Response to the National Marine Fisheries Service, National Atmospheric Administration, Department of Commerce Request for Information on the 5-Year Review of the Sacramento River Winter-Run Chinook Salmon, Central Valley Spring-Run Chinook Salmon, and the California Central Valley Steelhead

March 24, 2020

Dave Vogel, Senior Scientist
Natural Resource Scientists, Inc.
P.O. Box 1210
Red Bluff, CA 96080

As requested in the Federal Register Vol. 84, No. 193, October 4, 2019 Notice (p. 53117 – 53119), the following provides relevant updated information since the 2016 status review on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and the California Central Valley steelhead (hereinafter referred to as "the three listed species").

Most of the information described here is organized by the various freshwater life phases of anadromous salmonids like that used by Vogel (2011):

- Adult Upstream Migration
- Adult Holding, Spawning and Egg Incubation
- Fry and Juvenile Rearing
- Fry and Juvenile Outmigration

These comments include new information developed since the 2016 status review in regards to habitat improvements, alleviation of stressors to the species, relevant information that was available, but not included in the last status review, and some erroneous information and corrections in the 2016 status review that should be rectified in this current status review. The intent of these comments is to ensure the accuracy of the listing classification for the three listed species.

To a large extent, the 2016 status review of the three listed species mentioned some projects that were planned at that time to reduce stressors on salmonids and improve or expand their habitats. Because those planned activities had not yet been completed, they were largely discounted in the listing determinations. However, since that review, many projects to benefit the species have been implemented (e.g., the Sacramento Valley Salmon Recovery Program). Remarkable and unprecedented progress has been achieved. The information provided below, with supporting documentation (primarily by clicking on the hyperlinks), describes many, but not all, of those projects which should be considered and addressed in the current status review on the three listed species.

Adult Upstream Migration

Knights Landing Outfall Gates (completed in 2015)

Much of the following information was obtained from:
https://resources.ca.gov/docs/ecorestore/projects/Knights_Landing_Outfall_Gate.pdf

Historically, adult salmon were able to enter the Colusa Basin Drain (CBD) through the Knights Landing Outfall Gates (KLOG) when certain flow velocities were met that attracted migrating salmon. Once salmon enter the CBD, there is no upstream route for salmon to return to the Sacramento River and, absent fish rescue operations, the fish perish and are lost from production. Large numbers of adult winter-run Chinook were documented to die in the CBD. This has been a significant problem for decades. This project constructed a positive fish barrier (with new concrete wing walls and installation of a metal picket weir) on the downstream side of the existing KLOG in the CBD. This project serves primarily as a fish passage improvement action that will prevent salmon entry into the CBD while also maintaining outflows and appropriate water surface elevations. Implementation of the weir at KLOG is expected to benefit the three listed species. Although mechanical issues with the weir surfaced, those problems will be rectified in 2020.

Wallace Weir Fish Rescue Facility (completed in 2018)

Much of the following information was obtained from: www.rd108.org/wallace-weir-redevelopment/

Like the KLOG, salmonids can enter the CBD through the Knights Landing Ridge Cut (KLRC). Historically, migrating adult salmonid were able to enter the KLRC through the Wallace Weir when attracted by certain flow regimes. Construction of a permanent barrier at the Wallace Weir Fish Rescue Facility provided a near-term, permanent fix to block federally and state-listed anadromous fish entry into the CBD. The project facilitates fish relocation while maintaining outflows and improves the efficiency and safety of fish rescue operations under broader flow conditions. The fish collection facility is adjacent to the fish barrier and works in tandem with the barrier. The project involved removal of the existing Wallace Weir, which was a seasonally constructed, earthen berm that crossed the KLRC. The project was constructed in compliance with the Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project and the State Water Project issued by the National Marine Fisheries Service in 2009, and as part of the California EcoRestore initiative. The Wallace Weir Fish Rescue Facility Project Construction started on August 18, 2016 and was completed in 2018.

Fremont Weir Adult Fish Passage Modification Project (completed in 2019)

The following was obtained from: https://www.usbr.gov/mp/bdo/fremont-weir.html

The Fremont Weir, at the northern end of the Yolo Bypass, was completed in 1924. The weir is a 1.8-mile-long concrete structure designed to allow flow into the Yolo Bypass during high-flow events when the Sacramento River is higher than the weir's crest elevation. The weir has a

concrete stilling basin just downstream of the crest and along its full length to minimize scouring during overtopping events. Once the Sacramento River recedes below the crest of Fremont Weir, fish are likely to become stranded in the stilling basin. California Department of Fish and Game (now known as California Department of Fish and Wildlife) constructed a 4-foot-wide, 6-foot-deep concrete fish ladder in 1965. The ladder provided insufficient passage for adult salmon and no passage for adult sturgeon.

In 2018, the U. S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR) began the Fremont Weir Adult Fish Passage Modification Project to improve adult fish passage at the Fremont Weir and along the Tule Canal in the Yolo Bypass. The project constructed a new fish passage structure at Fremont Weir to widen and deepen the fish ladder and removed barriers in the Tule Canal.

This project benefits the three listed species and should be included in the current status review.

Fish Passage Improvement Program

The current status review should include a discussion on the benefits to the listed species derived from the Fish Passage Improvement Program. Project locations include Bear Creek, Clover Creek, Deer Creek, and the Sacramento River. As reported by DFW, "The Fish Passage Improvement Program (FPIP) is an interdisciplinary team of biologists and engineers that identify and evaluate the potential to modify or remove structures that impede the migration of anadromous fish within the Central Valley. FPIP works to further fish passage projects on streams, creeks and rivers in the Ecosystem Restoration Program (ERP) focus area that have ERP fish passage goals. FPIP staff performs fish passage assessments, stream habitat assessments, hydraulic modeling and more in order to develop conceptual and preliminary designs. When implemented these fish passage projects will open up instream habitat that was partially or completely unavailable to Central Valley spring-run and fall-run Chinook salmon and Central Valley steelhead. Over 50 miles of instream habitat could become more accessible to these species if all the projects identified in the proposal move forward."

An example project is the Clover Creek/Millville Dam Passage Project which was completed in 2017. According to the Western Shasta Resource Conservation District: The "project components include: Construction of two fish ladders; replacement of an inverted siphon; reinforcing the diversion dam; gravel augmentation; and installation of aquatic cameras to monitor fish populations."

Adult Holding, Spawning and Egg Incubation

Painter's Riffle (completed in 2014)

Much of the following was obtained from: https://www.gcid.net/painters-riffle-project

In 1986, the California Department of Fish and Game worked on the design and construction of a side channel for salmon spawning in the upper Sacramento River near Redding just downstream of the Highway 44 Bridge. However, with the combination of gravel additions to areas upstream

of the channel and the high reservoir releases in 2011, the site became unusable for salmon spawning. Heavy equipment was used to successfully extract the extra gravels and open up this important area that is highly favorable to salmon and steelhead.

Although the 2016 status review on the three listed species mentioned the Painter's Riffle project, since that review, the project has been documented to have salmon spawning at the site and it withstood high Shasta Reservoir flood control releases maintaining the reconstructed configuration. The site benefits all three listed species.

Upper Sacramento River under Market Street Bridge in Redding (completed in 2016 and 2019)

Much of the following information was obtained from: https://www.gcid.net/market-street-project and www.rd108.org/market-street-gravel-project/

In 2016, approximately 9,400 cubic yards of gravel were placed into the Upper Sacramento River to provide new spawning habitat for Chinook salmon and steelhead trout. In partnership with local, state and federal agencies, Glenn-Colusa Irrigation District (GCID) constructed the Market Street Bridge gravel project in Redding, CA to restore salmon spawning habitat. The project, carried out over several weeks, placed salmonid spawning gravel in the Sacramento River, immediately below the Anderson Cottonwood Irrigation District Diversion Dam and Market Street Bridge in Redding.

In 2019, an additional 9,400 cubic yards of gravel were added to the site. Partners in the effort included the Bureau of Reclamation, the California State University – Chico Foundation, California Department of Water Resources, California Department of Fish and Wildlife, the Sacramento River Forum, and Sacramento River Settlement Contractors. The following districts specifically contributed personnel and equipment for the project – Reclamation District 108, Glenn-Colusa Irrigation District, Sutter Mutual Water Company, River Garden Farms, Provident Irrigation District, Princeton-Cordora-Glenn Irrigation District and Anderson-Cottonwood Irrigation District.

Gravel Additions Below Keswick Dam (2011 - Present)

In order to create functional spawning habitat between Keswick Dam and the Highway 44 Bridge on the Sacramento River, private, state and federal entities worked to commence the injection of spawning gravels beginning in 2011. It is an ongoing activity. Injection locations include, below Keswick Dam, the inlet to Salt Creek, near the Market Street Bridge, upstream of the Sundial Bridge, south end of Tobiasson Island, near Shea Island, and upstream of Anderson, California.

As reported by Vogel (2016):

"On an overall basis, the physical spawning habitats in the reach just upstream of Diestelhorst Bridge have exhibited a remarkable improvement in the mixture of gravels and cobbles ideal for salmon spawning as compared to initial riverbed surveys conducted in 1987. Several other surveys have corroborated that conclusion. This circumstance is likely attributable to many years of spawning gravel injection downstream of Keswick Dam (primarily the Salt Creek

injection site). This area also appears to be more-heavily utilized for salmon spawning than occurred prior to gravel injection. When comparing spawning habitats and redds in this reach observed during surveys conducted during 1987 with surveys conducted in 2015, a dramatic improvement in ideal composition and mixture of gravels and cobbles for salmon spawning is apparent. Although the surveys are not directly comparable because of different survey methods, it is nevertheless readily apparent that a major increase in the total area of good spawning habitat has occurred over the years. Vast swaths of good spawning substrate are now present in the wide river reach upstream of Diestelhorst Bridge. Solely based on the gravel/cobble composition (not including water velocities and aquatic vegetation), a rough approximation of good spawning gravels in this reach probably exceeds a half million square feet of area."

Since the 2016 status review, the California Department of Fish and Wildlife implemented a sport fishing closure between Keswick Dam and the Highway 44 bridge from early April to the end of July to further protect winter-run Chinook spawning (CDFW). Additionally, a variety of organizations recently installed signage at sport fishing access locations to educate the public to not walk on salmon redds to protect winter-run eggs incubating in the river gravels: Redd Sign.

This recent and relevant information should be included in the current status review.

Fry and Juvenile Rearing

Although significant efforts have focused on the increase of the quantity and quality of salmonid spawning habitats in the upper Sacramento River, negligible attention had been made on restoring rearing conditions at the time of the 2016 status review. While massive quantities of spawning gravels have been added to the upper Sacramento River, there are indications that rearing habitats may be an equally, if not more, important factor limiting the fish populations. As pointed out by the USFWS, "… there would be little value in increasing the quantity of available spawning gravel if the problem that actually limits juvenile production is lack of adequate rearing habitat" (USFWS 1995).

A presumed serious problem exists for emergent salmon fry in the upper main-stem Sacramento River downstream of Keswick Dam. Loss of rearing habitat was considered one of the numerous reasons for the listing of the endangered winter-run Chinook. In 2014, NMFS reported that rearing habitats are considered very limited and predation during juvenile rearing is believed to be a stressor of very high importance (NMFS 2014). The best habitats, in conventional theory, would be on the channel fringes. However, due to the nature of the upper-most reaches of the river where a majority of winter-run salmon spawn in deep water, many of the desirable habitat attributes for rearing are lacking (e.g., appropriate depths, velocities, and cover). Although much of the river reach possesses riparian vegetation, river subsurface structure (e.g., large woody debris) is severely deficient and would be challenging to restore due to lack of significant recruitment and periodic extremely high-flow events that would dislodge such structures. Additionally, and importantly, in many areas where salmon spawn, the channel is wide (e.g., 500 feet) and channel edges are deep. Fry emerging from redds in the main-stem riverbed encounter a paucity of velocity and predator refugia. Underwater observations and sonar camera (DIDSON^{TM}) footage near artificial structures in the main channel (e.g., bridge piers) have frequently shown extensive fry and juvenile rearing activity, but may suggest the fish are utilizing those areas because insufficient natural structures on the riverbed are limited or absent

(Vogel 2011). Because of the overlap in run timing, increasing the quantity and quality of fry and juvenile rearing habitats would provide year-round benefits for all four runs of Chinook salmon and steelhead.

Painter's Riffle (completed in 2014)

The Painter's Riffle project previously described for salmon spawning habitat improvements also provides improved rearing habitats for the three listed species. Although the 2016 status review mentioned this project, the current status review should also recognize the project benefits for salmonid rearing habitats.

Channel Restoration Above Cypress Street Bridge, Redding, CA (completed in January 2017)

The Glenn-Colusa Irrigation District along with other local, state, and federal agencies teamed up to initiate and complete this project. A 1/3-mile long stretch of the east side on the Sacramento River above the Cypress Street Bridge was excavated to provide rearing habitat when river flows are low. Approximately 1.5 acres of aquatic habitat were opened up and woody debris was added to give young salmon protection from predators. Source: https://norcalwater.org/wp-content/uploads/North-Cypress.pdf

Lake California Side Channel Reconnection Project (completed in December 2017)

This collaborative effort resulted in restoration of a one-mile long side channel in Tehama County near the Lake California inlet which was plugged with accumulated gravel and blocked during low flows. Water now flows through the channel during low flow events which take place in late fall and early winter creating additional rearing habitat for the endangered winter run salmon and other fish species. Source: https://norcalwater.org/wp-content/uploads/LakeCaliforniaSideChannel-FINAL-1.26.pdf

Kapusta 1a Side Channel (completed in 2018)

Thanks to a private, state and federal collaboration, a side channel previously blocked was opened and water flowed into the Sacramento River again. Salmon favor refuge during high water temperatures and flows. Getting access to side channels provides high quality rearing and foraging areas. The project took place upstream of Anderson, California. Source: https://norcalwater.org/2018/06/14/kapusta-1a-side-channel-project-is-now-open/

Other Side Channel Projects (completed in 2019)

Other areas of the side channel project on the Sacramento River include: Anderson River Park, Reading Island, and Rio Vista. Source: https://www.sacramentoriver.org/forum/index.php?id=channels

North Tobiasson Deep Water Rearing Structures (completed in 2017)

Underwater observations in the Sacramento River found that juvenile salmon were rearing in much-deeper water (e.g., >10 feet) than originally surmised. For example, SCUBA surveys on the riverbed at the site of the Lake Redding Bridge (Vogel and Taylor 1987) and the bridge expansion project at the South Bonnyview Bridge (Vogel 1995) revealed that young salmon were rearing near the base of bridge piers and in deeper water than anticipated. Those discoveries prompted additional surveys using a sonar camera which enabled observations on salmon rearing in areas difficult to conduct solely from underwater examinations using snorkeling or SCUBA.[1] Exhaust bubbles from SCUBA startles juvenile salmon making it difficult to see the natural behavior of fish in their habitats. Besides fish observations, more-extensive surveys of the upper Sacramento River using SCUBA, underwater cameras, side-scan sonar, and DIDSON sonar found that much of the riverbed is featureless and largely absent of rearing structures and habitat complexity for juvenile salmon. Most areas where juvenile salmon were viewed in the deep channel lack refugia from predatory fish (Vogel 2016a, 2016b). For these reasons, it was recommended that habitat structures be placed in deeper waters of the Sacramento River to add structural complexity in otherwise featureless riverbed areas to provide juvenile salmon velocity and predator refugia; this was the basis for the North Tobiasson Deep Water Rearing Structures project.

In the spring of 2017, 4.5- to 6-ton limestone boulders with attached large woody material were placed on the Sacramento River bed near the South Bonnyview Bridge just upstream of North Tobiasson Island. Water depths were up to 20 feet. The intent of the project was to provide habitat complexity for rearing as well as provide predator refugia. Monitoring of juvenile salmon utilization (primarily winter-run Chinook) was performed using a sonar camera during the summer and early fall in 2017, 2018, and 2019. In summary, it was evident that salmon utilization undoubtedly occurred at many of the structures and the pilot project was deemed very successful. Juvenile salmon quickly occupied some of the new habitats within only days after placement on the riverbed. Overall, compared to prior years of observations[2] in this vicinity of South Bonnyview Bridge, the 2017, 2018, and 2019 surveys revealed the highest numbers of juvenile salmon (particularly winter-run Chinook) ever observed there. It is expected that this project will benefit all three listed species. Additional details on the project and monitoring data are provided in Vogel 2020.

Additional information on restoring and improving rearing habitats in the Sacramento River is available at the following web site using the CVPIA b13 Program Interactive Map (passcode = restore): https://www.sacramentoriver.org/channels/

Bullock Bend Mitigation Project (completed in 2016)

The Bullock Bend Mitigation Bank was created on an approximate 120-acre site in Yolo County, California. The area was chosen because of being surrounded on three sides of the Sacramento River. The bend was opened by the breaching of a farm berm causing natural flooding. This

[1] These surveys were too deep to use snorkeling as the observation method.
[2] Using a combination of direct SCUBA observations, underwater cameras, and sonar camera.

restoration effort created salmonid rearing habitat by reconnecting the river to the historic floodplain. Source:
https://www.wesmitigation.com/projects/bullock-bend-mitigation-project/

Fry and Juvenile Outmigration

The 2016 status review on the three listed species identified unscreened water diversions in the Sacramento River as a significant stressor. At present, all the large and medium water diversions on the Sacramento River have now been screened to prevent fish entrainment. Recent projects include screening diversions at Bella Vista Water District (2012), South Sutter Water District Pleasant Grove Canal (2015), Feather Water District North and South Diversions (2014), and Compton Diversion (2015).

Additionally, many of the smaller diversions have now also been screened; numerous examples are provided at:

http://fwafishforum.com/program-overview/

http://fwafishforum.com/#top

http://fwafishforum.com/fish-screen-projects/

http://fwafishforum.com/fish-screen-configurations/

The 2016 status review mentions a technical report on the evaluation of fish entrainment in 12 small unscreened water diversions on the Sacramento River. That report (Vogel 2013) was prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and the Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and NOAA Fisheries). Although it was mentioned in the last status review, the report's findings were not incorporated. The focus of the study was on native anadromous salmonids. The monitoring sites were located on the Sacramento River between Knights Landing (RM 91) and Colusa (RM 143) where the majority of the remaining unscreened diversions on the Sacramento River are located, plus one site in Steamboat Slough. A range of diversion sizes and locations were chosen in order to obtain the most useful scientific data. On an overall basis, entrainment of juvenile salmon in the unscreened diversions monitored during this study was low relative to other fish species. Based on the premise that the middle to lower Sacramento River is not heavily utilized by juvenile salmon for rearing during the late-spring and summer months (which corresponds to when irrigation diversions occur), it is not surprising that relatively few salmon were entrained into the irrigation canals monitored. Among those salmon entrained, the vast majority were fall-run Chinook (not the three listed species) based on the length-date criteria that are commonly used to assign designation of a salmon run. As expected, because most of the diversion intakes were positioned on or near the riverbed, the dominant species entrained were typically bottom-oriented fish. The significance of these findings is that the remaining small, unscreened diversions should not be considered a considerable stressor or threat to the three listed species. The importance of the report's findings should be incorporated into the present status review on the three listed species.

The 2016 status review identified predation as a significant stressor on the three listed species. The dominant predator on juvenile salmon is considered to be striped bass. As reported in the newspaper Sacramento Bee (SacBee), on February 21, 2020, the California Fish and Game Commission amended the management policy for striped bass: "The California Fish and Game Commission on Friday voted unanimously to amend its decades-old policy regarding striped bass, beginning a process that could allow the population to decline. The decision ends a 1996 policy that had committed the state to sustaining a population of about 1 million striped bass in the Delta and other California waterways." Also, since the 2016 status review, Congress enacted the Water Infrastructure Improvements for the Nation Act (WIIN Act) with a provision striking striped bass from the list of anadromous fish in the Central Valley Project Improvement Act and, therefore, that species is no longer considered under the Anadromous Fish Restoration Program. The current status review should recognize that these management actions may reduce this stressor for the three listed species.

As reported by FishBio 2018:

"The interaction between light pollution and predation could deal a heavy blow to species already struggling to survive. Bridges, in particular, often have lighting that shines into rivers at night, and attraction to these stationary lights can stop juvenile fish in their tracks as they migrate downstream, making them vulnerable to predators. Fish also frequently migrate and feed at night to hide from predators in the darkness, and bright lights shining on the water eliminate their protective cover. In rivers where salmon spawn, juvenile salmon can be especially impacted by bright nighttime lights or reflections on the surface of the water because predation is a major contributing factor to the high mortality of juvenile salmon. Light pollution from the iconic Sundial Bridge in Redding, California (shown above), was a suspected factor that contributed to the near loss of Sacramento River fall-run Chinook salmon from 2011–2013."

"The good news is that not all lights are bad for fish. Researchers discovered that certain spectrums of light, such as low-intensity LED lights, are less disruptive to fish because they don't trigger the same hormonal and physiological responses (Migaud et al. 2007). In 2014, new fish-friendly LED lights were installed to replace the more than 200 lights on the Sundial Bridge, which included using a different light with a lower intensity, and installing the lights at an angle to point away from the water. This simple, science-backed solution may have a big impact on fish survival – and it also saved the city money on their electric bill. While salmon in the Sacramento River and elsewhere face a barrage of threats such as climate change, habitat destruction, predation, and pollution, addressing known issues that have a relatively simple solution, like switching a light bulb, can contribute towards a fighting chance at species recovery."

Because all three of the listed species can be affected by the Sundial Bridge, the current status review should include this information.

Underestimates of Fry and Juvenile Winter-Run Chinook Salmon Passage at Red Bluff Diversion Dam (RBDD)

An important component of assessing the status of winter-run Chinook is data collected in rotary screw traps at RBDD. Since the last status review, there has been information developed

indicating the numbers of young winter run passing RBDD are higher than originally surmised. The following discussion provides information on that topic which should be incorporated into the present status review.

Inaccuracies in Computations of Winter-Run Egg to Fry Survival in 2014 and 2015

Many statements have been made about potential water temperature impacts to winter-run Chinook salmon eggs and juveniles in the Sacramento River below Keswick Dam during 2014 and 2015. Purported water-temperature mortality of 95% in 2014, and higher mortality estimates in 2015 have been reported in various forums, including the last status review. However, the validity of the extremely high mortality estimates had not yet been fully evaluated. A close, comprehensive examination of the methods, data, and assumptions used to generate annual winter-run Chinook in-river survival estimates is crucial and warranted to ensure that appropriate resource management decisions are made in the future. It must be determined if the postulated mortalities are reasonably accurate, and if so, what caused the low survival? Alternatively, if the mortality estimates are not reasonably accurate, why not? What would define more scientifically sound values and how can fish survival estimates in future years be made more reliable?

In this regard, an initial report on those topics was prepared and widely disseminated in draft form in 2016 for peer review to a variety of state and federal agencies and other organizations to obtain technical feedback. Additionally, meetings to discuss the draft preliminary report were held with representatives of the California Department of Fish and Wildlife (CDFW[3]), State Water Resources Control Board (SWRCB), Placer County Water Agency, U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and the National Marine Fisheries Service (NMFS). Numerous individuals provided thoughtful and helpful comments on the report. Reviewers offered invaluable supportive material which subsequently strengthened the analyses and conclusions in a final preliminary report (Vogel 2017). Where scientifically appropriate, the initial draft report's contents were revised and additional information was integrated accordingly. The report provided logical scientific conclusions on water temperature impacts, calculations of fish survival/mortality, analogous comparisons to the annual survival of other salmon runs, and environmental variables other than water temperature that may have impacted salmon in 2014 and 2015. Additionally, analyses and results of field studies, as well as further recommendations were also incorporated.

The final preliminary report conducted detailed analyses of water temperature effects on incubating winter-run Chinook eggs using three independent, widely accepted, mathematical models which revealed that some mortality did occur but was far less than presumed. Depending on the model, survival of eggs from time of deposition to fry emergence from the river gravels, based solely on water temperatures, ranged from 81% to 91% in 2014 and 82% to 98% in 2015, far different from the assumed fish survival of only 5% or less. These results indicate several possibilities:

[3] The California Department of Fish and Wildlife (CDFW) changed the agency's title from the California Department of Fish and Game (CDFG) several years ago; the two titles are sometimes used interchangeably in this report.

1) The method used to estimate the 95% mortality in 2014 and even higher mortality is 2015 was subject to significant error and uncertainty;
2) some indirect effects of water temperature (but presently unknown) may have contributed to mortality; and/or
3) most of the assumed mortality was attributable to one or more variables other than water temperature.

Surprisingly, the estimated purported high mortality of 95% for winter-run eggs in 2014 and subsequent higher mortality for 2015 reported in the last status review were not based on modeling of thermal impacts on eggs. Instead, the origin of those estimates used a simple equation that compared the estimated total numbers of eggs laid in the river gravels in upstream spawning areas with juvenile production indices estimated from numbers of fish captured by the U.S. Fish and Wildlife Service (USFWS) using three to four eight-foot-diameter rotary screw traps at the Red Bluff Diversion Dam (RBDD), located approximately 50 river miles downstream, that filter a small percentage of the river flow. Unfortunately, the fish traps are commonly not in operation during high-flow events when large numbers of juvenile winter-run Chinook would be expected to migrate downstream, particularly under the extraordinary hydrologic conditions present in 2014 and 2015.

This latter circumstance was deemed problematic because large numbers of young winter-run salmon display a pattern of holding and rearing in upstream areas during summer and fall low-flow conditions, and then exhibit a large-scale, episodic outmigration when the first seasonal storms cause increased flows and turbidity (such as occurred in 2014 and 2015). During 2014 when large numbers of winter-run salmon would be expected to migrate downstream during increased flows, the RBDD fish traps were not in operation much of the time and, undoubtedly, the fish passed undetected. To account for these data gaps, the USFWS estimated the numbers of fish passing RBDD on days or weeks not sampled (when traps are removed or cones are raised) using data developed from days of the week or month when sampling was conducted. The gaps are filled in based simply on calendar dates, not biological or environmental conditions (e.g., flow and turbidity). This interpolation method to estimate the numbers of salmon migrating past RBDD during un-sampled days is probably satisfactory ***if*** riverine conditions (e.g., flow and turbidity) are relatively stable, the period of consecutive un-sampled days is short, and expansion (extrapolation) factors are appropriate. However, if riverine conditions during un-sampled days change substantially as compared to sampled days, the present interpolation method is likely to bias the estimates low, possibly extremely low, because of large-scale salmon outmigration occurring during high, turbid flows. Consequently, the overall estimates of fish survival can be significantly underestimated (and mortality overestimated). This situation likely occurred in 2014 and possibly 2015. Additionally, factors used to expand the actual numbers of fish captured in the fish traps at RBDD to estimate total daily numbers of fish passing the dam possessed questionable reliability and accuracy to compare annual fish survival estimates. For example, an examination of past USFWS estimates for late-fall-run Chinook survival revealed the 11-year average of mortality from 2002 through 2012 was 97.2% (higher than the purported winter-run mortality in 2014 and 2015), indicating something is fundamentally faulty in how fish survival is estimated.

The key conclusions of that report (Vogel 2017) can be summarized as follows:

- Compelling scientific evidence indicates that the alleged high mortality of winter-run Chinook in 2014 was not primarily attributable to water temperatures during the periods when eggs were incubating in the river gravels, and the potential deleterious effects of water temperature were substantially overestimated in 2014, and likely were overestimated again in 2015.

- The USFWS methodology used to estimate the purported 95% mortality in 2014 was not based on modeling thermal impacts on salmon egg incubation. The technique was subject to significant error and uncertainty and was not biologically valid or reliable.

- Using three independently constructed mathematical models, it is estimated that the overall probability of survival of winter-run Chinook eggs from time of deposition in the river gravels to fry emergence (based solely on water temperatures) in 2014 was between approximately 81% and 91%, and in 2015 was between approximately 81% and 98%. These estimates are far different than the assumed fish survival of 5% or less.

- For the mortality that did occur in 2014 and 2015, additional plausible contributing factors include predation, disease, redd superimposition, and poor physical spawning and rearing habitats caused by four years of drought and very low flows.

Additionally, the 2014 and 2015 winter-run mortality estimates reported in the last status review used a highly unorthodox "egg to fry survival" nomenclature. The phrase "egg-to-fry survival" could be interpreted in a variety of ways. The following are examples:

Survival from time of:

1) Egg fertilization to fry emergence from the gravel
2) Egg fertilization to egg hatching
3) Egg hatching to fry emergence from the gravel
4) Eyed egg to hatching
5) Eyed egg to fry emergence from the gravel

Instead, as mentioned above, the last status review was based on a simple equation that compared the estimated total numbers of eggs laid in the river gravels in upstream spawning areas with juvenile production indices estimated from a very small proportion of outmigrating winter-run salmon captured in small fish traps at RBDD, located approximately 50 river miles downstream from the location where most adult winter-run salmon spawn. This misleading discrepancy should be reconciled in the present status review for winter-run Chinook.

<u>Misclassification of Some Winter-Run Chinook as Spring-Run Chinook</u>

In 2017, the USFWS discovered a significant error in the estimates of brood year (BY) 2017 winter-run Chinook passage at RBDD. Historically, the agency used a length-at-date (LAD)

criteria to segregate the four runs of juvenile salmon captured in their fish traps. On any given date, the designation of a fish according to salmon run captured in the fish traps was based on the size (length) of the salmon using predicted growth rates. The LAD criteria for their fish sampling program have been used since 1995. In 2017, tissue samples for genetic analyses were taken from salmon to evaluate if the LAD was accurate in determining the true salmon run. The genetic work found that significant numbers of winter-run Chinook were designated as spring-run Chinook resulting in substantial negative bias to winter-run Chinook estimates and the LAD did not accurately portray juvenile salmon passage. As a result, the USFWS revised the BY 2017 winter-run passage estimates upwards (Poytress 2018). This same problem occurred for BY 2018 (Poytress 2019) and for BY 2019 (Voss 2020). There is a high probability this same problem occurred for prior winter-run brood years when genetic analyses were not performed (i.e., significantly underestimating winter-run salmon passage at RBDD). The importance of this situation is that original USFWS estimates of winter-run Chinook brood year survival were probably biased low (and, therefore, mortality biased high), including the BY 2014 and BY 2015 estimates previously discussed. The current status review for winter-run Chinook should reconcile this circumstance.

Resiliency of Winter-Run Chinook Recovering from the 2014 – 2015 Drought

As discussed previously, although the mortality estimates of winter-run Chinook in the drought years of 2014 and 2015 remain in question, some mortality undoubtedly occurred. Interestingly, despite the purported low numbers of juveniles estimated during the drought years, three years later after the drought years when the adult fish would have returned and spawned, a significant increase in production was evident for BYs 2017 and 2018 (Figure 1). This phenomenon suggests some resiliency in the winter-run recovering from the deleterious effects of the drought.

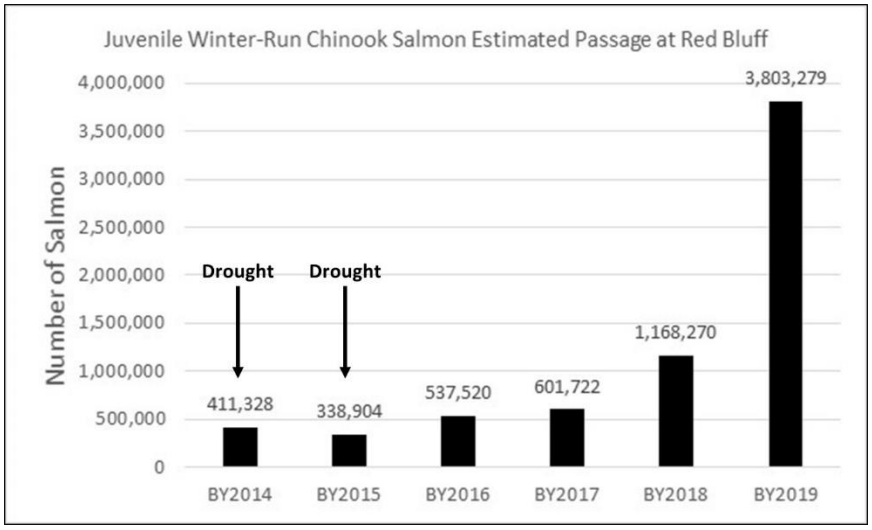

Figure 1. USFWS estimates of the number of young winter-run Chinook passing Red Bluff Diversion Dam by brood year (BY), 2014 – 2019. Note that the USFWS adjusted the numbers for BY 2017 – 2019 upwards based on genetic analyses but BYs 2014 – 2016 were not adjusted because no genetic analyses were performed.

Large Rainbow Trout Population

If resident rainbow trout are considered part of the population of threatened steelhead, the current status review should reconcile the fact that the upper Sacramento River possesses a very large rainbow trout population. The upper Sacramento River is considered a "blue-ribbon" rainbow trout fishery and is extremely popular for fly fishing. As described by a local fly fishing business, "The river below Shasta Dam is one of the top tailwater trout fisheries in the West" (TheFlyShop). Interestingly, water temperature management efforts to benefit winter-run Chinook egg incubation may have enhanced the resident rainbow trout population (Poytress et al. 2014). The current status review for steelhead should reconcile this circumstance.

Battle Creek Salmon and Steelhead Restoration Project

As described by USBR, "the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) is being implemented near the town of Manton, California in Shasta and Tehama Counties. Upon its completion, the Restoration Project will reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional 6 miles on its tributaries. The species include the Central Valley spring-run Chinook salmon (state- and federally listed as threatened), the Sacramento River winter-run Chinook salmon (state- and federally listed as endangered), and the Central Valley steelhead (federally listed as threatened). The Restoration Project is a collaborative effort between the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Pacific Gas and Electric Company and various resource agencies, including the California State Water Resources Control Board (State Water Board), the U.S. Fish and Wildlife Service, National Marine Fisheries Service (NOAA Fisheries), the California Department of Fish and Game, the Federal Energy Regulatory Commission and the California Bay Delta Authority, with valuable participation from the public, including the Greater Battle Creek Watershed Working Group and the Battle Creek Watershed Conservancy. This partnership provides the framework for restoring one of the most important anadromous fish spawning streams in the Sacramento Valley, while maintaining a renewable energy resource for electric customers in California."

Details on this major restoration project for the three listed species are provided at:

Battle Creek Salmon and Steelhead Restoration Project - USBR

and

Battle Creek Salmon and Steelhead Restoration Project - DFW

The current status review should include the relevant details.

Butte Creek Restoration

Significant progress has been made on Butte Creek to benefit spring-run Chinook and steelhead. As described by the Northern California Water Association: "Butte Creek is one of only four Sacramento River tributaries with remaining populations of the endangered spring-run Chinook

salmon. Resource agencies and conservation groups value Butte Creek as a keystone in preserving and recovering spring-run salmon, which in some years had dwindled to less than 100 returning adults from 1970 to the early 1990s. Today, as a result of the Butte Creek Fish Passage Improvement projects, in tandem with a valuable food supply and safe rearing habitat in the Sutter Bypass wetlands, more than 10,000 spring-run salmon return on average to Butte Creek." Details on Butte Creek restoration are provided at:

https://norcalwater.org/wp-content/uploads/06_15_17_ButteCreekSheet_final-002-1.pdf

https://norcalwater.org/2017/06/22/secrets-of-salmon-success-how-lessons-learned-on-butte-creek-can-help-recover-fish-in-the-sacramento-valley/

https://norcalwater.org/wp-content/uploads/2012/01/remanaged-flows-nov2014.pdf

http://salmonpartnership.org/wp-content/uploads/2017/08/CVSHP-FactSheet-web.pdf

This relevant information should be included in the current status review.

References

National Marine Fisheries Service. 2014. Recovery plan for the Evolutionarily Significant Units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the Distinct Population Segment of California Central Valley steelhead. California Central Valley Area Office. July 2014. 406 p.

Poytress, W.R, J.J. Gruber, F.D. Carrillo, and S.D. Voss. 2014. Compendium Report of Red Bluff Diversion Dam Rotary Trap Juvenile Anadromous Fish Projection Indices for Years 2002-2012. July 2014. 151 p. Accessible at: Poytress et al. 2014

Poytress, W.R. 2018. Genetic-based revisions to brood year 2017 winter and spring Chinook passage and production estimates in an effort to improve the accuracy of Red Bluff juvenile monitoring estimates. Memorandum to file. 2 p. Accessible at: Poytress 2018

Poytress, W.R. 2019. Linear-model and genetic-based revisions to brood year 2018 juvenile winter and spring Chinook salmon passage and production estimates. Memorandum to file. 4 p. Accessible at: Poytress 2019

U. S. Fish and Wildlife Service 1995. Working paper: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

Vogel, D.A. 1995. Technical memorandum on the results of a November 1995 riverbed survey of the Sacramento River in the vicinity of the South Bonnyview Bridge. Natural Resource Scientists, Inc. December 1, 1995.

Vogel, D.A. 2011. Insights into the Problems, Progress, and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration. 161 p. Accessible at: Vogel (2011)

Vogel, D.A. 2013. Evaluation of fish entrainment in 12 unscreened Sacramento River diversions, Final Report. Report prepared for the CVPIA Anadromous Fish Screen Program (U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation) and Ecosystem Restoration Program (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, NOAA Fisheries). Natural Resource Scientists, Inc. July 2013. 153 p. Accessible at: Vogel 2013

Vogel, D.A. 2016a. Monitoring summary of juvenile winter-run Chinook and spawning and rearing habitats during 2015. Natural Resource Scientists, Inc. February 29, 2016. 7 p.

Vogel, D.A. 2016b. Enhanced monitoring of winter-run Chinook habitats in 2015 and 2016. Technical Memorandum to the Northern California Water Association. Natural Resource Scientists, Inc. December 17, 2016. 33 p.

Vogel, D.A. 2017. Evaluation of Annual Estimates of Winter-Run Chinook Salmon Early Life Stage Survival/Mortality with Particular Focus on 2014 and 2015. Preliminary Report. Natural Resource Scientists, Inc. March 3, 2017. 84 p. Accessible at: Vogel 2017

Vogel, D.A. 2020. Evaluation of the North Tobiasson Deep-Water Juvenile Salmon Rearing Habitat Structures. 2020 Final Draft Report. Upper Sacramento River Anadromous Salmonid Habitat Restoration Program. Natural Resource Scientists, Inc. 103 p.

Vogel, D.A. and G. Taylor 1987. Survey of the Chinook Salmon Spawning Substrate in the Sacramento River from the Highway 273 Bridge to Keswick Dam, July-August, 1987. Contract Report for the Federal Energy Regulatory Commission Request for Information Concerning the Proposed Lake Redding Hydroelectric Project (FERC No. 2828). 13 p.

Voss, S.D. 2020. Linear-model and genetic-based revisions to brood year 2019 juvenile winter and spring Chinook salmon passage and production estimates. Memorandum to file. 3 p. Accessible at: Voss 2020