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The Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE

Salmonid Populations of the Upper Sacramento River Basin In 2016

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RBFO Technical Report No. 03-2017

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Cover photo: Sacramento River from Deschutes Road Bridge, taken by D Killam.

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SUMMARY

Population sizes were estimated for Chinook Salmon and steelhead (where possible) passing upstream of Princeton Ferry in the upper Sacramento River basin (USRB), (Figure 1). Annual population estimates for the USRB were determined through a number of methodologies including: carcass surveys, hatchery counts, aerial and in-stream redd surveys, snorkel counts, angler interviews, and video and DIDSON (acoustic sonar) counts in streams and in fish ladders. This report does not include salmonid information from tributaries that enter into the Sacramento River downstream of the town of Princeton (Butte Creek, Feather and American River). These and other lower Central Valley waterways are detailed in reports from other projects. A summary of the entire California Central Valley Chinook salmon stocks is available annually in the California Department of Fish and Wildlife (CDFW) reports titled "Annual Report: Chinook Salmon Spawning Stocks in California's Central Valley" (CDFW Annual Reports).

In 2016, there were an estimated **30,234** ocean returning Chinook Salmon in the USRB, upstream of Princeton Ferry. This includes an estimate of 5,803 late-fall-run, 1,548 winter-run, 727 spring-run, and 22,156 fall-run Chinook Salmon (Table 1). The majority (89%) of these salmon migrated above the Red Bluff Diversion Dam (RBDD) to spawn in the tributaries or the Sacramento River upstream of Red Bluff. Although no longer used as a tool to determine population estimates, the RBDD location is still utilized to maintain historical data consistency in the reporting of salmonid populations in the USRB, (up and downstream of RBDD). Additionally 794 adult steelhead were counted during monitoring operations for the 2015-2016 reporting year.

Readers interested in conducting further analysis of the data provided in this report should be aware that the summaries of data herein might be generalized to fit the limited scope of the report. **For specific analytical data needs, readers should directly contact the authors** for their needs and any limitations to the data. The authors can be reached via e-mail at doug.killam@wildlife.ca.gov, matt.johnson@wildlife.ca.gov, and rrevank@psmfc.org. This report and others from this project can be found on the Calfish.org website. Interested readers can go to the Calfish.org website:

http://www.calfish.org/ProgramsData/ConservationandManagement/CDFWUpperSacRiverBasinSalmonidMonitoring.aspx

To view: Open the Data Access tab and select the category to view (reports, or spreadsheets, presentations, etc.) from within the download menu located near each file. If interested, readers may request specific tables from this report in spreadsheet formats (most tables in this report are in picture formats), to allow further analysis based on their individual needs or requirements.

This program received financial assistance through the **Federal Aid in Sport Fish Restoration Program**. The U.S. Department of the Interior prohibits discrimination on the basis of race, color, national origin, age, sex, or disability. If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information, please write to:

The Office of Human Resources U.S. Fish and Wildlife Service
4040 N. Fairfax Drive, Room 300 Arlington, CA 22203

INTRODUCTION

Readers of this and earlier reports should be aware that revisions to population estimates might occur at any time. Reader comments received by the authors in the past have indicated that readers can be frustrated by population numbers changing from one year to the next or inconsistent reporting between reports. Many of the estimates are dependent on multiple sources of information (hatchery sex ratios, hatchery counts, aerial redd data, etc.) that are often revised after periods of time. These revisions are outside the control of the authors and represent efforts to obtain the most accurate estimates for historical purposes. Should a conflict arise between a number in this report and a later report, readers should use the most recently published data as the most up-to-date source of information. An online summary of salmon populations is available in the California Department of Fish and Wildlife's (CDFW) electronic summary report of salmon counts titled "GrandTab".

Readers will also note the large volume of data presented in the tables of this report. Please use the zoom function (try pressing "ctrl" while rolling mouse wheel up or down). Tables and figures are inserted as images in this report to reduce file size and simplify formatting. The spreadsheet file with the actual tables is also available for download.

Please note that the CDFW was formerly the Department of Fish and Game (CDFG) and historical reports written before January 2013 will have the former name. Persons interested in receiving the latest Chinook numbers should check the GrandTab file that is updated once a year, or contact the authors. The GrandTab file is now online at the following link or by "searching" the term "GrandTab fish":

https://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp

The upper Sacramento River basin (USRB) of California's Central Valley is unique worldwide because it has four separate runs of Chinook Salmon (*Oncorhynchus tshawytscha*) each year. The USRB for purposes of this report refers to the anadromous portions of the Sacramento River watershed upstream of Princeton, CA at river mile 164 (RM-164). Each run of Chinook Salmon, hereafter referred to as salmon or run, (i.e., winter-run) has adopted a different life history (spawning locations, and seasonal timing) that allows it to survive many different environmental conditions found over the course of a year in the USRB (Figure 1).

The historical migration timing of the four adult salmon runs into the USRB is provided in Appendix A Table A1. This data came from historical trapping operations at the Red Bluff Diversion Dam fish ladders. The data represents the timing of upstream migrating adult salmonids at Red Bluff (RM-243) prior to spawning. The naming of the runs can be confusing (e.g., winter-run spawn in July). The salmon run names originate from the time salmon canneries operated in the lower river (i.e., 1860's). The name of each run described when the peak of the salmon run was passing through the San Francisco Bay.

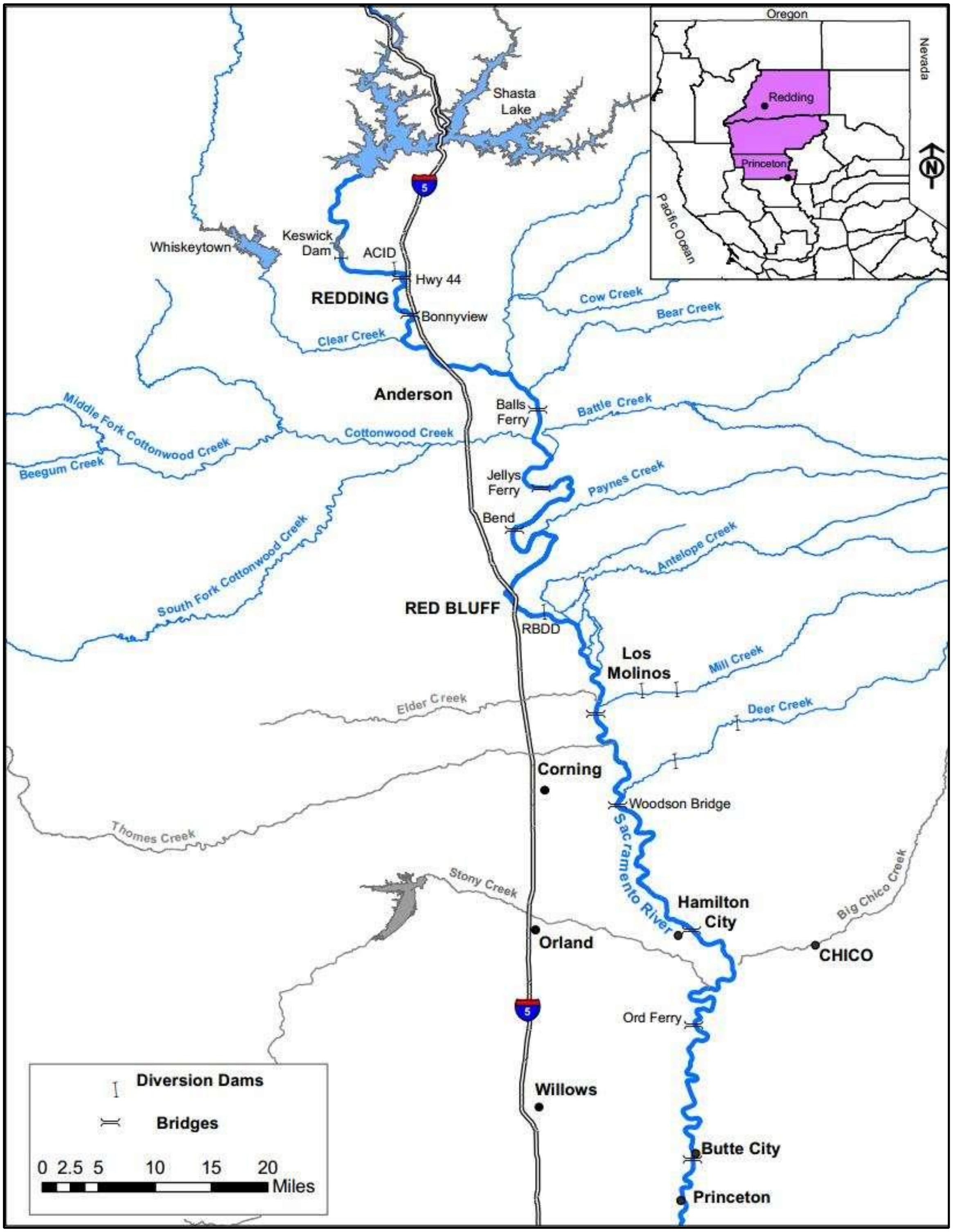

Figure 1. Map of the upper Sacramento River basin (Princeton Ferry to Keswick Dam).

Monitoring for salmon populations in the USRB has been routinely conducted annually since 1953 (CDFW Annual reports). During earlier years, the primary purpose for monitoring salmon was to manage for commercial and sport salmon harvest. The USRB has salmon and steelhead (*Oncorhynchus mykiss*) stocks, **but no** perennial spawning populations of the other Eastern Pacific-genus *Oncorhynchus* (*O.*) salmon species including: Chum/Dog (*O. keta*), Coho/Silver (*O. kisutch*), Humpback/Pink (*O. gorbuscha*), and Sockeye/Red (*O. nerka*). In recent years, the focus of monitoring has been directed to include monitoring for restoration activities (including protection of listed stocks), and water transfers in the Central Valley, drought impacted water quality, as well as the traditional role of managing stocks for sport and commercial harvest.

This report provides a summary of the 2016 USRB salmon monitoring activities conducted by staff from the CDFW's Red Bluff Fisheries Office (RBFO). The RBFO staff included three CDFW Environmental Scientists. In addition, there were seven full time RBFO staff from the Pacific States Marine Fisheries Commission (PSMFC) and additional PSMFC seasonal staff working on salmonid monitoring activities in the office.

In 2016, the RBFO staff conducted independent monitoring surveys as well as cooperative surveys. Cooperative surveys occurred with the staff from several organizations: the U.S Fish and Wildlife Service's Red Bluff Fish and Wildlife Office (USFWS), the Coleman National Fish Hatchery (CNFH), the U.S. Forest Service Lassen National Forest (USFS), the National Marine Fisheries Service (NMFS) and a variety of other watershed related organizations. Details of other specific monitoring surveys in the USRB can be found on the internet sites of these groups. The data found in this report is a compilation of the different sources and methodologies used to produce population estimates within the USRB. Annual reports providing data on the USRB salmon populations are available going back to the early 1950's, (CDFW Annual reports). In the earlier years, data is often lacking for particular streams due to no monitoring from lack of funding and personnel. Fish ladders, walking surveys, and hatchery counts were the primary methods of data collection until 1967.

From 1967 until 1986, the Red Bluff Diversion Dam (RBDD) provided a method of monitoring all four salmon runs, as well as steelhead trout and other fish species. During this period, the RBDD was typically operated throughout the year. This allowed for nearly complete accounting of salmon and steelhead escapement above the dam (the dam was removed during flooding periods). The RBDD was operated by lowering 11 large steel gates (15-feet tall) into the Sacramento River at Red Bluff. The resulting pool formed Lake Red Bluff and provided gravity flow water "free" (no pumping necessary) into agricultural diversions. During RBDD "gates down" operation, adult salmon migrating into the USRB had to find and use one of the three fish ladders at the dam. The delay in finding these ladders at the RBDD was thought to be a major reason for the decline of the winter-run populations (NMFS 1996). Beginning in 1987, the period of operation of the RBDD was limited for portions of each year to facilitate improved passage of winter-run salmon. When not in operation, the RBDD gates were raised up completely out of the water. This returns the river to natural flow conditions and eliminates any passage delay. This action was deemed necessary for winter-run salmon, which were at critically low and declining population levels, and had been previously petitioned for listing (October 1985) under state and federal Endangered Species Act (ESA).

From 1995 to 2007, the RBDD was operated from approximately May 15 through September 15. Beginning in 2008, the gates were removed on September 01 in response to a Federal District court order issued to protect salmon and steelhead populations. For years 2009 to 2011, the RBDD operations were even further curtailed and lasted only from June 15 until the first week of September. The RBDD ceased operation in 2011 and the gates on the dam are now raised permanently out of the water.

Construction of a large-scale pumping plant with modern in-river juvenile fish screens just upstream of the RBDD was completed during the spring of 2012. Although still in place, the RBDD is no longer seen as a fish passage problem. The dam will remain in place for the foreseeable future with the gates permanently raised above the river and the outdated fish ladders inoperable.

Table 1. Summary of the 2016 Chinook Salmon and steelhead population estimates for the USRB, (Sacramento River and tributaries from Keswick Dam downstream to Princeton Ferry).

LOCATION RUN	Late-Fall-Run	Winter-run	Spring-Run	Fall-Run	Steelhead
Keswick Dam to Red Bluff (upstream of RBDD) [$]					
Sacramento River upstream	3,085	1,409	0	3,981	n/a
Livingston Stone Hatchery/ Keswick Trap	65	137	0	282	n/a
Clear Creek	55	1	29	2,481	103
Cow Creek	n/a	0	0	822	0
Bear Creek	31	0	2	32	310
Cottonwood Creek	n/a	0	3	813	42
Battle Creek into Coleman Hatchery	2,348	1	0	8,531	n/a
Battle Creek above Hatchery (trap + video)	57	0	180	0	n/a
Battle Creek below Hatchery	n/a	0	0	1,021	n/a
Paynes Creek	n/a	0	0	8	n/a
Angler Harvest	57	0	0	1,345	n/a
SUB-TOTAL UPSTREAM OF RBDD	*5,698*	*1,548*	*214*	*19,316*	*455*
Red Bluff to Princeton (downstream of RBDD)					
Sacramento River downstream	0	0	0	309	n/a
Antelope Creek	4	0	7	138	94
Mill Creek	25	0	175	602	190
Deer Creek	0	0	331	253	55
Big Chico Creek (from CDFW-NC Region)	n/a	0	0	n/a	n/a
Angler Harvest	76	0	0	1,538	n/a
SUB-TOTAL DOWNSTREAM OF RBDD	*105*	*0*	*513*	*2,840*	*339*
SYSTEM GRAND TOTAL	**5,803**	**1,548**	**727**	**22,156**	**794**
All Upper Sacramento River Basin (Keswick Dam to Princeton) [$]					
2016 TOTAL SALMON ALL COMBINED:			**30,234**		
PLEASE View the CDFW Grandtab file for most up-to-date information: this table not updated after reporting.					
^ n/a: Is Not Available, represents salmon possibly present but no estimate available.					
$ There are numerous smaller creeks not surveyed for some runs (primarily late-fall and fall-run).					
Specific data from each creek available upon request to authors.					

METHODS AND RESULTS

The RBFO personnel utilized many different methodologies to obtain the fisheries data presented in this report. Methods utilized in 2016 include walking and boat based carcass surveys, hatchery counts, live fish counts from video stations at fish ladders or weirs, snorkel surveys, and salmon redd surveys utilizing counts made by walking, kayak, jet boat, and aerial transport (airplane or helicopter).

Carcass surveys using modern mark-recapture methodologies were initiated in 1996 on the Sacramento River above RBDD using jet boats. Currently there are three annual carcass surveys used to estimate the late-fall-run, winter-run, and fall/spring-run escapements by the RBFO.

The late-fall-run Chinook escapement on the Sacramento River is monitored through a boat mark-recapture carcass survey and aerial redd counts (December-April). In addition to the Sacramento River, small numbers of late-fall-run are known to spawn in many tributaries of the USRB. Mark-recapture late-fall-run carcass surveys are normally difficult to conduct on these tributaries due to small numbers of carcasses and typically high flow (or flood) conditions that make consistent, weekly mark-recapture surveys impractical. The use of video monitoring allowed tributary late-fall-run monitoring in late 2015 into early 2016 on Clear Creek (with additional USFWS carcass and redd counts) and on Bear, Antelope, Mill and Deer Creek's. Late-fall-run on Battle Creek were also monitored at the CNFH (hatchery, trap and video counts).

A winter-run Chinook Sacramento River carcass survey (late-April to early-September) has been conducted since 1996. Since 2001, the survey has provided the "official" annual escapement estimate for this federally and state-listed endangered species (replacing the RBDD estimate). This species currently spawns only in the Sacramento River and is the focus of many restoration activities throughout the Central Valley. The winter-run estimate forms the scientific basis for establishing the allowable juvenile winter-run "take" limits at the pumping facilities in the Sacramento-San Joaquin Delta, and also is directly linked to the management of California's ocean based salmon fisheries (mainly the fall and late-fall-run). Additional winter-run data is obtained from operations of the USFWS Livingston Stone National Fish Hatchery (LSNFH). This hatchery is located at base of Shasta Dam and collects hatchery brood stock from a trap at Keswick Dam (Figure 1) to supplement the small population of naturally spawning winter run. In 2016, ongoing drought concerns and uncertainty about low numbers again resulted in the LSNFH staff collecting additional broodstock for spawning as a precaution against collapse of the in-river spawners due to poor water quality (high water temperatures).

Spring-run Chinook Salmon inventories have been sporadically conducted since the 1940's on USRB waterways. Methodologies from the 1940's through the 1980's were incomplete, inconsistent and not replicable. In many years, surveys were not conducted. Spawning escapement estimates were derived from incomplete spawning ground surveys, carcass surveys with unknown expansion factors, and partial ladder and weir counts. Since the early 1990's, there has been an effort to standardize sampling methods to provide consistent and reproducible spring run population estimates. On Mill Creek this standardization was an annual redd count through 2012. For Antelope and Deer Creeks, standardized snorkel surveys provided annual spring-run population estimates through 2013. Beginning in 2012, video and DIDSON counts replaced redd counts on Mill Creek, and in 2014, video counts replaced snorkel counts on Antelope and Deer Creeks as the escapement methodology following the development video stations on these tributaries. In 2016 the RBFO continued conducting redd counts on Mill, and snorkel counts on Deer and Antelope to maintain established trend data, and to monitor summer holding distribution patterns and survival of adult spring-run through the summer months.

Since 1953, fall-run Chinook surveys were routinely conducted on the USRB tributary streams. Prior to 1988, Peterson mark-recapture methodologies, ladder counts, walking surveys and aerial redd surveys were used with varying sampling intensity and reliability of estimates. Since 1988, mark-recapture surveys have been standardized into weekly surveys for the duration of the spawning run on some tributaries. The mark-recapture estimator used on each creek (Peterson, Schaefer or Jolly-Seber), was based on the total carcasses encountered and weekly percent recovery of tags.

Beginning in 2003, video stations have been utilized to obtain fall-run escapement estimates in the larger tributaries of the USRB. These stations use multiple cameras to record 24/7 video footage of passing fish through existing fish ladders or in-stream portable weirs. In 2016 video stations were used to monitor salmon escapement in Clear, Cow, Bear, Cottonwood, Battle, Antelope, Mill and Deer Creek(s). Flood conditions late in 2015 and early in 2016 forced video station removals in Cow, Cottonwood, and Battle Creeks until late summer. The use of new resistance board weirs on Cow, Cottonwood, and Battle Creeks in the fall of 2016 allowed for extended monitoring opportunity as this type of weir resists minor flooding better than the older horizontal weirs.

The use of the resistance board weirs will allow better steelhead tributary accounting. Steelhead (anadromous forms of rainbow trout) will be included in this report when information is available. Because steelhead do not die after spawning (although many do) counting them is not possible on traditional carcass surveys. The video stations on fish ladders have provided counts of steelhead for many years but as more in-stream stations utilize resistance board weirs the RBFO is collecting more steelhead information over the winter periods. Steelhead in this report generally refer to fish over 16 inches long. Currently there is no consistent way to distinguish a larger resident trout from a steelhead without handling and sacrificing the fish for bio-samples that can be analyzed for ocean life history. Resident trout are common in the USRB waters year round and it is possible that larger resident trout and steelhead are included together in the counts. RBFO biologists use their best judgement based on their knowledge of local steelhead populations when tallying fish as steelhead.

In the fall of 2016, the RBFO staff used a VAKI Riverwatcher device for the first time on the South ladder of the Stanford-Vina Dam on Deer Creek. The VAKI was used to count salmonids passing through the fish ladder until major floods threatened, forcing the removal of the unit in late 2016. Continued deployments of acoustic cameras (DIDSON) also complemented and enhanced video monitoring efforts by RBFO staff to be able to provide population estimates in many USRB streams.

The goal for monitoring by RBFO staff is to utilize the video stations to collect information year-round on steelhead and other salmon runs and fish species. Data collected by using combinations of video and other technologies such as Dual Frequency

Identification Sonar (DIDSON) and Adaptive Resolution Imaging Sonar (ARIS) cameras and the VAKI Riverwatcher provides possibilities to overcome the lack of monitoring opportunities during the typical high flow and muddy water periods of fall, winter, and spring in the USRB.

Readers may note the lack of metric equivalents for distances and volumes in this report. River miles are used as descriptors of locations rather than river kilometers. Conventional use in the USRB is the English system (used by other state and federal agencies) and this report maintains these conventions to simplify reading except in the case of fork length data, which is in millimeters (mm), by tradition. Readers wishing to convert to kilometers can multiply the miles written by roughly 1.6 and can convert water volumes written in cubic-feet-per second (cfs) to cubic-meters-per second (cms) by multiplying cfs by 0.028 to get cms. (e.g., 2 miles = 3.2 km, and 200 cfs = 5.6 cms).

Carcass Mark-Recapture Surveys

Carcass mark-recapture surveys (carcass surveys) have been used by the CDFW for many years to estimate salmon populations on rivers throughout the state. Since all Chinook salmon die after spawning, a population can be counted by estimating how many carcasses are present each year. The carcass surveys have been used as the "official" alternative to the RBDD count for the Sacramento River since the late 1990's (fall-run, late-fall-run) and in 2001 (winter-run) due to the limited operation of the RBDD. Carcass surveys can be conducted by boat or by wading along a tributary creek examining carcasses. Carcasses are tagged with a colored tag or numbered disc or some other type tag to enable personnel to recognize them on subsequent surveys. Carcasses that were tagged in previous periods and recaptured in new periods form the basic proportion of "carcasses tagged" to "carcasses recaptured" that creates a population estimate. Data is normally collected on sex, fork length; adipose fin clips, location, and other categories of interest (see Appendix C Figure C1).

There are different methods and/or population models that can be employed to create an estimate from a carcass survey. The population models were originally created for populations of live organisms and each model has a list of sampling assumptions that must be met in order for the model to reflect an accurate portrayal of the population size. The three models previously used by the RBFO staff in the USRB are the Peterson, the Schaefer, and the Jolly-Seber. Beginning with the September fall-run surveys of 2011 (Sacramento River and Clear Creek) a newer "Cormack-Jolly-Seber" (CJS) method was utilized for the first time in the USRB, allowing generation of confidence limits surrounding each estimate. Regardless of the model used, each has been modified from the original intent of studying live organisms and applied to carcasses. In 2010, the CDFW and PSMFC created the Central Valley Chinook Salmon In-river Escapement Monitoring Plan that provides recommendations for a consistent approach to monitoring salmon populations throughout the Central Valley (Bergman et al. 2012). This plan recommends all carcass surveys in the Central Valley use the newer CJS model for consistency between watersheds. Details of the CJS process (and video station) methods and instructional information for expanding the estimates based on redd counts and other expansions are available in Appendix D.

Each mark-recapture model has built in advantages and disadvantages. The Peterson model is the simplest, and is useful in developing an estimate when major disruptions to the sampling schedule occur. The Peterson treats the entire survey timeframe as two periods, a tagging period and a recapture period. This is the most simplistic mark-recapture model but in some surveys is the only one that can be used due to flooding causing low numbers of recaptures, budget cuts, or other survey disruptions.

The Schaefer and the Jolly-Seber (JS) models are more complicated because they depend on repetitive survey periods and recaptured carcasses throughout the survey. Of the two, the JS is the more complicated to analyze but software programs have been developed to allow simpler calculation of this method. The CJS method differs from the Schaefer and JS models in that it can account for different survival rates of different size or sex fish and accounts for survival of carcasses between survey periods. The CJS method requires that all carcasses be individually tagged and allows for the inclusion of smaller 2-year old salmon (grilse) and adipose fin clipped fish into the pool of mark-recapture survey data. The CJS method has now generally replaced the other mark-recapture methods used in the Central Valley. Beginning with the last survey of 2011 (fall-run) the new CJS methodology was implemented for all mark-recapture carcass surveys in the USRB. The protocols of the 2016 CJS mark-recapture method used on the Sacramento River included:

1. Every fish (carcass) observed was checked for a CJS numbered tag.
2. Fish in good condition (including hatchery fish) received a numbered tag on the lower jaw and were released back to the waterway.
3. Fish in poor condition were chopped in half upon first observance.
4. Tagged fish that were recaptured were chopped upon first recapture.

The option of releasing (instead of chopping them) recaptured tagged fish to produce multiple recaptures is available during CJS surveys with expected low abundance of carcasses but this option was not utilized in 2016.

The CJS estimates used only data from female carcasses for the mark-recapture portion of the data analysis. This is because some unknown portion of post-spawning male fish are known, through observations, to leave the spawning areas and swim slowly downstream moving outside the survey locations before they die. Female fish typically guard their redds until close to death and are much more abundant (as carcasses) than males in survey databases compared to the sex ratios of live fish observed at hatcheries for the same run of fish. The CJS mark-recapture method accounts only for carcasses and not live fish. The tendency of males to move downstream out of the survey area while alive reduces the number of male carcasses available to the CJS survey and results in an underestimation of the true number of males (if only CJS methods are used). These and other details are summarized for each run in Appendix A.

Sacramento River Carcass Survey Methods

Appendix A Tables A3 through A5 provide summaries of the population details for each run and other information for the three Sacramento River surveys in 2016. The final population estimate of each run of salmon was produced through a five-step process. These steps included:

1. Estimate females within survey area using the CJS methodology.
2. Estimate total females using redd counts of survey and downstream areas.
3. Estimate large males using ratio of females to males from live fish counts.
4. Estimate small male salmon from survey ratio of fresh adult male to fresh grilse.
5. Add in any salmon that were removed for hatchery spawning or other observations.

The CJS mark-recapture survey (described below) was the first of the five steps in each population estimate and resulted in an estimate of the number of female salmon in the survey area (see Figure 2). The second step was to expand the CJS total female number for additional females spawning downstream of the survey area. The results of a series of aerial redd surveys (described below) were used to determine the number of female spawners downstream of the survey locations based on the number of new redds observed downstream of the lowermost survey area (Balls Ferry Bridge) and the number observed within the survey area. The resulting expansion, based on the ratio of redds within the survey to those downstream of the survey area, and the CJS females within the survey area produced an estimate of the total females in the Sacramento River. The third step was to estimate the large males (defined as males >609 mm). The large male component of each population estimate was derived from data using the ratio of females to males from the CNFH (for fall and late-fall) or the LSNFH data comparing ratios of females to large males (for winter-run). The fourth step was to estimate the number of male grilse or "jacks". The data on all fresh male carcasses from the survey was used to calculate an estimate of the smaller (typically 2-year old) jack salmon. The ratio of fresh small and large male carcasses was used to develop a proportion that was compared to the total large male numbers. This "proportion based" calculation resulted in the total small number of males. The total females (Steps 1-2) and the total males (Steps 3-4) were summed resulting in a total in-river spawning estimate. Step 5 tallied any additional fish that were removed for hatchery brood stock purposes. Combining all five steps provided the final estimate for each run of salmon.

Once the overall population estimate was developed, additional steps were undertaken to produce sub-estimates of adults and grilse and hatchery and natural origin categories of interest for management purposes. The CJS survey data of fresh carcasses of both sexes was analyzed and allowed development of a variety of categories of interest to fisheries managers. These categories are shown in Appendix A for each run of monitored salmon.

Traditionally, the Sacramento River carcass surveys are conducted by boat, each having two or more observers. Three multi-month surveys are conducted each year with crews normally on the river year-round. Survey protocols and methods may change slightly in each survey but in general terms the protocols have remained similar since 2003. The late-fall-run survey begins typically in mid-December and ends in early-May. The winter-run survey begins in late-April or early-May and ends in late-August or early-September. The fall/spring-run survey begins in early-September and ends in late-December or early-January. The beginning or end of each survey is determined by the number of carcasses

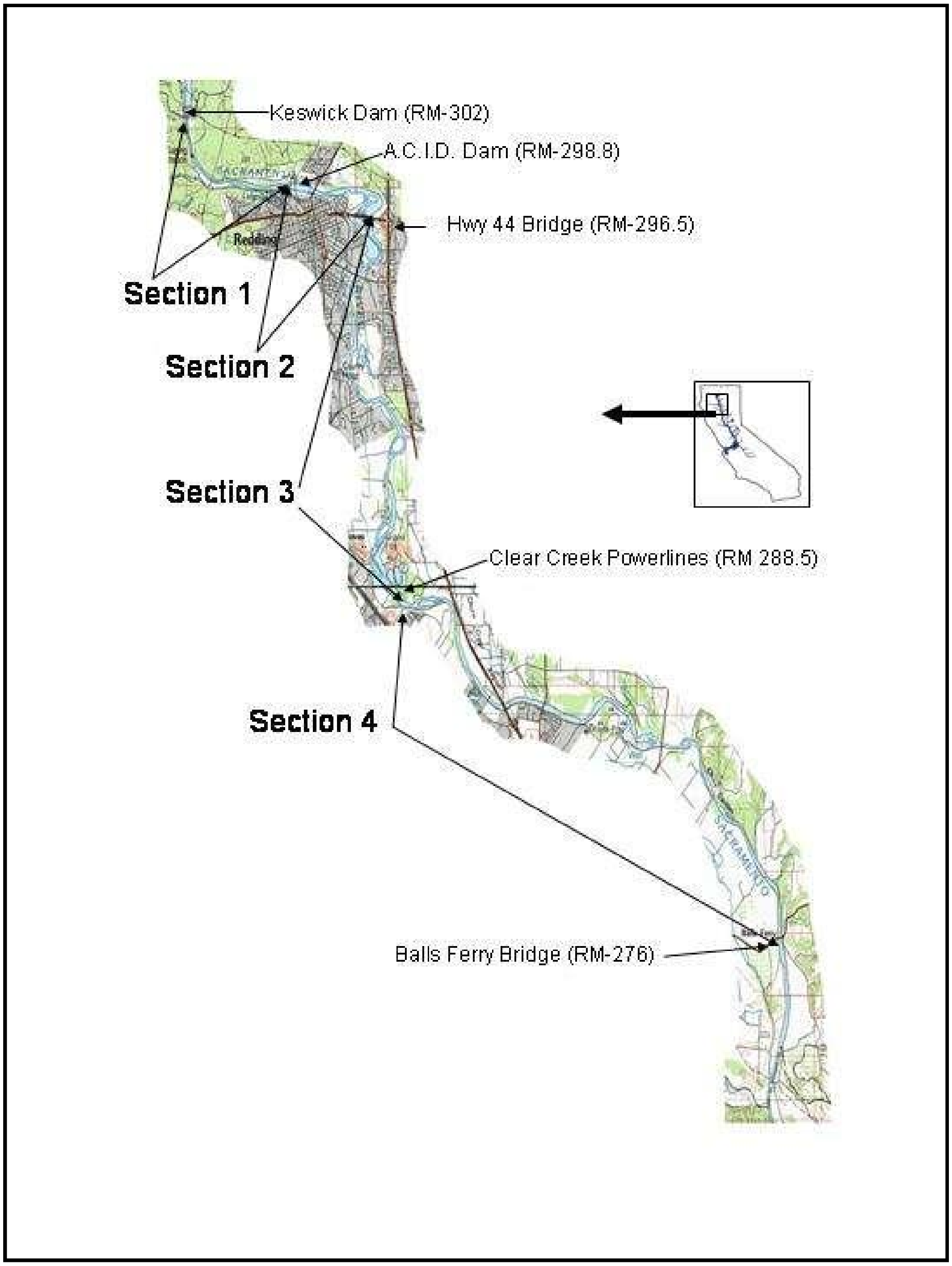

Figure 2. Map of the Sacramento River showing carcass survey sections and landmarks.

being observed by the crews at those times. The spawn timing of each run can vary by a few weeks each year so survey dates are flexible and can overlap from one survey to another. Figure 2 shows the 2016 geographical location of the surveys with prominent landmarks identified, and the river section designations used as survey start and end points by the crews.

Normally, two boats are used with each boat surveying the areas from either shore out to the center of the river. At some times during high carcass numbers, three or more boats may be used to finish the daily survey section. At times of very low carcass numbers or staff shortages, a single boat may be used if the entire section can be surveyed effectively. In some areas of high carcass concentrations (e.g., Turtle Bay at RM 296.5), the boats work side-by-side to process the carcasses, while at other times they may be out of sight of each other. Carcasses are not accessible in some areas of the river due to hazards or deep water so crews will typically bypass these areas and focus in areas where observations are possible. In addition, crews are instructed to search all areas of the visible river bottom to avoid pre-determining search patterns based upon their prior experiences in locating carcasses.

The surveys are divided into four sections. The sections were chosen as convenient areas for crews to start or stop work for the day. The sections are as follows:

1. Keswick Dam to ACID (Anderson-Cottonwood Irrigation District) Dam–RM-302 to RM-298.8,
2. ACID Dam to Highway 44 Bridge – RM-298.8 to RM-296.5,
3. Highway 44 Bridge to Clear Creek power lines – RM-296.5 to 288.5,
4. Clear Creek power lines to Balls Ferry Bridge – RM-288.5 to 276.

Each of the three surveys is broken down into individual survey periods with each period representing a single complete coverage of all sections of the river by the boats. Each carcass survey, when completed, has numerous survey periods. Survey periods for fall/spring and late-fall-runs are one week long. Crews begin a new survey period in the lower end of section 4 (or 3 during busy years) on Tuesdays and work their way upstream normally finishing near Keswick Dam on Thursday or Friday of each week. Winter-run survey periods are three days long and repeat throughout the survey without skipping any days. This is done because the flows in the river are higher at this time of year and the winter-run is the focus of intense management concern. Increased effort is put forth to capture as many carcasses as possible given the increased flows, deeper waters, and low numbers of winter-run available for crews to sample.

Typically, all carcasses encountered that are not in an advanced state of decay are marked (tagged). Carcasses not receiving tags are tallied then cut in two (chopped). All chopped carcasses are disregarded in subsequent survey periods. All carcasses upon tagging are returned to flowing water near where they were collected in an attempt to simulate "natural" carcass dispersion. All "recaptured" carcasses bearing a tag from a previous survey period are tallied according to tag number or color. An example of a completed 2016 fall-run boat datasheet is provided in Appendix C Figure C1. Chopped carcasses are normally tallied by their size (small <610 mm and large >609 mm), and by their sex (female, male, or unknown-typically skeletons).

Sacramento River Carcass Sampling

The following summary provides the techniques and methods used to collect information on the Sacramento River carcass surveys. Carcasses are collected by crews standing on the bow of a jet boat using 16-foot wooden poles with a five-pronged spearhead attached to one end (see Appendix F Figure F1). Data is collected from carcasses after they are speared and lifted onto the deck of the boat (or held on the surface for chopping). Each carcass is then categorized using the following criteria:

1. recaptured (previously tagged) or new encounter,
2. fresh (recently died-with clear eyes) or non-fresh (decayed),
3. adipose fin absent (hatchery), present, or unknown,
4. male or female,
5. spawned or not spawned (eggs present in females, males not scarred from fights),
6. fork length and biological samples if taken,
7. location (river mile and GPS waypoint),
8. carcass to be tagged or chopped.

Recaptured fish (recaptures) are chopped in two pieces using a RBFO fabricated “V” shaped “choppinator” (two modified machetes welded together and bolted on a pole). Recaptures are tallied on the reverse side of the datasheet (Appendix C Figure C1 cont.), and the GPS location and tag number are recorded for each recaptured fish.

If the fish does not have a previously applied tag then the freshness condition of the carcass is determined. Carcasses are classified as either fresh or non-fresh. A fresh carcass is one with at least one clear eye and or reddish gills, and normally has a firm body indicating a recent death. All tagged carcasses are tagged in the lower jaw using a 1.25-inch round aluminum numbered “disc” tag. Both fresh and non-fresh fish can be tagged or chopped. Crews evaluate the condition of the fish and make a decision on tagging the fish based on the carcass characteristics. If the carcass is missing parts because of scavenging by otters, turkey vulture, etc., then it is normally chopped. As the carcasses decay, they become soft and rotten making tagging difficult. If a crew determines that a fish is not suitable for tagging due to decay, then it is chopped and tallied. This distinction between what is a non-fresh carcass to be tagged and a non-fresh carcass to be chopped is one area that is very subjective and is difficult to qualify as each carcass can be different and each crewmember may have slightly different views on this distinction.

At the other end of the decay process timeline are the carcasses tallied as skeletons. These fish are severely decayed resembling a bony skeleton or a bag of skin over a skeleton. Skeletons are carcasses missing the adipose fin area that prevents crews from determining if the fish was clipped. If the skeletal carcass is missing its lower jaw then it is chopped and ignored for purposes of the mark-recapture data (it is tallied separately). If the skeletal carcass has the lower jaw present then it is observed for a tag recapture. All skeletons are chopped after processing. An important distinction of skeletons from other, better condition fish, is that no heads are removed and sampled for coded wire tags on skeletons due to missing soft tissue from advanced decay.

A carcass with a missing adipose fin (indicating hatchery origin) has the upper portion of the head removed. Crews leave the lower jaw intact so that if the fish meets the tagging criteria for freshness and is non-scavenged, then it is tagged for CJS purposes. The head is placed in a bag and labeled for future dissection of the coded wire tag (CWT) within the head tissue to enable analysis of the hatchery of origin for it. Carcasses of "unknown" adipose fin clip status (area around the fin was eaten or rotten) are treated similarly to adipose fin clipped carcasses to ensure collection of all possible hatchery origin CWT fish. The RBFO motto of "when in doubt, take the snout" is useful in reminding new crew to always check for adipose fin status on all carcasses. An important exception to this motto is that no heads are ever collected from skeletons due to their advanced decay. The sex of carcasses is typically readily apparent and experienced crews normally have little difficulty in classifying carcass sex. Smaller carcasses (and some larger ones) can be difficult to determine. Crews are instructed to check gonads (cut with knife to observe) for any carcasses they are not positive of sex determination.

Spawn condition is determined by observing the external appearance of each carcass. Female carcasses are classified as spawned if few eggs remained in the carcass and the caudal (tail) fin is worn from redd construction. Unspawned females typically are those with unworn caudal fins indicating they have not constructed redds or those where numerous eggs remain in the carcass after it has died. Male carcasses are by default classed as spawned. The few males that are classed as unspawned have no fighting scars and wounds that are typical of the spawning males that constantly bite each other in their struggle to obtain a dominant position near a spawning female.

Nearly all fresh (and some non-fresh) carcasses are measured for fork length to determine age structure of the population. Additionally, tissue samples, otoliths (limited to winter-run), scales (all runs), and heads (all runs) are collected from fresh carcasses for further analysis. Sub-sampling for biological samples occurs when carcass counts are expected to be high. Sub-sampling (if used) commences and ends in complete survey periods to allow subsequent expansion of the results. All clipped or unknown clipped fish (except skeletons) are sampled (heads removed and checked for CWT) without sub-sampling to ensure maximum information on hatchery origin is collected.

For each carcass that is measured the river mile and a GPS location is recorded. This allows analysis of carcass distributions to determine if differences exist between different categories of fish or for other management queries. Other data collected by survey day includes the following:

1. outflow from Keswick Dam,
2. water temperature,
3. water clarity,
4. weather conditions.

River flow based on the outflow from Keswick Dam is obtained from the California Data Exchange Center (CDEC) using the KWK gauge at http://cdec.water.ca.gov. Water temperature is collected for each survey section via a handheld thermometer and recorded in degrees Fahrenheit. Water clarity is measured by lowering a Secchi disc attached to a spear into the water column. When the Secchi disc disappears/reappears, the measurement at the water surface is recorded. Water clarity distances greater than 15 feet are recorded as "15.9" for survey purposes since the maximum depth crews can spear a carcass is limited by the spear length. Weather conditions are noted as to the daily conditions (rain, clear, etc.) encountered for each section.

Sacramento River Aerial Flight Redd Distribution

In 2016, a CDFW airplane was used to conduct monthly surveys for the late-fall and fall/spring-run redd distributions. During the winter-run spawning period, a helicopter was used to conduct surveys to enable detailed inspection of winter-run spawning areas.

Aerial redd maps are created by RBFO staff on the flights to document the location of spawning areas and distributions in the Sacramento River (scanned versions available upon request of author: doug.killam@wildlife.ca.gov). These maps are used in conjunction with the corresponding carcass surveys to expand the overall population estimate for each run of salmon. Table 2 presents the data from the aerial redd surveys conducted by the RBFO. These surveys also create a historical database on redd distribution in the Sacramento River from Princeton (RM-164) to Keswick Dam (RM-302) (1969-present), available in Appendix A Table A2. The aerial redd data is also used to estimate spawning escapement in the Sacramento River downstream of both the RBDD (for historical comparisons) and carcass survey areas. The ratio of redds upstream to redds downstream is used in conjunction with the upstream escapement estimate of the carcass surveys. A simple proportion is used to calculate the downstream estimate. The proportion is constructed as follows: number of salmon downstream = (salmon upstream after harvest in Sacramento River / redds upstream) * redds downstream.

Aerial redd surveys do not provide complete counts of new redds. Variability in turbidity, river depth, riparian vegetation, weather and wind all effect the ability of the observer to count new redds. Not all redds that are new are able to be counted but it is assumed that the proportion of redds visible in the various sections during a single flight are identical. The aerial redd data should be used with caution. The RBFO staff recommend using aerial redd data only for comparisons of redd distributions by river sections or for specific needs such as use of a specific area as a spawning location.

The RBFO conducted 23 aerial redd flights on the Sacramento River for the 2016 escapement surveys (Table 2). **Three late-fall-run** flights were conducted in 2016 with 118 new redds observed and all located upstream of the Airport road Bridge. **Sixteen winter-run** flights were conducted using a helicopter from May 12 through August 25, 2016. All of the 18 new winter-run redds were observed in the sections from the ACID Dam downstream to the Airport Road Bridge. It is very likely that poor water visibility caused by turbidity in Shasta Lake prevented observers from viewing any redds in the deep water of the uppermost section between ACID and Keswick Dam. This section contains the coolest water available to the winter-run and all salmon entering into the Keswick Fish Trap for use at LSNFH must pass through this section. Many of the fish trapped are returned to the river and are likely to spawn in this section but unfortunately, conditions prevented their observation in the summer of 2016. **One spring**-run survey was conducted in the month of September and a single redd was reported. **Three fall-run** flights between October 13 and December 7, 2016 observed fall-run redds (see example photo in Appendix F Figure F2) from Woodson Bridge (RM-218) upstream to Keswick Dam (RM-302).

Table 2. Summary of new redd count data collected from aerial flights for year 2016.

2016 Summary of Aerial Redd Survey Data*										
Late-Fall	% Dist.	Winter	% Dist.	Spring	% Dist.	Fall	% Dist	ALL	% Dist.	RIVER SECTIONS
77	65%	0	0%	0	0%	51	37%	128	47%	Keswick to A.C.I.D. Dam.
19	16%	12	67%	0	0%	12	9%	43	16%	A.C.I.D. Dam to Highway 44 Bridge
22	19%	6	33%	1	100%	23	17%	52	19%	Highway 44 Br. to Airport Rd. Br.
0	0%	0	0%	0	0%	11	8%	11	4%	Airport Rd. Br. to Balls Ferry Br.
0	0%	0	0%	0	0%	2	1%	2	1%	Balls Ferry Br. to Battle Creek.
0	0%	0	0%	0	0%	21	15%	21	8%	Battle Creek to Jellys Ferry Br.
0	0%	0	0%	0	0%	3	2%	3	1%	Jellys Ferry Br. to Bend Bridge
0	0%	0	0%	0	0%	5	4%	5	2%	Bend Bridge to Red Bluff Diversion Dam
0	0%	0	0%	0	0%	8	6%	8	3%	Red Bluff Diversion Dam to Tehama Br.
0	0%	0	0%	0	0%	2	1%	2	1%	Tehama Br. To Woodson Bridge
0	0%	0	0%	0	0%	0	0%	0	0%	Woodson Bridge to Hamilton City Br.
0	0%	0	0%	0	0%	0	0%	0	0%	Hamilton City Bridge to Ord Ferry Br.
0	0%	0	0%	0	0%	0	0%	0	0%	Ord Ferry Br. To Princeton Ferry.
118	**100%**	**18**	**100%**	**1**	**100%**	**138**	**100%**	**275**	**100%**	
* Summary of: 3 late-fall-run, 16 winter-run, 1 spring-run, and 3 fall-run Chinook Salmon redd counting flights.										

In summary, during 2016 there were 275 new redds observed in the Sacramento River from Keswick Dam to Woodson Bridge (RM-218) over 23 separate flights. The majority of these redds (96.4%) were upstream of Red Bluff Diversion Dam. Appendix A Table A2 presents a summary of Aerial Redd survey information for years 1969-2016.

Historically the fall-run, and to a lesser extent the late-fall-run, are observed to spawn throughout the upper river from Princeton (RM 164) to Keswick Dam. In 2016 no redds were observed in the 54 miles of the three lowermost sections below Woodson Bridge. This section contains sub-optimal spawning habitat but the reason for the complete lack of spawning in this area is unknown at present, but likely is due to the drought conditions from recent past years reducing survival of juveniles that were originally from this section of the USRB. Water temperatures in the USRB normally decline in the autumn and winter months (as air temperatures decline) and this allows these runs to spawn in suitable habitat further downstream than the summer and early autumn spawning winter-run and spring-run (Appendix A Table A2). Drought conditions in 2013-2015 resulted in warmer than normal water temperatures in the Sacramento River and could have reduced survival of the eggs from fish spawning in this lowermost section.

Video Station Monitoring Methods

In 2016, video monitoring stations (stations) were constructed on eight tributaries and at the ACID Dam in Redding to monitor fish passage. Tributaries with stations included: Clear, Cow, Bear, Cottonwood, Battle, Antelope, Mill, and Deer Creek(s). Details of each station's data analysis are available later in this report. Each station was constructed by staff from the RBFO (with assistance from USFWS crews on Clear and Battle Creek stations). Discussion of the construction of each station can be divided into two basic groups of equipment for discussion purposes.

<u>Weir System:</u>

1. stream or fish ladder bottom white plates,
2. weir panels (in-river stations only).

<u>Electronics:</u>

1. power supply-(solar or power company electric)
2. lock box and equipment,
3. backup batteries power supply,
4. lights,
5. overhead camera with supporting structural cables and electronic cables,
6. underwater cameras with supporting plates and electronic cables,
7. digital video recording devices (DVR's) or laptop computer (DIDSON-ARIS), or VAKI Riverwatcher control box.

The stations (e.g., Battle Creek shown in Figure 3) functioned by video recording salmon and other migrating fish as they passed through an opening in a partial in-stream weir (Clear, Cow, Bear, Cottonwood, and Battle) or fish ladders (ACID, Antelope, Mill and Deer (Deer has two ladders, each with a separate station).

In 2014, the CDFW and PSMFC were funded to begin a Steelhead Monitoring Program. Funding from this Program allowed RBFO steelhead staff to construct two full sized resistance board weirs that were installed on Clear Creek and Bear Creek in 2015. In 2016, three additional resistance board weirs were fabricated and located in the fall on Cow, Cottonwood and Battle Creeks in the hopes of observing steelhead passage over the fall, winter and spring periods. Methods for construction of these weirs are described in Stewart 2002. A photo of the Clear Creek resistance board weir is shown in Figure 4. The weirs are constructed of PVC (polyvinyl chloride) pipe and use the force of water flowing past an adjustable underwater "resistance" board to lift the downstream end out of the water. An advantage of the resistance board weir over the previously used "horizontal panel" RBFO weir is that downstream moving flood debris can push the panels underwater allowing the debris to move past the weir without destroying it. Resistance board weirs allow monitoring at much higher flows typical of steelhead passage periods (winter-spring) and have now mostly replaced the horizontal weirs on major tributaries monitored by the RBFO. Both types of weirs funnel the upstream moving salmon through the opening in the main channel of the streams. At the opening, the fish swam above a white plastic plate attached on the stream bottom. As fish swim through the weir opening, they are video recorded by a camera system positioned on cables directly overhead of the white plate. A through description of video station methods including detailed discussion of equipment, construction, maintenance, and data analysis is available in the 2011 annual report by the RBFO titled “Chinook Salmon Populations for the Upper Sacramento River Basin In 2011” (Killam 2012). There were not significant changes to the counting methodology and procedures for the 2016 stations compared to 2011 so the authors direct interested readers to the earlier report for discussion of RBFO video stations methods.

In 2016, both DIDSON and ARIS cameras were used at various stations. These cameras incorporate a relatively new and expensive technology to view underwater objects including fish. The ARIS camera is the newest version of the sonar technology and replaces the no longer available for purchase DIDSON. The cameras are about the size of a small watermelon (ARIS is slightly smaller) and must be submerged to function. The cameras send images to a computer through a waterproof cable. The computer saves the video like images to a hard drive and the DIDSON or ARIS software enables viewers to play the footage on a computer and view it in many different ways. The monochromatic footage resembles the ultrasound images of a human baby in the womb. The RBFO requested the cameras (loaned) to assist in counting fish during the fall, late-fall, and spring-run migration periods at the video stations.

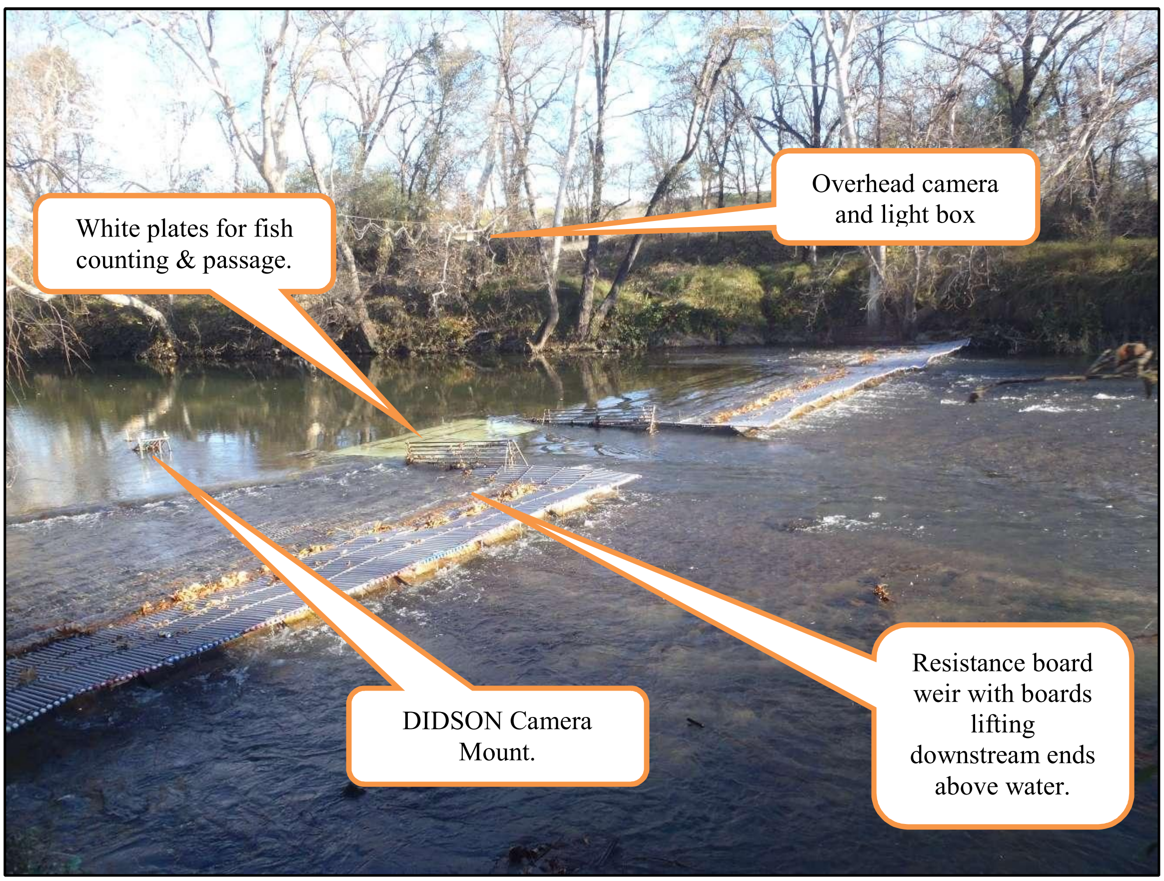

Figure 3. The 2016 Battle Creek video station with camera box, resistance board weir, and passage opening with white plates visible.

Figure 4. The 2016 Clear Creek video station showing the resistance board weir and RBFO crew brushing debris off the weir.

The sonar cameras can “see” in turbid water enabling fish counting to continue during periods of flooding and snowmelt on streams in the USRB. The use of the cameras supplemented the regular video coverage during these muddy water periods. The DIDSON or ARIS pairs well with the video station equipment as it functions by “shooting” a sonar beam across the entire opening of the weir or fish ladder allowing for wide relatively unrestricted passage both up and downstream for multiple species. A disadvantage of the sonar cameras (beside the cost) is that it is difficult to distinguish different fish species of similar size. RBFO staff viewing DIDSON and ARIS footage reported little difficulty in identifying the larger adult salmon. However, for the smaller fish (e.g., 18 to 24-inch, (46 to 61-cm)) common to the USRB, viewers often were unable to identify individual species. Species such as steelhead, smaller salmon, Sacramento Pikeminnow, (*Ptychocheilus grandis*), Hardhead, (*Mylopharodon conocephalus*), Sacramento Sucker, (*Catostomus occidentalis*) and even beavers and river otters were difficult to distinguish using just the DIDSON footage.

A Vaki Riverwatcher device was purchased by the Steelhead Program and was used for the first time by the RBFO on the south fish ladder of the Stanford Vina Dam in Deer

Creek in October of 2016. The Vaki device uses both a traditional video camera and infrared light beams to monitor fish passage. An advantage of the device is that is capable of collecting silhouettes of passing fish in turbid water (using infrared multi beams) as well as video images of fish passage during clear water. Fish are funneled into a narrow tunnel opening where they are recorded and characterized by a control box computer that allows users to easily (relative to continuous video) tabulate fish counts. The Vaki has some limitations for use in the USRB tributaries. These include a substantial size and weight, (making placement and flood removal complicated), a substantial cost, and potential clogging. In addition, all fish passage (including downstream passage) must be funneled through the narrow tunnel possibly interfering with normal fish migration of both salmonids and non-salmonids alike. Many other non-fish species travel in the USRB tributaries on daily migrations (otters, beavers, turtles, ducks, etc.) and the ability (or behavior) of these non-target species passing through the narrow tunnel opening is uncertain.

Details of the various surveys including carcass surveys, bio-sampling surveys, video stations, DIDSON-ARIS sonar cameras, and Vaki Riverwatcher use in 2016 are discussed in the specific waterway sections below.

Tributary Walking, Snorkeling and Kayaking Survey Methods

During various times of the year the RBFO staff and other agency staff conduct numerous surveys to collect salmonid population data in tributary streams of the USRB. These surveys involve surveying specific reaches or sections of tributaries and documenting the number of salmon or other categories of interest. Typically, methods can include boating, walking, snorkeling (swimming), or kayaking and counting and collecting data on salmon populations. Data collected can include number of live fish observed, number of carcasses observed (data is then collected on each carcass), number of redds observed and locations of these observances.

In 2016, salmon carcass bio-sampling surveys of each USRB waterway were used to evaluate the characteristics of the populations for origin, age, sex, and spawning success. No mark-recapture is done in the tributaries because video stations provide population estimates. Fresh carcasses are normally the only ones sampled when counts are high. Crews are instructed to ignore non-fresh carcasses after the first weekly survey to avoid sampling the same fish twice.

The estimate of natural and hatchery origin ratios of fall-run spawning in the waterways in the USRB is based on fresh carcass examinations. Usually less than a few days old, fresh carcasses allow reliable determination of the presence or absence of the adipose fin. Fresh carcasses are also more likely to retain their CWT before the decay process allows rotten tissue to shed the tag. Appendix B Table B1 shows the CWT information for all RBFO surveys in 2016.

Age structure is determined by post-season analysis of fork lengths of both males and females separately. CWT information is used to assist in determining length “cut-offs” for both sexes. Fish under a certain fork length are listed as "grilse" or two-year olds (jacks-male, jills-female), while fish greater than the cut-off are listed as adults (3-years or greater). Scale samples are taken from all fresh carcasses on each creek in the expectation that they allow a more accurate method to age a fish. At present time, scale reading of samples collected by RBFO crews has not been adequately funded to provide any up-to-date age information so the fork length and CWT methodology is used.

Sex is determined through visual observation or by cutting the body cavity of questionable fish and visually checking for eggs or milt. Spawned females normally have eroded tails from digging redds and have little or no eggs remaining. Spawned males typically show the presence of wounds, scratches and sores along their sides indicating they were in competition with other males for prime spawning positions when females were laying their eggs. The wounds are caused by other males biting at the sides of other males to force them away from the female.

Spawn success is determined by comparing the ratio of fully spawned out females to those that died prior to expelling their eggs. Normally in low count years unspawned females are uncommon, as most can find room to construct a redd and lay their eggs. In some years, large counts can result in high numbers of unspawned females as many die before finding a suitable redd location. Disease, poor water quality, and predators are other causes of pre-mature death for female and male salmon. Male salmon are normally not noted as unspawned unless it is obvious a male died prior to competing with other males.

In 2016 RBFO staff conducted these surveys on Clear, Cow, Cottonwood, Paynes, Antelope, Mill and Deer Creek(s). Details are described for each creek in the sections below.

The 2016 Salmon Escapement Results for Specific Waterways

Appendix E of this report contains an abbreviated image of the latest CDFW GrandTab report file (April 07, 2017 version) available at the time of this report's writing. Note that the 2016 estimates in this report are the most-up-to-date, many calculated after the GrandTab 2016 version was made. The file contains the current and previous salmon estimates of waterways in the California Central Valley. Numbers in GrandTab are usually considered draft for a few years giving time for quality control reviews and other updates to estimates to occur. **Readers should also note that GrandTab does not include sport angler catch in the USRB**. Readers should use caution when comparing GrandTab totals to totals in Table 1 and throughout the text below. Typically, the most recent source of information, based on date, will provide the most up-to-date estimates. **Significant revisions can be made to numbers during agency reviews and these often go undocumented**. The following section of this report provides details of the salmonid escapement surveys made on the USRB waterways in 2016.

Sacramento River

Late-fall-run. Please note that late-fall-run salmon spawn over the calendar year change. For the purposes of reporting late-fall-run numbers it is customary to report estimates based on when the juveniles emerge from redds. Late-fall salmon spawning in November and December are classified as belonging to the following year, (i.e., December of 2015 spawners are put into the 2016 estimate, and December of 2016 spawners will be part of the 2017 estimate).

A Sacramento River mark-recapture carcass survey was conducted from December 15, 2015 through May 10, 2016. The 22 weekly surveys covered a 26-mile section of the Sacramento River between Keswick Dam, (RM-302), and the Balls ferry bridge (RM-276). Weather during late-fall-run surveys can often make surveying difficult or impossible. The ongoing drought in the USRB effectively ended in December of 2015 when rains began filling Lake Shasta and a flood release from Keswick Dam of over 20,000 cfs in March of 2016 was made for flood control purposes. The late-fall season was marred by these high flow releases. Conditions for observing carcasses were poor, with visibility ranging from zero to ten feet during all 22 weeks of the survey (visibility greater than 16 feet is common in the Sacramento River). An estimated **3,150 late-fall were present** with 65 of these transferred to the CNFH for broodstock purposes. Ninety percent confidence limits for the estimate were 2,373-lower and 3,927-upper (see Appendix A Table A3), reflecting the poor (high variance) conditions (turbid) of the survey in 2016.

Appendix A Table A3 provides a summary of the 2016 Sacramento River late-fall-run population. Crews observed 637 carcasses. Crews tagged 174 of these and recaptured 41 for a recapture rate of 23.6%. Crews measured 145 fresh carcasses, and a grilse (2-year old) percentage of 5.0% was estimated based on a length cut-off of 610 mm for both females and males. Males represented 60.6% of the population. Females were checked for egg retention following spawning. One of 115 fresh females (0.9%) had not completely spawned. Keswick Dam flow releases ranged from a low of 3,189 to a high of 20,204 cfs during the survey (from CDEC gauge KWK). Water temperatures taken by RBFO crews ranged from 47 to 58 degrees over the five months of the survey.

All fish examined were checked for adipose fin clips representing hatchery origin (except skeletons). Appendix B provides data on hatchery origin salmon encountered by RBFO staff in 2016. Appendix B Table B1 provides a summary of the RBFO surveyed carcasses examined for hatchery origins for each waterway and the results for all surveys including the Sacramento River late-fall-run. Of the 637 late-fall observed carcasses, 494 were checked for clips, while the other 143 were skeletons that were too decayed for crews to check for clips. Crews removed heads for CWT checks on 16 carcasses and determined that all of these were of hatchery origin. All but one of these were from the late-fall production at the CNFH (Appendix B Table B2). The one non-CNFH fish was a fall-run from the Merced River Fish Facility. Appendix B, Tables B2 through B5 provide a summary of CWT and hatchery origin information for the late-fall-run as well as for all salmon observed by RBFO staff in 2016.

The late-fall-run are subject to sport fishing in the Sacramento River below Deschutes Road Bridge (RM-280.9). In late 2015, anglers were estimated to have harvested 133 late-fall-run salmon from the Sacramento River. The sport-fishing season for what are classified as 2016 late-fall-run spawners was from July 16 to December 16, 2015 below RBDD, and from August 01 through December 16, 2015 above RBDD. The CDFW's Angler Harvest Survey reported angler harvest numbers during the 2015 late-fall-run season as 76 below RBDD and 57 above RBDD for the total of 133, (Table 1). All of these were determined to be late-fall-run (i.e. they could have been strays from other systems) after CWT analysis.

Based on the Sacramento River carcass survey, angler harvest estimate, CNFH data, various tributaries, and aerial redd data it is estimated that **at least 5,803 late-fall-run** salmon were present in the USRB above Knights Landing in late 2015 and early 2016 (Table 1). The RBFO monitoring begins at Princeton; angler data above Knights Landing was included since fish caught above Knights Landing were likely destined to spawn in the USRB. This estimate does not include the tributaries that had no surveys due to limited staffing and typically poor weather and turbidity conditions during late autumn and winter.

Winter-run. Appendix C1, and Appendix C Table C1 provides readers with an extensive summary table and notes of the winter-run Chinook Salmon data collected in 2016 and previous years. This table, and all other data found in this report are available for download on the CALFISH site, or upon request, in spreadsheet format. Requests can be directed to authors at the e-mail addresses in the Summary section of this report.

The CJS mark-recapture carcass survey for winter-run was conducted on the Sacramento River (Figure 2) from May 02 through September 15, 2016 (Appendix A Table A4). The total **spawner** population estimate for the 2016 Sacramento River winter-run was **1,546** with a 90% Confidence interval of 329-lower and 2,763-upper. In-river winter-run were estimated at 1,409. The LSNFH staff collected 137 winter-run for broodstock in 2016. This is more than the typical "up to 120 fish" collected in typical years as a response to the drought conditions that raised concerns similar to those of 2014 and 2015 (see Appendix C2 in Killam et al., 2015).

The Appendix A Table A4, and Appendix B Table B1 provide a summary of the 2016 in-river spawning winter-run population. Crews observed 297 carcasses. Crews tagged 223 of these and recaptured 59 for a recapture rate of 26.5%. Crews measured 161 fresh fish, and a grilse (2-year old) percentage of 36.8% was estimated for all fish based on a length cut-off of 630 mm for females and 710 mm for males. Males represented 53.6% of the total population (including the fish from LSNFH). An estimated 658 females were estimated to have spawned in-river (including 98 jills). Females were checked for egg retention following spawning. Only one of 128 fresh females (0.8%) had not completely spawned. Keswick flow releases ranged from a low of 5,545 to a high of 10,692 cfs during the survey indicating an attempt to conserve limited cold water in Shasta Lake compared to typical years that see a wider range in flows during the summer major agricultural water release season. Water temperatures taken by joint USFWS-RBFO crews ranged from 51 to 56 degrees over the four-month survey.

All fish examined were checked for adipose fin clips representing hatchery origin (except skeletons). Appendix B Table B1 provides a summary of the winter-run carcasses examined for hatchery origins. Of the 297 winter-run carcasses, 284 were checked for clips (13 skeletons not checked). Crews removed heads for CWT checks on 84 carcasses and determined that 77 of these were of hatchery origin. An estimated 466 of the 1,546 or 30.2% of the spawning population were hatchery origin. Additional tag data on hatchery winter-run is available in Appendix B Tables B2 through B5.

Other winter-run data. Two additional winter-run salmon were reported in Clear and Battle Creeks leading to a final escapement of 1,548. Sixteen helicopter aerial redd surveys (Table 2) were conducted to count new redds and determine winter-run spawning distributions in the Sacramento River from the RBDD (RM-243) to Keswick Dam (RM-302). In 2016, all 18 winter-run redds were found upstream of the Airport Road Bridge (RM-284) in Anderson, CA. The USRB winter-run spawner total of 1,548 in 2016 represents a negative cohort replacement from the three-year-ago population of 6,086 (i.e. 2013) (Appendix C1 Table C1 row-49).

There was zero estimated in-river angler harvest of winter-run based on limited angling season and no reported catch of winter-run from the CDFW Angler Harvest Survey. It is likely that some winter-run mortality is associated with angling and poaching but no quantitative data was available to quantify this. In 2016, the CDFW again took an additional protective step of closing the Sacramento River to all angling from Keswick Dam downstream to the State Highway 44 Bridge just below Turtle Bay from April to July 31, 2016. In past years, this uppermost anadromous river section was open to non-salmon angling year round. Expected low winter run counts, drought concerns, and observational reports of incidental hooking of salmon in this area led to the closure.

In 2013, a large number of winter-run were found to have strayed into the Colusa Basin irrigation waterways resulting in significant losses to winter-run adults, (Killam et al., 2014). Because of these losses the CDFW implemented a monitoring program with a trap and haul rescue plan for the Colusa Basin again in 2016. No winter-run salmon were observed to stray into the Colusa Basin in 2016. This monitoring effort is expected to continue in future years.

Spring-run. Spawning of natural origin spring-run natal to the Sacramento River is considered by the CDFW to have largely been eliminated through competition plus hybridization with fall-run salmon (CDFG 1998). Historically spring-run salmon migrated upstream in the spring and early summer and held over the summer in higher elevations with cooler water temperatures. These fish were then spatially separated from the later arriving fall-run by low flows and warmer temperatures in the lower sections of the waterways. Presently, Keswick Dam prevents the spring-run from being spatially isolated from the fall-run. Since spring-run salmon are spawning around the same time as early spawning fall-run each year (mid-September into October) in the same location they may not be genetically isolated.

Currently, the CDFW cannot make reliable carcass survey estimates of natural spring-run upstream of RBDD in the Sacramento River. This is because of the overlap between spring and fall runs and the lack of a suitable means of distinguishing them. In 2016, carcass surveys continued with no breaks between winter-run and the fall-run survey. Carcass counts in September were zero indicating very few salmon spawned during this period. Previous limited genetic analysis in 2013 indicated that fish from the winter, spring and fall runs were all present in small numbers during this segue period between the winter and fall runs (Killam et al., 2014). The traditional process of estimating spring-run uses the aerial redd data and assigns a spring-run number based on new redds observed in late-August through September. In 2016, one spring-run flight was conducted and one redd observed (Table 2). Because the fall-run carcass survey started immediately after the end of the winter-run survey any carcasses of spring-run spawners would have been incorporated into the CJS estimate for fall-run (see below). Because of this continued uncertainty, an estimate of **zero** was made for the natural origin spring-run in the Sacramento River (Table 1).

Data from Appendix B Tables B2 and B4 indicate that two Feather River Hatchery (FRH) spring-run salmon were encountered during the fall-run surveys on the Sacramento River in 2016. These FRH strays are historically found early on the fall-run surveys in the USRB indicating their early spawn timing and persistence. There is considerable uncertainty and discussion amongst biologists as to the exact nature of the spring-run population in the Sacramento River. Until further research is conducted, this uncertainty will continue. It should be noted that these two FRH spring-run expand out to a population of 21 hatchery-origin spring-run present in the Sacramento River, (1.3% of the 1,643 hatchery origin fish present in Appendix Table A5).

Fall-run. A CJS mark-recapture carcass survey for fall-run salmon was conducted on the Sacramento River (Figure 2) from September 6, 2016 through January 05, 2017 (see Appendix A Table A5 and Appendix B Table B1). The expanded population estimate for the 2016 Sacramento River fall-run was **4,517**. Ninety percent confidence limits for the expanded estimate were 3,267-lower and 5,875-upper, indicating relatively good carcassing conditions (tight intervals-low variance) of the fall survey in 2016. Conditions were good for survey crews with low clear flows into December in the survey area. This year's estimate for the mainstem Sacramento River is the lowest on record (see Appendix E Figure E1). Crews observed 860 carcasses. Crews tagged 322 of these and recaptured 100 for a recapture rate of 31.1% for the weekly survey. Crews measured 216 fresh fish, and a grilse (2-year old) percentage of 4.0% was estimated based on a length cut-off of 610 mm for females and 650 mm for males. Males represented 42.2% of the population. An estimated 2,481 females spawned in-river (including 47 jills). Females were checked for egg retention by survey crews. Two of 158 fresh females (1.3%) had not completely spawned. Note for record keeping purposes that **0 spring-run are subtracted from the 4,571** to calculate for the fall-run only. An estimated 21 FRH hatchery origin spring-run were present in the Sacramento River but these are considered by the authors to be part of the overall fall-run numbers by historical calculations. Further research on the nature of natural origin spring-run in the mainstem is desirable.

All fish examined were checked for adipose fin clips representing hatchery origin (except skeletons). Appendix B Table B1 provides a summary of the fall-run carcasses examined for hatchery origins. Of the 860 fall/spring-run carcasses, 730 were checked for clips (130 skeletons not checked). Crews removed heads for CWT checks on 61 carcasses and determined that 61 of these were of hatchery origin. Of the total 4,289 in-river fall/spring-run an estimated 1,643 (38.3%) were of hatchery origin. In addition, for the first time in modern times, the staff at the CNFH transferred fall-run fish from the Keswick Trap to the CNFH for supplemental broodstock due to the low numbers of fall-run in Battle Creek. These 282 fish removed from the Sacramento are part of the 4,571 value given above and were determined to be all hatchery origin based on CWT expansion (82 clipped, 200 not adipose fin clipped). The overall hatchery percentage for the in-river and hatchery transfers is 42.1% ((1643+82)/4571). This value was calculated from a hatchery fish expansion based on the data from the Constant Fractional Marking Program (CFM). Fresh fish data were utilized in this expansion and specific CWT codes were expanded based on the percentage of juvenile tagging that each CWT code represented. Specific CWT tag codes recovered from the in-river fall-run are shown in Appendix-B Table B2. Additional tag data on the in-river fall-run is available in Appendix B Tables B3-B5.

Water temperatures taken by RBFO crews ranged from 48 to 55 degrees over the three-month long survey. Keswick Dam flow releases ranged from a low of 4,985 to 10,025 cfs during the survey in a flow regime that typically starts high and progressively decreases as agricultural needs decrease during the period from summer to early winter. These systematic flow reductions during fall-run and late-fall-run spawning in the Sacramento River can lead to redd dewatering and subsequent egg and juvenile stranding and mortality. From the summer of 2016 to the spring of 2017 a continuing effort to document dewatered redds was made by RBFO staff. Results of this redd dewatering effort are available in (Revnak et al, 2017). Redd dewatering can impact all four salmon runs that occur in the Sacramento River, and large numbers of fall-run redds can be dewatered after autumn reductions in flow. Dewatering of redds and stranding of juveniles is of concern to fisheries agencies, and the RBFO crews continue to investigate impacts to salmon redds and juvenile stranding of salmon in the river.

The CDFW Angler Harvest Survey reported that **anglers in the Sacramento River caught 2,883 fall/spring salmon** upstream of Knights Landing from July 16 through December 16, 2016, (E. Ferguson CDFW pers. comm.). This included **1,538 below the RBDD** (includes 0 during the traditional late-fall period after October 31) and **1,345 upstream** of the RBDD (Table 1). Included in these numbers are 35 (all above RBDD) "non-Sacramento River fall-run" that were all FRH spring-run hatchery origin fish. Note that the late-fall-run fish (N= 130) caught in this angling season (through December 16) are tallied as 2017 angler caught late-fall-run fish. In 2016, the in-river angling season was from July 16 to December 16, 2016. These dates represent a fully open (normal) fishing season bracketed by seasonal closures for concern of angling take of winter-run from late-December to mid-July.

Steelhead. No steelhead monitoring surveys take place in the mainstem Sacramento River in the USRB. Boat crews measure and tally all trout/steelhead carcasses they encounter but no population mark and recapture effort is conducted. Crews observed 103 trout/steelhead carcasses on the river from September 10, 2015 to September 01, 2016. The average forklength of these was 17.5 inches (447 mm). The majority of these were thought to be resident-trout carcasses and were observed on the fall-2015, late-fall-2015-2016, and winter-run-2016 mark recapture surveys.

Clear Creek

Clear Creek is a western anadromous tributary of the USRB. Clear Creek enters the Sacramento River at RM-289 (Figure 1). In recent decades, Clear Creek has benefited from extensive restoration and recovery actions. These actions include channel reconstruction, spawning gravel augmentation, and prescribed Whiskeytown Reservoir releases. Fall-run have responded to these improvements. Clear Creek normally contains the third largest fall-run population in the USRB. Clear Creek late-fall and spring-run populations (monitored by the USFWS) have not responded to restoration actions as well as fall-run. Video monitoring, snorkel surveys, carcass surveys, and redd surveys were used to estimate Clear Creek Chinook Salmon and steelhead populations in 2016.

Late-fall-run. Chinook entering Clear Creek after December 15 are within the period of late-fall-run migration and spawning observed in the Sacramento River and Battle Creek (Killam 2012). During the winter and early-spring months USFWS personnel conduct redd counts and collect biological data on late-fall-run carcasses encountered in Clear Creek using kayak-based surveys. A mark-recapture survey is not possible due to low numbers of carcasses and frequent flooding, (S. Gallagher USFWS pers. comm.). The Clear Creek video station is operated by the USFWS from December 16 through August 14 each year. Redd count data from USFWS (N=20, and 2.75 males per female expansion) collected on Clear Creek during late-fall-run migration and spawning periods resulted in an estimate of **55 late-fall-run salmon**. Late-fall-run data from previous year's surveys is on the Red Bluff USFWS internet site at: (www.fws.gov/redbluff/). No summary of video counts was available from USFWS at the time this report was written (October 2017)

Winter-run. No winter-run populations are known to exist in Clear Creek at this time. This may change in future years as drought conditions in the Sacramento River and favorable flow management strategies in Clear Creek designed to attract and enhance spring-run populations may attract winter-run into Clear Creek. In recent years some winter-run have been observed milling around the video station site located near the confluence of Clear Creek and the Sacramento River, and **one** winter-run carcass was collected upstream (R.J. Bottaro USFWS pers comm.). High summer flows in the river back up into the creek making the very lower end of Clear Creek cool enough to support salmonids and may serve to attract winter-run from the river to Clear Creek during summer months.

Spring-run. The USFWS conducts snorkel surveys in August to determine an annual index of spring-run abundance. During the August 2016 survey **29** spring-run were counted (Table 1 and Appendix E, Figure E1). A temporary picket weir was again installed in 2016 to spatially separate spring-run from fall-run in Clear Creek. Details for this effort are available in USFWS reporting at (www.fws.gov/redbluff/).

Fall-run. A final estimate of **2,481** fall-run, with 90% confidence intervals of 2,171-lower and 2,791-upper, was obtained using data collected at the Clear Creek video station (see Figure 4) in 2016. Methodology used to obtain this final estimate and confidence intervals is available in Appendix D3. The Clear Creek video station is located adjacent to the Redding City Wastewater Treatment Plant (RM-0.1) and has been in continuous operation since June of 2012. The RBFO annually maintains the station from mid-August through December 16 for fall-run and steelhead escapement and life history information. In 2015, funding from the Steelhead Monitoring Program allowed replacement of the former horizontal bar weir with a resistance board weir. The resistance board weir can withstand high flows (shown in Appendix F Figures F3 and F4) and allows better accounting of salmonids during winter months when high flows from rain events may frequently occur. A thorough description of video station construction and methodology, including detailed discussion of design, equipment used, maintenance, and data analysis, is available in the 2011 RBFO Annual Report (Killam 2012). Details of the resistance board weir can be found in Stewart 2002. A DIDSON camera was used during 28 hours when video counts were not possible over four separate turbid water periods. There were nine days where neither video or DIDSON were functional. During these times a statistical R software based GAM processing (see Appendix D3) was applied to the data and resulted in 169 additional salmon. Daily fall-run passage at the video station, average daily stream flow (recorded at Igo (CDEC Station: IGO), and average daily water temperatures recorded at the video station is presented in Table 3.

Bio-Sampling. Eleven kayak carcass surveys were made weekly on Clear Creek during the fall in 2016. The survey area encompasses Clear Creek's primary fall-run spawning habitat, located between RM-6.3 and the mouth. The data from the bio-sampling is used to categorize the video count's official number of 2,481. There were 139 carcasses observed. These fish were used to describe the characteristics of the population by recording the fork-length, sex, and the presence or absence of the adipose fin (Appendix B Table B1).

In 2016, Clear Creek fall-run spawners (see Table 3) were 72% natural origin, 93% adults (fork cut-off of 610 mm-female, 650 mm-male), and 58% females (0% unspawned) based on bio-sampling. Crews collected 13 heads from these sampled carcasses and dissected them at the RBFO for CWT extraction and reading. Twelve CWT's were recovered. The tag codes revealed that the stray hatchery origin Chinook spawning in Clear Creek in the fall of 2016 were 92% CNFH fall-run, and 8% CNFH late-fall-run. Additional data on the hatchery origin fish in Clear Creek is available in Appendix B, Tables B2 to B5.

Table 3. Daily information on salmonid passage, flow (CDEC-IGO) and average water temperature from August 16 to December 14, 2016 at the Clear Creek video station.

2016 Fall-run Clear Creek Creek Video Station Salmonid Passage

Date	Salmon	Steelhead	Flow	Water °F	Date	Salmon	Steelhead	Flow	Water °F	Date	Salmon	Steelhead	Flow	Water °F
16-Aug	0	0	148	65	30-Sep	42	0	267	58	14-Nov	30	-1	263	57
17-Aug	0	1	148	66	1-Oct	19	0	233	57	15-Nov	27	3	263	58
18-Aug	0	1	147	66	2-Oct	65	0	233	56	16-Nov	30	2	262	55
19-Aug	0	0	147	66	3-Oct	111	1	230	56	17-Nov	14	0	262	54
20-Aug	0	0	147	66	4-Oct	5	2	230	58	18-Nov	18	0	262	54
21-Aug	0	0	148	66	5-Oct	49	0	247	57	19-Nov	68	1	368	55
22-Aug	1	0	148	66	6-Oct	55	0	246	58	20-Nov	13	4	483	55
23-Aug	0	0	148	65	7-Oct	50	2	245	58	21-Nov	12	5	387	55
24-Aug	0	1	148	65	8-Oct	29	1	244	59	22-Nov	2	7	316	54
25-Aug	0	0	149	65	9-Oct	56	2	244	59	23-Nov	3	1	331	54
26-Aug	-1	1	150	64	10-Oct	52	3	245	59	24-Nov	5	2	304	52
27-Aug	0	3	149	64	11-Oct	46	0	245	58	25-Nov	6	0	295	53
28-Aug	0	1	150	64	12-Oct	50	0	244	58	26-Nov	15	1	393	52
29-Aug	0	0	150	63	13-Oct	74	2	244	58	27-Nov	0	1	400	52
30-Aug	1	0	150	63	14-Oct	537	1	260	59	28-Nov	0	0	332	53
31-Aug	2	0	147	63	15-Oct	176	1	255	58	29-Nov	1	1	310	51
1-Sep	-1	0	144	63	16-Oct	56	0	259	58	30-Nov	4	-1	299	52
2-Sep	3	2	144	63	17-Oct	-2	0	254	58	1-Dec	12	-1	291	51
3-Sep	1	0	144	63	18-Oct	21	0	258	58	2-Dec	3	0	285	50
4-Sep	2	0	144	62	19-Oct	28	0	273	57	3-Dec	13	1	282	51
5-Sep	1	1	144	62	20-Oct	22	0	272	58	4-Dec	4	0	279	51
6-Sep	2	0	140	62	21-Oct	29	4	250	58	5-Dec	0	-3	277	50
7-Sep	3	2	135	63	22-Oct	17	0	247	58	6-Dec	-5	0	276	49
8-Sep	2	2	135	62	23-Oct	10	0	247	57	7-Dec	14	-1	276	48
9-Sep	2	0	135	62	24-Oct	15	0	239	57	8-Dec	11	0	283	49
10-Sep	3	2	134	62	25-Oct	51	0	251	58	9-Dec	11	1	283	50
11-Sep	6	2	135	62	26-Oct	10	0	244	59	10-Dec	26	1	544	51
12-Sep	2	0	135	62	27-Oct	95	6	279	58	11-Dec	-1	2	355	49
13-Sep	12	3	136	60	28-Oct	1	1	272	58	12-Dec	3	1	319	48
14-Sep	8	0	136	60	29-Oct	13	0	276	59	13-Dec	3	0	308	48
15-Sep	1	1	135	60	30-Oct	38	1	349	58	14-Dec	8	1	369	49
16-Sep	4	1	142	60	31-Oct	25	0	302	57		Salmon	Steelhead		
17-Sep	2	1	150	60	1-Nov	20	0	322	57	**TOTALS**	**2,481**	103	Flow-IGO	
18-Sep	-1	3	150	61	2-Nov	-2	0	288	56					
19-Sep	11	3	167	62	3-Nov	8	0	277	56	Salmon 90% lower confidence limit				**2,171**
20-Sep	15	1	199	61	4-Nov	7	0	272	57	Salmon 90% upper confidence limit				**2,791**
21-Sep	5	4	212	59	5-Nov	6	1	270	56	Natural Origin			**1,797**	**72.4%**
22-Sep	4	0	212	58	6-Nov	4	0	269	58	Hatchery Origin			**684**	**27.6%**
23-Sep	26	5	221	57	7-Nov	0	0	267	58	Number Adults			**2,310**	**93.1%**
24-Sep	3	0	237	59	8-Nov	17	-1	267	57	Number Grilse			**170**	**6.9%**
25-Sep	6	1	250	59	9-Nov	19	0	265	57	Females	adults		**1,401**	**56.5%**
26-Sep	9	2	271	59	10-Nov	6	-2	263	57		jills		**34**	**1.4%**
27-Sep	9	0	271	59	11-Nov	15	1	264	57	Males	adults		**909**	**36.7%**
28-Sep	5	0	271	59	12-Nov	17	1	264	58		jacks		**136**	**5.5%**
29-Sep	4	2	270	59	13-Nov	18	2	263	57	Note: Temp and Flows are daily averages				

Steelhead. Anadromous forms of rainbow trout begin migration into the USRB in July and continue entering through the early summer months of the following year (Appendix A Table A1). An estimated **103 steelhead** (with 90% CI's of 80 and 131) were counted passing through the Clear Creek video station from August 16 through December 14, 2015 (Table 3). Note that because of the close proximity (0.1 miles) to the Sacramento River's large population of resident-trout, steelhead data obtained at the station is based on fish lengths (rainbow trout >16 inches are tallied as steelhead for reporting purposes) and should be interpreted with caution.

Other time periods. Data from December 15, 2015 to August 15, 2016 at the video station is available from the USFWS Red Bluff office upon request, (S. Gallagher USFWS pers. comm.).

Cow Creek

Late-fall-run. The limited fall-run operation of the video station on Cow Creek until only December 08, 2015 prevented monitoring of any late-fall 2016 spawners.

Late-fall-run Chinook Salmon spawn from December through April in the nearby Sacramento River. The low flow and high temperatures in Cow Creek (Figure 1) during the summer months may inhibit survival of any juvenile late-fall-run produced by spawners in the creek. Late-fall-run populations are currently known to persist in waterways with flows and lower water temperatures suitable for juvenile salmon survival in the summer months (Battle, Clear, and Sacramento River). Large schools of juvenile late-fall-run commonly rear over the summer in the uppermost section of the cool Sacramento River indicating the need for a cool water refuge for survival of the late-fall-run populations. Additionally the large tributaries of the Sacramento River (Clear, Cow, Bear, Cottonwood, Battle, Antelope, Mill, Deer, Butte) can typically have large redd scouring floods that likely limit the successful and consistent success of late-fall salmon spawners in these creeks.

Spring and winter-run. No populations of either species are known to exist in Cow Creek although individuals of either run may stray into this creek. Warm water and low flows in Cow Creek would likely prove lethal to any of the over-summering fish of either run.

Fall-run. A video monitoring station located in lower Cow Creek (RM-1.3) was used to estimate the **passage of 822 fall-run** salmon in 2016. A summary of the data from the Cow Creek video station is shown in Table 4. Pictures of the station are available in Appendix F Figures F5-F8. The Cow Creek video station recorded fish passage continuously using a single overhead and three underwater cameras from September 29 to December 10, 2016. Confidence intervals (see Appendix D3) around this estimate were made at the 90% level and were 680 and 1,071 respectively.

Four kayak bio-sampling surveys on Cow Creek observed only four carcasses of which one was adipose fin clipped. Due to low sample size, the Clear Creek results were used as surrogates for the Cow Creek population characteristics. In 2016, Cow Creek fall-run spawners (see Table 4) were 72% natural origin, 93% adults (fork cut-off of 610 mm-female, 650 mm-male), and 58% females (0% unspawned) based on bio-sampling. Crews collected one head for CWT analysis. This fish was from the Feather River Hatchery (see Appendix B tables).

Flooding at the video stations caused major problems beginning in mid-October and continuing well into 2017. The use of DIDSON and ARIS cameras provided data during minor flooding events but the record setting rainfall experienced in the USRB ultimately resulted in significant damage and loss of equipment. A DIDSON was used at the Cow

Creek station for over 210 hours from October 14 to December 10. The Cow Creek station was destroyed during flooding after December 10 with the loss of the overhead and underwater cameras, lights, white plates, and associated cables, see photos Appendix F Figures F6-F8. The DIDSON camera was ripped free of its secure mounting system and only its safety cable prevented the loss of the DIDSON camera.

Table 4. Daily information on salmon passage, flow (CDEC-COW) and average water temperature for the 2016 Cow Creek video station.

2016 Cow Creek Video Station Chinook Salmon Passage Data											
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
29-Sep	0	18	72.6	28-Oct	61	1,225	58.2	26-Nov	5	1,034	47.2
30-Sep	0	21	70.6	29-Oct	64	692	59.1	27-Nov	6	2,715	48.1
1-Oct	0	23	67.9	30-Oct	52	1,431	58.5	28-Nov	6	1,326	49.3
2-Oct	0	25	64.8	31-Oct	29	1,793	56.4	29-Nov	4	912	47.5
3-Oct	1	31	61.0	1-Nov	11	1,715	55.9	30-Nov	0	635	46.9
4-Oct	2	34	61.6	2-Nov	1	807	54.2	1-Dec	0	509	46.2
5-Oct	1	33	62.2	3-Nov	10	418	53.1	2-Dec	-1	416	45.3
6-Oct	0	31	62.6	4-Nov	17	282	53.6	3-Dec	2	360	44.9
7-Oct	-2	28	63.5	5-Nov	19	219	53.7	4-Dec	3	324	45.2
8-Oct	0	29	65.0	6-Nov	6	191	55.2	5-Dec	0	298	44.8
9-Oct	2	30	65.5	7-Nov	6	184	56.8	6-Dec	-5	277	43.0
10-Oct	0	29	66.2	8-Nov	6	158	57.4	7-Dec	0	262	41.0
11-Oct	0	28	65.1	9-Nov	11	143	57.3	8-Dec	3	827	41.1
12-Oct	1	30	64.4	10-Nov	18	134	57.0	9-Dec	4	1,967	43.4
13-Oct	11	35	63.4	11-Nov	25	124	56.4	10-Dec	0	12,478	48.0
14-Oct	47	97	61.7	12-Nov	20	125	57.7		Salmon		
15-Oct	46	164	60.3	13-Nov	22	128	57.8	**TOTAL**	**822**	Flow-COW	
16-Oct	10	105	59.6	14-Nov	18	117	57.0				
17-Oct	12	100	60.0	15-Nov	15	114	56.7	90% lower confidence limit			**680**
18-Oct	17	140	60.4	16-Nov	14	134	53.8	90% upper confidence limit			**1,071**
19-Oct	18	108	58.9	17-Nov	7	123	50.5	Natural Origin		**595**	**72.4%**
20-Oct	8	78	59.0	18-Nov	6	120	49.0	Hatchery Origin		**226**	**27.6%**
21-Oct	4	66	59.5	19-Nov	1	903	49.3	Number Adults		**765**	**93.1%**
22-Oct	5	65	60.2	20-Nov	1	5,180	51.2	Number Grilse		**56**	**6.9%**
23-Oct	10	63	59.5	21-Nov	1	1,690	53.4	Females	adults	**464**	**56.5%**
24-Oct	14	68	57.9	22-Nov	2	777	51.0		jills	**11**	**1.4%**
25-Oct	28	429	57.3	23-Nov	7	1,594	50.6	Males	adults	**301**	**36.7%**
26-Oct	36	506	58.5	24-Nov	8	752	48.8		jacks	**45**	**5.5%**
27-Oct	49	679	59.2	25-Nov	9	540	48.1	Note: Temps and Flows are daily averages			

The RBFO planning in September was to use the new resistance board weirs on Cow and Cottonwood Creeks to operate the video stations throughout the fall, winter, and spring period in conjunction with the existing in-creek Clear and Bear Creek resistance board stations and the fish ladder stations to the south at Antelope, Mill and Deer Creeks. Battle Creek, with the CNFH trapping fish upstream, was not planned to operate past the fall-run. Ultimately, the record setting rainfall and subsequent flooding ruined the plans for Cow and Cottonwood stations (both destroyed) and caused major lapses in monitoring for the remaining stations. It should be noted that the actual resistance board weirs themselves survived the floods but water depths throughout the December-March period prevented their operations. Appendix F contains photos of the various stations and shows examples of the dramatic flooding at the stations.

Bear Creek

Late-fall-run. From Dec 16, 2015 to February 19, 2016, the Bear Creek station reported **31 late-fall-run** salmon passing upstream. Due to low numbers of salmon, confidence intervals were calculated using the entire season (fall-2015, late-fall-2016, and spring-2016) counts were combined to allow the model to run. Confidence intervals for the entire season were 8-lower and 73-higher with the overall count being 35 (2-fall, 31-late-fall, and 2 spring-run). Table 5A provides counts by date of the partial 2015 fall-run counts of two in green from November 25, to December 15, 2015, late-fall-run (blue) counts of 31 from December 16, 2015 to February 19, 2016, and spring-run (red) counts of two from February 20 to June 06, 2016.

Spring-run. **Two** salmon were counted after February 19, 2016 (Table 5A) and were tallied as spring run. The station operated until June 06, 2016. It is likely that Bear Creek (see Figure 1) will support consistently only fall-run and steelhead spawners, with other runs testing the watershed for suitability by straying into it. Spring-run, winter-run and late-fall-run (various life stages) typically require cooler summer water temperatures, not available in Bear Creek, for successful reproduction and rearing.

Fall-run. The Bear Creek video station again became operational on September 30, 2016 as water levels began to increase enough to allow salmon passage. Photos of the station on Bear Creek are shown in Appendix F Figures F9 and F10. The station counts resulted in an estimated population of **32 fall-run** Chinook in 2016 through December 14, 2016. Results after this date will be reported as late-fall-run fish for 2017 reporting. Three bio-sampling surveys downstream of the video station did not count any carcasses, redds, or live fish. Bear Creek is a smaller tributary compared to the nearby Cow and Cottonwood Creeks. As a result, the video station was better suited to survive large floods without significant damage, and it continued operation until spring of 2017. DIDSON use from October 30 through December 14 was 87 hours, indicating significant turbidity during this period. Table 5 B. Provides daily passage for fall-run salmon at the Bear Creek video station from September 30 through December 14, 2016.

Steelhead. The Bear Creek station first became operational on November 25, 2015. Steelhead counts from then through June 6, 2016 were **310** with confidence intervals of 246-lower and 418-upper. Bear Creek appears to be a significant steelhead stream in contrast to the low numbers of Chinook observed there in recent times. In addition to the 310 adults, many steelhead smolts (1-2 year olds) were observed leaving the creek as water temperatures were warming in the spring months. Table 5C provides a summary of adult steelhead passage from November 25, 2015 through June 06, 2016. Steelhead results from the period from September 30 through December 14, 2016 will be presented in the 2017 annual reporting, as these fish will be counted with other steelhead passage as part of the 2016-2017 season.

Table 5A. Daily information on salmon passage, and average water temperature from November 25, 2015 to June 06, 2016 at the Bear Creek video station.

2015-2016 Bear Creek Creek Video Station Salmon Passage								
Date	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**
25-Nov	0	45.2	30-Jan	1	47.9	5-Apr	0	57.9
26-Nov	0	42.9	31-Jan	0	45.8	6-Apr	0	58.7
27-Nov	0	40.8	1-Feb	0	43.9	7-Apr	0	60.7
28-Nov	0	39.0	2-Feb	0	43.9	8-Apr	0	61.8
29-Nov	0	36.9	3-Feb	-1	43.4	9-Apr	0	61.0
30-Nov	0	36.1	4-Feb	0	45.3	10-Apr	0	59.6
1-Dec	0	36.7	5-Feb	0	45.1	11-Apr	0	60.0
2-Dec	0	39.9	6-Feb	0	46.0	12-Apr	0	60.3
3-Dec	0	42.8	7-Feb	0	47.4	13-Apr	0	59.3
4-Dec	0	45.1	8-Feb	0	48.8	14-Apr	0	56.8
5-Dec	0	44.9	9-Feb	0	48.8	15-Apr	0	55.6
6-Dec	0	45.2	10-Feb	0	49.0	16-Apr	0	57.0
7-Dec	0	46.8	11-Feb	0	50.2	17-Apr	0	59.5
8-Dec	0	48.9	12-Feb	-1	50.3	18-Apr	0	62.0
9-Dec	0	50.8	13-Feb	0	50.4	19-Apr	0	63.8
10-Dec	0	52.2	14-Feb	0	50.9	20-Apr	0	64.7
11-Dec	1	49.5	15-Feb	0	51.8	21-Apr	0	63.0
12-Dec	1	46.7	16-Feb	0	51.9	22-Apr	0	60.2
13-Dec	-1	47.6	17-Feb	0	52.3	23-Apr	0	57.7
14-Dec	0	44.5	18-Feb	0	50.6	24-Apr	0	59.1
15-Dec	0	41.9	19-Feb	0	49.1	25-Apr	0	58.1
16-Dec	0	40.8	20-Feb	0	48.3	26-Apr	0	56.1
17-Dec	0	42.2	21-Feb	0	47.7	27-Apr	0	56.5
18-Dec	0	43.6	22-Feb	0	48.5	28-Apr	0	58.7
19-Dec	0	45.1	23-Feb	0	47.6	29-Apr	0	60.9
20-Dec	0	44.2	24-Feb	0	48.8	30-Apr	0	61.4
21-Dec	0	45.7	25-Feb	0	50.0	1-May	0	63.5
22-Dec	5	48.5	26-Feb	0	51.0	2-May	0	64.9
23-Dec	0	46.1	27-Feb	0	52.0	3-May	0	64.5
24-Dec	-1	44.7	28-Feb	-1	51.1	4-May	0	63.7
25-Dec	1	43.1	29-Feb	0	51.3	5-May	0	64.7
26-Dec	0	40.4	1-Mar	0	51.1	6-May	0	62.4
27-Dec	0	39.2	2-Mar	0	51.7	7-May	0	60.4
28-Dec	0	40.9	3-Mar	0	54.4	8-May	0	61.1
29-Dec	0	39.5	4-Mar	0	54.4	9-May	0	65.0
30-Dec	0	39.7	5-Mar	0	55.3	10-May	-1	67.1
31-Dec	0	38.3	6-Mar	0	52.4	11-May	0	67.4
1-Jan	0	36.4	7-Mar	0	49.3	12-May	0	68.2
2-Jan	0	36.4	8-Mar	0	47.4	13-May	0	70.3
3-Jan	0	38.6	9-Mar	0	48.7	14-May	0	69.9
4-Jan	0	40.4	10-Mar	1	50.8	15-May	0	69.4
5-Jan	2	44.3	11-Mar	0	50.9	16-May	0	69.9
6-Jan	2	45.6	12-Mar	0	49.3	17-May	0	70.7
7-Jan	-1	45.5	13-Mar	0	49.5	18-May	0	72.4
8-Jan	0	44.3	14-Mar	1	49.3	19-May	0	72.4
9-Jan	1	44.5	15-Mar	0	48.9	20-May	0	66.3
10-Jan	0	45.1	16-Mar	0	50.2	21-May	0	61.4
11-Jan	0	44.5	17-Mar	0	52.1	22-May	0	61.1
12-Jan	1	45.8	18-Mar	0	53.2	23-May	0	63.4
13-Jan	2	47.6	19-Mar	0	54.8	24-May	0	66.3
14-Jan	3	44.8	20-Mar	0	55.1	25-May	0	68.0
15-Jan	3	45.3	21-Mar	1	52.6	26-May	0	69.4
16-Jan	3	47.0	22-Mar	1	50.1	27-May	0	69.6
17-Jan	3	49.5	23-Mar	0	50.1	28-May	0	70.3
18-Jan	3	49.8	24-Mar	0	52.1	29-May	0	71.7
19-Jan	3	50.4	25-Mar	0	52.9	30-May	0	73.8
20-Jan	3	50.2	26-Mar	0	52.4	31-May	0	75.8
21-Jan	-7	49.8	27-Mar	0	52.8	1-Jun	0	77.0
22-Jan	3	51.1	28-Mar	0	52.1	2-Jun	0	77.9
23-Jan	2	50.5	29-Mar	0	49.8	3-Jun	0	78.4
24-Jan	2	48.1	30-Mar	0	51.6	4-Jun	0	78.2
25-Jan	-1	48.7	31-Mar	0	53.6	5-Jun	0	79.7
26-Jan	0	46.7	1-Apr	0	55.8	6-Jun	0	82.3
27-Jan	0	47.0	2-Apr	0	57.7		Salmon	
28-Jan	0	47.3	3-Apr	0	59.2	**TOTALS**	**35**	
29-Jan	2	49.3	4-Apr	0	59.3			
2015 partial fall-run	**2**		2015-16 late-fall-run	**31**		2016-spring-run	**2**	

Table 5B. Daily information on fall-run salmon passage, and average water temperature from September 30 to December 14, 2016 at the Bear Creek video station.

2016 Bear Creek Video Station Fall Salmon Passage Data								
Date	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**
30-Sep	0	67.8	26-Oct	2	57.9	21-Nov	1	52.7
1-Oct	0	64.5	27-Oct	2	58.4	22-Nov	-1	50.1
2-Oct	0	61.3	28-Oct	2	57.6	23-Nov	4	50.2
3-Oct	0	58.0	29-Oct	2	58.7	24-Nov	-1	47.7
4-Oct	0	59.2	30-Oct	1	58.3	25-Nov	0	47.1
5-Oct	0	59.2	31-Oct	0	56.3	26-Nov	2	47.0
6-Oct	0	59.5	1-Nov	3	55.3	27-Nov	2	47.3
7-Oct	0	59.4	2-Nov	1	53.6	28-Nov	1	48.2
8-Oct	0	60.9	3-Nov	-2	52.2	29-Nov	1	46.2
9-Oct	0	61.5	4-Nov	0	52.5	30-Nov	0	45.6
10-Oct	0	62.3	5-Nov	0	52.6	1-Dec	1	44.9
11-Oct	0	61.5	6-Nov	0	54.3	2-Dec	-1	43.2
12-Oct	0	60.9	7-Nov	0	55.9	3-Dec	0	42.8
13-Oct	0	60.7	8-Nov	0	56.0	4-Dec	-1	43.3
14-Oct	0	60.9	9-Nov	0	55.6	5-Dec	0	43.2
15-Oct	3	59.6	10-Nov	0	55.1	6-Dec	-1	41.2
16-Oct	0	58.9	11-Nov	0	54.9	7-Dec	0	39.5
17-Oct	0	58.8	12-Nov	0	56.6	8-Dec	1	40.8
18-Oct	0	58.9	13-Nov	-2	56.2	9-Dec	0	43.6
19-Oct	0	57.3	14-Nov	0	55.2	10-Dec	1	48.8
20-Oct	0	56.9	15-Nov	0	55.0	11-Dec	1	46.4
21-Oct	1	57.0	16-Nov	0	52.0	12-Dec	1	46.2
22-Oct	1	57.4	17-Nov	0	48.7	13-Dec	1	45.1
23-Oct	2	56.8	18-Nov	0	46.9	14-Dec	2	46.8
24-Oct	2	56.2	19-Nov	0	48.2	**TOTAL**	**32**	
25-Oct	2	56.5	20-Nov	0	51.8			

Table 5C. Daily information on steelhead passage, and average water temperature from November 25, 2015 to June 06, 2016 at the Bear Creek video station.

2015-2016 Bear Creek Creek Video Station Steelhead Passage								
Date	**Steelhead**	**Water °F**	**Date**	**Steelhead**	**Water °F**	**Date**	**Steelhead**	**Water °F**
25-Nov	0	45.2	30-Jan	4	47.9	5-Apr	0	57.9
26-Nov	0	42.9	31-Jan	2	45.8	6-Apr	0	58.7
27-Nov	0	40.8	1-Feb	0	43.9	7-Apr	0	60.7
28-Nov	0	39.0	2-Feb	0	43.9	8-Apr	-1	61.8
29-Nov	0	36.9	3-Feb	-1	43.4	9-Apr	0	61.0
30-Nov	0	36.1	4-Feb	0	45.3	10-Apr	0	59.6
1-Dec	0	36.7	5-Feb	0	45.1	11-Apr	-1	60.0
2-Dec	0	39.9	6-Feb	0	46.0	12-Apr	0	60.3
3-Dec	0	42.8	7-Feb	0	47.4	13-Apr	0	59.3
4-Dec	2	45.1	8-Feb	0	48.8	14-Apr	0	56.8
5-Dec	1	44.9	9-Feb	-1	48.8	15-Apr	-1	55.6
6-Dec	5	45.2	10-Feb	0	49.0	16-Apr	0	57.0
7-Dec	24	46.8	11-Feb	1	50.2	17-Apr	0	59.5
8-Dec	4	48.9	12-Feb	0	50.3	18-Apr	0	62.0
9-Dec	15	50.8	13-Feb	0	50.4	19-Apr	0	63.8
10-Dec	15	52.2	14-Feb	0	50.9	20-Apr	-1	64.7
11-Dec	10	49.5	15-Feb	-1	51.8	21-Apr	-2	63.0
12-Dec	-1	46.7	16-Feb	-2	51.9	22-Apr	0	60.2
13-Dec	1	47.6	17-Feb	-5	52.3	23-Apr	0	57.7
14-Dec	0	44.5	18-Feb	47	50.6	24-Apr	0	59.1
15-Dec	0	41.9	19-Feb	4	49.1	25-Apr	0	58.1
16-Dec	0	40.8	20-Feb	1	48.3	26-Apr	0	56.1
17-Dec	0	42.2	21-Feb	1	47.7	27-Apr	0	56.5
18-Dec	0	43.6	22-Feb	0	48.5	28-Apr	0	58.7
19-Dec	0	45.1	23-Feb	0	47.6	29-Apr	-1	60.9
20-Dec	0	44.2	24-Feb	-1	48.8	30-Apr	0	61.4
21-Dec	0	45.7	25-Feb	0	50.0	1-May	-1	63.5
22-Dec	12	48.5	26-Feb	0	51.0	2-May	0	64.9
23-Dec	0	46.1	27-Feb	0	52.0	3-May	0	64.5
24-Dec	0	44.7	28-Feb	-1	51.1	4-May	-1	63.7
25-Dec	0	43.1	29-Feb	0	51.3	5-May	0	64.7
26-Dec	0	40.4	1-Mar	0	51.1	6-May	0	62.4
27-Dec	-1	39.2	2-Mar	0	51.7	7-May	0	60.4
28-Dec	-1	40.9	3-Mar	0	54.4	8-May	0	61.1
29-Dec	0	39.5	4-Mar	0	54.4	9-May	0	65.0
30-Dec	-2	39.7	5-Mar	1	55.3	10-May	0	67.1
31-Dec	0	38.3	6-Mar	0	52.4	11-May	0	67.4
1-Jan	0	36.4	7-Mar	0	49.3	12-May	0	68.2
2-Jan	0	36.4	8-Mar	0	47.4	13-May	-1	70.3
3-Jan	-2	38.6	9-Mar	0	48.7	14-May	-1	69.9
4-Jan	-1	40.4	10-Mar	0	50.8	15-May	0	69.4
5-Jan	1	44.3	11-Mar	0	50.9	16-May	-1	69.9
6-Jan	2	45.6	12-Mar	0	49.3	17-May	0	70.7
7-Jan	0	45.5	13-Mar	0	49.5	18-May	0	72.4
8-Jan	0	44.3	14-Mar	0	49.3	19-May	0	72.4
9-Jan	0	44.5	15-Mar	0	48.9	20-May	0	66.3
10-Jan	0	45.1	16-Mar	1	50.2	21-May	0	61.4
11-Jan	0	44.5	17-Mar	1	52.1	22-May	0	61.1
12-Jan	0	45.8	18-Mar	1	53.2	23-May	0	63.4
13-Jan	28	47.6	19-Mar	2	54.8	24-May	0	66.3
14-Jan	18	44.8	20-Mar	1	55.1	25-May	0	68.0
15-Jan	16	45.3	21-Mar	0	52.6	26-May	0	69.4
16-Jan	22	47.0	22-Mar	0	50.1	27-May	0	69.6
17-Jan	33	49.5	23-Mar	-1	50.1	28-May	0	70.3
18-Jan	28	49.8	24-Mar	0	52.1	29-May	0	71.7
19-Jan	14	50.4	25-Mar	0	52.9	30-May	0	73.8
20-Jan	6	50.2	26-Mar	-1	52.4	31-May	0	75.8
21-Jan	0	49.8	27-Mar	0	52.8	1-Jun	-2	77.0
22-Jan	8	51.1	28-Mar	1	52.1	2-Jun	-1	77.9
23-Jan	7	50.5	29-Mar	0	49.8	3-Jun	0	78.4
24-Jan	4	48.1	30-Mar	1	51.6	4-Jun	0	78.2
25-Jan	0	48.7	31-Mar	1	53.6	5-Jun	0	79.7
26-Jan	0	46.7	1-Apr	-1	55.8	6-Jun	0	82.3
27-Jan	0	47.0	2-Apr	0	57.7		Steelhead	
28-Jan	-2	47.3	3-Apr	-1	59.2	**TOTALS**	**310**	
29-Jan	3	49.3	4-Apr	0	59.3			

Cottonwood Creek

Late-fall-run. In late 2015, flooding concerns resulted in station removal for the remainder of the season on December 11. Flows reached over 1,000 cfs and the forecast was for bigger storms later in the week. Therefore, no late-fall-run estimate for 2016 Cottonwood spawners is available.

The juvenile late-fall-run salmon that may be produced from the adult spawners likely find lower Cottonwood Creek conditions inhospitable for survival similar to Cow Creek and must migrate downstream soon after emergence in the spring to the cooler Sacramento River. The lower sections of Cottonwood Creek (Figure 1) and other similar USRB streams can heat up quickly in the spring months, attracting predatory warm water tolerant species including: Sacramento Pikeminnow, Hardhead, Largemouth Bass and Smallmouth Bass (*Micropterus salmoides*, *M. dolomieu*) and recently Striped Bass (*Morone saxatilis*). These species may contribute to the lack of an adult late-fall-run salmon population in Cottonwood Creek by predating on the out-migrating juveniles that would return to the creek in future years.

Winter-run. No winter-run populations are known to exist in Cottonwood Creek due to high water temperatures unsuitable for adult salmon survival in the summer months.

Spring-run. Similar to the late-fall-run monitoring, spring-run migration monitoring in Cottonwood Creek was not possible since the station was removed in late 2015

No spring-run were observed in Beegum Creek a tributary to the Middle Fork of Cottonwood Creek in 2016. In the summer of 2008, a large wildfire burned much of the Beegum watershed resulting in severe loss of soil stabilizing vegetation. In June of 2009, an intense and prolonged rain from a large thunderstorm system produced massive mudflows in the watershed. This mud filled the entire reach of Beegum Creek that salmon are known to over-summer in and probably killed any adult salmon and trout that were present in 2009. In 2016, the creek was continuing to flush out much of the smaller sediments from this event.

Three spring-run salmon were observed in the North Fork of Cottonwood Creek at the uppermost limit to anadromy in the North Fork at a large waterfall downstream of Rainbow Lake. Temperature monitoring below the falls indicates that creek temperatures can reach near lethal limits so large self-sustaining populations of spring-run in this creek are probably limited annually by extreme heat spells during summer months.

Fall-run. The Cottonwood Creek video station fall-run salmon count was **813** in 2016. Daily station information on salmon passage, flow and temperature is provided in Table 6. The station is located close to the mouth of the creek at RM-1.2. Photos of the station with the new resistance board weir are available in Appendix F Figures F11-F14. Confidence limits around this estimate were at the 90% level and were 720-lower and 954-upper. The station recorded fish passage continuously from September 12 to December 10, 2016 when continuous flooding caused severe damage to the station and prevented repairs from occurring. Four bio-sampling kayak surveys observed only 10 carcasses. Two of these were adipose fin clips, and two CWT's were recovered from the heads. Both of these were CNFH fish from the San Pablo net pen releases. This data is shown in Appendix B Table B1, along with other hatchery information in Appendix B Tables B2-B5. Due to low carcass numbers, the population characteristics of the Cottonwood Creek fall-run is assumed similar to Clear Creek, and are reported as being 72% natural origin, 93% adults (fork cut-off of 610 mm-female, 650 mm-male), and 58% females (0% unspawned).

<u>Steelhead</u>. During the fall of 2016, the video station obtained a partial count of **42 steelhead** before flooding resulted in the shutdown of the station. Even before the major flood in December, there were several minor floods in October and November that required the DIDSON camera and time intensive weir cleaning and maintenance at the station. The DIDSON was used for 229 hours from October 28 through December 10, 2016. In other cases no video or DIDSON was available due to debris or equipment failures. There were 134 hours of missing counts that were accounted for by the statistical model (GAM) that imputes counts from missing data periods (Appendix D3).

Table 6. Daily information on salmonid passage, flow (CDEC-CWA) and average water temperature for the 2016 Cottonwood Creek video station.

2016 Cottonwood Creek Video Station Chinook Salmon Passage Data														
Date	Salmon	Steelhead	Flow	Water °F	Date	Salmon	Steelhead	Flow	Water °F	Date	Salmon	Steelhead	Flow	Water °F
12-Sep	0	0	55	73.8	17-Oct	23	0	110	62.6	21-Nov	0	0	1,401	53.4
13-Sep	0	0	55	71.6	18-Oct	13	0	110	62.6	22-Nov	0	0	898	51.6
14-Sep	0	0	57	70.8	19-Oct	17	0	119	62.0	23-Nov	0	0	774	51.5
15-Sep	0	0	63	70.4	20-Oct	23	12	108	62.2	24-Nov	0	0	693	49.4
16-Sep	0	0	71	71.4	21-Oct	7	1	93	63.0	25-Nov	0	0	598	49.3
17-Sep	0	0	60	71.8	22-Oct	8	0	85	63.4	26-Nov	4	0	724	48.6
18-Sep	0	0	57	72.7	23-Oct	8	0	79	62.7	27-Nov	0	0	1,214	48.5
19-Sep	0	0	57	73.7	24-Oct	49	0	78	61.2	28-Nov	0	0	934	49.8
20-Sep	0	0	59	73.3	25-Oct	59	0	103	60.8	29-Nov	1	0	895	48.5
21-Sep	0	0	60	71.2	26-Oct	39	0	221	62.1	30-Nov	1	0	687	47.9
22-Sep	0	0	58	68.6	27-Oct	19	6	262	62.1	1-Dec	2	0	595	47.6
23-Sep	0	0	67	67.4	28-Oct	11	2	458	60.9	2-Dec	4	0	525	46.7
24-Sep	0	0	61	68.8	29-Oct	3	0	486	61.1	3-Dec	2	0	473	46.7
25-Sep	0	0	63	70.3	30-Oct	0	0	502	60.6	4-Dec	4	0	435	46.8
26-Sep	0	0	61	70.7	31-Oct	0	0	1,053	57.3	5-Dec	5	0	413	46.4
27-Sep	0	0	51	70.9	1-Nov	0	0	1,103	56.2	6-Dec	5	0	392	45.2
28-Sep	0	0	56	71.2	2-Nov	0	0	873	55.2	7-Dec	0	0	345	43.7
29-Sep	0	0	57	70.4	3-Nov	3	0	619	55.0	8-Dec	0	0	375	43.0
30-Sep	1	0	66	68.9	4-Nov	5	0	478	55.8	9-Dec	2	0	440	44.2
1-Oct	0	0	57	66.8	5-Nov	3	0	393	56.1	10-Dec	0	0	3,543	47.4
2-Oct	1	0	59	64.4	6-Nov	4	0	341	58.2					
3-Oct	4	0	67	61.7	7-Nov	8	0	326	59.4		Salmon	Steelhead		
4-Oct	5	0	71	63.0	8-Nov	16	0	298	59.6	TOTAL	813	42	Flow-CWA	
5-Oct	10	0	80	63.6	9-Nov	3	0	272	59.6					
6-Oct	3	0	84	63.8	10-Nov	17	0	251	59.2	Salmon 90% lower confidence limit				**720**
7-Oct	0	0	74	64.3	11-Nov	11	0	241	58.7	Salmon 90% upper confidence limit				**954**
8-Oct	5	0	71	65.7	12-Nov	11	0	255	59.4	Natural Origin			**589**	**72.4%**
9-Oct	3	0	66	66.4	13-Nov	14	0	258	59.2	Hatchery Origin			**224**	**27.6%**
10-Oct	2	0	63	66.5	14-Nov	15	0	259	58.8	Number Adults			**757**	**93.1%**
11-Oct	3	0	69	65.0	15-Nov	14	0	248	58.8	Number Grilse			**56**	**6.9%**
12-Oct	73	0	70	64.5	16-Nov	8	0	236	55.9	Females	adults		**459**	**56.5%**
13-Oct	21	0	62	64.8	17-Nov	19	10	202	53.3		jills		**11**	**1.4%**
14-Oct	129	0	78	64.0	18-Nov	5	12	194	52.0	Males	adults		**298**	**36.7%**
15-Oct	53	0	91	62.8	19-Nov	9	0	268	52.4		jacks		**45**	**5.5%**
16-Oct	19	0	104	62.3	20-Nov	0	0	1,413	52.5	Note: Temps and Flows are daily averages				

Battle Creek

Late-fall-run. No in-river surveys were planned or made for late-fall-run in Battle Creek in 2015-2016. Weather conditions during late-fall-run spawning make consistent surveying on an annual basis difficult to conduct in Battle Creek and other USRB tributaries. With the CNFH ladder and trapping facility, a short distance upstream the RBFO has decided that late-fall-run monitoring in Battle Creek is more efficiently conducted at the CNFH.

The CNFH staff excessed and spawned late-fall salmon from November 10, 2015 through March 09, 2016 (note: spawning operations commenced December 23). Additionally, the USFWS Tributary Monitoring Program also handled late-fall after CNFH staff completed operations. Combined both groups resulted in a hatchery count of **2,405 late-fall fish** spawned, trapped, released upstream, and excessed. This does not include the 64 removed at Keswick Trap and transferred (accounted as Sacramento River fish) to the CNFH. Of the 2,405, a number of natural origin (adipose fin present) late-fall-run salmon (N=57) were allowed to pass upstream of the barrier weir at the CNFH (see Table 1). The CNFH allows natural origin salmon to pass upstream, as these fish may be natural origin late-fall, spring, or winter-run salmon.

Final accounting of Battle Creek late-fall-run salmon can be time consuming and revisions are common, as there are numerous sources of data to compile from different programs with individual timelines and program reporting efforts. It is difficult for CNFH staff to accurately identify fall-run and late-fall-run fish that are present in late-November and December. The late-fall-run are 100% marked with an adipose fin clip and CWT that enables identification and accurate accounting but processing the CWT information from the two large runs at the CNFH requires a large amount of staff time. The best source (other than the USFWS Red Bluff office) of late-fall-run final accounting is the GrandTab file (Appendix E Figure E1) after a year or more has passed giving different programs an opportunity to conduct quality control on databases and assign run identifications to each salmon observed.

Winter-run. **One** winter-run salmon was observed in Battle Creek in 2016. Appendix C Table C1 documents the winter-run numbers in previous years. The Battle Creek Restoration Program is a large-scale restoration project ongoing in the upper watershed to provide increased habitat for winter-run and other fish species. One goal of this project is to eventually establish a second population of naturally spawning winter-run in Battle Creek (the only remaining population being in the Sacramento River). In 2016, the Battle Creek Winter-run Introduction Plan was completed and funds are being sought to implement it and enable the future reintroduction of winter-run into Battle Creek The Restoration Program is not yet complete and at this time only the occasional stray winter-run are observed in Battle Creek. Details of this restoration effort are available on the Bureau of Reclamation's website: http://www.usbr.gov/mp/battlecreek/

Spring-run. The USFWS monitored spring-run passage in Battle Creek using the CNFH fish ladder and pre and post-spawn snorkel, carcass, and redd surveys. If water temperatures were below 60°F (16°C) salmon could be trapped for adipose fin clip observations and for genetic sample collection. Trapped salmon with an adipose fin clip representing hatchery origin were taken into the hatchery. Salmon with no clip were allowed to pass upstream. When water temperatures were at or above 60°F a video monitoring system was installed in the ladder and salmon were counted as they passed. In 2016 a reported **180 spring-run** salmon were observed passing upstream of the CNFH into upper Battle Creek during monitoring at the CNFH fish ladder (R.J. Bottaro USFWS pers. comm.). Further information on this monitoring can be found online at www.fws.gov/redbluff/

Fall-run. The Battle Creek video monitoring station counts incoming salmon and steelhead including both the hatchery and in-creek totals and is located downstream of the in-creek spawning grounds. A resistance board weir replaced the former horizontal board weir in 2016. The station reported an escapement of 9,762 total salmon of which 210 were later determined to be 2017 late-fall-run, leaving **9,552 fall-run as the total escapement estimate**. The station was operated from August 22 through December 02, 2016. Daily station information on salmon passage, flow and average water temperature is given in Table 7. The station was located 1.7 miles upstream from the confluence with the Sacramento River. See Appendix F Figures F7 and F8 for photos of the station and typical visitors in 2016.

Confidence limits around the 9,762 estimate were made at the 90% level and were 8,919-lower and 10,642-upper. The Battle Creek station estimate represents the total number migrating into the creek, and includes both the in-creek spawners and those moving into the CNFH. The **CNFH reported that 8,531 fall-run salmon** (Table 1) entered into the hatchery along with 210 late-fall-run that came in early and were counted with the fall run at the video station. The remaining **1,021 are counted as the in-creek** fall-run spawning population estimate for Battle Creek downstream of the hatchery. Note that if revisions to the CNFH number are made it will subsequently reduce or augment the in-stream number, as they are interdependent.

All salmon entering into Battle Creek were determined to be hatchery origin fish based on the proportions observed at the CNFH. The CNFH portion of the fish counted at the video station are used to determine the biological properties of the entire Battle Creek population including the 9,300 (97.4%) number of adults and the other categories listed in Table 7. The station recorded fish passage continuously using an overhead camera to December 02, 2016 after which it was not operated because the fall-run was determined to be over and late-fall-run fish were beginning to dominate the counts. Flooding and turbidity were also an issue at Battle Creek and a DIDSON was used for 54 hours during the season.

The Battle Creek station was the first RBFO video station developed. It began in 2003 as an effort to reduce the staffing necessary to monitor in-stream Battle Creek spawners with a mark-recapture survey that could take up to 10 staff members and four days each week for over two months to complete. This left little time for other tributary and Sacramento River monitoring the RBFO now routinely conducts. The station replaced the mark-recapture survey in 2006 and quickly became a critical real-time management tool for CNFH operations and a system for the CDFW to monitor many other streams that were not monitored in the past.

<u>Steelhead.</u> The CNFH raises, spawns, collects and samples the majority of steelhead that enter into Battle Creek. Readers can obtain information on these fish by contacting the USFWS at (www.fws.gov/redbluff/). The video station only collects a partial count of these fish during the fall.

Table 7. Daily information on salmon passage, flow (CDEC-BAT) and average water temperature for the 2016 Battle Creek video station.

2016 Battle Creek Video Station Chinook Salmon Passage Data											
Date	Salmon	Flow	Water °F	Date	Salmon	Flow	Water °F	Date	Salmon	Flow	Water °F
22-Aug	0	205	70.5	1-Oct	374	193	59.4	10-Nov	4	289	54.8
23-Aug	0	198	69.9	2-Oct	511	201	57.0	11-Nov	20	279	54.5
24-Aug	0	198	69.5	3-Oct	376	211	54.4	12-Nov	8	273	55.8
25-Aug	0	196	69.0	4-Oct	511	207	55.8	13-Nov	27	275	55.4
26-Aug	0	193	68.6	5-Oct	637	205	56.6	14-Nov	33	263	54.6
27-Aug	0	197	67.8	6-Oct	377	202	56.5	15-Nov	28	265	54.5
28-Aug	6	198	67.5	7-Oct	235	203	56.8	16-Nov	27	275	52.4
29-Aug	1	197	66.5	8-Oct	216	201	58.3	17-Nov	9	266	49.5
30-Aug	1	197	66.2	9-Oct	200	198	58.9	18-Nov	15	263	48.6
31-Aug	0	196	66.6	10-Oct	174	202	59.4	19-Nov	24	453	50.1
1-Sep	0	198	66.1	11-Oct	72	202	58.5	20-Nov	58	1057	51.9
2-Sep	0	203	65.7	12-Oct	150	203	57.9	21-Nov	6	540	52.5
3-Sep	2	204	65.0	13-Oct	57	204	57.6	22-Nov	4	379	50.2
4-Sep	3	204	65.2	14-Oct	1,364	270	58.5	23-Nov	5	399	50.5
5-Sep	4	203	63.8	15-Oct	229	288	57.5	24-Nov	4	359	48.3
6-Sep	5	203	63.4	16-Oct	70	270	56.8	25-Nov	11	328	48.2
7-Sep	5	202	64.8	17-Oct	112	310	56.4	26-Nov	11	428	48.1
8-Sep	8	201	65.7	18-Oct	18	278	56.5	27-Nov	15	436	48.2
9-Sep	9	200	66.3	19-Oct	35	259	55.2	28-Nov	5	421	49.1
10-Sep	9	200	66.4	20-Oct	30	244	55.2	29-Nov	1	392	47.5
11-Sep	14	201	66.4	21-Oct	45	238	56.1	30-Nov	6	347	47.4
12-Sep	14	201	65.9	22-Oct	24	237	56.5	1-Dec	8	330	47.0
13-Sep	48	199	64.0	23-Oct	42	236	56.1	2-Dec	-1	320	45.4
14-Sep	84	200	62.6	24-Oct	23	239	55.4				
15-Sep	100	200	62.5	25-Oct	194	517	55.8		Salmon	Flow-BAT	
16-Sep	61	203	62.8	26-Oct	53	440	56.1	**TOTAL**	**9,762**	Note includes CNFH fall-run and early LFR	
17-Sep	145	203	63.1	27-Oct	42	323	56.4				
18-Sep	57	200	63.9	28-Oct	46	386	56.5	90% lower confidence limit			**8,919**
19-Sep	129	201	65.6	29-Oct	25	452	57.6	90% upper confidence limit			**10,642**
20-Sep	108	199	65.7	30-Oct	34	448	56.3	Number going into the CNFH FR			**8,531**
21-Sep	153	199	63.6	31-Oct	6	444	54.7	Number In-Creek minus (210) LFR			**1,021**
22-Sep	272	191	60.9	1-Nov	8	1045	54.4	Natural Origin FR		**n/a**	**0.0%**
23-Sep	282	200	59.2	2-Nov	7	469	52.5	Hatchery Origin FR		**9,552**	**100.0%**
24-Sep	70	201	60.5	3-Nov	2	352	51.9	Number Adults FR		**9,300**	**97.4%**
25-Sep	340	201	61.7	4-Nov	1	322	52.6	Number Grilse FR		**252**	**2.6%**
26-Sep	459	197	62.8	5-Nov	5	309	52.7	Females	adults	**5,524**	**57.8%**
27-Sep	156	194	63.3	6-Nov	4	301	54.3		jills	**0**	**0.0%**
28-Sep	164	196	63.6	7-Nov	8	299	55.5	Males	adults	**3,775**	**39.5%**
29-Sep	191	193	63.4	8-Nov	7	296	55.3		jacks	**252**	**2.6%**
30-Sep	202	192	61.8	9-Nov	5	292	55.1	Note: Temp and Flows are daily averages			

Paynes Creek

Paynes Creek is a small tributary that flows into the Sacramento River from the east above Red Bluff (Figure 1). The Paynes Creek watershed is not of sufficient size to enable cold water holding habitat during the summer months. The lower watershed has agricultural diversions that remove most of the in-stream water during summer months. Paynes Creek is primarily a fall-run and possibly a steelhead stream. Success of either species is dependent on rainfall on a year-to–year basis.

Late-fall-run. It is possible that some late-fall-run may spawn in Paynes Creek but summer temperatures make juvenile survival unlikely unless the small salmon are able to migrate downstream to the Sacramento River immediately after emerging from the gravel. No surveys are conducted.

Spring and winter-run. High water temperatures and low flow in Paynes Creek in summer months make the survival of any pioneers from these runs unlikely. No surveys are conducted.

Fall-run. Four walking surveys from the power line crossing in the Bend Recreational Area to the mouth were made in 2016. The first of these was made on October 27 and unlike in 2015, the creek had flowing water by this date. During the surveys seven live salmon and one carcass was noted. The final estimate is **eight fall-run salmon**. Two redds were observed and the one carcass was too decayed to note if it had an adipose fin clip. Due to later flooding, no other surveys in Paynes creek were made.

Antelope Creek

Antelope Creek is an east-side tributary entering the Sacramento River downstream of Red Bluff (Figure 1) and contains runs of all salmonids but winter-run. Antelope Creek after reaching the valley floor branches into four smaller distributary channels each flowing into the Sacramento River. These are, from north to south, New Creek, Craig Creek, Butler Slough, and Antelope Creek. The largest of these, Craig Creek, enters the Sacramento at RM-238. During low flow periods, it is the dominant migration corridor for adult and juvenile salmonids. Adult Chinook Salmon and steelhead are monitored using a video station shown in Appendix F Figures F15 and F16. This station is located at Edwards Dam (RM-4.1). Snorkel surveys were completed to monitor spring-run holding in the upper watershed, and fall-run bio sampling and redd surveys were completed downstream of the video station.

Late-fall-run. Late-fall-run counting on Antelope Creek occurred from December 16, 2015 through February 19, 2016. Only **four late-fall-run** were observed at the Antelope video station in the 2015-2016 season on December 19th and 20th. Late-fall-run may spawn in Antelope Creek or its distributaries downstream of Edwards Diversion Dam. Late-fall-run surveys were not conducted in these creek sections in during the 2015-2016 season. Late-fall-run monitoring after December 14, 2016 will be reported in the 2017 RBFO Annual Report.

Spring-run. The Antelope station was operated to count spring-run from February 20 through June 28, 2016 there were **seven spring-run** salmon observed. These passed the station from February 28 to the last one on May 06. A snorkel survey to discover where these fish went upstream of the station was conducted on August 3 from the confluence to the Paynes Bridge with no salmon observed. Another survey below the Paynes Bridge to the canyon mouth conducted on September 15 reported one spring-run. No other sections were surveyed due to the low station counts.

Fall-run. After a summer break, the station was operated again from October 3 through the end of the year. Between October 3 and December 15, the station reported 107 fall-run passing upstream. An additional 31 salmon were estimated to have spawned downstream of the video station based on 13 redd counts (females) and a male expansion of 18 fish. **The total count of 138 fall-run salmon** had confidence intervals of 116-lower and 160-upper. Low carcass counts (0) during five downstream surveys resulted in the population characteristics of Clear Creek being used as a surrogate for Antelope Creek. Table 8A presents the fall-run data for Antelope Creek.

Table 8A. Fall-run salmon passage at the 2016 Antelope Creek video station, and daily average water temperature.

2016 Fall-run Salmon Passage at the Antelope Creek Video Station								
Date	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**	**Date**	**Salmon**	**Water °F**
3-Oct	0	58	1-Nov	2	56	30-Nov	0	46
4-Oct	0	58	2-Nov	2	54	1-Dec	1	45
5-Oct	0	58	3-Nov	1	53	2-Dec	0	43
6-Oct	0	59	4-Nov	1	53	3-Dec	0	43
7-Oct	0	59	5-Nov	1	53	4-Dec	0	43
8-Oct	0	60	6-Nov	0	54	5-Dec	0	43
9-Oct	0	61	7-Nov	0	56	6-Dec	0	42
10-Oct	0	61	8-Nov	0	57	7-Dec	0	40
11-Oct	0	61	9-Nov	0	56	8-Dec	0	41
12-Oct	0	60	10-Nov	1	56	9-Dec	0	45
13-Oct	0	60	11-Nov	1	55	10-Dec	0	50
14-Oct	1	60	12-Nov	0	57	11-Dec	0	47
15-Oct	5	59	13-Nov	0	57	12-Dec	0	47
16-Oct	7	59	14-Nov	0	56	13-Dec	0	45
17-Oct	2	58	15-Nov	0	55	14-Dec	0	48
18-Oct	8	59	16-Nov	0	53	15-Dec	0	51
19-Oct	0	57	17-Nov	0	49	Note: Temp is daily average		
20-Oct	1	57	18-Nov	0	48	**Video Up**	107	**138**
21-Oct	0	57	19-Nov	0	48	**plus 31 Down =**		
22-Oct	0	57	20-Nov	2	52	90% lower CI		**116**
23-Oct	0	57	21-Nov	3	52	90% upper CI		**160**
24-Oct	0	56	22-Nov	2	50	Natural	**n/a**	**n/a**
25-Oct	3	57	23-Nov	1	50	Hatchery	**n/a**	**n/a**
26-Oct	48	58	24-Nov	1	48	Adults	**130**	**93.9%**
27-Oct	5	58	25-Nov	0	47	Grilse	**8**	**6.1%**
28-Oct	3	58	26-Nov	1	47	Females	**78**	**56.5%**
29-Oct	1	59	27-Nov	0	48	Jills	**2**	**1.4%**
30-Oct	0	58	28-Nov	1	48	Males	**51**	**36.7%**
31-Oct	2	56	29-Nov	0	47	Jacks	**8**	**5.5%**

Steelhead. Steelhead passage into most tributaries is limited to the fall through spring period due to high water temperatures and low flows at the mouths of most streams in the summer and early fall. In this report, when a video station steelhead counts are only partially available from the fall to the summer period the counts will be presented adjacent to the salmon counts for the abbreviated portion of the video counts (i.e. Table 6). In cases where the entire fall-to-summer season is available, (i.e. Bear, Antelope) the steelhead will be presented as a separate table, instead of presenting them in two different annual reports. Table 8B provides steelhead counts in Antelope creek by date from October 29, 2015 to May 03, 2016. During this period 94 **steelhead** passed the video station during the fall-to-early summer migration period. The station remained operational until June 28 but no steelhead were noted after April 18. Steelhead counts beginning in October of 2016 will be provided in the 2017 annual report.

Table 8B. Daily information on steelhead passage, and average water temperature from November 25, 2015 to May 03, 2016 at the Antelope Creek video station.

2015-2016 Steelhead Passage at the Antelope Creek Video Station											
Date	**Steelhead**	**Water °F**	**Date**	**Steelhead**	**Water °F**	**Date**	**Steelhead**	**Water °F**	**Date**	**Steelhead**	**Water °F**
29-Oct	0	58	15-Dec	2	42	31-Jan	0	46	18-Mar	11	51
30-Oct	0	57	16-Dec	0	41	1-Feb	0	44	19-Mar	0	52
31-Oct	0	57	17-Dec	0	42	2-Feb	0	43	20-Mar	3	53
1-Nov	0	57	18-Dec	0	44	3-Feb	0	43	21-Mar	1	54
2-Nov	0	58	19-Dec	0	47	4-Feb	0	45	22-Mar	0	51
3-Nov	0	55	20-Dec	6	46	5-Feb	0	45	23-Mar	0	49
4-Nov	0	53	21-Dec	1	46	6-Feb	0	46	24-Mar	0	49
5-Nov	0	51	22-Dec	0	49	7-Feb	0	47	25-Mar	0	51
6-Nov	0	50	23-Dec	0	48	8-Feb	0	48	26-Mar	0	52
7-Nov	0	49	24-Dec	2	45	9-Feb	0	54	27-Mar	0	51
8-Nov	0	49	25-Dec	0	44	10-Feb	2	49	28-Mar	0	52
9-Nov	0	49	26-Dec	0	41	11-Feb	1	50	29-Mar	0	51
10-Nov	0	47	27-Dec	0	39	12-Feb	0	51	30-Mar	0	50
11-Nov	0	46	28-Dec	0	41	13-Feb	0	51	31-Mar	0	51
12-Nov	0	46	29-Dec	0	40	14-Feb	0	51	1-Apr	1	53
13-Nov	0	46	30-Dec	0	40	15-Feb	1	52	2-Apr	0	55
14-Nov	0	46	31-Dec	0	39	16-Feb	0	52	3-Apr	0	57
15-Nov	0	47	1-Jan	0	37	17-Feb	0	53	4-Apr	1	58
16-Nov	0	46	2-Jan	0	37	18-Feb	0	51	5-Apr	0	58
17-Nov	0	45	3-Jan	0	39	19-Feb	0	49	6-Apr	0	56
18-Nov	0	46	4-Jan	0	41	20-Feb	0	49	7-Apr	0	57
19-Nov	0	47	5-Jan	0	45	21-Feb	0	49	8-Apr	0	60
20-Nov	0	48	6-Jan	0	46	22-Feb	1	49	9-Apr	0	60
21-Nov	0	49	7-Jan	1	46	23-Feb	0	48	10-Apr	0	59
22-Nov	0	49	8-Jan	2	45	24-Feb	0	49	11-Apr	0	57
23-Nov	0	48	9-Jan	0	45	25-Feb	0	51	12-Apr	0	58
24-Nov	0	49	10-Jan	0	46	26-Feb	0	52	13-Apr	1	58
25-Nov	0	46	11-Jan	0	45	27-Feb	1	53	14-Apr	0	57
26-Nov	0	43	12-Jan	0	46	28-Feb	0	52	15-Apr	0	56
27-Nov	0	41	13-Jan	0	48	29-Feb	0	52	16-Apr	0	54
28-Nov	0	39	14-Jan	0	46	1-Mar	2	52	17-Apr	0	56
29-Nov	0	38	15-Jan	0	46	2-Mar	0	52	18-Apr	1	58
30-Nov	0	37	16-Jan	0	47	3-Mar	1	52	19-Apr	0	60
1-Dec	0	39	17-Jan	7	50	4-Mar	0	54	20-Apr	0	62
2-Dec	0	41	18-Jan	8	51	5-Mar	0	55	21-Apr	0	62
3-Dec	0	44	19-Jan	2	51	6-Mar	0	56	22-Apr	0	61
4-Dec	0	46	20-Jan	0	51	7-Mar	0	51	23-Apr	0	59
5-Dec	0	45	21-Jan	0	50	8-Mar	0	49	24-Apr	0	57
6-Dec	0	46	22-Jan	3	51	9-Mar	0	47	25-Apr	0	58
7-Dec	0	47	23-Jan	4	50	10-Mar	7	48	26-Apr	0	56
8-Dec	0	50	24-Jan	0	49	11-Mar	16	51	27-Apr	0	55
9-Dec	1	51	25-Jan	0	49	12-Mar	0	50	28-Apr	0	56
10-Dec	0	53	26-Jan	0	47	13-Mar	0	49	29-Apr	0	59
11-Dec	0	51	27-Jan	0	47	14-Mar	0	50	30-Apr	0	60
12-Dec	0	48	28-Jan	0	47	15-Mar	1	49	1-May	0	62
13-Dec	0	48	29-Jan	0	49	16-Mar	3	48	2-May	0	63
14-Dec	0	45	30-Jan	0	48	17-Mar	1	49	3-May	0	63
						Total Steelhead Count				**94**	

Mill Creek

Mill Creek is a large east-side tributary entering the Sacramento River at RM-230 near Los Molinos (Figure 1). Mill Creek is a critical stronghold for wild Central Valley spring-run and steelhead populations. Adult Chinook salmon and steelhead are monitored using a video station (Appendix F Figures F17 and F18). This station is located at Ward Dam (RM-2.7). Redd surveys were completed late September through October to monitor spring-run spawning distribution. Fall-run bio-sampling surveys to obtain CWT and other biological data were completed. Water temperature data was recorded in the upper watershed using Hobo loggers.

Late-fall-run. **Twenty-five late-fall-run** passed the Mill Creek video station December 16, 2015 through February 19, 2016 (Table 9A).

Table 9A. Late-fall-run salmon passage at the 2015-2016 Mill Creek video station, and average daily flow and water temperature data recorded at the Mill Creek (CDEC-MLM) stream gage.

2015-2016 Late-Fall Salmon Mill Creek Video Station							
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
16-Dec	0	132	40	19-Jan	0	1,465	49
17-Dec	0	120	42	20-Jan	0	967	48
18-Dec	0	326	44	21-Jan	0	615	48
19-Dec	5	888	47	22-Jan	0	706	49
20-Dec	3	291	44	23-Jan	0	1,162	48
21-Dec	3	384	45	24-Jan	0	879	47
22-Dec	2	1,024	48	25-Jan	0	639	47
23-Dec	2	489	46	26-Jan	0	482	46
24-Dec	2	308	44	27-Jan	0	396	46
25-Dec	2	234	42	28-Jan	0	349	47
26-Dec	0	187	41	29-Jan	0	1,195	49
27-Dec	2	162	39	30-Jan	0	1,864	46
28-Dec	0	150	41	31-Jan	0	914	45
29-Dec	0	138	40	1-Feb	0	628	42
30-Dec	1	129	40	2-Feb	0	497	43
31-Dec	0	122	40	3-Feb	0	417	43
1-Jan	0	114	38	4-Feb	0	368	45
2-Jan	0	111	37	5-Feb	0	326	45
3-Jan	0	110	39	6-Feb	0	298	46
4-Jan	1	110	41	7-Feb	0	278	47
5-Jan	0	484	45	8-Feb	0	270	49
6-Jan	0	734	45	9-Feb	0	268	49
7-Jan	1	538	45	10-Feb	0	265	49
8-Jan	0	292	44	11-Feb	0	266	49
9-Jan	0	245	44	12-Feb	0	281	49
10-Jan	0	213	45	13-Feb	0	285	49
11-Jan	0	178	44	14-Feb	0	279	49
12-Jan	0	161	46	15-Feb	0	294	50
13-Jan	0	642	47	16-Feb	0	305	50
14-Jan	0	570	44	17-Feb	0	318	50
15-Jan	0	578	45	18-Feb	0	534	48
16-Jan	0	518	47	19-Feb	0	453	46
17-Jan	1	1,249	49	**Totals**	**25**	**MLM AVG**	**MLM AVG**
18-Jan	0	2,339	48				

Late-fall-run may spawn in Mill Creek below Ward Dam. Late-fall-run surveys were not conducted in this stream sections in 2016. Late-fall-run monitoring after December 15, 2016 will be reported in the 2017 RBFO Annual Report.

Winter-run. Winter-run are not present in Mill Creek.

Spring-run. An estimate of **175 spring-run** returned to Mill Creek in 2016 (90% confidence intervals of 150 to 201 fish respectively), (Table 9B). Mill Creek spring-run population estimates from the 1990's through 2011 were based on a redd count expansion. These expansions assumed single redd construction by females, and one to one female to male population ratios. Redd surveys (Table 9C) were completed to maintain this dataset and to document the spawning distribution of spring-run in 2016. Thirty miles (RM-48 to RM-18) of spring-run spawning habitat were surveyed. Forty-seven completed redd**s** were counted. Crews observed one spring-run carcass. This carcass was not marked (no adipose fin-clip) (Appendix Table B1).

Fall-run. An estimated **602 fall-run** (90% confidence interval of 547 to 652 fish respectively) returned to Mill Creek in 2016. This estimate is from video passage estimate and redd counts below Ward Dam (Table 9D). A final estimated 566 fall-run passed through the video station. Twenty-one completed redds were counted below Ward Dam. It was assumed that each redd equals one female, or 21 fish. The male to female ratio based on observations at CNFH in 2016 (4,934 females to 3,597 males) was used to estimate a population of **15** male fall-run below Ward Dam. Fall-run bio-sampling surveys were conducted between the mouth and RM-7 to collect CWT and other information. Crews examined 11 carcasses. Three carcasses were marked (adipose fin clip). Based on constant fractional mark rates encoded in the CWT's the population was composed of an estimated 100% stray hatchery fall- run (Appendix B Tables B1-B5).

Steelhead. There were **190 steelhead** estimated passing the Mill Creek video station from October 26, 2015 through the end of operation in July 03, 2016. The last steelhead was observed on April 17 (Table 9E). Steelhead counts in the fall-winter of 2016 will be reported in the 2017 report.

Table 9B. Spring-run salmon passage at the 2016 Mill Creek video station, and daily average flow and water temperature data recorded at the Mill Creek stream gage (CDEC-MLM).

2016 Spring Salmon Passage at the Mill Creek Video Station											
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
20-Feb	0	431	46	10-Apr	0	543	53	30-May	3	339	63
21-Feb	0	384	47	11-Apr	0	542	54	31-May	0	357	64
22-Feb	0	346	47	12-Apr	0	511	53	1-Jun	1	369	65
23-Feb	0	317	47	13-Apr	1	511	53	2-Jun	4	375	64
24-Feb	0	297	48	14-Apr	1	478	51	3-Jun	3	366	64
25-Feb	0	286	49	15-Apr	1	426	49	4-Jun	2	362	64
26-Feb	0	287	50	16-Apr	0	380	52	5-Jun	1	371	65
27-Feb	0	299	51	17-Apr	0	368	55	6-Jun	4	365	66
28-Feb	0	296	50	18-Apr	1	380	56	7-Jun	0	376	67
29-Feb	0	282	49	19-Apr	5	403	57	8-Jun	1	376	66
1-Mar	0	271	49	20-Apr	5	436	57	9-Jun	1	343	63
2-Mar	0	263	50	21-Apr	0	434	55	10-Jun	1	317	63
3-Mar	0	279	52	22-Apr	0	486	54	11-Jun	0	300	63
4-Mar	0	328	52	23-Apr	0	488	51	12-Jun	1	284	63
5-Mar	0	1,428	52	24-Apr	1	419	54	13-Jun	3	275	64
6-Mar	0	3,810	48	25-Apr	0	387	53	14-Jun	3	274	64
7-Mar	0	2,395	47	26-Apr	0	358	52	15-Jun	4	263	60
8-Mar	0	1,171	46	27-Apr	0	343	52	16-Jun	2	252	59
9-Mar	0	871	47	28-Apr	0	336	53	17-Jun	2	246	58
10-Mar	0	1,850	49	29-Apr	0	325	56	18-Jun	1	354	59
11-Mar	0	2,465	48	30-Apr	2	329	56	19-Jun	3	289	61
12-Mar	0	1,819	47	1-May	0	335	57	20-Jun	2	257	64
13-Mar	0	2,112	48	2-May	2	350	58	21-Jun	4	245	65
14-Mar	0	1,982	47	3-May	2	346	57	22-Jun	0	227	67
15-Mar	0	1,183	47	4-May	3	350	57	23-Jun	1	226	68
16-Mar	1	904	49	5-May	3	379	57	24-Jun	0	223	67
17-Mar	0	743	50	6-May	3	376	55	25-Jun	0	216	67
18-Mar	0	653	51	7-May	2	411	54	26-Jun	0	210	67
19-Mar	0	602	52	8-May	6	500	55	27-Jun	1	206	69
20-Mar	0	632	52	9-May	10	532	57	28-Jun	0	203	70
21-Mar	0	1,132	49	10-May	5	511	58	29-Jun	1	198	70
22-Mar	0	1,148	47	11-May	1	456	58	30-Jun	0	193	71
23-Mar	0	823	48	12-May	2	434	59	1-Jul	0	192	72
24-Mar	0	689	50	13-May	5	454	60	2-Jul	0	190	72
25-Mar	0	608	51	14-May	19	490	59	3-Jul	1	186	72
26-Mar	0	541	50	15-May	3	434	57	4-Jul	0	183	72
27-Mar	0	501	51	16-May	4	419	58	5-Jul	1	179	71
28-Mar	0	467	49	17-May	0	416	59	6-Jul	1	174	71
29-Mar	0	432	47	18-May	2	425	61	7-Jul	0	169	70
30-Mar	0	399	49	19-May	5	439	60	8-Jul	0	165	70
31-Mar	0	380	51	20-May	1	432	56	9-Jul	0	162	70
1-Apr	0	379	54	21-May	0	386	53	10-Jul	0	160	69
2-Apr	1	392	55	22-May	0	352	53	11-Jul	0	156	68
3-Apr	0	412	55	23-May	0	321	54	12-Jul	0	153	68
4-Apr	0	414	54	24-May	2	307	56	13-Jul	0	152	69
5-Apr	2	400	53	25-May	2	306	58	**TOTALS**	**175**	**MLM AVG flow**	**MLM AVG temp**
6-Apr	1	395	55	26-May	3	298	61				
7-Apr	0	425	56	27-May	7	305	61				
8-Apr	1	462	56	28-May	4	316	61	90% low confidence interval			**150**
9-Apr	2	513	55	29-May	2	326	62	90% up confidence interval			**201**

Table 9C. Number and location of spring-run Chinook salmon redds, live fish and carcasses observed during the 2016 Mill Creek spring-run redd survey.

2016 Mill Creek Spring-Run Chinook Salmon Redd Survey				
Survey Reaches	**Miles**	**Redds**	**Salmon**	**Caracsses**
Above Hwy 36-Not Surveyed	n/s	n/s	n/s	n/s
Hwy 36 to Little HIG	4.0	1	0	0
Litte HIG to HIG	2.1	2	0	0
HIG to Mill Trail Head	2.5	0	0	0
Mill Trail Head to Big Bend	2.0	4	0	0
Big Bend to Canyon Camp	2.0	5	0	0
Canyon Camp to Sooner	3.0	24	3	1
Sooner to McCarty	2.3	2	0	0
McCarty to Savercool	1.6	1	0	0
Savercool to Black Rock	1.2	4	1	0
Black Rock to below Ranch House	2.4	2	0	0
Ranch House to above Avery	2.4	2	0	0
Above Avery to Pape	1.6	0	0	0
Pape to Buckhorn Gulch	3.0	0	0	0
Totals	**30.1**	**47**	**4**	**1**

Table 9D. Fall-run salmon passage at the 2016 Mill Creek video station, and average daily flow and water temperature data recorded at the Mill Creek stream gage (CDEC-MLM).

2016 Fall-Run Chinook Salmon Passage at the Mill Creek Video Station											
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
13-Oct	0	86	57	8-Nov	7	184	54	4-Dec	1	182	44
14-Oct	17	179	58	9-Nov	6	178	54	5-Dec	1	176	44
15-Oct	73	167	56	10-Nov	18	171	54	6-Dec	1	170	43
16-Oct	26	179	56	11-Nov	25	165	54	7-Dec	0	165	41
17-Oct	30	198	55	12-Nov	17	163	55	8-Dec	0	247	42
18-Oct	22	155	55	13-Nov	15	170	55	9-Dec	5	481	45
19-Oct	11	139	54	14-Nov	11	158	53	10-Dec	0	3,256	49
20-Oct	16	126	54	15-Nov	7	155	52	11-Dec	1	1,507	46
21-Oct	10	122	55	16-Nov	4	166	51	12-Dec	5	759	45
22-Oct	11	119	55	17-Nov	3	143	48	13-Dec	2	529	44
23-Oct	9	117	54	18-Nov	4	139	46	14-Dec	0	1,389	48
24-Oct	13	119	54	19-Nov	4	328	47	15-Dec	0	6,521	50
25-Oct	4	794	55	20-Nov	10	488	50	**Video**	566	**MLM flow**	**MLM temp**
26-Oct	32	407	55	21-Nov	4	380	50	below dam	36		
27-Oct	20	228	56	22-Nov	0	287	48	**Total**	**602**		
28-Oct	22	414	56	23-Nov	1	478	48	90% lower CI			**547**
29-Oct	7	727	58	24-Nov	4	351	46	90% upper CI			**652**
30-Oct	9	475	56	25-Nov	1	266	46	Natural Origin		**0**	**0.0%**
31-Oct	5	441	54	26-Nov	4	326	46	Hatchery Origin		**602**	**100.0%**
1-Nov	1	814	53	27-Nov	4	423	47	Number Adults		**565**	**93.9%**
2-Nov	5	463	51	28-Nov	2	354	47	Number Grilse		**37**	**6.1%**
3-Nov	2	304	51	29-Nov	3	298	45	Females	adults	**382**	**63.4%**
4-Nov	4	245	52	30-Nov	2	253	45		jills	**9**	**1.5%**
5-Nov	8	219	51	1-Dec	3	228	45	Males	adults	**184**	**30.6%**
6-Nov	11	201	53	2-Dec	5	205	43		jacks	**28**	**4.6%**
7-Nov	11	196	54	3-Dec	1	189	43	Note: Temps and Flows are daily averages			

Table 9E. Steelhead passage at the 2015-2016 Mill Creek video station, and average daily flow and water temperature data recorded at the Mill Creek stream gage (CDEC-MLM).

2015-2016 Steelhead Passage at the Mill Creek Video Station											
Date	**Steelhead**	**Flow**	**Water °F**	**Date**	**Steelhead**	**Flow**	**Water °F**	**Date**	**Steelhead**	**Flow**	**Water °F**
26-Oct	3	72	57	26-Dec	0	187	41	25-Feb	2	286	49
27-Oct	8	73	56	27-Dec	0	162	39	26-Feb	1	287	50
28-Oct	1	77	56	28-Dec	0	150	41	27-Feb	1	299	51
29-Oct	1	81	56	29-Dec	0	138	40	28-Feb	2	296	50
30-Oct	2	76	54	30-Dec	0	129	40	29-Feb	2	282	49
31-Oct	3	75	55	31-Dec	0	122	40	1-Mar	0	271	49
1-Nov	0	75	56	1-Jan	0	114	38	2-Mar	2	263	50
2-Nov	0	92	56	2-Jan	0	111	37	3-Mar	4	279	52
3-Nov	3	87	53	3-Jan	0	110	39	4-Mar	0	328	52
4-Nov	0	80	50	4-Jan	1	110	41	5-Mar	0	1,428	52
5-Nov	1	77	48	5-Jan	0	484	45	6-Mar	0	3,810	48
6-Nov	0	77	48	6-Jan	3	734	45	7-Mar	0	2,395	47
7-Nov	0	76	48	7-Jan	3	538	45	8-Mar	0	1,171	46
8-Nov	0	78	49	8-Jan	0	292	44	9-Mar	0	871	47
9-Nov	1	106	49	9-Jan	3	245	44	10-Mar	0	1,850	49
10-Nov	0	98	48	10-Jan	1	213	45	11-Mar	0	2,465	48
11-Nov	0	85	46	11-Jan	0	178	44	12-Mar	0	1,819	47
12-Nov	1	82	45	12-Jan	1	161	46	13-Mar	0	2,112	48
13-Nov	0	81	46	13-Jan	0	642	47	14-Mar	0	1,982	47
14-Nov	1	81	47	14-Jan	2	570	44	15-Mar	2	1,183	47
15-Nov	0	99	48	15-Jan	4	578	45	16-Mar	0	904	49
16-Nov	0	102	46	16-Jan	9	518	47	17-Mar	0	743	50
17-Nov	1	86	44	17-Jan	15	1,249	49	18-Mar	0	653	51
18-Nov	0	84	45	18-Jan	16	2,339	48	19-Mar	0	602	52
19-Nov	0	83	47	19-Jan	8	1,465	49	20-Mar	0	632	52
20-Nov	1	83	48	20-Jan	5	967	48	21-Mar	0	1,132	49
21-Nov	2	83	49	21-Jan	2	615	48	22-Mar	0	1,148	47
22-Nov	1	82	49	22-Jan	4	706	49	23-Mar	0	823	48
23-Nov	0	81	49	23-Jan	2	1,162	48	24-Mar	0	689	50
24-Nov	0	84	49	24-Jan	0	879	47	25-Mar	0	608	51
25-Nov	0	92	46	25-Jan	1	639	47	26-Mar	0	541	50
26-Nov	0	83	43	26-Jan	2	482	46	27-Mar	0	501	51
27-Nov	0	81	41	27-Jan	1	396	46	28-Mar	0	467	49
28-Nov	0	80	40	28-Jan	0	349	47	29-Mar	0	432	47
29-Nov	0	79	39	29-Jan	2	1,195	49	30-Mar	0	399	49
30-Nov	0	79	39	30-Jan	0	1,864	46	31-Mar	0	380	51
1-Dec	0	80	40	31-Jan	0	914	45	1-Apr	0	379	54
2-Dec	0	81	43	1-Feb	0	628	42	2-Apr	0	392	55
3-Dec	0	89	45	2-Feb	1	497	43	3-Apr	0	412	55
4-Dec	0	116	47	3-Feb	2	417	43	4-Apr	0	414	54
5-Dec	3	102	46	4-Feb	2	368	45	5-Apr	0	400	53
6-Dec	0	110	46	5-Feb	2	326	45	6-Apr	0	395	55
7-Dec	0	130	48	6-Feb	1	298	46	7-Apr	0	425	56
8-Dec	2	121	49	7-Feb	1	278	47	8-Apr	0	462	56
9-Dec	2	121	50	8-Feb	4	270	49	9-Apr	0	513	55
10-Dec	2	439	50	9-Feb	3	268	49	10-Apr	0	543	53
11-Dec	4	277	47	10-Feb	1	265	49	11-Apr	0	542	54
12-Dec	8	165	46	11-Feb	0	266	49	12-Apr	0	511	53
13-Dec	0	312	47	12-Feb	0	281	49	13-Apr	0	511	53
14-Dec	3	248	43	13-Feb	1	285	49	14-Apr	0	478	51
15-Dec	2	159	41	14-Feb	1	279	49	15-Apr	0	426	49
16-Dec	0	132	40	15-Feb	0	294	50	16-Apr	0	380	52
17-Dec	0	120	42	16-Feb	5	305	50	17-Apr	1	368	55
18-Dec	0	326	44	17-Feb	0	318	50	18-Apr	0	380	56
19-Dec	0	888	47	18-Feb	0	534	48	19-Apr	0	403	57
20-Dec	0	291	44	19-Feb	0	453	46	20-Apr	0	436	57
21-Dec	3	384	45	20-Feb	0	431	46	21-Apr	0	434	55
22-Dec	3	1,024	48	21-Feb	0	384	47	22-Apr	0	486	54
23-Dec	0	489	46	22-Feb	0	346	47	23-Apr	0	488	51
24-Dec	1	308	44	23-Feb	0	317	47	24-Apr	0	419	54
25-Dec	0	234	42	24-Feb	1	297	48	25-Apr	0	387	53
					Total Steelhead Count				**190**		

<u>Deer Creek</u>

Deer Creek is a large east-side USRB tributary entering the Sacramento River at RM-220 near Vina (Figure 1). This tributary (in tandem with Mill Creek) is an important stronghold for populations of wild Central Valley spring-run and steelhead. Adult Chinook salmon and steelhead are monitored using video stations located on the north and south fish ladders at Stanford Vina Ranch Irrigation Company (SVRIC) Dam (RM-5) Photos of the stations are shown in Appendix F Figures F19-F22. A spring-run snorkel survey was completed in August to monitor adult spring-run distribution in the upper watershed. Fall-run bio-sampling surveys were completed to obtain CWT and other biological data. Water temperature data was recorded at the video station and upper watershed using Hobo loggers.

<u>Late-fall-run</u>. **No late-fall-run** were detected at either of the Deer Creek video stations during the period from December 16, 2015 to February 19, 2016. Late-fall-run may spawn in Deer Creek below SVRIC Dam. Late-fall-run surveys were not conducted in this stream section in 2016. Late-fall-run monitoring after December 16, 2016 will be reported in the 2017 RBFO Annual Report.

<u>Spring-run</u>. An estimated **331 spring-run** returned to Deer Creek in 2016 (confidence intervals of 207-lower to 1,854-upper). (Table 10A). Deer Creek spring-run population estimates from the 1990's through 2013 were based on snorkel surveys (Appendix E, Figure E1). This snorkel survey was completed in 2016 to document the distribution of spring-run over-summering in upper Deer Creek. Twenty-two miles of stream were surveyed beginning at Upper Deer Creek Falls and ending 2.7 miles below Ponderosa Way. There were 268 spring-run counted on the 2016 summer holding survey (Table 10B).

<u>Winter-run</u>. No winter-run population exists in Deer Creek.

<u>Fall-run</u>. An estimated **253 fall-run** returned to Deer Creek in 2016. Confidence intervals were 214-lower and 328-upper around this estimate. This estimate is based on a combination of video monitoring at SVRIC Dam, and redd counts below SVRIC Dam. A combined 231 fall-run went above the video stations (166 North ladder, 65 South ladder). Table 10C provides counts from both video stations combined. An estimated 22 fall-run spawned below SVRIC Dam in 2016. Kayak surveys were used to count completed redds and bio-sample fall-run carcasses from below SVRIC Dam to the Sacramento River. There were 13 redds counted and this was assumed to be the population of female fall-run below SVRIC in 2016. The male to female ratio based on observations at CNFH in 2016 (4,934 females to 3,597 males) was used to estimate a population of nine male fall-run below SVRIC Dam. Twenty fall-run carcasses were sampled for biological and CWT information. One of the examined carcasses was marked (missing adipose fin) (Appendix B Tables B1-B5). An estimated 20% of fall-run returning to Deer Creek in 2016 were hatchery origin strays based on fractional mark rates encoded in the CWT recovered from this carcass.

Steelhead. There were **55 steelhead** estimated passing the Deer Creek video stations from October 23, 2015 through the end of operation in July 15, 2016. The last steelhead was observed on March 28 (Table 10D). Steelhead counts in the fall-summer of 2016-2017 will be reported in the 2017 report.

VAKI. During the fall of 2016, RBFO staff installed a VAKI Riverwatcher in the south fish ladder at SVRIC Dam. This was done to test the effectiveness of the VAKI unit to monitor upstream migration of fall-run Chinook and steelhead in the ladder. The VAKI was installed in the south fish ladder on October 12, 2016, and was operated through December 13, 2016. The video monitoring equipment at the south ladder was installed prior to the VAKI installation, and monitored continuously through July 15, 2017. Both monitoring systems were operating simultaneously from October 14 through December 13, 2016. The VAKI was removed from the ladder just prior to a large storm. During large floods, the south ladder can be filled with rocks. These rocks would have severely damaged the VAKI unit, possibly destroying the camera glass and other exposed components. RBFO staff spent an entire day with 15 staff removing the sediment from the ladder and replaced the removable boards separating the cells, making the ladder operational after the flood. During further flood events in early 2017, RBFO staff removed the boards just prior to the expected flood and replaced them immediately afterwards. This allows flood-mobilized rocks to flush through the ladder preventing them from clogging the ladder cells.

Preliminary results for the VAKI were promising. During the period of VAKI operation there were 16 steelhead initially observed passing the overhead camera at the south video station. During the same period, the VAKI Riverwatcher unit produced an estimate of 34 steelhead. The VAKI was located four ladder cells downstream from the overhead camera. A complete review of the video camera footage for the missing steelhead noted some of the VAKI fish that were missed on the initial viewing. These fish tended to use the edges of the white plate area to cryptically move past the camera system. Other missing fish were not observed and could have possibly jumped over the VAKI and went downstream to pass after the VAKI was removed or go upstream through the north ladder. Due to the bed load movement during floods, the use of the VAKI in the south ladder will be problematic for periods of flooding. The design of the ladder also presented difficulty for use of the VAKI. Air bubbles and debris triggered frequent false detections, and flow velocity in the tunnel caused difficulty for many fish in moving voluntarily up and downstream in the VAKI tunnel. Analysis of the VAKI placement and data is ongoing and result of this analysis will be reported in the future.

Table 10A. Spring-run salmon passage at the 2016 Deer Creek video stations and average daily flow and water temperature data from the Deer Creek stream gage (CDEC-DCV).

2016 Spring Salmon Passage at the Deer Creek Video Station											
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
20-Feb	0	575	48	11-Apr	5	377	57	1-Jun	0	188	73
21-Feb	0	480	48	12-Apr	10	357	57	2-Jun	0	180	74
22-Feb	0	420	48	13-Apr	7	354	57	3-Jun	0	173	74
23-Feb	0	379	48	14-Apr	1	351	55	4-Jun	0	171	74
24-Feb	0	345	49	15-Apr	0	337	53	5-Jun	0	170	75
25-Feb	0	327	50	16-Apr	3	299	55	6-Jun	0	166	77
26-Feb	1	337	51	17-Apr	2	279	57	7-Jun	0	161	77
27-Feb	0	333	51	18-Apr	11	270	59	8-Jun	0	156	76
28-Feb	0	329	51	19-Apr	11	262	61	9-Jun	0	151	74
29-Feb	0	313	51	20-Apr	10	259	61	10-Jun	0	148	74
1-Mar	0	301	51	21-Apr	4	253	60	11-Jun	0	144	72
2-Mar	0	290	51	22-Apr	3	298	58	12-Jun	0	139	72
3-Mar	0	297	53	23-Apr	4	401	56	13-Jun	0	136	73
4-Mar	4	352	53	24-Apr	3	311	56	14-Jun	0	132	72
5-Mar	5	1,407	53	25-Apr	2	279	56	15-Jun	0	131	69
6-Mar	0	4,229	52	26-Apr	7	259	55	16-Jun	0	131	67
7-Mar	0	2,988	49	27-Apr	4	249	55	17-Jun	0	130	66
8-Mar	0	1,570	48	28-Apr	3	248	56	18-Jun	0	192	67
9-Mar	0	1,146	48	29-Apr	2	232	58	19-Jun	1	172	68
10-Mar	0	2,068	50	30-Apr	4	222	59	20-Jun	0	134	70
11-Mar	0	3,480	49	1-May	4	215	61	21-Jun	0	122	72
12-Mar	0	2,735	48	2-May	7	208	62	22-Jun	0	116	74
13-Mar	0	3,222	49	3-May	8	203	62	23-Jun	0	111	74
14-Mar	0	3,157	49	4-May	8	202	62	24-Jun	0	107	74
15-Mar	0	1,904	48	5-May	5	202	62	25-Jun	0	103	74
16-Mar	0	1,335	49	6-May	1	207	60	26-Jun	0	99	75
17-Mar	0	1,059	51	7-May	0	213	58	27-Jun	0	98	77
18-Mar	0	891	52	8-May	2	226	59	28-Jun	0	96	78
19-Mar	6	785	53	9-May	4	211	62	29-Jun	0	94	78
20-Mar	0	746	53	10-May	2	200	64	30-Jun	0	93	79
21-Mar	2	1,156	50	11-May	3	192	65	1-Jul	0	92	80
22-Mar	0	1,123	48	12-May	2	192	66	2-Jul	0	90	80
23-Mar	0	889	48	13-May	0	189	67	3-Jul	0	89	79
24-Mar	0	771	50	14-May	1	187	67	4-Jul	0	89	79
25-Mar	1	701	52	15-May	0	191	67	5-Jul	0	88	78
26-Mar	3	636	51	16-May	1	188	66	6-Jul	0	88	77
27-Mar	4	585	52	17-May	0	185	67	7-Jul	0	88	77
28-Mar	1	540	51	18-May	2	182	69	8-Jul	0	88	76
29-Mar	1	495	49	19-May	2	182	68	9-Jul	0	88	76
30-Mar	2	452	50	20-May	0	198	64	10-Jul	0	88	75
31-Mar	3	419	52	21-May	2	237	61	11-Jul	0	88	74
1-Apr	12	398	54	22-May	0	226	60	12-Jul	0	87	75
2-Apr	18	385	56	23-May	0	213	60	13-Jul	0	87	76
3-Apr	23	378	57	24-May	0	213	62	14-Jul	0	85	77
4-Apr	23	367	56	25-May	1	214	64	15-Jul	0	85	78
5-Apr	9	350	55	26-May	0	210	66	**TOTALS**	**331**	**DCV AVG flow**	
6-Apr	16	337	57	27-May	0	200	67				
7-Apr	18	340	58	28-May	0	194	67				
8-Apr	20	348	59	29-May	0	191	69	90% low confidence interval			**286**
9-Apr	4	359	58	30-May	0	188	70	90% up confidence interval			**1,854**
10-Apr	3	382	57	31-May	0	185	72	Temp and Flows are daily averages			

Table 10B. The 2016 Deer Creek spring-run Chinook snorkel survey results by reach.

2016 Deer Creek Spring-Run Snorkel Survey Results	
Deer Creek spring-run snorkel reaches	**Spring-Run Chinook Count**
Upper Falls to Potato Patch (1.9 miles)	56
Potato Patch to Lower Falls (3.4 miles)	22
Lower Falls to A-Line (1.3 miles)	50
A-Line to Wilson Cove (2.5 miles)	2
Wilson Cove to Polk Springs (4.3 miles)	32
Polk Springs to Murphy Trail (2.5 miles)	30
Murphy Trail to Ponderosa Way (3.5 miles)	52
Ponderosa Way to Trail 2E17 (2.7 miles)	24
Totals	**268**

Table 10C. Fall-run salmon passage at the 2016 Deer Creek video stations, and average daily flow and water temperature data recorded at the Deer Creek stream gage (CDEC-DCV).

2016 Fall Salmon at the Deer Creek Video Station											
Date	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**	**Date**	**Salmon**	**Flow**	**Water °F**
13-Oct	4	78	61	8-Nov	4	130	56	4-Dec	0	163	44
14-Oct	18	117	61	9-Nov	6	125	56	5-Dec	0	157	44
15-Oct	38	151	59	10-Nov	5	122	55	6-Dec	0	152	43
16-Oct	46	145	58	11-Nov	1	119	55	7-Dec	0	147	42
17-Oct	8	136	58	12-Nov	0	117	56	8-Dec	2	174	42
18-Oct	3	127	58	13-Nov	3	119	56	9-Dec	3	253	43
19-Oct	3	110	56	14-Nov	0	117	55	10-Dec	1	2,189	48
20-Oct	2	102	57	15-Nov	1	115	54	11-Dec	3	1,389	46
21-Oct	2	98	57	16-Nov	-1	126	52	12-Dec	0	708	46
22-Oct	3	97	58	17-Nov	-3	123	50	13-Dec	0	501	45
23-Oct	3	95	57	18-Nov	2	118	48	14-Dec	0	987	47
24-Oct	3	99	57	19-Nov	3	321	49	15-Dec	1	5,658	50
25-Oct	10	491	57	20-Nov	2	467	50	**Video**	231	**DCV AVG flow**	
26-Oct	19	291	57	21-Nov	0	343	51	below dam	22		
27-Oct	-1	157	57	22-Nov	0	269	50	**Total**	**253**		
28-Oct	5	163	58	23-Nov	0	302	50	90% lower CI			**155**
29-Oct	5	372	59	24-Nov	1	268	47	90% upper CI			**328**
30-Oct	7	311	58	25-Nov	0	223	46	Natural Origin		**202**	**79.8%**
31-Oct	3	351	56	26-Nov	2	251	46	Hatchery Origin		**51**	**20.2%**
1-Nov	0	465	54	27-Nov	3	347	47	Number Adults		**236**	**93.1%**
2-Nov	1	369	53	28-Nov	1	300	48	Number Grilse		**17**	**6.9%**
3-Nov	0	242	52	29-Nov	0	273	46	Females	adults	**143**	**56.5%**
4-Nov	0	190	52	30-Nov	0	232	46		jills	**3**	**1.4%**
5-Nov	-1	162	52	1-Dec	0	208	45	Males	adults	**93**	**36.7%**
6-Nov	3	147	54	2-Dec	1	186	44		jacks	**14**	**5.5%**
7-Nov	6	137	55	3-Dec	0	170	44	Temps and Flows are daily average			

Table 10D. Steelhead passage at the 2015-2016 Deer Creek video stations, and daily average flow and water temperature (from CDEC-DCV).

2015-2016 Steelhead Passage at the Deer Creek Video Station											
Date	**Steelhead**	**Flow**	**Water °F**	**Date**	**Steelhead**	**Flow**	**Water °F**	**Date**	**Steelhead**	**Flow**	**Water °F**
23-Oct	0	63	61	23-Dec	0	485	46	22-Feb	0	420	48
24-Oct	0	64	61	24-Dec	2	305	45	23-Feb	0	379	48
25-Oct	0	64	61	25-Dec	0	230	44	24-Feb	0	345	49
26-Oct	0	64	60	26-Dec	0	183	42	25-Feb	0	327	50
27-Oct	0	64	59	27-Dec	0	158	41	26-Feb	0	337	51
28-Oct	0	66	59	28-Dec	0	144	41	27-Feb	1	333	51
29-Oct	0	70	58	29-Dec	0	131	41	28-Feb	0	329	51
30-Oct	0	66	57	30-Dec	0	120	41	29-Feb	0	313	51
31-Oct	0	65	58	31-Dec	0	114	41	1-Mar	1	301	51
1-Nov	0	66	59	1-Jan	0	105	40	2-Mar	0	290	51
2-Nov	1	80	59	2-Jan	0	101	40	3-Mar	0	297	53
3-Nov	0	81	56	3-Jan	0	100	40	4-Mar	2	352	53
4-Nov	1	71	53	4-Jan	0	100	41	5-Mar	0	1,407	53
5-Nov	0	68	52	5-Jan	1	437	43	6-Mar	0	4,229	52
6-Nov	0	67	51	6-Jan	2	696	46	7-Mar	0	2,988	49
7-Nov	0	67	51	7-Jan	1	531	46	8-Mar	0	1,570	48
8-Nov	0	69	51	8-Jan	0	306	45	9-Mar	0	1,146	48
9-Nov	0	96	50	9-Jan	1	238	45	10-Mar	0	2,068	50
10-Nov	0	96	50	10-Jan	1	201	46	11-Mar	0	3,480	49
11-Nov	0	76	48	11-Jan	0	172	45	12-Mar	0	2,735	48
12-Nov	0	73	48	12-Jan	2	154	46	13-Mar	0	3,222	49
13-Nov	0	71	48	13-Jan	2	574	47	14-Mar	0	3,157	49
14-Nov	0	71	48	14-Jan	1	588	45	15-Mar	0	1,904	48
15-Nov	0	85	49	15-Jan	1	558	45	16-Mar	0	1,335	49
16-Nov	0	97	47	16-Jan	0	491	46	17-Mar	0	1,059	51
17-Nov	0	76	46	17-Jan	0	1,130	48	18-Mar	0	891	52
18-Nov	0	74	46	18-Jan	0	2,398	49	19-Mar	2	785	53
19-Nov	0	74	48	19-Jan	0	1,642	49	20-Mar	1	746	53
20-Nov	0	73	49	20-Jan	0	1,120	49	21-Mar	0	1,156	50
21-Nov	0	72	50	21-Jan	0	734	48	22-Mar	0	1,123	48
22-Nov	0	71	50	22-Jan	3	816	49	23-Mar	0	889	48
23-Nov	0	71	50	23-Jan	0	1,489	49	24-Mar	0	771	50
24-Nov	0	73	50	24-Jan	0	1,092	48	25-Mar	0	701	52
25-Nov	0	78	47	25-Jan	0	809	48	26-Mar	1	636	51
26-Nov	0	73	45	26-Jan	0	604	47	27-Mar	0	585	52
27-Nov	0	71	43	27-Jan	0	488	47	28-Mar	1	540	51
28-Nov	0	69	42	28-Jan	0	414	47	29-Mar	0	495	49
29-Nov	0	68	41	29-Jan	1	961	49	30-Mar	0	452	50
30-Nov	0	68	41	30-Jan	0	2,185	47	31-Mar	0	419	52
1-Dec	0	69	41	31-Jan	0	1,185	45	1-Apr	0	398	54
2-Dec	0	70	43	1-Feb	0	838	44	2-Apr	0	385	56
3-Dec	0	75	45	2-Feb	1	646	44	3-Apr	0	378	57
4-Dec	0	98	46	3-Feb	0	526	44	4-Apr	0	367	56
5-Dec	0	90	46	4-Feb	0	448	45	5-Apr	0	350	55
6-Dec	1	84	47	5-Feb	0	382	46	6-Apr	0	337	57
7-Dec	1	104	48	6-Feb	0	339	46	7-Apr	0	340	58
8-Dec	0	96	49	7-Feb	0	306	47	8-Apr	0	348	59
9-Dec	0	90	50	8-Feb	2	293	49	9-Apr	0	359	58
10-Dec	1	217	52	9-Feb	1	285	50	10-Apr	0	382	57
11-Dec	0	258	49	10-Feb	0	271	50	11-Apr	0	377	57
12-Dec	1	142	47	11-Feb	2	260	50	12-Apr	0	357	57
13-Dec	0	255	48	12-Feb	1	255	50	13-Apr	0	354	57
14-Dec	1	237	46	13-Feb	0	249	50	14-Apr	0	351	55
15-Dec	1	145	43	14-Feb	1	242	50	15-Apr	0	337	53
16-Dec	1	116	42	15-Feb	0	246	51	16-Apr	0	299	55
17-Dec	1	102	43	16-Feb	1	258	51	17-Apr	0	279	57
18-Dec	1	199	44	17-Feb	0	270	51	18-Apr	0	270	59
19-Dec	1	572	46	18-Feb	2	527	50	19-Apr	0	262	61
20-Dec	2	251	45	19-Feb	1	527	48	20-Apr	0	259	61
21-Dec	1	260	45	20-Feb	0	575	48	21-Apr	0	253	60
22-Dec	0	844	47	21-Feb	0	480	48	22-Apr	0	298	58
					Total Steelhead Count				**55**		

Other Tributaries

There are numerous unmonitored smaller tributaries in the USRB that salmon migrate into to spawn (primarily the fall-run). The RBFO priority on any given year is to conduct surveys on the larger tributaries as staff time, management priorities, and budgets allow. Many of the other tributaries remain unmonitored because they are not expected to have more salmon going into them then the monitored creeks during pre-season monitoring planning. These tributaries (Figure 1) include: Big Chico Creek for fall-run (note Big Chico is not a RBFO responsibility), Stoney Creek, Thomes Creek, Toomes Creek, Dye Creek, Elder Creek, Coyote Creek, Salt Creek, Red Bank Creek, Reeds Creek, Inks Creek, Ash Creek, Stillwater Creek, Churn Creek, Olney Creek, Sulfur Creek, Jenny Creek, Middle Creek, and Salt Creek near Redding. All of these creeks have the potential to have salmon spawners in them, typically during autumn months with early rainfall.

In addition to the monitoring detailed in this report, staff from the RBFO also worked with Rancho Cordova, CA based Region 2 of the CDFW to plan, design and build another station on Auburn Ravine Creek near Sacramento. This station counted steelhead and fall-run salmon and is shown in Appendix F Figure F23. RBFO staff also built a station on the ACID Dam's north ladder to assist USFWS with collection of winter-run broodstock for the LSNFH. A figure of this station is shown if Appendix F Figure 24. In addition to these other two stations, RBFO staff partnered with the Western Shasta Resource Conservation District (WSRCD) to design, plan and construct a video station on a new fish ladder on Clover Creek (tributary of Cow Creek). The results of this effort are available from the WSRCD. Finally, RBFO and Redding CDFW staff assisted in a much-needed river clean-up and removed over 100 old tires from the upper Sacramento River. Photos of this cleanup are shown in Appendix F Figures F25 and F26.

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APPENDIX A - Data Tables

Appendix A Table A1. Average migration timing for the various salmonid runs passing the Red Bluff Diversion Dam 1970-1988.

Percentage and cumulative percentages

		Based on years--82-86 Winter Run		1970-1988 Spring Run		1970-1988 Fall Run		1970-1986 Late-Fall		1970-1988 Steelhead	
	Week	%	cum.%	%	cum.%	%	cum.%	%	cum.%	%	cum.%
	1	1.70	3.45					6.50	55.39	0.97	91.84
JAN	2	1.78	5.23					6.32	61.71	0.80	92.64
	3	0.35	5.57					3.07	64.77	0.61	93.25
	4	1.28	6.85					2.91	67.69	0.50	93.75
	5	2.38	9.23					3.58	71.26	0.29	94.05
FEB	6	3.12	12.35					4.08	75.34	0.45	94.50
	7	3.08	15.44					4.19	79.54	0.56	95.06
	8	0.97	16.41					4.38	83.91	0.53	95.59
	9	6.35	22.76					3.29	87.20	0.49	96.09
MAR	10	7.72	30.48					2.14	89.34	0.46	96.54
	11	9.23	39.70	start				1.74	91.08	0.38	96.92
	12	7.79	47.49	0.10	0.10			3.39	94.47	0.30	97.22
	13	4.91	52.40	0.25	0.35			2.08	96.55	0.28	97.50
	14	7.64	60.04	0.59	0.93			1.82	98.37	0.35	97.85
APR	15	8.26	68.29	0.96	1.89			1.39	99.76	0.28	98.12
	16	9.19	77.48	1.38	3.27			0.24	100.00	0.19	98.31
	17	3.47	80.95	1.63	4.90			end		0.17	98.48
	18	2.02	82.98	1.60	6.50					0.16	98.63
MAY	19	1.60	84.58	1.71	8.21					0.17	98.80
	20	2.17	86.75	2.16	10.37					0.23	99.03
	21	3.09	89.84	2.63	13.00	start				0.18	99.20
	22	2.03	91.87	2.86	15.86	0.01	0.01			0.20	99.40
JUN	23	1.63	93.50	2.61	18.47	0.00	0.02			0.13	99.54
	24	1.84	95.34	2.93	21.40	0.01	0.03			0.14	99.68
	25	0.51	95.85	3.50	24.89	0.03	0.06			0.15	99.82
	26	0.76	96.61	3.10	27.99	0.08	0.14			0.18	100.00
	27	1.60	98.20	3.67	31.66	0.10	0.24			0.13	0.13
JUL	28	0.31	98.52	6.02	37.68	0.29	0.53			0.18	0.31
	29	1.04	99.55	4.75	42.44	0.49	1.02			0.18	0.49
	30	0.44	99.99	3.21	45.65	0.70	1.72			0.22	0.72
	31	0.01	100.00	4.12	49.77	0.96	2.68			0.26	0.98
AUG	32	end		6.97	56.74	1.68	4.36			0.39	1.36
	33			6.07	62.81	2.95	7.31			0.68	2.04
	34			6.75	69.55	3.53	10.84			1.12	3.16
	35			5.74	75.29	3.91	14.75			2.36	5.52
	36			7.22	82.51	4.54	19.29			3.82	9.34
SEP	37			6.68	89.19	5.59	24.88			5.80	15.14
	38			5.23	94.42	8.58	33.46			7.54	22.67
	39			3.70	98.12	9.24	42.70			8.95	31.63
	40			1.19	99.31	10.49	53.19	start		11.75	43.37
OCT	41			0.69	100.00	10.59	63.78	0.26	0.26	11.27	54.65
	42			end		8.97	72.75	2.06	2.32	9.79	64.44
	43					6.99	79.74	2.33	4.65	6.51	70.95
	44					6.70	86.44	3.27	7.92	5.17	76.12
NOV	45					4.68	91.12	4.24	12.16	4.04	80.17
	46					2.71	93.83	3.42	15.58	2.44	82.61
	47					2.23	96.06	3.65	19.23	2.21	84.82
	48	start				1.68	97.74	5.37	24.60	2.05	86.87
DEC	49	0.17	0.17			0.90	98.64	5.27	29.87	1.44	88.31
	50	0.38	0.55			0.66	99.30	5.27	35.14	1.04	89.35
	51	0.49	1.04			0.51	99.81	6.94	42.08	0.69	90.04
	52	0.71	1.75			0.19	100.00	6.81	48.89	0.83	90.87

Appendix A Table A2. Summary of aerial redd count percentages for the Sacramento River from Keswick Dam downstream to Red Bluff Diversion Dam-RBDD (% Up) and from RBDD downstream to Princeton Ferry (% Down) for years 1969-2016.

Percentages of Chinook Salmon redds in Sacramento River from aerial flights (up and downstream of RBDD)										
YEAR	**Late-Fall**		**Winter-Run**		**Spring-Run**		**Fall-Run**		**ALL COMBINED**	
	% Up	% Down	% Up	% Down	% Up	% Down	% Up	% Down	% Up	% Down
1969	n/a	n/a	n/a	n/a	n/a	n/a	74.4%	25.6%	74.4%	25.6%
1970	n/a	n/a	n/a	n/a	n/a	n/a	85.6%	14.4%	85.6%	14.4%
1971	n/a	n/a	n/a	n/a	n/a	n/a	68.5%	31.5%	68.5%	31.5%
1972	67.2%	32.8%	n/a	n/a	n/a	n/a	63.5%	36.5%	64.8%	35.2%
1973	75.9%	24.1%	n/a	n/a	n/a	n/a	69.9%	30.1%	74.7%	25.3%
1974	n/a	n/a	n/a	n/a	n/a	n/a	60.9%	39.1%	60.9%	39.1%
1975	n/a	n/a	n/a	n/a	n/a	n/a	56.4%	43.6%	56.4%	43.6%
1976	64.7%	35.3%	n/a	n/a	n/a	n/a	72.9%	27.1%	71.9%	28.1%
1977	n/a	n/a	n/a	n/a	n/a	n/a	45.1%	54.9%	45.1%	54.9%
1978	25.6%	74.4%	n/a	n/a	n/a	n/a	46.0%	54.0%	43.2%	56.8%
1979	42.7%	57.3%	n/a	n/a	n/a	n/a	53.9%	46.1%	52.0%	48.0%
1980	n/a	n/a	n/a	n/a	n/a	n/a	48.7%	51.3%	48.7%	51.3%
1981	63.5%	36.5%	87.8%	12.2%	n/a	n/a	63.0%	37.0%	63.5%	36.5%
1982	n/a	n/a	97.0%	3.0%	n/a	n/a	67.1%	32.9%	67.5%	32.5%
1983	71.2%	28.8%	n/a	n/a	81.1%	18.9%	47.6%	52.4%	59.3%	40.7%
1984	78.9%	21.1%	n/a	n/a	93.3%	6.7%	66.6%	33.4%	67.2%	32.8%
1985	81.5%	18.5%	71.8%	28.2%	78.6%	21.4%	55.5%	44.5%	56.3%	43.7%
1986	72.8%	27.2%	n/a	n/a	100.0%	0.0%	64.5%	35.5%	64.9%	35.1%
1987	64.1%	35.9%	95.5%	4.5%	n/a	n/a	71.4%	28.6%	71.0%	29.0%
1988	98.9%	1.1%	74.5%	25.5%	97.4%	2.6%	77.9%	22.1%	78.3%	21.7%
1989	41.9%	56.4%	97.9%	2.1%	100.0%	0.0%	83.3%	16.7%	82.6%	17.4%
1990	87.4%	12.6%	93.3%	6.7%	100.0%	0.0%	66.8%	33.2%	67.8%	32.2%
1991	81.6%	18.4%	100.0%	0.0%	100.0%	0.0%	66.9%	33.1%	67.8%	32.2%
1992	85.8%	14.2%	96.3%	3.7%	100.0%	0.0%	73.8%	26.2%	75.1%	24.9%
1993	100.0%	0.0%	97.7%	2.3%	100.0%	0.0%	72.5%	27.5%	72.7%	27.3%
1994	77.0%	23.0%	100.0%	0.0%	85.1%	14.9%	77.8%	22.2%	77.8%	22.2%
1995	61.9%	38.1%	99.4%	0.6%	90.9%	9.1%	83.5%	16.5%	83.5%	16.5%
1996	n/a	n/a	100.0%	0.0%	100.0%	0.0%	85.5%	14.5%	85.9%	14.1%
1997	n/a	n/a	100.0%	0.0%	99.0%	1.0%	82.8%	17.2%	83.6%	16.4%
1998	97.2%	2.8%	97.9%	2.1%	100.0%	0.0%	90.6%	9.4%	92.5%	7.5%
1999	n/a	n/a	99.9%	0.1%	100.0%	0.0%	78.8%	21.2%	98.9%	1.1%
2000	98.6%	1.4%	100.0%	0.0%	100.0%	0.0%	90.8%	9.2%	94.6%	5.4%
2001	95.2%	4.8%	99.6%	0.4%	96.6%	3.4%	76.9%	23.1%	86.2%	13.8%
2002	100.0%	0.0%	99.8%	0.2%	100.0%	0.0%	69.3%	30.7%	80.5%	19.5%
2003	97.3%	2.7%	99.7%	0.3%	100.0%	0.0%	74.5%	25.5%	79.8%	20.2%
2004	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	78.1%	21.9%	87.1%	12.9%
2005	90.2%	9.8%	100.0%	0.0%	84.8%	15.2%	78.8%	21.2%	90.9%	9.1%
2006	75.5%	24.5%	99.7%	0.3%	100.0%	0.0%	84.0%	16.0%	86.5%	13.5%
2007	90.4%	9.6%	100.0%	0.0%	100.0%	0.0%	82.6%	17.4%	88.1%	11.9%
2008	92.7%	7.3%	100.0%	0.0%	82.6%	17.4%	93.5%	6.5%	96.4%	3.6%
2009	98.1%	1.9%	100.0%	0.0%	n/a	n/a	91.1%	8.9%	95.1%	4.9%
2010	89.7%	10.3%	100.0%	0.0%	100.0%	0.0%	84.4%	15.6%	89.7%	10.3%
2011	100.0%	0.0%	100.0%	0.0%	n/a	n/a	88.8%	11.2%	92.9%	7.1%
2012	99.6%	0.4%	100.0%	0.0%	n/a	n/a	78.2%	21.8%	83.8%	16.2%
2013	n/a	n/a	100.0%	0.0%	100.0%	0.0%	80.4%	19.6%	86.3%	13.7%
2014	90.9%	9.1%	100.0%	0.0%	n/a	n/a	85.9%	14.1%	89.3%	10.7%
2015	n/a	n/a	100.0%	0.0%	n/a	n/a	75.9%	24.1%	78.7%	21.3%
2016	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	92.8%	7.2%	96.4%	3.6%
AVERAGE	**82%**	**18%**	**97%**	**3%**	**96%**	**4%**	**73%**	**27%**	**76%**	**24%**
n/a = not available: no flights conducted or water turbid during period										

Appendix A Table A3. Summary of the 2016 Late-fall-run Chinook Salmon carcass survey results for the Sacramento River.

2016 Sacramento River Late-Fall-Run Chinook Salmon Survey		
Dec 15, 2015 to May 10, 2016		Dates Survey conducted during total of 22 weekly periods
3,150		Final Population Estimate using Cormack Jolly-Seber method and downstream redd expansion
2,373		90% Lower Confidence Limit (includes Keswick transfers to CNFH)
3,927		90% Upper Confidence Limit (includes Keswick transfers to CNFH)
3,085		Total in-river salmon numbers
65		Total salmon into Keswick Dam Trap (61 natural origin to CNFH, 4 hatchery origin had cwt checks)
201	6.5%	Hatchery Origin estimated in-river numbers. Note: see Appendix B for hatchery-origin salmon information
2,884	93.5%	Natural Origin estimated in-river numbers
2,929	94.9%	Adult in-river salmon
156	5.1%	Grilse in-river salmon
1,184	38.4%	Adult Females >2 yrs (in-river)
1,744	56.5%	Adult Males >2 yrs (in-river)
32	1.0%	Female Grilse-2yr old based on fresh fish and 610 mm fork length cut-off (in-river)
125	4.0%	Male Grilse-2yr old based on fresh fish and 610 mm fork length cut-off (in-river)
174		Number of salmon carcasses tagged
463		Number of salmon carcasses chopped
41		Number of salmon carcasses recaptured
0		Number of aerial redd surveys conducted during carcass survey time frame
118		Number of new redds observed
0	0.0%	number and percentage of redds downstream of Balls Ferry Survey area-used to expand mark-recapture data
60.6%		Percent of males from CNFH data: used to develop an estimate of males on the Sacramento River survey
0.9%		Percent of unspawned females observed on Survey
3,189	20,204	Minimum and maximum flows (cfs) (KWK) during Survey
47	58	Minimum and maximum water temperatures (Fahrenheit) of river during Survey
0	10	Minimum and maximum water visibility (feet) during Survey

Appendix A Table A4. Summary of the 2016 Winter-run Chinook Salmon carcass survey results for the Sacramento River.

2016 Sacramento River Winter-Run Chinook Salmon Survey		
May 02, 2016 to Sep 15, 2016.	Dates Survey conducted during total of 43 continuous three day periods	
1,546	Final Population Estimate Cormack Jolly-Seber method, Keswick trap sex ratios and downstream redd expansion	
329	90% Lower Confidence Limit	
2,763	90% Upper Confidence Limit	
1,409	Total in-river salmon numbers	
137	Total salmon taken into Livingston Stone NFH for use as hatchery broodstock (includes all fish spawned or morts)	
2	WR salmon observed on other surveys	
0	WR salmon observed in Colusa Basin that were not rescued	
466	30.1%	Hatchery Origin in-river and into LSNFH (n = 109). Note: see Appendix B for hatchery-origin information
1,080	69.9%	Natural Origin estimated in-river numbers and into LSNFH (n = 28).
924	59.8%	Adult in-river and into LSNFH (n = 33)
621	40.2%	Grilse in-river and into LSNFH (n = 103)
583	37.7%	Adult Females >2 yrs in-river and into LSNFH (n = 23)
341	22.1%	Adult Males >2 yrs in-river and into LSNFH (n = 10)
135	8.8%	Female Grilse-2yr old in-river based on fresh fish and 630 mm fork length cut-off and into LSNFH (n = 37)
487	31.5%	Male Grilse-2yr old in-river based on fresh fish and 710 mm fork length cut-off and into LSNFH (n = 67)
223	Number of salmon carcasses tagged	
74	Number of salmon carcasses chopped	
59	Number of salmon carcasses recaptured	
16	Number of aerial redd surveys conducted during carcass survey time frame	
18	Number of new redds observed	
0	0.0%	Number and percentage of redds downstream of Balls Ferry Survey area-used to expand mark-recapture data
42.8%	Percent of fish (> 609 mm) that were males from Keswick Trap data: used to estimate "large" males on the river	
0.8%	Percent of unspawned females observed on Survey	
5,545	10,692	Minimum and maximum flows (cfs) (KWK-CDEC) during Survey
51	56	Minimum and maximum water temperatures (Fahrenheit) of river during Survey
5	10	Minimum and maximum water visibility (feet) during Survey
2	Number of additional winter-run observed in Upper Sac River basin not included above	

Appendix A Table A5. Summary of the 2016 Fall-run Chinook Salmon carcass survey results for the Sacramento River.

2016 Sacramento River Fall-Run/spring-run Chinook Salmon Survey		
Sep 06, 2016 to Jan 05, 2017		Dates Survey conducted during total of 18 weekly periods
4,571	Final Population Estimate using Cormack Jolly-Seber method and other expansions	
3,267	90% Lower Confidence Limit	
5,875	90% Upper Confidence Limit	
1,643	**38.3%**	Hatchery Origin in-river numbers. Keswick transfers (282) all hatchery-final is 42.1% or 1,925 hatchery origin.
2,646	**61.7%**	Natural Origin estimated in-river numbers
4,117	**96.0%**	Adult in-river salmon
172	**4.0%**	Grilse in-river salmon
2,434	**56.7%**	Adult Females >2 yrs
1,684	**39.3%**	Adult Males >2 yrs
47	**1.1%**	Female Grilse-2yr old based on fresh fish and 610 mm fork length cut-off
125	**2.9%**	Male Grilse-2yr old based on fresh fish and 650 mm fork length cut-off
322	Number of salmon carcasses tagged	
538	Number of salmon carcasses chopped	
100	Number of salmon carcasses recaptured	
4	Number of aerial redd surveys conducted during carcass survey time frame (note 1 Spring run flight in 2016)	
139	Number of new redds observed	
54	**38.8%**	Number and percentage of redds downstream of Clear Powerlines Survey area-to expand mark-recapture data
42.2%	Percent of males from CNFH data: used to develop an estimate of males on the Sacramento River survey	
1.3%	Percent of unspawned females observed on Survey	
4,985	**10,025**	Minimum and maximum daily average flows (cfs) (KWK) during Survey
48	**55**	Minimum and maximum water temperatures (Fahrenheit) of river during Survey
6	**12**	Minimum and maximum water visibility (feet) during Survey
21	**Hatchery Spring-run estimated from carcass survey. These should be subtracted to determine fall-run**	

Appendix A Table A6. Summary of the Chinook Salmon population estimates by run in the upper Sacramento River basin, upstream of Princeton (RM-164) for the years 1980-2016. Angler caught sport catch not included in this table. Table is summary of GrandTab file.

"GrandTab" Chinook Salmon Totals for the Upper Sacramento River Basin above Princeton ^+					
YEAR **	**Late-Fall**	**Winter**	**Spring**	**Fall**	**TOTALS**
1980	9,093	1,156	11,369	67,538	89,156
1981	6,718	22,797	20,655	98,537	148,707
1982	6,899	1,281	25,356	72,161	105,697
1983	15,089	1,831	6,206	74,567	97,693
1984	10,388	2,663	8,014	98,014	119,079
1985	10,180	5,407	13,335	144,173	173,095
1986	8,301	2,596	22,892	139,447	173,236
1987	16,571	2,185	12,661	132,277	163,694
1988	13,218	2,878	10,810	155,675	182,581
1989	12,872	696	5,785	94,193	113,546
1990	8,078	429	5,540	70,383	84,430
1991	8,263	211	1,624	50,574	60,672
1992	10,131	1,240	817	48,121	60,309
1993	1,267	387	754	68,140	70,548
1994	889	186	2,072	105,745	108,892
1995	489	1,297	2,324	156,424	160,534
1996	1,385	1,337	1,289	163,595	167,606
1997	4,578	880	905	230,960	237,323
1998	42,419	2,992	4,644	109,701	159,756
1999	15,758	3,288	2,690	289,094	310,830
2000	12,883	1,352	1,469	178,481	194,185
2001	21,813	8,224	3,750	211,463	245,250
2002	40,406	7,441	4,445	547,445	599,737
2003	8,882	8,218	4,631	254,128	275,859
2004	14,150	7,869	2,380	144,494	168,893
2005	16,282	15,839	3,727	238,418	274,266
2006	15,089	17,296	4,188	148,732	185,305
2007	18,843	2,541	2,357	47,714	71,455
2008	10,372	2,830	861	48,764	62,827
2009	10,196	4,537	753	19,736	35,222
2010	9,986	1,596	971	49,416	61,969
2011	8,448	827	934	77,250	87,459
2012	5,986	2,671	2,371	157,982	169,010
2013	9,004	6,084	2,620	163,459	181,167
2014	13,050	3,015	2,042	106,038	124,145
2015	9,410	3,440	626	59,671	73,147
2016	5,613	1,546	722	19,484	27,365
AVERAGE	11,703	4,083	5,367	130,865	152,017
^ Data from RBDD counts + aerial redd flights + tributary surveys beneath RBDD + other methods w hen noted					
+ Note: **Angler harvest not** included in this table, see table 1 or text for angler harvest estimate numbers					
** Totals reflect available data, many streams not surveyed have populations of salmon					
Estimates calculated using carcass survey results, hatchery counts, video counts, and redd surveys					
This table includes Big Chico Creek but does not include Butte Creek data					

APPENDIX B – Coded Wire Tag Results Tables

Appendix B Table B1. Summary of the 2016 results comparing adipose fin clipped carcasses to non-clipped carcasses for Chinook Salmon surveys conducted by staff from the RBFO and joint surveys with the USFWS.

* Notes for readers analyzing this data:
1. Carcass survey results need attention to prevent errors when comparing cwt proportions to total encountered. It is suggested to use only fresh fish to conduct most analysis because some non-fresh fish are too decayed (skeletons) and crews are unable to know if that fish had a adipose fin clip. Using fresh fish eliminates this potential error.
2. Crews only collect measurements and data on non-fresh fish if it has an ad-clip.
3. Original data stored in Access databases by the survey the data was collected on and are available for analysis if requested: doug.killam@wildlife.ca.gov
4. Skeletons are carcasses without ad-clip determination; crews do not collect heads on these but determine proportion of clips from fresh fish proportions.
5. Skeletons are not checked for a CWT and are chopped. If creating ratios (i.e. total fish vs. hatchery) do not include skeletons these could never produce a cwt even if they had one.
6. 100% of winter and late-fall hatchery fish are clipped (though in reality some small % are not clipped) at hatchery, so a total estimate is made for these runs.
7. Fall-run/Spring-run hatchery fish are not 100% marked so analysis should be done with extreme caution to details for this run. The CFM 25% mark does not apply to all fall-run
8. The late-fall spawn over the calendar year break. It is standard to report fish from late in 2015 and early in 2016 as 2016 fish. Fish late in 2016 will be included in the 2017 reporting.
9. If crews were positive that the fish was missing adipose fin and then no CWT was detected the fish was still tallied as a hatchery fish and included in cwt fish tallies below.
10. Potential ad-clipped and actual CWT fish counts obtained directly from Access files on individual runs and hand entered in this sheet.

RBFO 2016 Surveys collecting CWT information*	Late-fall-run Sacramento	Winter-run Sacramento	Fall-run/ Spring-run Sacramento	Fall-run Clear	Fall-run Cow	Fall-run Cottonwood	Fall-run Paynes	Fall-run Antelope-Redd	Spring-run Mill-Redd	Fall-run Mill	Fall-run Deer	TOTALS
Dates of Survey Effort	12/15/15 - 05/10/16	05/02/16 - 09/15/16	09/06/16- 01/05/16	10/11/16- 12/12/16	11/04/16 - 12/7/16	10/27/16 - 12/07/16	10/27/16 - 12/08/16	11/10/16- 12/08/16	09/30/16- 10/21/16	11/04/16- 12/07/16	11/03/16- 12/07/16	
Types of Survey effort to determine hatchery estimates	boat-carcass	boat-carcass	boat-carcass	walk-carcass-video	kayak - video	kayak - video	walk-carcass	kayak - video	redds - video	kayak - video	kayak - video	
Fresh fish (carcasses) encountered (clear eye)	145	164	217	131	2	2	0	0	0	5	6	672
Fresh Potential ad-clips encountered	9	46	29	12	1	0	0	0	0	2	1	100
Fresh (1st) unknown and (2nd) partial clipped fish	0 - 0	4 - 0	3 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	n/a
Fresh fish after analysis with CWT (inc NTD's w/ full clips)	9	42	29	12	1	0	0	0	0	2	1	96
Percent Fresh fish determined to have CWT	6.2%	25.6%	13.4%	9.2%	50.0%	0.0%	n/a	n/a	n/a	40.0%	16.7%	20.1%
Total fish encountered- (see note 5)	637	297	860	139	4	10	1	0	1	11	20	1,980
Total fish checked for clips (does not include skeletons)	494	284	730	139	4	9	0	0	1	11	19	1,691
Total skeletons observed (not checked for CWT's)	143	13	130	0	0	1	1	0	0	0	1	289
Total potential ad-clips encountered (of those checked)	16	84	61	13	1	2	0	0	0	3	1	181
Total (1st) unknown and (2nd) partial clipped fish	0 - 0	9 - 2	3 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	n/a
Total after analysis with CWT (inc NTD's with full clips)	16	77	61	13	1	2	0	0	0	3	1	174
Percent all (inc Non-fresh) fish determined to have CWT	3.2%	27.1%	8.4%	9.4%	25.0%	22.2%	0.0%	0.0%	0.0%	27.3%	5.3%	11.6%
Expanded (CFM) number of hatchery fish in population	201	466	1,925	684	226	224	0	0	0	602	51	4,379
Percent of hatchery origin fish in population	7%	30%	42%	28%	27%	28%	0%	0%	0%	100%	20%	25.6%
Total population estimate for survey efforts	3,085	1,546	4,571	2,481	822	813	8	138	127	602	253	14,446
Confidence limit (90%) of estimate (low, high)	2,373 - 3,927	329 - 2,763	3,267 - 5,875	2,171 - 2,791	680 - 1,071	720 - 924	n/a - n/a	109 - 133	104 - 150	547 - 652	214 - 328	n/a

Appendix B Table B2. Summary of the 2016 coded wire tag results, **by tag code,** for adipose fin clipped (hatchery) Chinook Salmon, in the upper Sacramento River basin collected on RBFO and joint USFWS surveys.

CWT Code	Hatchery*	Release Location	Brood Year	Run	Survey	Clear	Cotton	Cow	Deer	Mill	Sac Riv.
52288	LSNFH	Sac Riv at Redding Park	2012	Winter	Winter						1
52778	LSNFH	Sac Riv at Redding Park	2013	Winter	Winter						3
54032	LSNFH	Sac Riv at Redding Park	2013	Winter	Winter						3
54175	LSNFH	Sac Riv at Redding Park	2012	Winter	Winter						1
55065	LSNFH	Sac Riv at Redding Park	2013	Winter	Winter						18
55268	LSNFH	Sac Riv at Redding Park	2012	Winter	Winter						1
55349	LSNFH	Sac Riv at Redding Park	2013	Winter	Winter						3
55537	CNFH	CNFH	2012	Late-fall	Late-fall						1
55538	CNFH	CNFH	2012	Late-fall	Late-fall						1
55539	CNFH	CNFH	2012	Late-fall	Late-fall						4
55541	CNFH	CNFH	2012	Late-fall	Late-fall						1
55542	CNFH	CNFH	2012	Late-fall	Late-fall						1
55543	CNFH	CNFH	2012	Late-fall	Late-fall						2
55546	CNFH	CNFH	2012	Late-fall	Late-fall						1
55593	CNFH	CNFH	2012	Fall	Fall						1
55598	CNFH	CNFH	2012	Fall	Fall						1
55599	CNFH	CNFH	2012	Fall	Fall						1
55605	CNFH	CNFH	2012	Fall	Fall						1
55606	CNFH	CNFH	2012	Fall	Fall					1	
55610	CNFH	CNFH	2012	Fall	Fall					1	4
55693	CNFH	San Pablo net pen	2013	Fall	Fall						1
55694	CNFH	San Pablo net pen	2013	Fall	Fall						2
55695	CNFH	San Pablo net pen	2013	Fall	Fall	1	2				
55699	CNFH	CNFH	2013	Fall	Fall						2
55704	CNFH	San Pablo net pen	2013	Fall	Fall						2
55705	CNFH	San Pablo net pen	2013	Fall	Fall	1					1
55706	CNFH	San Pablo net pen	2013	Fall	Fall						1
55707	CNFH	Sac Riv at Rio Vista	2013	Fall	Fall	1					2
55708	CNFH	CNFH	2013	Fall	Fall						1
55709	CNFH	CNFH	2013	Fall	Fall	1					6
55739	CNFH	CNFH	2014	Late-fall	Late-fall						1
55771	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						4
55772	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						8
55773	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						8
55774	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						2
55775	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						6
55776	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						9
55777	LSNFH	Sac Riv at Redding Park	2014	Winter	Winter						3
55852	CNFH	CNFH	2015	Late-fall	Fall	1					
60436	MRFF	San Joaq Riv Jesey Pt	2012	Fall	Late-fall						1
60462	FRH	Wickland Oil net pen	2012	Spring	Fall						1
60462	FRH	Wickland Oil net pen	2012	Spring	Winter						1
60465	FRH	San Pablo net pen	2012	Fall	Fall						1
60466	FRH	San Pablo net pen	2012	Fall	Fall	2					2
60468	FRH	Half Moon Bay	2012	Fall	Fall						1
60472	FRH	Fort Baker Minor Pt	2012	Fall	Fall						1
60483	MRFI	San Joaq Sherm Isl net	2012	Fall	Fall						1
60553	MRFI	San Joaq Sherm Isl net	2014	Fall	Fall						1
60564	FRH	Wickland Oil net pen	2013	Fall	Fall					1	2
60565	FRH	Wickland Oil net pen	2013	Fall	Fall						1
60566	FRH	Wickland Oil net pen	2013	Fall	Fall						1
60570	MRFI	San Fran Maj Pt	2013	Fall	Fall						1
60581	NIM	Mare Island net pen	2013	Fall	Fall						2
60593	MRFI	San Fran Maj Pt	2013	Fall	Fall						1

Appendix B Table B2. Continued.

CWT Code	Hatchery*	Release Location	Brood Year	Run	Survey	Clear	Cotton	Cow	Deer	Mill	Sac Riv.
60617	MRFI	Santa Cruz Harbor	2013	Fall	Fall						1
60618	FRH	Half Moon Bay	2013	Fall	Fall	3					12
60656	FRH	Mare Island net pen	2014	Fall	Fall	1					
60662	FRH	Half Moon Bay	2014	Fall	Fall	1		1			2
68681	FRH	Wickland Oil net pen	2013	Fall	Fall						1
				Sub-Total	160	12	2	1	0	3	142
Hatchery carcasses that had CWT problems						Clear	Cotton	Cow	Deer	Mill	Sac
100000	No Tag	No Tag Detected			Fall				1		2
100000	No Tag	No Tag Detected			Late-fall						1
100000	No Tag	No Tag Detected			Winter						5
200000	CWT lost	CWT lost in dissection			Fall						1
200000	CWT lost	CWT lost in dissection			Late-fall						2
300000	Head lost	Head Not Recovered			Winter						1
400000	No Read	Tag Illegible			Fall	1					
				Sub-Total	14	1	0	0	1	0	12
						Clear	Cotton	Cow	Deer	Mill	Sac
* Hatchery abbreviations are as follows:			**2016 TOTALS**		**174**	**13**	**2**	**1**	**1**	**3**	**154**
CNFH-Coleman National Fish Hat, FRH-Feather River Hat., LSNFH-Livingstone Nat Fish Hat., NIM-Nimbus Fish Hat.,											
MRFI-Mokelumne River Fish Installation, MRFF-Merced River Fish Facility											

Appendix B Table B3. Summary of the coded wire tag results, by **brood year** and **waterway** for adipose fin clipped (hatchery) Chinook Salmon, in the upper Sacramento River basin in 2016 collected on RBFO and joint USFWS surveys.

Brood Year	Sac. Riv.	Clear	Cow	Cottonwood	Mill	Deer	Totals	Age	Percent
2012	31	2	0	0	2	0	35	4 year old	21.9%
2013	67	7	0	2	1	0	77	3 year old	48.1%
2014	44	2	1	0	0	0	47	2 year old	29.4%
2015	0	1	0	0	0	0	1	1 year old	0.6%
No tag data	12	1	0	0	0	1	14	unknown	not inc.
Totals	154	13	1	2	3	1	174		100.0%

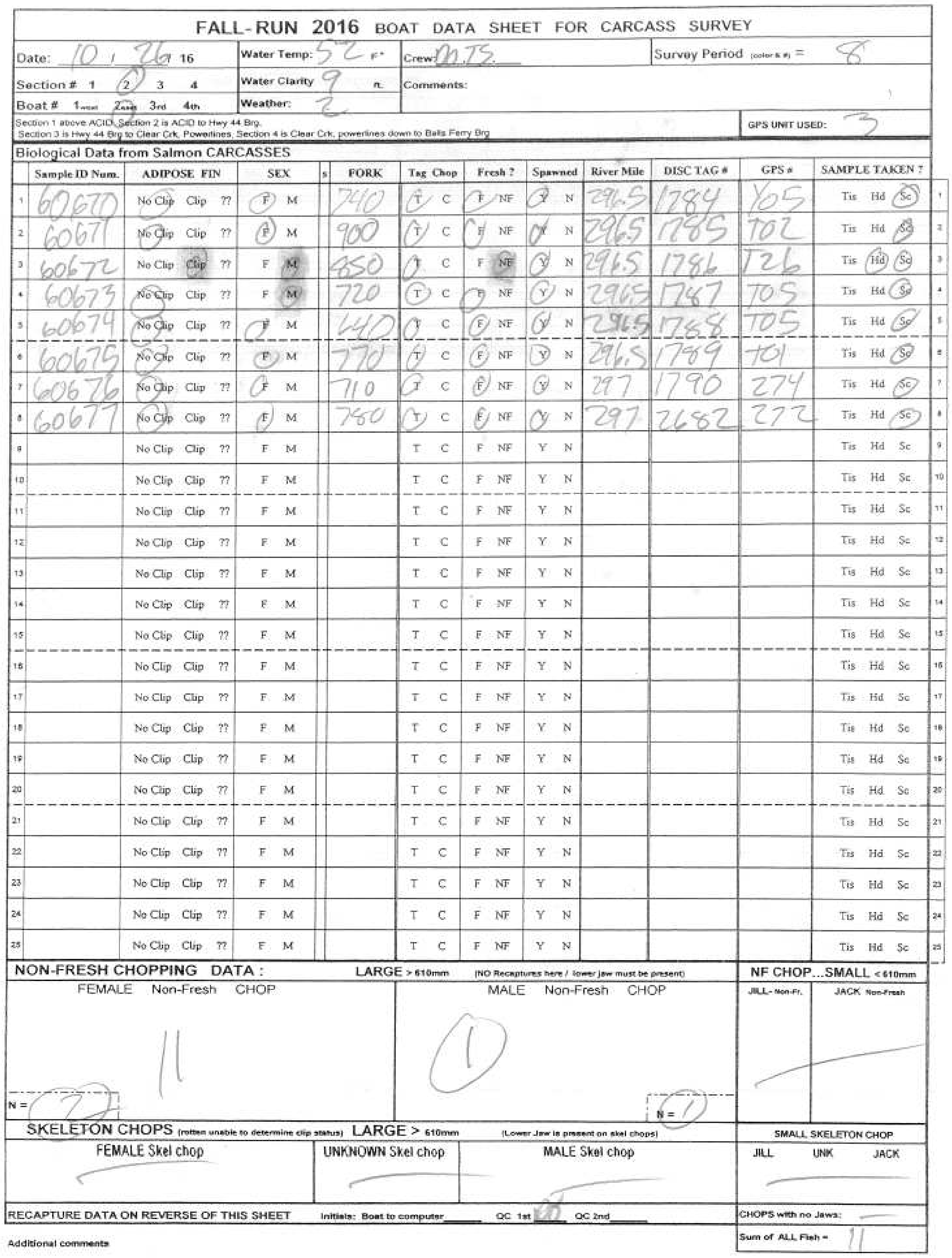
Appendix B Table B4. Summary of the coded wire tag results, by **waterway** and **run**, for adipose fin clipped (hatchery) Chinook Salmon, in the upper Sacramento River basin in 2016 collected on RBFO and joint USFWS surveys.

Location	Late-Fall	Winter	Spring	Fall	Totals
Sacramento Riv	12	70	2	58	142
Clear Creek	1	0	0	11	12
Cow Creek	0	0	0	1	1
Cottonwood Creek	0	0	0	2	2
Mill Creek	0	0	0	3	3
Deer Creek	0	0	0	0	0
Totals	13	70	2	75	160

Appendix B Table B5. Summary of the 2016 coded wire tag results, by **hatchery**, for adipose fin clipped (hatchery) Chinook Salmon, in the upper Sacramento River basin collected on RBFO and joint USFWS surveys.

HATCHERY SOURCE		Total	Percentage
Coleman National Fish Hatchery		47	29.4%
Feather River Hatchery		35	21.9%
Livingston Stone NF Hatchery		70	43.8%
Merced River Fish Facility		1	0.6%
Mokelumne River Fish Installation		5	3.1%
Nimbus Fish Hatchery		2	1.3%
CWT's with good reads:	Total	160	100.0%
TAG NOT DETECTED	(100000)	9	
TAG LOST	(200000)	3	
HEAD NOT SEEN-LOST	(300000)	1	
TAG ILLEGIBLE	(400000)	1	
Total Problem CWT's		14	8.0%
Overall CWT (found) Totals		160	percent Tag not detected
Total heads thought to be hatchery		**174**	

APPENDIX C – Carcass Survey Data and Related Information


FALL-RUN 2016 BOAT DATA SHEET FOR CARCASS SURVEY

Date: 10 / 26 / 16 | Water Temp: 52 F° | Crew: M.T.S. | Survey Period (color & #) = 8

Section # 1 2 3 4 | Water Clarity 9 ft. | Comments:

Boat # 1west 2east 3rd 4th | Weather: 2

Section 1 above ACID, Section 2 is ACID to Hwy 44 Brg.
Section 3 is Hwy 44 Brg to Clear Crk, Powerlines, Section 4 is Clear Crk, powerlines down to Balls Ferry Brg

GPS UNIT USED: 3

Biological Data from Salmon CARCASSES

	Sample ID Num.	ADIPOSE FIN	SEX	s	FORK	Tag Chop	Fresh ?	Spawned	River Mile	DISC TAG #	GPS #	SAMPLE TAKEN ?	
1	60670	No Clip Clip ??	F M		740	T C	F NF	Y N	296.5	1784	Y05	Tis Hd Sc	1
2	60671	No Clip Clip ??	F M		900	T C	F NF	Y N	296.5	1785	T02	Tis Hd Sc	2
3	60672	No Clip Clip ??	F M		850	T C	F NF	Y N	296.5	1786	T26	Tis Hd Sc	3
4	60673	No Clip Clip ??	F M		720	T C	F NF	Y N	296.5	1787	T05	Tis Hd Sc	4
5	60674	No Clip Clip ??	F M		640	T C	F NF	Y N	296.5	1788	T05	Tis Hd Sc	5
6	60675	No Clip Clip ??	F M		770	T C	F NF	Y N	296.5	1789	T01	Tis Hd Sc	6
7	60676	No Clip Clip ??	F M		710	T C	F NF	Y N	297	1790	274	Tis Hd Sc	7
8	60677	No Clip Clip ??	F M		780	T C	F NF	Y N	297	2682	272	Tis Hd Sc	8
9		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	9
10		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	10
11		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	11
12		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	12
13		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	13
14		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	14
15		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	15
16		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	16
17		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	17
18		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	18
19		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	19
20		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	20
21		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	21
22		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	22
23		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	23
24		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	24
25		No Clip Clip ??	F M			T C	F NF	Y N				Tis Hd Sc	25

NON-FRESH CHOPPING DATA : LARGE > 610mm (NO Recaptures here / lower jaw must be present) | NF CHOP...SMALL < 610mm

FEMALE Non-Fresh CHOP: 11 N = 2 | MALE Non-Fresh CHOP: 1 N = 1 | JILL- Non-Fr. | JACK Non-Fresh

SKELETON CHOPS (rotten unable to determine clip status) LARGE > 610mm (Lower Jaw is present on skel chops) | SMALL SKELETON CHOP

FEMALE Skel chop | UNKNOWN Skel chop | MALE Skel chop | JILL UNK JACK

RECAPTURE DATA ON REVERSE OF THIS SHEET Initials: Boat to computer ____ QC 1st ____ QC 2nd ____ | CHOPS with no Jaws:

Additional comments | Sum of ALL Fish = 11

Appendix C Figure C1. Example of 2016 Sacramento River fall-run carcass survey **front** of datasheet.

DISC TAGGED RECAPTURES CHOP THESE: DO NOT tally as Chops on Front

#	Disc Tag #	GPS point	#	Disc Tag #	GPS point	#	Disc Tag #	GPS point	#	Disc Tag #	GPS point
1	3935	T01	26			51			76		
2	3936	T02	27			52			77		
3			28			53			78		
4			29			54			79		
5			30			55			80		
6			31			56			81		
7			32			57			82		
8			33			58			83		
9			34			59			84		
10			35			60			85		
11			36			61			86		
12			37			62			87		
13			38			63			88		
14			39			64			89		
15			40			65			90		
16			41			66			91		
17			42			67			92		
18			43			68			93		
19			44			69			94		
20			45			70			95		
21			46			71			96		
22			47			72			97		
23			48			73			98		
24			49			74			99		
25			50			75			100		

2016 Sacto fall run

WEEK	PERIOD	COLOR of DISCs
9/05/16	1	pink
9/12/16	2	red
9/19/16	3	yellow
9/26/16	4	lt blue
10/03/16	5	lt grn
10/10/16	6	dk blue
10/17/16	7	silver
10/24/16	8	purple
10/31/16	9	orange
11/07/16	10	dk grn
11/14/16	11	pink
11/21/16	12	red
11/28/16	13	yellow
12/05/16	14	lt blue
12/12/16	15	lt grn
12/19/16	16	dk blue
12/26/16	17	silver
01/02/16	18	no tag
01/09/17	19	no tag

DISC TAG COMMENTS HERE

Floy Tag Recovery DATA

#	Row Number of fish from front page	1st Floy Tag #	2nd Floy Tag #	Floy COLOR	Comments (Save Floy tags give to DFG to store)
1					
2					
3					
4					

Biological Data from TROUT CARCASSES ....(ENTER AS RAITRO into the COMPUTER DATABASE)

#	SAMPLE ID#	ADIPOSE FIN	SEX	FORK	FRESH ?	SPAWNED	River mile	GPS #	SAMPLE TAKEN
1		No Clip Clip ??	F M		F NF	Y N			Tis Hd Sc
2		No Clip Clip ??	F M		F NF	Y N			Tis Hd Sc
3		No Clip Clip ??	F M		F NF	Y N			Tis Hd Sc

Date: 10 / 26 / 16 Section: 2 Boat: 2 Additional Comments:

Appendix C Figure C1. Continued. Example of 2016 Sacramento River fall-run carcass survey **reverse** side of datasheet.

Appendix C1. Notes for winter-run survey results in Appendix C1-Table C1.

1 – Official total system estimate: This is the official number used by the CDFW and other agencies when reporting winter-run spawning populations (both hatchery and in-river). This data is also available in the CDFW's "GrandTab", an electronic summary of Central Valley salmon escapements. This number may include winter-run observed in Battle Creek (i.e., the six seen in Battle Creek in 2006). The RBDD number was used from 1996 to 2000. From 2001 to 2011, the Jolly-Seber estimate from the carcass survey was used. From 2012 to present, the Cormack Jolly Seber method is used. It is important to note that this number includes some winter-run that were estimated to have entered Battle Creek or seen on Sacramento River in other surveys (1996 = 325, 1997 = 44, 2006 = 6, 2011 = 3, 2012 = 2, and 2013=367). ***Note a revision occurred to 2012 and 2013 winter-run escapements that raised the number of males by 3 for 2012 and 38 for 2013. The revision was a result of including small females in the sex ratio obtained from fish collected alive at Keswick trap.***

2 – In-river spawner estimate: This number is the number of winter-run salmon thought to have spawned naturally in the Sacramento River during the winter-run survey (not including those found on other efforts-LF survey morts, etc.). It includes both natural origin and hatchery fish that spawned in the river. It also includes adults and grilse and fish assumed to have spawned downstream determined by aerial redds.

3 – Removed for hatchery use: This number is the number of fish removed for hatchery brood stock including fish that died before being spawned. It includes mostly natural origin fish as well as some hatchery origin fish used for brood stock or sacrificed to determine hatchery origin. In 1996 and 1997, this number represents the number of fish that were observed in Battle Creek at Coleman National Fish Hatchery. In 2006, five coded wire tagged winter-run were sacrificed at the Coleman Barrier Weir to determine hatchery origin. These five fish (along with a one natural winter-run) are not listed here, but are included in the total System estimate row above.

4 – Other winter-run: In years 96, 97, 06, and 2011 winter-run salmon were surveyed in Battle Creek based on timing and passage dates. In 2011, three were observed, 1 in the upstream video system, and 2 sacrificed at CNFH during fall-run spawning procedures. In 2012, two WR cwt fish were observed in the CDFW LF surveys in April. In 2013, a single WR cwt fish was found on the earlier LF survey.

5 – Peterson standardized estimate: This number represents an expanded and corrected Peterson estimate from earlier carcass surveys that allows for comparison of numbers for all years using identical data parameters to generate an estimate. In this estimate, both fresh and non-fresh adult carcasses are used in calculations. In addition grilse numbers and salmon spawning outside of carcass survey area (determined by aerial redd counts) are included. A correction to the Peterson estimate was applied to the 1996-2002 survey results. The correction eliminated the inclusion of tagged fish in the "examined fish" variable of the Peterson formula. A discussion of the details surrounding this correction is available in the 2004 CDFG Winter-run carcass survey report: Appendix 6. Note beginning in 2012 a methods change to Cormack Jolly Seber (CJS) changed the Peterson methods from the 2003-2011 method. In 2012, the Peterson was developed incorporating large ad-clips into tagged fish but keeping the small females out of the Peterson and later expanding for them as similar *to previous years. The 2012 CJS method incorporates all females into CJS eliminating expansion for small females from the "official" CJS but for consistency to previous Peterson methods (what this row is primarily for) it was decided to continue expanding for small females based on fresh fish ratios.*

6 - Reported Peterson estimate: This number represents the Peterson estimate reported in the CDFW reports from 1996-2002. In years 1998-2000 it does not include spawners outside of the carcass area (in 1996-1997 this number was zero, and in 2001-2002 aerial redd data was included). It also includes (except 1996-1997) the data from only fresh adult carcasses. Estimates produced using only fresh carcasses must account for the non-fresh tagged carcasses as fish examined or the Peterson estimate will be incorrect (WR carcass survey annual report, 2004: Appendix 6). This problem is corrected for by using both fresh and non-fresh data in the Peterson Standardized estimate in the row above.

7 – (Cormack-(since 2012) Jolly-Seber in-river + expansions: This number represents the number of in-river spawners estimated with the Jolly-Seber model (and CJS years since 2012) and other expansions (including hatchery in-river spawners, downstream spawners, adult males, and grilse). The Jolly-Seber and now CJS number was the official CDFW estimate since 2001. Due to insufficient recaptures in earlier years, the Jolly-Seber model was unable to be used, because during the calculations in the Jolly-Seber model if recaptures are zero for any recovery period an error is generated as a result of dividing by zero. This problem was prevalent in earlier years when populations were low but this difficulty was eliminated using the CJS method in since 2012.

8 – RBDD estimate: This number results from calculations at the Red Bluff Diversion Dam fish trap and fish ladders. The RBDD numbers go back to 1967 and represent a long-term database for winter-run populations. From 1986 to 2008, the RBDD number was calculated using an average number, which resulted in significantly different numbers from the carcass survey. In 2001, the CDFW recognized that the carcass survey provided an improved method of counting winter-run salmon. The RBDD number was still developed until 2008 to provide a continuation of data trends since 1967. After 2008, the RBDD estimate was discontinued and in fact, the Dam was decommissioned in 2012.

9 – Estimated adult females in-river: This number (from carcass survey) provides an estimate of the number of adult females (jills not included) that can be useful in comparing the number of juveniles produced by the winter-run spawners. The calculation of this number has been "standardized" for the survey years. The numbers in Table 1 years 1996-2000 are based on the standardized Peterson estimates for those years, but these numbers are not the official ones (RBDD was official). From 2001 to present, the number is based on the Jolly-Seber (CJS >2012) estimates (official). The adult female numbers for years 1996 to 2000 from the RBDD "official" reporting are as follows: 1996 = 421, 1997 = 308, 1998 = 1,183, 1999 = 427, and 2000 = 394. This number is useful in calculating the JPE number used by NMFS to determine the number of juveniles produced each year and the subsequent expectations of "take" numbers to be set for the pumping plants in the South Delta.

10 – Carcasses encountered on survey: This number is the total number of individual salmon carcasses encountered during the survey. It does not include the fish recaptured after they *were initially tagged. It can be compared to the total population to determine what proportion of the population was sampled.*

11 – Percent of population observed during survey: This is number of fish encountered divided by the official system estimate. It can give readers a sense of the conditions and efficiency of the survey methods. Note for years 96-2000 this number is based on number of carcasses vs the Peterson carcass estimate and not the official RBDD number.

12 – The date of peak carcasses encountered: This is the date, during each yearly survey, that the most carcasses were found. It does not include recaptured carcasses. It includes all sizes, sexes and hatchery fish. This date can be used to estimate the timing of peak spawning activity. It can be assumed that the peak carcass date precedes peak spawning by a two-week (14-day) period. Thus if peak carcasses occurs on July 15 then peak spawning likely occurred around July 1. Caution in interpreting this data should be used, as often there are two or more peaks or many days of similar but slightly lower counts either earlier or later in survey.

13 – Carcasses tagged (all): This number is the total of all carcasses tagged during the surveys. It includes males and females, hatchery fish and grilse. In earlier surveys, the grilse and adults were recorded as separate categories. Starting in 2003 through 2011 hatchery fish were not tagged on the survey (because head removed) so they were not part of the tagged numbers. Also large (>609 mm) and small (<610 mm) tagged fish tallied separately. Beginning in 2012, hatchery clipped fish were included in tagging methods since the CJS method tags all fish in lower jaw. Population estimates were based on adult (large fish (defined as >609 mm for years 2003-2011, similar-years 96-2002). Since 2012, all females included in CJS and expanded for grilse after a large (adult) estimate was made, (note since 2012 small males continue to be expanded for using fresh fish ratios but small females included in CJS method). Subsequent expansions utilize other data to calculate the final population estimate.

14 – Carcasses chopped (all-mark recapture): In Table 1 this number includes the carcasses (including grilse) that were not tagged and did not have a survey jaw tag in them (recaptures). A chopped carcass is typically non-fresh; meaning it is not suitable for tagging or collecting biological data from. They are checked for survey tags placed in prior periods and then chopped in half to avoid re-counting. In some cases, fresh carcasses were chopped if they had been partially eaten by scavengers. It is also important to note that a recaptured previously tagged carcass is also chopped after the tag color or tag number and location is recorded, but these are not labeled as chopped in the database. For purposes of the Peterson estimate calculation the category labeled "Examined" includes both recaptured and chopped carcasses, but not tagged fish. Note that note 14 was added in 2012. Beginning in 2012 ad-clips were mark-recapture tagged along with non-clipped fish using the protocols of the Cormack Jolly Seber methodology. For years 2003-2011 adipose fin clipped fish were chopped upon first observation and were not part of the mark-recapture study since the whole head was removed for CWT tag collections. Starting in 2012 all carcasses were disc tagged in lower jaw, and crews took CWT heads from only upper jaws so adipose fin clipped fish began being incorporated into CJS mark-recapture study in 2012.

15 – Carcasses chopped (clips years 03-11): This row is an attempt to document the number of fish that were determined to be of (unknown, partial or definitely missing) possible adipose fin clip status before CWT analysis. For years 2003-2011, this row provides the number of heads collected by crews for later CWT analysis. During these years, these ad-clip fish were not part of mark-recapture study as their heads removed upon first observation and they would never have been M-R tagged to begin with. ***Since 2012, the fin clips were included in CJS study so numbers are salmon with possible clips provided for reference only*** *and not added to formula to obtain the total carcasses encountered row formula. For years 1996-2002 methodologies are not fully documented for treatment of these fish and "n/a" is listed. Also note that reports for year 1998 the totals in tagged and chopped rows do not equal the total observed, (difference = 2), no clear explanation for the reporting of these numbers is present in the report.*

16 – Carcasses recaptured (all): This number represents the number of previously tagged carcasses (including grilse) that are recaptured in the subsequent survey periods. It does not include hatchery tags or other types of tags applied when the fish was alive. The survey protocols dictate that all recaptures be chopped upon recapture. This was done to ensure that the surveys were conducted as "sampling without replacement" surveys. Starting in 2004, individually numbered "disc" tags were also applied to fresh carcasses to determine carcass decay times and movements over time. These carcasses were not chopped upon recapture but their first recapture date was used as if they were chopped for purposes of the population estimate protocols, (all subsequent recaptures were ignored for mark-recapture purposes). This type of sampling was still "sampling without replacement" but the data on these disc tagged fish can be used in the future as "sampling with replacement" if desired. In 2012 using the new Cormack-Jolly-Seber method disc tags were applied to all fish and were chopped upon first recapture. This methodology was used to simplify the switch over. The CJS can be conducted using either chop on first recapture or returning disc tagged fish recaptured without chopping them effectively generating multiple recaptures to be used in CJS method. In future years, crews might return to not chopping recaptures depending on fish numbers (e.g., low numbers: recommended no chopping recaptures).

17 – Percent recaptured: This row simply calculates number recaptured divided by the number tagged expressed as a percentage. It is a useful way to see if there was consistency over the yearly surveys. A high percent recapture indicates that many of the tagged fish released are recovered in future survey periods. A high recapture rate generally means that the survey periods were spaced close in time and that a lot of effort by crews was applied to the survey. Water visibility and number of fish both can lead to varying recapture rates. Turbid water makes the decaying tagged fish harder to see and lowers recapture percentages. Fewer fish makes finding any fish difficult and increases the likelihood of scavengers eating the released tagged fish (often observed at the start and end of the surveys). Recapture rates can vary widely throughout the carcass surveys due to flooding and muddy water for brief periods (more common in fall and late-fall surveys). This can have a large effect on the final population estimate, especially if such an episode occurs in the busy part of the survey. A flood immediately following the tagging of many new fish will make recapture of these fish difficult and effectively increase the overall population artificially by making it seem as if many fish were tagged but few recaptured. This is one of many possible biases of carcass surveys, but rarely occurs during the winter-run survey.

18 – Carcasses showing hatchery origin: Carcasses with an adipose fin clip or unknown clip that were determined to be hatchery origin fish based on fin clip status and presence of cwt upon later analysis. In the CDFW databases these fish have "final ad-fin" status of one or greater. This number represents the number of adipose fin clipped (clipped) or coded-wire tagged (CWT) hatchery fish that were collected during the surveys. A carcass is identified as a hatchery fish by the absence of the adipose fin that is clipped off during hatchery tagging when the fish was a juvenile. In some cases the carcass is too decayed (or eaten) to tell if the fin has rotted off or was clipped off. In these "unknown clipped" cases the carcass head was removed and the fish was classified as a hatchery fish if a tag was found or as a natural origin fish if no tag was found. Because some clipped fish shed their CWT there are often fish that are obviously clipped, but when dissected have no tag detected. If crews were positive that it was a clipped, the fish (with no tag detected) was labeled as a hatchery fish even if no CWT was found. Not all hatchery fish found on the surveys were winter-run (these are also included in counts on this row) as some late-fall-run and spring-run fish were encountered. In recent years (2001-present), the vast majority of hatchery fish were winter-run salmon raised at the Livingston Stone National Fish Hatchery. More specific details of hatchery evaluation are located in the USFWS's Annual winter-run carcass survey reports.

19 – Number of coded wire tags found: This number represents the total number of coded wire tags actually recovered by crews dissecting heads. The tag codes 200000 and 400000 are included here (lost and illegible) as these were actual tags present in the fish. Codes returning no-tag detected-100000 or 300000-head not recovered are not included. The number given is the total number of coded wire tags. The number in the parentheses is the number of coded wire tags (included in the total) that were from other runs (i.e., CNFH late fall, or Feather River spring-run).

20 – Percent of hatchery fish in population: This value is the percent of hatchery fish present in the overall total population. It is calculated by survey data and the fresh fish ratios of clipped to natural origin carcasses. The value given here is based upon the database used by the CDFW in generating the population estimate. Values in the USFWS final reports are different before 2009 but generally similar. The differences occur in the methodologies used by the two agencies. From 2003 to 2008, the value given is based on the "final ad-clip" status in the CDFW database. The final ad-clip data attempts to account for all fish sampled in the survey. Fish are listed as natural if they had no adipose fin clip or had an unknown fin clip that no CWT was detected. Fish that were listed as clipped by crews receive a hatchery label. Unknown and partial clipped fish are listed according to the dissection results. Unknowns with CWT are hatchery, those without are natural, this is similar for partials. Another category during dissection is "head lost" or 300000 tag code. In the rare cases of unknown clip and head lost carcasses, the final database status is proportioned to the ratio of the rest of the population. In short, all sampled carcasses are assigned one origin or the other (natural or hatchery).

21 – Number of hatchery fish in population: This number is the number of hatchery fish in the overall population. In February of 2017, this number was revised to incorporate the latest USFWS Hatchery Evaluation numbers from 2001 forward. In earlier versions this USFWS number was from 2009 forward but is now from 2001. For in-depth analysis of hatchery fish populations the Red Bluff USFWS Hatchery Evaluation Program's annual *reports provide a more detailed evaluation of hatchery origin fish. Note this number includes other winter-run observed during the year (CNFH, LF survey, etc)*

21a – Number of hatchery fish in river: This number is the number of hatchery origin fish in the river and not removed for use at the LSNFH. This number does not include the very few non-winter-run hatchery fish observed during the winter-run survey on some years.

22 – Number of winter-run floy tagged and released in river from the Keswick Trap: This is the number of winter-run fish sampled at the Keswick Dam trap that were subsequently released back into the river. Brood stock collection (Dec-July) for Livingston Stone Hatchery requires trucking all the trapped Keswick fish from the trap site to the hatchery at the base of Shasta Dam. Once at the hatchery site, the catch from the trap is sorted for brood stock and the remaining by-catch of salmon is currently floy tagged and trucked back to the boat ramps in Redding for release. These floy-tagged salmon are then later observed as carcasses during the winter-run carcass survey crews. Note the term floy tag is a generalization of an external tag type that is a short straight plastic type tag that is partially injected into the salmon just below the dorsal fin using a gun that inserts the tag with a "T" or "V" shaped barb on the inserted end. This barb locks between the vertebrae of the fish and resists pulling free. Crews can then note the tag number that is outside the body of the fish.

23 – Number of floy tagged carcasses recaptured on winter-run carcass survey: This is the number of fish observed that had floy tags from the earlier live fish tagging that occurred at Livingston Stone Fish Hatchery.

24 – Percent of the total floy-tagged fish recaptured as compared to the total live fish released with floy tags earlier in each year.

25 – Percent males in carcass survey: This value is the percent (of both jacks and adults and hatchery fish) calculated from the fresh fish ratios determined by the survey for years 96-02. Beginning in year 2003 and continuing to the present this percentage is calculated using the number of males determined in the population methodology. This methodology attempts to correct for a known bias that some proportion of male fish leave the carcass survey area alive after spawning and are not available to crews sampling fresh carcasses. This is "corrected" for by using the ratios of large (>609 mm) winter-run males to females observed (alive) at the Keswick Dam Fish Trap (Keswick). This ratio is incorporated into the methodology and generates a large male (>609mm) population estimate. This large male number is used to generate a small male number (<610mm) based on the ratio of these categories in the fresh carcasses sampled database of the survey. Additionally all fresh survey males are plotted by length and frequency to visually estimate a fork length cut-off (see categories below for this value each year). After chart plotting, a cut-off length is selected and the jacks vs. adult male numbers are generated. The percent males from years 2003 to present include all fish including those taken into LSNFH. Years 1996 to 2002 include estimates for in-river fish only.

26 – Percent adult males to all adults in survey: This number compares male to female adults (greater than 2-year-old fish). It incorporates fresh fish survey data for years 96-02 and for years 03-present is based on data from Keswick and survey results (includes LSNFH broodstock fish).

27 – Percent adult males to all fish in survey: This number is similar to above only it compares the percentage of the adult male category to all the other categories (jacks, jills and adult females). It is useful in comparing year-to-year trends and gives some indication of the proportions of other categories (includes LSNFH fish).

28 – Percent jacks to all fish in survey: This number compares 2-year-old males (jacks) (based on length frequency analysis) to all other fish in the survey (includes adult males and adult females and jills (includes LSNFH fish)).

*29 – Number of jacks from survey that were in-river + those in LSNFH: This number is the estimated number of jacks present in the river during the year. From 1996-2002 It represents in river percentages (final carcass estimate * percent jacks) plus the number of LSNFH fish from years 1998 on.*

30 – Percent jacks to all fish from RBDD: This number compares the number of jacks (based on fork length cut-off of <610 mm) to all other winter-run encountered at annually at the RBDD.

31 – Number of jacks from the RBDD expanded for the entire system: This number is the estimated number of jacks present in the river for each year based on RBDD data. It would include jacks entering into LSNFH. It does not include the few winter-run jacks downstream of RBDD.

32 – Fork length cut-off for jacks (mm) from survey: This number is the fork length cut-off determined by biologists after viewing a length frequency graph of male fish lengths. For years 96-02, it was chosen post-survey but may have conflicted with the mark-recapture efforts since mark-recapture requires a pre-season cut-off to determine adult size during data collection efforts. For years 03 to present a 610 mm cut-off is used to collect mark-recapture data on ***small*** *and* ***large*** *carcasses. This eliminates the conflict between mark-recapture data and biological grilse vs. adult data, because the mark recapture generates an estimate, and the number of jacks is derived from within the confines of this estimate after it is complete. Afterwards, the length frequency histogram of all males is observed by biologists and a fork length cut-off is chosen specific to biological data of fresh carcasses independent of mark-recapture data.*

33 – Fork length cut-off for jacks from RBDD data: The traditional cut-off for jacks and jills has been 610 mm. Of note is that Coleman National Fish Hatchery (CNFH) uses 650 as their cut-off for jacks. These two numbers may not be that different since fish migrating past the RBDD site are not yet typically mature. As the male reaches maturity, its upper snout lengthens and fork lengths may increase on some jacks to be comparable with either site's cut-off.

34 – Percent females in carcass survey: Similar to note 25- but for females. Exception is that females are calculated for years 03 to present by the mark-recapture estimate. The assumption made is that large females (for years 2003-2011) and all females (for years 2012-to-present) are truly represented by the mark-recapture survey alone and that no bias is associated with this data. (Unlike males that use Keswick fish trap data).

35 – Percent adult females to all adults from survey: Similar to note 26 except for females.

36 – Percent adult females to all fish from survey: Similar to note 27 except for females.

37 – Percent jills to all fish from survey: Similar to note 28 except for females.

*38 – Number of jills from survey that were in-river + those into LSNFH: Similar to note 29 except for females. From 1996-2002 It represents in river percentages (final carcass estimate * percent jacks) plus the number of LSNFH fish from years 1998 on.*

39 – Fork length cut-off for jills from survey: Similar to note 32 except for females.

40 – Percent adults vs. percent grilse from survey: This number summarizes the proportion of adults and grilse for all winter-run from each year. It includes all adults vs. all grilse (jack and jills). For years 96 to 00 it is based on the standardized Peterson estimate (note 4) for 01-02 it was based on Jolly-Seber in-river estimate (note 6). For years 03 to present, it is based on all fish, including LSNFH fish.

41 – Number of adults vs. number of grilse from survey: These numbers added together equal the standardized Peterson (note 4) for years 96-00. For years 01-02, they equal the Jolly-Seber estimate in-river estimate (note 6) and for years 2003-to-present, equals the overall official estimate including the LSNFH fish.

42 – Percent female spawn success: This number is the ratio of completely spawned to unspawned fresh female fish primarily based on crew's judgment of carcass appearance, (e.g., shrunken abdomen, worn tail). Unsuccessful spawners are those without tail damage or those with more than a small (handful) of eggs remaining in their body cavity. Unspawned winter-run female fish are uncommon. Otters and incidental hooking by trout anglers are thought to be primary causes. Habitat or water quality limitations have not affected, (in any observable way) winter-run in most years, although this is not the case for post-spawning periods while eggs or alevins are in the gravel, water temperatures and flow levels can vary widely during late-summer and fall months.

43 – Average fork length of fresh females: This is the average fork length from the survey's fresh female fish. It does not include fresh fish not measured (these can be eaten in half by scavengers). It may be useful to create an index of female sizes on an annual basis, which may relate to the number of eggs produced by each female.

44 – Number of hatchery juveniles released in-river: This is the number of juvenile winter-run released by the LSNFH staff (typically in late-Jan to early-Feb) in the Redding area. Nearly all juvenile winter-run have a CWT (100% is goal). These fish typically migrate downstream to Delta area immediately following release. Because LSNFH is a conservation hatchery limited to 120 adult fish as brood stock the number of juveniles is relatively fixed and carefully managed to maintain genetic integrity of the overall winter-run population. In 2014 drought related efforts included the inclusion of many more broodstock (N=388) into LSNFH to provide protection against in-river mortality due to warm water. This increased broodstock resulted in higher than normal juvenile releases.

45 – Juvenile Production Estimate (females): This number is a calculation based on a series of constants developed to estimate and predict the number of juvenile winter-run that will be present at various geographical locations along their migration to the ocean. The JPE calculation begins with the number of adult females estimated by the carcass mark-recapture survey. The presented value in the table is the number of juveniles expected to pass the site at the RBDD. Constants in the JPE calculation include, number of eggs per female, egg to fry survival, and survival to RBDD, etc. One primary use of the NMFS developed JPE is to "set" the take number of winter-run juveniles that can be killed at the Delta pumping facilities in the South Delta. In 2014, revisions to the JPE methodology occurred to better account for drought related mortality impacts. It is anticipated that similar revisions may occur in the future as more information becomes available from ongoing focused researched efforts.

46 – Juvenile Production Index (RST-RBDD): This number is developed by the Red Bluff USFWS office. It is based on the catch of juvenile winter-run in the RBDD rotary screw traps. The winter-run catch of both fry and smolt sized fish is used to develop the JPI number, (note this is the JPI with fry equivalents-meaning smolt numbers have been augmented to the equivalent number of fry they represent) which is based on actual numbers of juveniles at the RBDD, in contrast to the JPE estimate that is based on the number of adults that produced the juveniles observed at RBDD. Both the JPI and JPE are designed to give fisheries agencies the tools to better manage water distribution in the Central Valley to aid survival of winter-run salmon.

47 – Cohort Replacement Rate: This number is a measure of the total winter-run numbers from one generation to the next (includes hatchery fish). It is basically the current year's total population divided by the population from three years previous. Winter-run are considered to primarily have a three-year life cycle. The CRR gives an idea of the trend for winter-run yearly size classes. A number greater than 1.0 represents a growing population and less than 1.0 represents that the population is shrinking (i.e. the adult fish from three years previous produced less adults three years later). Readers are cautioned against rigorous analysis of this number as many factors can influence this number making it only useful for trends.

48 – Total number of winter-run redds observed: This is the total number of new redds counted by observer on helicopter or fixed wing plane. Typically, the flights are flown from mid-April to late August. Only new redds are counted and counting normally starts at Woodson Bridge in near the town of Corning and goes upstream to Keswick Dam. In 2014 due to warm drought water later flights began at the RBDD.

49 – Percent of redds within the survey area: This number represents the percentage of new redds observed within the boundaries of the carcass survey by the CDFW's aerial redd flights. The carcass survey area (see note 52) presently goes from Balls Ferry upstream to Keswick Dam. These flights are to count new redds and determine the spawning distributions of all salmon runs on the Sacramento River. The winter-run flights are typically done in helicopters (an airplane if no helicopter is available) and begin downstream of RBDD at Woodson Bridge. If winter-run redds are observed outside of the survey area the population estimate is expanded by the percent of redds noted outside the boundaries.

50 – Survey start date: The date in which new fresh fish are tallied as winter-run salmon. Typically, carcass surveys are ongoing year round on the Sacramento River. After the winter-run survey commences any older recaptures from the late-fall survey (few) are removed from winter-run databases. After two weeks from the start date all fish (decayed, skeletons, etc) encountered are tallied as winter-run.

51 – Survey end date: This date typically represents the end of the intensive seven days per week sampling for winter-run carcasses. Some fresh fish observed during the last few days of the survey may be transferred to the subsequent fall-run survey that begins soon after the winter-run survey ends. When the fall survey begins immediately following the winter-run survey some categories of fish are moved around in the post-season analysis to account for stray fish, (e.g., a disc tag recaptured fish from the winter-run survey found on the fall-run survey would be added into the winter-run survey database).

52 – Number of survey periods: This is the number of survey periods typically characterized by a single pass through the entire survey area marking fish with a single color tag. A new period starts the next day (2003 to present; periods are 3 days long). A survey period starts at the downstream end of the river distance being surveyed and continues until the crews reach near the Keswick Dam.

53 – Survey river mile range: This category lists the range of river miles surveyed by crews from 1996 to present. Surveys have shortened or lengthened based on opinions of biologists to ensure that the majority of winter-run spawning is encompassed by the carcass survey.

54 – Flow range in cfs: This cubic feet per second river volume number is determined post season by analysis of Keswick outflow data on the CDEC website using the gauge labeled "KES" or beginning in 2013 the "KWK" gauge as the KES malfunctioned.

55 – Water temperature: This number is determined by crews taking a single water temperature using a low-cost thermometer at the end of each day in the section just completed. It should not be used for rigorous analysis of temperature relationships for winter-run.

56 – Visibility range: This number is the visibility in feet observed by the crews after finishing each day. It is taken in conjunction with the water temperature measurement above. Due to the large variability in techniques and crews over the years, it should not be used for in-depth analysis of data. It is designed to provide a general sense of the daily visibility conditions (e.g., wind, glare, turbidity) that crews encounter on the river. For years 1996-2002, a Secchi disc was lowered on a flexible measuring tape into a deep hole on the river and the resulting depth at which it was no longer visible recorded. For years 2003 to present a Secchi disc was attached to a rigid measuring pole and the depth at which the disc was no longer visible was recorded. A "+" after a number in this category means that the Secchi was visible past the depth available for crews to reach (i.e., either to the river bottom or the length of the pole).

Appendix C1 Table C1. Summary of the 1996 to 2016 winter-run carcass survey data categories. (Use zoom function of Software-(hold Ctrl button down while rolling mouse wheel) for viewing details of file).

Category	Note	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Official total System estimate	1	1337	880	2998	3289	1353	8,223	7,459	8,218	7,869	15,839	17,297	2,543	2,830	4,537	1,596	827	2,673	6,086	3,015	3,440	1,548
In-river spawner estimate	2	1,012	836	2,889	3,264	1,263	8,120	7,360	8,133	7,784	15,730	17,197	2,487	2,725	4,416	1,533	738	2,578	5,920	2,627	3,182	1,409
Into Hatchery (CNFH or LSNFH)	3	325	44	103	24	89	102	96	85	85	109	94	55	105	121	63	86	93	164	388	257	137
Other Winter-run (e.g. -Battle, LF survey)	4	237	226	6	1	1	1	3	0	0	0	6	1	0	0	0	3	2	2	0	1	2
Peterson Standardized estimate	5	273	564	2,162	1,136	4,290	6,760	6,106	6,602	6,205	13,549	13,919	2,161	2,448	3,307	1,338	712	2,246	5,198	2,475	2,454	829
Reported Peterson estimate	6	820	2,053	5,501	2,262	6,670	11,502	10,541	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cormack / Jolly-Seber in-river + expansions	7	n/a	n/a	n/a	n/a	6,023	8,120	7,360	8,133	7,784	15,730	17,197	2,487	2,725	4,416	1,533	824	2,673	6,086	3,015	3,440	1,548
RBDD estimate	8	1,337	880	2,992	3,288	1,352	5,523	9,169	9,757	7,192	5,299	7,436	6,144	3,635	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estimated Adult Females in-river-survey	9	193	395	1908	817	3,483	5,262	5,682	5,179	3,252	9,005	8,807	1,542	1,462	2,717	822	424	1,498	3,613	1,698	2,058	560
Carcasses Encountered on survey	10	118	239	785	475	2,482	5,145	4,959	4,549	3,280	8,771	7,698	1,581	1,409	1,904	908	430	1,348	3,219	1,389	1,194	297
Percent of Population Observed on survey	11	43%	42%	36%	42%	58%	63%	66%	55%	42%	55%	45%	62%	50%	42%	57%	52%	50%	53%	46%	35%	19%
Date of peak carcasses encountered	12	15-July	11-July	01-July	22-June	02-July	08-July	15-July	11-July	15-July	23-July	14-July	14-July	5-July	5-July	4-July	21-July	22-July	19-July	6-July	17-July	21-July
Carcasses Tagged (all fish)	13	86	191	575	313	2,000	4,364	3,770	3,457	2,072	4,758	4,121	1,063	841	1,146	582	253	881	1,734	731	721	223
Carcasses Chopped (all-mark-recapture)	14	32	48	208	162	482	781	1,189	882	958	2,448	2,656	427	502	606	189	134	467	1,485	658	473	74
Carcasses Chopped (clips years 2003-2011)	15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	210	250	1,565	921	91	66	152	137	43	388	183	211	213	83
Carcasses Recaptured (all)	16	13	22	75	57	829	2,200	2,159	2,175	1,128	3,001	2,206	716	475	401	384	124	533	990	335	252	59
Percent Recaptured (all)	17	15%	12%	13%	18%	41%	50%	57%	63%	54%	63%	54%	67%	56%	35%	66%	49%	60%	57%	46%	35%	26%
Carcasses showing hatchery origin	18	0	5	4	4	4	155	208	179	250	1,565	885	83	60	137	112	32	362	158	196	195	76
Number of CWT's found	19	0	5 (0)	2 (0)	2 (1)	1 (1)	124 (0)	148 (8)	134 (0)	168 (1)	1269 (1)	776 (0)	66 (1)	46 (1)	116 (1)	100 (4)	21 (0)	312 (0)	133 (3)	168 (1)	161 (0)	71 (1)
Percent Hatchery Fish in Population	20	0	2.1%	0.5%	0.8%	0.2%	5.2%	7.6%	5.1%	8.1%	19.3%	13.8%	5.6%	6.0%	10.3%	12.5%	9.7%	30.3%	6.6%	23.4%	22.4%	30.1%
Number of Hatchery Fish in Population	21	0	12	11	10	7	429	566	423	636	3,056	2,386	143	170	467	199	80	810	399	705	770	466
Number of Hatchery Fish in-river	21a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	413	628	3,048	2,379	134	161	461	197	79	808	399	454	638	358
Number of WR Floy tags released	22	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of WR Floy tags recaptured	23	n/a	n/a	n/a	n/a	20	106	100	152	261	281	219	103	93	157	359	293	714	197	41	177	303
Percent of Floy tags observed	24	n/a	n/a	n/a	n/a	0%	1%	5%	17%	4%	12%	15%	10%	10%	8%	7%	3%	6%	10%	0%	6%	7%
Percent males: survey and LSNFH (>2002)	25	n/a	n/a	n/a	n/a	0%	1%	5%	17%	4%	12%	15%	10%	10%	8%	7%	3%	6%	10%	0%	6%	7%
Percent adult males to all adults: survey	26	13%	24%	10%	11%	17%	29%	18%	32%	43%	38%	48%	35%	42%	38%	45%	28%	39%	34%	29%	35%	37%
Percent adult males to all fish: survey	27	11%	22%	10%	9%	16%	26%	17%	30%	32%	35%	47%	33%	39%	38%	44%	21%	37%	32%	26%	34%	22%
Percent jacks to all fish: survey	28	18%	4%	2%	17%	2%	9%	5%	6.1%	25.9%	7.3%	1.9%	5.2%	7.3%	1.1%	2.4%	13%	5%	7%	9%	1%	32%
Number of Jacks: survey + into LSNFH	29	50+n/a	21+n/a	40+0	189+12	90+17	738+22	360+15	496+8	2015+26	1110+4	327+0	129+2	203+4	48+1	39+0	87+22	142+2	393+2	183+88	43+6	420+67
Percent jacks to all fish: RBDD	30	42%	37%	18%	58%	46%	65%	13%	34%	64%	30%	35%	51%	58.6%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Number of jacks from RBDD-system	31	564	328	522	1,907	620	3,566	1,152	3,282	4,570	1,604	2,630	3,140	2,131	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fork length cutoff for jacks (mm): survey	32	< 645	< 645	< 595	< 635	< 605	< 665	< 685	< 610	< 710	< 670	< 660	< 670	< 670	< 670	< 670	< 705	< 645	< 675	< 700	< 610	< 710
Fork length cutoff for jacks (mm): RBDD	33	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Percent females in carcass survey	34	71%	75%	88%	75%	82%	65%	78%	64%	42%	57%	52%	62%	53.5%	61.4%	53.5%	65.4%	57.9%	62.0%	65.1%	64.2%	46.4%
Percent adult females to all adults: survey	35	87%	76%	90%	89%	83%	71%	82%	68%	57%	62%	52%	65%	57.8%	62.0%	54.8%	72.4%	61.2%	65.9%	70.9%	65.1%	63.1%
Percent adult females to all fish: survey	36	71%	70%	88%	72%	81%	64.30%	77%	64%	42%	57%	51%	62%	53.5%	61.3%	53.4%	55.9%	57.9%	60.8%	63.2%	64.0%	37.7%
Percent jills to all fish: survey	37	0%	4.7%	0%	2.9%	0.6%	0.4%	0.7%	0.5%	0.5%	0.3%	0.3%	0.3%	0.0%	0.1%	0.1%	9.5%	0.0%	1.1%	1.9%	0.2%	8.7%
Number of Jills: in-river + into LSNFH	38	0+n/a	27+n/a	0+3	32+0	25+0	33+0	51+0	39+0	40+1	42+0	51+0	8+0	0+0	5+0	2+0	66+12	0+0	67+0	46+11	5+2	98+37
Fork length cutoff for jills (mm): survey	39	< 645	< 645	< 595	< 595	< 585	< 605	< 545	< 610	< 610	< 600	< 590	< 600	< 600	< 600	< 580	< 645	< 540	< 626	< 610	< 575	< 630
Percent Adults vs Percent Grilse-survey	40	82%-18%	92%-8%	98%-2%	80%-20%	97%-3%	90%-10%	94%-6%	93%-7%	74%-26%	93%-7%	98%- 2%	95%-5%	92%-8%	99%-1%	97%-3%	77%-23%	95%-5%	92%-8%	89%-11%	98%-2%	60%-40%
Number Adults vs Number Grilse-survey	41	223 - 50	516 - 48	2122 - 40	915 - 221	4175- 115	7349- 771	6949- 411	7675- 543	5786- 2083	14683-1156	16918-378	2402- 139	2622-207	4483-54	1555-41	637-187	2527-144	5576-462	2688-328	3383-56	924-622
Percent female spawn success	42	95%	96%	95%	97%	100%	99%	99%	99%	99%	98%	98%	98%	98%	99%	99%	99%	99%	99%	99%	98%	99%
Average fork length (mm) fresh females	43	n/a	n/a	n/a	n/a	n/a	n/a	n/a	739	760	757	756	770	766	752	748	732	715	806	748	721	691
Number hatchery juveniles released in-river	44	4,718	21,271	153,909	30,840	166,206	252,684	233,613	218,617	168,261	173,344	196,288	71,883	146,211	198,582	123,859	194,264	181,857	205,224	609,311	420,006	141,388
Juvenile Production Estimate (females)	45	550,872	1,386,346	4,676,143	1,490,249	4,946,418	5,643,635	6,964,626	6,181,925	2,786,832	12,109,474	11,818,006	1,864,521	1,952,614	3,728,444	1,049,385	512,192	1,809,584	4,431,054	2,409,171	2,630,547	166,189
Juvenile Production Index (RST RBDD)	46	469,183	2,205,163	5,000,416	1,366,161	n/a	n/a	7,635,469	5,781,519	3,677,989	8,943,194	7,301,362	1,637,804	1,371,739	4,972,954	1,572,628	996,621	1,785,259	2,481,324	523,839	440,951	613,675
Cohort Replacement Rate	47	3.5	4.7	2.3	2.5	1.5	2.7	2.3	6.1	1.0	2.1	2.1	0.3	0.2	0.3	0.6	0.3	0.6	3.8	3.6	1.3	0.3
Total number of winter redds observed	48	43	30	141	1,146	572	1,396	610	878	621	1,968	717	288	441	86	223	18	261	569	127	196	18
Percent of redds within survey	49	100%	100%	94%	92.5%	72.1%	89.5%	95.9%	99.3%	100%	100%	99.7%	96.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Survey Date Start	50	4-Apr	30-Apr	5-May	5-May	3-May	2-May	1-May	30-Apr	30-Apr	28-Apr	1-May	1-May	1-May	4-May	3-May	2-May	30-Apr	30-Apr	29-Apr	28-Apr	2-May
Survey Date End	51	5-Sep	29-Aug	28-Aug	27-Aug	29-Aug	29-Aug	27-Aug	4-Sep	3-Sep	2-Sep	25-Aug	24-Aug	22-Aug	28-Aug	27-Aug	1-Sep	2-Sep	5-Sep	11-Sep	17-Sep	15-Sep
Number of Survey Periods	52	19	41	39	38	40	40	40	41	43	43	39	39	38	39	39	41	42	43	43	45	45
Survey River Mile Range	53	271 -301	288 -301	288 -301	288 -301	288 -301	288 -301	288 -301	286.5 -301	273.5-301	273.5-301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301	276 - 301
Flow range (cfs x 1000)	54	7 - 16	8 - 15	10 - 23	9 - 13	8 - 16	8 - 15	7 - 15	8 - 29	8 - 16	4 - 37	6 - 15	8 - 15	8 - 13	7 - 13	7 - 15	6 - 19	6 - 14	7 - 14	4 - 11	7 - 7.5	5-10.7
Water temp (^{o}F) range	55	52 - 59	49 - 52	50 - 54	50 - 54	51 - 54	50 - 55	50 - 56	50 - 54	50 - 57	51 - 59	50 - 56	50 - 58	50 - 58	51 -58	49 - 54	50 - 57	50 - 55	50 - 58	50- 59	53- 60	51-56
Visibility range (ft)	56	n/a	3 - 10	4.5 - 11	6 - 11	9 - 21	14 - 21	17 - 22	8 - 15+	8.5 - 16	2 - 16+	5 - 13	2.5 - 20+	10.5 - 16+	2 - 11	4 - 16+	5 - 14	6 - 15+	8 - 15+	7 - 15+	7 - 15	5-10

APPENDIX D – Cormack-Jolly-Seber and Video Station Methods and Information

Appendix D1. Cormack Jolly Seber Mark-Recapture Analysis for carcass surveys using R.

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This document contains instructions for analyzing Chinook Salmon carcass mark-recapture data with the super-population modification to the Cormack-Jolly-Seber (CJS) analysis and the R program, using code developed by WEST, Inc.. For a detailed description of the recommended survey protocol and statistical analysis procedures see Chapter 4 of the California Central Valley Chinook Salmon Escapement Monitoring Plan (Bergman et al. 2011).

Analysis Steps:

1) Place the following files in the same folder on your computer (**not** on your desktop):
   a. "CJS v2.2.R",
   b. A .csv file containing capture histories for individually marked carcasses. See "Capture History Matrix Examle.csv"
   c. (Potentially) a .csv file containing information regarding carcasses that were chopped (i.e., removed from the survey) on 1st capture. See "Chops Table Example.csv".
   d. (Potentially) a .csv file containing covariates for marked carcasses. See "Covariate Table Example.csv"

2) Open R by double-clicking on the R icon on your desktop or via the Start menu.
   a. Direct R to the folder described in Step (1) via **File -> Change dir..**
3) On the R Console command prompt, type
   source("CJS v2.2.R")
4) Answer questions at the prompts. Note that multiple models can be selected at once.
5) Once the best model has been identified (lower QAICc is better), in R hit the up arrow and then return, or type in the following line of code (again)
   source("CJS v2.2.R")

Literature Cited

Bergman, J. M., R. M. Nielson, and A. Low. 2011. California Central Valley Chinook Salmon escapement
monitoring plan. Pacific States Marine Fisheries Commission and California Department of Fish and Game.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. ISBN 3-900051-07-0. URL: http://www.R-project.org/

Source R. Neilson, WEST Inc, pers. comm.

Appendix D2. Expanding the Cormack-Jolly-Seber estimate of Chinook Salmon Escapement in the mainstem of the Sacramento River with aerial redd count information.

Chinook Salmon spawning habitat in the mainstem of the Sacramento River covers many river miles, and the lower section (~1/2) is very wide and river access is problematic. A carcass mark-recapture survey (the superpopulation modification to the Cormack-Jolly-Seber) is recommended for estimating Chinook Salmon escapement in the upper section of the river (E_1). However, it has been determined that a mark-recapture survey is not logistically feasible for the lower section. Historically, total escapement for the entire river (E_{total}) has been estimated by multiplying an expansion factor (c) to $\hat{E}_1$. This expansion factor comes from repeated aerial redd surveys over both sections of the river. Thus,

$$\hat{E}_{total} = (\overline{1 + R_2 / R_1}) \times \hat{E}_1, \qquad [1]$$

where $\overline{1 + R_2 / R_1} = c$ is the average ratio of redds counted in the downstream section to the redds counted upstream.

Assuming independence between the expansion factor (c) and total escapement in the upper section of the river, the $\mathrm{var}\left(\hat{E}_{total}\right)$ can be estimated using the following:

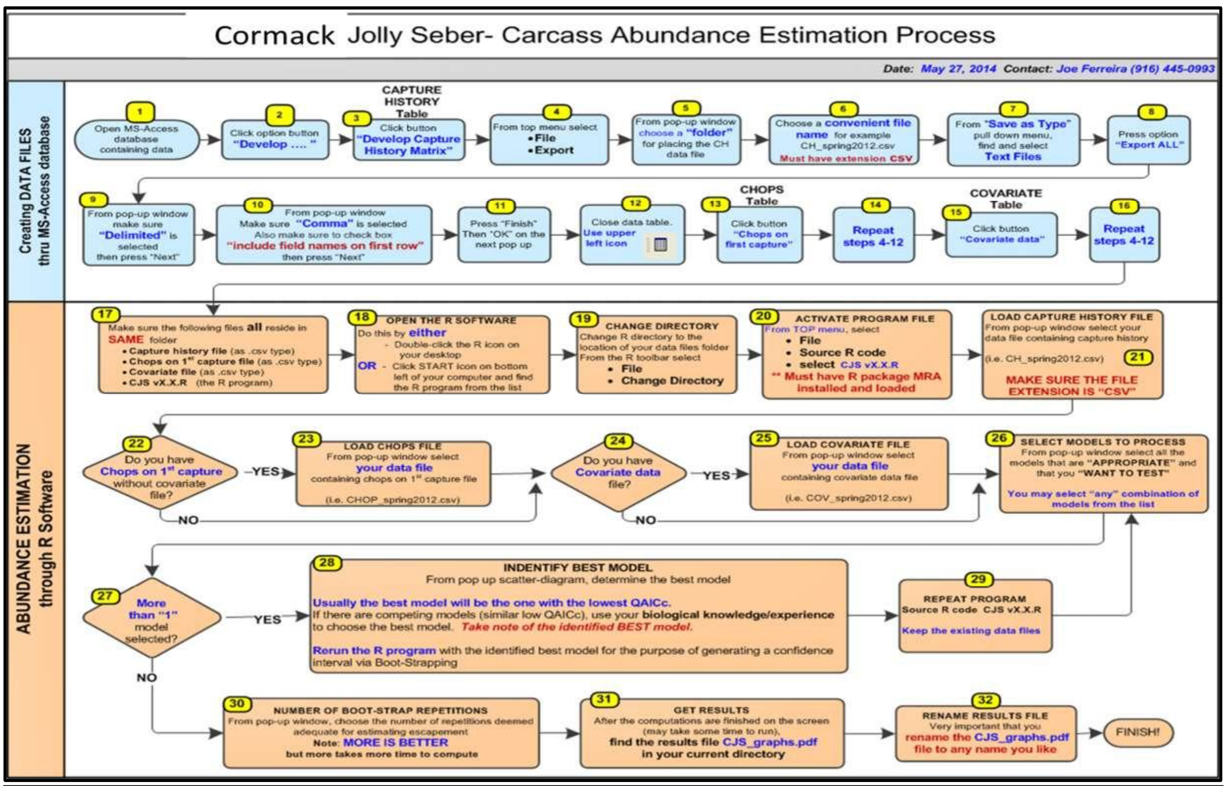
$$\widehat{var}(E_{total}) = [[c]^2 \times \widehat{var}(E_1)] + \left[\left([\widehat{E_1}]\right)^2 \times \widehat{var}\left(1 + \frac{R_2}{R_1}\right)\right] - \left[\widehat{var}(E_1) \times \widehat{var}\left(1 + \frac{R_2}{R_1}\right)\right]$$

,

where $\widehat{var}(E_1)$ is the estimated variance for the total escapement in the upper section, which is obtained via bootstrapping and the superpopulation CJS model, and $\widehat{var}\left(1 + \frac{R_2}{R_1}\right)$ is the estimated variance of the expansion factor (c) from multiple aerial surveys.

Equation [1] provides an estimate of total escapement for the portion of river (upper and lower sections) surveyed. Assumptions necessary for equation [1] to produce unbiased estimates of total escapement are: (1) productivity (number of redds per fish) is the same in the upper and lower river sections; (2) probability of redd detection is similar in both the upper and lower sections; and (3) the same survey protocol, including flight path and effort, is used during all repeated aerial surveys within a spawning season.

Source: R. Neilson, WEST Inc., pers. comm.



Appendix D2 Figure D1. Flow chart of steps for developing escapement estimates using the Cormack-Jolly-Seber methodology. Source: J. Ferreria, CDFW pers. comm.

Appendix D3. Estimating Escapement Using Device Counters.

This document describes how to estimate escapement from device counter (e.g., video camera) monitoring data using R (R Development Core Team 2012) and code developed by WEST, Inc. A statistical analysis has been developed for the following situations:

1. Device counter results are recorded for each 'segment' of each day during the season. Segments are likely to be 1/2-hour or 1-hour in length. Segments when the device counter was not operational, or results are not reliable, are represented in the data with count=NA.
2. A portion of the original counts are reviewed (QC'ed) by an 'expert' or preferably a team (e.g., 3 or more) of experts who arrive at a consensus on what is the true net upstream count. For example, a systematic sample of segments with non-missing counts is reviewed by 3 observers who come to a consensus on the true net count. These 'truths' are then compared to the original counts. Another example involves reviewing and coming to a consensus for all extremely large counts (counts >= x), and then getting consensus on a sample of counts < x.
3. A combination of 1) and 2) above.

For simplicity, the statistical analysis is described below using video monitoring data as an example, but these methods could also apply to fish counts from Vaki Riverwatcher® or dual frequency identification sonar (DIDSON) (or ARIS) equipment. See Bergman et al. (2012; Chapter 2) and Killam et al. (2012) for more discussion on use of device counters for monitoring Chinook Salmon escapement.

First (Situation 1), a trained observer views each video segment and records the net number of fish passing upstream. Thus, fish passing downstream are subtracted from the total passing upstream. This net passage is referred to as the **original count** for a video segment. If the device counter was not 100% operational (Situation 1), a generalized additive model (GAM; Wood 2006) is used to impute the missing counts. The model relates the net daily count, divided by the proportion of the day the video equipment was operational, to a smoothed function of the daily totals. This results in adjustments of counts for days when the video equipment was operational for only a portion of the day, and imputation of counts for days when the equipment was not in use.

During GAM estimation, Akiake's information criterion (AIC; Burnham and Anderson 2002) is used to choose the basis-dimension for the smoothing, and then generalized cross validation is used for smoothness selection. A Poisson GAM is used. If necessary, counts are transformed prior to modeling to better represent a Poisson distribution (e.g., shifted up if some net counts are negative), and GAM-based imputations are then back-transformed for estimation of final escapement.

Second (Situation 2), if there is uncertainty in original video counts, a systematic sample of segments is reviewed by one or more (preferably 3) experts. The experts reach a **consensus count** on the net count for each sampled segment. A systematic sample can be obtained by arranging the video segments in sequential order, sorted by date and time, and then selecting every i^{th} segment for review. The recommended minimum sample size is 75, but obviously more is better, and the number of segments reviewed should depend on the uncertainty in the original counts.

The analysis code developed for this type of data allow for an alternative to this approach, which involves a thorough review of all video segments with an original count $\geq x$, and then review of a sample of segments with counts $< x$. This scenario was developed on the idea that larger original counts may be less precise, and thus require a higher level of review. Regardless, the ratio of original counts to consensus counts based on the reviewed video segments is used to adjust the remaining original counts. For example, if the sum of the consensus counts is 100, and the sum of original counts for the same video segments is 95, the net counts from video segments not sampled are adjusted by dividing by 0.95 – if the sample of original counts are on average lower than the consensus counts by 5%, then the original counts need to be adjusted by 5%. In this situation Total escapement is estimated by summing the adjusted counts and any imputed counts.

If a sample of segment counts is reviewed and a consensus count is obtained (Situation 2), the ratio of original/consensus counts is used to adjust all non-consensus counts. The consensus and adjusted counts are used as the response in the GAM in place of the original counts if there are missing values.

Finally, given Situation 1 and/or 2, total escapement is estimated using a combination of daily totals of consensus counts (Situation 2), adjusted counts (Situation 1 or 2), and imputed counts (Situation 1). A ninety percent confidence interval (CI) for the final escapement estimate is calculated by bootstrapping (Manly 2006) the segment counts and re-running the entire analysis 500 times on the re-sampled data.

See 'DeviceCount1.csv' for example data with missing counts (Situation 1). See 'DeviceCount12.csv' for an example of Situations (1) and (2). When creating data for use with "DeviceCounterAnalysis v2.2.r", follow the same data format (e.g., date 9/15/2012 and time 4:00:00 AM) as shown in the examples, including the names and order of the columns.

If you don't have R installed on your computer, see "Installing R.pdf". You will also need the **chron** and **mgcv** contributed packages (instructions for downloading packages are in "Installing R.pdf").

Analysis Steps:

1. Place the following files in a unique folder (e.g., 2012 Cottonwood Creek R-files) on your computer (**not** on your desktop):
    a. “DeviceCounterAnalysis v2.2.r”,
    b. A .csv file containing the device counter data of interest. See “DeviceCount1.csv” and "DeviceCount12.csv", for examples of correct formats and number of columns, etc.
2. Open R by double-clicking on the R icon on your desktop or via the Start menu.
    a. Direct R to the folder described in Step (1) via
        a. **File –> Change dir..** ,
3. At the R Console command prompt (>), type exactly:
    1. **source("DeviceCounterAnalysis v2.2.r")**
4. Identify the data source (e.g., your data in a .csv file format) when prompted, and

5. Select a maximum limit of the number of degrees of freedom (df) available for GAM estimation, represented in terms of a proportion. The default is 0.95, or 95%. More df available can result in tighter fit, but larger values can also result in problems – which should produce error messages in R – when the data are particularly troublesome (e.g., highly variable). If error messages are printed to the R console prior to estimates of confidence interval endpoints, then re-run the analysis and choose a lower value during this step (e.g., 0.90), decreasing the proportion of df available for GAM estimation until no error messages are encountered.
6. When R is finished processing the data it will copy a file titled "AdjustedCounts.csv to your assigned directory. This file contains a summary of the original, consensus, and the R generated adjusted counts that can be used to summarize, by segment, (e.g., half hour) your data set.
7. The R console also provides a summary of information on the total escapement, confidence intervals, and imputed counts (if any) resulting from the analysis of your data. If desired these can simply be pasted from R into a spreadsheet or document to allow further analysis. An example of this reporting and use of imputed counts is available in the file titled (BTVS 2012.xls). The R program will also produce a graph of the dataset if there were imputed counts (Situation 1) comparing the GAM estimation to the original counts. This graph can be saved in various picture formats for later reporting.

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Bergman, J. M., R. M. Nielson, and A. Low. 2012. Cetral Valley in-river Chinook Salmon escapement monitoring plan. California Department of Fish and Game, Sacramento, CA, USA.

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Manly, B. F. J. 2006. Randomization, Bootstrap and Monte Carlo Methods in Biology, Third Edition. Third edition. Chapman and Hall/CRC.

Wood, S. N. 2006. Generalized Additive Models: An Introduction with R. Chapman & Hall, London, England.

Source: R. Neilson, WEST Inc., pers. comm.

APPENDIX E – Image of GrandTab File With 2016 Data

Note to readers: The information below is a **partial** version of the GrandTab file. The full electronic version is available online at the following site: http://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp Then click on the GrandTab file.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab Date Compiled: **4/7/2017**

CHINOOK SALMON ESCAPEMENT - ALL RUNS

CENTRAL VALLEY: Sacramento and San Joaquin river systems

LATE-FALL			
YEAR	Hatcheries	In-River	TOTAL
Nov 1989 - Apr 1990	92	7,986	**8,078**
Nov 1990 - Apr 1991	161	8,102	**8,263**
Nov 1991 - Apr 1992	344	9,787	**10,131**
Nov 1992 - Apr 1993	528	739	**1,267**
Nov 1993 - Apr 1994	598	291	**889**
Nov 1994 - Apr 1995	323	166	**489**
Nov 1995 - Apr 1996	1,337	48	**1,385**
Nov 1996 - Apr 1997	4,578		**4,578**
Nov 1997 - Apr 1998	3,079	39,340	**42,419**
Nov 1998 - Apr 1999	7,075	8,683	**15,758**
Nov 1999 - Apr 2000	4,181	8,702	**12,883**
Nov 2000 - Apr 2001	2,439	19,374	**21,813**
Nov 2001 - Apr 2002	4,186	36,220	**40,406**
Nov 2002 - Apr 2003	3,183	5,699	**8,882**
Nov 2003 - Apr 2004	5,166	8,984	**14,150**
Nov 2004 - Apr 2005	5,562	10,720	**16,282**
Nov 2005 - Apr 2006	4,822	10,267	**15,089**
Nov 2006 - Apr 2007	3,361	15,482	**18,843**
Nov 2007 - Apr 2008	6,334	4,038	**10,372**
[Nov 2008 - Apr 2009]	6,436	3,760	**10,196**
[Nov 2009 - Apr 2010]	5,505	4,481	**9,986**
[Nov 2010 - Apr 2011]	4,637	3,811	**8,448**
[Nov 2011 - Apr 2012]	3,048	2,938	**5,986**
[Nov 2012 - Apr 2013]	3,615	5,389	**9,004**
[Nov 2013 - Apr 2014]	4,869	8,181	**13,050**
[Nov 2014 - Apr 2015]	6,827	2,583	**9,410**
[Nov 2015 - Apr 2016]	2,351	3,262	**5,613**

WINTER		
YEAR	TOTAL	RBDD
Dec 1989 - Apr 1990	430	402
Dec 1990 - Apr 1991	211	211
Dec 1991 - Apr 1992	1,240	1,196
Dec 1992 - Apr 1993	387	378
Dec 1993 - Apr 1994	186	186
Dec 1994 - Apr 1995	1,297	1,290
Dec 1995 - Apr 1996	1,337	1,337
Dec 1996 - Apr 1997	880	880
Dec 1997 - Apr 1998	2,992	2,930
Dec 1998 - Apr 1999	3,288	3,288
Dec 1999 - Apr 2000	1,352	1,352
Dec 2000 - Apr 2001	8,224	5,499
Dec 2001 - Apr 2002	7,441	9,157
Dec 2002 - Apr 2003	8,218	9,724
Dec 2003 - Apr 2004	7,869	7,192
Dec 2004 - Apr 2005	15,839	5,299
Dec 2005 - Apr 2006	17,296	7,415
Dec 2006 - Apr 2007	2,541	6,144
Dec 2007 - Apr 2008	2,830	3,635
[Dec 2008 - Apr 2009]	4,537	
[Dec 2009 - Apr 2010]	1,596	
[Dec 2010 - Apr 2011]	827	
[Dec 2011 - Apr 2012]	2,671	
[Dec 2012 - Apr 2013]	6,084	
[Dec 2013 - Apr 2014]	3,015	
[Dec 2014 - Apr 2015]	3,440	
[Dec 2015 - Apr 2016]	1,546	

YEAR	SPRING			FALL		
	Hatcheries	In-River	TOTAL	Hatcheries	In-River	TOTAL
1990	1,893	5,790	**7,683**	25,725	62,128	**87,853**
1991	4,303	1,623	**5,926**	28,611	103,844	**132,455**
1992	1,497	1,547	**3,044**	31,249	79,164	**110,413**
1993	4,672	1,404	**6,076**	32,807	132,616	**165,423**
1994	3,641	2,546	**6,187**	45,622	175,045	**220,667**
1995	5,414	9,824	**15,238**	49,249	280,919	**330,168**
1996	6,381	2,702	**9,083**	41,960	309,591	**351,551**
1997	3,653	1,540	**5,193**	78,888	323,909	**402,797**
1998	6,746	24,903	**31,649**	78,918	167,108	**246,026**
1999	3,731	6,369	**10,100**	54,444	359,815	**414,259**
2000	3,657	5,587	**9,244**	58,361	427,320	**485,681**
2001	4,135	22,528	**26,663**	68,709	555,922	**624,631**
2002	4,189	20,854	**25,043**	106,001	766,668	**872,669**
2003	8,662	22,035	**30,697**	126,763	464,229	**590,992**
2004	4,212	12,938	**17,150**	128,275	258,573	**386,848**
2005	1,774	21,319	**23,093**	193,411	244,282	**437,693**
2006	2,181	10,725	**12,906**	84,883	208,071	**292,954**
2007	1,916	9,228	**11,144**	23,641	73,527	**97,168**
2008	1,460	11,927	**13,387**	19,100	52,191	**71,291**
[2009]	989	3,440	**4,429**	22,703	30,426	**53,129**
[2010]	1,661	2,962	**4,623**	51,726	111,463	**163,189**
[2011]	1,969	5,805	**7,774**	103,681	123,917	**227,598**
[2012]	3,738	18,688	**22,426**	143,326	197,493	**340,819**
[2013]	4,294	19,402	**23,696**	112,998	334,623	**447,621**
[2014]	2,776	7,125	**9,901**	60,667	195,553	**256,220**
[2015]	4,440	1,195	**5,635**	53,528	99,127	**152,655**
[2016]	1,659	6,453	**8,112**	47,678	84,796	**132,474**

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA

Appendix E Figure E1. Image of CDFW GrandTab file summary of salmon counts for selected USRB streams.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab

Date Compiled: 4/7/2017

CHINOOK SALMON ESCAPEMENT - LATE-FALL RUN

SACRAMENTO RIVER SYSTEM

YEAR	SACRAMENTO RIVER MAIN STEM						Battle Creek 5/							Feather River		TOTAL LATE-FALL RUN
	Upstream of RBDD 1/			Downstream of RBDD												
	In-River 2/	Coleman NFH 3/	TOTAL	TCFF 4/	In-River	TOTAL	In-River Above CNFH	Coleman Hatchery	TOTAL	Clear Ck	Cotton-wood Ck	Salt Ck	Craig Ck	In-River	Hatchery	
Nov 2006 - Apr 2007	13,798	66	13,864		1,477	1,477	72	3,361	3,433	69						18,843
Nov 2007 - Apr 2008	3,673	0	3,673		291	291	19	6,334	6,353	55						10,372
[Nov 2008 - Apr 2009]	3,271	58	3,329		63	63	32	6,436	6,468	336						10,196
[Nov 2009 - Apr 2010]	3,843	81	3,924		439	439	27	5,505	5,532	91						9,986
[Nov 2010 - Apr 2011]	3,686	39	3,725		0	0	28	4,637	4,665	58						8,448
[Nov 2011 - Apr 2012]	2,811	47	2,858		11	11	19	3,048	3,067	50						5,986
[Nov 2012 - Apr 2013]	4,918	43	4,961		309	309	42	3,615	3,657	77						9,004
[Nov 2013 - Apr 2014]	7,227	39	7,266		723	723	120	4,869	4,989	72						13,050
[Nov 2014 - Apr 2015]	2,039	83	2,122		92	92	97	6,827	6,924	272						9,410
[Nov 2015 - Apr 2016]	3,085	65	3,150		0	0	57	2,351	2,408	55						5,613

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA

1/ Red Bluff Diversion Dam

2/ May include numbers of fish for tributaries where estimates were not made

3/ Coleman National Fish Hatchery. Transferred to Coleman National Fish Hatchery from Keswick Dam and / or RBDD

4/ Transferred to Tehama Colusa Fish Facility from Red Bluff Diversion Dam

5/ In 2009 USFWS conducted a comprehensive analysis of Battle Creek coded wire tag data from 2000 - 2008 to estimate numbers of fall and late-fall Chinook returning to Battle Creek. Previously, a cutoff date of December 1st was used to assign run. This changed some Battle Creek estimates.

Appendix E Figure E1. Continued.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab Date Compiled: 4/7/2017

CHINOOK SALMON ESCAPEMENT - WINTER RUN

CENTRAL VALLEY: Sacramento and San Joaquin river systems

YEAR	SACRAMENTO RIVER SYSTEM							San Joaquin System	TOTAL CENTRAL VALLEY SYSTEM	Sacramento Mainstem Winter Salmon Data 1/			
	Mainstem In-River			Hatchery Transfers 1/		Battle Creek 4/	TOTAL 5/ SAC SYSTEM	Calaveras River		Fish Passing RBDD 3/	Angler Harvest 4/	REDD distribution 2/	
	Upstream RBDD 2/	Downstr. RBDD 3/	TOTAL In-River	Coleman Hatchery	Livingston Stone NFH							Upstream of RBDD	Downstr. of RBDD
Dec 2006 - Aug 2007	2,487	0	2,487	0	54	0	2,541	0	2,541	6,144	0	100.0%	0%
Dec 2007 - Aug 2008	2,725	0	2,725	0	105	0	2,830	0	2,830	3,635	0	100.0%	0%
[Dec 2008 - Aug 2009]	4,416	0	4,416		121	0	4,537	0	4,537			100.0%	0%
[Dec 2009 - Aug 2010]	1,533	0	1,533	0	63	0	1,596	0	1,596			100.0%	0%
[Dec 2010 - Aug 2011]	738	0	738	2	86	1	827	0	827			100.0%	0%
[Dec 2011 - Aug 2012]	2,578	0	2,578	0	93		2,671		2,671			100.0%	0%
[Dec 2012 - Aug 2013]	5,920	0	5,920	0	164		6,084		6,084			100.0%	0%
[Dec 2013 - Aug 2014]	2,627	0	2,627	0	388		3,015		3,015				
[Dec 2014 - Aug 2015]	3,182	0	3,182	1	257		3,440		3,440		0		
[Dec 2015 - Aug 2016]	1,409	0	1,409	0	137		1,546		1,546				

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA

1/ Fish transferred from Red Bluff Diversion Dam (RBDD) and Keswick Trap to hatcheries

2/ Upstream mainstem in-river estimates prior to 2001 were based on RBDD counts. Subsequent estimates are based on carcass surveys. Numbers using RBDD data are adjusted for angler harvest.

3/ Downstream mainstem numbers based on upstream estimates and redd distribution.

4/ Fish passed upstream of Coleman Weir

5/ Total winter estimate includes mainstem in-river, tributaries, hatcheries, and angler harvest

1/ Data used (when appropriate) to determine mainstem in-river estimate.

2/ Based on aerial survey

3/ Estimated from fish counts at Red Bluff Diversion Dam (RBDD)

4/ Estimated angler harvest upstream of RBDD. After 1995, it was assumed that there was no harvest due to winter-run salmon angling closure.

Appendix E Figure E1. Continued.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab

Date Compiled: 4/7/2017

CHINOOK SALMON ESCAPEMENT - SPRING RUN

CENTRAL VALLEY: Sacramento and San Joaquin river systems

YEAR	Sacramento River Mainstem			Battle Ck 4/	Clear Ck	Cotton-wood Ck	Antelope Ck	Mill Ck	Thomes Ck	Deer Ck	Big Chico Ck	Butte Ck Snorkel	Butte Ck 5/ Carcass	Feather River			Yuba River	Calaveras River	TOTAL SPRING RUN
	Upstr. RBDD 1/	Downstr. RBDD	TOTAL											In-River 2/	Hatchery 3/	TOTAL			
2008	0	52	52	105	200	0	3	381		140	0	3,935	11,046		1,460	1,460			13,387
[2009]	0	0	0	194	120	0	0	220		213	6	2,059	2,687		989	989			4,429
[2010]	0	0	0	172	21	15	17	482		262	2	1,160	1,991		1,661	1,661			4,623
[2011]	0	0	0	157	8	2	6	366		271	124	2,130	4,871		1,969	1,969			7,774
[2012]	0	0	0	799	68	1	1	768		734	0	8,615	16,317		3,738	3,738			22,426
[2013]	0	0	0	608	659	1	0	644		708	0	11,470	16,782		4,294	4,294			23,696
[2014]	0	0	0	429	95	2	7	679		830	0	3,616	5,083		2,776	2,776			9,901
[2015]	0	0	0	181	45	0	5	127		268	0	1,651	569		4,440	4,440			5,635
[2016]	0	0	0	180	29	0	7	175		331	0	10,181	5,731		1,659	1,659			8,112

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA

1/ Red Bluff Diversion Dam. Estimates for 1960 - 1968 spring run are included with fall run.

2/ Feather River Survey does not provide separate estimates for fall and spring escapement. Spring-run estimates are included with fall-run estimates. Fish were transported above Oroville Dam in 1964-1966.

3/ Feather River Hatchery implemented a methodology change in 2005 for distinguishing spring-run from fall-run. Fish arriving prior to the spring-run spawning period were tagged and returned to the river. The spring-run escapement was the number of these tagged fish that subsequently returned to the hatchery during the spring-run spawning period.

4/ In 2009 USFWS conducted a comprehensive analysis of Battle Creek coded wire tag data from 2000 - 2008 to estimate numbers of fall and late-fall Chinook returning to Battle Creek. Previously, a cutoff date of December 1st was used to assign run. This changed some Battle Creek estimates.

5/ Butte Creek CARCASS survey estimate is included in the "Total Spring Run" INSTEAD OF the snorkel survey estimate, when the carcass survey estimate is available. Carcass survey estimates are shown alongside snorkel survey estimates for comparison.

Appendix E Figure E1. Continued.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab Date Compiled: **4/7/2017**

CHINOOK SALMON ESCAPEMENT - FALL RUN Section 1

SACRAMENTO RIVER SYSTEM: Keswick Dam to Red Bluff Diversion Dam (RBDD)

YEAR	Sacramento River Mainstem			Battle Creek 5/															
	In-River 1/	Trans. to CNFH	TOTAL	CNFH	Downstr. CNFH	Upstr. CNFH	TOTAL	Clear Ck	Spring Gulch	China Gulch	Olney Ck	Cotton-wood	Paynes Ck	Cow Ck	Bear Ck	Ash Ck	Still-water	Inks Ck	Other 4/
1990	32,109		32,109	14,635	6,453		21,088	1,011											
1991	20,523		20,523	10,683	6,558		17,241	2,026				676							
1992	23,914		23,914	7,275	5,433		12,708	600				1,585							
1993	33,471		33,471	7,587	11,029		18,616	1,246											
1994	44,729		44,729	18,991	24,274		43,265	2,546											
1995	53,385		53,385	26,677	56,515		83,192	9,298											
1996	71,725		71,725	21,178	52,409		73,587	5,922											
1997	98,765		98,765	50,670	50,744		101,414	8,569											
1998	5,718		5,718	44,351	53,957		98,308	4,259											
1999	133,365		133,365	26,970	92,929		119,899	8,003											
2000	87,793		87,793	21,659	53,447	0	75,106	6,687											
2001	57,920		57,920	24,698	100,604	0	125,302	10,865											
2002	45,552		45,552	65,924	397,149	0	463,073	16,071											
2003	66,485		66,485	88,234	64,764	0	152,998	9,475											
2004	34,050		34,050	69,172	23,861	0	93,033	6,365											
2005	44,950		44,950	142,673	20,520	0	163,193	14,824											
2006	46,568		46,568	57,832	19,493	0	77,325	8,422						4,209					
2007	14,097		14,097	11,744	9,904	0	21,648	4,157				1,250		2,044	140				
2008	23,134		23,134	10,639	4,286	0	14,925	7,677				510		478	19				
[2009]	5,311		5,311	6,152	3,047	0	9,199	3,228				1,055		261	6				
[2010]	13,824		13,824	17,237	6,631	1	23,869	7,192				1,137		536					
[2011]	10,623		10,623	42,092	12,513	0	54,605	4,841				2,144		1,810					
[2012]	22,435		22,435	84,289	31,554		115,843	7,631				2,556		1,488					
[2013]	32,515		32,515	70,021	30,834		100,855	13,337				2,774	175	3,011					
[2014]	29,966		29,966	19,277	27,064		46,341	15,794				1,940	72	3,535					
[2015]	21,766		21,766	15,712	3,642		19,354	8,809				604	0	591	2				
[2016]	3,982	282	4,264	8,526	1,236		9,762	2,481				813	8	822	32				

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA.

1/ For 1952-1955, the original data provided a total for the Sacramento mainstem. Data presented here is that total multiplied by the average % of the fall-run estimate above Red Bluff, from 1956-2007.
2/ Salmon from the mainstem population that were trapped at Keswick or Anderson-Cottonwood dams and transferred to Coleman National Fish Hatchery (CNFH)
3/ Salmon in Battle Creek upstream of the Hatchery
4/ The data source did not provide a breakdown of individual tributaries.
5/ In 2009 USFWS edited some 2000 - 2008 estimates of fall and late-fall Chinook returning to Battle Creek based on CWT data. Previously, a December 1st cutoff was used to assign run.

Appendix E Figure E1. Continued.

California Department of Fish and Wildlife - Fisheries Branch Anadromous Assessment - GrandTab

Date Compiled: 4/7/2017

CHINOOK SALMON ESCAPEMENT - FALL RUN Section 2

SACRAMENTO RIVER SYSTEM: Red Bluff Diversion Dam (RBDD) to Princeton Ferry

YEAR	Sacramento River Mainstem			TCFF	Salt Ck	Antelope Ck	Craig Ck	Dye Ck	Mill Ck	Toomes Ck	Thomes Ck	Deer Ck	Coyote Ck	Stoney Ck	Singer Ck	Big Chico	Other 3/
	In-River 1/	Trans. to TCFF 2/	TOTAL														
1990	16,175		16,175														
1991	10,108		10,108														
1992	8,315		8,315			0			999								
1993	12,760		12,760						1,975			72					
1994	13,817		13,817						1,081			307					
1995	10,549		10,549														
1996	12,361		12,361														
1997	20,531		20,531						478			1,203					
1998	600		600						546			270					
1999	27,827		27,827														
2000	8,895		8,895														
2001	17,376		17,376														
2002	20,138		20,138						2,611								
2003	22,744		22,744						2,426								
2004	9,554		9,554						1,192			300					
2005	12,062		12,062						2,426			963					
2006	8,900		8,900						1,403			1,905					
2007	2,964		2,964						851			563					
2008	1,609		1,609						218			194					
[2009]	516		516						102			58					
[2010]	2,548		2,548						144			166					
[2011]	1,334		1,334						1,231			662					
[2012]	6,266		6,266						890			873					
[2013]	7,569		7,569						2,197			1,026					
[2014]	4,910		4,910			143			2,488			849					
[2015]	6,894		6,894			6			1,033			612					
[2016]	309		309			138			602			253					

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY. BLANK ENTRY INDICATES NO DATA

1/ For 1952-1955, the original data source only provided a total estimate for the entire Sacramento mainstem, above and below Red Bluff combined. The data presented here is that total estimate multiplied by the average % of the fall-run estimate below Red Bluff, from 1956-2007.

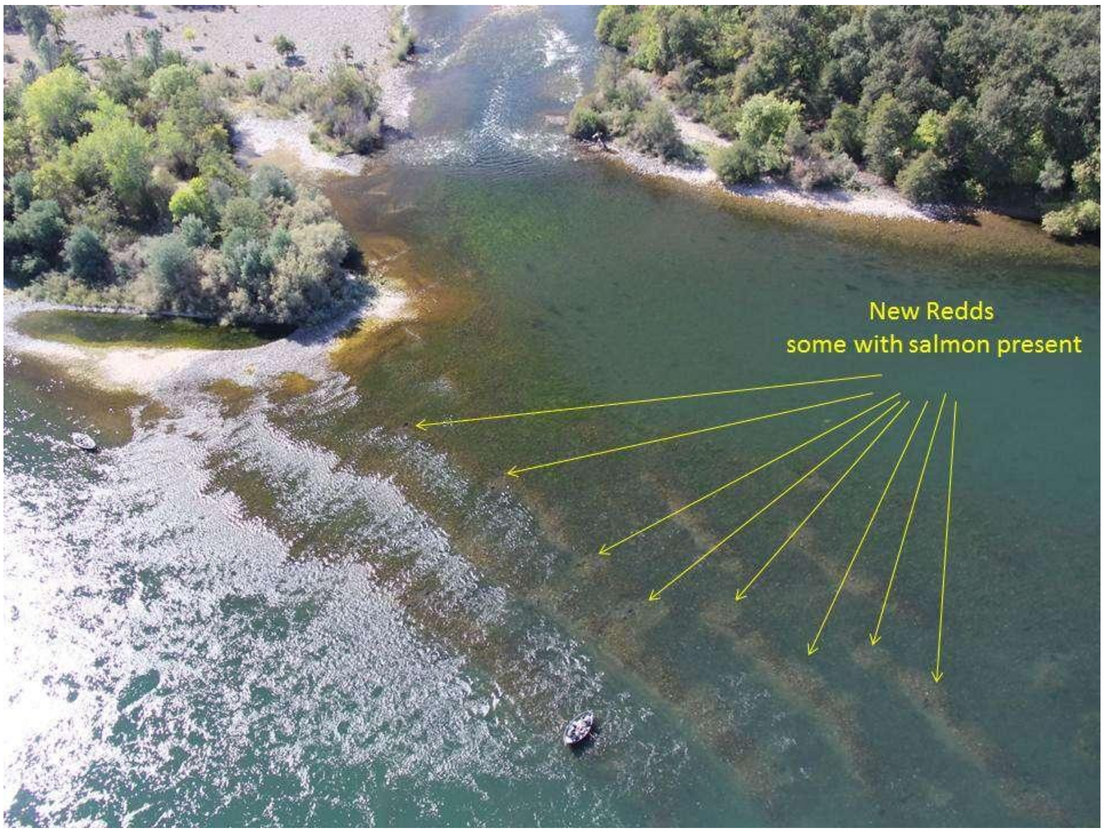
2/ Salmon from the mainstem population that were trapped at Red Bluff Diversion Dam (RBDD) and transferred to Tehama-Colusa Fish Facility (TCFF)

3/ The data source did not provide a breakdown of individual tributaries. NOTE: The number of fish listed may include those for tributaries from Keswick Dam to RBDD.

Appendix E Figure E1. Continued.

APPENDIX F - Photos of 2016 Red Bluff Fisheries Office Activities

Appendix F Figure F1. Carcass survey boat crew spearing carcasses on the Sacramento River.



Appendix F Figure F2. Photo of new aerial redds as seen from CDFW aircraft. Yellow arrows point to some examples of the numerous redds in this area, some with salmon present.

Appendix F Figure F3. The Clear Creek video station in 2016 during low flows.

Appendix F Figure F4. RBFO crew cleaning the Clear Creek video station in the fall of 2016.

Appendix F Figure F5. The Cow Creek video station new resistance board weir under construction in fall of 2016. Note the height of the overhead camera and lights, destroyed by flooding later in season.

Appendix F Figure F6. The Cow Creek video station after minor flooding in November of 2016.

Appendix F Figure F7. The Cow Creek video station during flooding in December 09, 2016. Photo taken from fixed trail camera, note portion of weir at upper left in this photo.

Appendix F Figure F8. The Cow Creek video station during flooding in December 10, 2016. Photo taken from fixed trail camera, one day after previous photo. Note splashes from destruction of camera that was positioned 17 feet above water surface as shown in Appendix F Figure F5.

Appendix F Figure F9. The Bear Creek video station just prior to fall season start up showing low flows in 2016.

Appendix F Figure F10. The Bear Creek video station during high flows in 2016.

Appendix F Figure F11. The Cottonwood Creek video station with new resistance board weir during low flows in 2016.

Appendix F Figure F12. The Cottonwood Creek video station during floods, contrast with previous photo.

Appendix F Figure F13. The Cottonwood Creek video station from trail camera during low flows in 2016.

Appendix F Figure F14. The Cottonwood Creek video station from trail camera during January 2017 floods.

Appendix F Figure F15. The Antelope Creek video station during low flows.

Appendix F Figure F16. The Antelope Creek video station during high flows.

Appendix F Figure F17. The Mill Creek video station at top of Ward Dam during low flows.

Appendix F Figure F18. Mill Creek video station during flooding in December 2016.

Appendix F Figure F19. The Deer Creek South video station in 2016 at the fish ladder at Stanford Vina Dam. The North station is visible in the distance across the dam.

Appendix F Figure F20. The Deer Creek North video station in at the top of the fish ladder at Stanford Vina Dam.

Appendix F Figure F21. The RBFO video crew cleaning the Deer Creek video stations at Stanford Vina Dam.

Appendix F Figure F22. The RBFO video crew watching the flooding at the South Deer Creek video station.

Appendix F Figure F23. The RBFO video crew assisting with the Auburn Ravine video station in 2016.

Appendix F Figure F24. The video station in the north ACID fish ladder for monitoring winter-run passage in 2016.

Appendix F Figure F25. The CDFW boat loaded down with river trash and tires during a Sacramento River cleanup.

Appendix F Figure F26. The river tires removed by the CDFW/PSMFC crews during a Sacramento River cleanup in 2016.