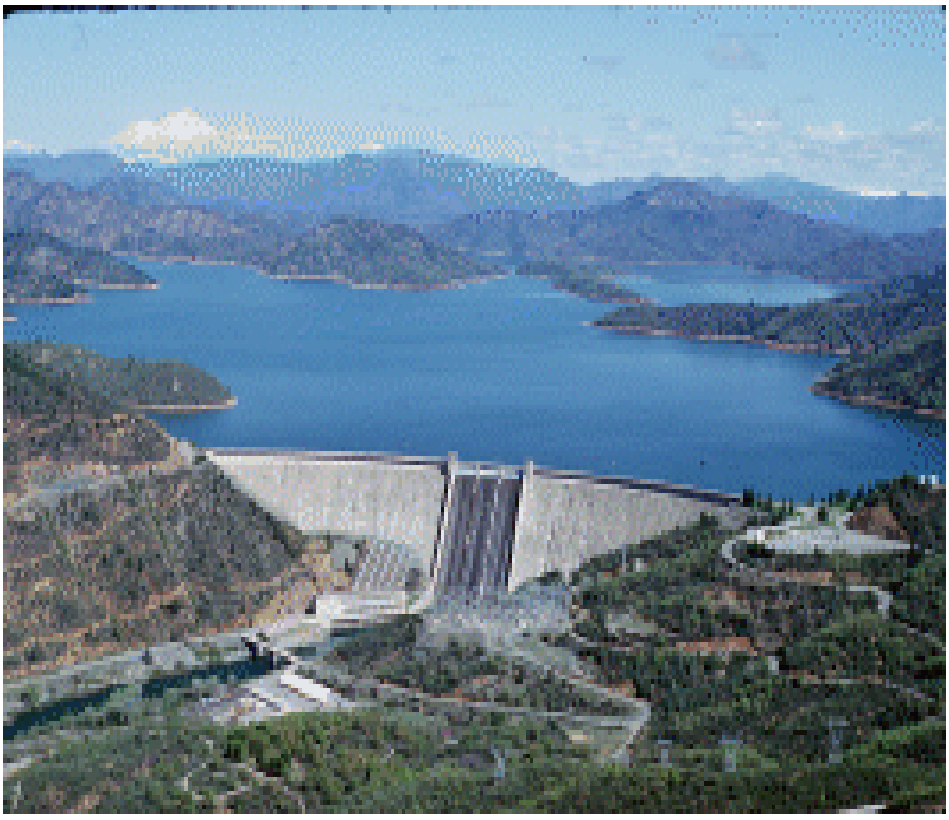
Sacramento River Temperature Task Group



Annual Report of Activities

October 1, 2013 through September 30, 2014

Sacramento River Temperature Task Group Annual Report

Outline

1. List of Tables and Figures

2. Acronyms:

BiOp	Biological Opinion
BND	Bend Bridge compliance point
BSF	Balls Ferry compliance point
CDFG	California Department of Fish & Game
CDEC	California Data Exchange Center
CVPIA	Central Valley Project Improvement Act
cfs	cubic feet per second
CVP	Central Valley Project
DWR	California Department of Water Resources
EOS	End-of-September
ESA	Endangered Species Act
FWS	U.S. Fish & Wildlife Service
JLF	Jellys Ferry compliance point
maf	million acre feet
NMFS	National Marine Fisheries Service
NASA	National Aeronautics and Space Administration
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
SRTTG	Sacramento River Temperature Task Group
SWRCB	State Water Resources Control Board
taf	thousand acre feet
TCD	temperature control device (Shasta Dam)
TCP	temperature compliance point
WAPA	Western Area Power Administration
WR	Water Rights

3. Background

The purpose of the Sacramento River Temperature Task Group (SRTTG) is to provide advice to Reclamation on managing water temperatures downstream of Central Valley Project (CVP) reservoirs in the Sacramento River, Trinity River and Clear Creek. The SRTTG deals with the short-term operational aspects of reservoir management such as coordinating real-time operations. The Clear Creek Technical Team plans and implements long-term restoration actions and reports on such things as pulse flows, gravel augmentation, and channel forming flow required in the National Marine Fisheries Service (NMFS) 2009 Biological Opinion (BiOp). It also coordinates monitoring for these actions. The SRTTG reports on the temperature requirements as specified in the State Water Resource Control Board (SWRCB) Water Rights Order (WR) 90-5 and also the required actions described in NMFS' 2009 reasonable and prudent alternative (RPA) with 2011 amendments. Both groups coordinate their actions with the B2 Interagency Team which manages the use of CVPIA (b)2 water in CVP reservoirs.

The SRTTG advises the U.S. Bureau of Reclamation (Reclamation) on the best course of action to take to implement Water Rights Order 90-5 to establish a temperature compliance point (TCP) for winter-run Chinook salmon, depending on carryover storage, water year type, and fish distribution. The SRTTG used historical data, the latest modeled water temperatures, operator experience, and the latest biological data available to adaptively manage water releases from Shasta, Trinity and Whiskeytown Reservoirs. In many years, it is not possible to attain 56° Fahrenheit (F) at Bend Bridge, and the SRTTG will advise that the TCP be established farther upstream. This was the case in 2009, 2010, 2011, 2012, 2013 and 2014. A salmon decision tree process was used as initial guidance in prioritizing actions.

The objectives of the May 15 through October 31 Sacramento River in-stream temperature criteria are to manage the cold water storage within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat temperatures for winter-run Chinook salmon, spring-run Chinook salmon, California Central Valley steelhead, and the Southern Distinct Population Segment of North American green sturgeon in the Sacramento River between Keswick Dam and Bend Bridge, while retaining sufficient carryover storage to manage for the following year's winter-run Chinook salmon cohort. In addition, to the extent feasible, another objective is to manage for suitable temperatures and stabilize flows for naturally-spawning fall-run/late-fall-run Chinook salmon.

This document describes the water year (WY) 2014 actions taken in the upper Sacramento River by the SRTTG to meet the requirements NMFS BiOp on the long-term water operations of the CVP and State Water Project (SWP). Full accounting for WY 2014 has not yet been completed; therefore, this report only describes the actions taken in a qualitative format.

A. Membership

The SRTTG consists of representatives from Reclamation, FWS, NMFS, California Fish and Wildlife Service (CFWS), State Water Resources Control Board (SWRCB), Western Area Power Administration (Western), and the Hoopa Tribe. Other agencies have participated in the past and may be added to the SRTTG, provided existing agencies approve of the addition in membership. SRTTG member agencies and the lead contacts are:

U.S. Bureau of Reclamation (Reclamation)
Thuy Washburn
Russ Yaworsky
Rod Wittler
Stacey Smith

National Marine Fisheries Service (NMFS)
Seth Naman
Garwin Yip
Bruce Oppenheim
Brycen Swart

U.S. Fish & Wildlife Service (FWS)
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Matt Brown

California Department of Fish & Wildlife (CFWS)
Alice Low
Mike Berry

State Water Resource Control Board (SWRCB)
Kari Kyler

Western Area Power Administration (Western)
Tom Patton

Hoopa Valley Tribe
Robert Franklin

4. Summary of Actions and Results

There were seven SRTTG meetings/calls on: 3/27/14, 4/24/14, 5/22/14, 6/26/14, 7/24/14, 8/28/2014 and 9/25/2014. In the first meeting, the group discussed operational forecasts and water temperature modeling results for the year in the Sacramento River, Trinity River, and Clear Creek. This was such a dry year that the group recognized how critical it was to conserve as much cold water as possible for the summer. The group agreed to target a TCP of 58°F at Clear Creek starting on March 28, 2014. The next meetings dealt with operational issues,

forecasting, and the need to adjust the TCP on the Sacramento River. At the April 24, 2014 meeting, there was concurrence among the SRTTG members to maintain the TCP at Clear Creek but target a cooler temperature of 56°F. The TCP remained at 56°F above Clear Creek through the entire summer.

A. Sacramento River

RPA Action I.2.1. Shasta Operation Performance Measures

Action: The following long-term performance measures shall be attained. Reclamation shall track performance and report to NMFS at least every 5 years. If there is significant deviation from these performance measures over a 10-year period, measured as a running average, which is not explained by hydrological cycle factors (*e.g.,* extended drought), then Reclamation shall reinitiate consultation with NMFS.

Measured as a 10-year running average, performance measures for temperature compliance points during summer season shall be:

Meet Clear Creek Compliance point 95 percent of time
Meet Balls Ferry Compliance point 85 percent of time
Meet Jelly's Ferry Compliance point 40 percent of time
Meet Bend Bridge Compliance point 15 percent of time

Result: Since the RPA has been in place (2010), Reclamation has met the TCP with the exception of WY2014, given the drought conditions. In WY2014, Reclamation expressed concerns with maintaining the TCP at Balls Ferry. Due to the low storage at Shasta Reservoir, the TCD had limited abilities to blend cold water. The upper control gates could not be accessed. The temperature modeling results suggested that the TCP should be at Clear Creek and after coordination of the data with the SRTTG, the TCP was moved to Clear Creek

RPA Action I.2.2. Fall Actions, Keswick Releases (November – February)

Action: Depending on EOS carryover storage and hydrology, Reclamation shall develop and implement a Keswick release schedule, and reduce deliveries and exports as detailed below.

Action I.2.2.C. Implementation and Exception Procedures for EOS Storage of 1.9 MAF or Below

If the EOS storage is at or below 1.9 MAF, then Reclamation shall:

1) In early October, reduce Keswick releases to 3,250 cfs as soon as possible, unless higher releases are necessary to meet temperature compliance points (see action I.2.3).

2) Starting in early October, if cool weather prevails and temperature control does not mandate higher flows, curtail discretionary water deliveries (including, but not limited to agricultural rice decomposition deliveries) to the extent that these do not coincide with temperature management for the species. It is important to maintain suitable temperatures targeted to each life stage. Depending on air and water temperatures, delivery of water for

rice decomposition, and any other discretionary purposes at this time of year, may coincide with the temperature management regime for spring-run and fall-run. This action shall be closely coordinated with NMFS, USFWS, and CDFG.

3) By November 1, submit to NMFS storage projections based on 50 percent, 70 percent, and 90 percent hydrology through February. In coordination with NMFS, Reclamation shall: (1) develop a monthly average Keswick release schedule similar in format to that in Action I.2.2.B, based on the criteria below and including actions specified below; and (2) review updated hydrology and choose a monthly average release for every month, based on the release schedule. November releases shall be based on a 90 percent hydrology estimate.

Criteria and actions:

1) Keswick releases shall be managed to improve storage and maintained at 3,250 cfs unless hydrology improves.

2) November monthly releases will be based on 90 percent hydrology.

3) Consider fall-run needs through January as per CVPIA AFRP guidelines, including stabilizing flows to keep redds from dewatering.

4) Continue to curtail discretionary agricultural rice decomposition deliveries to the extent that these do not coincide with temperature management for the species, or impact other ESA-listed species. It is important to maintain suitable temperatures targeted to each life stage. Depending on air and water temperatures, delivery of water for rice decomposition may coincide with the temperature management regime for spring-run and fall-run. This action shall be closely coordinated with NMFS, USFWS, and CFWS.

5) If operational changes are necessary to meet Delta outflow, X2, or other legal requirements during this time, then:

CVP/SWP Delta combined exports shall be curtailed to 2,000 cfs if necessary to meet

legal requirements while maintaining a 3,250 cfs Keswick release (or other planned release based on biological needs of species); and if it is necessary to curtail combined exports to values more restrictive than 2000 cfs in order to meet Delta outflow, X2, or other legal requirements, then Reclamation and DWR shall, as an overall strategy, first, increase releases from Oroville or Folsom; and in general, Reclamation shall increase releases from Keswick as a last resort. Based on updated monthly hydrology, this restriction may be relaxed, with NMFS' concurrence.

6) If the hydrology and storage have not improved by January, additional restrictions apply.

Result: The End of Month September 2013 storage was 1.9 TAF. Reclamation was seeking to conserve storage as directed by Action I.2.2.C 1. In multiple SRTTG meetings,

Reclamation proposed conserving storage at Keswick, however, the Fishery agencies stressed the need to keep flows up at 6,250 cfs to prevent dewatering of redds. Although Delta outflows were a concern, a cut would have resulted in some adjustments with Reclamation's Jones Pumping Plant. The Keswick release continued to be 6,250 cfs until a reduction was made in mid-November. On November 16, 2013, flows were reduced to 5,000 cfs and by the end of the month, the Keswick release was down to 3,750 cfs. The release remained at 3,750 cfs until January 5, 2014, when a reduction was made to the NMFS BO's recommended flow of 3,250 cfs. However, the Keswick releases were not supportive of other obligations of the CVP and releases from Keswick began to increase for Delta salinity requirements and Wilkins Slough in-river demands.

RPA Action I.2.3. February Forecast Keswick Releases (March – May 15)
Action: Reclamation shall make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin at least as conservative as the 90 percent probability of exceedance. Subsequent updates of water delivery commitments must be based on monthly forecasts at least as conservative as the 90 percent probability of exceedance. NMFS shall review forecast and allocations for consistency with temperature management and provide written evaluation to Reclamation. Reclamation must maintain a TCP not in excess of 56°F between Balls Ferry and Bend Bridge between April 15 and May 15.

RPA Action I.2.3.C Drought Exception Procedures if February Forecast, Based on 90 Percent Hydrology, Shows that Clear Creek Temperature Compliance Point or 1.9 MAF EOS Storage is Not Achievable

1) On or before February 15, Reclamation shall reduce Keswick releases to 3,250 cfs, unless NMFS concurs on an alternative release schedule. This reduction shall be maintained until a flow schedule is developed per procedures below.

2) In coordination with NMFS, by March 1, Reclamation shall develop an initial monthly Keswick release schedule, based on varying hydrology of 50 percent, 70 percent, and 90 percent (similar in format to the fall and winter action implementation procedures – see table above). These schedules shall be used as guidance for monthly updates and consultations.

3) Based on this guidance, Reclamation shall consult with NMFS monthly on Keswick releases. Reclamation shall submit a projected forecast, including monthly average release schedules and temperature compliance point to NMFS every month, within 7 business days of receiving the DWR runoff projections for that month. Within 3 business days of receiving this information from Reclamation, NMFS will review the draft schedule for consistency with the criteria below and provide written recommendations to Reclamation.

4) The initial monthly Keswick release schedule, and subsequent monthly updates, shall be developed based on the following criteria and including the following actions:

a) Maintain minimum monthly average flows necessary to meet nondiscretionary delivery obligations and legal requirements.
b) Provide for flow-related biological needs of spring life stages of all species covered by this Opinion in the Sacramento River and Delta, to the greatest extent possible.
c) If operational changes are necessary to meet Delta outflow, X2, or other legal requirements during this time, then:

- CVP/SWP Delta combined exports shall be curtailed to 2,000 cfs if necessary to meet legal requirements while maintaining a 3,250 cfs Keswick Dam release (or other planned release based on biological needs of species); and
- if it is necessary to curtail combined exports to values more restrictive than 2000 cfs in order to meet Delta outflow, X2, or other legal requirements, then Reclamation and DWR shall, as an overall strategy, first, increase releases from Oroville or Folsom Dam; and
- in general, Reclamation shall increase releases from Keswick Dam as a last resort.
- Based on improvements in updated monthly hydrology, this restriction may be relaxed, with NMFS' concurrence.

5) By March 1, provide a contingency plan with a written justification that all actions within Reclamation's authorities and discretion are being taken to preserve cold water at Shasta Reservoir for the protection of winter-run.

6) The contingency plan shall also, at a minimum, include the following assessments and actions:

a) Relaxation of Wilkins Slough navigation criteria to at most 4,000 cfs.
b) An assessment of any additional technological or operational measures that may be feasible and may increase the ability to manage the cold water pool.
c) Notification to State Water Resources Control Board that meeting the biological needs of winter-run and the needs of resident species in the Delta, delivery of water to nondiscretionary Sacramento Settlement Contractors, and Delta outflow requirements per D-1641, may be in conflict in the coming season and requesting the Board's assistance in determining appropriate contingency measures, and exercising their authorities to put these measures in place.

7) If, during the temperature control season, a Clear Creek TCP on the Sacramento River cannot be achieved, then Reclamation shall bypass power at Shasta Dam if NMFS determines a bypass is necessary for preserving the cold water pool. This power by-pass may be necessary to maintain temperature controls for winter-run, or later in the temperature season, for spring-run.

Results: Beginning November 1, 2013, Keswick releases were being ramped down to conserve storage and by the end of the month releases were at 3,750 cfs. The Fishery agencies continued to stress the need to keep flows up for the fall-run redds to prevent them from dewatering. It was not until January 5, 2014, that the release out of Keswick

was down to the minimum flow of 3,250 cfs. Reclamation maintained a Balls Ferry TCP between March 1, 2014 and March 27, 2014. Starting on March 28, 2014, the TCP was moved from Balls Ferry to Clear Creek and targeted 58°F to conserve the cold water pool in Shasta Reservoir. Starting April 25, 2014 the TCP at Clear Creek was recommended to target 56°F.

RPA Action 1.2.4. Keswick Release Schedule (May 15 –October)
Action: Reclamation shall develop and implement an annual Temperature Management Plan by May 15 to manage the cold water supply within Shasta Reservoir and make cold water releases from Shasta Reservoir and Spring Creek to provide suitable temperatures for listed species, and, when feasible, fall-run.

Reclamation shall manage operations to achieve daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows:

1) Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and not in excess of 56°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31 for protection of mainstem spring run, whenever possible.

2) Reclamation shall operate to a final Temperature Management Plan starting May 15 and ending October 31.

3) As part of the adaptive management process, and in coordination with NMFS, by March 2010, Reclamation shall fund an independent modeler to review these procedures and the recommendations of the Calfed Science Panel report on temperature management and recommend specific refinements to these procedures to achieve optimal temperature management.

Results: The SRTTG recommended a TCP at Clear Creek targeting 56°F starting April 25, 2014. With minimal storage in Shasta Reservoir this year, the TCD was not fully utilized. The upper shutters were unable to be lowered due to the low storage at Shasta Reservoir. This is the first year since operation of the TCD began that the upper shutters could not be lowered. Reclamation provided modeling runs at all the SRTTG meetings, and expressed concern that meeting 56° F at Clear Creek was going to be challenging this year because Shasta Reservoir had never been this low in storage. Reclamation also expressed concern with the output from the temperature model due to the low storage levels. Reclamation recognized that a power bypass would be necessary to help meet the TCP at Clear Creek. Reclamation maintained to the extent possible 56°F at the TCP from April 25, 2014 through August 2014. Beginning September 2014, the TCP target at Clear Creek of 56°F was not achievable. By September 3, 2014, the Clear Creek TCP exceeded 56°F. Reclamation operated to optimize temperatures by releasing the coldest water possible out of Shasta Reservoir, stretching out the cold water resources through October 15, 2014. Reclamation's operations included power bypass at Shasta Dam, minimizing warmer water through the power plant. In August 2014, Reclamation was very concerned about using up the cold water pool too quickly with the high releases made out of Keswick. Keswick releases were 7,250 cfs at the beginning of September. A slow ramp down was requested by the

Fishery agencies to prevent stranding of redds. By September 26, 2014, releases at Keswick were reduced to 5,000 cfs. Power bypassing began on September 9, 2014 in the amount of 2,200 cfs. The remaining 2,800 cfs was brought through the Shasta power plant. Reclamation stressed that further decreases in flow would be beneficial as water temperatures would be improved by blending less warm water into the total release. From September 9 -15, 2014, the temperature going through the outlet had increased by 4°F. From September 16 – 22, 2014, the outlet temperature had increased by almost 9°F. During this time period the temperature from the water flowing through the power plant had also increased by 7°F. Shasta Reservoir cold water pool was diminishing rapidly.

5. Summary of Operations

Initial carryover storage in Shasta Reservoir was 1.9 MAF at the beginning of Water Year 2014, and the year was classified as a Critically Dry year. This followed a Dry year in Water Year 2013. Precipitation in November 2013 was 30% of average. January 2013 to November 2013 was the driest on record with a total of 6.51 inches of precipitation. The mean for this period is 18.97 inches. Releases out of Keswick Dam averaged 6,100 cfs for the month of October. On November 15, flows were reduced from 6,250 to 5,000 cfs. After many discussions in B2IT meetings, the Fishery agencies requested for flows to remain higher at 5,500 cfs. These flows were supported by B2 water. Due to the dry conditions forecasted, Reclamation strongly recommended that Keswick releases be reduced to conserve storage at Shasta Reservoir. By the end of November, Keswick flows were reduced to 3,750 cfs. Reclamation stressed that Shasta Reservoir storage was low and that flow reductions should go all the way down to the minimum flow of 3,250, as per the NMFS BO. Starting on January 5, 2014, Keswick releases were reduced to the recommended NMFS BO flow of 3,250 cfs. Releases were increased on January 27, 2014 to support D-1641 requirements for Delta salinity. In February, Reclamation continued to reduce flows from Keswick to conserve storage.

The TCP started out at Balls Ferry at the beginning of the temperature control season. (See Table 1) After several discussions in the SRTTG meetings, the TCP was moved up to Clear Creek targeting 58°F. On April 25, 2014, the TCP target at Clear Creek was changed to 56°F based on the April 24, 2014 temperature analysis. This analysis indicated that with low storage and a minimal cold water pool in Shasta Reservoir, the Clear Creek TCP was the only choice to target. Reclamation expressed minimal confidence in the temperature modeling results given the low storage in Shasta Reservoir and that the temperature model had never been run with such low storage conditions. Due to the low water surface elevation at Shasta Reservoir this year, Reclamation was unable to utilize the upper gate operation of the TCD. On September 9, 2014, Reclamation began a power plant flow bypass operation of 2,200 cfs. The amount of bypass was increased to 3000 cfs starting on September 26, 2014. On September 25, 2014, Reclamation began to draw 1,000 af of cooler water from Whiskeytown reservoir through Spring Creek power plant into Keswick.

In summary, water year 2014 has been one of the driest years in decades and it follows two consecutive dry years throughout the state. The Northern Sierra precipitation accumulation as a percent of average for the Water Year was 59%. Shasta Reservoir was projected to have end of year storage of 1.2 TAF in the February 90% forecast, and in the May 90% forecast, end of year

storage of 940 TAF was projected. . The average Keswick release from October to November was 5,200 cfs. The minimum flows during this time period was 3,250 cfs per the NMFS BO. Due to such low storage in Shasta Reservoir, Reclamation utilized Trinity River water to conserve Shasta Reservoir storage. The amount of water brought over from Trinity River was a great benefit to the temperature operations on the Sacramento River.

Table 1. Monthly Average Temperature at Clear Creek

Month	Monthly Average (degree)
May	54.3
June	55.9
July	55.6
August	56.1
September	58.3 *(as of September 26,2014)*

6. Past Independent Review Panel Feedback and Agency Responses

From water years 2010 through 2013, the SRTTG received feedback from the Independent Review Panel (IRP) annual review of the water year's operations. The following are updates and agency responses to individual IRP recommendations from past annual reviews. Some IRP recommendations are grouped together due to their similarity in nature.

- **Link RPA action physical metrics (*i.e.*, flows and temperature) to biological responses;**
- **Re-evaluate temperature compliance points should and possibly moved to better match actual fish habitat usage;**
- **Consider adjusting RPA actions I.2.1 - I.2.4 so that redd location and juvenile abundance are better related to temporal and spatial patterns in habitat quality (*e.g.*, water temperature, depth, and velocity pattern) at the scale salmon life stages respond to their environments;**
- **Better address spatial variation in water temperature and water level within the context of impacts on salmonid spawning habitat and early life stages by monitoring temperatures in the main channel, secondary channels, hyporheic (within the gravel) zones , and tributaries.**
- **Instead of meeting a TCP, consider a model-derived estimate of salmonid freshwater survival (*e.g.*, Hueristic Optimal Temperature Compliance Point Model).**

A consistent theme that has been reiterated among the four annual review reports is to create a temperature management system that links spatial-temporal life-stage specific fish distributions with the spatial-temporal temperature distributions. Over the past four years the fish agencies have taken a number of steps to address this important issue. For WY 2014, the fish agencies are monitoring temperature, dissolved oxygen, flow and water depth in select redd locations and important juvenile rearing habitats. The Interagency Ecological Program (IEP) winter-run

Chinook salmon project work team (PWT) developed a plan to monitor redds at the downstream end of the spawning distribution (near the TCP) to determine whether healthy fry emerge. Redds located close to the TCP may be exposed to higher water temperatures that result in some mortality. In addition, since WY 2010, CDFW and the California Department of Water Resources (DWR) have been monitoring redd dewatering and juvenile stranding, and will continue to do so in the future. For WY 2013 and WY 2014, the data collected from these surveys were incorporated into real-time operations management and temperature modeling and were reported to NMFS. See the "Fisheries Monitoring Activities" section 6, below, for more information.

As for the temperature compliance point, for WY 2011, the SRTTG created decision criteria for Sacramento River Water Temperature Management to serve as guidelines to provide maximum protection for winter-run spawning and egg incubation for most water year conditions. This adaptive management process for setting the temperature compliance point is based on real-time monitoring information, including Shasta Reservoir cold water volume, modeled daily water temperatures, and spatial and temporal distribution of Chinook salmon redds from weekly aerial redd and carcass surveys. For WY 2012 through WY 2014, CDFW continued to implement weekly to bi-weekly aerial winter-run redd surveys and to identify the downstream extent of winter-run spawning and document temporal redd construction. This monitoring addresses setting a more appropriate temperature compliance point that reflects actual salmonid habitat usage.

In addition to the annual aerial redd surveys, for WY 2014 CDFW proposed to collect and organize orthorectified aerial photos (ORAP) of the upper Sacramento River and use GIS to analyze winter-run Chinook salmon redd development over time. When overlaid with abiotic data (temperature, depth, and flow), this would provide the ability to predict location-specific fry emergence as well as relative impacts resulting from changes in water operations. The proposed ORAP project did not receive funding for WY 2014. Instead CDFW overlaid GPS data onto Google Earth and used real-time abiotic measures to predict potential dewatering and juvenile stranding sites.

In order to better address spatial variation in water temperature and water level, for WY 2014 CDFW implemented a network of temperature monitoring stations between Keswick Dam and Airport Road Bridge in the main channels, secondary channels, hyporheic zones, and tributaries. Thermographs have been downloaded weekly, but the data are not available for this report.

Also, NMFS is working on an egg mortality model to determine Sacramento River temperature effects on eggs and alevins. The simple spreadsheet model inputs include thirteen distinct egg cohorts that are separated by ten days (April 18 through August 16), CDFW carcass data with a 10-day delay to the start of spawning, and literature based accumulated degree days egg/alevin development and mortality rates. Currently the model is in draft form, however NMFS hopes to share it for next year's SRTTG annual review.

- **Work with the National Weather Service and existing collaborations between NMFS, NASA, and academic climate scientists to improve the long range 90% exceedance forecast**

In WY 2012 through WY 2014, the SRTTG utilized the Sacramento River Temperature Forecasting and Decision Support Tool. The SRTTG utilized the model in tandem with Reclamation's temperature model to forecast water temperatures and to assist in Temperature Control Device (TCD) operations to meet the temperature criterion.

- **Reconcile mismatch between temperature prediction scales (15 minute resolution of temperature over a 3 day window) and the scales needed to manage river temperature for salmonids (3 to 6 months for pre-spawning adult, egg, juvenile life stages).**
- **Utilize a more quantitative model-based program to analyze the biological response of temperature control operations and efficiently utilize the limited cold water resources in Shasta/Keswick Operations**
- **Better coordinate the temperature control programs and commit resources to developing a more state of the art management system that integrates hydraulic, biological and climatic factors at the appropriate temporal spatial scales of resolution.**
- **Increase communication between field survey teams monitoring redd dewatering and juvenile stranding and group members who simulate water temperatures**
- **Better integrate long-term forecast simulations with real-time operations**

The NMFS Southwest Fisheries Science Center (SWFSC) has developed a proposal for an integrated decision-support framework for water and salmon management on the Sacramento River that would combine existing model results and observations into a centralized data hub and provide scenario evaluation for the management of water resources. In addition, the SWFSC proposes to develop new biological models required to fill critical knowledge gaps, such as the impacts of temperature on early life stages. The core of the framework will be a web-based user interface that will integrate the complex suite of information on the past, current, and forecasted conditions of the system. Users will be able to select different hydroclimate scenarios, reservoir management scenarios, and fisheries management targets, and then run them through the framework to evaluate the outcomes.

- **Evaluate the likelihood of critical depletions more than 30 days in advance so that water deliveries can be scheduled over a longer time period and avoid the operational criteria that have the effect of forcing inefficient use of cold water storage.**

Reclamation coordinates with the Sacramento River Settlement Contractors every year with regards to water delivery. WY 2014 was remarkable in that Sacramento River Settlement Contractors voluntarily agreed to shift their typical April and May diversion patterns into late May and June. The shift in diversion timing allowed for more water to remain in storage at Shasta Lake until late May and June, when higher releases were necessary to sustain temperature compliance downstream during the hotter months of June through September. Cool temperatures were needed in these months to protect winter-run Chinook egg incubation. The revised releases increased Shasta storage by over 130 thousand acre-feet (TAF). In addition, the agencies experienced significant gains in Shasta storage through limiting fall withdrawal for rice decomposition.

- **Use a different model than HEC-5Q, such as CE-QUAL-W2, to increase forecast accuracy of long-term temperature forecasts**
- **Calibrate long-term temperature forecast models to reduce uncertainty**

Reclamation has no new progress on models or on calibration of temperature forecast models. Reclamation does utilize inputs on inflow forecast from the State's River Forecast Center.

7. Fisheries Monitoring Activities

7.1 Redd Dewatering and Juvenile Stranding in the Upper Sacramento River, August 2013 - March 2014 (brood year 2013)

From the summer of 2013 to the spring of 2014, staff from CDFW and Pacific States Marine Fisheries Commission monitored redd dewatering (fourth year) and juvenile stranding (second year) on the upper Sacramento River. During monitoring, a combined 813 winter, spring, fall, and late fall-run Chinook salmon redds were marked and monitored. Of these, 573 (5 winter, 23 spring, 515 fall and 30 late-fall) were observed to be dewatered[1] upon first observation or become dewatered as flows were reduced. An estimated 5,958 winter-run, 40,084 fall/spring-run mix, and 7,950 late fall-run salmon spawned in the upper Sacramento River in 2013 into 2014. Based on these population estimates, about 0.2% winter, 3.1% fall/spring mixed, and 1.2% late-fall-run Chinook salmon redds were dewatered to various degrees. For the fall/spring mix, large numbers of fish spawning over a period of months resulted in many fish likely spawning on or near the redds of earlier spawners. Individual redds are difficult to identify after multiple fish have spawned in close proximity. As a result, the combined fall and spring-run Chinook dewatered redd totals (538) observed this season represent only the actual marked and dewatered redds. The total number of redds dewatered was likely much higher, but crews did not have budget, staff, and equipment to accurately track and determine the amount of superimposition (multiple spawners at one site) that occurred.

Juvenile stranding surveys were implemented to observe and report on locations that could potentially contain stranded salmonids that were isolated to varying degrees by flow reductions. During monitoring, 188 stranding locations between the Keswick Dam and the Tehama Bridge (a total of 73 river miles) were observed. Crews logged 375 site visits to selected locations to observe and record data at different flow levels. An estimated 6,360 naturally-spawned Chinook salmon juveniles, including 2,143 winter-run, were observed stranded in isolated sites. Of these, crews estimated that 179 winter-run and 232 fall-run juveniles were unlikely to survive their stranding due to environmental conditions. Crews were uncertain of the survival of the remaining fish. Rescue efforts were initiated beginning in January 2014 after rescue permitting was granted to CDFW. Several thousand fish were successfully rescued, including 6,551 juvenile Chinook salmon and rainbow trout/steelhead.

Survey crews identified 30 winter-run redds that were thought to be susceptible to dewatering before the eggs and juveniles within them had a chance to emerge from their redds. These redds

[1] For the purposes of this study a dewatered redd was minimally identified as any active redd that had its highest section (the tailspill mound) exposed to the air. This would indicate that the river flow had decreased from the time when the redd was constructed and that impacts to egg or juvenile survival could occur.

were carefully monitored, as seasonal flow reductions began to "top" dewater five of these winter-run redds later in August. Managers met regularly (through the auspices of the B2IT conference calls) and decided to minimize further flow reductions until the end of October to allow these juvenile winter-run time to emerge from their redds. As a direct result of the monitoring from this survey, flows were stabilized for protection of these shallow winter-run redds.

All of these 30 winter-run redds were downstream of the Anderson Cottonwood Irrigation District (ACID) Dam, which creates a deep water pool in the Sacramento River in Redding (RM 298). Nearly 76 percent of the winter-run spawned upstream of the ACID dam based on aerial redds survey data in 2013. An additional management action taken to protect these upstream winter-run redds was to request that the ACID dam be kept in place until November 1, to prevent dewatering of those winter-run redds above the dam. The seasonal flashboard dam is normally taken out in October, but by keeping the dam in place through October, the redds upstream remained wetted, allowing winter-run juveniles the opportunity to emerge from the redds without being desiccated. One management recommendation of this study for future years is to investigate regularly leaving the ACID dam in place until November during dry years when redd dewatering is predicted.

The California Department of Water Resources (CDWR) actively assisted in monitoring flows around the winter-run and other redds. The CDWR's Northern District staff is working to produce flow rating tables for selected high density spawning areas that will enable managers to determine at what flows specific areas will become dewatered. This project, when complete, will complement the real-time monitoring of this survey and allow flow reductions to be carefully adjusted ahead of time to prevent dewatering of active redds observed by this survey in areas with up-to-date flow rating tables.

The work done on the endangered winter-run salmon redds transitioned into monitoring dewatering of spring, fall and late fall-run redds as flows decreased when winter-run redds had "expired" after November 1. Monitoring for these runs typically begins in October, but stable flows prevented dewatering through October in 2013. An unusually large number of spring-run adults were observed at the Keswick Dam trap in the spring of 2013. In most years the Sacramento River is thought to have a small number of adult spring-run "strays" from various tributaries (*i.e*, Feather River, Butte, Mill, Deer, Clear and Battle creeks). The river is not known to have a distinct run of spring-run. The reason for this is unknown but it is postulated that the much larger fall-run (that spawn at the same time and location) interbreed with these stray spring-run and the resulting offspring become mixed-run fish that eventually become genetically similar to the much larger fall-run population.

No attempt was made to quantify the spring-run population in the Sacramento River (due to lack of funding for genetic testing). Some carcasses in early September were genetically tested to separate the later spawning winter-run from other populations (genetic analysis found winter, spring and fall-run fish), but fall and spring-run carcasses were not sampled for genetics after early September. The survey noted that 23 redds identified as spring-run based on their time of construction (September) became dewatered. Agency managers realized that the ESA-threatened spring-run juveniles would require over 100 days (until January) to emerge from these

redds. Winter-run redds were protected by decisions to hold flows at around 6,000-7,000 cfs until November, but the continuing extreme drought conditions forced mangers to drop the flows to the 3 to 4 thousand cfs range in November over concerns that little cold water would be available for the 2014 winter-run spawners. The low storage in Shasta Reservoir essentially "pitted" the current and future needs of the endangered winter-run against the needs of an undocumented number of threatened spring-run redds. After discussion, the winter-run needs "trumped" the spring-run for fishery managers. In addition, the ongoing drought conditions were raising alarms for future agricultural and urban needs that resulted in agreements to conserve water by reducing releases from Shasta Reservoir after November 1 to absolute minimal needs.

Observations during 2013-2014 and prior studies indicate that oscillating river flows have the potential to dewater redds and strand juvenile salmonids repeatedly in the same locations. Juvenile salmon naturally move between shallow, slow moving waters to rest between venturing into swifter, food-carrying waters. This behavior makes them particularly susceptible to stranding as flows recede and isolate the shallow river margin areas. During dry periods in the winter with steady or decreasing tributary inputs, small flow changes (up or down) from Keswick Dam can result in repeated flooding and dewatering of pool and side channels throughout the upper Sacramento River. Stranding sites may occur in close proximity to spawning areas and to other stranding sites. During certain circumstances, recently-emerged juvenile salmonids have been observed stranded in pools surrounding dewatered redds. These unfortunate fish survive redd dewatering but then become susceptible to stranding as juveniles. Future efforts will shift towards monitoring, rescuing, and implementing preventive actions, including possibly developing strategies for reconnecting stranding sites to the river. This year's current redd dewatering monitoring activities are described below in Section 6.2.

7.2. Winter-run Salmon Contingency Plan Actions

RPA Action I.2.3.C, Drought Exception Procedures, requires that by March 1, Reclamation shall provide a contingency plan if the February forecast, based on 90 percent hydrology, shows that Clear Creek temperature compliance point or 1.9 million-acre-feet (MAF) End-of-September (EOS) storage in Shasta Reservoir is not achievable. The contingency plan provides written justification that all actions within Reclamation's authorities and discretion are being taken to preserve cold water in Shasta Reservoir for the protection of winter-run.

Although Reclamation had not yet completed the February forecast, the January 90 percent exceedance forecast showed Reclamation unable to meet 1.9 MAF at the EOS. Given that there had not been any appreciable precipitation in January, Reclamation expected the February forecast to show reduced storage levels from the January forecast. On January 31, 2014, NMFS received at Temporary Urgency Change (TUC) Petition from Reclamation and the Department of Water Resources (DWR), which served as the drought contingency plan for the month of February, consistent with the drought exception procedures in RPA Action I.2.3.C. The TUC petition requested the State Water Resources Control Board (State Board) consider modifying requirements of D-1641 Delta outflow requirements and Delta Cross Channel gate operations for February. The change reduced reservoir releases from those otherwise required to meet D-1641 in February to conserve storage for later fishery protection, minimum human health and safety

needs, and salinity control. In addition, Reclamation targeted a navigational control point at Wilkins Slough not to exceed 4,000 cubic feet per second during February.

On February 27, 2014, NMFS received a letter from Reclamation and DWR with a request to extend the February drought contingency plan provisions through March (Interim Contingency Plan). According to the February forecast showed that EOS Shasta storage was less than 1.9 MAF and a TCP above Clear Creek on the Sacramento River may be met through July, but releases from Keswick Dam may be greater than 56^{o}F by mid-August. On March 14, 2014, NMFS received a letter from Reclamation and DWR with adjustments to the Interim Contingency Plan. On April 8, 2014, NMFS received the CVP and SWP Drought Operations Plan and Operational Forecast (DOP) to serve as the Contingency Plan for the remainder of WY 2014 (April 1 through November 15, 2014) in accordance with RPA Action I.2.3.C.

In the DOP, the March forecast indicated that Shasta EOS storage would be too low (662 TAF in the 90% forecast) to maintain flows and water temperature for winter-run egg incubation and fry production through August and September in the Sacramento River. Temperature modeling showed greater than 50% of the eggs may be lost due to high temperatures in the 90% forecast (driest). In addition, the Livingston Stone National Fish Hatchery (LSNFH) winter-run production would also be subject to these projected high temperatures, since it relies on its water supply through Shasta Dam. The LSNFH will also likely lose their water intake, located on the powerhouse penstock if the forecast shows that the reservoir elevation will drop below the powerhouse intake on Shasta Dam.

The DOP included operational actions to increase the likelihood of meeting essential protective temperatures by including measures that increase cold water accessibility and storage. In addition, the DOP included the following fisheries measures to maintain juvenile winter-run Chinook salmon productivity and to increase the likelihood of meeting essential protective temperatures:

1) Enhanced Temperature, Flow, and Egg Survival Monitoring Program for assessing naturally spawned winter-run egg survival in the upper Sacramento River.

2) Increasing production at LSNFH: Infrastructure needs for normal operations, and additional needs for increasing production.

3) Collecting winter-run out of the Sacramento River for additional LSNFH broodstock or relocation into Battle Creek (see #5).

4) Releasing unfed fry from LSNFH at alternative locations.

5) Relocating winter-run to suitable spawning and rearing habitat outside of the Sacramento River.

Of particular relevance to the SRTTG were the key actions under the enhanced temperature, flow, and egg survival monitoring, which included the following:

a. Implement a permanent temperature monitoring station at Airport Road Bridge.
   - CDFW has secured funding and is working on a contract to transfer the money to DWR for implementation. Although the new permanent temperature monitoring station is important, it was not critical for this water year, as the temperature compliance point was set at the CDEC Clear Creek temperature monitoring station (CCR), upstream of the Airport Road Bridge. In addition, CDFW installed a temporary temperature gage at Airport Road Bridge for this year.

b. Place temperature and water level sensors in redds and primary juvenile rearing habitat (in place by May 15).
   - Probes could not be installed within winter-run redds because the necessary ESA section 10(a)(1)(A) permitting was not in place. Twenty temperature and dissolved oxygen (DO) probes were placed adjacent to marked winter-run redds at the downstream end. Temperature, and especially DO, data could not be used because the probes were not within the redd. The probes will be deployed again within and adjacent to fall-run redds this fall to compare results.

c. Monitor temperatures in the secondary channels, within spawning gravel areas, and tributaries.
   - Fifty temperature probes were installed between Deer Creek and Keswick Dam. A majority (44) were installed upstream of Red Bluff Diversion Dam (RBDD). One probe was deployed every two miles from RBDD upstream to Keswick Dam. The remaining probes were deployed inside rearing areas and in other locations of interest to better understand temperature differences in the watershed. Monitoring is currently going on. Results will be provided in next year's annual report.

d. Monitor 7-Day Average Daily Maximum.
   - In 2013, NMFS expressed to the SRTTG the idea of tracking 7-day average of daily maximum water temperature in order to determine whether sub-lethal effects on salmonid life history stages (spawning, egg incubation, and fry emergency) exist, despite the current temperature requirement metric of daily average. As explained in Appendix B of the 2013 SRTTG Annual Report of Activities, daily average temperature does not consider the impacts of diurnal temperature changes and daily maximum temperature. The stressful impacts of higher water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival. Sub-lethal effects from high water temperature can lead to delayed mortality due to reduced fry and smolt sizes from sub-optimal growth. These effects could result in reduced productivity of a stock and reduced population size. As the term suggests, 7-day average of daily maximum (7DADM) reflects an average of maximum temperatures that fish are exposed to in a week long period. Since this metric is oriented to daily maximum temperatures, it can be used to protect against acute and sub-lethal or chronic effects.

     7DADM was monitored for WY2014, and as seen in Figure 1 below, it can be greater than the daily average temperature by as much as 3^{o}F.

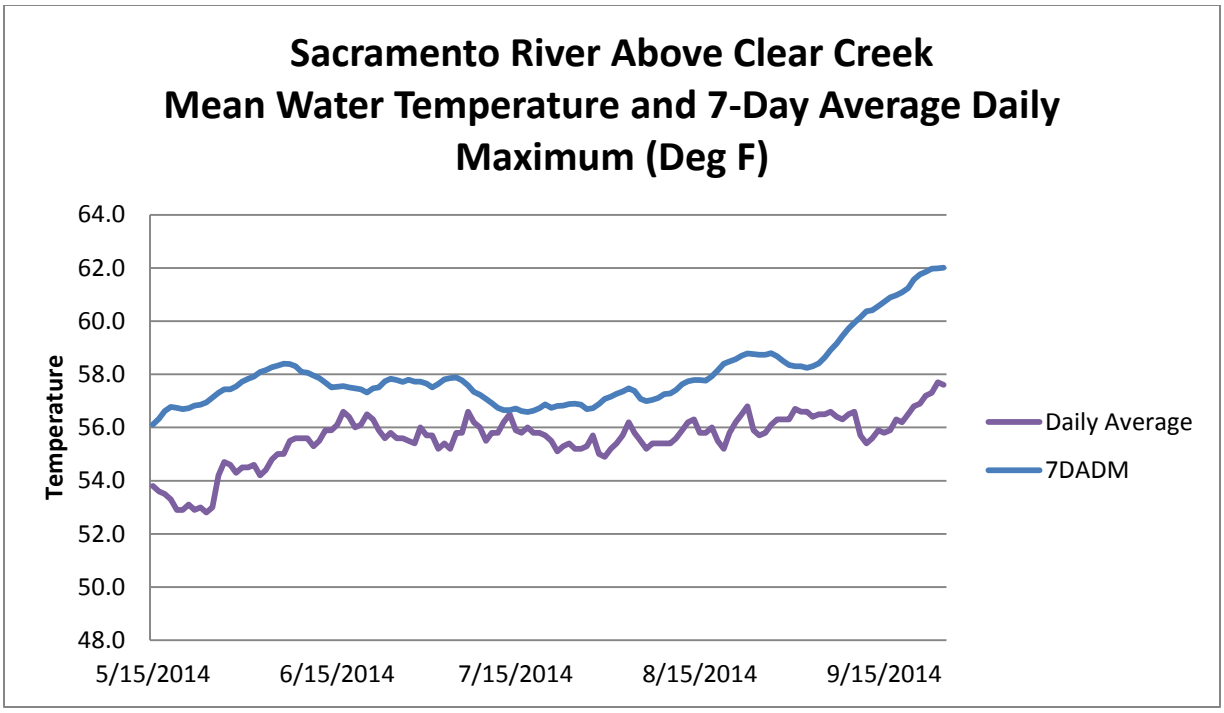

Figure 1. 2014 Water Temperatures on the Sacramento River at Clear Creek TCP showing daily average and 7DADM, May 15 through September 25, 2014.

e. Monitor redds at the downstream end of the spawning distribution (near the temperature compliance point) to determine whether healthy fry emerge. Incorporate weekly (or daily as needed) winter-run redd dewatering and juvenile stranding real-time monitoring data into water level management and temperature modeling.

- As of August 13, a total of 57 winter-run redds (brood year 2014) had been observed, recorded and monitored by boat since June 6. About 35% (20) of these redds were identified above ACID Dam[2] at Caldwell Park and the remaining 37 located downstream of ACID Dam, with the furthest downstream located at RM 293. The depth of redds at a Keswick release of 8,500 cfs ranged from 11 to 120 inches.

  As mentioned earlier, CDFW proposed to collect and organize orthorectified aerial photos of the upper Sacramento River and use GIS and abiotic data (temperature, depth, and flow), to analyze winter-run Chinook salmon redd development over time. The proposed project was never funded. Instead CDFW overlaid past and current GPS redd data onto Google Earth and used real-time abiotic measures to predict potential redd dewatering and juvenile stranding sites based on water operations. See Figure 2 below for an example of this.

[2] ACID agreed to leave their flashboards in until October 31, so the 20 winter-run redds upstream of the ACID Dam are expected to be protected from dewatering.

Figure 2. This figure is an example of this year's winter-run Chinook redd locations (green squares) overlaid next to prior year dewatered redd locations with the associated flows at which they became dewatered (brown, red, purple, blue, and yellow circles). Past years data was used to predict the potential flows that could dewater this year's redds.

Based on previous redd dewatering surveys, redds were likely to begin to dewater at a flow of 6,000 cfs. The majority of the identified winter-run redds would emerge by October 18, with the alevin from one redd estimated to emerge by November 7. See Figure 3 and Table 2 below for more information.

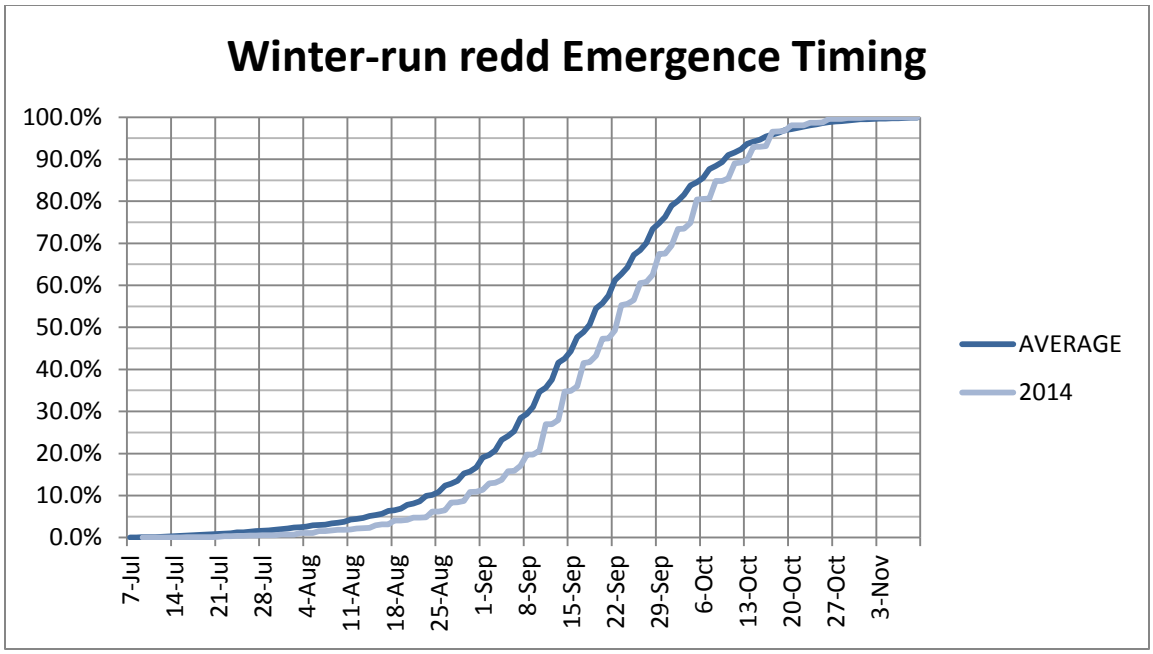

Figure 3. Winter-run Chinook emergence timing based on carcass surveys minus 10 days and 80 days to emergence.

Table 2. The 37 monitored redds downstream of ACID at 8500 cfs on August 13 with unique ID, construction date, expiration date, depth, and projected dewatering flows.

Redd #	Date	Expiration	Depth (in)	Projected dewatering Flows (cfs)
1057	8/12/2014	10/31/2014	11	6000
1027	7/7/2014	9/25/2014	12	5000
1054	7/30/2014	10/18/2014	12	6000
1044	7/14/2014	10/2/2014	13	5000
1048	7/16/2014	10/4/2014	13	5000
1050	7/26/2014	10/14/2014	14	5000
1029	7/7/2014	9/25/2014	15	5000
1031	7/7/2014	9/25/2014	15	
1053	7/30/2014	10/18/2014	15	6000
1026	7/7/2014	9/25/2014	16	4000
1030	7/7/2014	9/25/2014	17	5000
1052	7/30/2014	10/18/2014	17	
1002	6/6/2014	8/25/2014	19	5000
1021	7/3/2014	9/21/2014	20	5000
1023	7/3/2014	9/21/2014	23	5000
1005	6/18/2014	9/6/2014	24	
1022	7/3/2014	9/21/2014	24	
1045	7/14/2014	10/2/2014	24	5000
1055	8/8/2014	10/27/2014	26	4000
1001	6/6/2014	8/25/2014	34	
1049	7/23/2014	10/11/2014	40	
1034	7/11/2014	9/29/2014	43	4000
1040	7/11/2014	9/29/2014	45	
1028	7/11/2014	9/29/2014	46	
1051	7/26/2014	10/14/2014	46	
1018	7/1/2014	9/19/2014	48	
1019	7/1/2014	9/19/2014	48	
1039	7/11/2014	9/29/2014	49	
1037	7/11/2014	9/29/2014	53	
1036	7/11/2014	9/29/2014	54	
1041	7/11/2014	9/29/2014	55	
1035	7/11/2014	9/29/2014	58	
1043	7/11/2014	9/29/2014	61	
1020	7/1/2014	9/19/2014	62	
1038	7/11/2014	9/29/2014	63	
1042	7/11/2014	9/29/2014	63	
1032	7/7/2014	9/25/2014	84	

The winter-run contingency plan has a trigger of the documentation of 5 or more dewatered winter-run redds in order for NMFS to make operational recommendations to the SRTTG. The fish agencies have been discussing and suggesting various Keswick release schedules in order to minimize redd dewatering. In addition, any juvenile salmonids found stranded in isolated pools, CDFW will relocate back to the nearest point on the main channel.

f. Calibrate long-term temperature forecast models to reduce uncertainty.
g. Evaluate the likelihood of critical depletions through coordination with water contractors more than 30 days in advance of forecasted operations.
h. Use an existing, more current model than HEC-5Q, such as CE-QUAL-W2, to increase forecast accuracy of long-term temperature forecasts.

7.3. Winter-run Chinook Salmon Assessment and Monitoring, March – August 2014

- *Carcass Surveys* – As of August 24, the preliminary count of winter-run carcasses is 1,386. The number of carcasses to date is similar to 2012, which had a final population estimate of around 2,600. Last year's carcass count was 3,219.
- *Aerial Redd Surveys* – As of August 25, CDFW observed a total of 127 redds in its weekly aerial surveys. All of the winter-run redds are at or above the Clear Creek (CCR) temperature compliance point (TCP) at approximately RM 291. Peak winter-run spawning was observed during the July 2 and 9 aerial redd surveys.
- *Water Temperature Effects* – As of September 25, water temperatures exceeded the 56^{o}F daily average at the CCR TCP for 54 days, including 15 consecutive days in August and 23 days in September.

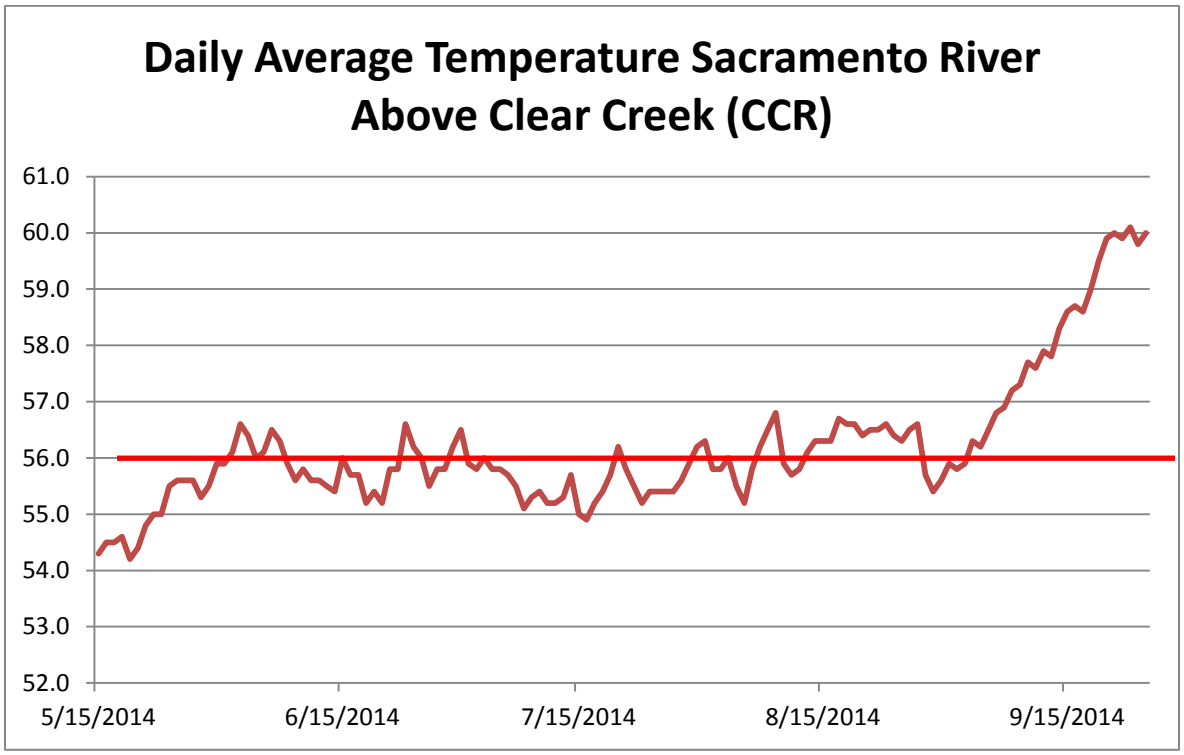

Figure 4. Daily average temperature Sacramento River at the CDEC Temperature Monitoring Station Above Clear Creek (CCR), May 15 through September 25, 2014.

One hundred percent of winter-run brood year 2014 redds were exposed to temps above 56^{o}F degrees at the CCR TCP at some time period during WY 2014. Of significant concern were those redds exposed to the consistently elevated temperatures throughout August and September. The effects of temperatures above 56^{o}F are uncertain because it would depend on the magnitude of the water temperature, duration and life history stage (e.g., eggs vs. alevin). NMFS is working on an egg mortality model to determine temperature effects on eggs and alevins. Using mean daily temperatures from CDEC through August 28 and the August 90% forecast, preliminary results show survival is 81%. However, these results should be taken with caution, as Reclamation's temperature model was inaccurate this water year. For example, water temperatures were tracking about 4^{o}F higher than the modeled temperatures. Using actual CDEC data, NMFS will run an analysis at the end of the WY 2014 to provide a more accurate estimate of winter-run survival rate based on temperature-related mortality.