LOWER YUBA RIVER ACCORD MONITORING AND EVALUATION PROGRAM

ANNUAL REDD SURVEY REPORT

2010-2011

Prepared for: The Lower Yuba River Accord Planning Team

by

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The information contained in this annual data report represents study results at the date of publication. Recent analysis using multi-year data have fostered a more up-to-date understanding of lower Yuba River fisheries interactions. The results presented in this annual data report may or may not represent the current understanding stemming from recent analysis using comprehensive multi-year data. Please refer to the M&E Interim Report for a more recent analysis and discussion.

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1. INTRODUCTION

The lower Yuba River Accord (Accord) consists of a Fisheries Agreement and several other elements. The Fisheries Agreement includes descriptions of the River Management Team (RMT), the River Management Fund (RMF), and the Monitoring and Evaluation Plan (M&E Plan). The Fisheries Agreement in its entirety can be found on the Accord RMT website[1].

The RMT Planning Group includes representatives of the California Department of Fish and Game (CDFG), National Marine Fisheries Service, Pacific Gas and Electric, U.S. Fish and Wildlife Service, Yuba County Water Agency, and one representative for the four non-government organizations (Friends of the River, South Yuba River Citizen's League, The Bay Institute and Trout Unlimited) that are parties to the Fisheries Agreement. The RMT planning group has developed the M&E Plan to guide study efforts through the efficient expenditure of RMF funds.

Multiple survey techniques will be utilized to address the specific analytics that are necessary to evaluate the performance indicators detailed in the M&E Plan. Analytical goals of the redd surveys conducted in the lower Yuba River include: 1) an evaluation and comparison of the spatial and temporal distribution of redds and redd superimposition over the spawning seasons for Chinook salmon and steelhead trout spawning in the lower Yuba River; 2) a comparison of the magnitude and seasonal trends of lower Yuba River flows and water temperatures with the spatial and temporal distribution of redds (and rates of redd superimposition) for the Chinook salmon and steelhead trout; 3) an evaluation of the total annual abundance of Chinook salmon and steelhead trout in conjunction with escapement surveys, angler surveys and Vaki Riverwatcher data; and 4) to establish a long-term data set to be used to evaluate habitat utilization by the Chinook salmon and steelhead trout in the lower Yuba River under variable biotic and abiotic conditions.

The purpose of this Annual Lower Yuba Accord Redd Survey Data Report is to: 1) document findings for the analytics in the M&E Program that are dependent on annual data collection from redd surveys; 2) document any deviations from the redd survey sampling protocols and procedures described in the M&E Program; and 3) provide recommendations for changes in following year's redd survey field protocols and procedures.

1.1. Analytics Overview

Several analytic applications have been identified in the M&E Plan framework associated with data collected from the annual redd surveys. The major categories to be addressed in this annual report include redd survey efficacy, redd abundance and diversity. A brief description of each analytic is described below.

Redd Survey Efficacy

- Examine the duration of the annual redd surveys and document temporal periods when surveys could not be implemented.

Abundance

- Evaluate the spatial and temporal distribution of redds and the temporal distribution of redd superimposition over the spawning periods for spring-, fall-, and late fall-run Chinook salmon.

[1] http://www.yubaaccordrmt.com

- Estimate the number of Chinook salmon and steelhead trout redds located upstream and downstream of Daguerre Point Dam (DPD).

- Examine the spatial and temporal distribution of redds over the spawning period for steelhead trout.

- Compare the magnitude of lower Yuba River flows and water temperatures with the temporal and spatial distribution of adult spring-, fall-, and late fall-run Chinook salmon and steelhead trout spawning.

- Compare the magnitude of lower Yuba River flows and water temperatures with the annual total number of redds and redd superimposition indices for Chinook salmon, taking into account the annual variability in spawning Chinook salmon abundance.

- Compare the magnitude of lower Yuba River flows and water temperatures with the annual total number of redds for steelhead trout, taking into account the annual variability in spawning steelhead trout abundance.

Diversity

- Determine temporal variation in spawning by spring-, fall-, and late fall-run Chinook salmon adults.

- Examine the timing of spring-, fall-, and late fall-run Chinook salmon spawning and, relationships between timing of spawning with water temperature and flow.

- Examine attributes for each individual redd encountered during the surveys; including the physical redd measurements, substrate and habitat characterizations.

2. FIELD METHODS

Field sampling methods are described in the Annual Redd Surveys Protocols and Procedures (Appendix I of the Accord M&E Plan).

2.1. Deviations from the Redd Survey Protocols and Procedures

Specific protocols and procedures for the annual redd surveys were developed to include a weekly survey frequency beginning at the onset of spawning in the fall and concluding on or near January 1, after which a bi-weekly sampling frequency was to be implemented. However, the weekly sampling protocol was extended and continued through the entire survey period. The protocols and procedures also required the cessation of sampling on April 30 each year. Due to high flows and sustained turbidity levels, sampling through the entire month of April was not feasible during this reporting period.

The protocols and procedures required redd size measurements to be collected at each newly constructed redd observed where an adult salmonid was either actively building, or guarding a redd. This convention was not implemented because surveyors were unable to associate individual redds with observed fish in the area. The pontoon boats used to navigate the river during surveys frightened spawning salmonids from redds prior to observation by surveyors.

No surveys were completed in the 0.4 mile section of river directly upstream of Daguerre Point Dam due to safety concerns of working in close proximity to the dam. Additionally during the weeks of December 13, 2010, January 31, 2011 and April 11, 2011 no surveys were completed in the Englebright Dam and Narrows Reaches due to high flows and turbid conditions.

Two individual redds, observed during the weeks of September 20, 2010 and November 15, 2010, had no associated positional data due to poor satellite coverage and were removed from all analyses.

The substrate class size descriptions and classification systems were also modified by direction of the RMT in March 2010 to reduce observer error and to obtain a more detailed description of the undisturbed substrate elements at each redd location. Substrate descriptions and results for Chinook salmon and steelhead trout redds were reported from this modified substrate classification scheme.

3. DATA ANALYSIS METHODS

3.1. Redd Survey Efficacy

The duration and number of days required to implement this annual redd survey were evaluated, including temporal sampling periods and causal descriptions for missed surveys.

3.2. Abundance

An evaluation and comparison of the spatial and temporal redd distributions, including temporal distributions of redd superimposition for spring-, fall-, and late fall-run Chinook salmon spawning periods was performed. Correlative analysis using simple linear regression of GIS-based spatial outputs for mapped spring-, fall-, and late fall-run Chinook salmon redds was completed during each of the run-specific spawning periods to assess the location and number of fresh redds observed during each weekly strata. Evaluations included: 1) changes in the weekly spatial distributions of the spawning locations over the entire spawning season; and 2) changes in the weekly temporal distributions of spawning locations over the entire spawning season.

Weekly and annual indices of redd superimposition from the annual Chinook salmon redd surveys were estimated using GIS-based spatial output. Ellipse buffers were created for each individual redd using the mean physical measurements of all redds included in the sample size. The magnitude of redd superimposition was estimated using ArcGIS to quantify the percent overlap of each redd constructed in the surveyed area. Redd superimposition within each strata was expressed as the frequency of individual redds that exhibited overlap versus the total number of redds observed in the surveyed area. A correlative analysis using simple linear regression of the weekly index of superimposition for spring-, fall-, and late fall-run Chinook salmon redds during each of the run-specific spawning periods was performed for the entire spawning season.

Redd data were used to enumerate Chinook salmon and steelhead trout redds observed upstream and downstream of Daguerre Point Dam (DPD). The temporal and spatial distributions of spawning steelhead were identified using the number of redds observed and the redd locations documented for each survey period for the entire steelhead trout spawning season.

Chinook salmon redd observations were assigned by morphological unit for each of the eight lower Yuba River reach delineations using ArcGIS. Descriptors for each of the eight reaches have been tabulated to include measures of the valley width, best-fit bed slope, presence of tributary inflow, distance from the mouth, and a start point description (Table 1). Table 2 has been created to illustrate depth and velocity value delineations used in conjunction with outputs from the 2D model and other sources to determine morphological units in ArcGIS.

Table 1. Reach descriptors developed by the RMT from LIDAR-based topographic mapping and 2D flow modeling on the lower Yuba River, CA (Appendix I, Lower Yuba River Accord Monitoring and Evaluation Plan).

Reach Name	Valley Width (m)			Best-Fit Bed Slope	Tributary Inflow?	Thalweg Distance from Mouth (km)	Start Point
	Min.	Mean	Max.				
Englebright Dam Reach	55	95	176	0.310%	No	n/a	Englebright Dam
Narrows Reach	n/a	n/a	n/a	n/a	Yes	n/a	Deer Creek Confluence
Timbuctoo Bend Reach	97	166	411	0.201%	No	31.1 - 37.4	Onset of Emergent Gravel Floodplain Upstream of Blue Point Mine
Parks Bar Reach	95	297	434	0.188%	No	23.2 - 31.1	State Route 20 Bridge
Dry Creek Reach	239	308	490	0.135%	Yes	19.4 - 23.2	Dry Creek Confluence
Daguerre Point Dam Reach	198	449	554	0.176%	No	13.7 - 23.2	Daguerre Point Dam
Hallwood Reach	71	271	569	0.131%	No	5.3 - 13.7	Eddie Drive aims at Slope Break
Marysville Reach	68	171	381	0.052%	No	0 - 5.3	No Evident Feature

Table 2. Depth and velocity value delineations used in conjunction with NAIP aerial imagery, topography, contours, sediment mapping and the GIS 2D (SRH-2D) model to determine morphological units in the lower Yuba River, CA (courtesy Josh Wyrick, PhD and Greg Pasternack, PhD – U.C. Davis).

Morphological Unit	Description
Bedrock	Bedrock outcropping at elevation greater than the valley to slope break.
Chute	Area of high velocity, steep water surface slope, and moderate to high depth located in the channel thalweg. Chutes are often located in a convergent constriction downstream of a riffle as it transitions into a run, forced pool, pool, or glide. Depths exceed 2.25 ft (0.69 m) and velocities exceed 3 ft/s (0.91 m/s).
Cutbank	Steep bank that is eroding heavily. Often located on the outside of a meander bend. Can be composed of either gravel/cobble alluvium or angular hillslode rocks and boulders, depending on the location of occurrence.
Fast Glide	Area of moderate velocity and depth and low water surface slope. Depth can range from 2.25-4.6 ft (0.69-1.4 m). Commonly occur along periphery of channel and flanking pools. Also exist in straight sections of low bed slope.
Floodplain	Area located at an elevation higher than the bankful channel and lower than that of the valley toe slope break.
Hillside	Natural colluvium at an elevation greater than the valley toe slope break.
Lateral Bar	Area located at the channel margins at an elevation band between the autumnal low-flow stage and bankful stage. Lateral bars are orientated parallel to the flow. The feature slopes toward the channel thalweg with an associated increase in both flow depth and velocity when submerged. Sediment size tends to be smaller than in adjacent sections of the channel.
Medial Bar	Emerged bar surrounded by water at low discharge. Higher flows may temporarily submerge the bar.
Point Bar	Area located on the inside of a meander bend at an elevation band between the autumnal low-flow stage and bankful stage. Point bars are curved and begin where there is clear evidence of point-bar deposition. The feature slopes toward the channel thalweg with an associated increase in both flow depth and velocity when submerged. Sediment size tends to be smaller than in adjacent sections of the channel.
Pond	Located on the floodplain and not attached to the main channel by a surface opening during low flow
Pool / Forced Pool	Pools are areas of high depth and low velocity, specifically for water depth > 4.6 ft (1.4 m) and velocity < 2.0 ft/s (0.61 m/s), and low water surface slope. A 'forced pool' is one that is typically along the periphery of the channel and is "over-deepened" from local convective acceleration and scour during floods that is associated with static structures such as wood, boulders, and mostly bedrock outcrops (Montgomery and Buffington, 1997; Thompson et al., 2001). A 'pool' is not formed by a forcing obstruction.
Riffle	Area with shallow depths of <2.25' (0.69 m), moderate to high velocities greater than 2 ft/s (0.61 m/s), rough water surface texture, and steep water surface slope. Riffles are associated with the crest and backslope of a transverse bar.
Riffle Transition	Typically a transitional area between an upstream morphological unit into a riffle, or from a riffle into a downstream morphological unit. Water depth is relatively low, ranging from 0-2.25 ft (0.69 m). Velocity is low, ranging from 1-2 ft/s (0.3-0.61 m/s), but increases downstream due to convective acceleration toward the shallow riffle crest that is caused by lateral and vertical flow convergence. The upstream limit is at the approximate location where there is a transition from a divergent to convergent flow pattern. The downstream limit is at the slope break of the channel bed termed the riffle crest.
Run	Area with a moderate velocity, between 2 and 3 ft/s (0.61 and 0.91 m/s), and moderate water surface slope. Depths are greater than 2.25 ft (0.69 m). Runs typically occur in straight sections that exhibit a moderate water surface texture and tend not to be located over transverse bars.
Slackwater	Shallow, low-velocity regions of the stream that are typically located in adjacent embayments, side channels, or along channel margins. Velocities are near stagnant, less than 0.5 ft/s (0.15 m/s), and depths can range from 0-4.6 ft (1.4 m).
Slow Glide	Area of low velocity and low to moderate depths and low water surface slope. Velocities range from 0.5 -1.0 ft/s (0.15-0.3 m/s) and depths are less than 4.6 ft (1.4 m). May be located near water's edge as a morphological unit along the channel thalweg transitions laterally towards the stream margins
Swale	A poorly defined geometric channel located in the floodplain adjacent to the main channel, but does not contain water at low discharge. Higher discharges will overflow into the channel due to backwater effects in the main stem.
Tailings	Alluvium artificially piled up to an elevation higher than the floodplain surface during historic dredging for gold.
Terrace	A natural alluvial deposit at an elevation higher than the floodplain surface.
Tributary Channel	Waterway that confluences with the main channel and whose headwater source is separate from the main channel. The mouth of the tributary channel may backwater during high flow events in the main channel.
Tributary Delta	Alluvial fans penetrating the floodplain and main channel at tributary junctions.

Potential relationships between flow, temperatures and peak spawning for spring-, fall-, and late fall-run Chinook salmon and steelhead trout were examined using estimated peak spawning periods derived from the temporal redd distributions observed. Flow and water temperature observations were described using various metrics (e.g., maximum, minimum, average, median and variance of mean daily flow) during the spring-, fall-, and late fall-run Chinook salmon and steelhead trout spawning periods. Simple linear regression was used to examine potential relationships between multi-year peak spawning periodicities (response variable) and corresponding flow and water temperature metrics (explanatory variables). Dates associated with percentile expressions (1%, 10%, 25%, 50%, 75%, 90% and 99%) of the cumulative temporal distribution of spring-, fall-, and late fall-run Chinook salmon and steelhead trout spawning were identified by fitting an asymmetric logistic function to the cumulative temporal distribution of fresh redds from the redd survey data (Richards 1959):

$$\sum_{i=1}^{D_i=n} Y_i(\%) = 100 \times \left(\frac{1}{1+\exp(\alpha + \beta \times D_i)} \right)^{\frac{1}{\delta}};$$

where $\sum_{i=1}^{D_i=n} Y_i(\%)$ is the percentage of the cumulative temporal distribution of each run of Chinook salmon and steelhead trout spawning from day 1 through time D_i, and α, β and δ are parameters (i.e., constants) that describe the shape of the resulting relative cumulative curve. The values of these parameters were obtained through non-linear least squares estimation. Once the asymmetric logistic function curve was fitted to the data, the dates at which a particular percentage (X) of each run of Chinook salmon and steelhead trout spawning ($\hat{D}_{X\%}$) was identified using the inverse estimation:

$$\hat{D}_{X\%} = \frac{\log_e\left(\frac{100}{X^{\delta}} - 1\right) - \alpha}{\beta};$$

where α, β and δ were the parameter values obtained from the asymmetric logistic function, and *X* was the percentage of interest (e.g., 1%, 10%, 25%, 50%, 75%, 90% and 99%). For example, the resulting estimates of $\hat{D}_{10\%}$, $\hat{D}_{25\%}$, $\hat{D}_{50\%}$, $\hat{D}_{75\%}$ and $\hat{D}_{90\%}$ summarized the characteristics of the corresponding annual temporal distribution of spawning adult salmonids.

Potential relationships between the timing of spawning with the magnitude of flow and water temperature were examined by plotting the dates associated with the percentile expressions (1%, 10%, 25%, 50%, 75%, 90% and 99%) of the cumulative temporal redd distribution for spring-, fall-, and late fall-run Chinook salmon and steelhead trout against various flow and water temperature metrics (e.g., maximum, minimum, average, median and variance of mean daily flow). Simple linear regression was used to examine potential relationships between periodicities associated with the percentile expressions for spawning (response variable) and corresponding flow and water temperature metrics (explanatory variables).

Chinook salmon redd positional data were analyzed to determine if the observed spawning locations were randomly distributed along the longitudinal profile of the lower Yuba River utilizing protocols developed by Wyrick and Pasternack (2011). A line was manually drawn in ArcGIS that approximated the center of the geomorphically-active channel for the entire length of the river. Station lines were drawn at a longitudinal spacing of 20 feet that radiated perpendicularly from the centerline to a total width distance of

2,000 feet[2]. Each station line was used to create a box (bin) that measured 20 feet by 2,000 feet in size and was compiled to form a station buffer shapefile consisting of 6,086 bins. Coordinate data for each redd location was added to the station buffer shapefile to assign a longitudinal station to each location. Stations were plotted with location frequencies to create a graphical representation of the longitudinal distribution within the lower Yuba River. Because an equal chance exists of a random point occurring anywhere along the length of the river, a plot of the longitudinal frequency distribution for a random dataset should be approximately uniform. If the observational data exhibits a non-uniform frequency distribution, then an ordered, non-random plot demonstrating preferential selection should result.

3.3. Diversity

Redd attribute data were used to examine Chinook salmon and steelhead trout redd physical attributes. Redd size was described using standard metrics (e.g., maximum, minimum, mean, median and variance of redd measurements).

Redd attribute data were used to examine substrate characterizations for Chinook salmon and steelhead trout. Substrate characterizations were described using standard metrics (e.g., maximum, minimum, mean, median and variance of substrate characterizations).

4. RESULTS

4.1. Redd Survey Efficacy

The 2010-2011 redd survey began on September 13, 2010 following preliminary field reconnaissance surveys that observed Chinook salmon adults staging near gravel substrates. Redd surveys continued uninterrupted through October 26, 2010 when precipitation and runoff from an early winter storm caused turbidity levels to rise, suspending that week's and the following week's survey. Surveys resumed on November 8, 2010 continuing uninterrupted until December 6, 2010 when storm precipitation and runoff caused turbidity levels to rise and remain elevated until surveys resumed on December 14, 2010. On December 20, 2010, the weekly redd survey was again suspended due to winter storm runoff. Weekly surveys resumed during the week of January 17, 2011. On February 21, 2011, the weekly redd survey was suspended due to winter storm runoff. Redd surveys briefly resumed during the week of March 11, 2011, after which winter storm precipitation and runoff caused turbidity levels to rise and precluded sampling through the remainder of April 2011.

Results were tabulated for each weekly strata including the number of survey days required to complete all surveyed reaches, the mean weekly Secchi depth measurement, the minimum, maximum and mean of flows at the USGS Smartsville and Marysville gages, and water temperatures recorded at the USGS Smartsville and Marysville gages (Appendix A, Table A1).

4.2. Abundance

A total of 3,151 Chinook salmon redds were observed during the survey period. Peak observations of Chinook salmon redds for all surveyed reaches occurred during the week of November 8, 2010 when 624 Chinook salmon redds were observed in the surveyed reaches of the lower Yuba River[3] (Figure 1 and Appendix A, Table A2). The highest abundance of observed Chinook salmon redds occurred at river mile

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[2] A channel width of 2,000 feet was chosen to completely encapsulate the channel flow widths at high flow stages.

[3] See discussion page 17.

(RM) 15 (n=326), RM 19 (n=457), RM 20 (n=322) and RM 21 (n=455); accounting for nearly 50% of the observed Chinook salmon redds in all surveyed reaches (Appendix A, Tables A3-A6).

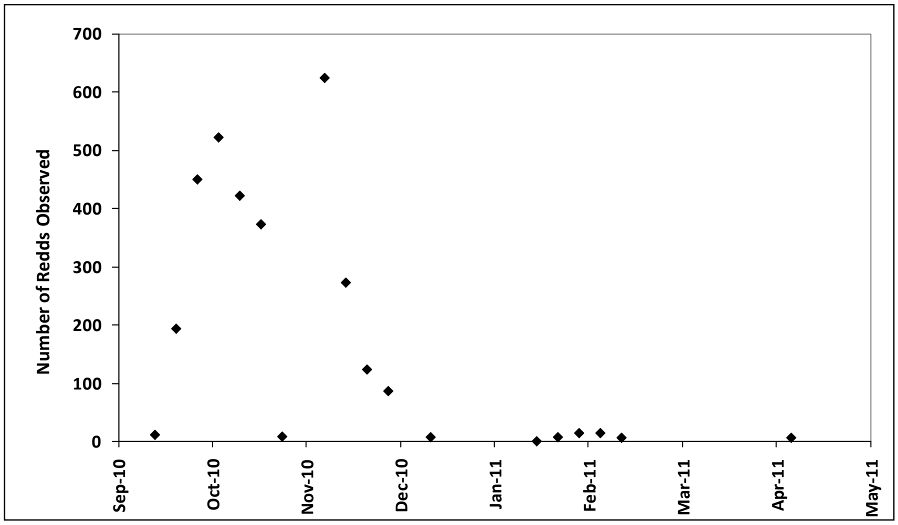

Figure 1. Weekly number of observed Chinook salmon redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

GIS spatial analysis of Chinook salmon redds identified that 62% of all redds were observed in riffle and riffle transition morphological unit delineations. Redds constructed in riffle units represented 36.2% (n=1,140) of the observed redds, whereas redds constructed in riffle transitions constituted 19.8% (n=624) of the observed totals (Table 3). No Chinook salmon redds were observed in bedrock, cutbank, floodplain, pond, tailings, terrace, tributary channel or tributary delta morphological units and thus, these units were not included in Table 3.

Nearly 75% of Chinook salmon redds were observed in the Timbuctoo Bend and Parks Bar reaches. Redds constructed in the Timbuctoo Bend reach represented 42.2% (n=1,329) of the observed Chinook salmon redds, whereas redds constructed in the Parks Bar reach constituted 32.2% (n=1,016) of the cumulative total observed in all surveyed reaches (Table 3).

Table 3. Number of observed Chinook salmon redds stratified by morphological unit in each of the reach delineations of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Morphological Unit	Englebright Dam Reach	Narrows Reach[1]	Timbutoo Bend Reach	Parks Bar Reach	Dry Creek Reach	Daguerre Dam Reach	Hallwood Reach	Marysville Reach	TOTALS	Percent
Chute	1	n/a	50	50	6	2	0	0	109	3.5%
Fast Glide	0	n/a	302	53	12	5	12	4	388	12.3%
Hillside	0	n/a	0	0	0	0	0	0	0	0.0%
Lateral Bar	3	n/a	11	19	2	23	1	0	59	1.9%
Medial Bar	0	n/a	1	2	8	1	0	0	12	0.4%
Point Bar	0	n/a	3	9	0	1	2	0	15	0.5%
Pool	0	n/a	14	1	6	1	0	0	22	0.7%
Riffle	13	n/a	308	460	30	218	106	5	1,140	36.2%
Riffle Transition	1	n/a	282	167	42	66	65	1	624	19.8%
Run	2	n/a	275	211	22	15	22	2	549	17.4%
Slackwater	0	n/a	22	15	3	17	0	0	57	1.8%
Slow Glide	0	n/a	60	29	9	12	7	0	117	3.7%
Swale	0	n/a	0	0	0	1	0	0	1	0.0%
No MU ID[2]	0	56	1	0	1	0	0	0	58	1.8%
TOTALS	20	56	1,329	1,016	141	362	215	12	3,151	100.0%
Percent	0.6%	1.8%	42.2%	32.2%	4.5%	11.5%	6.8%	0.4%	100.0%	

[1] No morphological unit delineation yet exists for the Narrows Reach. [2] Two redds were located outside the current delineated MU map.

A total of 2,562 Chinook salmon redds were observed upstream of Daguerre Point Dam (DPD) during the survey period, whereas 589 were observed downstream of DPD. Peak observations of Chinook salmon redds upstream of DPD occurred during the week of October 4, 2010 when 494 Chinook salmon redds were observed. Peak observations of Chinook salmon redds downstream of DPD occurred during the week of November 8, 2010 when 227 Chinook salmon redds were observed (Appendix A, Table A2).

Simple linear regressions to assess redd abundance by river mile during each weekly stratum exhibited weak relationships between response and explanatory variables, with the strongest correlations between variants occurring either early in the survey period, or after combining all cumulative strata (Appendix A, Table A7).

A simple linear regression of Chinook salmon superimposition frequency for each weekly stratum (Appendix A, Table A8) was unable to identify a relationship between response and explanatory variables moving through the survey period. The resulting regression described less than 1% of the observations (Figure 2).

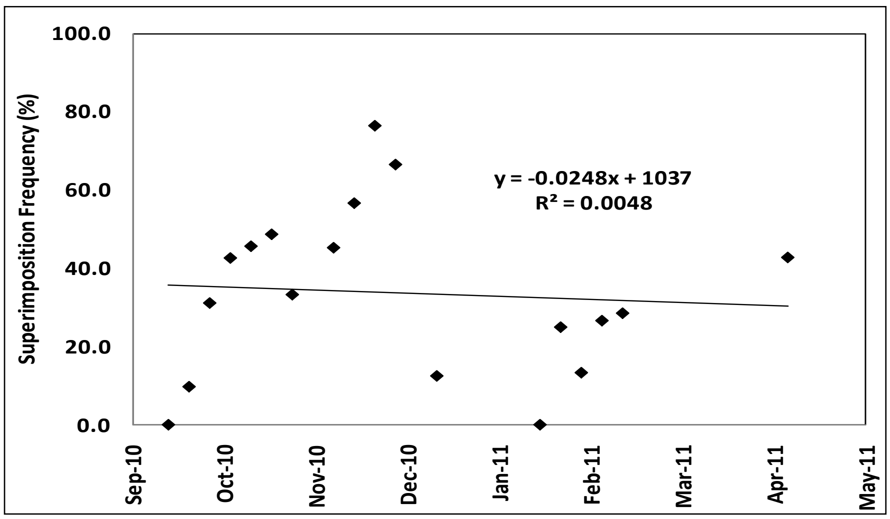

Figure 2. Simple linear regression of the weekly frequency of superimposition for Chinook salmon in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Redd superimposition analysis using ArcGIS demonstrated that 66% (2,091 of 3,151 total) of Chinook salmon redds exhibited a measureable degree of superimposition; 265 were found to have a level of superimposition greater than 50%[4] (Appendix A, Tables A9-A16). The highest frequency of superimposed Chinook salmon redds were found to occur at RM 19 (n=323), RM 20 (n=261) and RM 21 (n=360) (Appendix A, Tables A17-A24).

A fitted asymmetric logistic function predicted that 50% of Chinook salmon spawning was observed by October 18, 2010, with 90% of the observations occurring by November 22, 2010 (Figure 3). The predicted date associated with the percentile expressions for Chinook salmon was plotted against mean daily flow and water temperatures for each corresponding stratum (Figure 4).

[4] See discussion page 20.

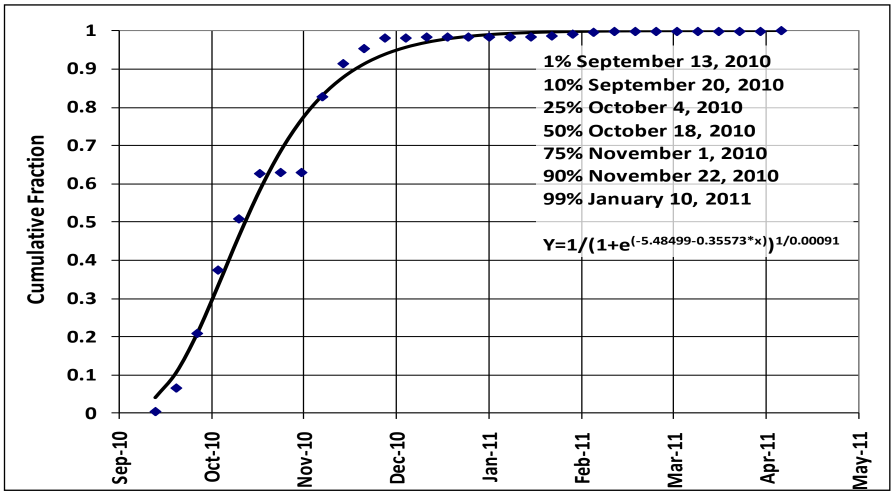

Figure 3. Cumulative temporal distribution of observed Chinook salmon redd abundance in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

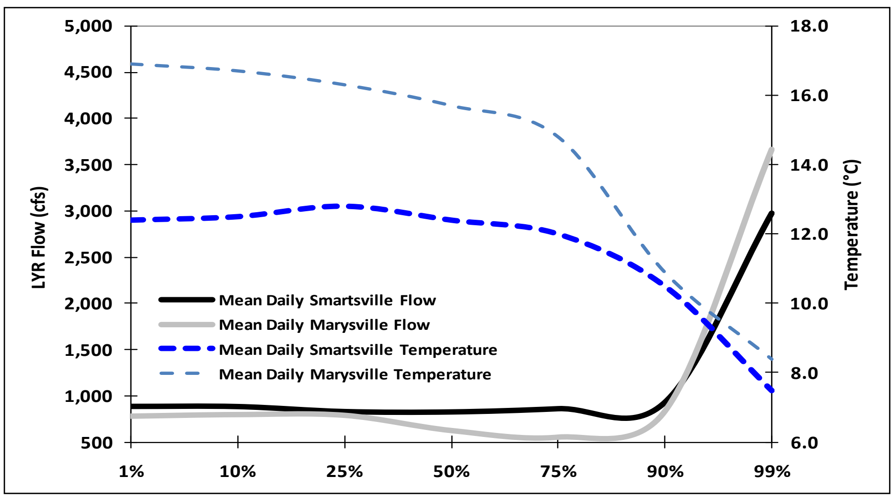

Figure 4. Mean daily flow (cfs) and mean daily temperature (°C) at the USGS Smartsville and Marysville gages through the percentile expressions (1%, 10%, 25%, 50%, 75%, 90% and 99%) for Chinook salmon redd abundance in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Spatial analysis of Chinook salmon redd positional data indicated a non-random distribution within the longitudinal length of lower Yuba River. The resulting plot (Figure 5) exhibited a non-uniform distribution, suggesting that selective preference influenced the location of redd construction. Additional analyses were completed to assess randomness versus preference in each of the eight reaches of the lower Yuba River. The Parks Bar and Timbuctoo Bend reaches illustrated random distributions with smaller scale sections within the reaches that exhibited preference[5] (Appendix A, Figure A1).

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[5] See discussion page 19.

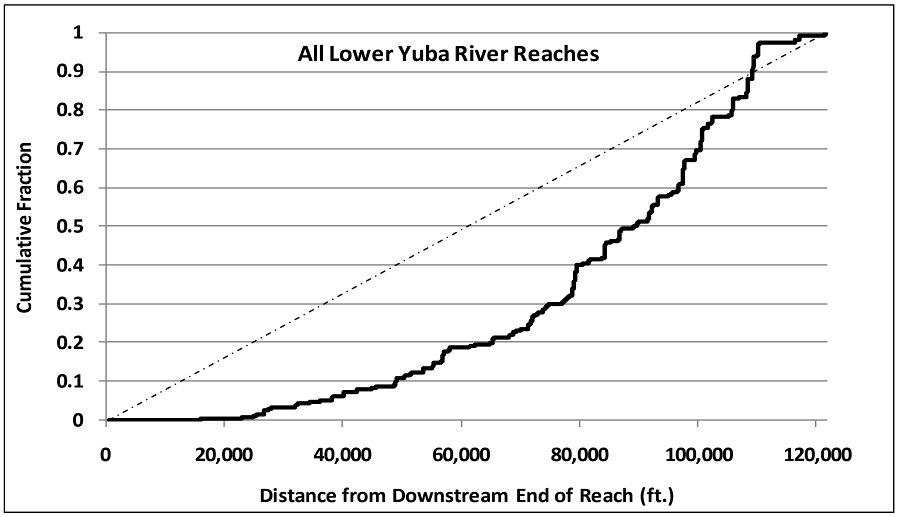

Figure 5. Cumulative plot of the longitudinal distribution of Chinook salmon redd locations in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

A total of 38 steelhead trout[6] redds were observed during the 2010-2011 survey period in all surveyed reaches of the lower Yuba River. Peak observations of steelhead trout redds for the survey period occurred during the week of January 31, 2011 when 12 redds were observed (Figure 6 and Appendix A, Table A2). The highest abundance of observed steelhead trout redds occurred in RM 18 (n=11), RM 19 (n=6) and RM 21(n=10); accounting for over 70% of the observed steelhead trout redds in the entire survey area (Appendix A, Tables A25-A28).

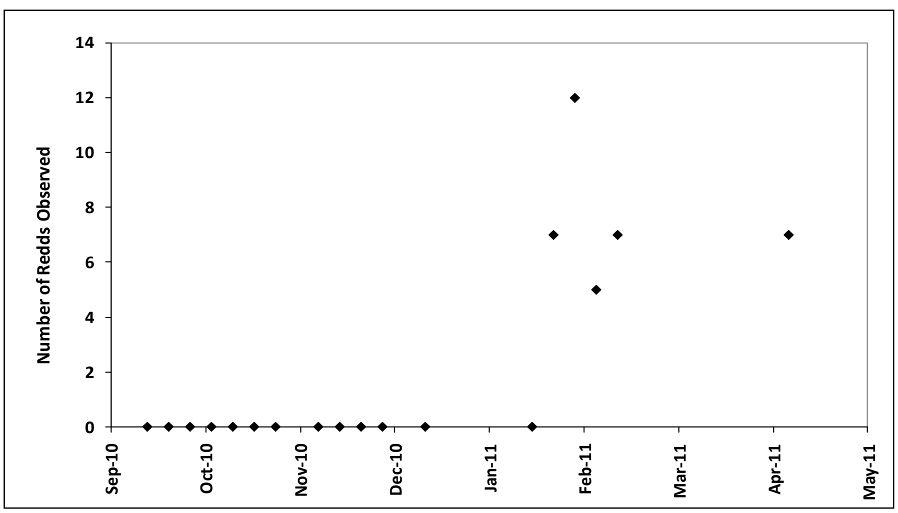

Figure 6. Weekly number of observed steelhead trout redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Spatial analysis of steelhead trout redd distributions using ArcGIS identified nearly 45% of redds occurring in lateral bar and slow glide morphological units. Redds constructed in lateral bars represented 21.1% (n=8) of the observed redds, whereas redds constructed in slow glides constituted 23.7% (n=9) of the observed redds in all morphological units (Table 4). No steelhead trout redds were observed in

[6] Steelhead trout refers to the species, *Oncorhynchus mykiss*, regardless of anadromous, potadromous, or resident life history.

bedrock, cutbank, floodplain, pond, tailings, terrace, tributary channel or tributary delta morphological units and thus, these units were not included in Table 4. Over 89% of all observed steelhead trout redds occurred in the Timbuctoo Bend and Parks Bar reaches. Redds constructed in the Timbuctoo Bend reach represented 60.5% (n=23) of the observed total, whereas redds constructed in the Parks Bar reach constituted 28.9% (n=11) of the cumulative total observed in all surveyed reaches (Table 4).

Table 4. Number of observed steelhead trout redds stratified by morphological unit in each of the reach delineations of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Morphological Unit	Englebright Dam Reach	Narrows Reach[1]	Timbutoo Bend Reach	Parks Bar Reach	Dry Creek Reach	Daguerre Dam Reach	Hallwood Reach	Marysville Reach	TOTALS	Percent
Chute	0	n/a	0	0	0	0	0	0	0	0.0%
Fast Glide	0	n/a	0	0	0	0	0	0	0	0.0%
Hillside	0	n/a	0	0	0	0	0	0	0	0.0%
Lateral Bar	0	n/a	2	5	0	1	0	0	8	21.1%
Medial Bar	0	n/a	0	0	0	0	1	0	1	2.6%
Point Bar	0	n/a	6	1	0	0	0	0	7	18.4%
Pool	0	n/a	0	0	0	0	0	0	0	0.0%
Riffle	0	n/a	2	0	0	0	0	0	2	5.3%
Riffle Transition	0	n/a	4	3	0	0	0	0	7	18.4%
Run	0	n/a	0	0	0	0	0	0	0	0.0%
Slackwater	0	n/a	1	2	0	1	0	0	4	10.5%
Slow Glide	0	n/a	8	0	0	1	0	0	9	23.7%
Swale	0	n/a	0	0	0	0	0	0	0	0.0%
No MU ID	0	n/a	0	0	0	0	0	0	0	0.0%
TOTALS	0	0	23	11	0	3	1	0	38	100.0%
Percent	0.0%	0.0%	60.5%	28.9%	0.0%	7.9%	2.6%	0.0%	100.0%	

[1] No morphological unit delineation yet exists for the Narrows Reach.

A total of 34 steelhead trout redds representing 89.5% of all observations were recorded upstream of DPD and 4 (10.5%) steelhead trout redds were observed downstream of DPD during the survey period. The peak observation of steelhead trout redds upstream of DPD occurred during the week of January 31, 2011 when 12 steelhead trout redds were observed, whereas peak observations downstream of DPD occurred during the weeks of January 24 and February 2, 2011 when 2 steelhead trout redds were observed during each weekly survey (Appendix A, Table A2).

A fitted asymmetric logistic function predicted that 50% of the steelhead trout redds were observed during the week of February 7, 2011 and 90% were observed during the week of March 7, 2011 (Figure 7). The predicted date associated with the percentile expressions for steelhead trout were plotted against mean daily flow and water temperatures for each corresponding stratum (Figure 8).

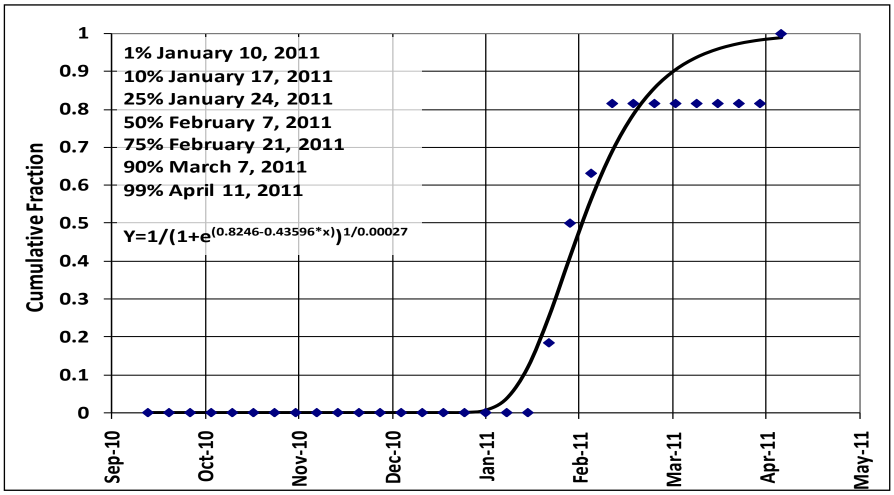

Figure 7. Cumulative temporal distribution of observed steelhead trout redd abundance in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

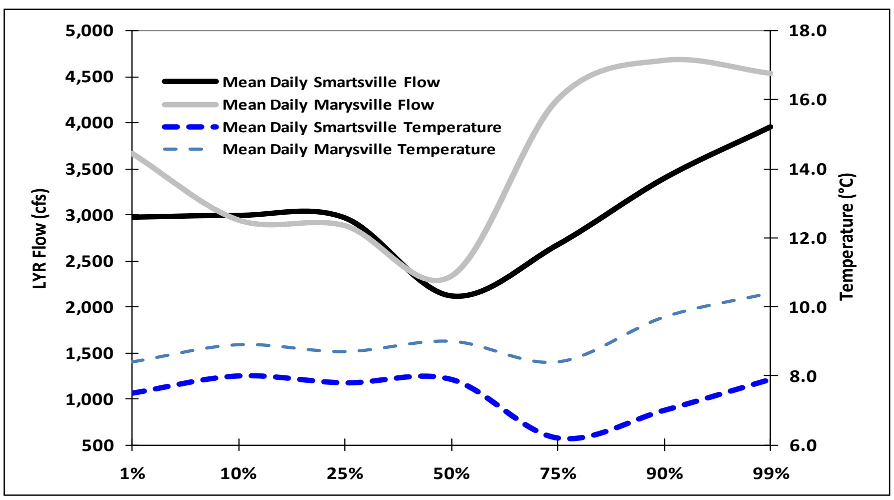

Figure 8. Mean daily flow (cfs) and mean daily temperature (°C) at the USGS Smartsville and Marysville gages through the percentile expressions (1%, 10%, 25%, 50%, 75%, 90% and 99%) from observed steelhead trout redd abundance in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

4.3. Diversity

Chinook salmon redd measurements indicated that the mean pot length was 1.6m ± 0.07m[7] and the mean pot width was 1.7m ± 0.09m. The mean tail spill length was 2.6m ± 0.12m, the mean tail spill width #1 was 1.9m ± 0.09m and the mean tail spill width #2 was 1.5m ± 0.08m (Table 5).

[7] All confidence intervals calculated at 95%.

Table 5. Descriptive statistics for the physical size measurements (m) of systematically sampled Chinook salmon redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

	Pot Length	Pot Width	Tail Spill Length	Tail Spill Width #1	Tail Spill Width #2
Sample Size	210	210	210	210	210
MIN	0.5	0.4	0.4	0.4	0.3
MAX	3.2	3.5	5.2	4.5	3.8
MEAN	1.6	1.7	2.6	1.9	1.5
MEDIAN	1.5	1.6	2.5	1.9	1.4
VARIANCE	0.2	0.4	0.8	0.4	0.3
STD DEV	0.5	0.7	0.9	0.7	0.6
CONFIDENCE	0.07	0.09	0.12	0.09	0.08

Substrate characterizations for Chinook salmon redds identified that fine cobble and cobble comprised the majority of observations. Substrate observations for fine cobble were represented by 39.97% ± 0.57%, whereas cobble represented 30.19% ± 0.59% (Table 8) of the characterizations for Chinook salmon redds.

Table 6. Descriptive Statistics for the substrate characterization percentages of sampled Chinook salmon redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

	Bedrock	Boulder >256mm	Lg. Cobble 128-256 mm	Cobble 90-128 mm	Fine Cobble 32-90 mm	Gravel 2-32 mm	Sand 0.0625-2 mm	Silt/Clay <0.0625 mm
Sample Size	3091	3091	3091	3091	3091	3091	3091	3091
MIN	0%	0%	0%	0%	0%	0%	0%	0%
MAX	20%	60%	80%	90%	100%	90%	40%	30%
MEAN	0.01%	0.87%	10.28%	30.19%	39.97%	18.16%	0.51%	0.02%
MEDIAN	0%	0%	0%	30%	40%	20%	0%	0%
VARIANCE	0%	0.28%	2.14%	2.78%	2.61%	2.64%	0.11%	0%
STD DEV	0%	5.33%	14.62%	16.66%	16.14%	16.25%	3.34%	0.65%
CONFIDENCE	0%	0.19%	0.52%	0.59%	0.57%	0.57%	0.12%	0.02%

Steelhead trout redd measurements indicated that the mean pot length was 0.6m ± 0.05m and the mean pot width was 0.8m ± 0.28m. The mean tail spill length was 0.9m ± 0.07m, the mean of tail spill width #1 was 0.7m ± 0.07m and the mean of tail spill width #2 was 0.6m ± 0.06m. The mean redd depth for steelhead trout was 0.6m ± 0.07m. The mean nose velocity was 0.66m/sec ± 0.07m/sec and the mean water column velocity was 0.81m/sec ± 0.09m/sec (Table 7).

Table 7. Descriptive statistics for the physical size measurements (m) and microhabitat features of sampled steelhead trout redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

	Pot Length	Pot Width	Tail Spill Length	Tail Spill Width #1	Tail Spill Width #2	Depth	Nose Velocity (m/sec)	Mean Velocity
Sample Size	38	38	38	38	38	38	32	32
MIN	0.3	0.3	0.2	0.1	0.1	0.2	0.22	0.37
MAX	1.0	6.0	1.4	1.3	0.9	1.1	1.01	1.70
MEAN	0.6	0.8	0.9	0.7	0.6	0.6	0.66	0.81
MEDIAN	0.6	0.7	0.9	0.7	0.5	0.6	0.69	0.80
VARIANCE	0.0	0.8	0.1	0.0	0.0	0.0	0.04	0.06
STD DEV	0.2	0.9	0.2	0.2	0.2	0.2	0.19	0.25
CONFIDENCE	0.05	0.28	0.07	0.07	0.06	0.07	0.07	0.09

Substrate characterizations for steelhead trout redds identified that gravel and fine cobble comprised the majority of observations. Substrate observations for gravel were represented by 44.74% ± 4.89%, whereas gravel represented 36.84% ± 3.40% (Table 8) of the characterizations for steelhead trout redds.

Table 8. Descriptive Statistics for the substrate characterization percentages of sampled steelhead trout redds in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

	Bedrock	Boulder >256mm	Lg. Cobble 128-256 mm	Cobble 90-128 mm	Fine Cobble 32-90 mm	Gravel 2-32 mm	Sand 0.0625-2 mm	Silt/Clay <0.0625 mm
Sample Size	38	38	38	38	38	38	38	38
MIN	0%	0%	0%	0%	20%	20%	0%	0%
MAX	0%	0%	10%	40%	60%	70%	30%	0%
MEAN	0%	0%	0.26%	16.84%	36.84%	44.74%	1.32%	0%
MEDIAN	0%	0%	0%	20%	40%	40%	0%	0%
VARIANCE	0%	0%	0.03%	1.90%	1.14%	2.36%	0.33%	0%
STD DEV	0%	0%	1.62%	13.78%	10.68%	15.38%	5.78%	0%
CONFIDENCE	N/A	N/A	0.52%	4.38%	3.40%	4.89%	1.84%	N/A

5. DISCUSSION

The vast majority of Chinook salmon and steelhead trout redds were observed upstream of DPD, representing 81% and 89.5% of the total observations during the survey period, respectively. Additionally, the highest abundance of redds recorded for both Chinook salmon (42.2%) and steelhead trout (60.5%) was in the Timbuctoo Bend Reach (TBR), located upstream of the SR20 Bridge. Similar observations have been made from other concurrent surveys (*e.g.*, escapement surveys); for example, 87% of fresh carcasses observations in 2010 were located upstream of DPD (Bergman and Massa 2011), and consecutive escapement surveys conducted from 2003 to present have consistently found that the majority of Chinook salmon spawning in the lower Yuba River was observed upstream of DPD (Bergman and Massa 2011; Massa 2006, 2007, 2008; Massa *et al*. 2009, 2010; Jones and Stokes 2006). Additionally, nearly half of the fresh Chinook salmon carcasses observed in 2010 were located upstream of the SR20 Bridge (Bergman and Massa 2011).

Despite the apparent affinity for Chinook salmon and steelhead to spawn in the uppermost reaches of the lower Yuba River, only 2.4% of the observed Chinook salmon redds were observed in habitats upstream of the Narrows Pool (*i.e.*, Narrows and Englebright Dam Reaches). This observation remains misaligned with those from the TBR, where the majority of both Chinook salmon and steelhead trout are spawning. Although areas upstream of the Deer Creek confluence have been identified as having suitable holding habitat, they are largely devoid of spawning habitat for spring-run Chinook salmon (Pasternack 2009). The quantity and quality of salmonid spawning habitat from Englebright Dam to the Narrows pool has been significantly reduced by the deposition of large, consolidated rock fragments (*i.e.* "shotrock") and a lack new gravel recruitment from upstream (Pasternack 2009) which has been largely impaired through the construction of Englebright Dam (CDWR 2009).

These observations continue to provide support for future restoration and habitat improvement actions on the lower Yuba River located upstream and DPD, and more specifically in the Englebright Dam and Narrows Reaches. Recently, the U.S. Army Corps of Engineers completed a pilot injection of appropriately-sized gravels in 2007 (500 tons) and an additional injection of 5,000 tons in November of 2010 as part of a long-term gravel augmentation program to restore natural spawning gravels downstream of Englebright Dam. The gravels are intended to rehabilitate and restore natural geomorphic processes and aquatic habitats, and to improve the overall ecological functionality of the river channel by providing suitable substrates for anadromous salmonid adult spawning, embryo incubation, and survival.

Correlative analysis using simple linear regression was utilized to examine the weekly frequency of redd superimposition by Chinook salmon over the entire spawning season. This analysis was unable to describe any correlation between the temporal observations of superimposition (Figure 2) using the complete dataset. However, after removing all Chinook redd observations that occurred following the week of November 22, 2010[8] (n=61), the resulting temporal regression described 79% of the previous strata's cumulative observations. This analysis sparked some additional ideas and considerations on how superimposition data are interpreted. Although superimposition has been observed in the lower Yuba River, the temporal separation between early redd construction and the subsequent superimposition by redds later in the year can result in potentially misleading causal effects. For example, juvenile Chinook salmon emerge from gravel interstices in approximately 93 days at 10° C post-spawning (Jensen and Jensen 1999). Following emergence, redd superimposition likely has little effect on juvenile Chinook salmon because the juvenile fish have already "left the nest" and subsequent superimposition activity on an existing redd would only serve to disrupt a previously vacated incubation area. Again, a redd that was first observed in early September and then later identified via GIS analysis as being superimposed by a redd constructed in January of the following year likely has no ecologically deleterious effects on inhabitants of the previously constructed redd. By focusing superimposition analyses on all observed redds regardless of the date of construction, a possibility exists that the effects of superimposition have been misrepresented, especially for redds that were superimposed at a more protracted date from original construction. The superimposition analyses completed in this report represent a precise exercise in cataloging the level of superimposition in the lower Yuba River. However the inclusion of all results, regardless of date, may have lead to an inflated frequency and magnitude, and an apparent lack of correlative understanding of the actual effects to incubating eggs or pre-emergent juveniles in the lower Yuba River.

Redd survey protocols at best provide for an index of relative spawner abundance, trend indicators and spawner distribution information (Kucera and Faurot 2004). The difficulties of surveying steelhead trout have been discussed at length in the available literature, largely due to their presence during winter months in riverine systems (McEwan 2001). This limitation is especially evident during the expected steelhead trout spawning period (*e.g.*, January-April, and to a lesser extent in May and June) (McEwan 2001). This temporal period normally corresponds with winter storms and surface run off which can lead to extended periods when surveys cannot be completed due to high flow and turbidity levels. As such, Chinook salmon redd surveys from this effort were suspended during the weeks of October 25, 2010 and November 1, 2010 due to an early storm event. Surveys were also canceled from December 20, 2010 to January 10, 2011 and again from February 21, 2011 to April 4, 2011 as a result of high turbidity levels associated with storm runoff. This undoubtedly led to missed observations of steelhead trout redds and created a fragmented picture of steelhead spawning during the winter/spring months of 2011.

Additionally, non-wadeable areas in excess of four feet in depth could not be sampled using current methods. Non-wadeable areas simply exceeded the depth at which a surveyor could maintain position against the hydraulic forces of the river. Anecdotal observations do suggest that some deep water Chinook salmon redds were present in non-wadeable areas, but spatial and associated data for these redds were not recorded as a result of these physical constraints to data collection efforts. New methods are being developed by the lower Yuba River Accord RMT to address this data limitation; vessel-mounted underwater videography is being explored as a possible solution to investigate spawning areas in excess of four feet in depth.

An examination of the temporal distributions during the 2010-2011 survey period did not provide a clear distinction between runs, thus run-specific estimates of redd abundance were not possible for this annual data report. Examination of previous redd data in 2009-2010 produced similar results (Campos and Massa 2011), where attempts at using a logistic function to arrive at parameter estimates failed. The resulting inability to differentiate between spring- and fall-run Chinook salmon distributions using temporal redd observations may be largely attributed to the spatial and temporal periodicities of adult

[8] This date coincides with the predicted 90th percentile expression for Chinook salmon spawning as identified from a asymmetric logistic function.

spawning that are known to overlap considerably in the lower Yuba River (Massa *et al*. 2009), as well as in other Central Valley streams (Moyle 2002). Spawning periods for spring- and fall-run Chinook salmon historically overlapped in the late summer and early fall (Yoshiyama *et. al.* 1996), yet spatial separation was maintained by the annual fluvial-geomorphic barriers that persisted between run-specific spawning locations; a natural hydrograph for most years dictated that fall-run spawned near the valley floor, whereas spring-run migrated into higher elevation reaches and tributaries (Yoshiyama *et. al.* 1996). The construction of the Central Valley rim dams during the last century restricted the historic spawning range of spring-run Chinook salmon and relegated their spawning areas to the lower elevation reaches of the existing river systems with fall-run Chinook salmon. The spatial separation that existed for these two runs is no longer extant. The point of this brief review is that these runs have always spawned (both historically and currently) during roughly the same temporal periods, and since the spatial separations that once existed are now gone, future investigations will likely not provide sufficient data to differentiate runs based on redd observations alone. To potentially address this limitation, genetic tissue samples have been collected since 2009 during annual escapement surveys with the intent of accurately designating specific run assignments to estimated adult abundance indices, although preliminary unpublished genetic results have suggested that Yuba River Chinook salmon runs are closely interrelated and that phenotypic spring-run Chinook salmon on this river share a single monophyletic clade with Central Valley fall-run Chinook salmon. Tissue samples will continue to be collected during future escapement surveys and results from this, and future studies will salmon be reported when available.

Spatial analysis of Chinook salmon redd positional data provided evidence that selection played a key role in spawning locations, as indicated by the non-random nature of redd distributions within the entire longitudinal length of lower Yuba River. Analyses identified clear distinctions between areas of use and non-use that varied between the survey reaches sampled, but differences between independent reaches were noticeably evident. Specifically, the Englebright Dam and Marysville Reaches[9] exhibited relative non-use compared with other areas. Additionally, most reaches exhibited some degree of selection or avoidance. Yet, reach scale analysis identified longitudinal distributions within the Parks Bar and Timbuctoo Reaches that closely approximated randomness (Appendix A, Figure A1), thus suggesting non-selection in these areas. This anomalous observation may be partly explained by the existing distribution of morphological units (MU) within these reaches; that is, if the sites that Chinook salmon are utilizing for redd construction within the Timbuctoo and Parks Bar Reaches are also distributed in a manner that closely approximates randomness, then the redd distributions will follow a similar pattern. In an effort to explain this observation, Chinook salmon redd positional data were more closely scrutinized by a smaller-scale morphological unit delineation. Each redd observed was assigned a specific MU based on geographic location. MU analysis found that riffle (36.2%), riffle transition (19.8%), run (17.4%) and fast glide (12.3%) MUs comprised the majority of areas utilized by spawning Chinook salmon. These same MUs exhibited reach-scale variations within the Timbuctoo and Parks Bar Reaches that closely approximated randomness in some instances (Wyrick and Pasternack 2011b). Specifically, fast glides were the most randomly distributed MU in these two reaches, whereas riffle transitions were slightly less-randomly distributed. In contrast, the prevalence of riffles was highly represented in both reaches. As three of the most utilized MUs (riffle transition, run and fast glide) within the Timbuctoo and Parks Bar Reaches exhibited a near-random distribution, redd distributions may simply follow the similar MU distributions in these specific reaches.

M&E Plan analytics pertaining to flow and temperature were not included in this report, since multivariate analyses associated with single year observations (*i.e.*, small sample size) can lead to spurious correlations (Gordon 1968). A more comprehensive evaluation is currently underway, with preliminary results available in late-2012. This approach is less likely to result in incorrect assertions and

[9] The Narrows Reach also appeared to exhibit relative avoidance, but was excluded from this discussion as the entire reach was not surveyed due to safety concerns.

will provide a better understanding of the overall effects of Accord flows on fisheries resources in the lower Yuba River.

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8. APPENDIX A

Table A1. Weekly survey results for the Annual Redd Survey on the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Week	Survey Days	Mean Secchi Depth (m)	Smartsville Flow (cfs) Min	Max.	Mean	Marysville Flow (cfs) Min	Max.	Mean	Smartsville Temperature (°C) Min	Max.	Mean	Marysville Temperature (°C) Min	Max.	Mean
9/13/2010	3	3.5	888	894	890	748	798	778	12.2	12.6	12.4	16.7	17.3	16.9
9/20/2010	4	3.5	887	889	888	783	805	795	12.5	12.6	12.5	16.5	16.9	16.7
9/27/2010	6.5	3.4	888	895	890	796	822	811	12.3	12.7	12.5	16.5	17.0	16.8
10/4/2010	5.5	3.4	805	886	834	760	824	787	12.7	13.0	12.8	16.0	16.7	16.3
10/11/2010	4	3.1	804	807	806	604	766	673	12.6	12.8	12.7	15.4	16.8	16.4
10/18/2010	4	3.5	805	964	830	536	994	622	12.3	12.6	12.4	14.9	16.2	15.7
10/25/2010[1]	1	1.1	799	2,668	1,127	589	2,706	1,068	12.0	13.3	12.4	14.3	15.0	14.7
11/1/2010	NO SURVEY		797	947	865	531	593	550	11.9	12.1	12.0	14.2	15.0	14.8
11/8/2010	4	1.6	857	913	877	535	692	577	11.4	11.8	11.6	12.9	13.7	13.2
11/15/2010	4.5	3.5	796	851	815	550	1,278	680	10.8	11.3	11.0	11.3	13.8	12.7
11/22/2010	3	1.9	764	991	934	769	978	832	10.3	10.7	10.5	10.4	11.7	10.9
11/29/2010	4	2.0	974	984	980	761	803	781	9.6	10.1	9.8	10.2	11.3	10.6
12/6/2010	NO SURVEY		1,290	3,110	1,858	1,251	3,036	1,893	9.3	9.6	9.4	10.4	11.3	11.0
12/13/2010[2]	2	0.9	1,452	17,237	5,677	1,334	26,875	7,388	8.7	9.5	9.1	9.6	10.9	10.2
12/20/2010	NO SURVEY		6,438	14,623	9,351	6,885	23,088	11,779	8.8	9.6	9.3	9.8	10.3	10.1
12/27/2010			4,449	9,577	6,018	5,628	13,166	7,652	8.2	9.0	8.6	8.9	9.9	9.3
1/3/2011			2,964	4,310	3,528	3,824	5,820	4,655	7.6	8.1	7.8	8.2	8.9	8.5
1/10/2011			2,972	2,988	2,980	3,475	3,770	3,671	7.4	7.7	7.5	7.8	8.8	8.4
1/17/2011	3	1.7	2,976	3,015	3,000	2,928	2,957	2,945	7.7	8.1	8.0	8.8	9.0	8.9
1/24/2011	4	2.2	2,945	3,008	2,973	2,816	2,988	2,884	7.7	7.8	7.8	8.6	8.9	8.7
1/31/2011[2]	3	2.9	2,541	2,707	2,574	2,343	2,805	2,514	7.6	7.9	7.8	8.6	9.3	8.8
2/7/2011	4	2.8	1,993	2,317	2,124	2,196	2,503	2,333	7.8	8.0	7.9	8.8	9.3	9.0
2/14/2011	4.5	2.0	1,989	3,164	2,685	2,296	5,527	3,768	6.2	7.8	7.3	8.4	9.3	8.7
2/21/2011	NO SURVEY		1,987	3,162	2,680	2,687	6,879	4,258	5.3	7.1	6.2	8.0	8.8	8.4
2/28/2011			1,988	3,584	2,781	2,917	4,806	3,954	3.9	6.9	6.1	8.4	9.3	8.9
3/7/2011			3,055	3,763	3,402	3,895	5,307	4,684	6.2	8.3	7.0	9.6	9.9	9.7
3/14/2011			3,484	17,173	11,234	4,857	26,833	15,404	7.6	8.2	7.9	8.9	10.2	9.5
3/21/2011			7,319	9,658	8,326	9,459	14,013	12,061	6.6	7.8	7.5	8.8	9.2	9.0
3/28/2011			5,001	6,113	5,644	6,598	8,256	7,177	7.5	8.9	8.4	9.3	10.8	10.2
4/4/2011			3,947	6,327	5,169	4,718	7,633	6,220	7.5	8.8	8.2	10.3	10.7	10.5
4/11/2011[2]	2.5	2.0	3,939	4,012	3,962	4,473	4,655	4,543	7.2	8.3	7.9	10.1	10.8	10.4

[1] Surveys completed in Englebright Dam and Narrows Reaches prior to storm event.

[2] Englebright Dam and Narrows Reaches not surveyed due to high flows and turbid conditions.

Table A2. Weekly observed Chinook salmon and steelhead trout redd abundance in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Week	Downstream of DPD		SR20 to DPD		Upstream of SR20		All Reaches	
	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
9/13/2010	0	0	5	0	7	0	12	0
9/20/2010	9	0	81	0	104	0	194	0
9/27/2010	18	0	173	0	259	0	450	0
10/4/2010	28	0	158	0	336	0	522	0
10/11/2010	41	0	150	0	231	0	422	0
10/18/2010	86	0	146	0	141	0	373	0
10/25/2010	NO SURVEY		2	0	7	0	9	0
11/1/2010	NO SURVEY		NO SURVEY		NO SURVEY		NO SURVEY	
11/8/2010	227	0	240	0	157	0	624	0
11/15/2010	86	0	116	0	71	0	273	0
11/22/2010	29	0	52	0	43	0	124	0
11/29/2010	42	0	22	0	23	0	87	0
12/6/2010	NO SURVEY		NO SURVEY		NO SURVEY		NO SURVEY	
12/13/2010	8	0	0	0	0	0	8	0
12/20/2010	NO SURVEY		NO SURVEY		NO SURVEY		NO SURVEY	
12/27/2010								
1/3/2011								
1/10/2011								
1/17/2011	0	0	0	0	1	0	1	0
1/24/2011	3	2	3	3	2	2	8	7
1/31/2011	4	0	0	3	11	9	15	12
2/7/2011	8	2	2	2	5	1	15	5
2/14/2011	0	0	3	3	4	4	7	7
2/21/2011	NO SURVEY		NO SURVEY		NO SURVEY		NO SURVEY	
2/28/2011								
3/7/2011								
3/14/2011								
3/21/2011								
3/28/2011								
4/4/2011								
4/11/2011	0	0	4	0	3	7	7	7
TOTALS	589	4	1,157	11	1,405	23	3,151	38

Table A3. Weekly observed Chinook salmon redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of September 13, 2010 to the week of November 1, 2010.

River Mile	9/13/2010	9/20/2010	9/27/2010	10/4/2010	10/11/2010	10/18/2010	10/25/2010[1]	11/1/2010
0	0	0	0	0	0	0	0	NO SURVEY
1	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	
3	0	0	0	0	3	3	0	
4	0	0	0	0	0	0	0	
5	0	0	0	0	7	16	0	
6	0	0	0	1	0	5	0	
7	0	0	0	0	1	11	0	
8	0	0	0	0	0	5	0	
9	0	1	1	7	4	8	0	
10	0	2	7	6	7	17	0	
11	0	6	10	14	19	21	0	
12	0	4	9	7	3	10	0	
13	1	5	4	9	12	10	0	
14	0	8	25	23	26	25	0	
15	2	35	52	46	36	38	0	
16	1	10	43	26	32	18	0	
17	0	10	23	30	25	31	0	
18	1	12	33	40	35	26	3	
19	1	43	80	101	79	37	1	
20	1	25	55	78	44	40	3	
21	3	28	99	117	67	46	2	
22	0	0	0	0	0	0	0	
23	2	5	9	17	22	6	0	
24	0	0	0	0	0	0	0	
TOTALS	12	194	450	522	422	373	9	N/A

[1] Incomplete survey week and incomplete reaches.

Table A4. Weekly observed Chinook salmon redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of November 8, 2010 to the week of December 27, 2010.

River Mile	11/8/2010	11/15/2010	11/22/2010	11/29/2010	12/6/2010	12/13/2010	12/20/2010	12/27/2010
0	0	0	0	0	NO SURVEY	0	NO SURVEY	NO SURVEY
1	0	0	0	0		0		
2	0	0	0	0		0		
3	5	1	1	0		0		
4	14	6	1	4		0		
5	22	7	5	3		0		
6	12	13	4	13		0		
7	31	15	5	14		2		
8	19	8	2	2		0		
9	49	15	4	3		2		
10	46	9	3	2		1		
11	29	12	4	1		3		
12	22	17	2	4		0		
13	16	8	3	1		0		
14	50	26	15	3		0		
15	66	29	14	7		0		
16	28	15	5	5		0		
17	30	12	4	0		0		
18	37	16	11	3		0		
19	47	25	19	7		0		
20	44	16	8	6		0		
21	49	22	10	7		0		
22	0	0	0	0		0		
23	8	1	4	2		0		
24	0	0	0	0		0		
TOTALS	624	273	124	87	N/A	8	N/A	N/A

Table A5. Weekly observed Chinook salmon redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of January 3, 2011 to the week of February 21, 2011.

River Mile	1/3/2011	1/10/2011	1/17/2011	1/24/2011	1/31/2011	2/7/2011	2/14/2011	2/21/2011
0			0	0	0	0	0	
1			0	0	0	0	0	
2			0	0	0	0	0	
3			0	0	0	0	0	
4			0	0	0	0	0	
5			0	0	0	0	0	
6			0	0	0	0	0	
7			0	0	0	0	0	
8			0	0	0	0	0	
9			0	0	0	2	0	
10			0	1	2	1	0	
11			0	2	2	5	0	
12	NO SURVEY	NO SURVEY	0	1	0	0	0	NO SURVEY
13			0	0	0	2	0	
14			0	0	0	0	0	
15			0	0	0	0	1	
16			0	0	0	0	1	
17			0	0	0	0	1	
18			0	3	0	1	0	
19			0	1	9	3	2	
20			0	0	0	1	1	
21			1	0	2	0	1	
22			0	0	0	0	0	
23			0	0	0	0	0	
24			0	0	0	0	0	
TOTALS	N/A	N/A	1	8	15	15	7	N/A

Table A6. Weekly observed Chinook salmon redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of February 28, 2011 to the week of April 11, 2011.

River Mile	2/28/2011	3/7/2011	3/14/2011	3/21/2011	3/28/2011	4/4/2011	4/11/2011	All Weeks
0							0	0
1							0	0
2							0	0
3							0	13
4							0	25
5							0	60
6							0	48
7							0	79
8							0	36
9							0	96
10							0	104
11							0	128
12	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	0	79
13							0	71
14							0	201
15							0	326
16							0	184
17							0	166
18							4	225
19							2	457
20							0	322
21							1	455
22							0	0
23							0	76
24							0	0
TOTALS	N/A	N/A	N/A	N/A	N/A	N/A	7	3151

Table A7. Simple linear regression analysis results to assess the number and location by river mile of Chinook salmon redds built during each weekly stratum and over the entire spawning season in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Week	Number of Redds in Analysis	R^2	Significance F	Coefficients Y	Coefficients X	P Values Y	P Values X
9/13/2010	12	0.311	0.004	-0.2677	0.0623	0.333	0.004
9/20/2010	194	0.258	0.009	-2.2369	0.8331	0.592	0.009
9/27/2010	450	0.298	0.005	-6.5354	2.0446	0.483	0.005
10/4/2010	522	0.309	0.004	-8.7046	2.4654	0.427	0.004
10/11/2010	422	0.341	0.002	-3.9723	1.7377	0.579	0.002
10/18/2010	373	0.256	0.010	2.9846	0.9946	0.552	0.010
10/25/2010	9	INCOMPLETE SURVEY					
11/1/2010	0	NO SURVEY					
11/8/2010	624	0.106	0.112	14.5662	0.8662	0.060	0.112
11/15/2010	273	0.106	0.112	6.2215	0.3915	0.073	0.112
11/22/2010	124	0.176	0.037	1.4431	0.2931	0.444	0.037
11/29/2010	87	0.001	0.861	3.2492	0.0192	0.043	0.861
12/6/2010	0	NO SURVEY					
12/13/2010	8	0.022	0.479	0.5138	-0.0162	0.116	0.479
12/20/2010	0	NO SURVEY					
12/27/2010	0						
1/3/2011	0						
1/10/2011	0						
1/17/2011	1	0.065	0.219	-0.0431	0.0069	0.580	0.219
1/24/2011	8	0.025	0.448	0.1262	0.0162	0.671	0.448
1/31/2011	15	0.052	0.275	-0.0923	0.0577	0.899	0.275
2/7/2011	15	0.012	0.598	0.3785	0.0185	0.441	0.598
2/14/2011	7	0.202	0.024	-0.1169	0.0331	0.548	0.024
2/21/2011	0	NO SURVEY					
2/28/2011	0						
3/7/2011	0						
3/14/2011	0						
3/21/2011	0						
3/28/2011	0						
4/4/2011	0						
4/11/2011	7	0.089	0.147	-0.1538	0.0362	0.652	0.147
ALL WEEKS	3,151	0.285	0.006	7.1015	9.9115	0.878	0.006

Table A8. Weekly Chinook salmon redd superimposition frequency in the surveyed reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.

Week	Number of New Redds in Analysis	Number Superimposed on Previous Redds	Superimposition Frequency (%)
9/13/2010	12	0	0.0
9/20/2010	195	19	9.7
9/27/2010	449	140	31.2
10/4/2010	522	223	42.7
10/11/2010	422	193	45.7
10/18/2010	373	182	48.8
10/25/2010[1]	9	3	33.3
11/1/2010		NO SURVEY	
11/8/2010	624	283	45.4
11/15/2010	273	155	56.8
11/22/2010	124	95	76.6
11/29/2010	87	58	66.7
12/6/2010		NO SURVEY	
12/13/2010[2]	8	1	12.5
12/20/2010			
12/27/2010		NO SURVEY	
1/3/2011			
1/10/2011			
1/17/2011	1	0	0.0
1/24/2011	8	2	25.0
1/31/2011[2]	15	2	13.3
2/7/2011	15	4	26.7
2/14/2011	7	2	28.6
2/21/2011			
2/28/2011			
3/7/2011			
3/14/2011		NO SURVEY	
3/21/2011			
3/28/2011			
4/4/2011			
4/11/2011[2]	7	3	42.9

[1] Surveys completed in Englebright Dam and Narrows Reaches prior to storm event.
[2] Englebright Dam and Narrows Reaches not surveyed due to high flows and turbid conditions.

Table A9. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of September 13, 2010 to the week of October 4, 2010.

Percentage of Redd Overlap	9/13/2010		9/20/2010		9/27/2010		10/4/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	0	0	6	9	13	57	21	131
5-10%	0	0	4	8	9	32	4	83
10-15%	0	0	0	2	12	15	1	36
15-20%	0	0	0	0	1	17	10	52
20-25%	0	0	0	2	1	28	3	46
25-30%	0	0	2	2	0	13	2	48
30-35%	0	0	0	0	0	10	0	30
35-40%	0	0	0	0	1	12	1	39
40-45%	0	0	0	0	1	8	1	28
45-50%	0	0	0	0	0	14	1	23
50-55%	0	0	0	0	2	13	0	27
55-60%	0	0	0	2	0	12	1	19
60-65%	0	0	0	0	0	4	0	6
65-70%	0	0	0	2	2	8	0	13
70-75%	0	0	0	0	0	4	0	8
75-80%	0	0	0	0	2	4	0	9
80-85%	0	0	0	0	0	3	0	6
85-90%	0	0	0	0	0	0	0	4
90-95%	0	0	0	0	0	0	0	2
95-100%	0	0	0	0	0	0	0	0
TOTALS	0	0	12	27	44	254	45	610

Table A10. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of October 11, 2010 to the week of November 1, 2010.

Percentage of Redd Overlap	10/11/2010		10/18/2010		10/25/2010[1]		11/1/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	8	228	4	296	0	296	NO SURVEY	296
5-10%	0	97	0	126	0	128		128
10-15%	0	68	0	97	0	97		97
15-20%	2	78	4	94	0	95		95
20-25%	0	66	0	96	0	100		100
25-30%	0	63	2	87	0	83		83
30-35%	0	38	0	48	0	48		48
35-40%	0	42	0	57	0	57		57
40-45%	0	52	0	67	0	67		67
45-50%	0	44	0	53	0	53		53
50-55%	0	30	0	30	0	30		30
55-60%	0	17	0	27	0	27		27
60-65%	0	15	0	20	0	20		20
65-70%	0	26	0	39	0	39		39
70-75%	0	13	0	18	0	19		19
75-80%	0	13	0	23	0	23		23
80-85%	0	14	0	12	0	12		12
85-90%	0	8	0	6	0	6		6
90-95%	0	2	0	4	0	4		4
95-100%	0	0	0	0	0	0		0
TOTALS	10	914	10	1200	0	1204	N/A	1204

[1] Incomplete survey week and incomplete reaches.

Table A11. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of November 8, 2010 to the week of November 29, 2010.

Percentage of	11/8/2010		11/15/2010		11/22/2010		11/29/2010	
Redd Overlap	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	6	404	0	485	2	535	0	572
5-10%	1	195	2	217	0	224	0	230
10-15%	0	125	0	142	0	164	0	167
15-20%	0	124	0	152	0	166	0	172
20-25%	2	124	0	147	0	154	0	160
25-30%	1	121	0	123	0	130	0	132
30-35%	1	82	0	102	0	114	0	116
35-40%	0	69	0	86	0	93	0	91
40-45%	0	79	0	79	0	83	0	90
45-50%	0	69	0	72	0	78	0	80
50-55%	0	45	0	56	0	57	0	61
55-60%	0	30	0	26	0	29	0	30
60-65%	0	27	0	31	0	33	2	37
65-70%	0	47	0	50	0	52	0	51
70-75%	0	25	0	26	0	24	0	26
75-80%	0	17	0	25	0	24	0	26
80-85%	0	15	0	17	0	14	0	12
85-90%	0	14	0	14	0	14	0	14
90-95%	0	2	0	4	0	4	0	4
95-100%	2	2	0	0	0	0	0	0
TOTALS	13	1616	2	1854	2	1992	2	2071

Table A12. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of December 6, 2010 to the week of December 27, 2010.

Percentage of	12/6/2010		12/13/2010		12/20/2010		12/27/2010	
Redd Overlap	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	NO SURVEY	572	0	572	NO SURVEY	572	NO SURVEY	572
5-10%		230	0	230		230		230
10-15%		167	0	167		167		167
15-20%		172	0	172		172		172
20-25%		160	0	160		160		160
25-30%		132	0	132		132		132
30-35%		116	0	116		116		116
35-40%		91	0	91		91		91
40-45%		90	0	90		90		90
45-50%		80	0	80		80		80
50-55%		61	0	61		61		61
55-60%		30	0	30		30		30
60-65%		37	0	39		39		39
65-70%		51	0	51		51		51
70-75%		26	0	26		26		26
75-80%		26	0	26		26		26
80-85%		12	0	12		12		12
85-90%		14	0	14		14		14
90-95%		4	0	4		4		4
95-100%		0	0	0		0		0
TOTALS	N/A	2071	0	2073	N/A	2073	N/A	2073

Table A13. Chinook salmon redd superimposition magnitude within each stratum and including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of January 3, 2011 to the week of January 24, 2011.

Percentage of	1/3/2011		1/10/2011		1/17/2011		1/24/2011	
Redd Overlap	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	NO SURVEY	572	NO SURVEY	572	0	572	0	572
5-10%		230		230	0	230	0	230
10-15%		167		167	0	167	0	167
15-20%		172		172	0	172	0	172
20-25%		160		160	0	160	2	162
25-30%		132		132	0	132	0	132
30-35%		116		116	0	116	0	116
35-40%		91		91	0	91	0	91
40-45%		90		90	0	90	0	90
45-50%		80		80	0	80	0	80
50-55%		61		61	0	61	0	61
55-60%		30		30	0	30	0	30
60-65%		39		39	0	39	0	39
65-70%		51		51	0	51	0	51
70-75%		26		26	0	26	0	26
75-80%		26		26	0	26	0	26
80-85%		12		12	0	12	0	12
85-90%		14		14	0	14	0	14
90-95%		4		4	0	4	0	4
95-100%		0		0	0	0	0	0
TOTALS	N/A	2073	N/A	2073	0	2073	2	2075

Table A14. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of January 31, 2011 to the week of February 21, 2011.

Percentage of	1/31/2011		2/7/2011		2/14/2011		2/21/2011	
Redd Overlap	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	0	575	0	575	0	578	NO SURVEY	578
5-10%	0	230	2	232	0	232		232
10-15%	0	168	0	170	0	171		171
15-20%	0	172	0	172	0	172		172
20-25%	0	162	0	162	0	160		160
25-30%	0	132	0	132	0	132		132
30-35%	0	115	0	115	0	117		117
35-40%	0	90	0	90	0	90		90
40-45%	0	90	0	90	0	90		90
45-50%	0	80	0	80	0	78		78
50-55%	0	61	0	61	0	61		61
55-60%	0	30	0	30	0	30		30
60-65%	0	39	0	41	0	41		41
65-70%	0	51	0	51	0	51		51
70-75%	0	26	0	26	0	26		26
75-80%	0	26	0	26	0	26		26
80-85%	0	12	0	12	0	12		12
85-90%	0	14	0	14	0	14		14
90-95%	0	4	0	4	0	4		4
95-100%	0	0	0	0	0	0		0
TOTALS	0	2077	2	2083	0	2085	N/A	2085

Table A15. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of February 28, 2011 to the week of March 21, 2011.

Percentage of Redd Overlap	2/28/2011		3/7/2011		3/14/2011		3/21/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	NO SURVEY	578	NO SURVEY	578	NO SURVEY	578	NO SURVEY	578
5-10%		232		232		232		232
10-15%		171		171		171		171
15-20%		172		172		172		172
20-25%		160		160		160		160
25-30%		132		132		132		132
30-35%		117		117		117		117
35-40%		90		90		90		90
40-45%		90		90		90		90
45-50%		78		78		78		78
50-55%		61		61		61		61
55-60%		30		30		30		30
60-65%		41		41		41		41
65-70%		51		51		51		51
70-75%		26		26		26		26
75-80%		26		26		26		26
80-85%		12		12		12		12
85-90%		14		14		14		14
90-95%		4		4		4		4
95-100%		0		0		0		0
TOTALS	N/A	2085	N/A	2085	N/A	2085	N/A	2085

Table A16. Chinook salmon redd superimposition magnitude within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of March 28, 2011 to the week of April 11, 2011.

Percentage of Redd Overlap	3/28/2011		4/4/2011		4/11/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0-5%	NO SURVEY	578	NO SURVEY	578	0	580
5-10%		232		232	0	232
10-15%		171		171	0	171
15-20%		172		172	0	174
20-25%		160		160	0	160
25-30%		132		132	0	132
30-35%		117		117	0	117
35-40%		90		90	0	90
40-45%		90		90	0	90
45-50%		78		78	0	80
50-55%		61		61	0	61
55-60%		30		30	0	30
60-65%		41		41	0	41
65-70%		51		51	0	51
70-75%		26		26	0	26
75-80%		26		26	0	26
80-85%		12		12	0	12
85-90%		14		14	0	14
90-95%		4		4	0	4
95-100%		0		0	0	0
TOTALS	N/A	2085	N/A	2085	0	2091

Table A17. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of September 13, 2010 to the week of October 4, 2010.

River Mile	9/13/2010		9/20/2010		9/27/2010		10/4/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	2	0	3
10	0	0	0	0	0	5	0	7
11	0	0	0	2	0	4	2	10
12	0	0	0	2	0	6	0	11
13	1	1	0	0	0	0	0	6
14	0	0	0	0	0	7	0	20
15	2	2	0	3	4	39	0	70
16	1	1	0	2	7	26	2	43
17	0	0	0	0	2	10	0	25
18	1	1	0	2	0	6	2	30
19	1	1	0	2	6	38	9	113
20	1	1	6	2	4	39	6	94
21	3	3	6	6	19	61	21	149
22	0	0	0	0	0	0	0	0
23	2	2	0	6	2	11	3	29
24	0	0	0	0	0	0	0	0
TOTALS	12	12	12	27	44	254	45	610

Table A18. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of October 11, 2010 to the week of November 1, 2010.

River Mile	10/11/2010		10/18/2010		10/25/2010[1]		11/1/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0	0	0	0	0	0	0		0
1	0	0	0	0	0	0		0
2	0	0	0	0	0	0		0
3	0	0	0	4	0	4		4
4	0	0	0	0	0	0		0
5	0	0	0	8	0	8		8
6	0	0	0	0	0	0		0
7	0	0	2	4	0	4		4
8	0	0	0	0	0	0		0
9	0	5	0	9	0	9		9
10	0	13	0	21	0	21		21
11	0	24	0	28	0	28		28
12	0	14	0	17	0	17	NO SURVEY	17
13	0	13	0	17	0	17		17
14	0	36	0	56	0	56		56
15	0	93	0	128	0	128		128
16	0	63	0	75	0	75		75
17	0	39	2	71	0	71		71
18	0	56	0	76	0	77		77
19	6	177	0	207	0	208		208
20	0	134	2	176	0	176		176
21	2	206	4	254	0	256		256
22	0	0	0	0	0	0		0
23	2	41	0	49	0	49		49
24	0	0	0	0	0	0		0
TOTALS	10	914	10	1200	0	1204	N/A	1204

[1] Incomplete survey week and incomplete reaches.

Table A19. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of November 8, 2010 to the week of November 29, 2010.

River Mile	11/8/2010		11/15/2010		11/22/2010		11/29/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	6	0	6	0	8	0	8
4	2	2	0	10	0	10	0	12
5	0	17	0	21	0	26	0	29
6	0	0	0	4	0	6	2	21
7	0	16	0	21	0	26	0	38
8	5	9	0	14	0	16	0	16
9	2	17	0	22	0	29	0	33
10	0	41	0	47	0	52	0	54
11	0	45	2	56	0	59	0	61
12	0	23	0	33	0	36	0	39
13	0	25	0	32	0	34	0	35
14	0	89	0	117	0	134	0	135
15	0	174	0	202	0	219	0	224
16	0	96	0	109	0	115	0	121
17	0	102	0	115	0	121	0	121
18	0	104	0	116	0	127	0	130
19	0	258	0	290	2	313	0	318
20	0	228	0	246	0	254	0	260
21	0	309	0	337	0	349	0	356
22	0	0	0	0	0	0	0	0
23	4	55	0	56	0	58	0	60
24	0	0	0	0	0	0	0	0
TOTALS	13	1616	2	1854	2	1992	2	2071

Table A20. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of December 6, 2010 to the week of December 27, 2010.

River Mile	12/6/2010		12/13/2010		12/20/2010		12/27/2010	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0		0	0	0		0		0
1		0	0	0		0		0
2		0	0	0		0		0
3		8	0	8		8		8
4		12	0	12		12		12
5		29	0	29		29		29
6		21	0	21		21		21
7		38	0	38		38		38
8		16	0	16		16		16
9		33	0	33		33		33
10		54	0	54		54		54
11		61	0	63		63		63
12	NO SURVEY	39	0	39	NO SURVEY	39	NO SURVEY	39
13		35	0	35		35		35
14		135	0	135		135		135
15		224	0	224		224		224
16		121	0	121		121		121
17		121	0	121		121		121
18		130	0	130		130		130
19		318	0	318		318		318
20		260	0	260		260		260
21		356	0	356		356		356
22		0	0	0		0		0
23		60	0	60		60		60
24		0	0	0		0		0
TOTALS	N/A	2071	0	2073	N/A	2073	N/A	2073

Table A21. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of January 3, 2011 to the week of January 24, 2011.

River Mile	1/3/2011		1/10/2011		1/17/2011		1/24/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0		0		0	0	0	0	0
1		0		0	0	0	0	0
2		0		0	0	0	0	0
3		8		8	0	8	0	8
4		12		12	0	12	0	12
5		29		29	0	29	0	29
6		21		21	0	21	0	21
7		38		38	0	38	0	38
8		16		16	0	16	0	16
9		33		33	0	33	0	33
10		54		54	0	54	0	54
11		63		63	0	63	2	65
12	NO SURVEY	39	NO SURVEY	39	0	39	0	39
13		35		35	0	35	0	35
14		135		135	0	135	0	135
15		224		224	0	224	0	224
16		121		121	0	121	0	121
17		121		121	0	121	0	121
18		130		130	0	130	0	130
19		318		318	0	318	0	318
20		260		260	0	260	0	260
21		356		356	0	356	0	356
22		0		0	0	0	0	0
23		60		60	0	60	0	60
24		0		0	0	0	0	0
TOTALS	N/A	2073	N/A	2073	0	2073	2	2075

Table A22. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of January 31, 2011 to the week of February 21, 2011.

River Mile	1/31/2011		2/7/2011		2/14/2011		2/21/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0	0	0	0	0	0	0		0
1	0	0	0	0	0	0		0
2	0	0	0	0	0	0		0
3	0	8	0	8	0	8		8
4	0	12	0	12	0	12		12
5	0	29	0	29	0	29		29
6	0	21	0	21	0	21		21
7	0	38	0	38	0	38		38
8	0	16	0	16	0	16		16
9	0	33	0	33	0	33		33
10	0	54	0	54	0	54		54
11	0	65	2	67	0	67		67
12	0	39	0	39	0	39	NO SURVEY	39
13	0	35	0	35	0	35		35
14	0	135	0	135	0	135		135
15	0	224	0	224	0	224		224
16	0	121	0	121	0	121		121
17	0	121	0	121	0	121		121
18	0	130	0	130	0	130		130
19	0	319	0	323	0	323		323
20	0	260	0	260	0	261		261
21	0	357	0	357	0	358		358
22	0	0	0	0	0	0		0
23	0	60	0	60	0	60		60
24	0	0	0	0	0	0		0
TOTALS	0	2077	2	2083	0	2085	N/A	2085

Table A23. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of February 28, 2011 to the week of March 21, 2011.

River Mile	2/28/2011		3/7/2011		3/14/2011		3/21/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0		0		0		0		0
1		0		0		0		0
2		0		0		0		0
3		8		8		8		8
4		12		12		12		12
5		29		29		29		29
6		21		21		21		21
7		38		38		38		38
8		16		16		16		16
9		33		33		33		33
10		54		54		54		54
11		67		67		67		67
12	NO SURVEY	39	NO SURVEY	39	NO SURVEY	39	NO SURVEY	39
13		35		35		35		35
14		135		135		135		135
15		224		224		224		224
16		121		121		121		121
17		121		121		121		121
18		130		130		130		130
19		323		323		323		323
20		261		261		261		261
21		358		358		358		358
22		0		0		0		0
23		60		60		60		60
24		0		0		0		0
TOTALS	N/A	2085	N/A	2085	N/A	2085	N/A	2085

Table A24. Chinook salmon redd superimposition frequency by river mile within each stratum including cumulative totals in the surveyed reaches of the lower Yuba River, CA from the week of March 28, 2011 to the week of April 11, 2011.

River Mile	3/28/2011		4/4/2011		4/11/2011	
	Within Stratum	Cumulative	Within Stratum	Cumulative	Within Stratum	Cumulative
0		0		0	0	0
1		0		0	0	0
2		0		0	0	0
3		8		8	0	8
4		12		12	0	12
5		29		29	0	29
6		21		21	0	21
7		38		38	0	38
8		16		16	0	16
9		33		33	0	33
10		54		54	0	54
11		67		67	0	67
12	NO SURVEY	39	NO SURVEY	39	0	39
13		35		35	0	35
14		135		135	0	135
15		224		224	0	224
16		121		121	0	121
17		121		121	0	121
18		130		130	0	134
19		323		323	0	323
20		261		261	0	261
21		358		358	0	360
22		0		0	0	0
23		60		60	0	60
24		0		0	0	0
TOTALS	N/A	2085	N/A	2085	0	2091

Table A25. Weekly observed steelhead trout redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of September 13, 2010 to the week of November 1, 2010.

River Mile	9/13/2010	9/20/2010	9/27/2010	10/4/2010	10/11/2010	10/18/2010	10/25/2010[1]	11/1/2010
0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	0	
11	0	0	0	0	0	0	0	
12	0	0	0	0	0	0	0	NO SURVEY
13	0	0	0	0	0	0	0	
14	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	
TOTALS	0	0	0	0	0	0	0	N/A

[1] Incomplete survey week and incomplete reaches.

Table A26. Weekly observed steelhead trout redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of November 8, 2010 to the week of December 27, 2010.

River Mile	11/8/2010	11/15/2010	11/22/2010	11/29/2010	12/6/2010	12/13/2010	12/20/2010	12/27/2010
0	0	0	0	0		0		
1	0	0	0	0		0		
2	0	0	0	0		0		
3	0	0	0	0		0		
4	0	0	0	0		0		
5	0	0	0	0		0		
6	0	0	0	0		0		
7	0	0	0	0		0		
8	0	0	0	0		0		
9	0	0	0	0		0		
10	0	0	0	0		0		
11	0	0	0	0		0		
12	0	0	0	0	NO SURVEY	0	NO SURVEY	NO SURVEY
13	0	0	0	0		0		
14	0	0	0	0		0		
15	0	0	0	0		0		
16	0	0	0	0		0		
17	0	0	0	0		0		
18	0	0	0	0		0		
19	0	0	0	0		0		
20	0	0	0	0		0		
21	0	0	0	0		0		
22	0	0	0	0		0		
23	0	0	0	0		0		
24	0	0	0	0		0		
TOTALS	0	0	0	0	N/A	0	N/A	N/A

Table A27. Weekly observed steelhead trout redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of January 3, 2011 to the week of February 21, 2011.

River Mile	1/3/2011	1/10/2011	1/17/2011	1/24/2011	1/31/2011	2/7/2011	2/14/2011	2/21/2011
0	NO SURVEY	NO SURVEY	0	0	0	0	0	NO SURVEY
1			0	0	0	0	0	
2			0	0	0	0	0	
3			0	0	0	0	0	
4			0	0	0	0	0	
5			0	0	0	0	0	
6			0	0	0	0	0	
7			0	0	0	0	0	
8			0	1	0	0	0	
9			0	0	0	0	0	
10			0	1	0	0	0	
11			0	0	0	2	0	
12			0	0	0	0	0	
13			0	1	0	0	0	
14			0	0	0	1	0	
15			0	0	0	0	0	
16			0	0	1	0	2	
17			0	1	0	0	1	
18			0	3	6	1	0	
19			0	0	5	0	1	
20			0	0	0	0	0	
21			0	0	0	1	3	
22			0	0	0	0	0	
23			0	0	0	0	0	
24			0	0	0	0	0	
TOTALS	N/A	N/A	0	7	12	5	7	N/A

Table A28. Weekly observed steelhead trout redds by river mile in the surveyed reaches of the lower Yuba River, CA from the week of February 28, 2011 to the week of April 11, 2011.

River Mile	2/28/2011	3/7/2011	3/14/2011	3/21/2011	3/28/2011	4/4/2011	4/11/2011	All Weeks
0	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	NO SURVEY	0	0
1							0	0
2							0	0
3							0	0
4							0	0
5							0	0
6							0	0
7							0	0
8							0	1
9							0	0
10							0	1
11							0	2
12							0	0
13							0	1
14							0	1
15							0	0
16							0	3
17							0	2
18							1	11
19							0	6
20							0	0
21							6	10
22							0	0
23							0	0
24							0	0
TOTALS	N/A	N/A	N/A	N/A	N/A	N/A	7	38

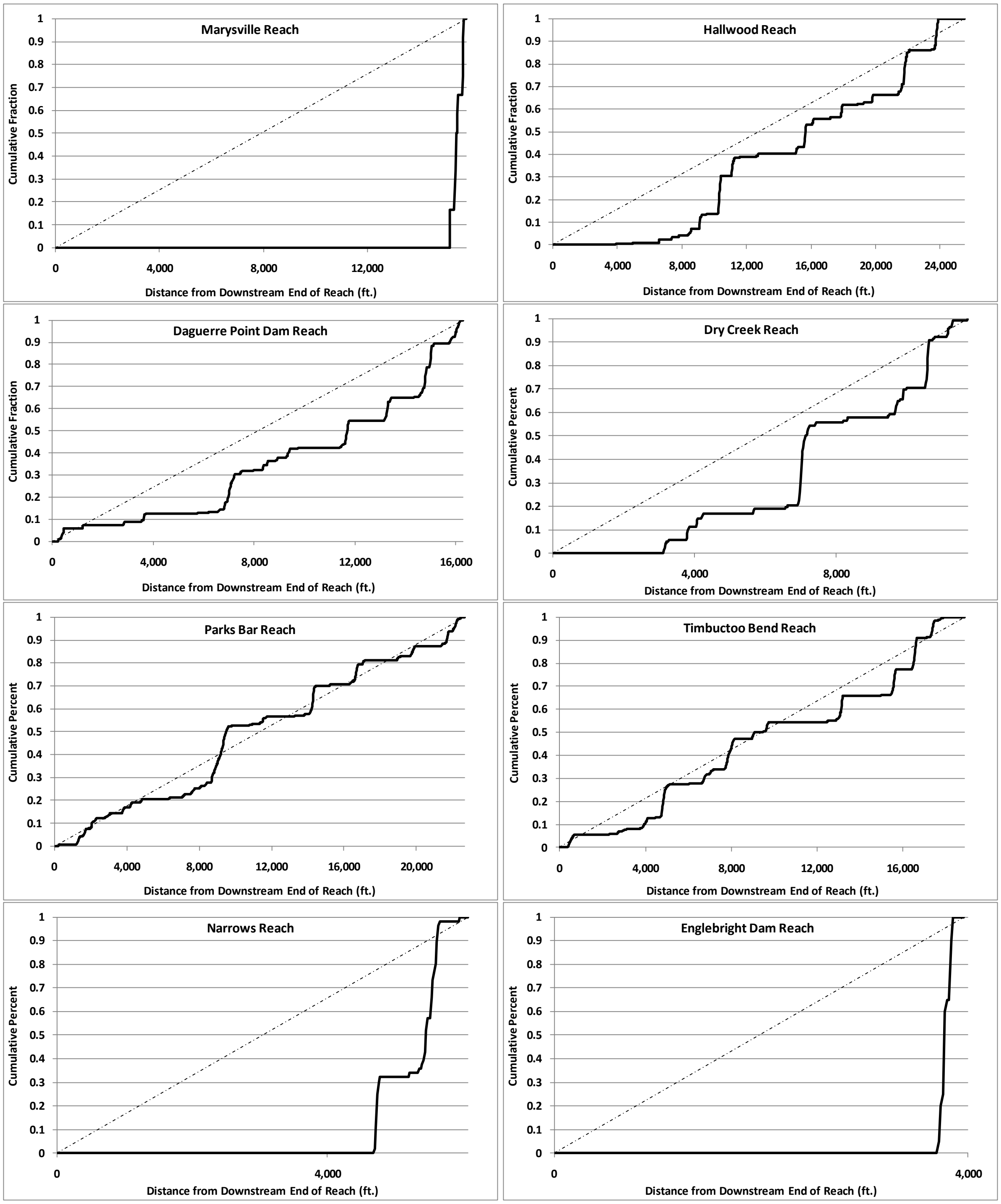

Figure A1. Cumulative plot of the longitudinal distributions of Chinook salmon redd locations in each of the reaches of the lower Yuba River, CA from September 13, 2010 to April 13, 2011.