2015 Clear Creek Technical Team Report for the Coordinated Long-Term Operation Biological Opinions Integrated Annual Review November 5, 2015

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Draft
2015 Clear Creek Technical Team Report for the
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Integrated Annual Review
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CHAPTER 1. BACKGROUND

1.1 Brief background on Clear Creek and the Technical Team:

Since 1995, Central Valley Project Improvement Act (CVPIA) and later CALFED have undertaken extensive anadromous salmonid habitat and flow restoration in Clear Creek (See Figure 1). The restoration has increased stocks of fall-run Chinook salmon (*Oncorhynchus tshawytscha*) four fold and re-established populations of spring-run Chinook and Central Valley (CV) steelhead (*O. mykiss*). The Clear Creek Technical Team (CCTT) has been working since 1996 to facilitate implementation of these CVPIA and CALFED restoration actions. Team attendance and /or participation have varied over the years depending on what topics are being covered in the meetings. The majority of the topics had involved physical habitat restoration. Since 2009 topics have included NOAA's National Marine Fisheries Service's (NMFS) Coordinated Long-Term Operations (CLTO) biological opinion (BO) Reasonable and Prudent Alternative (RPA) actions including flow and temperature management on Clear Creek.

The Clear Creek Restoration Program (CCRP) of CVPIA identified and implemented a variety of actions to improve salmon and steelhead populations and the ecosystem on which they depend, including increasing minimum flows, temperature control through flow management, dam removal, large scale stream and floodplain restoration, gravel augmentation, and erosion control. The effect of these actions has been to:

1) increase the escapement of fall-run Chinook four fold, primarily due to increased minimum flows,
2) re-establish populations of threatened spring-run Chinook and steelhead primarily through dam removal, increased flows and temperature management,
3) rehabilitation of stream and floodplain habitats,
4) re-initiation of sediment transport and stream channel movement processes, in some reaches, which help create and maintain fish habitat, and
5) greatly increase the amount of spawning habitat.

The actions are also believed to have increased the resilience of the fall-run Chinook population, allowing it to perform better than the rest of the Central Valley watersheds during the 2007 to 2010 coastal Chinook fishery collapse. During that period, while Central Valley escapement decreased to 24% of baseline, Clear Creek consistently maintained an average 74% of baseline escapement.

1.2 Current Active Members

Alicia Herrera, Natural Resources Conservation Service/Point Blue Conservation Service
Brycen Swart, NOAA Fisheries
Eda Eggeman, CA. Department of Fish and Wildlife
Gary Diridoni, U.S. Bureau of Land Management
Gretchen Garwood, Western Shasta Resource Conservation District
Guy Chételat, CA. Regional Water Quality Control Board
Jason Roberts, CA Department of Fish and Wildlife
Jim Earley, U.S. Fish and Wildlife Service
Justin Day, Redding Electrical Utility, City of Redding
Laurie Earley, U.S. Fish and Wildlife Service
Mark Gard, U.S. Fish and Wildlife Service
Matt Brown, U.S. Fish and Wildlife Service
Matt Johnson, CA. Department of Fish and Wildlife
Mike Berry, California Department of Water Resources
Naseem Alston, NOAA Fisheries
Patricia Bratcher, CA. Department of Fish and Wildlife
Russ Weatherbee, Whiskeytown National Recreation Area, National Park Service
Sarah Gallagher, U.S. Fish and Wildlife Service
Shiloe Braxton, Western Shasta Resource Conservation District
Smokey Pittman, Graham Matthews and Associates
Charles Chamberlain, U.S. Bureau of Reclamation

There are other people from various agencies and entities that participate on a less frequent basis.

1.3 List of Clear Creek Technical Team BO Related Discussions:

The following list of topics was covered in CCTT meetings in WY 2015.

September 23, 2014

- Update on review of Annual OCAP Science Panel Report for Clear Creek Technical Team
- Fish monitoring update
- Whiskeytown fall water release recommendations
- Clear Creek habitat synthesis report
- CVPIA Gravel update
- WSRCD staff changes
- Update on 3B additional projects
- AHMAP Project discussion: AHMAP spoils on BLM lands

November 13, 2014

- Incorporate team input into the USFWS Restoration and Monitoring Program report "CLEAR CREEK HABITAT SYNTHESIS REPORT"(relates to RPA I.1.6)

January 30, 2015

- Discussion of Oak Bottom Temperature Control Curtain
- Update on EWP

- Clear Creek Fish Monitoring
- Pulse Flow Proposal
- Discussion of Gravel Introductions
- Discussion of Lower Clear Creek Aquatic Habitat Mercury Abatement Program
- Discussion of NMFS Flow Recommendations

1.3.1.1 April 2, 2015

- Fall-Chinook escapement monitoring presentation
- Update on flow study synthesis report
- Discussion of pulse flows
- Update on Lower Clear Creek Aquatic Habitat Mercury Abatement Program

1.3.1.2 July 28, 2015

- CVPIA 2016 Annual Work Plan and New Implementation Plan
- Phase 3C update- begin this year
- Fisheries / water operations update
- Pulse flow results
- Flow prescription reports- Need to be written
- Gravel report 2015- what should be in it? Who writes it?
- Independent Science Panel Annual Report and Workshop 2015
- BLM Land Acquisition Update
- Discussion of spring 2015 pulse flows

1.3.1.3 September 24, 2015

- Fish, flows and temperatures update
- Annual Review report progress
- Phase 3B Update
- Phase 3C Update
- Clear Creek Environmental Water Program Update
- Lower Clear Creek Aquatic Habitat and Mercury Abatement Project Update

CHAPTER 2. 2014 REPORT OF THE INDEPENDENT REVIEW PANEL

The 2014 Delta Science Program Independent Review Panel (IRP) on the long-term operations opinions annual review (LOO) document presented its findings and recommendations to U.S. Bureau of Reclamation (Reclamation), NMFS, and the U.S. Fish and Wildlife Service (FWS). Portions of the IRP's 2014 review focused on implementation of NMFS' RPA actions for Clear Creek. Recommendations from the IRP that relate to Clear Creek activities are provided below in italics. CCTT responses are provided to each.

2.1 IRP Report regarding measurement of progress

From 2014 Independent Review Panel Report, page 11

> *"It was obvious that progress on some types of projects (e.g., gravel augmentations in Clear Creek, the Lower American River, and the Stanislaus River) is a source of pride in accomplishment for the technical teams. The IRP does not intend to diminish these*

valuable contributions to habitat improvement in any way. With that said, the IRP would be remiss if it did not point out that the ultimate success of such projects is inextricably tied to other aspects of the overall plan. For example, improvements in the structural value of spawning habitat (i.e., suitable gravel for redds) will have little realized benefit to salmonid populations if appropriate water temperatures and flows cannot be maintained within redds and juvenile rearing habitats to support improved survival of fry and smolts. The critically dry conditions in WY 2014 presented a real challenge in this regard and temperature and flow targets could not be met. Also, some projects affecting cold-water delivery capacity seem to be on long-term hold (e.g., Oak Bottom Temperature Control Curtain (OBTCC) at Whiskeytown Lake).

These delays clearly affect progress in other areas. For example, according to the Clear Creek Technical Team Report, the Spring Creek Temperature Control Curtain (SCTCC) was replaced but its effectiveness has not been tested because it was designed to operate in unison with the OBTCC and separate tests of effectiveness were deemed to have no useful purpose. So while claiming success toward meeting an RPA Action (i.e., replacement of the SCTCC), there is no basis on which to judge the effectiveness in terms of the intended purpose of the Action. Connecting the effects to the larger issue of maintaining temperature targets in Clear Creek to improve the survival of salmonid early life stages seems an even less attainable expectation. This harks back to the recommendations of previous panels which consistently encouraged progress toward demonstrable connections between biological responses of the protected species and the RPAs."

Response: We agree that the success of individual projects often requires successful implementation of a multitude of projects that together comprise a collective strategy. Regardless, individual milestones are important and provide a means to evaluate progress toward implementation of the broader strategy. Replacement of the Spring Creek Temperature Control Curtain (SCTCC) was one such measurable milestone, and a component of a larger strategy that includes replacement of the Oak Bottom Temperature Control Curtain.

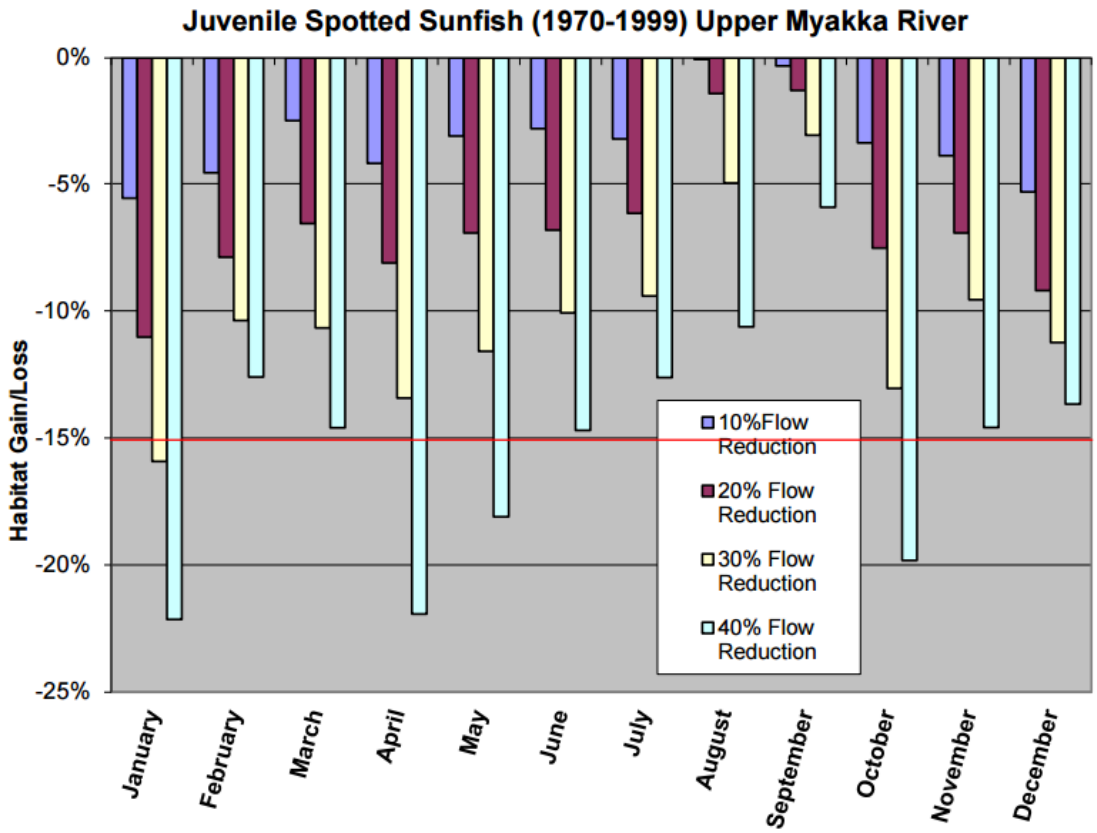
Replacement of the OBTCC is scheduled to begin in January 2016 and the curtain is expected to be operable by May 1, 2016. This will improve cold water delivery capacity for Clear Creek and Spring Creek diversions, including dry years when temperature conditions are particularly challenging. With both the OBTCC and SCTCC in place, monitoring of temperatures will allow evaluation of "effectiveness in terms of the intended purpose of the Action" beginning in summer 2016.

2.2 IRP Report regarding time series analysis

From 2014 Independent Review Panel Report, pages 33 to 34

"We are gratified that the Clear Creek Technical Team continues to complete its PHABSIM analysis, as reported this past year. Although there has been considerable effort to demonstrate that RIVER2D provides more accurate habitat assessments than IFG4, for example, the ultimate output still remains a relationship between habitat availability and daily, weekly, or monthly discharge. These outputs present an opportunity for a new project to analyze the ultimate gain or loss in habitat under reduced flow scenarios. A

relationship between habitat and discharge under flow reduction scenarios can be created from the model output. Time-series analysis, through TSLIB or other exceedance programs, should be based upon frequency and duration of habitat events rather than the discharges associated with those values. These graphical presentations can create the decisions necessary to create more effective management and monitoring strategies. See example in Figure 4."



"Figure 4. An estimate of habitat gain or loss during the AMO dry period on the Myakka River. If a 15% habitat loss cannot be exceeded, this model predicts that a 20% flow reduction is acceptable in January but in September even a 40% flow reduction does not significantly impact juvenile spotted sunfish. This analysis is repeated for a suite of target fish and macroinvertebrates."

Response: We agree with the IRP with regard to utility of time-series analysis, and flow to habitat models available for Clear Creek lend themselves to such an analysis. Reclamation and the CCTT will evaluate flow scenarios based on temperature, flow to habitat relationships, and temporal demand for habitat by life history utilizing frequency and duration of habitat events. Reclamation will work with NMFS to adaptively implement flow recommendations per RPA Action I.1.6. Adaptively Manage to Habitat Suitability/IFIM Study Results.

2.3 IRP Report regarding operational flexibility

From 2014 Independent Review Panel Report, pages 33 to 34

"The panel recognizes that water operation actions are driven by a set of mandated rules and that the agency personnel manning reservoir operations may not have the authority to take actions outside of the framework of these rules. However, it would appear that additional flexibility (altered rules) could be authorized by the appropriate agency management under critically dry conditions such as occurred in WY 2014 in order to conserve scarce water resources. "

Response: This IRP recommendation appears to address water operations CVP-wide (inclusive of Clear Creek). The Shasta Temperature Management Plan for 2015 and its revisions are demonstrative of CVP operational flexibility in a critically dry year.

CHAPTER 3. SUMMARY OF CLEAR CREEK RPA ACTIONS

RPA Action Item	Progress in WY 2015
I.1.1. Spring Attraction Flows	Yes
I.1.2. Channel Maintenance Flows	Yes
I.1.3. Replace Temperature Curtain	No
I.1.4. Thermal Stress Reduction	Yes
I.1.5. Adaptively Manage to Habitat Suitability / IFIM Study Results	Yes
Other required monitoring and operations	Yes

Implementation of RPA Actions in WY 2015

3.1.1 Action I.1.1. Spring Attraction Flows

Objective: Encourage spring-run movement to upstream Clear Creek habitat for spawning.

Action: "Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem. This may be done in conjunction with channel-maintenance flows (Action I.1.2)".

Results: One pulse of 800 cfs was provided from Whiskeytown Dam in May and another pulse of 360 cfs in June (Figure 2). The May pulse was timed to coincide with peak spring-run migration. The pulse flow in June was selected based on the increased rate of spring run passage observed during June pulse flows in 2013 and 2014.

Video station results showed that the average number of salmon that passed per day during the pulse flows (mean = 2.5; SE = 0.0092) was significantly greater ($t = 4.90$; $df = 151$; $P < 0.05$, all tests two-tailed) than what passed on non-pulse flow days during the migration period (mean = 0.6; SE = 0.0001). These higher passage rates during pulse flows suggest that the pulse flows were successful in attracting spring Chinook in to Clear Creek.

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Each pulse flow was also analyzed separately to determine if the rates of spring-run passage during periods before and after each pulse were different. In May, the average number of fish that passed per day during the nine-day period both before ($t = 2.52$; $df = 16$; $P < 0.05$) and after ($t = 2.42$; $df = 16$; $P < 0.05$, two-tailed test) the pulse flow was significantly less than the number that passed during the pulse flow (Figure 3). In June, the average number of fish that passed per day during the six-day period before the pulse flow was not significantly different from the pulse flow period ($t = 0.70$; $df = 10$; $P = 0.50$). Passage in the 6-day period after the pulse flow was significantly less than the pulse flow ($t = 2.80$; $df = 10$; $P < 0.05$) (Figure 3). Overall, in three of four comparisons, passage during pulse flows was higher than the adjacent time period, also suggesting that the pulse flows were successful in attracting spring Chinook into Clear Creek.

Snorkel survey results showed an increase in adult live Chinook salmon following each pulse flow. In May, counts increased from 13 before to 28 after the pulse flow (Figure 4). In June, counts increased from 49 before to 73 after the pulse flow. The increases in snorkel counts were 115% in May and 49% in June. The ability to detect differences may be reduced due to small sample sizes with fewer than 50 spring-run counted on three of the snorkel surveys.

3.1.2 Comparing results to previous years further suggests that the pulse flows in May and June attract spring Chinook into Clear Creek. Similar significant results comparing passage rates between pulse and non-pulse periods were found in 2013 and 2014 when population sizes were larger. RPA Action I.1.2. Channel Maintenance Flows

Objective: Minimize project effects by enhancing and maintain previously degraded spawning habitat for spring-run Chinook and CV steelhead.

Action: "Reclamation shall re-operate Whiskeytown Glory Hole spills during the winter and spring to produce channel maintenance flows of a minimum of 3,250 cfs mean daily spill from Whiskeytown for one day, to occur seven times in a ten-year period, unless flood control operations provide similar releases. Re-operation of Whiskeytown Dam should be implemented with other project facilities described in the Environmental Water Program (EWP) Pilot Program".

Results: This RPA Action was not implemented in this critically dry year (Figure 7). Planning and permitting are continuing through an Ecosystem Restoration Program contract between California Department of Fish and Wildlife (CDFW) and the FWS. Planning regarding implementation of this RPA Action will continue through the EWP Pilot Program.

3.1.3 RPA Action I.1.3. Spawning Gravel Augmentation

Objective: Enhance and maintain previously degraded spawning habitat for spring-run and CV steelhead.

Action: "Reclamation, in coordination with the Clear Creek Technical Team, shall continue spawning gravel augmentation efforts. By December 31 each year, Reclamation shall provide a report to NMFS on implementation and effectiveness of the gravel augmentation program".

Results: Ongoing spawning gravel actions that continued in Clear Creek were: design and permitting of the long-term gravel supply project, obtaining long-term permits for gravel additions and performing geomorphic monitoring and fish monitoring. Gravel projects were not conducted in 2015 due to a BOR vacancy. For 2016, gravel injections are proposed at five sites, for a total tonnage of 7,700 tons (Table 1).

Table 1. Anticipated 2016 gravel injection sites and quantities.

Location	Amount (tons)
Whiskeytown Dam	1,500
Below Dog Gulch	1,000
Guardian Rock	1,500
Placer Road Bridge	3,000
Clear Creek Road Crossing	1,500
Above 3A	1,700
Tule Backwater	1,000
Total	11,200

The Lower Clear Creek Aquatic Habitat and Mercury Abatement Project: CVPIA funded planning, design and permitting for this project to provide an inexpensive, long-term gravel supply for Clear Creek restoration. The project, which is located on Bureau of Land Management and CDFW land, could provide gravel for 20 to 40 years with a fixed acquisition cost. In February 2012, the Ecosystem Restoration Program decided to fund the entire 4-year project ($4.5 million) using a combination of Proposition 13 Mine Remediation and Proposition 84 funds. Revisions to the project design are being implemented with active assistance from the CCTT. Implementation of this project is expected to begin in 2015.

3.1.4 RPA Action I.1.4. Spring Creek Temperature Control Curtain

Objective: Reduce adverse impacts of project operations on water temperature for listed salmonids in the Sacramento River.

Action: "Reclamation shall replace the Spring Creek Temperature Control Curtain in Whiskeytown Lake by 2011".

Results: Replacement of the broken SCTCC in 2011 was one component of a strategy intended to reduce the temperature of water diverted to the Sacramento River via the Spring Creek tunnel. This down-reservoir curtain was designed to pull cold water from lower levels of Whiskeytown Reservoir. The OBTCC (currently inoperable) is intended to prevent mixing of cold and warm water at the upper end of the reservoir. Modeling shows that, when functional, OBTCC exerts even more influence on water temperatures than the SCTCC. The damaged OBTCC is scheduled for replacement beginning January 2015, and to be fully operational by May 1, 2015. The CCTT recognizes the importance of having the SCTCC and OBTCC functioning together in tandem, and being maintained in proper working condition to reduce water temperatures of water that is released into Clear Creek through Whiskeytown Dam, as well as the Sacramento River via the Spring Creek Tunnel.

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3.1.5 RPA Action I.1.5. Thermal Stress Reduction

Objective: To reduce thermal stress to over-summering steelhead and spring-run during holding, spawning, and embryo incubation.

Action: "Reclamation shall manage Whiskeytown releases to meet a daily water temperature of:

1) 60°F at the Igo gage from June 1 through September 15; and
2) 56°F at the Igo gage from September 15 to October 31.

Reclamation, in coordination with NMFS, will assess improvements to modeling water temperatures in Clear Creek and identify a schedule for making improvements."

Results: DATA AS OF 9/24/2015→ Water temperatures at Igo remained below holding criteria of 60° F for 100% of the criteria period June 1 to September 14 (Table 2, Figure 8). While Igo temperature criteria were met throughout holding, water temperatures during that period at the Whiskeytown outflow to Clear Creek were higher in 2015 than in 2014 (Figure 9). Both years were higher than all other years since beginning data collection in 2000.

Water temperature at Igo exceeded the criterion of 56 degrees for 47 of 47 days (100%, estimated on September 24, 2015). Eggs and embryos upstream of Igo were exposed to temperatures expected to incur 15 to 50% mortality (Figure 10). Unfortunately 76% of adults were holding downstream of Igo (Figure 11) and initial snorkel survey results suggest that most redds were also located downstream of Igo. Water temperatures from September 15 to September 24 averaged 1.6 higher than the most recent model results (August 29, Figure 12).

Table 2. Proportion of days that water temperatures at Clear Creek Igo gage met targets.

	Holding temperature 60° F June 1 to Sept 14	Spawning temperature 56° F Sept 15 to October 31
Pre-2009 (average)	99%	93%
2009	100%	26%
2010	100%	26%
2011	100%	62%
2012	100%	64%
2013	100%	96%
2014	100%	0%
2015	100%	0%

AS OF 9/24/2015

Average mean daily water temperatures were compared between similar model scenarios of hydrology and meteorology for the time period September 15 to September 24 (Figure 12). Model results varied by 3.1 degrees for this critical period during the beginning of spawning temperature criteria. Spring Chinook spawning was first detected on September 14th in 2015. Compared to actual water temperatures, modeled temperatures for September 15 to 24 were 1.8

degrees higher in the June model, and were 1.3 degrees lower in late August model. This range of 3.1 degrees may be significant. The range should be evaluated to see if it is within model error and if it has an impact on management actions.

Model results in 2014 differed from actual water temperatures considerably more after September 24 (Figure 13). This suggests that temperatures after September 24th 2015 may not decrease as much as predicted by model results. If so, spring Chinook eggs and embryos could have high levels of mortality due to lethal water temperatures.

By the latter half of September Whiskeytown Reservoir water temperature profiles suggested that there was no water cooler than 57 degrees left in the reservoir (Figure 14). Reservoir temperatures may have been higher because less cold water than forecasted was brought over from the Trinity River during the month of June. Additional water could not be brought over in July and August because of planned powerplant outages.

Fish and water temperature monitoring in WY 2014 and WY 2015 suggested that operations in WY 2014 resulted in better water temperatures in Clear Creek compared to the Sacramento River for spring Chinook (Figure 15) and fall Chinook (Figure 16). Cooler temperatures in Clear Creek may have attracted Sacramento River fall Chinook into Clear Creek which may have served as a refugia from lethal water temperatures in the Sacramento River. Rotary screw trap from Red Bluff Diversion Dam data suggests that few juveniles were produced in the Sacramento River probably due in part to high water temperatures. The number of juveniles produced per female was six times higher in Clear Creek than in the Sacramento River (Figure 17) suggesting that survival was higher in Clear Creek than in the Sacramento River. Note that 2014 produced the lowest juvenile productivity for spring Chinook to date in Clear Creek. Interpretation of the effects of high water temperatures on low juvenile productivity in Clear Creek is confounded by the high flow events that occurred in December 2014 during the early emergence period for spring Chinook fry. The high flows may have damaged redds and their inhabitants, swept fry out of the watershed while traps were not fishing, or made it difficult to catch the fry.
Even though the critically dry year of 2014 was a challenging one for salmon throughout the Sacramento Valley, Clear Creek provided critical juvenile fish production with recruitment per female many times higher than observed in the Sacramento River.

Reclamation has not yet identified a schedule for assessing water temperature modeling improvements in Clear Creek.

3.1.6 RPA Action I.1.6. Adaptively Manage to Habitat Suitability/IFIM Study Results

Objective: Decrease risk to Clear Creek spring-run and CV steelhead population through improved flow management designed to implement state-of-the-art scientific analysis on habitat suitability.

Action: Reclamation shall operate Whiskeytown Reservoir as described in the Project Description with the modifications in Action I.1 until September 30, 2012, or until 6 months after current Clear Creek salmonids habitat suitability (e.g. IFIM) studies are completed, whichever occurs later.

R**esults:** The FWS began a new IFIM study on Clear Creek in 2004 looking at flow habitat relationships for salmon and steelhead. The results of the study are contained in four final reports. In addition, a fifth report known as the "Synthesis Report" takes the findings of the four IFIM studies and recommends flows based on flow habitat relationships. This report is in draft form and should be finalized before the IRP meets in November. When these five salmonid habitat suitability studies are completed, Reclamation will, in conjunction with the CCTT, assess whether Clear Creek flows shall be further adapted to reduce adverse impacts on spring-run and CV steelhead, and report their findings and proposed operational flows to NMFS within six months of completion of the studies.

The CCTT has proposed to include 5 types of flow in this proposed operational plan, including flows to:

1) meet habitat needs based on IFIM and habitat suitability study results;
2) provide temperature control;
3) move and maintain spawning gravels and create and maintain riparian vegetation;
4) avoid fish and redd stranding / dewatering; and
5) encourage anadromy of *Oncorhynchus mykiss* (steelhead / rainbow trout) through an adaptive management approach.

The CCTT (which includes a NMFS representative) intends the report to address and meet the needs of both the RPA Action I.1.6 and the CVPIA Clear Creek Restoration Program which has a mandate under CVPIA to provide a long-term flow prescription to mitigate for the impacts of the CVP.

NMFS will review this report and determine whether the proposed operational flows are sufficient to avoid jeopardizing spring-run and CV steelhead or adversely modifying their critical habitats. Reclamation shall implement the flows on receipt of NMFS' written concurrence. If NMFS does not concur, NMFS will provide notice of the insufficiencies and alternative flow recommendations. Within 30 days of receipt of non-concurrence by NMFS, Reclamation shall convene the CCTT to address NMFS' concerns. Reclamation shall implement flows deemed sufficient by NMFS in the next calendar year.

Recommendations: Working with NMFS and the CCTT, Reclamation should assess if Clear Creek flows should be further adapted to reduce adverse impacts on spring-run Chinook and steelhead and encourage the restoration of these runs/species.

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Acronyms and Abbreviations

BO	Biological Opinion
CCRP	Clear Creek Restoration Program
CCTT	Clear Creek Technical team
CDFW	California Department of Fish and Wildlife
CLTO	Coordinated Long-term Operation
cfs	Cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
FWS	U.S. Fish & Wildlife Service
GMA	Graham Matthews and Associates
IFIM	Instream Flow Incremental Methodology
NOAA-Fisheries	(National Marine Fisheries Service)
OBTCC	Oak Bottom Temperature Control Curtain
Reclamation	U.S. Bureau of Reclamation
RPA	Reasonable and prudent alternative
SCTCC	Spring Creek Temperature Control Curtain

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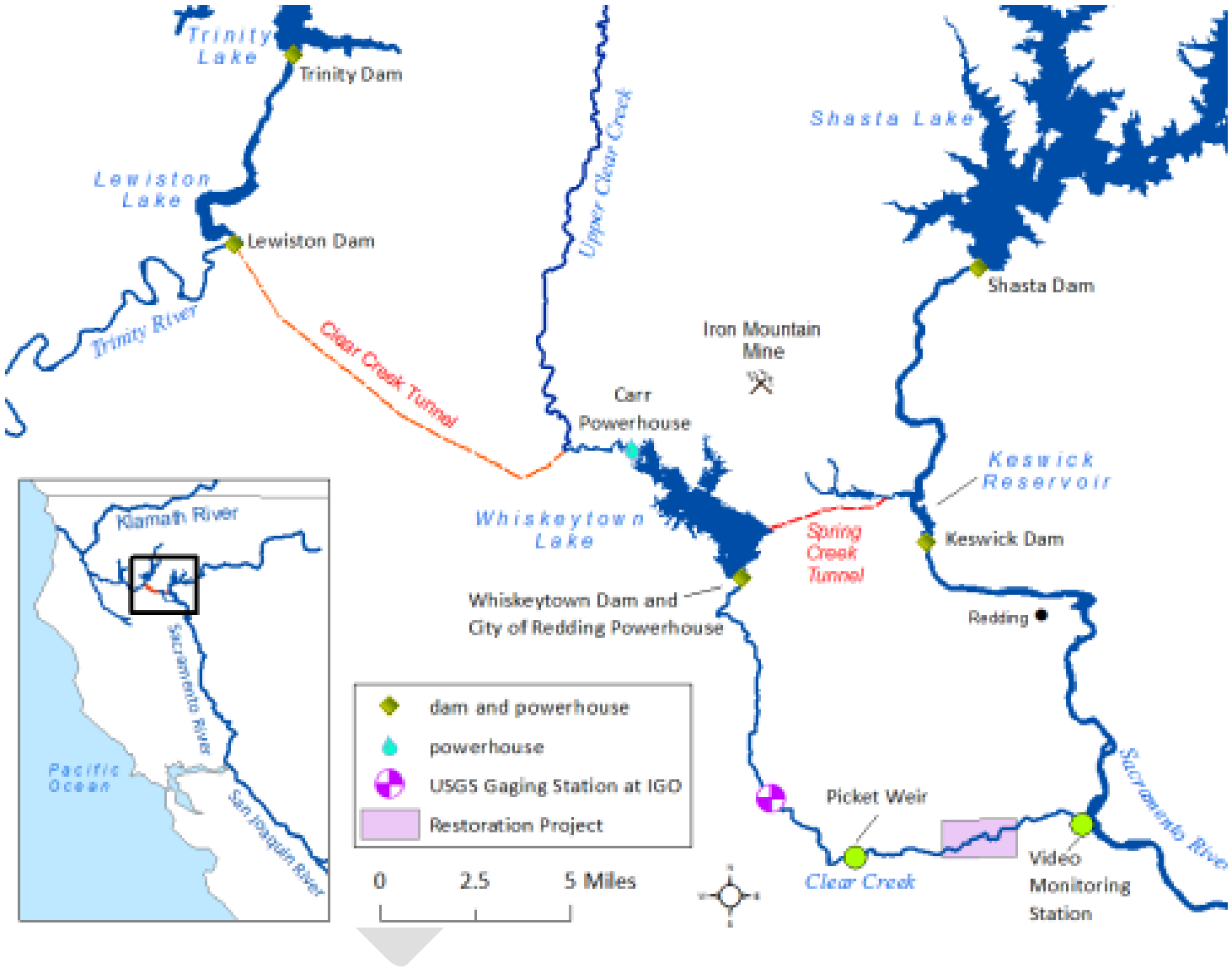

Figure 1. Location of Lower Clear Creek in Northern California, showing Trinity, Whiskeytown, and Shasta Reservoirs and related CVP facilities.

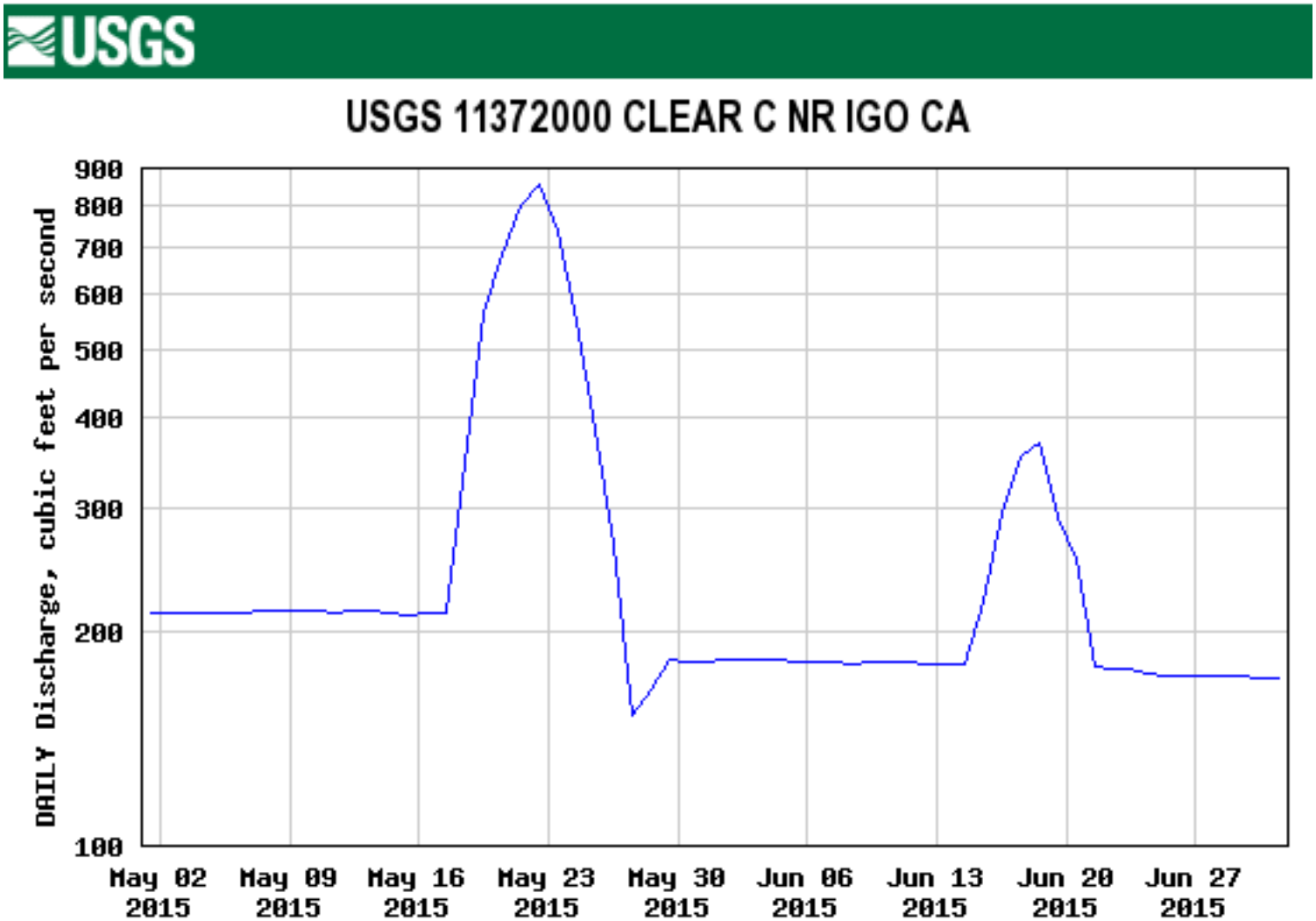

Figure 2. Clear Creek discharge as measured at Igo showing the pulse flow implemented in 2015. Data are preliminary as of August 14, 2015.

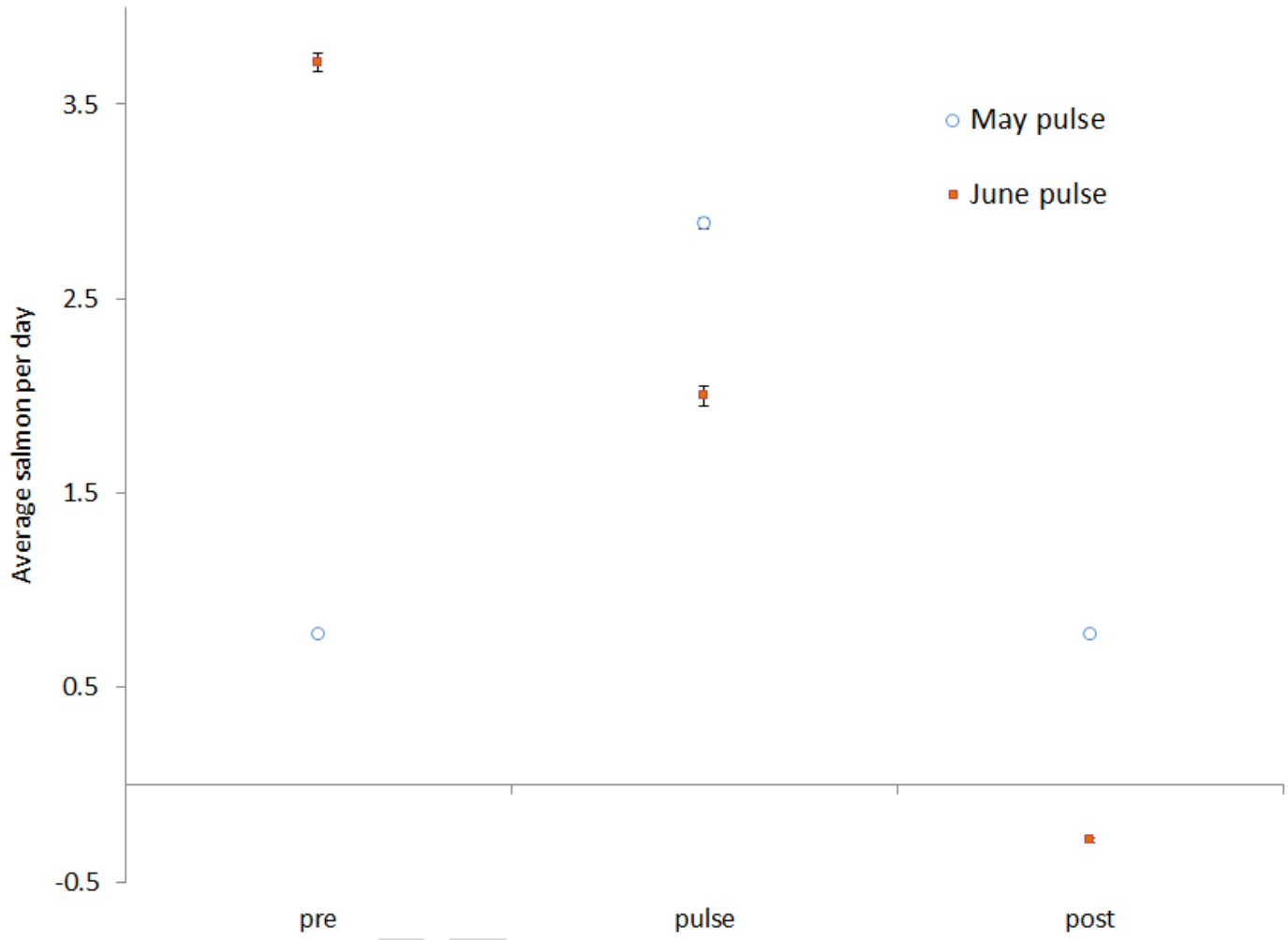

Figure 3. Average rate of spring-run Chinook Salmon daily passage before, during, and after the May and June pulse flows, Clear Creek, 2015. Pre and post period were the same duration as each pulse flow.

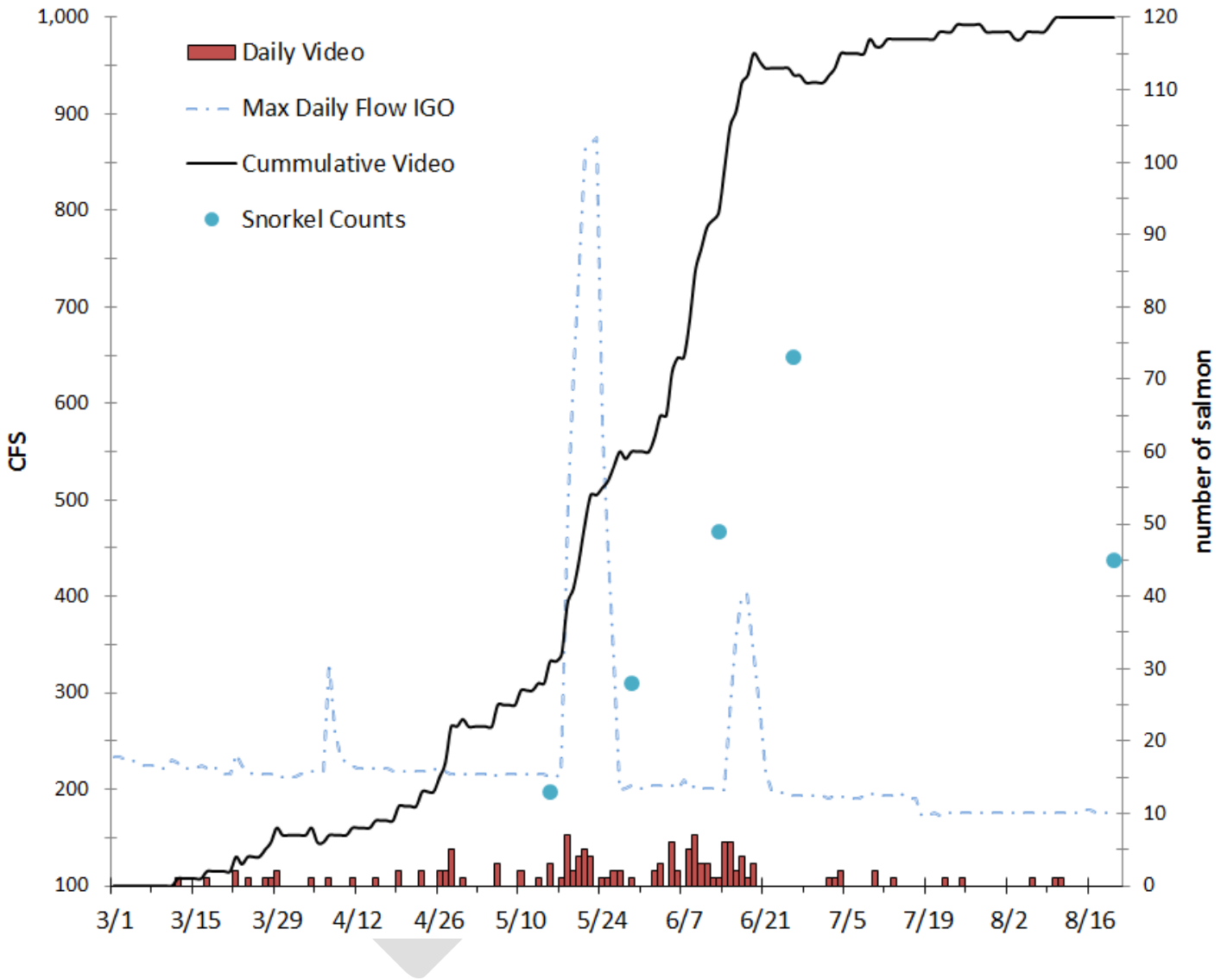

Figure 4. Spring-run Chinook Salmon daily passage at the video station during the migration period, and snorkel counts before and after pulse flows, Clear Creek, 2015.

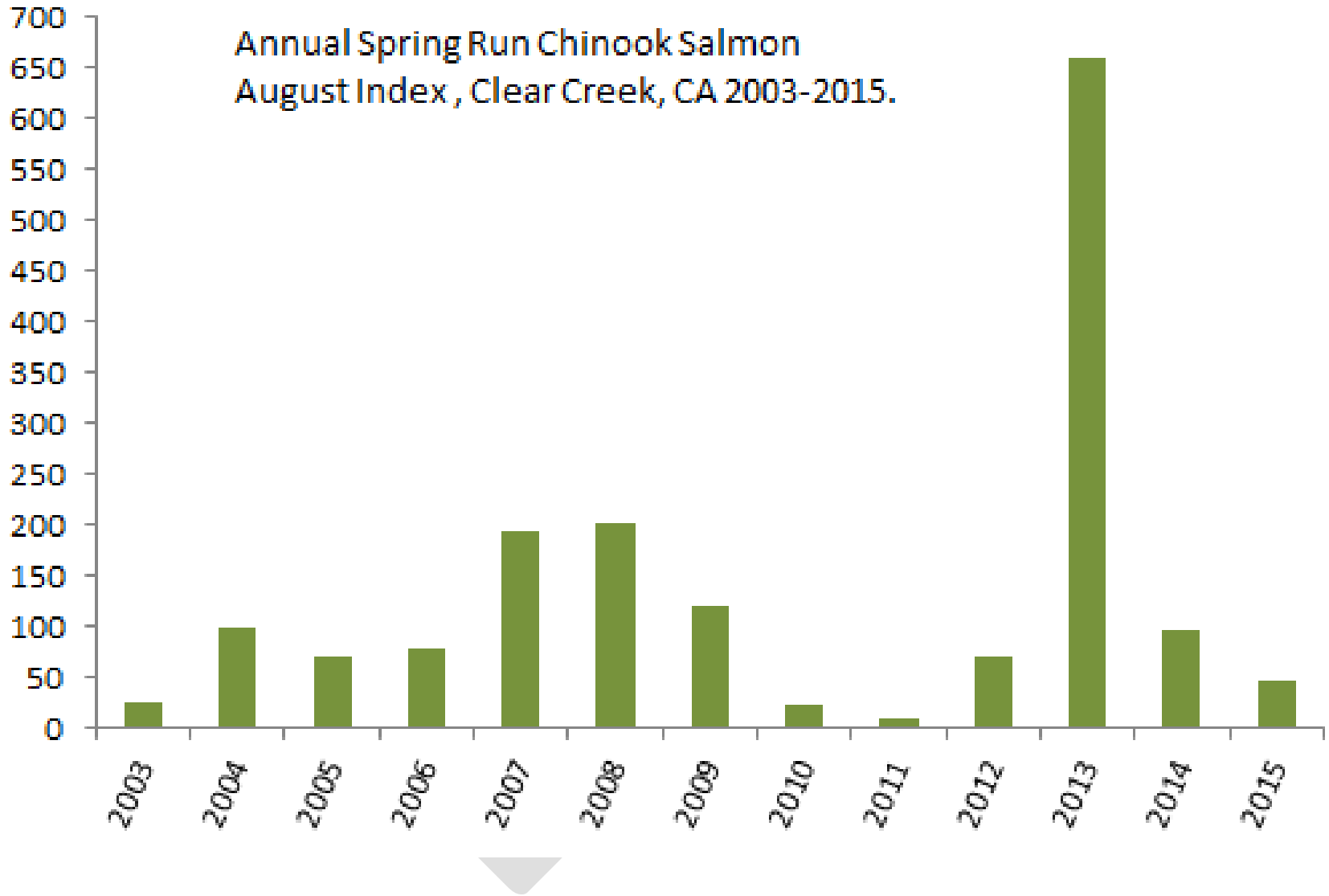

Figure 5. Spring Chinook salmon runs.

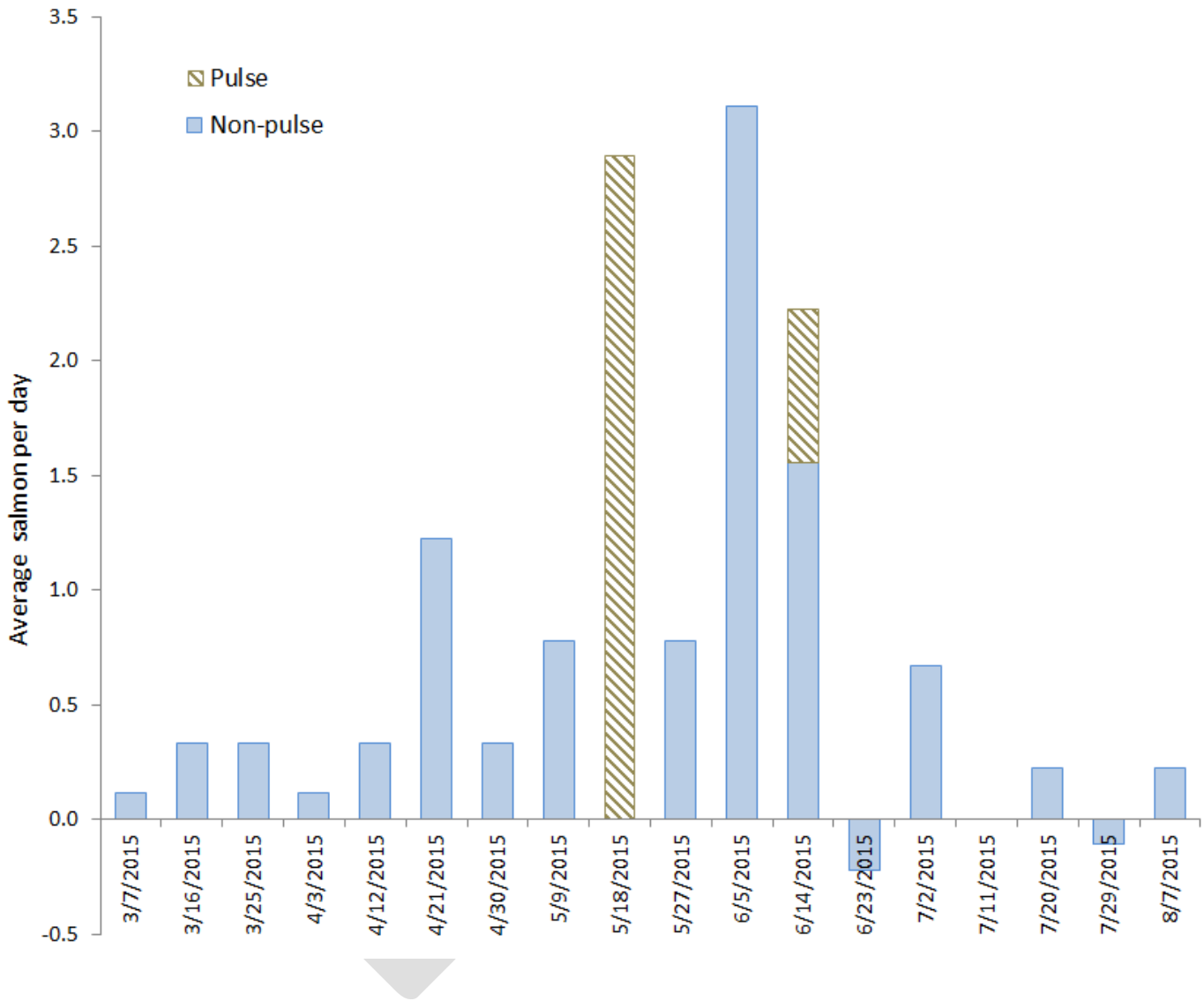

Figure 6. Average daily rate of spring-run Chinook Salmon passage at the video weir station per nine days, Clear Creek, 2015. Nine-day period is based on the length of the May pulse flow. Striped columns represent spring-run passage during the May and June pulse flows.

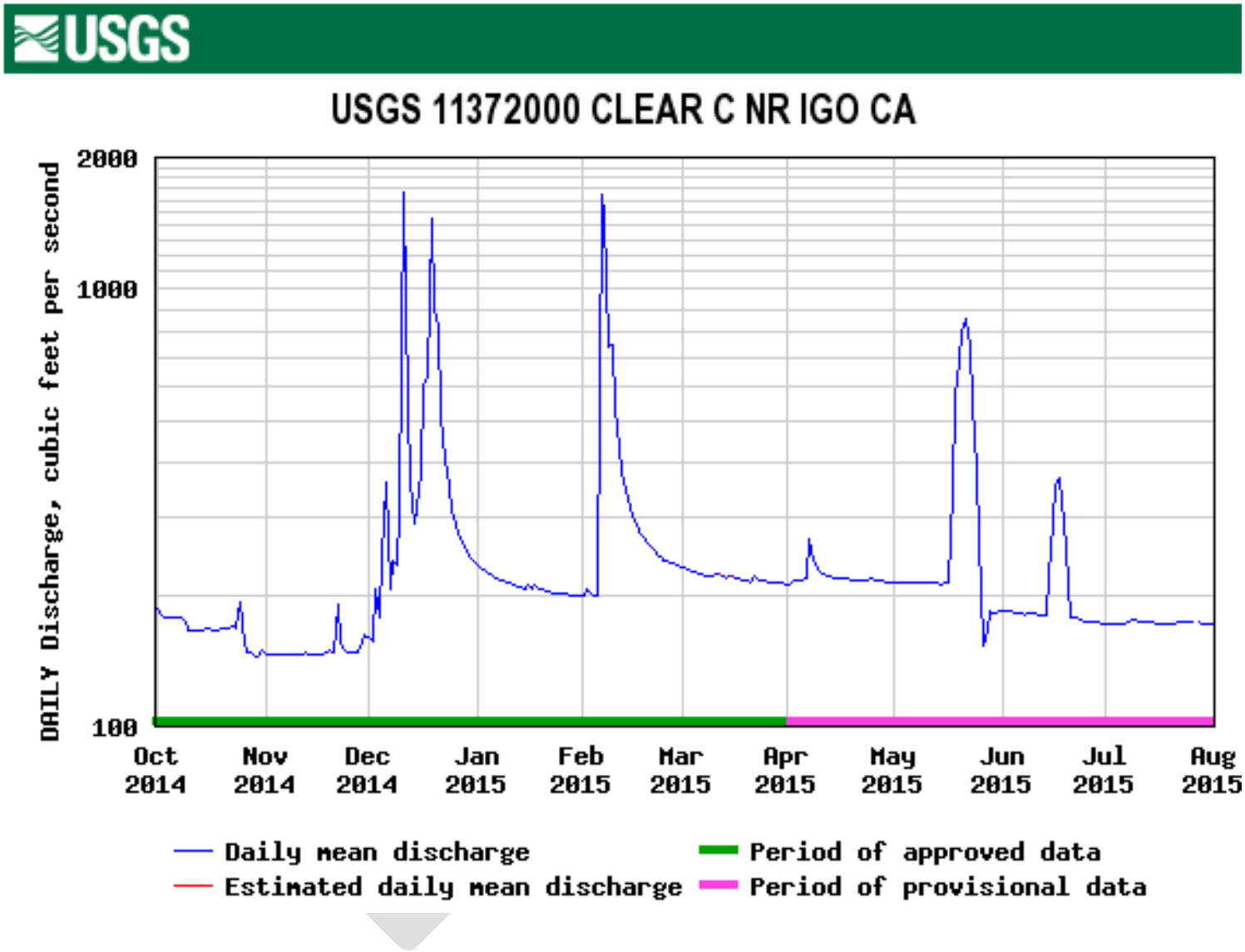

Figure 7. Clear Creek discharge at Igo October 1, 2014 to August 1, 2015.

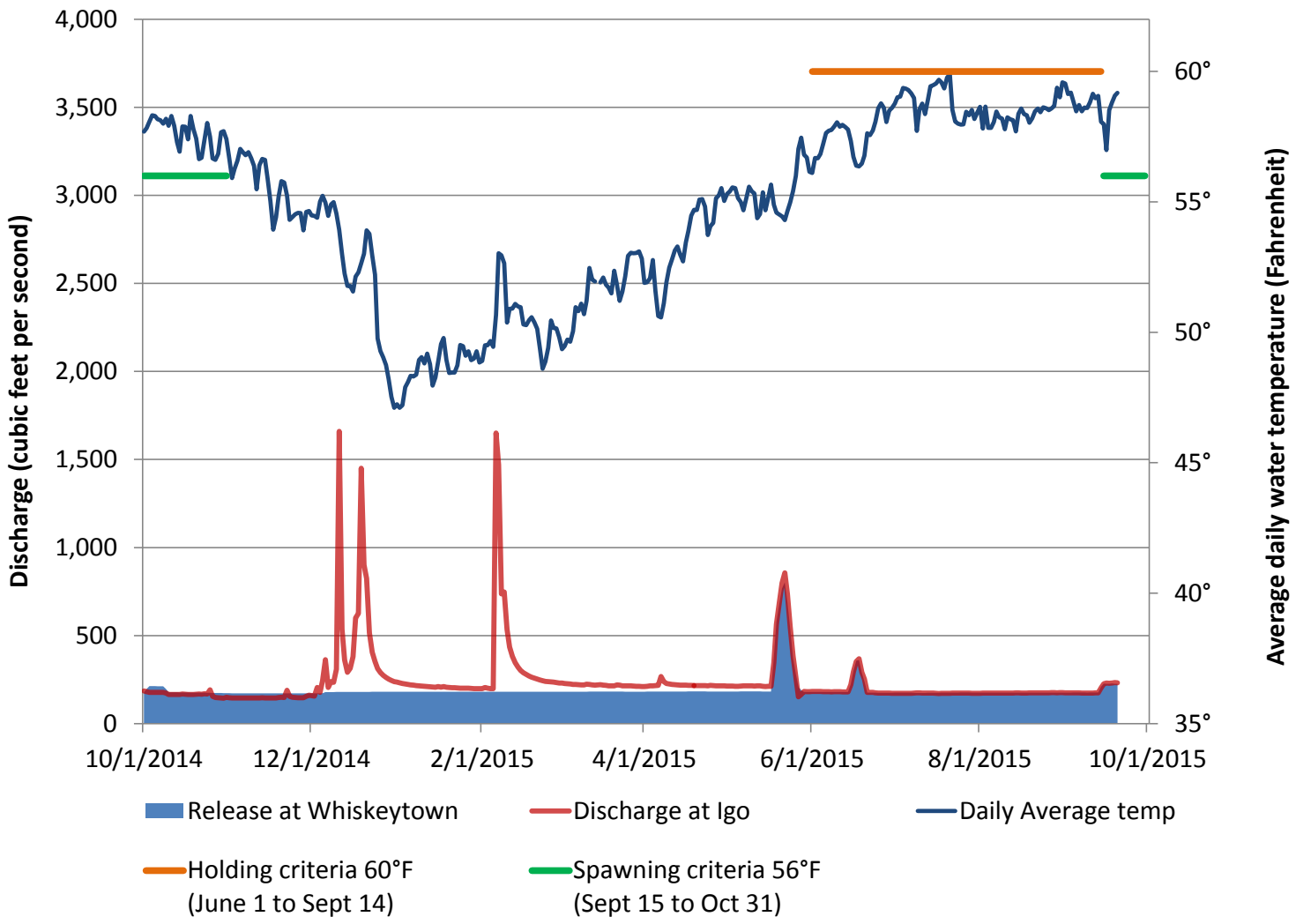

Figure 8. Water year 2015 release at Whiskeytown, discharge at Igo, and daily average water temperature at Igo compared to RPA I.1.5 criteria for holding (June 1 to September 14) and for spawning (September 15 to October 31). DATA AS OF 9/20/2015

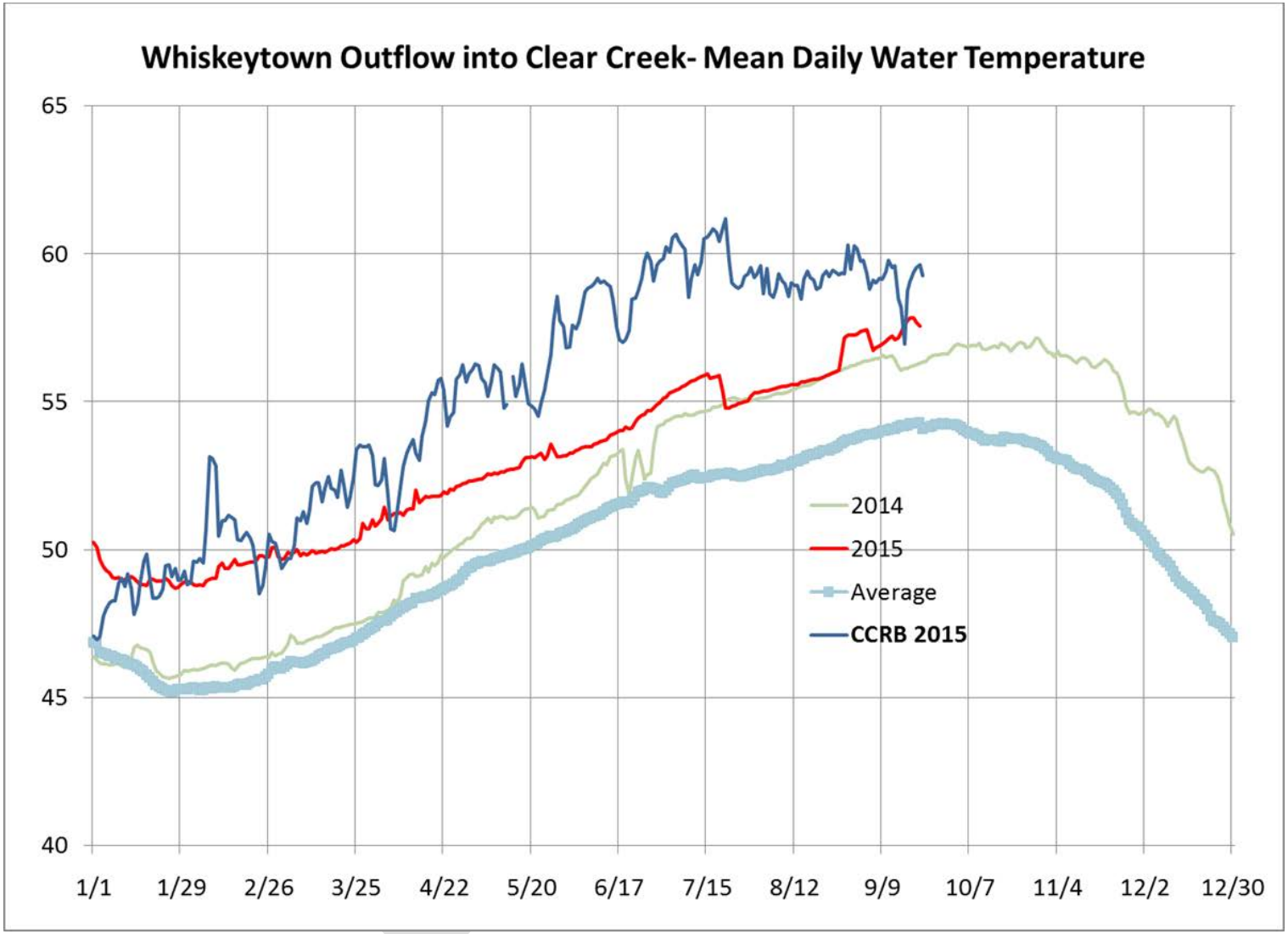

Figure 9. Water temperatures at Whiskeytown Reservoir outflow into Clear Creek in 2014, 2015 and the average of years from 2000 to 2013, and at Clear Creek Road Bridge (CCRB) which is near the lower end of the reach managed for spring Chinook in Clear Creek.

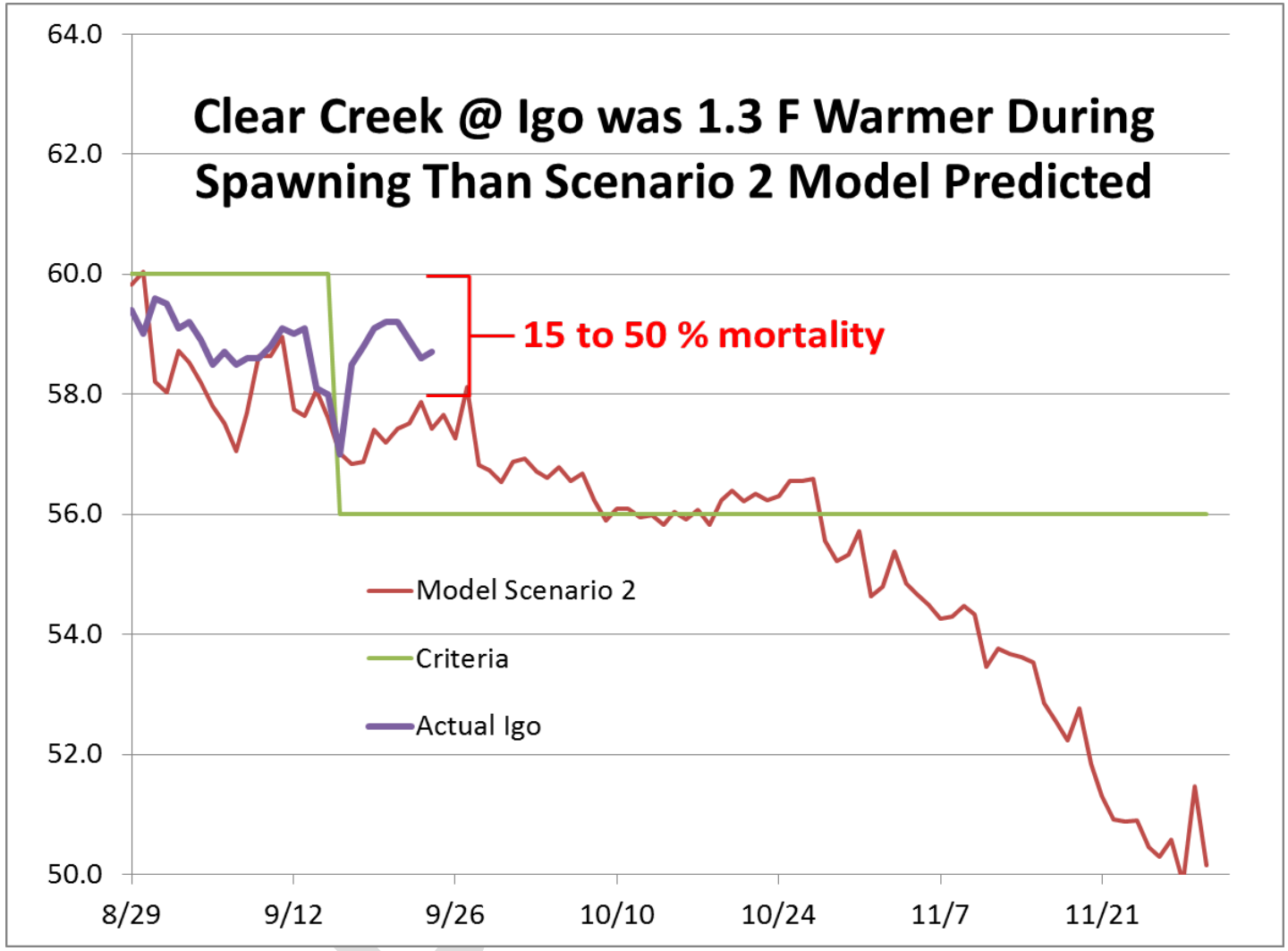

Figure 10. Actual and predicted water temperatures at Igo gage based on the model run on August 29, for scenario 2 using 10% meteorology, which was used for project management in September. Actual temperatures were mostly in the range of 15% to 50% mortality of eggs and embryos.

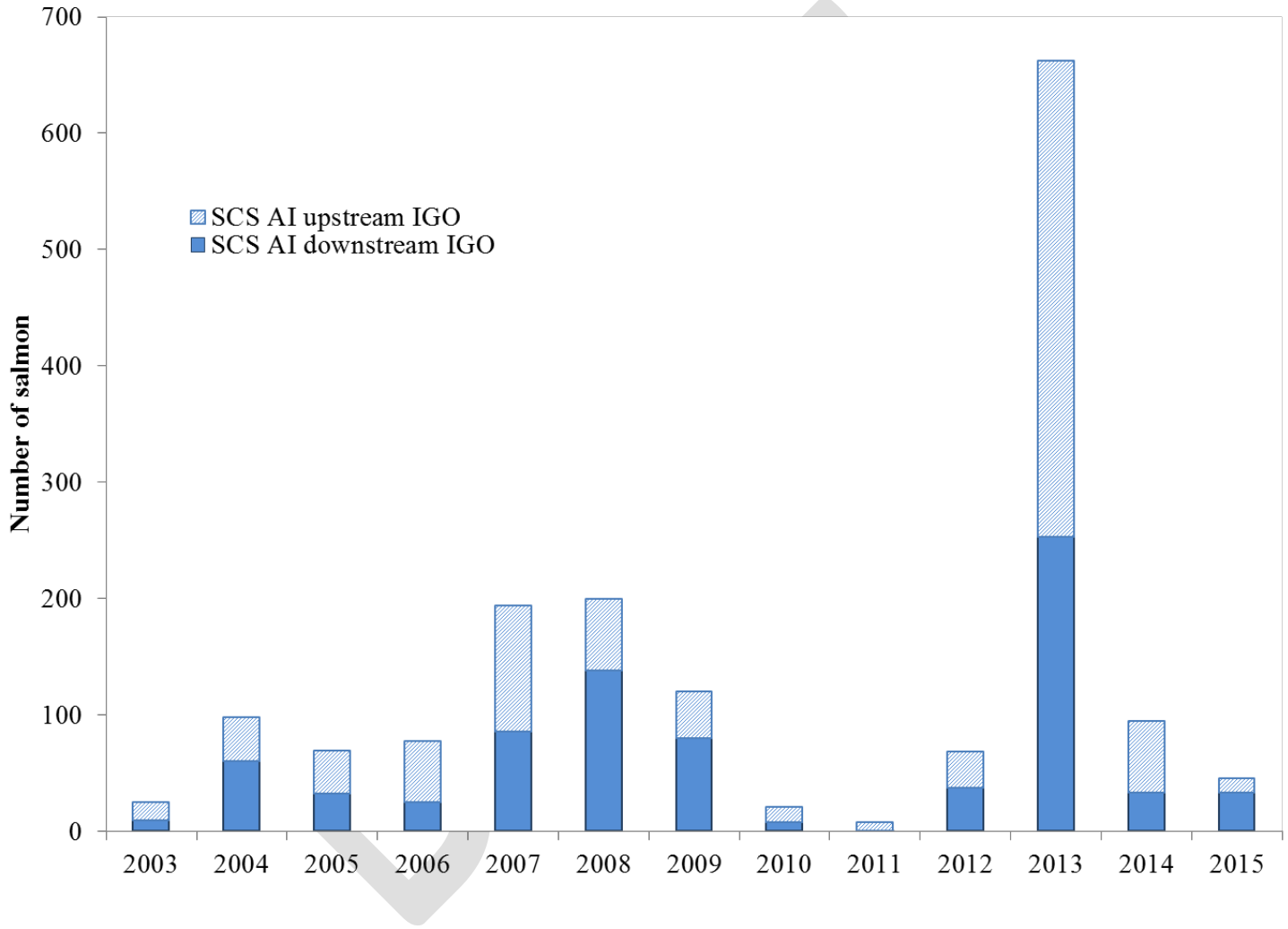

Figure 11. Number of adult Spring Chinook during August Index upstream and downstream of Igo.

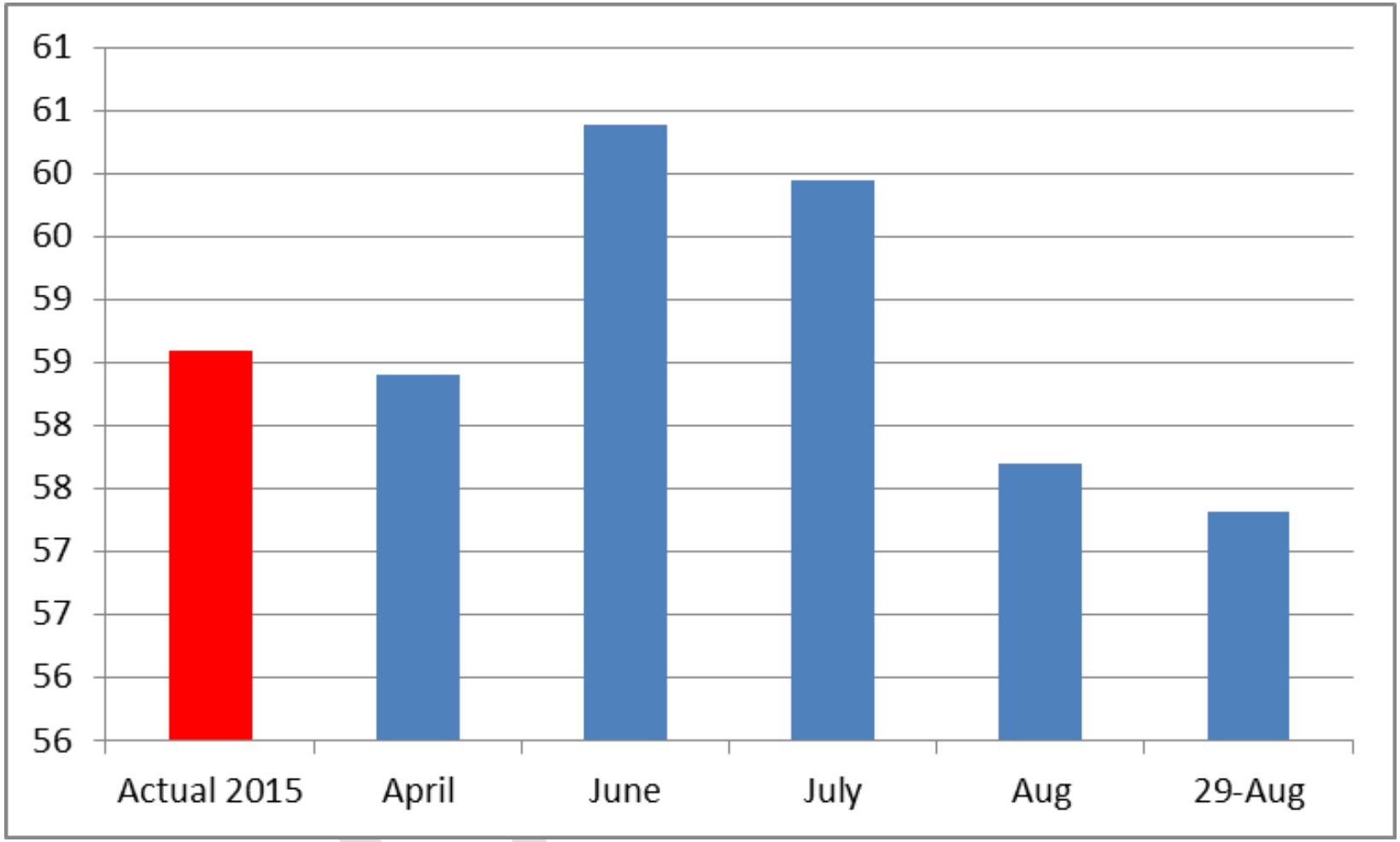

Figure 12. Actual average mean-daily-water temperature (red bar) and modeled average mean-daily-water temperatures (blue bars) for the time period September 15 to September 24. Model predictions were made in subsequent months using updated data using similar model scenarios of hydrology and meteorology.

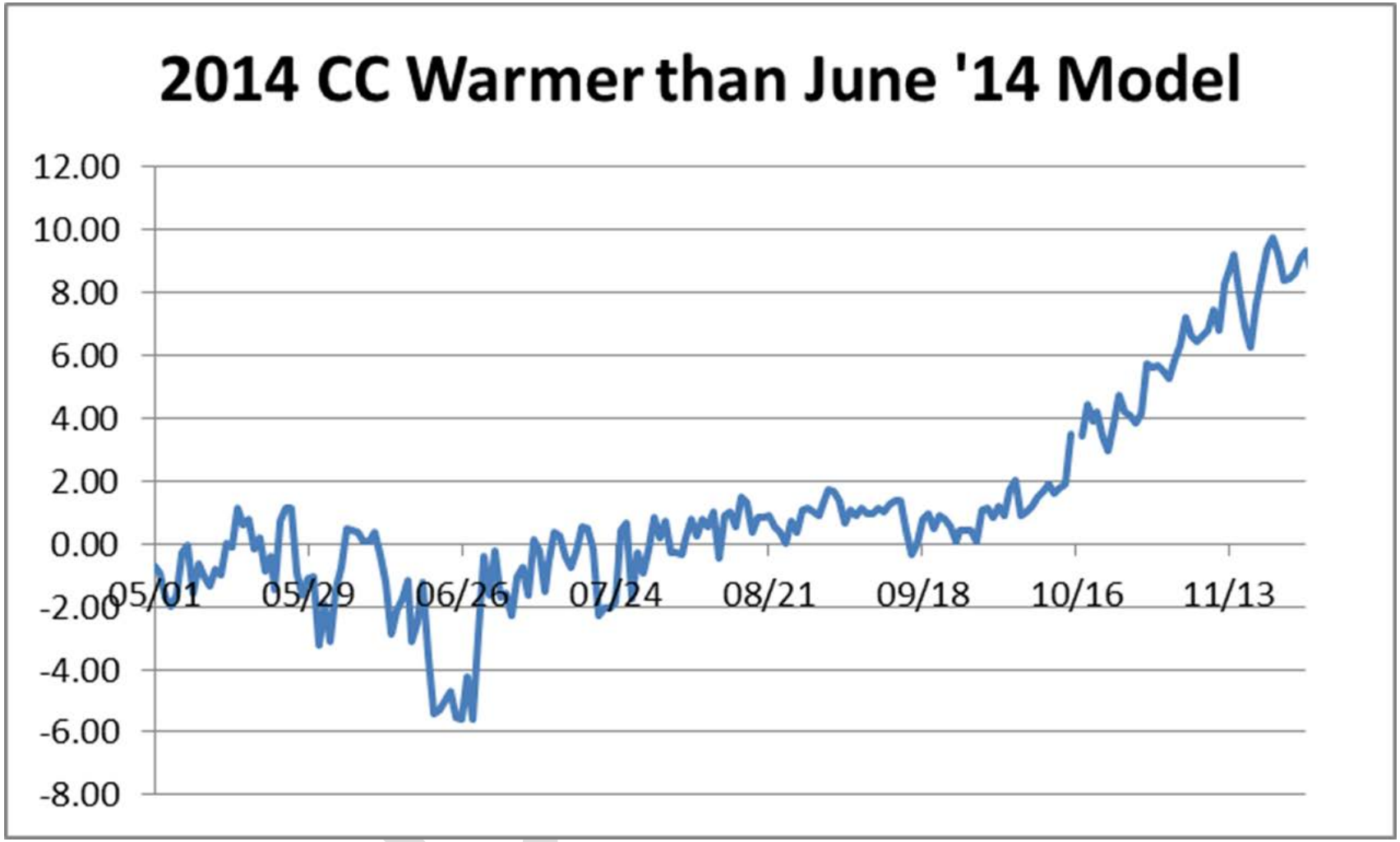

Figure 13. Difference in actual water temperatures at the Igo gage in 2014 and those predicted by modeling based on the June 2014 forecast using 90% hydrology. Actual water temperature became much higher than predicted after September 24.

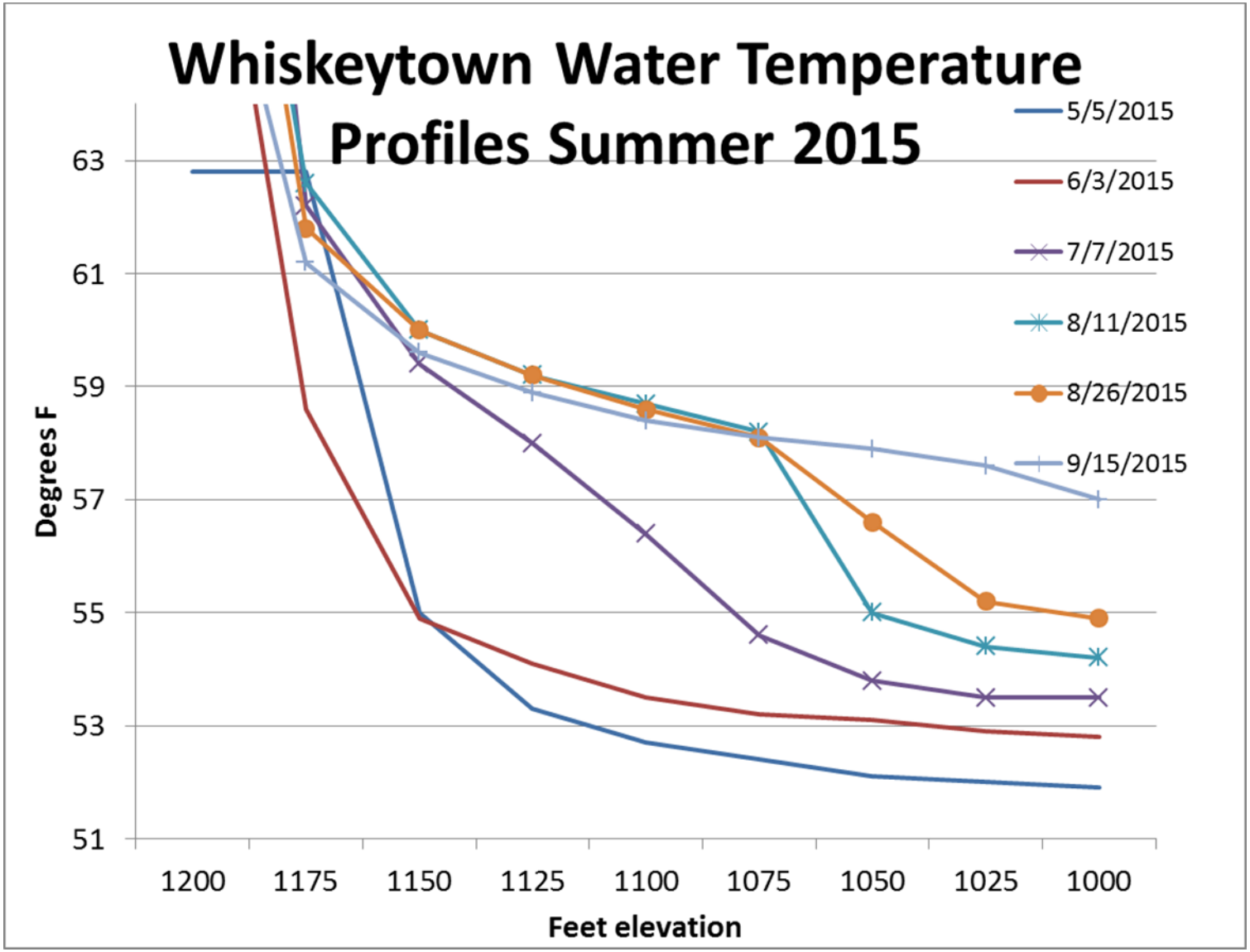

Figure 14. Whiskeytown water temperature profiles in 2015.

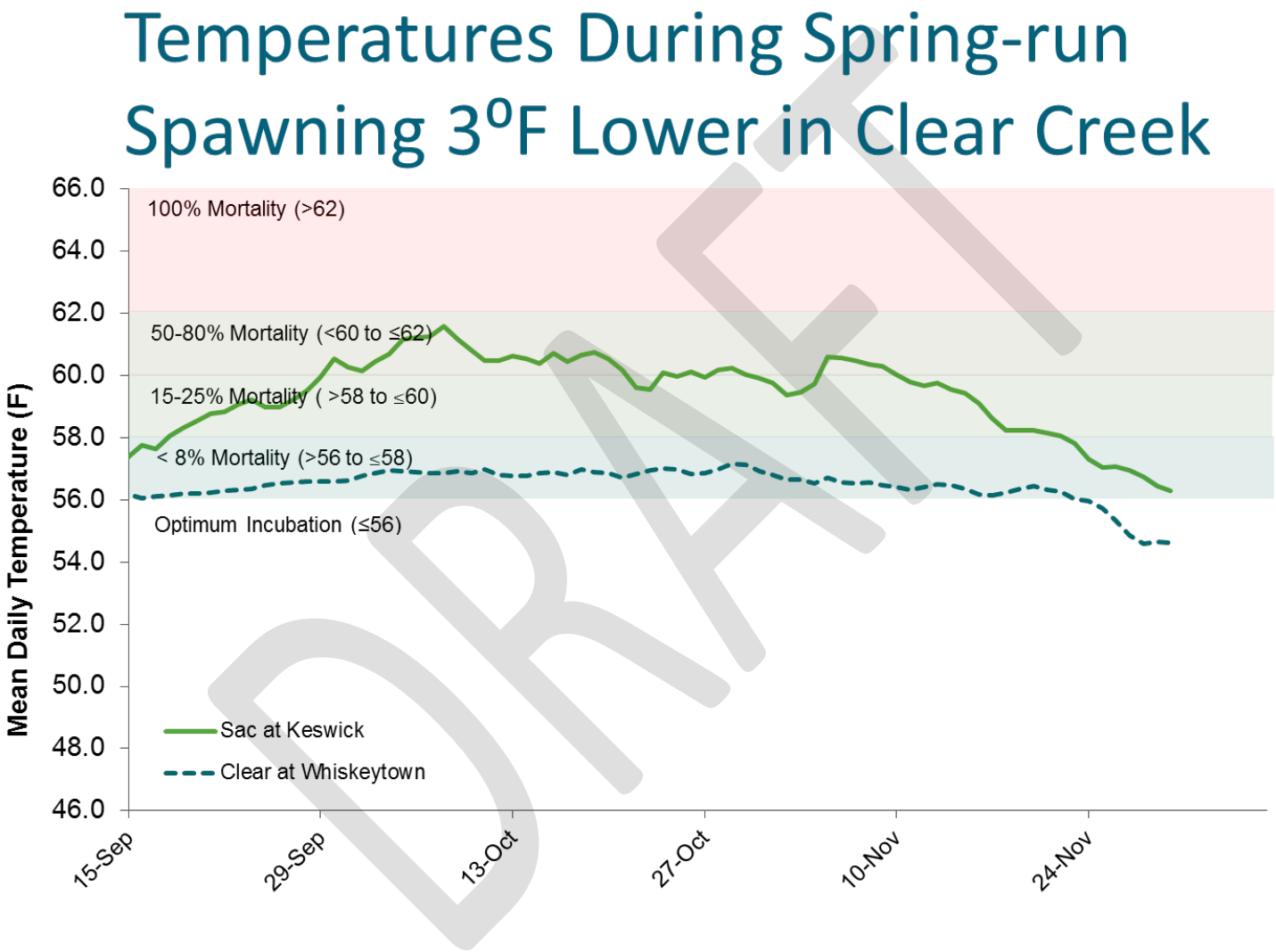

Figure 15. . Mean daily water temperatures in Clear Creek and the Sacramento River during the spring Chinook spawning period in 2014. Colored bands indicate increased mortality levels due to elevated water temperatures.

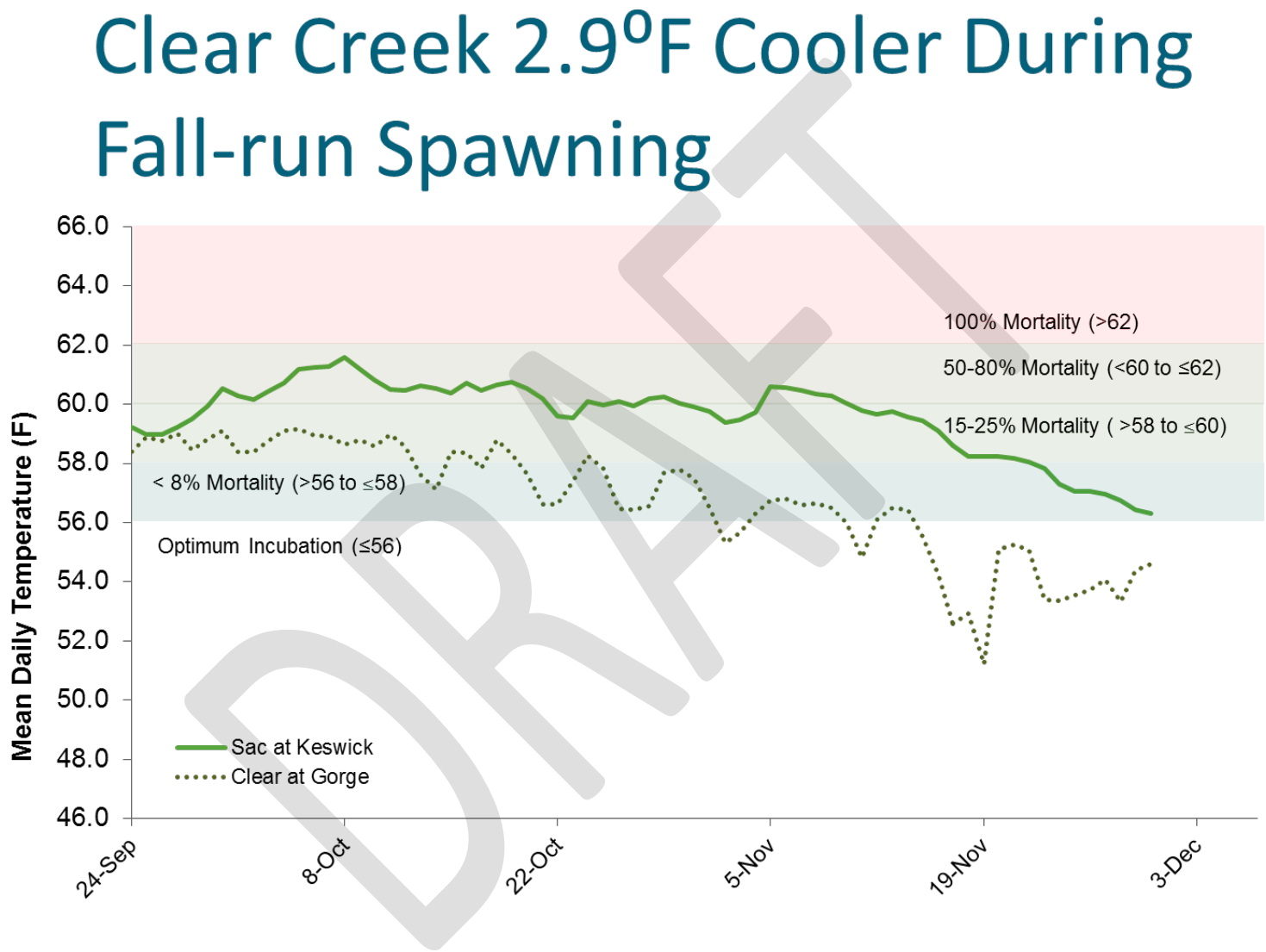

Figure 16. Mean daily water temperatures in Clear Creek and the Sacramento River during the fall Chinook spawning period in 2014. Colored bands indicate increased mortality levels due to elevated water temperatures.

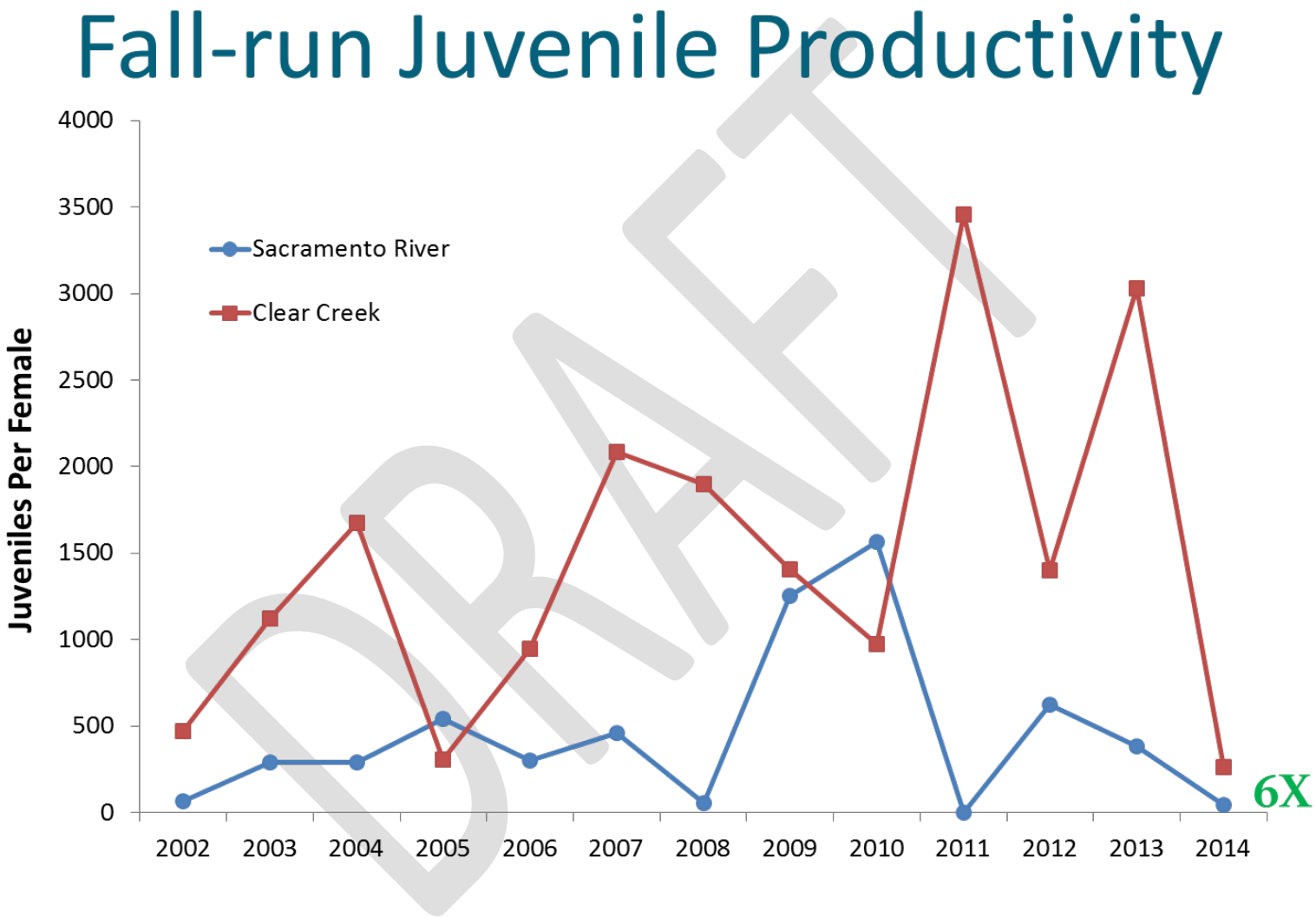

Figure 17. Annual juvenile productivity estimates of the number of juveniles per female, for Clear Creek and the Sacramento River, based on rotary screw trap estimates from lower Clear Creek and the Sacramento River at Red Bluff Diversion Dam.