Fish Passage

Appendix 4

Appendix 4

HABITAT QUALITY, BIOTIC CHARACTERIZATION, AND FISH PASSAGE ASSESSMENT OF WATER DIVERSIONS ON NINE TRIBUTARIES IN THE SOUTH FORK OF THE TRINITY RIVER WATERSHED, TRINITY COUNTY, CA

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EXECUTIVE SUMMARY

The California Department of Fish and Wildlife (CDFW) maintains and monitors water diversions around Trinity County. However, they do not conduct habitat or fish assessments around these diversions. In this report, nine stream sections were surveyed for potential habitat and fish population impacts from known and unknown diversion structures. Rattlesnake Creek, Silver Creek, and an unnamed tributary to the South Fork of the Trinity River were surveyed for the potential presence of unknown diversion structures. No unknown structures were found. Two previously reported diversion structures on Rattlesnake Creek and an unnamed tributary of the South Fork of the Trinity River had been removed. Two diversion structures were surveyed on Big Creek and one structure each was surveyed on Olsen Creek, Silver Creek, Upper Tule Creek, and West Tule Creek. No survey was conducted on the Lower Tule Creek structure because the creek was dry. Fish passage structures and efficiency were surveyed, where present, at the upper diversion structure on Big Creek, Olsen Creek, and Upper Tule Creek. There were no strong habitat trends above and below the structures except for in the undercut bank metric. On average, there was twice the undercut bank cover for aquatic organisms, 20%, above compared to below the diversions, 10%. There was also more overhanging vegetation below diversions as compared to above the diversions. Substrate had more distinct trends when compared above and below diversions. Overall, there was usually more bedrock below the diversions and more fines above the diversions. Only two species of salmonids, chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout/steelhead (*Oncorhynchus mykiss*) complexes were found in the snorkel surveys. Two species of warm water fish were also observed, speckled dace (*Rhinichthys osculus*) and suckerfish (*Catostomus* spp). Other species observed included Pacific Giant Salamanders (*Dicamptodon* spp), Foothill Yellow legged frogs (*Rana boylii*), and crayfish. It appears that the diversion structures are impacting fish populations. The average density of every size class, except the smallest (2.5-7.5 cm) and the two largest (22.9-27.5 cm and 60.96 cm), was higher below the diversion than above the diversion. At the time of the survey, the fish passage structures did not allow passage for any life history stage of fish. It is probable that none of the structures allow upstream passage of juveniles at any flows. This suggests that only adults are passing the diversions and spawning above the diversions, allowing the smallest size class to rear and, ideally, disperse downstream under certain flows. Management recommendations to improve fish passage through flow management, diversion retrofit, or diversion removal were made for each site.

INTRODUCTION

The South Fork Trinity River (SFTR) watershed is approximately 2,414 square km (932 square miles). The SFTR is the longest undammed river remaining in California. 56 miles of the river are protected by the California Wild and Scenic Rivers Act and large portions of the basin are designated as Roadless and Wilderness management prescriptions by the United States Forest Service (Foster Wheeler Environmental Corporation 2001; Truman et al. 1996). 82% of the basin is under federal ownership (NMFS, 2014). Sprinkled into river valley bottoms, small dispersed populations and communities, such as Hyampom and Hayfork, contribute to the main human-caused impacts to this watershed. Human population is limited by rugged terrain with approximately 3,500 people living in the entire basin. Many inhabitants rely on water diversions from local streams for domestic and agricultural purposes. Recently, Van Kirk and Naman (2008) found that "river discharge of the South Fork Trinity River was significantly lower in the period from 1977 to 2005 than the period from 1966 to 1976. This decrease in flow is likely due to a combination of increasing water utilization, land use changes, and climate change." The SFTR is presently TMDL listed for sediment and 303(d) listed for temperature impairment.

The SFTR holds vast potential as habitat for anadromous fisheries. A number of factors contribute to the watershed's suitability to support fisheries including high intrinsic potential, limited human population, land designations supporting the area's wild character, and the relatively healthy condition of the watershed. The SFTR, in particular Hayfork Creek, with its side channels, low gradient, and comparatively limited human influence, is well-suited coho habitat. According to 2008 studies by Everest and Boberg, "The lower part of Hayfork Creek has the greatest extent of high IP habitat and with increased water quality; this section of Hayfork Creek could serve as the major seat of recovery for coho salmon in the South Fork Trinity River basin. Other important tributaries where coho salmon have recently been found include Butter Creek, Eltapom Creek, Olsen Creek, and Madden Creek" (NMFS, 2014).

Numerous reports have recognized the need to identify, prioritize, and implement fish passage projects to increase access to rearing and refuge habitats. The Southern Oregon and Northern California Coast (SONCC) Coho Salmon Recovery Plan (NMFS, 2014) emphasizes the need to protect access to cold water tributary streams to ensure that thermal refugia are available for hot summer periods. The Pacific Watershed Associates Action Plan for the Restoration of the South Fork Trinity River and Fisheries (1994) calls for identification and implementation of improved fish passage. Recent research in the South Fork Trinity River indicates that both summer and winter refugia associated with the lower reaches of tributaries are critical for the survival of juvenile salmonids (NMFS, 2014).

The identification and prioritization of juvenile and adult fish passage barriers based on existing fish populations and habitat quality will help develop best management practices (BMPs) as well as identify restoration opportunities. Water diversions for domestic and agricultural use are limiting the watershed's ability to support coho by negatively influencing stream temperatures and associated water quality. Fortunately, with a relatively limited investment, we could make a big impact in the viability of coho habitat in the SFTR. According to Pacific Watershed Associates in a 1994 study, there are only 18 recorded diversions on the SFTR. This number has increased significantly in recent years. The California State Water Resources Control Board currently has water rights and statement of diversions filed for 217 diversions on the SFTR and its tributaries (California Environmental Protection Agency, 2016). However, there are also increasing numbers of illegal diversions being utilized in the South Fork of the

Trinity River watershed. “Dams and diversions present a high threat to the population and affect multiple life stages. Although no major dams exist on the South Fork Trinity River, numerous wells and diversions for domestic and agricultural uses occur throughout the watershed and reduce streamflows during critical low-flow periods” (NMFS, 2014). “Although there is a need for more recent assessments, the need for fish screens on diversions in Barker, Big, E. Fork Hayfork, Upper Hayfork, Little, Olsen, Salt, and Tule Creeks was identified by PWA (1994). Because of impacts on summer rearing, diversions pose a very high threat to the juvenile life stage.” (NMFS, 2014).

As a part of a larger Watershed Assessment for the SFTR the Watershed Research and Training Center (WRTC) assessed numerous tributaries within the South Fork Trinity River to identify chronic barriers to anadromous fish passage at a series of diversions. A stream summary report was prepared for each stream outlining the results of the biotic and habitat surveys as well as restoration recommendations. This report compares the different streams and discusses overall restoration opportunities and BMPs for the operation of diversions in the SFTR watershed.

PURPOSE AND NEED

The SONCC identified “Barrier Modification for Fish Passage” (HB) and “Fish Screening of Diversions” (SC) as high priority projects for coho recovery on the SFTR (NMFS, 2014).

The purpose of this project was to assess fish passage at all major known stream diversions, and if possible, treatments prescribed to enhance passage. Survey results will allow managers to understand which populations may be available to utilize habitat made available by improved passage conditions as well as infer potential impacts to tributary populations from impaired fish passage at diversion structures. The WRTC acquired a list of 63 *regulated* diversions from the Water Board’s Division of Water Rights. With limited funds for this assessment, we prioritized assessment on streams that were either known to have had coho salmon or had very high intrinsic potential for coho and were known to be utilized by other salmonids. The following stream diversions were not prioritized for assessment due to small stream size, small diversion size, or lack of fish presence: Duncan, Alder, Cold, Cow, Little Rat, Mill, and Monroe creeks. There were also several streams that were not assessed for additional factors, identified below:

- there were no known diversions: Grouse, and Madden/Old Campbell creeks.
- any known diversions exist above anadromous barriers: Butter, Plummer, Eltapom creeks.
- there was either no landowner contact or no permission: Philpot, Rusch, Barker, Carr, Summit, East Fork Hayfork, Kerlin, Salt, and mainstem Hayfork creeks.
- the second major diversion structure on Big Creek (Hayfork) was upgraded by CDFW very recently.

For this study we only surveyed constructed diversions. The vast majority of the diversions in the SFTR are pumps in streams, not constructed diversion infrastructure that needs fish passage structures. Attempts to walk a range of streams with CDFW wardens were made multiple times but scheduling conflicts arose often and in the end the wardens decided that they would conduct the surveys without a fish biologist due to the potentially dangerous nature of this effort. It is recommended that in the future, streams be surveyed for cumulative diversion impact based on population density.

METHODS

Diversion assessments determined whether constructed diversions were present in an area and whether there were sufficient operating fish passage structures to gain access to upstream habitat. This survey quantified fish habitat quality and fish assemblage characteristics (diversity, age structure, and density) below, in, and above diversion structures. Eight diversion structures (Upper Big Creek Diversion (Hayfork), Lower Big Creek Diversion (Hayfork), Lower Tule Creek, Olsen Creek, Rattlesnake Creek, Silver Creek, Upper Tule Creek, and West Tule Creek were surveyed by Samantha Chilcote using this methodology and are reported on herein. Three streams were walked in order to locate both known and unrecorded diversion structures. 0.15 km of an unnamed tributary to the South Fork of the Trinity River, 0.53 km of Silver Creek, and 0.85 km of Rattlesnake Creek were surveyed.

Survey timing

Surveys were conducted opportunistically because of the need in many cases to obtain permission from private property owners (Table 1).

Table 1. Diversion structure and stream survey dates and relative discharge at the USGS gauge on the South Fork of the Trinity River at Hyampom (USGS, 2016). Lower Tule is not included due to the creek being dry. Units are cubic meters per second (cms) and cubic feet per second (cfs).

Stream/Structure	Date	USGS Streamflow	
		cms	cfs
Big Creek Upper Diversion	6/25/15	1.95	68.90
Olsen Creek	11/13/14	2.35	83.04
Upper Tule Creek	9/4/15	0.40	14.13
Big Creek Lower Diversion	10/5/15	0.65	22.97
Silver Creek	11/11/14	2.10	74.20
West Tule Creek	9/4/15	0.40	14.13
Rattlesnake Creek	11/10/14	2.18	77.03
Unnamed tributary of the South Fork of the Trinity River	11/11/14	2.10	74.20

Reach determination

Initially, two reaches were identified for habitat and snorkel surveys. The first reach was below the diversion structure and the second reach was above the diversion structure. Any diversion channels were surveyed, as well as areas inside diversions, and fish passage structures if present. Reach locations and extents were determined by 1) diversion structure, 2) ideal reach length of 100-150 m, and 3) hydrogeomorphic structure of the water body (changes in geologic confinement, pool riffle structure, etc). For every reach, a GPS point and 2 georeferenced photos (looking upstream and looking downstream) were taken to characterize the beginning and end of each survey reach.

Biotic surveys

Snorkel surveys were conducted before there was any instream disturbance. The snorkeler started at the downstream end of the reach and pulled themselves upstream against the current. This allowed a more accurate count of fish because they are usually oriented upstream for feeding from the current (Fausch, 1984). When both banks of the stream were not visible from the thalweg due to stream width or reduced visibility, the snorkeler worked back and forth from bank to bank, moving in a zigzag fashion upstream until the reach end. Areas which were shallower than 0.1m were surveyed with overhead visual surveys and fish were noted.

Each fish was identified by species and size class, less than 2.5 cm (young of the year, YOY), 2.5-7.6 cm, 7.6-12.7 cm, 12.7-17.8 cm, 17.8-22.9 cm, and 22.9-27.9 cm. Size classes were used to infer age class structure of fish and other amphibians utilizing the reach. The stream dimensions are later used to convert the abundance numbers to density measurements for reach comparisons. Previous analyses has shown very close correlation between densities based on area and volume, so only densities based on area are used in statistical analysis.

Habitat surveys

Habitat surveys were conducted in all reaches where active diversion structures were found and the stream channel was not dry. Survey data was collected on a total of 6 diversions on 5 streams, Big Creek Upper Diversion (Hayfork), Big Creek Lower Diversion (Hayfork), Olsen Creek, Silver Creek, Upper Tule Creek, and West Tule Creek.

Habitat conditions in each survey reach were characterized by visually estimating average conditions of different components through the study reach. Data was collected on reach length and width, percent cover overhanging vegetation, percent canopy cover, percent aquatic vegetation, percent large wood cover, and substratum size. Reach width was the average wetted width of the channel. Reach length was estimated in the field and also verified with Google Earth pathway measurements.

Other habitat features, such as percent of the stream which was covered by refugia and different substrate types, were also characterized in the field. Refugia were defined as areas of potential cover for aquatic vertebrates, such as undercut banks, overhanging vegetation, and large wood. Undercut banks were defined as areas within the wetted channel that have been scoured by stream flows, causing concave areas under the bank. Overhanging vegetation was characterized as terrestrial grasses and low bushes. To determine the percent of overhanging and canopy cover, only the area of the wetted portion of the stream which has the particular vegetation type hanging over it was considered. Aquatic vegetation assessments included any plants which were rooted underwater as well as algae. Large wood was defined as pieces greater than 1.83m long and at least 7.6cm in diameter which were at least partially associated with the wetted channel. Wood provides cover to fish but also contributes to habitat complexity. Substrate type was visually estimated as the amount of bottom area of each pool with a particular substrate type or percent cover. Substrate types were defined as fine/sand (< 2mm), gravel (2 – 64 mm), cobble (64 – 256 mm), and boulder/bedrock (256 mm <) (Bain et al., 1985).

Supplemental Measures

There were important supplemental measures to investigate the particular objectives of this project. If a diversion structure was present, the physical attributes of the diversion were measured and recorded, such as height, width, depth, and composition (such as rock or concrete). Diversion height was measured as the distance from the water surface elevation to the lowest structure point within the active channel. If a fish passage structure was associated with the diversion, the fish passage structure was characterized with supplemental measures. For each section of the fish passage structure, the length and width of the potential pool areas, jumping and landing pool depth, flow notch width, water surface height to flow notch, and flow notch to top of the structure were measured and recorded (Figure 1).

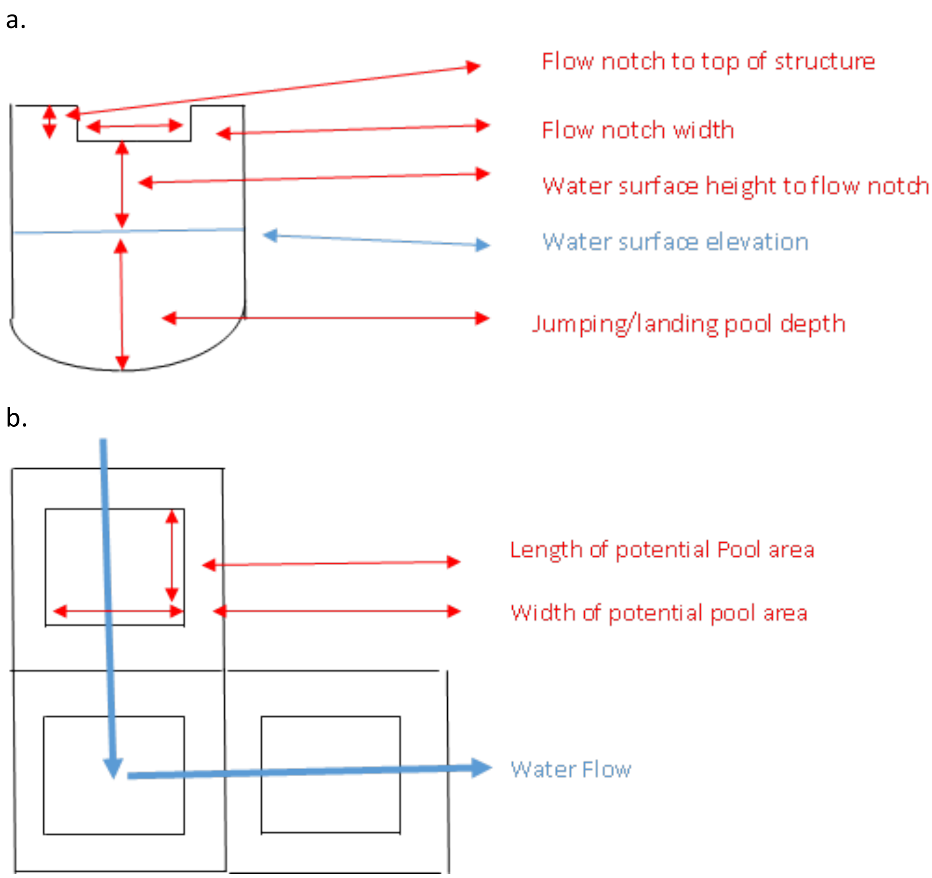

Figure 1. Measurements locations for supplemental measures on a diversion structure. a. looking frontally at a passage structure and b. planar view down on the fish passage structure.

The jumping pool depth was measured as the deepest part of the pool immediately below the notched wall as opposed to the landing pool depth which was measured as the deepest part of the pool immediately above the notched wall relative to the flow. These supplemental measures allowed fish passage efficiency to be determined, the feasibility of restoration activities to be evaluated, and supported the development of modified design standards.

Analysis

As part of the basic statistical analyses, surface area was calculated for each reach. This assumed each pool was rectangular, with surface area being calculated as the width multiplied by the length. Although this did not account for the heterogeneity of banks, it allowed some relative comparison of pool size and fish density across sites. Volume was not calculated because of the tight correlation of this metric with surface area. The total number of fish as well as total vertebrates by species and size class was also calculated for each reach. The density of fish as well as total vertebrates was calculated by dividing the number of vertebrates by the reach surface area for all species and size classes in each reach, yielding a number of individuals per square meter. Average, maximum, minimum, and standard deviation values were calculated for habitat measures. Size class density for each species was calculated and species richness was determined for each site. A stream summary was written for each surveyed mouth.

RESULTS

Diversions

As a result of walking the three stream sections, no unreported diversion structures were located on the unnamed tributary to the SFTR or Rattlesnake Creek. There was an old diversion associated with a USFS Guard Station on Rattlesnake Creek but the diversion system had been disconnected and no structures were left impacting the creek. One diversion structure was located on Silver Creek (Figure 8) that is discussed further in the Restoration Recommendations section of this report.

Seven diversion structures were surveyed to assess potential fish passage efficiency, population, and habitat impacts. There were fish passage structures associated with three diversions structures, Big Creek Upper diversion, Olsen Creek, and Upper Tule Creek (Figures 10b, 7, 13b). There were no dedicated fish passage structures on Big Creek Lower diversion, Silver Creek, or West Tule Creek (Table2). Fish were not able to pass any diversion structure at survey flows, though it should be noted that the surveys were conducted during a severe drought. Lower Tule Creek diversion was looked at but the creek was dry.

Table 2. General descriptions of diversion structures surveyed. Dimensions including height (H) and width (W) are provided where available.If measures were not able to be accurately obtained they were deemed Not Available (NA).

Stream	Diversion Type	Dimensions	Fish Passage Structure Present (Y/N)
Big Creek Upper (Figure 10)	Concrete	2.7 m (H)	Y
Big Creek Lower Primary Structure (Figure 12a)	Concrete	0.35 m (H) x 5.71 m (W)	N
Big Creek Lower Secondary Structure (Figure 12b)	Concrete	0.78 m (H) x 10.51 m (W)	N
Olsen Creek (Figure 6 & 7)	Concrete and Wood	1) 0.69 m (H) x 3.8 m (W) 2) 1.0 m (H) x 4.5 m (W) 3) 1.2 m (H) x 4.2 m (W) 4)1.43 m (H) x 4.73 m (W)	Y
Silver Creek (Figure 8 & 9)	Concrete	0.75 m (H) x 3 m (W)	N
Upper Tule Creek (Figure 13)	Concrete and rock	2.7 m (H) x 10.5 m (H)	Y
West Tule Creek (Figure 14)	Concrete apron	NA	N

More detailed information on each diversion can be found in the Restoration Recommendations section of this report.

Table 3. Physical characteristics of each concrete fish passage structure and hydrologic conditions. All measurements are in meters (m). Big Creek Upper (a), Olsen Creek (b), and Upper Tule Creek (c) fish passage structures are presented.

a. Big Creek Upper

Structure	Width of fish passage notch	Structure height above lower water surface elevation	Jumping pool depth	Landing pool depth	Notch height above lower water surface elevation	Depth of water flowing over notch
1	1.50	0.20	0.067	0.063	0.063	0
2	1.42	0.24	0.033	0.030	0.094	0
3	1.42	0.22	0.053	0.047	0.075	0
4	1.42	0.22	0.063	0.050	0.079	0

b. Olsen Creek

Structure	Width of fish passage notch	Structure height above lower water surface elevation	Jumping pool depth	Landing pool depth	Notch height above lower water surface elevation	Depth of water flowing over notch
1	3.80	0.69	0.30	0.65	0.075	0.05
2	4.50	1.00	0.58	0.40	0.20	0.038
3	4.20	1.20	0.35	0.28	0.08	0.063
4	4.73	1.43	3.43	1.09	1.50	*0.38

c. Upper Tule Creek

Structure	Width of fish passage notch	Structure height above lower water surface elevation	Jumping pool depth	Landing pool depth	Notch height above lower water surface elevation	Depth of water flowing over notch
1	0.90	0.70	0.23	0	0.40	0
2	1.35	1.0	0	0.18	0.90	0
3	1.80	0.60	0.22	0.013	0.45	0
4	1.65	0.85	0.025	0.13	0.75	0
2	1.50	0.85	0.075	0	0.60	0

Habitat Conditions

Habitat surveys were conducted in all reaches where active diversion structures were found. Lower Tule Creek was dry so no data was collected.

There were no consistent patterns in most habitat cover elements above and below the diversions. In some cases large wood debris (LWD), riparian canopy cover (RIP), overhanging vegetation (O VEG), and aquatic vegetation (A VEG) were higher above the diversions and in other cases they were higher below the diversions. There was a trend of cover from undercut banks (UB) being higher below the diversions in all cases except Olsen Creek. Olsen Creek had twice the UB above the diversion, 20%, compared to below the diversion, 10% (Figure2).

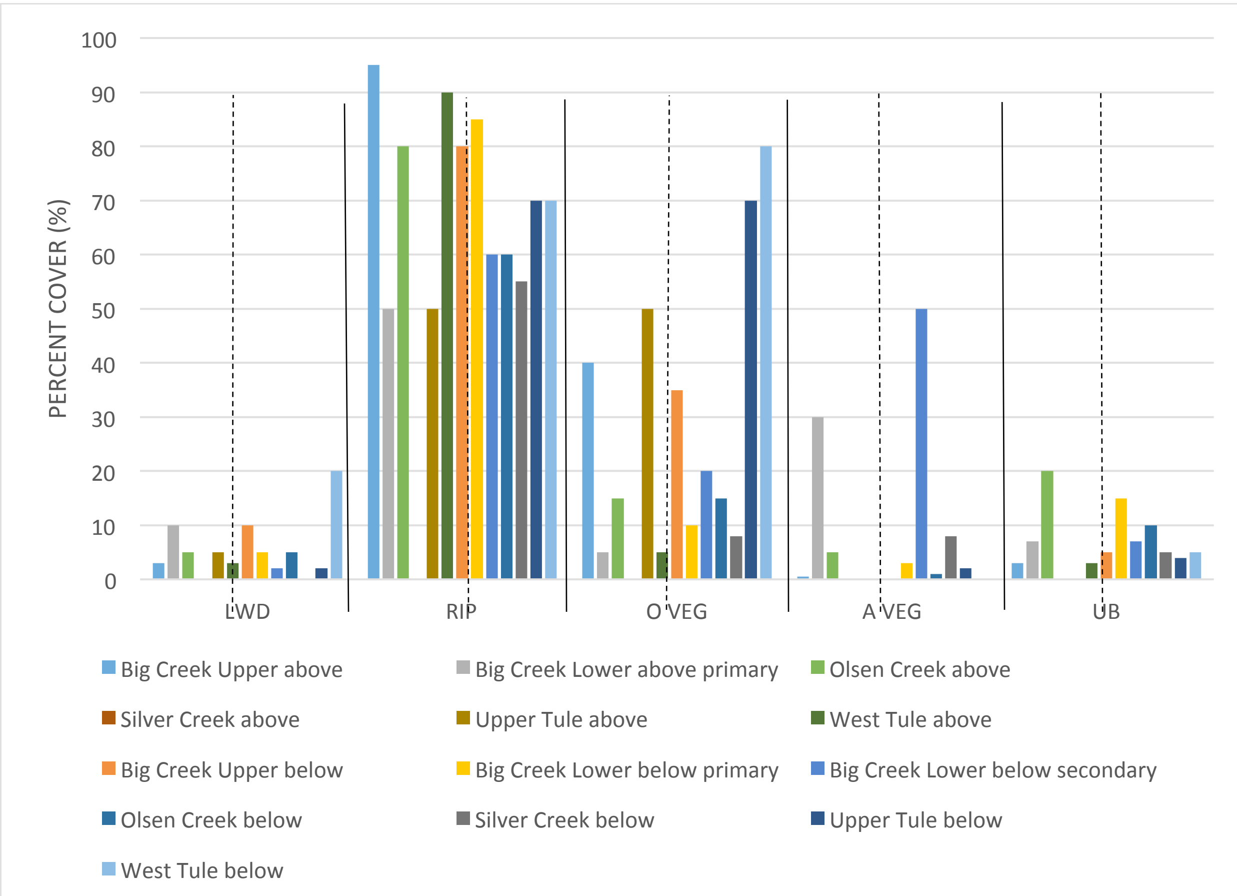

Figure 2. Habitat metrics for each survey site. Survey sites above the diversions are represented to the left of the dashed line and survey sites below the diversion are represented to the right of the dashed line. Solid lines separate the habitat metrics LWD, RIP, O VEG, A VEG, and UB.

Trends in substrate composition were more distinct than refugia elements above and below the diversions. All sites had more percent cover by bedrock (BD) below diversions than above the diversions except Upper Tule Creek. Upper Tule Creek had slightly more BD above the diversion, 15%, than below the diversion, 10%. All sites had more percent cover by fine (FI) substrate above the diversion compared to below the diversion except Olsen Creek. Olsen Creek had substantially more FI below the diversion, 30%, than above the diversion, 5%. The decreased velocity of water above the diversion was likely caused by pooling behind it that causes fine sediments to drop out of the water column and deposit on the bottom of the stream channel. Water velocity increases as flows pass over the diversion, scouring the channel with sediment deprived water and exposing bedrock substrate. (Figure 3).

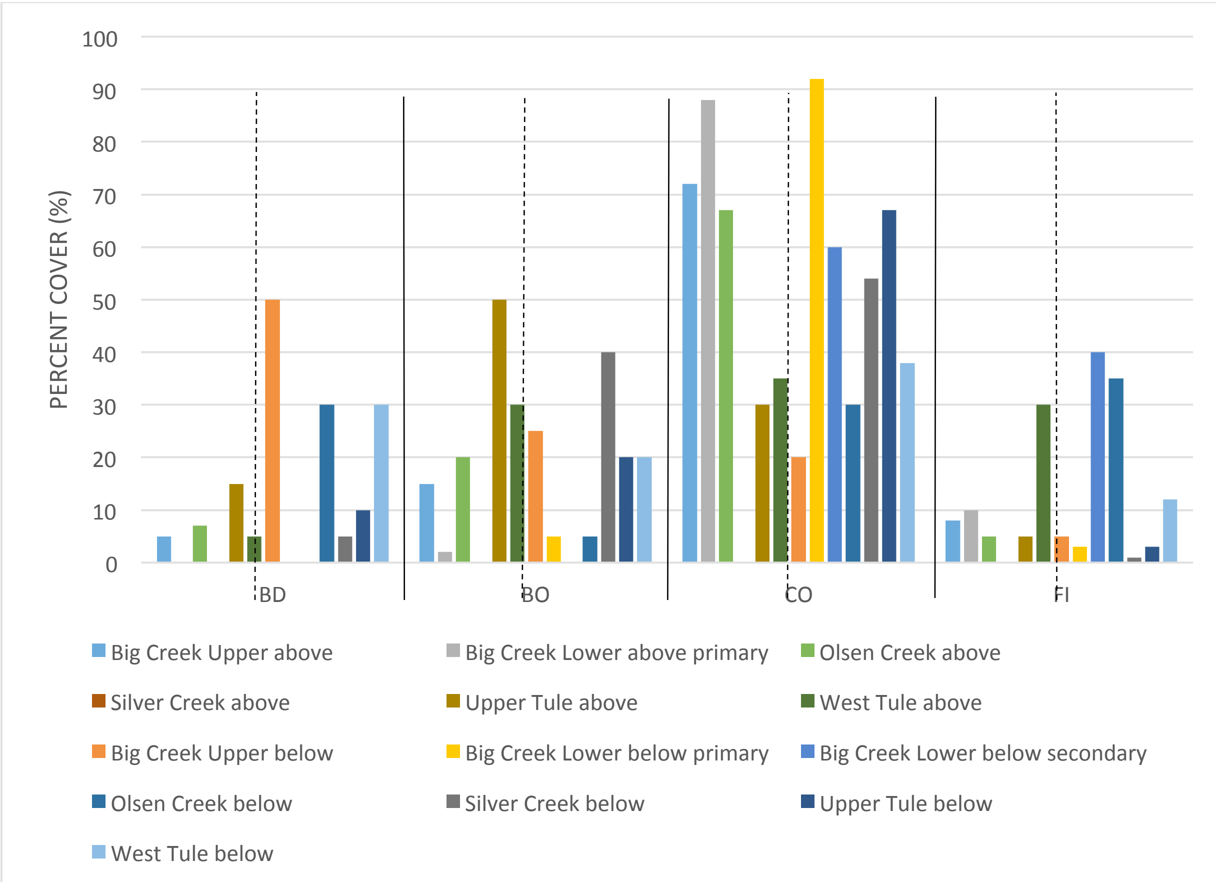

Figure 3. Substrate metrics for each survey site. Survey sites above the diversions are represented to the left of the dashed line and survey sites below the diversion are represented to the right of the dashed line. Solid lines separate the habitat metrics BD, BO, CO, and FI.

Slightly different trends emerged in habitat metrics above and below diversions in the summary statistics as opposed to the visual trends in individual sites. The average percent cover by bedrock (BD) was higher below diversions than above diversions, similar to the visual trend. However, the standard deviation and maximum percent cover were also higher below diversions than above the diversions. This may skew the average value. The average overhanging vegetation (O VEG) was also higher below diversions as opposed to above diversions. This may be due to reduced channel migration and flow below diversions sites which would encourage vegetation encroachment. O VEG also had a higher minimum value below the diversions as opposed to above the diversions (Table 4).

Table 4. Statistical summary of habitat metrics for diversion sites above diversions (a) and below diversions (b).

a.

	LWD (%)	RIP (%)	O VEG (%)	A VEG (%)	UB (%)	BD (%)	BO (%)	CO (%)	FI (%)
Avg	5.20	73.00	23.00	7.10	6.60	6.40	23.40	58.40	11.60
SD	2.86	21.68	20.80	12.97	7.89	5.46	17.97	24.95	10.50
Max	10.00	95.00	50.00	30.00	20.00	15.00	50.00	88.00	30.00
Min	3.00	50.00	5.00	0.00	0.00	0.00	2.00	30.00	5.00

b.

	LWD (%)	RIP (%)	O VEG (%)	A VEG (%)	UB (%)	BD (%)	BO (%)	CO (%)	FI (%)
Avg	6.38	70.83	38.33	9.33	7.67	24.00	14.00	51.17	16.33
SD	6.12	10.21	29.78	19.96	4.18	19.49	10.84	26.79	16.80
Max	20.00	85.00	80.00	50.00	15.00	50.00	25.00	92.00	40.00
Min	2.00	60.00	10.00	0.00	4.00	0.00	0.00	20.00	3.00

A few other habitat metric trends were exhibited by the summary statistic data. The standard deviation of riparian (RIP) percent cover was higher above diversions, the maximum large wood debris (LWD) was higher above diversions, and the minimum undercut bank (UB) was higher below the diversions. Lastly, the average boulder (BO) percent cover was higher above diversions as compared to below diversions. However, the maximum BO percent cover was higher above diversions as opposed to below diversions so this may have skewed the average value. However, it is difficult to deduce any significant trends from this information. Unfortunately, further statistical analysis to verify the significance of these results is not possible due to the small sample size.

Biotic Conditions

Sites above and below diversions were quantitatively surveyed for aquatic community composition, species richness and size classes, as well as density. All aquatic vertebrates, as well as crayfish (*Pacifasticus* spp), were recorded. Cold water associated salmonid species, chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout/steelhead (*Oncorhynchus mykiss*) complexes, as well as warm water associated species, speckled dace (*Rhinichthys osculus*) and suckerfish (*Catostomus* spp), were found (Tabe 5). Other aquatic vertebrate species observed included Pacific Giant Salamanders (*Dicamptodon* spp), Foothill Yellow legged frogs (*Rana boylii*).

Table 5. Species composition and richness in tributary sites.

Tributary	Fish Species	Species Richness
Silver Cr	Steelhead/rainbow, Chinook	2
Big Cr, Upper	Steelhead/rainbow, sucker fish	2
Big Cr, Lower	Steelhead/rainbow, speckled dace	2
Olsen Cr	Steelhead/rainbow	1
Upper Tule Cr	Steelhead/rainbow	1
West Tule Cr	Steelhead/rainbow	1

Crayfish were found in Olsen Creek and West Tule Creek. Salamanders and frogs were only found in the upper diversion on Big Creek.

Two chinook salmon juveniles were found in the survey of Silver Creek. The 2.5-7.6 cm individuals were found below the diversion at a density of 0.025 individuals per square meter. Speckled dace were found at all survey sites, except for within the diversion structure itself, around the lower diversion structure of Big Creek. The most dace were found below the diversion structure, with a count of 166 2.5-7.6 cm individuals and 10 7.6-12.7 cm individuals. Their densities were 0.63 and 0.19 individuals per square meter, respectively. The secondary channel below the diversion structure had 20 2.5-7.6 cm individuals and 6 7.6-12.7 cm individuals. Their densities were 0.63 and 0.19 individuals per square meter, respectively. The least number of dace at the lower diversion structure on Big Creek were found above the diversion structure, 2 2.5-7.6 cm individuals with a density of 0.01 individuals per square meter. The diversion structure is potentially limiting the upstream dispersal of dace. One suckerfish juvenile was the only one found in the survey below the upper diversion on Big Creek. The 2.5-7.6 cm individual had a density of 0.0067 individuals per square meter.

Steelhead/rainbow trout complexes were found in all tributary sites. Size class distribution was skewed toward smaller size classes in tributaries. This is consistent with these areas being used as rearing habitats for rainbow trout/steelhead complexes. There were some medium size classes present which is likely indicative of a resident rainbow population. However, it is possible these tributaries still contribute to the maintenance of the steelhead life history type as resident rainbow trout can have anadromous offspring (Pavlov et al, 2008). Adult steelhead were present in surveys above the screen in the diversion channel at the upper diversion structure on Big Creek. There was no flow over the diversion dam or through the fish ladder (Figure 4).

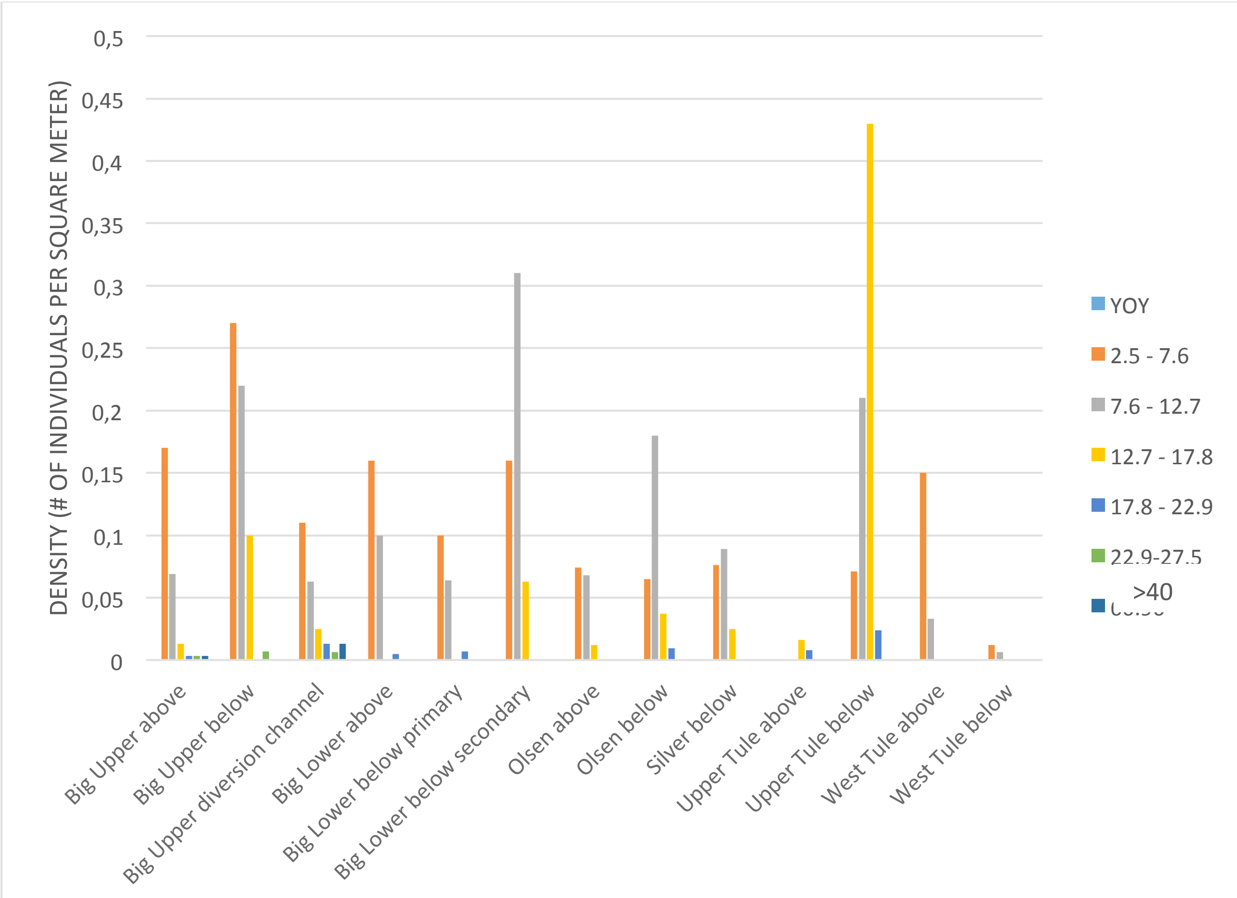

Figure 4. Steelhead/rainbow trout density by size class (cm) in each stream survey.

There were also rainbow trout/steelhead complex individuals found in the lower diversion structure on Big Creek as well as within remnant pools within fish passage structures at the upper diversion structure on Big Creek and the structure on Olsen Creek (Figure 5).

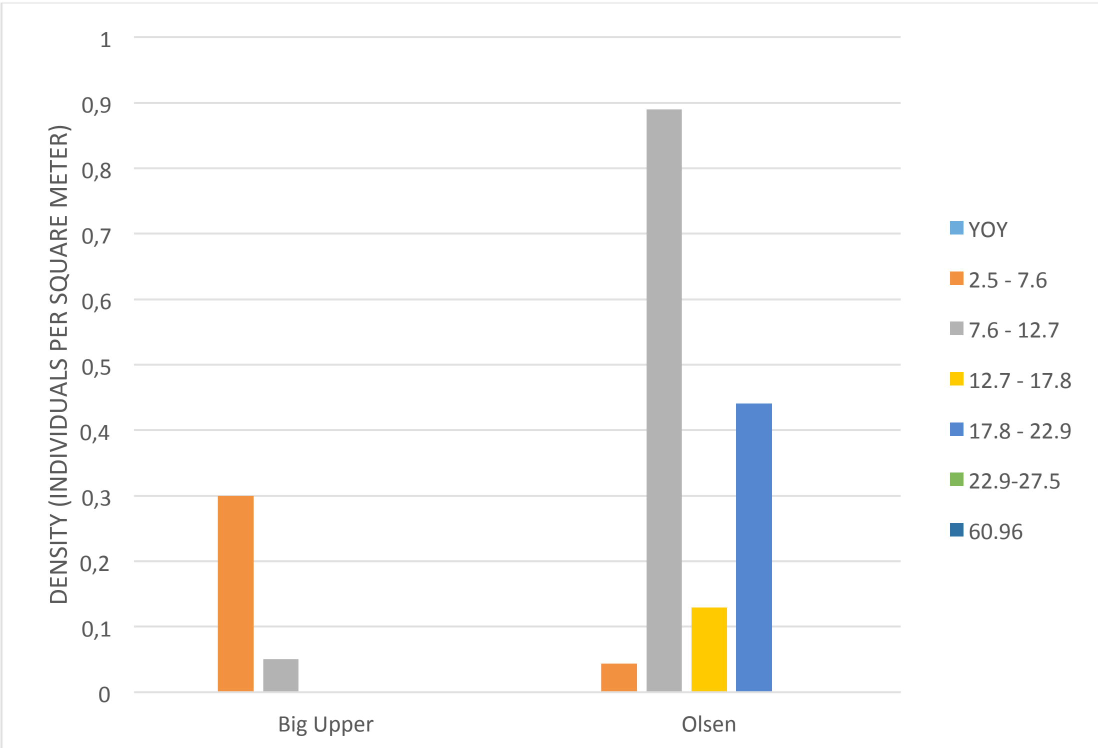

Figure 5. Steelhead/rainbow trout density by size class (cm) in fish passage structure surveys.

A single 2.5-7.6 cm individual was found along the margin of the concrete apron in the lower Big Creek diversion structure. There were no fish found in the fish passage structure or in the diversion channel below the fish screen at the Upper Tule Creek diversion.

The average density of all size classes of rainbow trout/steelhead complexes was higher below the diversion structures compared to above the diversion structure for all size classes except the smallest, 2.5-7.6 cm. The two largest size classes, 22.9-27.9 cm and 60.96 cm were excluded because they were only found at one site, above the diversion on the upper structure on Big Creek.

Table 6. Summary statistics for all rainbow trout/steelhead size classes above and below diversion structures.

Above				Below			
AVG	SD	MAX	MIN	AVG	SD	MAX	MIN
0.14	0.044	0.17	0.074	0.11	0.084	0.27	0.012
0.068	0.027	0.10	0.033	0.15	0.11	0.31	0.0062
0.013	0.00071	0.013	0.012	0.13	0.17	0.43	0.025
0.0041	0.0013	0.0050	0.0031	0.013	0.0092	0.024	0.0071

The standard deviation was also higher below the diversion structure for all size classes.

RESTORATION RECOMMENDATIONS

Eight diversion structures on seven streams were surveyed in the summer of 2014 and 2015. 1.53 km of streams (Rattlesnake Creek, Silver Creek, and an unnamed tributary of the South Fork of the Trinity River) were walked in order to locate both known and unrecorded diversion structures. The only known diversion structure at the USFS Guard Station on Rattlesnake Creek had been removed and was no longer in use. No unrecorded diversion structures were found on Rattlesnake Creek, Silver Creek or the unnamed tributary to the SFTR. Many tributaries, such as Hayfork Creek and Salt Creek, where there is a high likelihood that unrecorded diversion structures exist could not be surveyed due to safety concerns associated with illegal agricultural operations. CDFW wardens decided that they would conduct the surveys without a fish biologist due to the potentially dangerous nature of this effort. It is imperative that a complete survey of the type, screening, and diversion capacity of unrecorded structures be conducted on tributaries of the South Fork of the Trinity River in order to understand cumulative impacts on anadromous fish populations and habitat within the watershed.

Seven known diversion structures were surveyed to assess potential fish passage efficiency, population, and habitat impacts. There were fish passage structures associated with three diversions structures, Big Creek Upper diversion, Olsen Creek, and Upper Tule Creek. There were no dedicated fish passage structures on Big Creek Lower diversion, Silver Creek, Lower Tule Creek, or West Tule Creek. The following diversion structures are ordered by restoration priority based on the potential utilization by coho salmon, if structures are no longer being used, and cost of action (flow management as opposed to structure retrofit).

Olsen Creek

Although no coho salmon were observed in the current survey, coho salmon are known to occupy habitat in Olsen Creek (NMFS, 2014). Rainbow/steelhead complexes were also observed during the current survey. No warm water associated species, such as speckled dace or suckerfish were observed, indicating Olsen Creek might offer valuable cold water refugia habitat for salmonids. The presence of coho salmon, coldwater, and a fish passage structure make it a high priority restoration opportunity.

The diversion channel had a 3.18 mm fish screen and no approach velocity issues.


Figure 6. Diversion tube intake with fish screen at Olsen Creek.

The CDFW standard fish screen mesh size is 2.38 mm (CDWF, 2016).

The fish passage structure was comprised of four permanent concrete structures with wooden boards which could be removed and inserted to control flow.


Figure 7. Fish passage structure at Olsen Creek.

Two of the fish passage structures had sufficient flow, jumping pool depth (jump height to landing pool depth 1:1.25 or better (Taylor, 2011)), as well as a vertical rise less than 0.15 meters to allow fish passage for all life history stages of salmonids. However, the other two passage structures had vertical elevations greater than 0.15 m, 0.20 m and 1.5 m, respectively. This was due to the fact that there were 1 and 5 boards, respectively, placed in the concrete notch. Management recommendations would be to manage board placement relative to creek flow and potentially retrofit the structure to allow landowner diversion needs to be met while ensuring adequate fish passage for all salmonid life history stages. Conversations with the landowner found that the fish passage structure had been retrofitted by CDFW once already and they stated they would maintain the structure. To their knowledge this structure and board placement has not been maintained by CDFW. There are no downstream fish barriers.

Silver Creek

Silver Creek had the highest salmonid species richness, containing both rainbow/steelhead complexes as well as juvenile chinook salmon. There is a permanent diversion structure with no fish passage.

Figure 8. The diversion dam at Silver Creek.

There is no fish passage structure associated with the diversion. The structure was a total barrier to all life history stages at the survey flows due to insufficient jumping pool depth (Taylor, 2011) as well as the vertical height for juveniles (Whitman, 2011).

This diversion structure represents a high priority restoration opportunity because the structure is no longer being used to divert water from the creek. Therefore, it represents a fish barrier with no beneficial uses.

There is a partial natural fish passage barrier below the diversion structure (Figure 9).


Figure 9. The natural partial fish passage barrier downstream of the diversion on Silver Creek.

This would likely not be a barrier to all life history stages at all flows.

Big Creek Upper Diversion

There was no flow over the diversion structure at the time the survey was conducted. There was surface water downstream of the diversion structure due to subsurface flow. There was minimal surface flow through the fish passage structure.

a.

b.

Figure 10. Big Creek upper diversion flows over diversion structure (a) and into the fish passage structure (b).

The majority of surface flow was diverted into the diversion channel.

Although there are no historic accounts of coho salmon in Big Creek in the Hayfork Valley and none were observed in the current survey, Big Creek has a high Intrinsic Potential (IP) for Southern Oregon Northern California Coho (SONCC) Recovery (NMFS, 2014). Adult steelhead were observed above the diversion structure and in the diversion channel during the survey. CDFW monitors and maintains the fish screen in the diversion channel to their standards.

Figure 11. Adult steelhead in the diversion channel of Big Creek.

This suggests Big Creek is an important tributary for the spawning and rearing of anadromous fish populations in the South Fork of the Trinity River.

The adult steelhead were likely trapped in upper Big Creek and its diversion channel once water began to be diverted at the beginning of the growing season. There was not sufficient surface flow over the diversion structure or through the fish passage structure to allow out migration of the adult steelhead. Shortly after the survey occurred, a small storm raised water levels in the stream enough for the adult fish to exit the system (pers. comm. Murrison 2015), although it was not verified that this occurred. Therefore, a priority management recommendation would be to ramp up flows into the diversion channel more gradually, giving the adult steelhead a hydrologic cue to out-migrate, or to maintain sufficient flow through the fish passage structure year round to allow fish passage.

The maintenance of sufficient flow through the fish passage structure year round is not only important to the outmigration of adult steelhead, but also to other salmonid life history stages and resident life history types. Apparently, there is sufficient flow through the fish passage structure to allow partial fish passage, as is indicated by the presence of steelhead above the diversion, however, adequate flow to allow for juvenile fish passage is intermittent or non-existent. The maximum jumping height for juvenile salmonids with good landing and jumping pool depth is 0.15 m (Whitman, 2011). The minimum jumping height required to pass the Big Creek fish passage structure at the upper diversion was 0.20 m at survey flows. Thus the diversion structure does not allow juvenile passage at all flows. It is recommended that the diversion structure should be retrofitted so that the maximum distance from the lower water surface elevation to the top of the notch is less than 0.15 m to allow juvenile salmonid fish passage. There are at least two partial barriers below the upper Big Creek diversion, the lower Big Creek diversion, and a secondary channel diversion that are described below.

Lower Big Creek Diversion

There is a permanent concrete diversion structure on lower Big Creek. This structure extends across the main channel as well as a secondary channel on the tributary to Hayfork Creek.

a.

b.

Figure 12. The lower diversion structure on Big Creek. on the primary channel looking downstream with the diversion gate and screen on the right (a) and on the secondary channel looking upstream (b).

The diversion gate did not appear to be in use. There is no fish passage structure on either channel.

Rainbow/steelhead complexes were found above and below the diversion structure. Speckled dace were also found below and above the diversion structure. However, their abundance was much higher below the diversion structure. The flow through the lower diversion structure on Big Creek is greatly reduced by the diversion of all surface water at the Upper Big Creek Diversion structure, discussed above. The reduction in water quantity likely contributes to warmer water, encouraging the presence of warm water associated species such as speckled dace. Currently, this structure may be slowing the upstream spread of speckled dace.

There are several potential management recommendations for this structure. The structure is no longer in use. Therefore, the ideal management action would be to remove it. This action in conjunction with decreased diversion of surface flows at the upper diversion structure on Big Creek would allow passage of all fish life history stages and potentially limit the upstream spread of warm water associated species, such as speckled dace. However, an alternative strategy would be to install a fish passage structure on either the main channel or secondary channel structure with sufficient attraction flows that is less than 0.15 m high. This will allow passage of juvenile salmonids but also potentially limit the upstream distribution of speckled dace as they have much weaker swimming abilities than salmonids (Monk and Hotchkiss, 2012). It is important that management of both the lower and upper diversions structures is considered in the restoration and improvement of this valuable tributary.

Upper Tule Creek

Upper Tule Creek has a permanent stone and concrete diversion structure on this tributary to Hayfork Creek. It is equipped with a fish passage structure. There was no surface flow over the diversion structure or through the fish passage structure.

a.

b.

Figure 13. The Upper Tule Creek Diversion. Diversion structure and diversion pipe on the far right side of the photograph (a) and the fish passage structure (b).

CDFW maintains and monitors the screen on the diversion channel to its standards and specifications. The screen appeared to be properly functioning because no fish were found below the screen in the diversion channel during this survey.

The management recommendation for the diversion on Upper Tule Creek is to decrease diversion flows to allow surface flow through the fish passage structure. Alternatively, structures upstream of the diversion structure could also be added to divert surface flow through the fish passage structure. It was difficult to ascertain from current conditions the ability of the structure to pass all life history stages of salmonids if there was surface flow through the structure. Currently, the vertical elevation from any standing pools or the bottom of dry fish passage structures that a juvenile fish would have to jump to access the next fish passage structure ranged from 0.40 m to 0.90 m. Because typical jump distance for juveniles would have to be less than 0.15 m (Whitman, 2011) with a sufficient jumping and landing pool depth, it is assumed that juvenile salmonids would not be able to pass this barrier.

West Tule Creek

The West Tule diversion structure is a permanent concrete structure. There is no fish passage structure associated with the diversion.

Figure 14. The diversion on West Tule Creek.

The diversion structure was not actively operating during the survey due to extremely low flow in the creek. At this flow level, the diversion would be a barrier to fish passage at all salmonid life history stages due to insufficient jumping and landing depths. Additionally, the structure did interfere with the natural streamflow of West Tule Creek causing the flow to go subsurface for approximately 3m below the diversion structure. This is also a passage barrier for all life history stages of salmonids.

Management recommendations for this structure would be to retrofit it to another design that would not impede natural flow of the main channel, potentially by installing a tube screen or some other diversion device. This would restore the natural channel function and remove the concrete barrier to fish passage while maintaining diversion ability for beneficial uses.

CONCLUSIONS

There are several opportunities for improvement of fish passage at diversion structures in the South Fork of the Trinity River watershed.

Olsen Creek was identified as the highest restoration priority because it is known to be historically occupied coho habitat. CDFW has previously retrofitted the fish passage structure at the diversion. Regular monitoring and maintenance of the structure by CDFW would allow improved passage by managing flows within the fish passage structure.

Silver Creek is the next highest restoration priority. There is a concrete dam impairing fish passage. This diversion is no longer used. Removal of the obsolete diversion structure would allow fish passage of all life history stages to high quality upstream habitat.

The upper diversion structure on Big Creek is trapping adult steelhead above the diversion due to creek flows being entirely diverted into the diversion. A more gradual decrease of flows in the creek may provide the necessary hydrologic cue to adult individuals to out-migrate. Additionally, the maintenance of minimal flows through the fish passage structure would allow this to be utilized year round.

The lower diversion structure on Big Creek is no longer being utilized and should be removed to restore fish passage upstream.

The restoration recommendations for Upper Tule Creek diversion structure are similar to the upper diversion structure on Big Creek. Flow management would allow fish to potentially use the existing fish passage structure by maintaining minimal flows.

Lastly, West Tule Creek needs some sort of flow management, if possible, or a fish passage structure in the concrete apron. Specific actions were difficult to determine due to the extremely low flows in the creek.

The implementation of a few relatively low cost and opportunistic actions in these important tributaries to the South Fork of the Trinity River would greatly enhance fish passage for all life history stages to these vital cold water refugia area.

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