Appendix A: U.S. Fish and Wildlife Service Memo, August 10, 2015

United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer To:
AFWO

Memorandum

TO: Federico Barajas, Reclamation Northern California Area Manager

FROM: Nicholas Hetrick and Joe Polos, Arcata Fish and Wildlife Office

SUBJECT: Response to Request for Technical Assistance Regarding 2015 Fall Flow Releases

CC: Robin Schrock, Executive Director Trinity River Restoration Program

DATE: August 10, 2015

In response to Reclamation's request for technical assistance dated August 6, 2015, we've summarized several factors that we consider important to help inform Reclamation's decision regarding the release of augmented flows from Lewiston Dam in fall 2015, intended to reduce the risk of an adult fish kill occurring in the Klamath River. Much of the information contained in this memo has been previously expressed to Reclamation during co-manager meetings and conference calls regarding 2015 fall flow releases. We have also provided additional information and analyses as needed for clarity and scientific support to aid Reclamation's deliberations in determining appropriate fall flow actions.

In 2013, Reclamation requested that the US Fish and Wildlife Service and the National Marine Fisheries Service provide technical assistance in assessing the current and predicted hydrologic conditions for the time period overlapping the 2013 adult fall-run Chinook Salmon migration in the lower Klamath River, and in developing preventative and emergency measures that would reduce the risk of an adult fish kill. Inherent in this request was the need to be conservative of limited water resources given the dry hydrologic conditions and limited volume of the cold-water pool. As requested, we collaborated with NOAA Fisheries to write a joint memorandum to Reclamation outlining concepts for managing flows with accompanying scientific support pertaining to conditions present in fall 2013 (USFWS and NOAA 2013). This memorandum, referred to hereafter as the 2013 Joint Memo, contained technical analyses regarding flows and adult fall-run Chinook Salmon in the Klamath-Trinity Basin, and included management triggers based on real-time conditions such as run timing, water temperature, and severity of potential Ich infections. The 2013 Joint Memo did not contain analyses regarding the potential effects of fall flow releases on species listed under the Endangered Species Act (ESA) or compliance with the ESA or any biological opinions issued under the ESA.

In meetings and calls held by Reclamation in 2015, the Service has consistently expressed that information contained in the 2013 Joint Memo is largely relevant to this season, with the following clarifications and modifications:

- De-emphasis of the significance of run size,
- Clarification of the "Ich trigger" used to define severity of infections, and
- Alteration of the emergency trigger of "doubling the flow".

Flow Target for the Lower Klamath River

Following the epizootic of Ich and columnaris that resulted in the 2002 fish kill in the lower Klamath River (Guillen 2003a, Guillen 2003b), Reclamation has augmented late-summer/early-fall flow releases from Lewiston Dam to improve conditions in the lower Klamath River to reduce the risk of a major fish kill. Fall flow augmentations were implemented in 2003, 2004, 2012, 2013 and 2014, with release volumes ranging from 17,500 acre feet in 2013 to 64,000 acre feet in 2014 (Table 1). While a major fish kill did not occur during any of these years, or in years since 2002 when flow augmentation was not implemented, a large-scale outbreak of Ich in fall-run Chinook Salmon did occur in 2014 (Belchik 2015). Initial augmentation in 2014 targeted a flow of 2,500 cfs in the lower Klamath River and did not prevent a severe Ich epizootic from occurring, with the magnitude and severity of the outbreak necessitating an emergency release of nearly double the flow in the lower Klamath River for five consecutive days.

While definitive data on the causal relationships between flows in the lower Klamath River and Ich epizootics do not exist, we compared information from 2002, the year of the Klamath fish kill, to five years where flow augmentation actions were implemented. Flow augmentation targets for the lower Klamath River implemented by Reclamation were 3,200 cfs in 2012, 2,800 cfs in 2013, and 2,500 cfs in 2014, with an Ich outbreak only occurring during 2014. Additionally, we examined information from years where flow augmentation actions were not taken. Mean-monthly flow in the lower Klamath River for August was near or below 2,500 cfs during the two years when a severe Ich infestation occurred (2002 and 2014, Table 1). While mean flow for the month of August 2013 was below 2,800 cfs, flow augmentation actions were taken to achieve a flow target of 2,800 cfs in the lower Klamath River, resulting in the mean flow for the period August 15-31 of 2,795 cfs. For all other years that fall flow augmentation was implemented, mean-monthly flows for August in the lower Klamath ranged from 3,003 cfs (2004) to 3,463 cfs (2003).

Mean-monthly flow for August the lower Klamath River for the period of 2002 through 2014 has exceeded the 2,800 cfs level in all years except 2002, 2013 and 2014 (Figure 1). Focusing on the latter half of August, the only years when the 2,800 cfs flow level was not exceeded was in 2002 and 2014 (Figure 2).

Table 1. Volume of augmented flow (thousand acre-feet, TAF), occurrence of Ich infection, mean August and August 15-31 flow in the lower Klamath River (KNK), and in-river adult fall Chinook Salmon in-river run during the augmented flow years (bold) and the fish-kill year (2002).

Year	Augmented Flow (TAF) From Lewiston[1]	Severe Ich Infections (Y/N)	Mean August KNK Flow (cfs)	Mean August 15-31 KNK Flow (cfs)	Inriver Adult Fall Chinook Run[1]
2002	0	Y	2,327	2,161	160,788
2003	38	N	3,463	3,308	191,948
2004	36	N	3,003	3,237	78,943
2012	39	N	3,386	3,458	291,877
2013	17.5	N	2,673	2,795	165,025
2014	64	Y	2,269	2,419	160,444
2015					119,800[2]

[1] USBOR
[2] CDFW 2015
[3] In-river run projection (PFMC 2015)

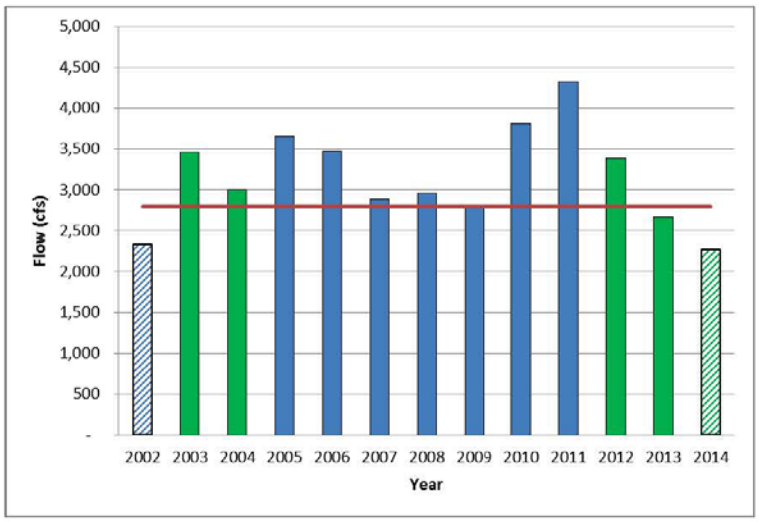

Figure 1. Mean August flow (cfs) in the Lower Klamath River (KNK), 2002-2014. Green bars are years when flow augmentation occurred and hatched bars are years when Ich outbreaks occurred. Horizontal red line represents 2,800 cfs flow.

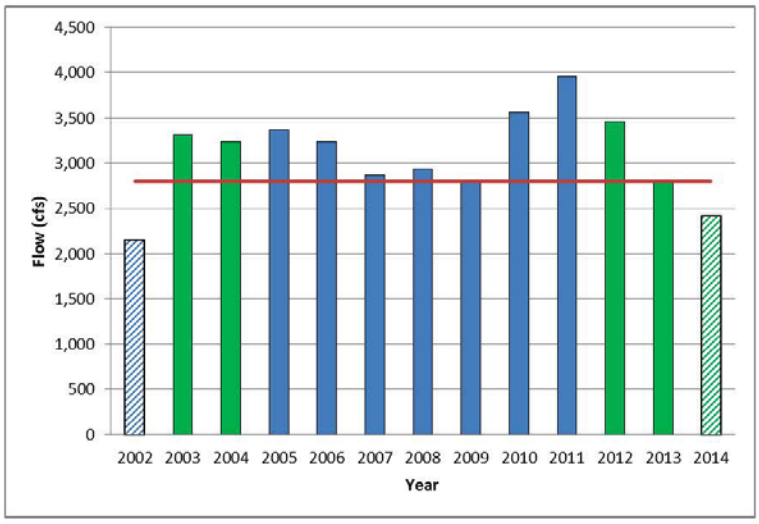

Figure 2. Mean August 15-31 flow (cfs) in the Lower Klamath River (KNK), 2002-2014. Green bars are years when flow augmentation occurred and hatched bars are years when Ich outbreaks occurred. Horizontal red line represents 2,800 cfs flow.

Run Size

Run size has been factor in technical discussions and several whitepapers addressing fall flow augmentation (Turek et al. 2004; Strange 2010a; TRRP 2012a; TRRP 2012b; USFWS and NOAA 2013). However, the Service considers the pattern of upstream migration to be a more important factor in determining disease risk than run size alone. The metric of concern is not run size, but rather the residence time of groups of fish within small confined habitats such as the thermal refugia that exists at Blue Creek in the lower Klamath River. An extended residence time in thermal refugia may occur given small or large runs under certain environmental conditions.

During the period since the 2002 fish kill, the in-river adult fall Chinook Salmon run has ranged from 61,373 in 2006 to 291,877 in 2012 (Figure 3). While run-size has been used as an indicator of the potential need for a flow augmentation action, it should not be used a binary (yes/no) trigger. A number of factors such as the timing of the run, flow, water temperatures, in-river fisheries, etc., can contribute to large congregations of adult salmonids holding for extended periods of time that could potentially trigger an Ich epizootic, and these factors are independent of run size. For example, in 2014 an estimate of about 10,000 adult Chinook Salmon and Steelhead were observed in the lower Klamath River in the thermal refugia near Blue Creek (Belchick 2015). A similar observation of extended residence time occurred in mid to late July in 2015, albeit to a lesser degree (1,000 adults estimated). It's important to note that these large congregations of fish occurred before the primary onset of the fall-run Chinook Salmon migration in the lower Klamath River.

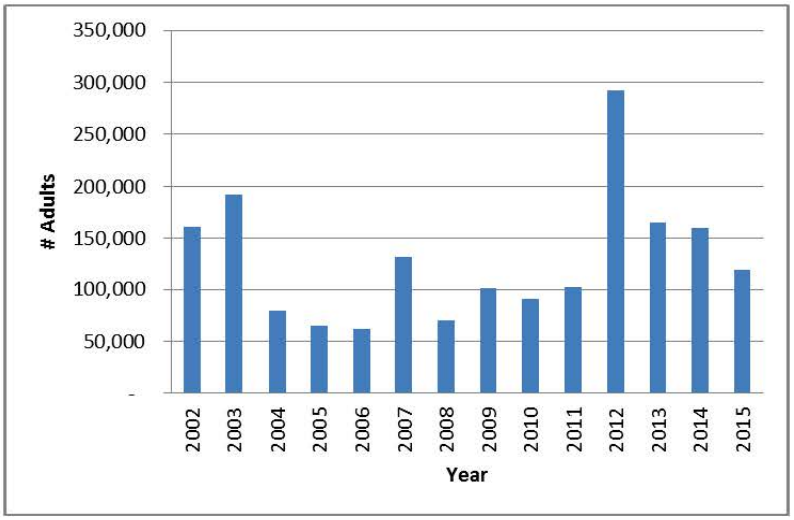

Figure 3. Klamath River adult fall Chinook Salmon in-river run, 2002-2014 and projected 2015 in-river run.

Water Temperature Modelling

To evaluate the potential effects of augmented Lewiston flows on water temperatures in the lower Klamath River, we applied the RBM10 temperature model using climate and accretion data from 1994, a year with meteorological and hydrological conditions similar to that experienced to date in 2015. The RBM10 temperature model has been calibrated, validated, and peer reviewed for the mainstem Klamath River using tributary inputs as boundary conditions. Results of this process suggest that temperature predictions matched historical data to within about 1^{o} C (Perry et al. 2011). A mainstem Trinity River version of RBM10 has recently undergone calibration and validation, but is not yet published as a peer-reviewed product. Lewiston Dam flow augmentation values were established to achieve discharge targets of 2500, 2800, and 3200 cfs on the mainstem Klamath River near Klamath, CA and were provided to our office by Reclamation. Reclamation also provided release-point water temperatures for the different flow release scenarios, which all incorporated the use of the bypass facilities except for the no action scenario. The Trinity River temperature predictions were then applied as boundary conditions to the Klamath River temperature model to obtain predicted Klamath River temperatures at the USGS gauge site near the town of Klamath, CA.

In evaluating the predicted temperature effects of the various management alternatives, temperatures near or exceeding 23^{o} C are of particular interest as this has been identified as a threshold for impairing the upstream migration of adult salmon (Strange 2010b), what we refer to as a "thermal migration barrier" in the 2013 Joint Memo. Under the no action scenario, water temperatures in the lower Klamath River were predicted to approach or exceed 23^{o} C during most of August and early September (Figure 4 top). Results from the model runs incorporating flow augmentation predicted that immediately after Lewiston flows are augmented, temperatures would drop below 23^{o} C regardless of augmentation level, with cooler temperatures in the lower Klamath River corresponding to the largest Lewiston Dam augmentation releases (Figure 4 top).

Over this same time period, the amount of predicted water temperature cooling is commensurate with flow augmentation level (Figure 4 bottom). During the naturally occurring warmest period of late August, the augmented flows are predicted to be between 1.5^{o} and 3.5^{o} C cooler. Given the stated validation precision of the model ($\pm 1^{o}$ C), results of the simulation suggest more certainty in preventing a thermal migration barrier by water temperature cooling effects associated with the 2,800 and 3,200 cfs scenarios compared to an augmentation level of 2,500 cfs.

The water temperature predictions also demonstrate the relative impacts on water temperatures in the lower Klamath River associated with Lewiston augmentation and use of the bypass. The larger temperature decreases are associated with the discharge augmentations, and water temperatures are predicted to approach those under the no action alternative almost immediately after the augmentation is stopped in the simulations on September 21st, with only modest water temperature cooling ($<1^{0}$ C) associated with use of the bypass thereafter (Figure 4 top and bottom).

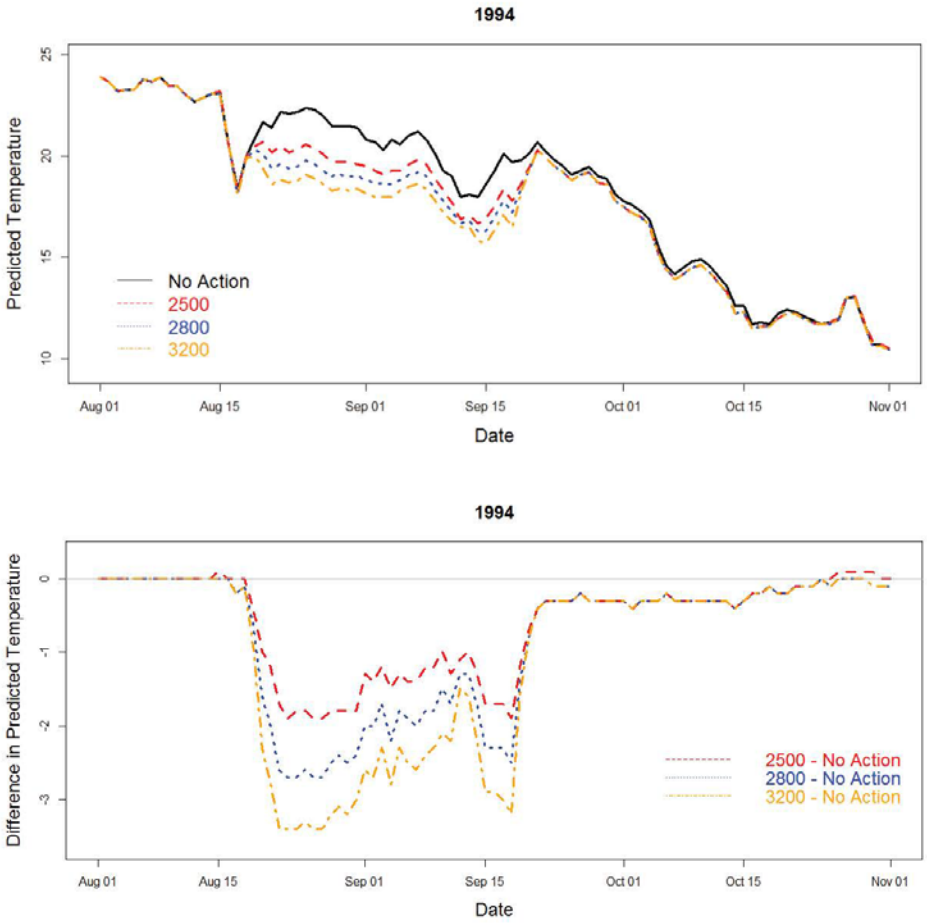

Figure 4. Predicted water temperatures (top) and difference in predicted water temperatures (bottom) in the lower Klamath River near the Klamath gage site, Klamath CA. No action refers to base operation flows from Lewiston Dam without using the bypass facility whereas the three augmented flow release scenarios reflect releases necessary to achieve targeted discharge of 2,500, 2,800, and 3,200 cfs at the Klamath gage site and included use of the bypass.

Tributary Accretions

This year, discharge in the Klamath River above the Trinity River confluence is similar to that observed in 2002, despite flow releases from Iron Gate Dam being significantly lower in 2002 than in 2014 (Figure 5). This difference can be attributed to the lower contributions of inflow from tributaries (Figure 6), which are generally of better water quality and are cooler than water temperatures in the mainstem Klamath River, particularly upstream of the Trinity River confluence. In 2015, cumulative tributary inflows to the Klamath and Trinity rivers are similar to, or lower than, other years when fall flow augmentation occurred (Figure 6). In addition, the low volume of tributary accretions is assumed to result in reduced volume of thermal refugia habitats along the mainstem river. The low tributary inflows provide limited thermal relief, thereby increasing stress of holding fish and minimizing conditions conducive to parasite replication and increased disease transmission due to crowding of fish. If the current drought conditions persist, the overall area of thermal refugia habitats is likely to be less than was available 2002 and similar to that experienced in 2015 due to the low tributary inflow.

Fish Metric

The purpose of the fish metric developed in the 2013 Joint Memo was to establish a real-time measure of the first substantial increase of fall-run Chinook Salmon in the lower Klamath River and was intended to be used as a trigger to initiate fall flow augmentation. The benefit of this real-time management approach is its potential to more efficiently use limited water resources as needed to protect returns of Klamath Basin fall-run Chinook Salmon, rather than relying on fixed dates to start and end flow augmentation. However, it's critical that an abundance-based metric be conservative so that augmented flows are released in time to protect the run. A metric that is not conservative enough may result in large numbers of adult fall-run Chinook Salmon entering the river and commencing their upstream migration under flow conditions that are similar to those that occurred during the 2002 fish-kill.

A key component of the fish metric was to establish August 22nd as a "back-stop" start date to ensure that augmented flows would reach the lower Klamath River before the peak of the run. Rationale for the August 22nd trigger date are provided in the 2013 Joint Memo, and include the observation that in four of the five years included in the break-point analysis, large numbers of fish had been harvested in the estuary area by this date and harvest in the Middle Klamath Area increased in the following weeks, suggesting that the upstream migration of the run had commenced.

In 2015, operational flows from Lewiston Dam are scheduled to increase on August 16th to provide a peak flow at Hoopa on August 18th for the Hoopa Boat Dance. Given an approximate two-day ramp-down time from the Boat Dance release and a similar two-day ramp-up time to meet the August 22nd suggested mandatory augmentation start date (assuming the 7,000 fish metric target is not met), it's questionable whether post Boat Dance flows would reach base levels prior to being ramped back up to the target of 2,800 cfs at the lower Klamath Gage site by August 22nd. The "two-fold pulse" in flow increases created by this scenario may trigger more fish to enter the river earlier than they would under the single pulse created by the Boat Dance release and ramping down to meet 2,800 cfs in the lower Klamath River.

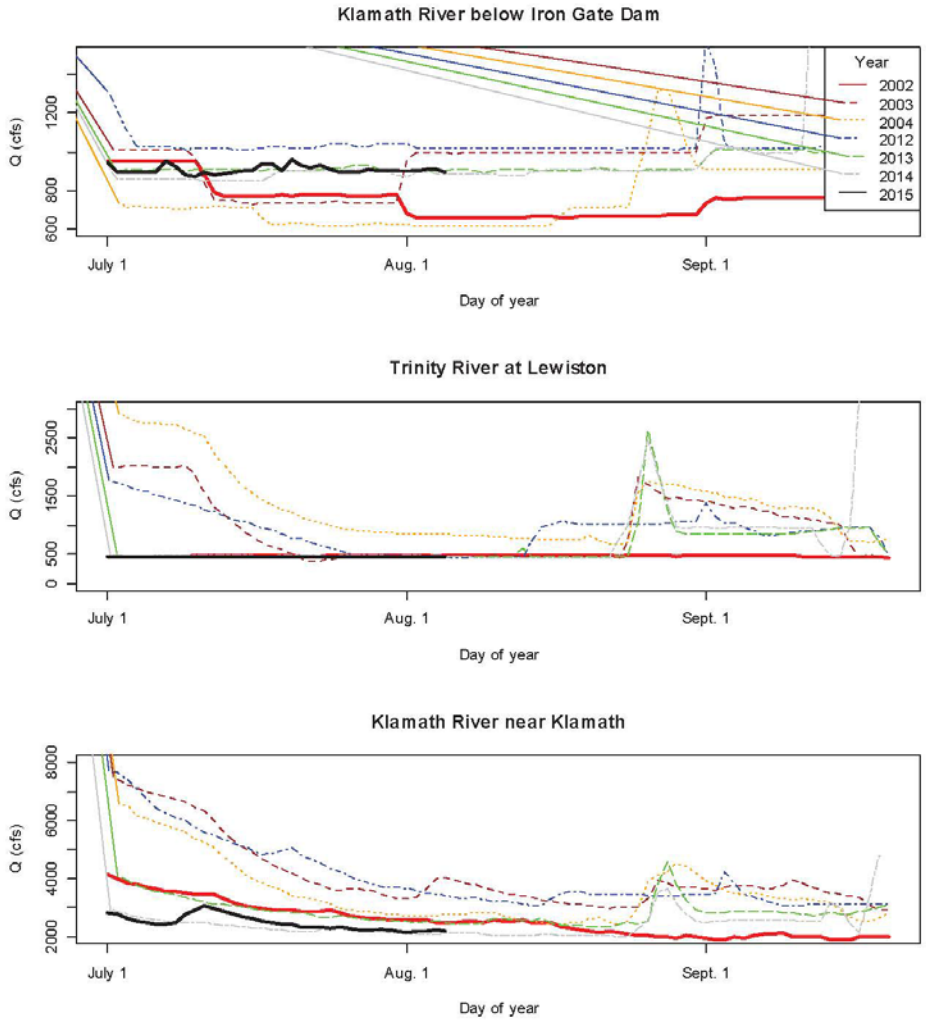

Figure 5. Dam releases and streamflow in the lower Klamath River near Klamath in 2002, 2015 and years with fall streamflow augmentation management actions.

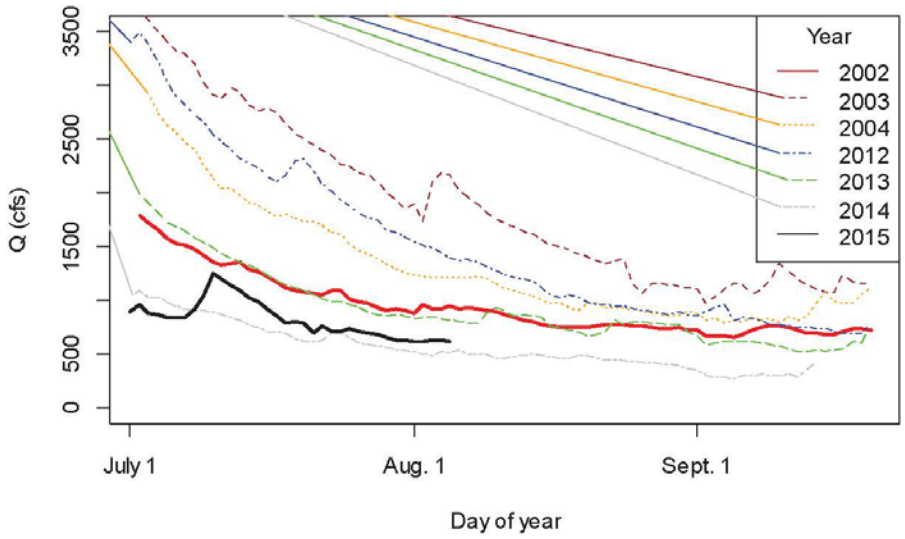

Figure 6. Estimated tributary accretions to the Klamath River downstream of the Trinity River confluence for 2002, 2015 and years where fall flow augmentation actions were implemented. Tributary accretion estimates were developed independently for the Klamath River and Trinity River and then summed. Klamath River tributary accretions were estimated by subtracting mean daily streamflow below Iron Gate Dam from Klamath River near Orleans. Similarly, Trinity River tributary accretions were estimated by subtracting mean daily streamflow below Lewiston Dam from the flow at Hoopa. In each case, calculations were offset by one day to account for travel time between gauges and smoothed to remove anomalies due to imperfect temporal offsets.

Emergency Criteria

In the 2013 Joint Memo, we recommended a two-tiered approach to emergency flow criteria, both of which are intended to minimize the potential for the occurrence of an epizootic disease outbreak and resulting fish-kill. The first phase recommends that flow in the lower Klamath River be increased to 3,200 cfs at rkm 13 when the fish metric criterion is met or exceeded and mean daily water temperature (actual and/or predicted) at rkm 13 is $\geq 23^{\circ}$ C for three consecutive days. Based on results of the water temperature modelling, this 3-day temperature criterion is unlikely to be exceeded in 2015 under augmented flow releases intended to meet the 2,800 cfs in the lower Klamath River (Figure 4 top).

The second phase of the emergency release is based on the fish pathology/mortality criteria adopted by the Trinity River Restoration Program - Fall Flow Subgroup's recommendation for 2012 (TRRP 2012a; TRRP 2012b), which recommends a 7-day duration pulsed spike to double pre-existing flows in the Lower Klamath River. This recommendation is based on a management practice often used in hatcheries, with increased flow as a control measure for Ich being well supported in the literature (Reshetnikova 1962; CDFG 1969; Bodensteiner et al. 2000; Hop Wo et al. 2003). However, a definitive target flow has not been determined for the Klamath River and as such, the hatchery practice of "doubling the flow" has been the basis of past recommendations.

In 2014, the emergency management action to double the flow from about 2,500 cfs up to about 5,000 cfs in the lower Klamath River was implemented and a fish kill did not occur. Given this data point, repeating the emergency flow release that occurred in 2014, if needed, is likely better supported than the general "doubling of the flow" as recommended by the Trinity River Restoration Program Fall Flow Work Group (TRRP 2012a, TRRP 2012b) and in the 2013 Joint Memo (USFWS and NOAA 2013). We are, however, receptive to Reclamation convening a workgroup to discuss possible alternatives to this emergency action, such as having two large pulses separated by 5-7 days based on the lifecycle of Ich and real-time water temperatures.

Emergency Ich Criteria

As stated in the 2013 Joint Memo

> *"We recommend the level and severity of an Ich infection that would trigger an emergency release be defined as a confirmed observation of a minimum of 5% of the sampled fish having 30 or more parasites on one gill arch."*

This methodology was developed by Dr. Scott Foott of the Service's CA/NEV Fish Health Lab as a rapid assessment protocol and was used in the baseline Ich monitoring the Service conducted with the Yurok Tribe in 2003. The method was not intended to be a census of Ich or an estimate of the average number of parasites/gill arch. Instead, it was developed as an efficient and rapid methodology to assess the prevalence and severity of infection, which requires recently captured and sacrificed salmon, due to the increased difficulty in identifying and quantifying Ich soon after mortality of the salmon host.

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