Trinity River Hatchery
Steelhead Feeding Reduction Study
Year One
Project Update

Yurok Tribal Fisheries Program
Trinity River Division

Introduction

The potential for hatchery-produced salmonids to impact natural stocks is well-documented, ranging from genetic (Christie et al. 2014) to pathogenic (Coutant 1998) and behavioral (Kostow and Zhou 2006). Hatchery supplementation of steelhead *Oncorhynchus mykiss* raises concerns about impacts on natural populations, including reduced growth and survival, displacement, and increased predation on natural populations after release (Weber and Fausch 2003; Riley et al. 2004; Pearsons 2008; Kostow 2009). In response, many hatcheries re-evaluated their programs via region-based hatchery scientific review groups (HSRG), and determined that avoiding negative ecological interactions between hatchery and natural-origin salmonids should be a primary concern for recovery efforts and fisheries management (PNW HSRG 2014). One of the recommendations from the California Hatchery Review Report (CA HSRG 2012) states that hatchery managers should release hatchery fish at the optimal size and date to promote rapid migration to sea (Guideline 2.6.2). For hatchery steelhead, in particular, the size and date of release should limit residualization, or extended rearing, near the release site prior to emigration (Guideline 2.6.4). Studies in the Pacific Northwest have shown that emigration rates of hatchery-raised steelhead are influenced by individual condition factor (Ewing et al. 1984; Tipping et al. 1985), a numeric expression of

the weight/length ratio, or *K*-value. Other studies indicate fish with high *K*-values may not be physiologically ready to migrate and eventually become residualized (Fessler and Wagner 1969; Folmar and Dickoff 1981). Hatchery managers in the Pacific Northwest have effectively reduced K-values of hatchery-raised salmonids by manipulating feeding regimes shortly before release (Tipping and Byrne 1996), and that reduced feeding regimes hasten the volitional migration of hatchery salmonids (Ewing et al. 1984).

In response to the CA HSRG recommendation of ensuring rapid migration of hatchery steelhead through the Trinity River, the Yurok Tribal Fisheries Program (YTFP) studied the effects of reducing the amount of food given to hatchery steelhead smolts immediately prior to volitional release from Trinity River Hatchery (TRH). For this study, we reduced feeding in one raceway of broodyear (BY) 2013 TRH steelhead and monitored them during and after the spring 2014 volitional release. We hypothesized that the reduction in food would result in lowered *K*-values, an increased volitional exit rate from TRH, and faster emigration through the Trinity River system.

Hypothesis 1

H_A = TRH steelhead fed less during the month prior to volitional release will have a significantly lower Fulton's K-value compared to TRH steelhead given standard portion of feed.

H_O = There will not be a significant difference in Fulton's K-value measured between the two groups.

Hypothesis 2

H_A = TRH steelhead subjected to a reduced feeding regime will volitionally leave TRH at a higher rate than fish given the normal feeding regime.

H_O = There will not be a significant difference in the exit rate between the two groups.

Hypothesis 3

H_A = TRH steelhead given a reduced feeding regime will have faster emigration rates, as seen by capture at the Willow Creek outmigrant trap, than fish given the normal feeding regime.

H_O = There will be no significant difference between the emigration rates of the two groups measured at the Willow Creek outmigrant monitoring site.

Study Area

The Trinity River is the largest tributary of the Klamath River Basin, the second largest river system in California, which drains approximately 31,000 km^2 in northern California and southern Oregon, with the Trinity River draining approximately 7,690 km^2 in California (see figure 1). It once supported large anadromous populations of fall and spring-run Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *Oncorhynchus kisutch*, steelhead, Pacific lamprey *Lamptera tridentata* and green sturgeon *Acipenser medirostris*, all of which supported commercial and recreational fisheries, as well as providing for cultural, subsistence, and commercial needs of native tribes throughout the region. The Klamath-Trinity River Basin is still an important producer of anadromous salmonids and the largest producer of steelhead in California (Hopelain 1998).

In 1957, the Bureau of Reclamation began construction on the Trinity River Division (TRD) of the Central Valley Project. The TRD consists of a series of dams, lakes, and tunnels built to store and transfer water from the Klamath Basin to the Sacramento Basin. When construction was completed in 1963 the newly built Lewiston Dam became the uppermost limit of anadromous fish migration for the Trinity River, and essentially removed 109 miles of pristine spawning and rearing habitat available for returning adult salmonids. In anticipation of these impacts the Trinity River Hatchery was created by B.O.R. and began operations in 1963, and is intended to mitigate for the impacts on salmonid production that resulted from the loss of available habitat and reduction of in-river flows caused by the TRD (CDFG 1963).

TRH is located at the base of Lewiston Dam at river kilometer 180 (see Figure 1). Since its completion in 1963 the CDFW has been under contract with BOR to operate and maintain TRH facilities so as to meet and fulfil all BOR mitigation responsibilities for the production and release of three species of salmonids: Chinook salmon, coho salmon, and steelhead. The mitigation goals were determined from pre-project studies of anadromous adult fish populations that passed above the Lewiston Dam site (USFWS and CDFG 1956) and are expressed as the total number of hatchery raised adults "available" at the hatchery (i.e. would have been available to migrate past Lewiston Dam). The mitigation goals for TRH include 10,000 steelhead (run timing was not designated); 35,000 Chinook (3,000 spring, 8,000 summer and 24,000 fall); and 5,000 coho. Total annual TRH adult production goals for the entire Trinity Basin (catch plus escapement) was later defined to be 22,000 steelhead, 6,000 spring Chinook, 70,000 fall Chinook, and 7,500 coho (Frederickson et al. 1980). Most recently, escapement goals to the TRH spawning facilities have been described as 10,000 steelhead, 3,000 spring Chinook, 9,000 fall Chinook, and 2,100 coho (USFWS 1983).

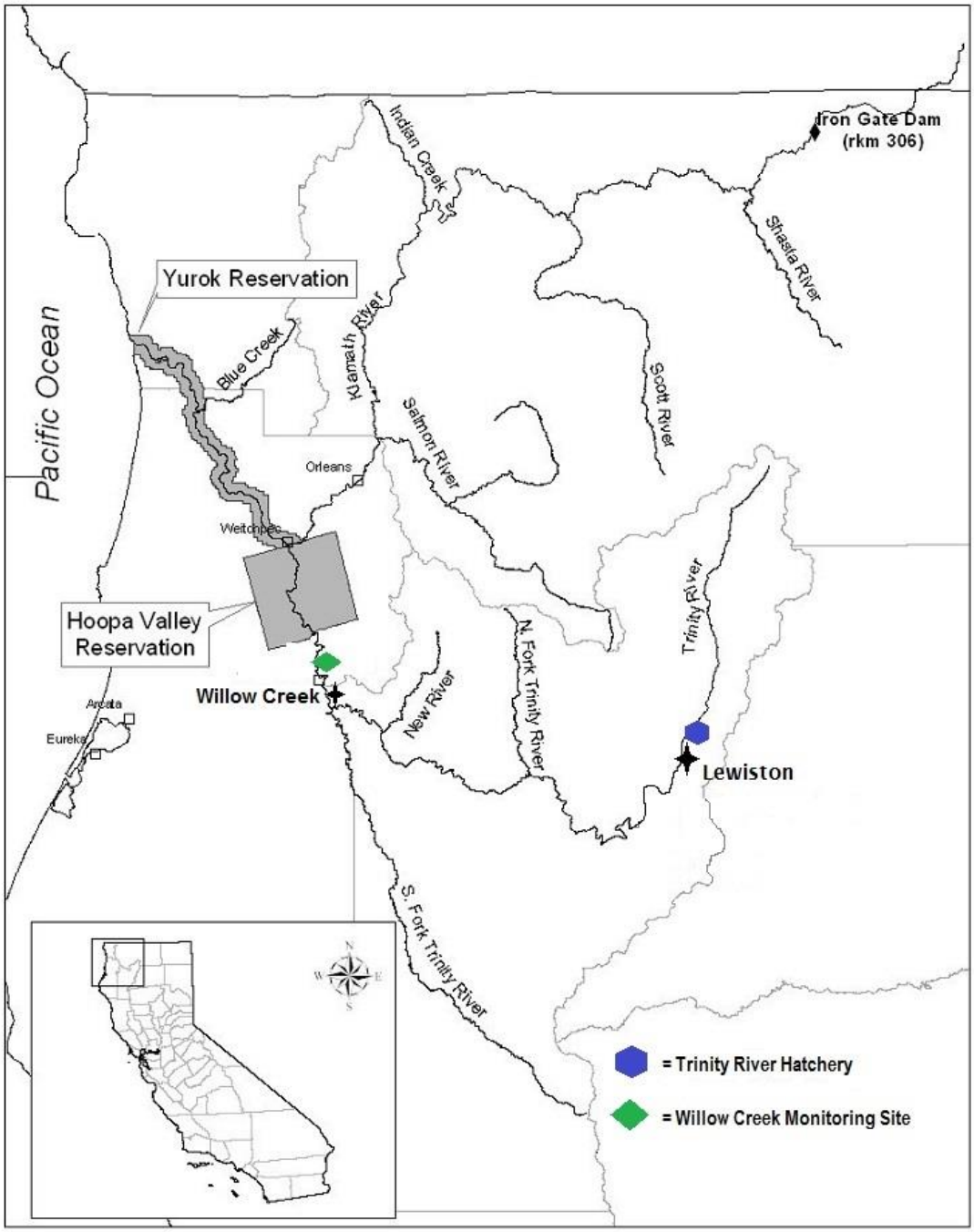

Figure 1. Map of the Trinity River Basin showing the location of Trinity River Hatchery at river kilometer 182 and the Willow Creek downstream juvenile monitoring site located at river kilometer 34.

Broodstock for the TRH steelhead program originated within the Klamath Basin watershed. From 1974 until 1986, steelhead eggs were imported from Iron Gate Hatchery (located on the Klamath River); however, no eggs or fish have been used to supplement this program in the last 19 years and all eggs used for broodstock have only been from adult returns collected within the spawning facilities located at the top of the TRH adult return ladder. To achieve the steelhead mitigation goal, TRH releases approximately 800,000 steelhead annually at roughly six inches in length (or at a size of six fish per pound) between March 15 and May 1. Recent litigation resulted in a "Consent Decree" that altered some goals and protocols required under current law. New requirements involving the TRH steelhead program are specific to the timing (later) and amount (fewer) of TRH steelhead released annually to the Trinity River, and 2014 was the initial year of a later release date. The "Consent Decree" states that "the 2014 volitional release of TRH steelhead is to begin between the dates of April 15, 2014 and April 30, 2014, within seven days prior to the New Moon".

The Trinity River downstream juvenile outmigrant monitoring site is located at river kilometer 34 at Riverdale Campground near Willow Creek, California (see Figure 1). This monitoring site was initially installed and operated by the U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office in 1989 and has continued as an annual monitoring site since inception. It is currently being monitored and maintained by the Yurok Tribal Fisheries Program in association with the Trinity River Restoration Program. Three eight foot rotary screw traps are deployed annually from March until September and are set/ran five days each week.

Methods

For the purpose of this study an experimental group (or test group) of TRH steelhead was subjected to a reduced feeding regime for the four weeks immediately prior to release from TRH and a control group was administered the normal amount of feed associated with standard TRH protocols. The test group received 50% of the normal ration for the initial two weeks (3/21/14 to 4/3/14), then no food for the final two weeks (4/4/14 to 4/21/14) prior to the onset of volitional release on 4/22/14. CDFW provided one pond (~128,004) of BY 2013 TRH steelhead for the test group. A total of 6 ponds were used to rear BY 2013 steelhead which represented a subsample of the total yearly release group (10 year avg. = ~802,314; 2014 actual = 804,079). The remaining five ponds of BY 2013 TRH steelhead (~681,150) represented the control group and received the normal amount of feed. Other than the amount of feed administered to both groups during the four week study, an earnest attempt was made to ensure both groups received similar treatments and subjected to the same conditions during the four weeks prior to release.

Bio-Oregon's *BioVita Fry Feed* was the feed used at TRH for all hatchery fish beginning in May 2013 and provides hatchery managers more control over fish growth and a better means of reducing size variance (L. Glenn, personal communication, November 20, 2013). The pellet size (mm) and amount (lbs.) given to each pond was determined weekly by hatchery staff and was based on average size (via weekly weight counts) and number (determined during ponding and fin clipping) of fish contained in each pond. The daily feed amounts were then partitioned into six rations and administered throughout the day via the TRH "feed truck" for the control group, which is the standard method of food delivery at TRH. In contrast, the test group was "hand fed" during the two weeks of 50% rations to ensure that they were administered the appropriate amount of food and not overfed.

All TRH steelhead are marked by removing the adipose fin prior to release from the hatchery. To provide a visually identifiable mark that distinguished the test group from the control group for subsequent recapture at the Willow Creek site, one of four additional fin clips was applied to the test group: a partial right pelvic, partial left pelvic, upper caudal, or lower caudal. Four different clips were applied to the test group to provide a mechanism for statistical analysis of within group and between group comparisons of both groups. An example of a right pelvic fin clip is provided in Figure 2. All clipping and PIT tagging procedures for the test group were completed prior to the initiation of the feed rationing which began on March 21. The PIT tagging of the control group occurred after the food rationing began and was finished on April 3.

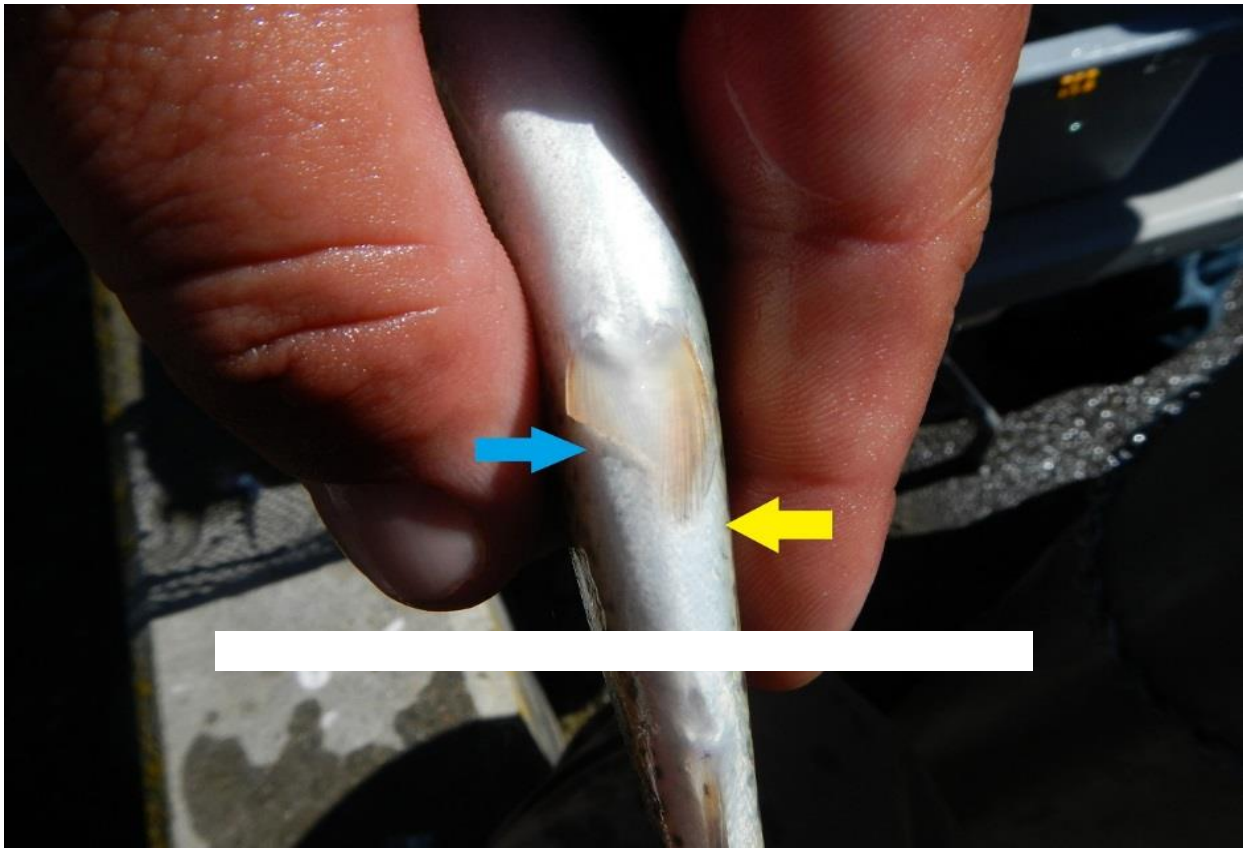

Figure 2. This photo is of a right pelvic fin clip that has been applied to a TRH steelhead. The blue arrow indicates where the fin has been clipped and part of the fin is removed. The yellow arrow is showing the unclipped left fin so to provide a comparison of the noticeable difference between the two fins after one has been clipped.

The volitional hatchery release was monitored through the use of PIT tags and PIT monitoring equipment. A subset of 1,000 fish from both the test (250 of each fin clip group) and control (200 from each of the five control ponds) groups received a PIT tag (Biomark 23 mm HDX tag) injected into the peritoneal cavity. Tagged fish were held for 24 hours in net pens and examined to determine post-handling mortality and to provide tag retention assessments. The post-handling mortality of tagged fish was less than 1% for the 24-hour period immediately after tagging and the initial tag retention rate for the 24-hour period after insertion was found to be over 99%. Only 17 of 2,000 tags were found to be shed during the 24-hour holding period. This, however, did not stand to be the eventual tag retention rate. The volitional release commenced on April 30 and the ponds were emptied on May 1 so that CDFW hatchery crew could begin cleaning the raceways. While cleaning the raceways they found 58 loose tags on the concrete floors of the raceways. On May 2 YTFP crew returned to TRH to perform a more thorough search using PIT tag detection equipment and found an additional 98 tags. 10 of the visually found tags were at least partially crushed which turns the tags undetectable. The final count of shed tags was 182, and dropped the retention rate to 90%, which is most likely a conservative estimate of how many tags were actually shed because it is unknown how many tags were crushed and became inoperable.

The volitional release was monitored by an antennae array that was placed within the exit drain of the TRH water system which dumps directly into the Trinity River roughly 100 feet

downstream of Lewiston Dam. The array consisted of wire drilled into two wooden frames and placed roughly 25 ft. apart and connected to a transceiver (Oregon RFID® MUX) that recorded and stored the date and time of each tag detection. The system was installed on April 15th and operated continuously and tested daily for the week prior to the volitional release to determine that the monitoring equipment was functioning properly. This was accomplished using test tags that were "fished" through the antennae with the use of fishing tackle. The test tags were detected 100% and the read range was determined to be four feet for each antenna (i.e. tags were detected when they got within two feet upstream of the antennae and continued to be detected until they were two feet past the antennae).

*Table 1. Summary of all clipping and PIT tagging of the 2014 TRH steelhead release. The "total clipped" are the number of hand-counted fish in each pond at time of clipping and "total released" reflects mortality between time of clipping and time of release. *Note that "total tagged" is adjusted for shed tags.*

POND	CLIP TYPE	TOTAL CLIPPED	TOTAL PIT TAGGED*	TOTAL RELEASED
P1	Upper Caudal	34,255	223	64,791
P2	Lower Caudal	30,680	231	
P3	Right Pelvic	32,977	224	63,213
P4	Left Pelvic	30,313	247	
Q	AD Only	130,516	182	130,424
R	AD Only	122,788	189	122,005
S	AD Only	131,059	170	129,951
T	AD Only	148,117	176	146,980
K	AD Only	147,451	176	146,715

To assess the smoltification potential and physical effects of feed reduction, a total of 2,000 hatchery steelhead (1,000 test and 1,000 control fish) were measured by length (mm) and weight (g) on March 20th (one day before the test group began the 50% reduction) and again on April 21st (one day prior to the start of volitional release). These measurements provided the values for Fulton's condition factor (*K*) calculated by the following equation:

$K = 10^5 * (\text{weight}) / (\text{length})^3$

Where: weight = weight (g) of fish measured in grams
length = length (fl) of fish measured in millimeters

Fish length was recorded by fork length (tip of snout to middle of caudal fin) to the nearest millimeter) using standard measuring boards. Weights were measured using a commercial grade A & D compact digital scale (HL-WP Series, Model HL-300WP) to the nearest one-tenth of a gram with a 90% accuracy rating (information provided by manufacturer). Differences between test and control groups and before/after treatments were evaluated using

a paired *t*-test and ANOVA was used to determine differences within each group and between raceways.

To assess emigration rates and timing, both test and control fish were recaptured by rotary screw trap at the Willow Creek outmigrant monitoring site which is located 146 rkm downstream of TRH (see Figure 1). All TRH steelhead captured at WC underwent normal trap procedures, including inspection for tags and recording lengths and weights of a sub-sample (up to 30 for each species per day). Because only three PIT tags were detected at WC, fin-clipped fish were used to assess emigration; therefore, the first day of the volitional release was assumed to be the starting date to determine emigration rates.

Results

Smoltification Index

Fork length (FL) and weight were recorded on March 20, 2014 (one day prior to food rationing) and again on April 21st (one day prior to volitional release) to assess physical effects from food rationing. A summary of the results are presented in Tables 1 and 2.

Table 2. Summary of TRH steelhead data on March 20, one day prior to the reduced feeding regime.

Pond	Fork Length (mm)		Weight (g)		Fulton's K	
	Mean	SE	Mean	SE	Mean	St Dev
P1	167.5	1.54	56.5	1.33	1.157	0.0071
P2	161.6	1.40	53.7	1.25	1.217	0.0079
P3	165.9	1.38	51.6	1.11	1.088	0.0057
P4	161.6	2.13	54.9	1.72	1.195	0.0083
Q1/Q2	174.7	2.13	63.5	2.07	1.152	0.0082
Q3/Q4	179.2	2.19	68.3	2.15	1.148	0.0092
R1/R2	175.1	2.05	64.2	2.11	1.157	0.0140
R3/R4	184.6	2.69	78.3	2.86	1.199	0.0127
S1/S2	174.1	2.42	63.6	2.25	1.146	0.0088
S3/S4	176.7	2.30	67.1	2.28	1.201	0.0484
T1/T2	170.9	2.53	60.2	2.26	1.145	0.0104
T3/T4	175.2	2.23	64.1	2.07	1.151	0.0097
K1/K2	169.6	2.25	61.3	2.26	1.205	0.0101
K3/K4	164.0	1.95	53.9	1.68	1.182	0.0098
Test Group	***164.2***	***0.82***	***54.2***	***0.69***	***1.159***	***0.0039***
Control Group	***174.4***	***0.74***	***64.5***	***0.72***	***1.169***	***0.0058***

An increase in mean FL and mean weight was observed for both groups during the food reduction from March 20th to April 21st. On March 20th the mean FL of the control group was 174.4 mm and the test group was 164.2 mm, a statistically significant (P = 3.41 X 10^{-18}) difference. On April 21st the mean FL for the control and test groups was 193.4 mm and 180.7 mm, respectively, and again had a significant statistical difference between the two groups. The mean FL of the test group increased by 16.5 mm during the 30-day food rationing (i.e. two weeks of 50% feed and two weeks of no feed), while the control group (fed at normal levels) had an increase in mean FL of 19 mm. The mean weight of the test

group, which was starved for the final two weeks, increased from 54.2 g to 62.5 g (15.3% increase) when compared to the 19.2 g increase of the control group (29.8% increase).

Table 3. Summary of TRH steelhead data taken on April 21, one day prior to volitional release. The sample size of both the test and control groups were equal (n = 1,000).

Pond	Fork length (mm)		Weight (g)		Fulton's K	
	Mean	SE	Mean	SE	Mean	St Dev
P1	179.7	1.54	58.8	1.31	0.973	0.0102
P2	180.2	1.67	65.2	1.56	1.080	0.0228
P3	181.8	1.26	63.1	1.16	1.024	0.0059
P4	181.1	1.99	62.8	1.69	0.993	0.0068
Q1/Q2	194.3	2.82	82.9	3.33	1.073	0.0088
Q3/Q4	196.8	2.15	87.9	2.77	1.120	0.0092
R1/R2	192.1	2.64	80.8	3.06	1.096	0.0092
R3/R4	206.2	2.22	101.7	3.08	1.128	0.0078
S1/S2	197.5	2.52	85.2	2.80	1.063	0.0086
S3/S4	196.7	2.10	89.7	2.63	1.175	0.0405
T1/T2	194.3	2.46	82.2	2.79	1.079	0.0087
T3/T4	188.6	2.74	79.8	3.06	1.137	0.0124
K1/K2	183.3	2.56	73.8	2.51	1.162	0.0126
K3/K4	184.5	2.70	72.8	2.83	1.102	0.0087
Test Group	***180.7***	***0.82***	***62.5***	***0.71***	***1.018***	***0.0068***
Control Group	***193.4***	***0.81***	***83.7***	***0.91***	***1.113***	***0.0051***

The average Fulton's *K*-values on March 20th was 1.16 for the test group and 1.17 for the control group with no significant difference between the two groups ($P = 0.17$). However, on April 21st the mean Fulton's *K*-value for the test and control groups was 1.02 and 1.11, respectively, which was statistically significant ($P = 9.19 \times 10^{-29}$). Table 3 provides a comparison of size and condition between the BY 2013 TRH steelhead release to the average of the prior 10 years (i.e. BY 2003 – 2012).

Table 4. Summary of the 10-year average size and condition of TRH steelhead prior to release compared to the 2014 release. The 2014 release is divided into the control and test groups.

GROUP	MEAN FL (MM)	MEAN WEIGHT (G)	MEAN *K*-VALUE
2014 TEST	180.7	62.5	1.01
2014 CONTROL	193.4	83.7	1.11
BY 2003-2012	179.9	75.1	1.23

Volitional Release

On April 22nd hatchery crews began the 2014 volitional release of BY 2013 steelhead smolts by removing the screens at the end of the raceways that prohibit access to the outflow tube. The first PIT-tagged fish, from the test group, passed the antenna six minutes later, while the last tagged fish was detected on April 30th, shortly after the remaining fish were crowded out of the raceways and the raceways drained. A summary of detections is presented in Table 3. After the first day of volitional release, 52% of the tagged control fish and 48% of the tagged test fish left the hatchery and entered the Trinity River, however after four days 95% of the test group exited the hatchery compared to 79% of the control group. The control group's average number of days to exit the hatchery was 2.29 days, and the test group average was 1.89 days. The total amount of PIT tagged TRH steelhead detected exiting the hatchery during the volitional release was substantially greater than anything previously recorded with 82.07% (n = 1,492). The only historic data on TRH volitional release timing or rate is provided by Naman (2008), who monitored the 2007 TRH steelhead volitional release using PIT tags (n = 991) and found that only 51% of the tagged TRH steelhead left the hatchery raceways during the 11-day volitional release that occurred from March 15 – March 25.

Table 5. Summary of TRH steelhead detected leaving the hatchery and entering the Trinity River in the spring of 2014. Rows represent the raceway where PIT tag was implanted. Columns represent the number detected each day.

Raceway	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr
K1/K2	37	10	5	9	4	3	2	7	1
K3/K4	41	12	3	6	1	5	3	2	1
Q1/Q2	41	7	9	5	4	4	4	1	1
Q3/Q4	41	5	2	7	3	3	5	4	2
R1/R2	40	10	12	2	6	5	2	0	0
R3/R4	42	7	5	10	5	4	2	3	1
S1/S2	37	5	10	5	5	7	5	2	1
S3/S4	29	3	8	3	9	3	2	4	0
T1/T2	37	13	7	1	3	4	0	2	2
T3/T4	35	7	7	6	3	8	2	1	0
P1	120	32	17	9	3	3	1	0	2
P2	65	55	29	29	5	3	1	1	1
P3	110	29	35	10	5	2	2	0	0
P4	70	45	35	35	5	4	2	1	0
Control Total	*380*	*79*	*68*	*54*	*43*	*46*	*27*	*26*	*9*
Cumulative %	52.3%	63.2%	72.6%	79.2%	85.1%	91.5%	95.2%	98.8%	100%
Test Total	*365*	*161*	*116*	*83*	*18*	*12*	*6*	*2*	*3*
Cumulative %	47.7%	68.7%	83.8%	94.6%	97.0%	98.6%	99.3%	99.6%	100%
Grand Total	**745**	**240**	**184**	**137**	**61**	**58**	**33**	**28**	**12**

Emigration

The first 2014 TRH-released steelhead was captured at WC on April 26th, four days after the volitional release began, and both test and control groups were present (16 test and 67 control). Since the sample size of the test group was 19% of the size of the control group, two totals are presented for the total catch of the test group (the higher number has an expansion factor applied). The total 2014 TRH steelhead catch at WC was 4,821, which was more than double the average of the previous 10 years (Table 5). The recapture rate for the test group was 0.80% compared to 0.56% for the control group, and the recapture rate average for TRH steelhead for the 10 years prior to 2014 was 0.24%.

Table 6. Summary of the 2014 TRH steelhead emigration season at the Willow Creek RST monitoring site. Also provided for comparison is the ten-year average recorded at WC.

GROUP	TOTAL CATCH	RECAPTURE RATE	EMIGRATION RATE	DURATION (WEEKS)	PEAK (JW)
TEST	1,020/5,387	0.80%	18.5 days	8	17
CONTROL	3801	0.56%	21.5 days	10	19
BY 2003-2012	1929	0.24%	40.4 days	18	20

** It should be noted that the total catch of the test group was considerably lower than that of the control group due to unequal sample sizes. The test group was roughly 1/6 the size of the control group.*

The travel rate for the 83 TRH steelhead caught on that initial day after volitional release began on April 22 was 37.25 rkm/day. Hatchery steelhead continued to be caught at WC for the next 10 weeks, which was the shortest emigration duration for TRH steelhead since at least 2001 (earlier data was not available). The last capture dates at WC for test and control group steelhead were June 12 (51 days post-release) and June 27 (66 days post-release), respectively. The previous ten-year average emigration duration of TRH steelhead was 18 weeks (Table 5).

Table 7. Summary of the time from volitional release to capture at WC for both groups. The threshold of 15%, 50%, and 90% are based on total numbers caught of each group in 2014.

GROUP	15%	50%	90%	LAST DAY CAUGHT
TEST	Day 11	Day 19	Day 26	June 12
CONTROL	Day 19	Day 21	Day 30	June 27

The test group arrived at the WC monitoring site in less time and at a higher rate (i.e. faster and in greater abundance) than did the control group (Figure 3). The difference between the two groups is more pronounced when capture within the initial 30 days after the start of the volitional release when the expansion factor is applied (control = 3,423 and $test_{expnd}$ = 5,171). Between the two groups, the control group (n = 231) had more late season (after Memorial Day) recaptures than did the test group ($n_{expanded}$ = 180).

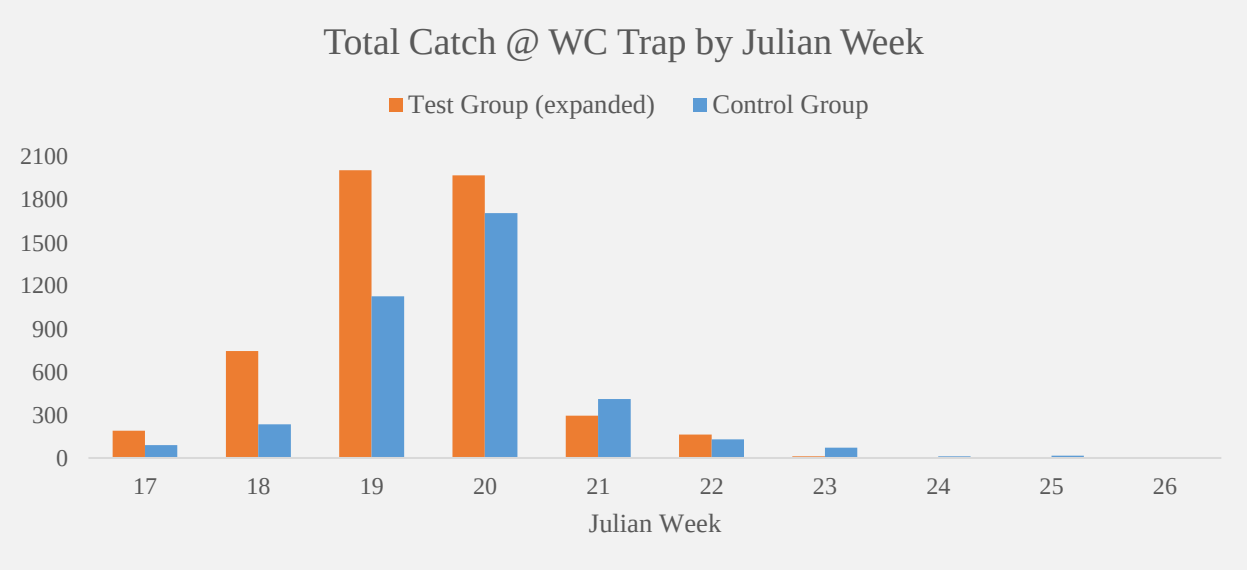

Figure 3. Raw catch summary for the 2014 TRH steelhead emigration season showing the difference in timing and magnitude between the test and control groups. The test group is expanded by an expansion factor used to compensate for sample size differences.

Discussion

The 2014 release of BY 2013 TRH steelhead was the initial release affected by the legally mandated "Consent Decree", which created new TRH protocols requiring delaying hatchery steelhead releases by six weeks. This new protocol likely altered many of this study's results compared to what might have been found in previous years. The extended rearing period likely lead to two unanticipated effects on the study:

1) Adjustments to the feeding regime were necessary to slow the growth of BY 2013 steelhead to maintain the release size goal of 6" or six fish per pound.

2) The adjusted release dates coincided with the Trinity River restoration flows conducted annually as part of the TRRP, and these flows can have a substantial effect on outmigration (Beeman et al. 2009).

Reduced feed levels had the anticipated effect on TRH steelhead condition, allowing rejection of the first null hypothesis. Both test and control groups had similar Fulton's *K* values before the study, but after one month of reduced feeding the test group showed a significantly lower Fulton's *K* value. The test group's K value reduction from 1.16 to 1.02 is indicative of the difference between not smolting and smolting (Naman 2008, Rhine 2002, Viola and Schuck 1995). Our data indicated that the test group continued to grow, even while starved, in both fork length and weight, but at about 50% of the control group. Continued growth, especially in fork length, is important because length at release influences adult survival and a release goal of at least 190 mm is optimal (Tipping 1997). The continued growth of the test group during the feed reduction should provide hatchery managers the justification to reduce feed levels prior to reaching the 190 mm goal and still meet the release size goal.

The second alternative hypothesis of food reduction resulting in an increased rate of volitional release was clearly confounded by major changes in TRH protocols that were also initiated in 2014. The factor that is most likely affecting these results were changes resulting in an extension of the rearing period by six weeks. Naman (2008) reported only 51% volitionally left the hatchery over an 11-day span compared to this study where 51% were gone after the first day, and 84% exited the hatchery during a shorter 9-day volitional release. The Naman (2008) study more closely resembled the typical TRH steelhead release from the past twenty years (personal communication, L. Glenn, April 2014, California Department of Fish and Wildlife, 1000 Hatchery Rd., Lewiston, CA 96052). A similar detection rate over the complete duration of the volitional release was seen in both groups (82%), indicating that food reduction had little to no effect on whether or not the fish were

actively leaving the hatchery raceways. The test group exited the hatchery raceways slightly faster than the control group, as they reached 95% at five and seven days, respectively.

Data from the WC monitoring site indicate the test group arrived at a higher rate and more quickly than did the control group, allowing rejection of the third null hypothesis. An earlier arrival to WC by TRH steelhead is likely to benefit natural Trinity River steelhead populations by reducing predation on salmonid fry upriver (Naman 2008). Any reduction in time spent in the upper Trinity River is likely to benefit all natural salmonid populations (Tatara et al 2011, Hawkins 1999, Berejikian et al 1996). There is also a potential benefit to the hatchery fish (assuming they continue their rate of downstream migration) through an earlier arrival to the Klamath River, where conditions have been known to negatively impact salmonids during the warm summer months (Bolick et al 2012). The higher rate of capture for the test group requires more investigation to gain a better understanding of the impetus causing the difference between the two groups. Potential causes that could explain the the measured differences between groups could be caused by an increased likelihood that the control group is residualizing at a highter rate in a location upstream of the WC monitoring site, or that the control group is suffering a higher rate of mortality prior to arrival at the WC monitoring site, or even that there is an inherent difference in the catchability between the two groups.

The results reported will hopefully be used to justify the continuation of recent changes to TRH protocols that appear to benefit both hatchery and natural process (i.e. continuing the extended rearing of TRH steelhead). And hopefully the results presented here will provide insight and justification for TRH managers to change some aspects of TRH protocols such as modifying and optimizing TRH feeding schedules that have the potential to:

1) Save money on fish food pucrchases by reducing the amount needed for the whole year
2) Reduce the predation potential that TRH steelhead pose to natural populations by expediting their movement through the Trinity River system.
3) Help ensure mitigation responsiblilites are met.

A second year to this study has been anticipated for two years and is planned to move forward and be completed in FY 2017 with the continued support from TRH co-managers and the Trinity River Hatchery Governance Board and Hatchery Coordination Team. Although some logistics need to be worked out and discussed, some of the aspects year two will hopefully address include:

1) What is the effect that the reduction in population size produced and released from TRH has on emigration timing.
2) Provide insight into both, determine in a more substatial manner as to the effect feeding levels has on the volitional release.

3) Acquire 2 equal sample sizes so that more direct comparisons can be made and inferred on the data.

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