velocity measurements.

Due to the large area being measured, measurements were taken in a 1-m by 1-m grid pattern. At the stream site, measurements started as close as possible to the right bank while maintaining adequate depth to get a reading and then continued with 1 meter between each measurement. The last point was taken as close as possible to the left bank. Just as with the average flow velocity measurements, all near-boundary velocity measurements were taken over 30 seconds.

5.0 RESULTS

5.1 Fish Data

We recaptured 139 of the 349 marked southern leatherside chub and 72 of the 363 marked speckled dace. During the 3-wk study, the majority of the recaptured fish had not moved more than 100 m upstream or downstream. However, five southern leatherside chub had moved 130 – 420 m downstream, one southern leatherside chub moved 130 m upstream, and one speckled dace moved 150 m downstream. Recaptured southern leatherside chub were significantly larger in the box culvert than in the arch culvert, but recaptured fish from the stream site were not significantly different in length compared to the culvert sites. Recaptured speckled dace were significantly larger from the box culvert than from the other two test sites, consistent with patterns observed in the marking event (Table 1).

Table 1. Mark and recapture data for all sites in Salina Creek, UT. Standard length measured in mm.

Species	Location	Number Marked	Mean Length (SE)*	Number Recaptured	Mean Length (SE)*
Leatherside chub	Arch	109	71.4 (1.48)[a]	36	75.2 (2.45)[a]
	Stream	121	71.6 (1.39)[a]	66	78.0 (1.83)[ab]
	Box	119	75.6 (1.40)[a]	37	84.8 (2.61)[b]
Speckled dace	Arch	121	60.4 (0.79)[a]	19	63.1 (1.69)[a]
	Stream	120	61.4 (0.80)[a]	30	63.8 (1.45)[a]
	Box	122	67.3 (0.79)[b]	23	70.2 (2.09)[b]

*Significant differences between means within a column for each species are noted with different letters.

The superscripts on values within the mean length columns indicate differences and similarities within a species and capture event. For example the length of chub did not differ significantly from each other when they were marked. However, when they were recaptured there were differences: although the lengths of fish from the arch and stream sites do not differ (indicated by the letter a) and the lengths of fish from the stream and box sites do not differ (indicated by the letter b) the lengths of fish from the arch and box site do differ significantly (indicated by the mismatched letters).

The best fit logistic regression model for the comparison of fish passage was the reduced model with no interactions (i.e. three fixed effects and covariate). The probability (not ability) of fish passage was significantly different among groups, but did not vary significantly by test site, species, or length (Table 2). Groups that included fish that were released at the opposite location of capture were much more likely to pass through a culvert than fish released where they were captured regardless of the direction of passage (Figure 7 and Figure 8). Group 1 includes fish captured downstream and released downstream. Group 2 includes fish captured downstream and released upstream. Group 3 includes fish captured upstream and released downstream. Group 4 includes fish captured upstream and released upstream.

Table 2. Probability of passage based on different effects.

Effect	DF	Wald Chi-Square	P-value
Test Site	2	0.1446	0.930
Group	3	52.8861	<0.001
Species	1	0.0586	0.809
Length	1	0.0189	0.891

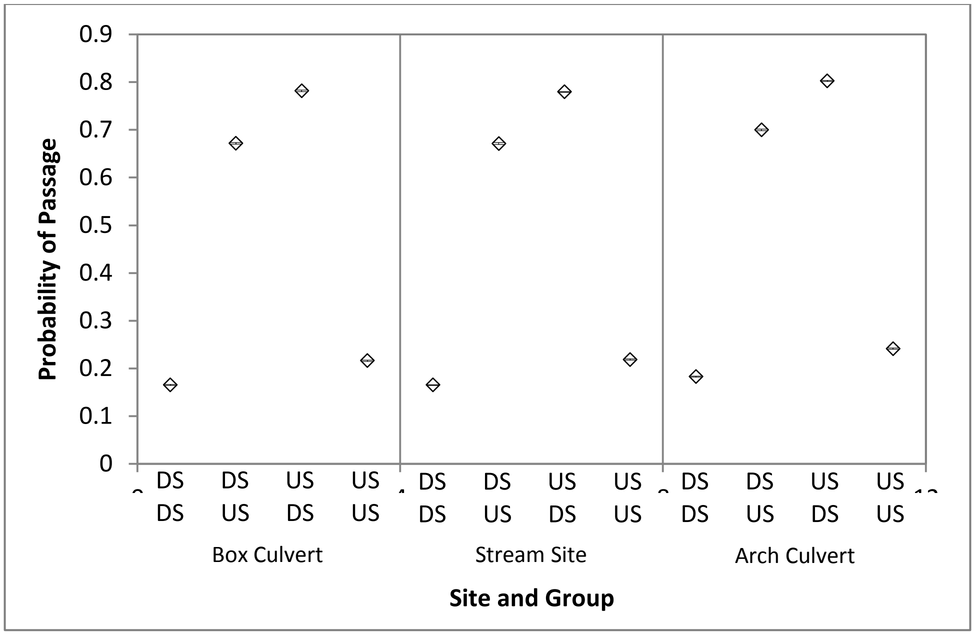

Figure 7. Probability of passage vs. group and site for chub.

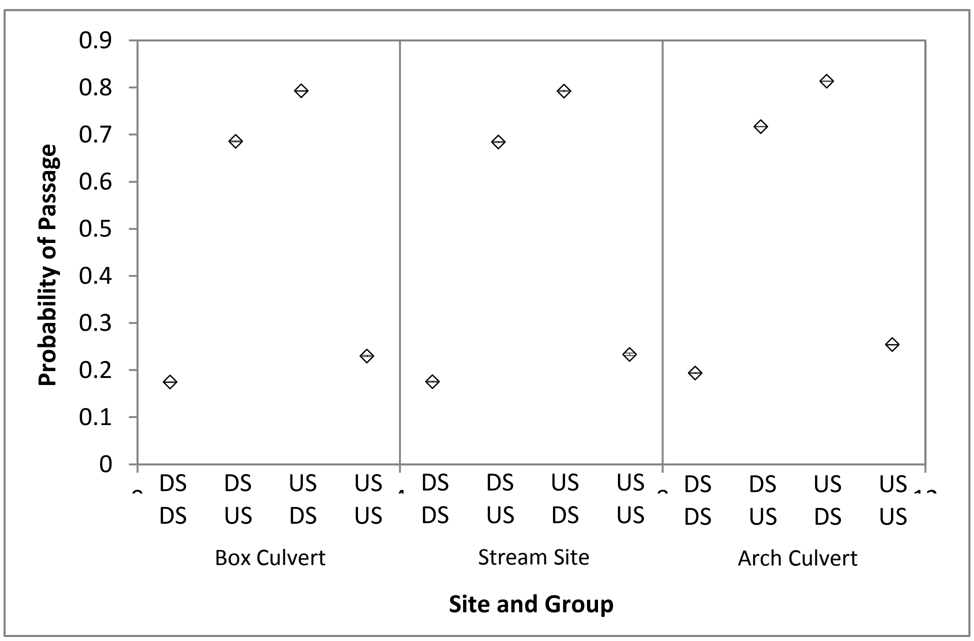

Figure 8. Probability of passage vs. group and site for dace.

The density of southern leatherside chub within the test sites did not differ significantly among test sites (Figure 9) but were significantly greater in the representative pool habitat than in the three test sites. The pool habitat was a length of stream selected after recapture based on observations of habitat throughout the shocked length of stream. Although recapture did occur at this site, no marking occurred. It was located upstream of the arch culvert and should not be confused with the stream site where marking did occur. Speckled dace had the lowest density in the box culvert, intermediate density in the arch culvert, and the highest densities in the riffle test site and representative pool habitat (Figure 9).

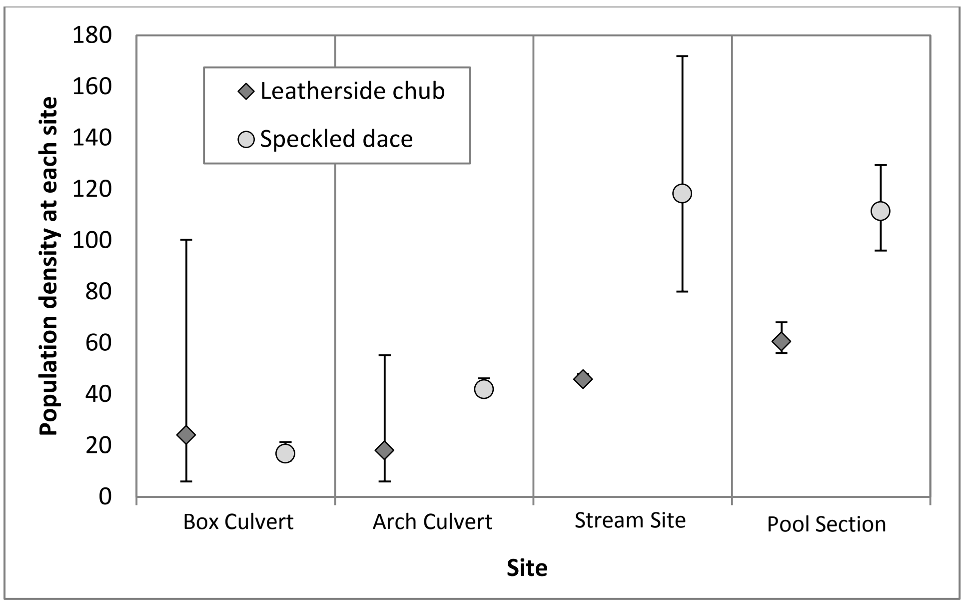

Figure 9. Population densities for each species at each site.

5.2 Statistical Analysis

We used a logistic regression model (Proc LOGISTIC; SAS Institute Inc. 2008) to compare the probability of passage of the two species through the tests sites. The response variable was binomial indicating passage or no passage; we considered a fish to successfully pass through the test site if it moved completely through the test site, either upstream or downstream. The model included three fixed effects: species, test site, and group. We ran the full model (all possible interactions of the fixed effects) and reduced models, and used model selection techniques (AIC) to determine the best fit model (Burnham and Anderson 2004; Johnson and Omland 2004). Length (SL) was used as a covariate in the full and reduced models.

To estimate the extent to which fish utilized each test site for habitat, we estimated the density of each species in each test site using the Zippin method (Hayes, et al. 2007):

$$\widehat{N} = \frac{n_1^2}{n_1 - n_2} \quad (1)$$

where

$\widehat{N}$	=	estimated density
n_1	=	number of fish removed on the first pass
n_2	=	number of fish removed on the second pass

We combined data for the first and second pass from both 10-m sections within each test site. The 95% confidence intervals (CI) were estimated using the following equation:

$$CI = \widehat{N} \pm 1.96 * SE \quad (2)$$

where

$$SE = \frac{n_1 n_2 \sqrt{n_1 + n_2}}{(n_1 - n_2)^2}. \quad (3)$$

We also estimated the density of each species from two representative pool segments (50 – 70 m upstream of arch culvert and outside of the stream test site) because southern leatherside chub prefer pool habitat (Wilson and Belk 2001) and the test sites represent fast-water habitats. We assumed that densities among test sites were significantly different if 95% CI did not overlap.

5.3 Velocity Characterization

Flow measurements were compared to USGS measurements that were taken upstream at site 10205030 on Salina Creek near Emery, Utah (U.S. Geological Survey 2012). The comparisons as well as all of the USGS measurements for the time period of study are shown below.

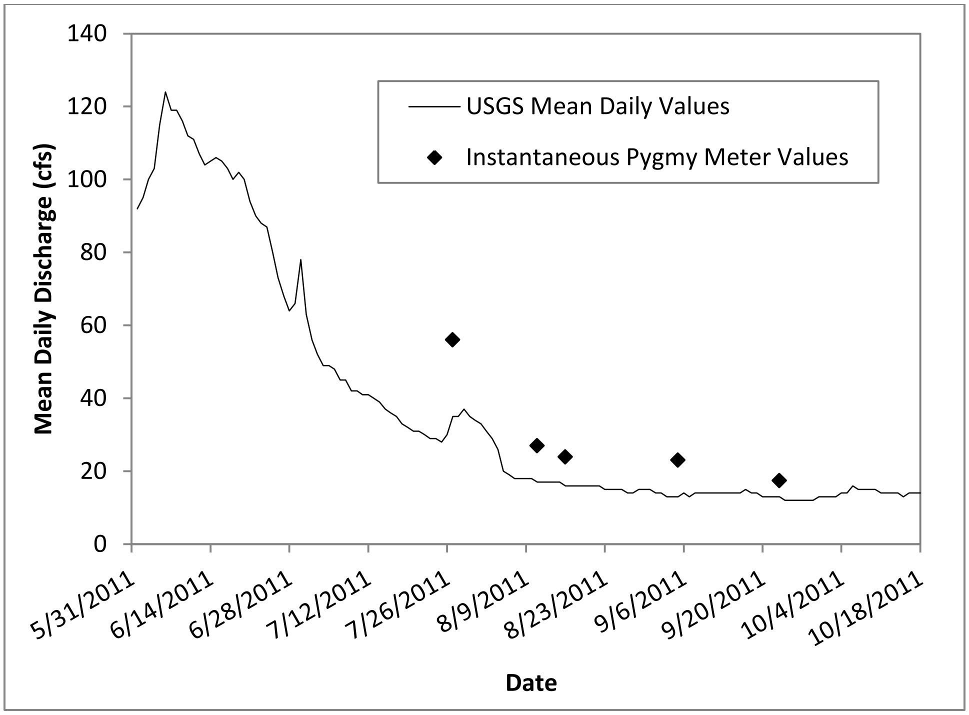

Figure 10. Measured flows and USGS measured discharges.

The difference in the measured values and the USGS values is probably due to the increase in drainage area between the two measurement sites. There is a significant increase in the drainage area between the site where USGS measurements were recorded and the study site. It should also be noted that this is a flashy area and there can be a large discrepancy between average daily flow measurements and instantaneous flow measurements.

The USGS data also show the late spring peak that delayed testing until August.

Small-scale velocity characterization was performed by taking point measurements at each site using the pygmy meter. The resulting velocity maps are shown below for each site. Flow is from right to left and velocity contours are shown in cm/s.

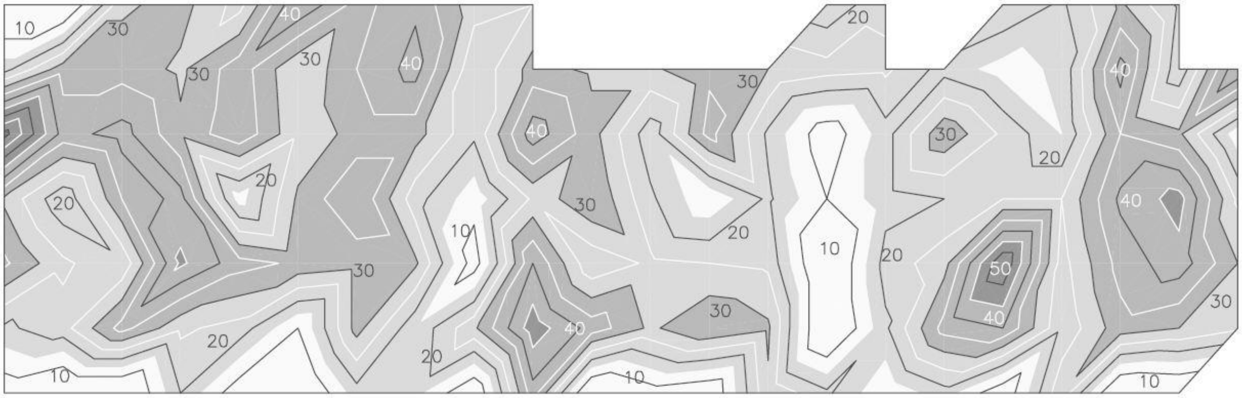

Figure 11. Velocity contour map at arch culvert site based on data 2 cm above the streambed.

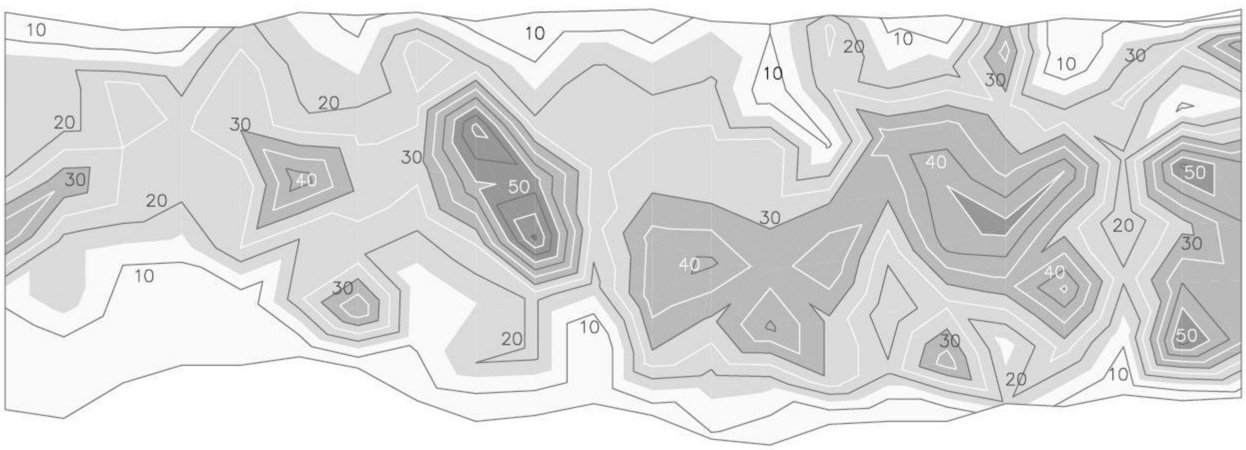

Figure 12. Velocity contour map at stream site based on data 2 cm above the streambed.

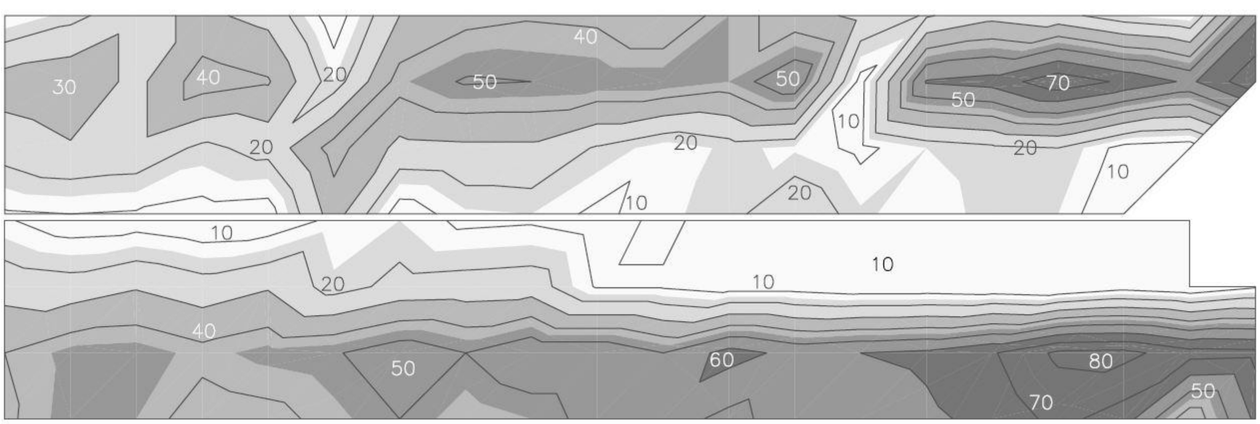

Figure 13. Velocity contour map at box culvert site based on data 2 cm above the concrete bottom.

Velocities are uniformly higher in the box culvert, the overall variation is greater at the other two sites, and the velocity distributions at the stream and arch culvert sites are similar.

5.4 Substrate classification

Using the data collected from the pebble counts, particle size distributions were created and representative diameters were determined. The particle size distributions and summary table are shown below.

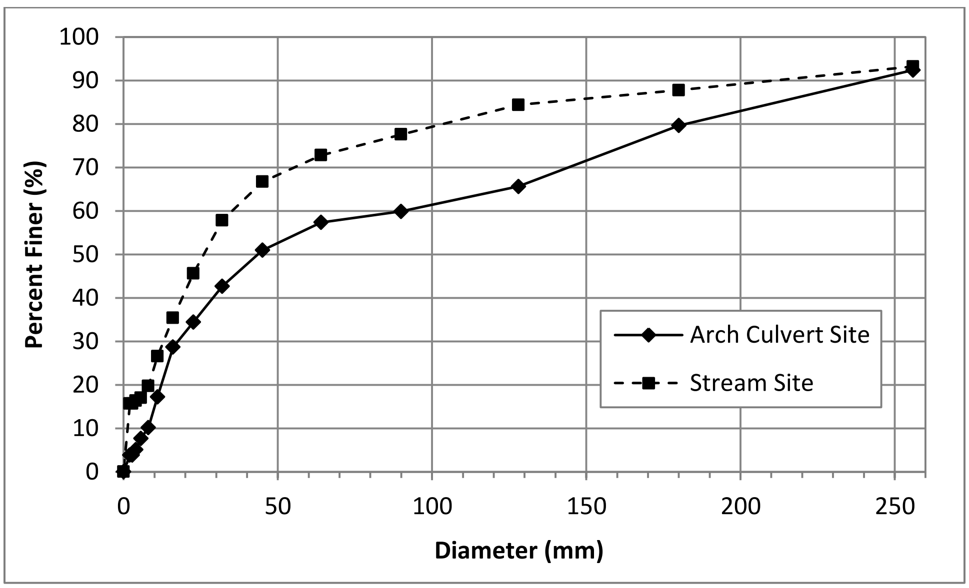

Figure 14. Particle size distribution for pebble count at stream and arch culvert sites.

Table 3. Representative diameters of substrate from each site.

	Arch Culvert	Stream Site	Difference (arch - stream)
D_{16} (mm)	11	4	7
D_{50} (mm)	44	26	18
D_{84} (mm)	205	126	79

The distributions are similar in shape, but the substrate measured at the arch culvert is large. The range of sizes is very similar, but a higher percentage of cobble-sized (larger than 64 mm) was found at the arch culvert.

5.5 Data Evaluation and Discussion

For several reasons, passage alone was not an adequate metric to judge whether or not fish would be able to pass through culverts. The average velocities at the sites were not great enough to prevent passage because they were not greater than the prolonged swim speeds of the fish in question. There also was not a great difference between passage rates for each species at each test site. The differences that were found were mainly due to the motivational factor that was introduced when fish were switched from upstream to downstream or vice versa. The groups that were switched had a much higher influence on the results than the fish that were not switched. Only 30% of marked fish were recaptured (211 recaptures of 712 marked fish) so this may have decreased the reliability of our results. It is also useful to note that the sites tested in this study are relatively short and differences may be more pronounced in longer culverts. However, fish were found upstream and downstream of each site which shows that they were able to pass through each of the three sites.

Population density estimates as well as velocity contour maps were used as additional indicators of whether fish would be able to pass through the sites. Population density estimates showed that more dace were found at the arch culvert site than at the box culvert site, which indicates that it provides better habitat for them. The numbers are not as high as the stream site population density estimate, but the difference between the two culvert estimates is attributed to the presence of substrate. Chub population densities were elevated at the box culvert due to the presence of the debris dam. However, fast water habitats, like both culverts and the stream site, are not optimal environments for chub because they are mid-column swimmers and do better in slow water habitats like pools, as evidenced in the pool section part of Figure 8. Differences in population densities at different sites are more easily seen when observing dace data rather than chub data.

Phase I concluded that substrate that scales with the size of the fish would provide adequate velocity heterogeneity for successful fish passage. A comparison of representative substrate diameters and average fish length is shown below.

Table 4. Comparison of D_{50}, D_{84}, and fish length.

	Marking	Recapture
Arch Culvert Site D_{50} (mm)	44	
Arch Culvert Site D_{84} (mm)	205	
Stream Site D_{50} (mm)	26	
Stream Site D_{84} (mm)	126	
Chub Length (mm)	79	73
Dace Length (mm)	65	63

The average substrate size at the stream site is between approximately 35 and 40% of the average fish length and the average substrate size at the arch culvert is between 58 and 70% of the average fish length. This shows that the substrate sizes and fish lengths are of the same order of magnitude. The D_{84} and D_{50} bound the range of lengths of the fish measured during marking and recapture events. The D_{84} may be a better measure than the D_{50} because it is only found sporadically throughout the streambed and would provide specific sites for fish to rest.

The variation in velocity provided by the substrate within the arch culvert and at the stream site aided in fish passage. The variation caused by the substrate enabled fish to find more easily navigable paths through the culvert than they would have been able to otherwise.

6.0 CONCLUSIONS

6.1 Conclusions

Passage was determined to be an inadequate measurement of success for several reasons. Average velocities at each of the sites as well as the shorter site lengths may have made it easier for fish to pass upstream than it may be at other impassable culverts. Also, most of the difference between passage rates may be attributed to switching some of the fish from upstream to downstream or vice versa, which would motivate them to swim through the site. Because of this, other measurements and calculations were made to determine the ability of the site to provide for fish passage.

Substrate analyses, velocity measurements, and population density estimates were made for each of the sites. These were used to compare the sites and determine if fish would be able to pass under more difficult conditions. A high degree of velocity variation was found to be helpful in aiding fish passage. This can be seen especially in population density estimates for dace at the three sites. Velocity variation is based on the substrate found at each site.

A comparison of average standard lengths of both species of fish that were tested and the average particle diameter at the arch culvert and stream sites showed that the particle diameter does scale with fish length as stated in Phase I conclusions. The D_{50} and D_{84} of both the stream and arch culvert sites bound the range of fish lengths measured during testing.

It is important to note that the two species of fish that were tested belong to different functional groups. Dace are benthic swimmers and generally perform better in fast-water segments like those usually found in culverts or riffles. Chub, however, are mid-column swimmers that prefer slow-water segments and pools. This explains the lower population densities at the three test sites and the elevated density estimate at the pool site for the chub. The higher density at the box culvert is improbable and can be explained by the presence of the debris dam.

These results may be applied to current culvert design practices to more easily provide for fish passage. More information may be necessary on the amount of variation that is necessary for the substrate and the relationship between fish length and the size of the substrate. However, this finding should simplify culvert design processes when fish passage is necessary for native Utah fishes. Simply filling the culvert with substrate similar to that in the near stream reaches could result in smaller and less expensive culverts.

6.2 Limitations of Conclusions

These conclusions should only be applied to watersheds with small native fishes that belong to the same functional groups as the ones tested. The general findings should be widely applicable, but more research would be necessary to verify the findings in other areas and with other functional groups.

7.0 Recommendations

It is recommended that in replication of this study, fish should not be switched from their capture location in order to promote movement. Although this shows that fish are capable of movement, it skews statistical analyses since it essentially introduces motivation as another variable. Not moving the fish also provides a larger sample population for each group at each site which would strengthen the statistical analysis.

Current federal fish passage design standards for culverts often require placed substrate significantly larger than what is found in the adjacent stream reaches to ensure stability during the design discharge (Kilgore et al. 2010). While this study shows that substrate that scales with fish length improves fish passage, the impact of using substrate consistently larger than fish length is unknown.

The role of turbulence generated by placed substrate is unknown. Field-collected acoustic Doppler velocimetry (ADV) data may reveal the impact of turbulence on fish passage.

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9.0 APPENDICES

9.1 Appendix A – Fish Marking Data

This section includes a spreadsheet of data recorded at the fish marking event. Mountain suckers were marked but not included in the final report due to insufficient numbers.

Date: 8/26/2011
Site: Arch Upstream
Released: Upstream
Color: Green
Position: Dorsal caudal fin

72 fish

	Chub	Dace	Sucker
	Length (mm)		
1	39	46	52
2	45	46	58
3	49	47	58
4	60	50	65
5	60	51	74
6	62	56	81
7	64	57	82
8	66	58	83
9	67	58	101
10	68	58	122
11	71	59	126
12	71	61	139
13	72	61	
14	73	62	
15	75	63	
16	75	63	
17	77	63	
18	80	64	
19	81	65	
20	81	65	
21	81	65	
22	84	65	
23	85	66	
24	87	67	
25	88	69	
26	89	69	
27	90	69	
28	90	70	
29	91	73	
30	101	74	
31			

Date: 8/26/2011
Site: Arch Upstream
Released: Downstream
Color: Green
Position: Anal fin

73 fish

	Chub	Dace	Sucker
	Length (mm)		
1	40	49	84
2	41	49	58
3	52	50	60
4	56	51	61
5	56	52	66
6	62	53	85
7	62	53	89
8	64	54	113
9	67	54	130
10	69	56	131
11	69	57	131
12	70	57	132
13	72	58	
14	72	58	
15	72	58	
16	74	59	
17	76	60	
18	76	60	
19	76	61	
20	77	62	
21	78	62	
22	79	63	
23	79	66	
24	79	68	
25	79	68	
26	82	70	
27	83	70	
28	90	72	
29	107	75	
30	115	77	
31		79	

Date: 8/26/2011
Site: Arch Downstream
Released: Upstream
Color: Pink
Position: Ventral caudal fin

63 fish

	Chub	Dace	Sucker
	Length (mm)		
1	39	47	76
2	44	48	85
3	44	49	86
4	60	50	94
5	62	51	106
6	62	55	114
7	63	55	125
8	63	55	130
9	64	57	
10	69	58	
11	70	60	
12	72	62	
13	74	62	
14	75	63	
15	76	64	
16	78	64	
17	79	65	
18	80	65	
19	80	65	
20	81	65	
21	82	66	
22	86	67	
23	90	67	
24	91	68	
25	91	68	
26		68	
27		69	
28		69	
29		72	
30		77	
31			

Date: 8/26/2011
Site: Arch Downstream
Released: Downstream
Color: Green
Position: Ventral caudal fin

63 fish

	Chub	Dace	Sucker
	Length (mm)		
1	42	40	85
2	43	41	90
3	45	46	92
4	46	47	104
5	60	47	110
6	62	47	117
7	63	48	117
8	64	50	125
9	66	53	133
10	67	53	
11	67	54	
12	68	56	
13	69	58	
14	71	59	
15	76	59	
16	76	60	
17	78	60	
18	78	61	
19	79	63	
20	81	63	
21	82	63	
22	83	65	
23	84	65	
24	85	67	
25		67	
26		67	
27		68	
28		68	
29		68	
30		74	
31			

Date:	8/26/2011		
Site:	Stream Upstream		
Released:	Upstream		
Color:	Orange		
Position:	Dorsal caudal fin		
			70 fish
	Chub	Dace	Sucker
	Length (mm)		
1	40	47	59
2	43	49	69
3	63	49	73
4	63	50	83
5	64	50	87
6	66	51	109
7	66	52	119
8	66	54	145
9	67	55	152
10	68	58	
11	68	59	
12	69	59	
13	74	60	
14	74	61	
15	75	62	
16	78	62	
17	80	63	
18	81	64	
19	81	64	
20	82	66	
21	85	67	
22	87	69	
23	87	69	
24	89	70	
25	90	73	
26	91	74	
27	93	74	
28	93	75	
29	99	78	
30	105	78	
31	106		

Date:	8/26/2011		
Site:	Stream Upstream		
Released:	Downstream		
Color:	Orange		
Position:	Anal fin		
			69 fish
	Chub	Dace	Sucker
	Length (mm)		
1	43	41	81
2	46	45	82
3	46	46	85
4	56	46	91
5	57	47	116
6	58	49	120
7	61	52	122
8	62	53	154
9	64	55	175
10	65	56	
11	65	56	
12	68	56	
13	68	57	
14	69	57	
15	74	60	
16	74	61	
17	75	61	
18	76	62	
19	76	66	
20	77	67	
21	78	69	
22	79	70	
23	79	70	
24	80	72	
25	81	73	
26	84	74	
27	85	74	
28	89	74	
29	89	76	
30	95	79	
31			

Date:	8/26/2011		
Site:	Stream Downstream		
Released:	Upstream		
Color:	Pink		
Position:	Dorsal caudal fin		
			68 fish
	Chub	Dace	Sucker
	Length (mm)		
1	40	40	60
2	42	43	69
3	43	47	81
4	43	48	82
5	44	49	87
6	45	51	90
7	58	51	117
8	63	53	133
9	64	53	
10	65	57	
11	66	58	
12	68	59	
13	74	60	
14	74	61	
15	75	63	
16	75	63	
17	76	64	
18	77	64	
19	77	65	
20	78	66	
21	79	67	
22	79	67	
23	79	68	
24	83	70	
25	84	70	
26	84	70	
27	85	74	
28	88	75	
29	92	78	
30	108	82	
31			

Date:	8/26/2011		
Site:	Stream Downstream		
Released:	Downstream		
Color:	Orange		
Position:	Ventral caudal fin		
			68 fish
	Chub	Dace	Sucker
	Length (mm)		
1	40	42	61
2	40	47	64
3	41	47	70
4	41	50	81
5	43	52	87
6	46	53	88
7	46	56	131
8	56	57	132
9	57	59	
10	61	61	
11	63	61	
12	65	62	
13	67	62	
14	69	64	
15	69	64	
16	71	65	
17	73	66	
18	74	66	
19	76	66	
20	78	66	
21	80	66	
22	81	66	
23	85	68	
24	86	68	
25	87	68	
26	89	68	
27	89	69	
28	90	70	
29	94	76	
30	94	77	
31			

Date:	8/26/2011		
Site:	Box		
	Upstream		
Released:	Upstream		
Color:	Yellow		
Position:	Anal fin		
			69 fish
	Chub	Dace	Sucker
	Length (mm)		
1	55	53	45
2	55	57	50
3	57	57	68
4	59	60	98
5	60	60	100
6	60	60	110
7	60	61	129
8	60	64	150
9	61	65	157
10	63	65	
11	69	65	
12	70	65	
13	73	65	
14	73	67	
15	75	68	
16	77	68	
17	78	69	
18	79	69	
19	79	70	
20	80	72	
21	80	72	
22	81	74	
23	82	74	
24	83	75	
25	84	77	
26	85	77	
27	86	78	
28	92	82	
29	95	83	
30	98	85	
31			

Date:	8/26/2011		
Site:	Box		
	Upstream		
Released:	Downstream		
Color:	Yellow		
Position:	Dorsal caudal fin		
			70 fish
	Chub	Dace	Sucker
	Length (mm)		
1	50	47	92
2	50	50	94
3	54	60	104
4	57	61	110
5	58	62	124
6	58	62	130
7	59	63	132
8	70	65	132
9	74	65	132
10	75	65	165
11	75	66	
12	75	66	
13	75	69	
14	75	69	
15	76	70	
16	77	70	
17	77	70	
18	80	70	
19	80	71	
20	81	72	
21	85	72	
22	85	72	
23	86	74	
24	87	75	
25	90	76	
26	94	77	
27	95	77	
28	97	78	
29	100	79	
30	105	80	
31			

Date:	8/26/2011		
Site:	Box		
	Downstream		
Released:	Upstream		
Color:	Pink		
Position:	Anal fin		
			66 fish
	Chub	Dace	Sucker
	Length (mm)		
1	40	45	93
2	42	51	109
3	42	54	115
4	43	57	124
5	59	60	155
6	62	62	158
7	65	62	
8	72	62	
9	74	64	
10	74	65	
11	75	65	
12	75	66	
13	77	66	
14	77	67	
15	78	67	
16	80	67	
17	80	68	
18	80	68	
19	82	68	
20	82	70	
21	85	70	
22	86	70	
23	88	70	
24	90	70	
25	92	71	
26	92	71	
27	100	71	
28	101	72	
29	105	78	
30		78	
31		82	

Date:	8/26/2011		
Site:	Box		
	Downstream		
Released:	Downstream		
Color:	Yellow		
Position:	Ventral caudal fin		
			68 fish
	Chub	Dace	Sucker
	Length (mm)		
1	40	47	75
2	42	53	82
3	48	54	89
4	52	55	115
5	57	56	118
6	65	56	118
7	66	62	156
8	70	62	
9	70	62	
10	73	62	
11	75	62	
12	76	64	
13	76	65	
14	76	65	
15	77	65	
16	77	67	
17	80	67	
18	82	68	
19	84	68	
20	85	68	
21	87	70	
22	87	70	
23	88	70	
24	88	70	
25	89	70	
26	90	71	
27	90	72	
28	94	74	
29	97	79	
30	114	84	
31		88	

9.2 Appendix B – Fish Recapture Data

This section includes a spreadsheet of data recorded during the recapture event.

Section	1
1st pass chubs	4
1st pass dace	14
1st pass suckers	6
2nd pass chubs	7
2nd pass dace	16
2nd pass suckers	5
Total chubs	11
Total dace	30
Total suckers	11
Recaptures	0

Section	2
1st pass chubs	11
1st pass dace	18
1st pass suckers	20
2nd pass chubs	2
2nd pass dace	9
2nd pass suckers	4
Total chubs	13
Total dace	27
Total suckers	24
Recaptures	0

Section	3
1st pass chubs	35
1st pass dace	25
1st pass suckers	6
2nd pass chubs	8
2nd pass dace	14
2nd pass suckers	0
Total chubs	43
Total dace	39
Total suckers	6
Recaptures	0

Section	4
1st pass chubs	20
1st pass dace	25
1st pass suckers	6
2nd pass chubs	4
2nd pass dace	14
2nd pass suckers	2
Total chubs	24
Total dace	39
Total suckers	8
Recaptures	0

Section	5
1st pass chubs	13
1st pass dace	8
1st pass suckers	6
2nd pass chubs	9
2nd pass dace	11
2nd pass suckers	3
Total chubs	22
Total dace	19
Total suckers	9
Recaptures	0

Section	6
1st pass chubs	5
1st pass dace	20
1st pass suckers	13
2nd pass chubs	1
2nd pass dace	3
2nd pass suckers	4
Total chubs	6
Total dace	23
Total suckers	17
Recaptures	0

Section	7
1st pass chubs	6
1st pass dace	43
1st pass suckers	14
2nd pass chubs	0
2nd pass dace	20
2nd pass suckers	4
Total chubs	6
Total dace	63
Total suckers	18
Recaptures	0

Section	8
1st pass chubs	8
1st pass dace	34
1st pass suckers	21
2nd pass chubs	10
2nd pass dace	14
2nd pass suckers	3
Total chubs	18
Total dace	48
Total suckers	24
Recaptures	0

Section	9
1st pass chubs	29
1st pass dace	13
1st pass suckers	2
2nd pass chubs	41
2nd pass dace	6
2nd pass suckers	0
Total chubs	70
Total dace	19
Total suckers	2
Recaptures	1

Section	10
1st pass chubs	12
1st pass dace	1
1st pass suckers	0
2nd pass chubs	8
2nd pass dace	0
2nd pass suckers	0
Total chubs	20
Total dace	1
Total suckers	0
Recaptures	1

Section	11
1st pass chubs	8
1st pass dace	11
1st pass suckers	2
2nd pass chubs	7
2nd pass dace	2
2nd pass suckers	2
Total chubs	15
Total dace	13
Total suckers	4
Recaptures	0

Section	12
1st pass chubs	6
1st pass dace	13
1st pass suckers	3
2nd pass chubs	2
2nd pass dace	4
2nd pass suckers	4
Total chubs	8
Total dace	17
Total suckers	7
Recaptures	0

Section	13
1st pass chubs	14
1st pass dace	29
1st pass suckers	4
2nd pass chubs	0
2nd pass dace	11
2nd pass suckers	3
Total chubs	14
Total dace	40
Total suckers	7
Recaptures	0

Section	14
1st pass chubs	2
1st pass dace	44
1st pass suckers	8
2nd pass chubs	0
2nd pass dace	7
2nd pass suckers	2
Total chubs	2
Total dace	51
Total suckers	10
Recaptures	0

Section	15
1st pass chubs	1
1st pass dace	23
1st pass suckers	8
2nd pass chubs	0
2nd pass dace	10
2nd pass suckers	2
Total chubs	1
Total dace	33
Total suckers	10
Recaptures	1

Section	16
1st pass chubs	10
1st pass dace	34
1st pass suckers	20
2nd pass chubs	0
2nd pass dace	12
2nd pass suckers	5
Total chubs	10
Total dace	46
Total suckers	25
Recaptures	1

Section	17
1st pass chubs	1
1st pass dace	29
1st pass suckers	21
2nd pass chubs	0
2nd pass dace	13
2nd pass suckers	2
Total chubs	1
Total dace	42
Total suckers	23
Recaptures	1

Section	18
1st pass chubs	2
1st pass dace	12
1st pass suckers	24
2nd pass chubs	4
2nd pass dace	7
2nd pass suckers	4
Total chubs	6
Total dace	19
Total suckers	28
Recaptures	1

Section	19
1st pass chubs	23
1st pass dace	43
1st pass suckers	12
2nd pass chubs	5
2nd pass dace	12
2nd pass suckers	6
Total chubs	28
Total dace	55
Total suckers	18
Recaptures	3

Section	20
1st pass chubs	17
1st pass dace	32
1st pass suckers	21
2nd pass chubs	2
2nd pass dace	10
2nd pass suckers	5
Total chubs	19
Total dace	42
Total suckers	26
Recaptures	2

Section	21
1st pass chubs	20
1st pass dace	23
1st pass suckers	27
2nd pass chubs	3
2nd pass dace	2
2nd pass suckers	0
Total chubs	23
Total dace	25
Total suckers	27
Recaptures	8

Section	22
1st pass chubs	1
1st pass dace	3
1st pass suckers	2
2nd pass chubs	4
2nd pass dace	5
2nd pass suckers	2
Total chubs	5
Total dace	8
Total suckers	4
Recaptures	3

Section	23
1st pass chubs	6
1st pass dace	4
1st pass suckers	0
2nd pass chubs	0
2nd pass dace	4
2nd pass suckers	0
Total chubs	6
Total dace	8
Total suckers	0
Recaptures	3

Section	24
1st pass chubs	9
1st pass dace	7
1st pass suckers	0
2nd pass chubs	4
2nd pass dace	3
2nd pass suckers	0
Total chubs	13
Total dace	10
Total suckers	0
Recaptures	9

BOX	25
1st pass chubs	2
1st pass dace	4
1st pass suckers	0
2nd pass chubs	4
2nd pass dace	1
2nd pass suckers	0
Total chubs	6
Total dace	5
Total suckers	0
Recaptures	1

BOX	26
1st pass chubs	16
1st pass dace	31
1st pass suckers	5
2nd pass chubs	2
2nd pass dace	10
2nd pass suckers	3
Total chubs	18
Total dace	41
Total suckers	8
Recaptures	2

Section	27
1st pass chubs	3
1st pass dace	37
1st pass suckers	16
2nd pass chubs	2
2nd pass dace	10
2nd pass suckers	6
Total chubs	5
Total dace	47
Total suckers	22
Recaptures	4

Section	28
1st pass chubs	6
1st pass dace	49
1st pass suckers	20
2nd pass chubs	1
2nd pass dace	17
2nd pass suckers	4
Total chubs	7
Total dace	66
Total suckers	24
Recaptures	8

Section	29
1st pass chubs	31
1st pass dace	14
1st pass suckers	8
2nd pass chubs	7
2nd pass dace	12
2nd pass suckers	1
Total chubs	38
Total dace	26
Total suckers	9
Recaptures	3

Section	30
1st pass chubs	24
1st pass dace	10
1st pass suckers	2
2nd pass chubs	3
2nd pass dace	3
2nd pass suckers	1
Total chubs	27
Total dace	13
Total suckers	3
Recaptures	3

Section	31
1st pass chubs	13
1st pass dace	14
1st pass suckers	7
2nd pass chubs	17
2nd pass dace	2
2nd pass suckers	3
Total chubs	30
Total dace	16
Total suckers	10
Recaptures	4

Section	32
1st pass chubs	4
1st pass dace	9
1st pass suckers	6
2nd pass chubs	2
2nd pass dace	3
2nd pass suckers	1
Total chubs	6
Total dace	12
Total suckers	7
Recaptures	1

Section	33
1st pass chubs	4
1st pass dace	17
1st pass suckers	13
2nd pass chubs	2
2nd pass dace	10
2nd pass suckers	6
Total chubs	6
Total dace	27
Total suckers	19
Recaptures	2

Section	34
1st pass chubs	2
1st pass dace	10
1st pass suckers	10
2nd pass chubs	0
2nd pass dace	5
2nd pass suckers	1
Total chubs	2
Total dace	15
Total suckers	11
Recaptures	0

Section	35
1st pass chubs	19
1st pass dace	69
1st pass suckers	0
2nd pass chubs	1
2nd pass dace	5
2nd pass suckers	1
Total chubs	20
Total dace	74
Total suckers	1
Recaptures	1

Section	36
1st pass chubs	8
1st pass dace	1
1st pass suckers	0
2nd pass chubs	0
2nd pass dace	0
2nd pass suckers	0
Total chubs	8
Total dace	1
Total suckers	0
Recaptures	0

Section	37
1st pass chubs	0
1st pass dace	0
1st pass suckers	0
2nd pass chubs	0
2nd pass dace	0
2nd pass suckers	0
Total chubs	0
Total dace	0
Total suckers	0
Recaptures	0

Section	38
1st pass chubs	25
1st pass dace	10
1st pass suckers	1
2nd pass chubs	7
2nd pass dace	1
2nd pass suckers	1
Total chubs	32
Total dace	11
Total suckers	2
Recaptures	1

Section	39
1st pass chubs	26
1st pass dace	19
1st pass suckers	6
2nd pass chubs	7
2nd pass dace	7
2nd pass suckers	4
Total chubs	33
Total dace	26
Total suckers	10
Recaptures	2

Section	40
1st pass chubs	16
1st pass dace	19
1st pass suckers	5
2nd pass chubs	3
2nd pass dace	6
2nd pass suckers	1
Total chubs	19
Total dace	25
Total suckers	6
Recaptures	3

Section	41
1st pass chubs	8
1st pass dace	30
1st pass suckers	24
2nd pass chubs	3
2nd pass dace	9
2nd pass suckers	2
Total chubs	11
Total dace	39
Total suckers	26
Recaptures	1

Section	42
1st pass chubs	3
1st pass dace	29
1st pass suckers	20
2nd pass chubs	0
2nd pass dace	1
2nd pass suckers	3
Total chubs	3
Total dace	30
Total suckers	23
Recaptures	1

Section	43
1st pass chubs	4
1st pass dace	31
1st pass suckers	16
2nd pass chubs	0
2nd pass dace	21
2nd pass suckers	7
Total chubs	4
Total dace	52
Total suckers	23
Recaptures	1

Section	44
1st pass chubs	9
1st pass dace	15
1st pass suckers	4
2nd pass chubs	11
2nd pass dace	31
2nd pass suckers	4
Total chubs	20
Total dace	46
Total suckers	8
Recaptures	0

Section	45
1st pass chubs	5
1st pass dace	33
1st pass suckers	9
2nd pass chubs	1
2nd pass dace	11
2nd pass suckers	1
Total chubs	6
Total dace	44
Total suckers	10
Recaptures	1

Section	46
1st pass chubs	1
1st pass dace	27
1st pass suckers	3
2nd pass chubs	3
2nd pass dace	18
2nd pass suckers	0
Total chubs	4
Total dace	45
Total suckers	3
Recaptures	0

Section	47
1st pass chubs	11
1st pass dace	31
1st pass suckers	13
2nd pass chubs	5
2nd pass dace	10
2nd pass suckers	4
Total chubs	16
Total dace	41
Total suckers	17
Recaptures	7

Section	48
1st pass chubs	28
1st pass dace	26
1st pass suckers	14
2nd pass chubs	12
2nd pass dace	18
2nd pass suckers	7
Total chubs	40
Total dace	44
Total suckers	21
Recaptures	7

Section	49
1st pass chubs	46
1st pass dace	39
1st pass suckers	13
2nd pass chubs	16
2nd pass dace	24
2nd pass suckers	5
Total chubs	62
Total dace	63
Total suckers	18
Recaptures	14

STREAM	50
1st pass chubs	35
1st pass dace	25
1st pass suckers	10
2nd pass chubs	5
2nd pass dace	23
2nd pass suckers	3
Total chubs	40
Total dace	48
Total suckers	13
Recaptures	9

STREAM	51
1st pass chubs	5
1st pass dace	26
1st pass suckers	16
2nd pass chubs	0
2nd pass dace	6
2nd pass suckers	0
Total chubs	5
Total dace	32
Total suckers	16
Recaptures	2

Section	52
1st pass chubs	4
1st pass dace	13
1st pass suckers	7
2nd pass chubs	5
2nd pass dace	13
2nd pass suckers	5
Total chubs	9
Total dace	26
Total suckers	12
Recaptures	6

Section	53
1st pass chubs	33
1st pass dace	28
1st pass suckers	10
2nd pass chubs	4
2nd pass dace	8
2nd pass suckers	1
Total chubs	37
Total dace	36
Total suckers	11
Recaptures	17

Section	54
1st pass chubs	32
1st pass dace	42
1st pass suckers	8
2nd pass chubs	16
2nd pass dace	48
2nd pass suckers	4
Total chubs	48
Total dace	90
Total suckers	12
Recaptures	16

Section	55
1st pass chubs	26
1st pass dace	35
1st pass suckers	7
2nd pass chubs	5
2nd pass dace	8
2nd pass suckers	2
Total chubs	31
Total dace	43
Total suckers	9
Recaptures	6

Section	56
1st pass chubs	23
1st pass dace	32
1st pass suckers	6
2nd pass chubs	9
2nd pass dace	9
2nd pass suckers	2
Total chubs	32
Total dace	41
Total suckers	8
Recaptures	3

Section	57
1st pass chubs	10
1st pass dace	13
1st pass suckers	2
2nd pass chubs	9
2nd pass dace	5
2nd pass suckers	3
Total chubs	19
Total dace	18
Total suckers	5
Recaptures	2

Section	58
1st pass chubs	16
1st pass dace	22
1st pass suckers	5
2nd pass chubs	5
2nd pass dace	12
2nd pass suckers	5
Total chubs	21
Total dace	34
Total suckers	10
Recaptures	0

Section	59
1st pass chubs	8
1st pass dace	13
1st pass suckers	4
2nd pass chubs	3
2nd pass dace	8
2nd pass suckers	2
Total chubs	11
Total dace	21
Total suckers	6
Recaptures	0

Section	60
1st pass chubs	28
1st pass dace	30
1st pass suckers	8
2nd pass chubs	1
2nd pass dace	5
2nd pass suckers	1
Total chubs	29
Total dace	35
Total suckers	9
Recaptures	1

Section	61
1st pass chubs	5
1st pass dace	17
1st pass suckers	3
2nd pass chubs	4
2nd pass dace	13
2nd pass suckers	5
Total chubs	9
Total dace	30
Total suckers	8
Recaptures	0

Section	62
1st pass chubs	15
1st pass dace	23
1st pass suckers	4
2nd pass chubs	7
2nd pass dace	5
2nd pass suckers	1
Total chubs	22
Total dace	28
Total suckers	5
Recaptures	1

Section	63
1st pass chubs	14
1st pass dace	49
1st pass suckers	1
2nd pass chubs	5
2nd pass dace	15
2nd pass suckers	2
Total chubs	19
Total dace	64
Total suckers	3
Recaptures	1

Section	64
1st pass chubs	2
1st pass dace	29
1st pass suckers	12
2nd pass chubs	3
2nd pass dace	12
2nd pass suckers	7
Total chubs	5
Total dace	41
Total suckers	19
Recaptures	1

Section	65
1st pass chubs	4
1st pass dace	24
1st pass suckers	13
2nd pass chubs	3
2nd pass dace	13
2nd pass suckers	1
Total chubs	7
Total dace	37
Total suckers	14
Recaptures	0

Section	66
1st pass chubs	3
1st pass dace	23
1st pass suckers	6
2nd pass chubs	0
2nd pass dace	8
2nd pass suckers	3
Total chubs	3
Total dace	31
Total suckers	9
Recaptures	0

Section	67
1st pass chubs	3
1st pass dace	18
1st pass suckers	6
2nd pass chubs	4
2nd pass dace	6
2nd pass suckers	4
Total chubs	7
Total dace	24
Total suckers	10
Recaptures	0

Section	68
1st pass chubs	15
1st pass dace	19
1st pass suckers	6
2nd pass chubs	6
2nd pass dace	16
2nd pass suckers	2
Total chubs	21
Total dace	35
Total suckers	8
Recaptures	3

Section	69
1st pass chubs	15
1st pass dace	33
1st pass suckers	3
2nd pass chubs	7
2nd pass dace	11
2nd pass suckers	0
Total chubs	22
Total dace	44
Total suckers	3
Recaptures	5

Section	70
1st pass chubs	10
1st pass dace	17
1st pass suckers	2
2nd pass chubs	1
2nd pass dace	7
2nd pass suckers	1
Total chubs	11
Total dace	24
Total suckers	3
Recaptures	1

Section	71
1st pass chubs	4
1st pass dace	13
1st pass suckers	6
2nd pass chubs	1
2nd pass dace	4
2nd pass suckers	0
Total chubs	5
Total dace	17
Total suckers	6
Recaptures	4

Section	72
1st pass chubs	14
1st pass dace	24
1st pass suckers	6
2nd pass chubs	5
2nd pass dace	10
2nd pass suckers	3
Total chubs	19
Total dace	34
Total suckers	9
Recaptures	4

Section	73
1st pass chubs	2
1st pass dace	33
1st pass suckers	47
2nd pass chubs	2
2nd pass dace	17
2nd pass suckers	6
Total chubs	4
Total dace	50
Total suckers	53
Recaptures	5

Section	74
1st pass chubs	4
1st pass dace	27
1st pass suckers	10
2nd pass chubs	0
2nd pass dace	15
2nd pass suckers	5
Total chubs	4
Total dace	42
Total suckers	15
Recaptures	6

ARCH	75
1st pass chubs	1
1st pass dace	13
1st pass suckers	0
2nd pass chubs	0
2nd pass dace	2
2nd pass suckers	0
Total chubs	1
Total dace	15
Total suckers	0
Recaptures	0

ARCH	76
1st pass chubs	5
1st pass dace	20
1st pass suckers	1
2nd pass chubs	4
2nd pass dace	5
2nd pass suckers	5
Total chubs	9
Total dace	25
Total suckers	6
Recaptures	2

Section	77
1st pass chubs	5
1st pass dace	6
1st pass suckers	3
2nd pass chubs	2
2nd pass dace	7
2nd pass suckers	3
Total chubs	7
Total dace	13
Total suckers	6
Recaptures	2

Section	78
1st pass chubs	25
1st pass dace	15
1st pass suckers	3
2nd pass chubs	9
2nd pass dace	7
2nd pass suckers	4
Total chubs	34
Total dace	22
Total suckers	7
Recaptures	8

Section	79
1st pass chubs	7
1st pass dace	13
1st pass suckers	3
2nd pass chubs	5
2nd pass dace	6
2nd pass suckers	0
Total chubs	12
Total dace	19
Total suckers	3
Recaptures	8

Section	80
1st pass chubs	7
1st pass dace	17
1st pass suckers	8
2nd pass chubs	5
2nd pass dace	24
2nd pass suckers	13
Total chubs	12
Total dace	41
Total suckers	21
Recaptures	9

Section	81
1st pass chubs	14
1st pass dace	4
1st pass suckers	0
2nd pass chubs	10
2nd pass dace	4
2nd pass suckers	2
Total chubs	24
Total dace	8
Total suckers	2
Recaptures	2

Section	82
1st pass chubs	30
1st pass dace	66
1st pass suckers	0
2nd pass chubs	2
2nd pass dace	22
2nd pass suckers	2
Total chubs	32
Total dace	88
Total suckers	2
Recaptures	2

Section	83
1st pass chubs	6
1st pass dace	34
1st pass suckers	17
2nd pass chubs	1
2nd pass dace	11
2nd pass suckers	3
Total chubs	7
Total dace	45
Total suckers	20
Recaptures	1

Section	84
1st pass chubs	3
1st pass dace	11
1st pass suckers	15
2nd pass chubs	4
2nd pass dace	9
2nd pass suckers	8
Total chubs	7
Total dace	20
Total suckers	23
Recaptures	2

Section	85
1st pass chubs	8
1st pass dace	31
1st pass suckers	9
2nd pass chubs	2
2nd pass dace	12
2nd pass suckers	1
Total chubs	10
Total dace	43
Total suckers	10
Recaptures	1

Section	86
1st pass chubs	4
1st pass dace	22
1st pass suckers	4
2nd pass chubs	0
2nd pass dace	10
2nd pass suckers	4
Total chubs	4
Total dace	32
Total suckers	8
Recaptures	1

Section	87
1st pass chubs	10
1st pass dace	19
1st pass suckers	2
2nd pass chubs	3
2nd pass dace	10
2nd pass suckers	4
Total chubs	13
Total dace	29
Total suckers	6
Recaptures	0

Section	88
1st pass chubs	45
1st pass dace	15
1st pass suckers	4
2nd pass chubs	6
2nd pass dace	11
2nd pass suckers	0
Total chubs	51
Total dace	26
Total suckers	4
Recaptures	0

Section	Species	Length	Color	Location	Initial Placement	Originally Caught	Originally Released
9	chub	77	yellow	ventral caudal	Box	Box DS	DS
10	chub	76	orange	dorsal caudal	Stream	Stream US	US
15	dace	57	yellow	anal	Box	Box US	US
16	chub	47	pink	anal	Box	Box DS	US
17	dace	63	green	dorsal caudal	Arch	Arch US	US
18	dace	66	pink	anal	Box	Box DS	US
19	chub	75	yellow	ventral caudal	Box	Box DS	DS
19	sucker	118	yellow	ventral caudal	Box	Box DS	DS
19	sucker	154	yellow	anal	Box	Box US	US
20	chub	102	pink	anal	Box	Box DS	US
20	chub	80	pink	anal	Box	Box DS	US
21	chub	83	yellow	ventral caudal	Box	Box DS	DS
21	chub	92	pink	anal	Box	Box DS	US
21	chub	90	pink	anal	Box	Box DS	US
21	chub	85	yellow	ventral caudal	Box	Box DS	DS
21	chub	74	pink	anal	Box	Box DS	US
21	chub	62	yellow	anal	Box	Box US	US
21	dace	75	pink	anal	Box	Box DS	US
21	sucker	157	pink	anal	Box	Box DS	US
22	chub	95	pink	anal	Box	Box DS	US
22	dace	66	yellow	ventral caudal	Box	Box DS	DS
22	dace	73	pink	anal	Box	Box DS	US
23	chub	110	yellow	ventral caudal	Box	Box DS	DS
23	chub	72	pink	anal	Box	Box DS	US
23	dace	65	pink	anal	Box	Box DS	US
24	chub	78	pink	anal	Box	Box DS	US
24	chub	76	pink	anal	Box	Box DS	US
24	chub	101	pink	anal	Box	Box DS	US
24	chub	92	yellow	ventral caudal	Box	Box DS	DS
24	chub	86	yellow	ventral caudal	Box	Box DS	DS
24	chub	92	yellow	ventral caudal	Box	Box DS	DS
24	chub	78	yellow	ventral caudal	Box	Box DS	DS
24	chub	98	pink	anal	Box	Box DS	US
24	chub	83	yellow	ventral caudal	Box	Box DS	DS
25	dace	71	yellow	ventral caudal	Box	Box DS	DS
26	chub	91	yellow	dorsal caudal	Box	Box US	DS
26	dace	65	pink	anal	Box	Box DS	US
27	chub	102	yellow	dorsal caudal	Box	Box US	DS
27	dace	65	yellow	anal	Box	Box US	US
27	dace	83	yellow	anal	Box	Box US	US
27	sucker	102	yellow	anal	Box	Box US	US
28	chub	94	pink	anal	Box	Box DS	US
28	chub	90	pink	anal	Box	Box DS	US
28	dace	72	yellow	dorsal caudal	Box	Box US	DS
28	dace	67	yellow	anal	Box	Box US	US
28	dace	77	yellow	anal	Box	Box US	US
28	dace	83	yellow	anal	Box	Box US	US
28	dace	60	pink	anal	Box	Box DS	US
28	dace	77	yellow	dorsal caudal	Box	Box US	DS
29	chub	79	yellow	anal	Box	Box US	US
29	dace	69	yellow	ventral caudal	Box	Box DS	DS
29	dace	67	yellow	anal	Box	Box US	US
30	chub	78	pink	anal	Box	Box DS	US
30	chub	87	yellow	dorsal caudal	Box	Box US	DS
30	chub	98	yellow	dorsal caudal	Box	Box US	DS
31	chub	75	yellow	anal	Box	Box US	US

Section	Species	Length	Color	Location	Initial Placement	Originally Caught	Originally Released
31	chub	86	yellow	anal	Box	Box US	US
31	chub	75	yellow	dorsal caudal	Box	Box US	DS
31	chub	84	yellow	anal	Box	Box US	US
32	chub	83	yellow	anal	Box	Box US	US
33	sucker	111	yellow	dorsal caudal	Box	Box US	DS
33	sucker	108	yellow	anal	Box	Box US	US
35	chub	84	pink	dorsal caudal	Stream	Stream DS	US
38	chub	95	pink	ventral caudal	Arch	Arch DS	US
39	chub	74	orange	anal	Stream	Stream US	DS
39	chub	74	orange	dorsal caudal	Stream	Stream US	US
40	chub	80	orange	ventral caudal	Stream	Stream DS	DS
40	chub	37	orange	dorsal caudal	Stream	Stream US	US
40	chub	85	orange	ventral caudal	Stream	Stream DS	DS
41	chub	44	orange	ventral caudal	Stream	Stream DS	DS
42	sucker	94	orange	dorsal caudal	Stream	Stream US	US
43	chub	81	orange	ventral caudal	Stream	Stream DS	DS
45	chub	64	orange	ventral caudal	Stream	Stream DS	DS
47	chub	45	orange	dorsal caudal	Stream	Stream US	US
47	chub	92	orange	ventral caudal	Stream	Stream DS	DS
47	chub	73	orange	ventral caudal	Stream	Stream DS	DS
47	chub	79	pink	dorsal caudal	Stream	Stream DS	US
47	dace	70	orange	ventral caudal	Stream	Stream DS	DS
47	dace	72	pink	dorsal caudal	Stream	Stream DS	US
47	sucker	86	orange	anal	Stream	Stream US	DS
48	chub	110	pink	dorsal caudal	Stream	Stream DS	US
48	chub	98	orange	ventral caudal	Stream	Stream DS	DS
48	chub	87	orange	dorsal caudal	Stream	Stream US	US
48	chub	95	orange	ventral caudal	Stream	Stream DS	DS
48	chub	83	orange	ventral caudal	Stream	Stream DS	DS
48	dace	65	pink	dorsal caudal	Stream	Stream DS	US
48	dace	59	pink	dorsal caudal	Stream	Stream DS	US
49	chub	81	orange	ventral caudal	Stream	Stream DS	DS
49	chub	81	orange	anal	Stream	Stream US	DS
49	chub	93	orange	dorsal caudal	Stream	Stream US	US
49	chub	79	orange	ventral caudal	Stream	Stream DS	DS
49	chub	74	orange	anal	Stream	Stream US	DS
49	chub	66	orange	dorsal caudal	Stream	Stream US	US
49	chub	75	pink	dorsal caudal	Stream	Stream DS	US
49	chub	69	orange	dorsal caudal	Stream	Stream US	US
49	chub	45	orange	ventral caudal	Stream	Stream DS	DS
49	dace	69	orange	ventral caudal	Stream	Stream DS	DS
49	dace	54	pink	dorsal caudal	Stream	Stream DS	US
49	dace	66	orange	ventral caudal	Stream	Stream DS	DS
49	dace	74	orange	ventral caudal	Stream	Stream DS	DS
49	sucker	119	orange	anal	Stream	Stream US	DS
50	chub	79	orange	anal	Stream	Stream US	DS
50	chub	81	orange	ventral caudal	Stream	Stream DS	DS
50	chub	52	orange	dorsal caudal	Stream	Stream US	US
50	chub	75	pink	dorsal caudal	Stream	Stream DS	US
50	chub	80	orange	dorsal caudal	Stream	Stream US	US
50	chub	72	orange	anal	Stream	Stream US	DS
50	dace	53	pink	dorsal caudal	Stream	Stream DS	US
50	dace	55	pink	dorsal caudal	Stream	Stream DS	US
50	dace	58	pink	dorsal caudal	Stream	Stream DS	US
51	dace	70	orange	dorsal caudal	Stream	Stream US	US
51	dace	53	orange	anal	Stream	Stream US	DS

Section	Species	Length	Color	Location	Initial Placement	Originally Caught	Originally Released
52	chub	98	orange	ventral caudal	Stream	Stream DS	DS
52	chub	106	orange	dorsal caudal	Stream	Stream US	US
52	chub	96	orange	dorsal caudal	Stream	Stream US	US
52	chub	81	orange	anal	Stream	Stream US	DS
52	dace	78	orange	anal	Stream	Stream US	DS
52	dace	63	orange	dorsal caudal	Stream	Stream US	US
53	chub	78	orange	anal	Stream	Stream US	DS
53	chub	71	orange	anal	Stream	Stream US	DS
53	chub	108	orange	dorsal caudal	Stream	Stream US	US
53	chub	83	orange	anal	Stream	Stream US	DS
53	chub	82	orange	dorsal caudal	Stream	Stream US	US
53	chub	90	orange	dorsal caudal	Stream	Stream US	US
53	chub	88	orange	dorsal caudal	Stream	Stream US	US
53	chub	72	orange	dorsal caudal	Stream	Stream US	US
53	chub	98	orange	dorsal caudal	Stream	Stream US	US
53	dace	75	orange	dorsal caudal	Stream	Stream US	US
53	dace	59	orange	dorsal caudal	Stream	Stream US	US
53	dace	66	orange	dorsal caudal	Stream	Stream US	US
53	dace	74	orange	dorsal caudal	Stream	Stream US	US
53	dace	65	orange	dorsal caudal	Stream	Stream US	US
53	dace	64	orange	ventral caudal	Stream	Stream DS	DS
53	dace	68	orange	anal	Stream	Stream US	DS
53	sucker	70	green	anal	Arch	Arch US	DS
54	chub	88	orange	dorsal caudal	Stream	Stream US	US
54	chub	72	orange	anal	Stream	Stream US	DS
54	chub	93	orange	anal	Stream	Stream US	DS
54	chub	93	orange	dorsal caudal	Stream	Stream US	US
54	chub	88	orange	anal	Stream	Stream US	DS
54	chub	77	orange	anal	Stream	Stream US	DS
54	chub	62	orange	ventral caudal	Stream	Stream DS	DS
54	chub	66	orange	anal	Stream	Stream US	DS
54	dace	77	orange	anal	Stream	Stream US	DS
54	dace	44	orange	ventral caudal	Stream	Stream DS	DS
54	dace	67	orange	ventral caudal	Stream	Stream DS	DS
54	dace	68	orange	ventral caudal	Stream	Stream DS	DS
54	dace	54	orange	anal	Stream	Stream US	DS
54	dace	51	orange	dorsal caudal	Stream	Stream US	US
54	dace	43	pink	dorsal caudal	Stream	Stream DS	US
54	sucker	102	pink	dorsal caudal	Stream	Stream DS	US
55	chub	91	orange	ventral caudal	Stream	Stream DS	DS
55	chub	79	pink	dorsal caudal	Stream	Stream DS	US
55	chub	71	orange	dorsal caudal	Stream	Stream US	US
55	chub	60	pink	dorsal caudal	Stream	Stream DS	US
55	chub	60	orange	anal	Stream	Stream US	DS
55	dace	74	orange	anal	Stream	Stream US	DS
56	chub	50	pink	ventral caudal	Arch	Arch DS	US
56	chub	89	orange	anal	Stream	Stream US	DS
56	chub	84	orange	anal	Stream	Stream US	DS
57	chub	80	pink	dorsal caudal	Stream	Stream DS	US
57	chub	69	pink	dorsal caudal	Stream	Stream DS	US
60	dace	51	green	ventral caudal	Arch	Arch DS	DS
62	chub	68	orange	ventral caudal	Stream	Stream DS	DS
63	dace	72	pink	ventral caudal	Arch	Arch DS	US
64	sucker	108	pink	ventral caudal	Arch	Arch DS	US
68	chub	63	green	dorsal caudal	Arch	Arch US	US
68	chub	79	pink	ventral caudal	Arch	Arch DS	US

Section	Species	Length	Color	Location	Initial Placement	Originally Caught	Originally Released
68	dace	65	green	anal	Arch	Arch US	DS
69	chub	71	green	dorsal caudal	Arch	Arch US	US
69	chub	92	pink	ventral caudal	Arch	Arch DS	US
69	chub	73	green	ventral caudal	Arch	Arch DS	DS
69	chub	50	green	ventral caudal	Arch	Arch DS	DS
69	chub	82	green	ventral caudal	Arch	Arch DS	DS
70	dace	67	pink	ventral caudal	Arch	Arch DS	US
71	chub	78	green	anal	Arch	Arch US	DS
71	chub	86	green	ventral caudal	Arch	Arch DS	DS
71	chub	69	green	anal	Arch	Arch US	DS
71	dace	65	pink	ventral caudal	Arch	Arch DS	US
72	chub	82	pink	ventral caudal	Arch	Arch DS	US
72	chub	67	green	ventral caudal	Arch	Arch DS	DS
72	chub	64	pink	ventral caudal	Arch	Arch DS	US
72	chub	68	green	ventral caudal	Arch	Arch DS	DS
73	dace	68	pink	ventral caudal	Arch	Arch DS	US
73	dace	53	green	ventral caudal	Arch	Arch DS	DS
73	dace	68	green	ventral caudal	Arch	Arch DS	DS
73	dace	69	pink	ventral caudal	Arch	Arch DS	US
73	dace	44	green	ventral caudal	Arch	Arch DS	DS
74	dace	69	green	ventral caudal	Arch	Arch DS	DS
74	dace	55	green	ventral caudal	Arch	Arch DS	DS
74	dace	67	pink	ventral caudal	Arch	Arch DS	US
74	dace	68	pink	ventral caudal	Arch	Arch DS	US
74	dace	62	green	ventral caudal	Arch	Arch DS	DS
74	sucker	120	green	ventral caudal	Arch	Arch DS	DS
76	dace	54	green	dorsal caudal	Arch	Arch US	US
76	sucker	120	green	ventral caudal	Arch	Arch DS	DS
77	chub	80	green	anal	Arch	Arch US	DS
77	sucker	118	green	anal	Arch	Arch US	DS
78	chub	88	green	anal	Arch	Arch US	DS
78	chub	89	green	anal	Arch	Arch US	DS
78	chub	67	green	anal	Arch	Arch US	DS
78	chub	78	green	anal	Arch	Arch US	DS
78	chub	70	green	dorsal caudal	Arch	Arch US	US
78	chub	79	green	anal	Arch	Arch US	DS
78	chub	103	green	dorsal caudal	Arch	Arch US	US
78	chub	82	green	anal	Arch	Arch US	DS
79	chub	72	pink	ventral caudal	Arch	Arch DS	US
79	chub	56	green	anal	Arch	Arch US	DS
79	chub	93	green	dorsal caudal	Arch	Arch US	US
79	chub	102	green	dorsal caudal	Arch	Arch US	US
79	chub	103	green	anal	Arch	Arch US	DS
79	chub	76	green	dorsal caudal	Arch	Arch US	US
79	dace	67	green	anal	Arch	Arch US	DS
79	dace	62	yellow	anal	Box	Box US	US
80	chub	67	green	dorsal caudal	Arch	Arch US	US
80	chub	65	pink	ventral caudal	Arch	Arch DS	US
80	chub	83	green	anal	Arch	Arch US	DS
80	chub	76	green	anal	Arch	Arch US	DS
80	dace	72	green	anal	Arch	Arch US	DS
80	dace	64	green	anal	Arch	Arch US	DS
80	dace	67	green	dorsal caudal	Arch	Arch US	US
80	dace	59	green	anal	Arch	Arch US	DS
80	sucker	130	green	anal	Arch	Arch US	DS
81	chub	50	green	dorsal caudal	Arch	Arch US	US

Section	Species	Length	Color	Location	Initial Placement	Originally Caught	Originally Released
81	chub	58	pink	dorsal caudal	Stream	Stream DS	US
82	chub	64	green	dorsal caudal	Arch	Arch US	US
82	dace	62	green	dorsal caudal	Arch	Arch US	US
83	sucker	68	green	anal	Arch	Arch US	DS
84	sucker	139	green	anal	Arch	Arch US	DS
84	sucker	125	yellow	anal	Box	Box US	US
85	sucker	73	orange	ventral caudal	Stream	Stream DS	DS
86	sucker	130	green	dorsal caudal	Arch	Arch US	US