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TECHNICAL MEMORANDUM

Date: 23 July 2015
FROM: Mike Orcutt, Director Hoopa Valley Tribal Fisheries Department
TO: Paul Zedonis, Northern California Area Office, US Bureau of Reclamation
RE: 2015 Klamath River Flow Augmentation Requirement

This memorandum summarizes the Hoopa Valley Tribe's analysis of lower Klamath River conditions and fish kill risk, and sets forth the Tribe's minimum conditions on use of contractual rights to Trinity Division water in the lower Klamath River for the 2015 adult fall Chinook salmon migration season. Fish kill risk due to *Ichthyophthirius multifiliis* (Ich) requires establishing a proactive hydrograph for the lower Klamath River. Ich was the key pathogen in the September 2002 Klamath River catastrophic fish kill of primarily adult fall-run Chinook salmon and the non-lethal outbreak in September 2014. This memorandum was developed by the Hoopa Valley Tribal Fisheries Department in collaboration with Dr. Joshua Strange of Stillwater Sciences.

Riverine conditions in 2015 reflect the continuation of drought in the region. Flow conditions are generally worse as compared to 2002, and equivalent to 2014 (Figure 1). Flows are significantly lower than in July of 2002, and will likely continue to drop throughout the summer. Flows measured in the lower Klamath River 13 km above the Pacific Ocean as of 7/6/2015 fell to 2,450 cubic feet per second (cfs). A recent atypical moisture flow from the east produced thunderstorms, which provided temporary decreases in water temperatures and increases in flows to creeks and rivers, including some flash floods with associated turbidity spikes (Figure 2). However, flows as of 7/23/2015 dropped to 2,350 cfs. By way of comparison, the average flow of record for this date exceeds 4,000 cfs.

Thus far for the summer of 2015, flows in the lower Klamath River are generally equivalent to the cluster of the driest years recorded since 1963 (1977, 1992, 1994, and 2014 see Figure 3). Depending on the period of analysis used, flows conditions in 2015 are slightly lower than these with the lone exception of 1977. However, reservoir release baseflows are higher in 2015, as they were in 2014, compared to the drought years in the 1970s, 1990s and in 2002. This means that, just like 2014, accretions are exceptionally low and likely are significantly lower than any on record. In addition, the extreme drought year of 1977 had the driest July and September on record yet flows did increase on September 20th of that year to over 3,200 cfs from precipitation. Simply put, the drought conditions of 2015 are extreme, generally equivalent to 2014, and appear to be headed toward record low levels for the month of September in the lower Klamath River. This leads us to conclude that flows are more likely than not to continue to drop more than is typical from July to October (flows from accretions typically continue to


PACIFIC LAMPREY


STEELHEAD


GREEN STURGEON

slowly decrease until around September 1st). The level to which flows will fall between now (mid-July 2015) and the period of concern (primarily mid-August and through September) is of serious concern.

The U.S. Geological Survey's (USGS') CA-NV River Forecast Center advance hydrologic prediction tool provides one means for forecasting flows in the lower Klamath River during the month of September (www.cnrfc.noaa.gov/ahps.php). This tool is designed for forecasting flood events, however, and was previously generating less-than-reliable predictions during low-flow conditions (due to variability and uncertainties in a sub-model of soil moisture levels). In 2014, the USGS worked to improve the accuracy of predictions during low-flow conditions. For example, improved model predictions for flows on 7/10/2015 were only 38 cfs higher than the actual river flows in the lower Klamath River, although prior to the recent precipitation, flows were 440 cfs lower (7/6/2015), thus the model bias was considerably over-estimating flows. While not perfect, these model outputs can still be useful. The prediction for flows in the lower Klamath River for 9/1/2015 is approximately 2,041 cfs with a range of 2,015 to 2,180 cfs. The model predicts flows will reach the annual minimum on 9/15/2015 with a flow of 2,008 cfs with a range of 1,985 to 2,233 cfs. Given the striking similarity in flows in the lower Klamath River thus far in 2015 compared to 2014, with the exception of recent stormflows, it is likely that discharge will continue to follow a trajectory similar to 2014, which resulted in flows reaching 2,020 cfs on 8/24/2014 immediately prior to the supplemental release. In summary, flows in the lower Klamath River in 2015, without additional reservoir releases, are projected to be equivalent to flows in 2014 and 2002 in August and September.

Based on projected flow conditions alone, and given the biology of Ich, a fish kill is more likely than not in 2015 among adult fall Chinook salmon migrating in the lower Klamath River if supplemental flow releases are not made. Additional uncertainties and stressors increase the risk level for an Ich outbreak in 2015, are discussed below.

Adult fall-run Chinook salmon run size is another consideration in assessing risk. The mean run size for the period of record (1978 to 2014) is approximately 130,000 total fish for adults and 2-year old jacks/grilse (increased slightly due to larger returns in recent years), and the 2002 run size was above average at approximately 170,000 total fish (Figure 4). The Pacific Fishery Management Council (PFMC) pre-season forecast for 2015 in the Klamath Basin is slightly below average at 119,753 fall run Chinook salmon (adults only) predicted to return to the river.

However, as outlined in previous technical documents, primary mechanisms driving an Ich outbreak—such as occurred in 2002—are not nullified by below average run size; rather flow (i.e., water velocities and turnover rates) is the primary determinant of an Ich outbreak (e.g., Bodensteiner et al. 2000). While there may be a theoretical run size that is small enough to preclude a fish kill no matter how low flows are, multiple lines of evidence regarding fish schooling, fish migration behavior, and Ich's mode of infection via swimming cilia indicate that a below average run size will not adequately compensate for low flows in terms of fish kill risk. A fish kill event occurs as a result of multiple interacting probabilities; its prevention requires informed risk management. In the face of uncertainty regarding the subject of a threshold run size for an Ich outbreak in the lower Klamath River, a cautionary and protective approach

commensurate with the Secretary's fiduciary duty for trust fishery resources warrants a buffer of flow above the minimum thought to be necessary.

In this regard, pre-season forecasts are subject to annual error and variability. However, the record reports that larger magnitude under-predictions than over-predictions occur more frequently for Klamath adult fall Chinook stocks (Figure 5, data points above the 1:1 line are under-predictions). For example, in 2014 the PFMC pre-season forecast for the Klamath Basin was below average with 92,800 adult fall run Chinook salmon predicted to return; however, the post-season return was estimated at 182,792 total fish (160,444 adults), which is well above average and larger than the 2002 run size and would have resulted in higher recommended minimum flows to protect fish health (i.e., 2,800 cfs instead of 2,500 cfs base flows).

Several other stress factors are notably contributing to increased fish kill risk in 2015. First, as in 2014, other potential stressors such as myxosporidian parasites and toxic blue-green algae (*Microcystis aeruginosa*) are already significantly elevated in 2015 (http://www.kbmp.net/), which has the potential to reduce immune system performance in general and immune response to Ich infections specifically.

Second, and more important, the non-lethal Ich outbreak that occurred in 2014 could contribute to elevated background levels of Ich entering the 2015 salmon spawning migration season. This potential "hangover" effect is hypothesized to be responsible for the detection of Ich in 2003, the year after the 2002 lethal Ich outbreak, and the only other year that Ich has been detected since last year's full-blown outbreak. In similar fashion, spring and summer run Chinook salmon in the Klamath Basin again appear to be experiencing higher than normal levels of stress due to the unusually low flows and high water temperatures, which can also result in elevated background levels of fish diseases, including columnaris and potentially Ich. This situation could increase the subsequent disease risk to fall run fish entering the river later in the season, such as what may have occurred in 2002, a year that was also unusually stressful to spring and summer run Chinook salmon in the Klamath Basin.

Previous recommendations generally called for a minimum flow rate of 2,500 cfs to be maintained proactively for all forecasted run sizes of less than 170,000 fall run Chinook salmon during a four-week peak migration season approximately in late August/September, and 2,800 cfs for run sizes larger than 170,000, which was the run size in the lethal outbreak of 2002 (i.e., Strange 2010a, Hayden et al. 2012, TRRP 2012, USFWS and NMFS 2013—these citations and others contain additional supporting background information and analysis). Given the unreliability in run size forecasts and the need to buffer flows beyond the level extant during the outbreak in 2014, the Tribe requires 2,800 cfs as the new minimum flow regardless of predicted adult run size. In addition, larger pulsed flows should be employed to: (1) help flush safely out to sea any Ich parasites that have may have built up over the summer and further disrupt Ich infectivity; and (2) move residual spring and summer run Chinook salmon out of thermal refuges in the lower Klamath River (e.g., 2013). Pulsed flows in early to mid-August should be used move these residual fish upriver to holding habitat in the upper Trinity River. Additional pulsed flows should be used in mid-September to flush and disrupt Ich during the most crucial window for Ich outbreak initiation. Combined with a minimum flow target for the lower Klamath River of 2,800 cfs for the period of concern, such pulsed flows will afford risk reduction for an Ich

outbreak while using the minimum amount of water necessary to afford a reasonable level of protection. In addition, we call for an emergency doubling of flow for 7 days if Ich levels exceed disease criteria used in 2014 to detect the early stages of an Ich outbreak (30 Ich/gill arch in 5% of the fish sampled).

Based on the best available scientific data, in 2015, the Hoopa Valley Tribal Fisheries Department concludes that proactive flow releases are required in the form of an initial pulse flow in mid-August (which can be provided by the Hoopa boat dance flows on August 18th) to ensure any residual spring/summer run fish are able to leave thermal refuges and migrate upstream, followed by flows of at least 2,800 cfs throughout the primary fall Chinook migration season (through at least the third week of September). Further, because there is a strong rationale and probable significant benefit, another large pulse flow that would peak in the lower Klamath River in the second week of September is required to coincide with the typical peak of fall run Chinook salmon abundance in the lower Klamath, which is also in the time frame that Ich started to spread exponentially in 2002 and 2014. This pulse should be large enough to double flows in the lower Klamath River (i.e., 5,600 cfs), with the goal of flushing out any Ich and disrupting their ability to successfully find a host salmon before they perish during the most important window for infectivity.

Accordingly, the HVTF has developed the attached hydrograph to meet these proactive flow objectives and afford a sufficient level of protection from the risk of an Ich outbreak in 2015, consistent with the best available science (Figure 6). The shaping of these proactive flow releases are consistent with the priorities established for use of Trinity Division water in section 2 of the Act of August 12, 1955 (Pub. L. 84-386). Failure to abide by these priorities in 2014 appear to have resulted in more water having been released in reaction to fishery threats than if sufficient proactive flow releases had occurred (Figure 7).

In conclusion, the risk of a lethal Ich epizootic outbreak occurring in the lower Klamath River in 2015 as occurred in 2002 without protective flow releases is more likely than not, with unacceptably high risk due to continued drought conditions and projected extreme low flows. While the emergency doubling of flows in 2014 in response to the Ich outbreak had the intended effect of minimizing mortality, releasing insufficient proactive flows increases the risk of needing emergency flow releases, resulting in the use of more water than would sufficient proactive flows and risks mortality, including to later entering ESA listed SONCC Coho. The increased risk of an Ich outbreak in 2015 due to uncertainty in run-size forecasts, synergistic drought-related secondary stressors, and a potential increase in background levels of Ich resulting from the non-lethal Ich outbreak in 2014 requires the foregoing described flow releases at minimum.

FIGURES

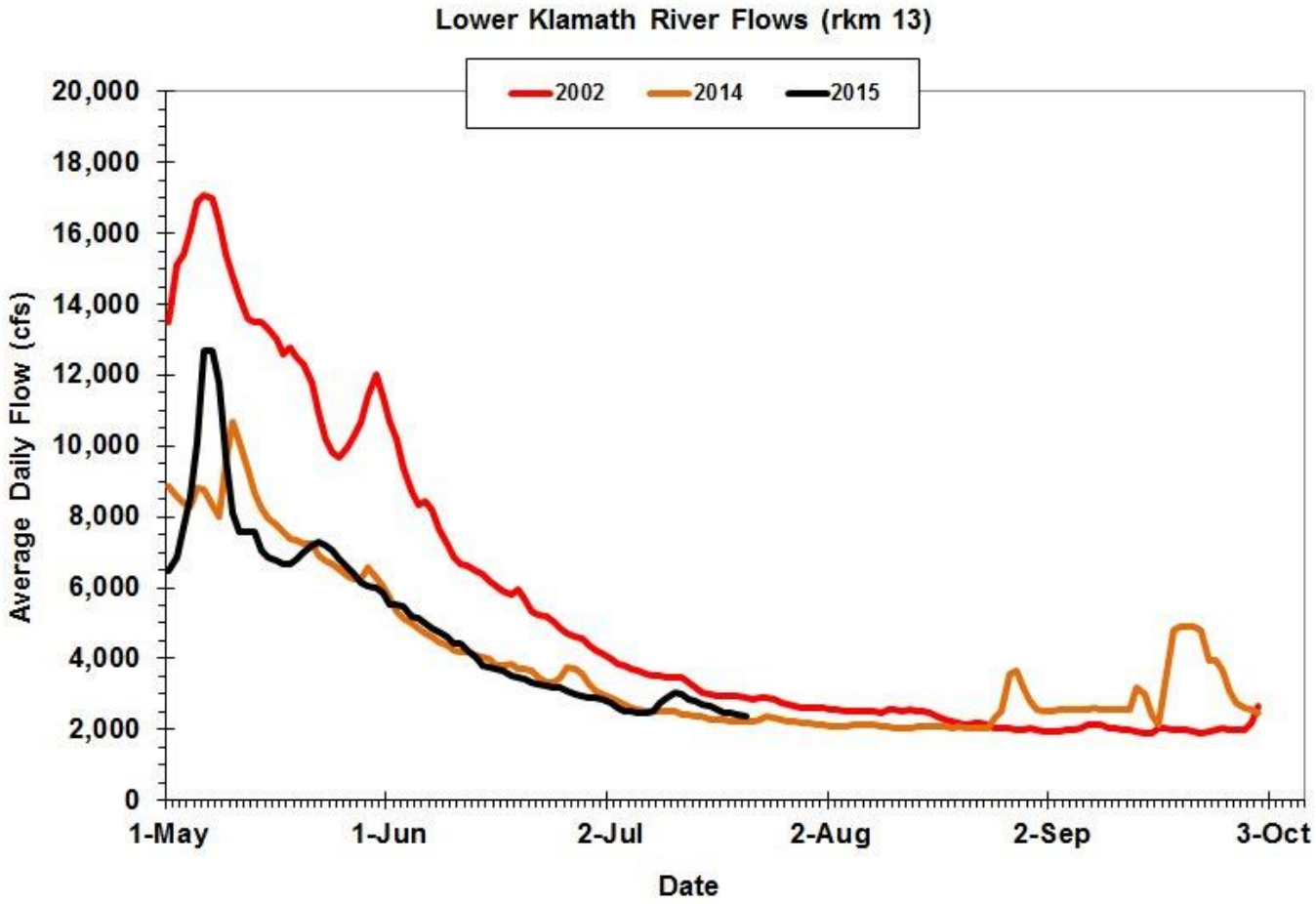

Figure 1. Flows in the lower Klamath River in 2015 compared to years when Ich outbreaks occurred (2002 lethal and 2014 non-lethal). All flow data is from USGS gauge #11530500 Klamath River near Klamath CA: http://waterdata.usgs.gov/ca/nwis/uv/?site_no=11530500&PARAmeter_cd=00065,00060

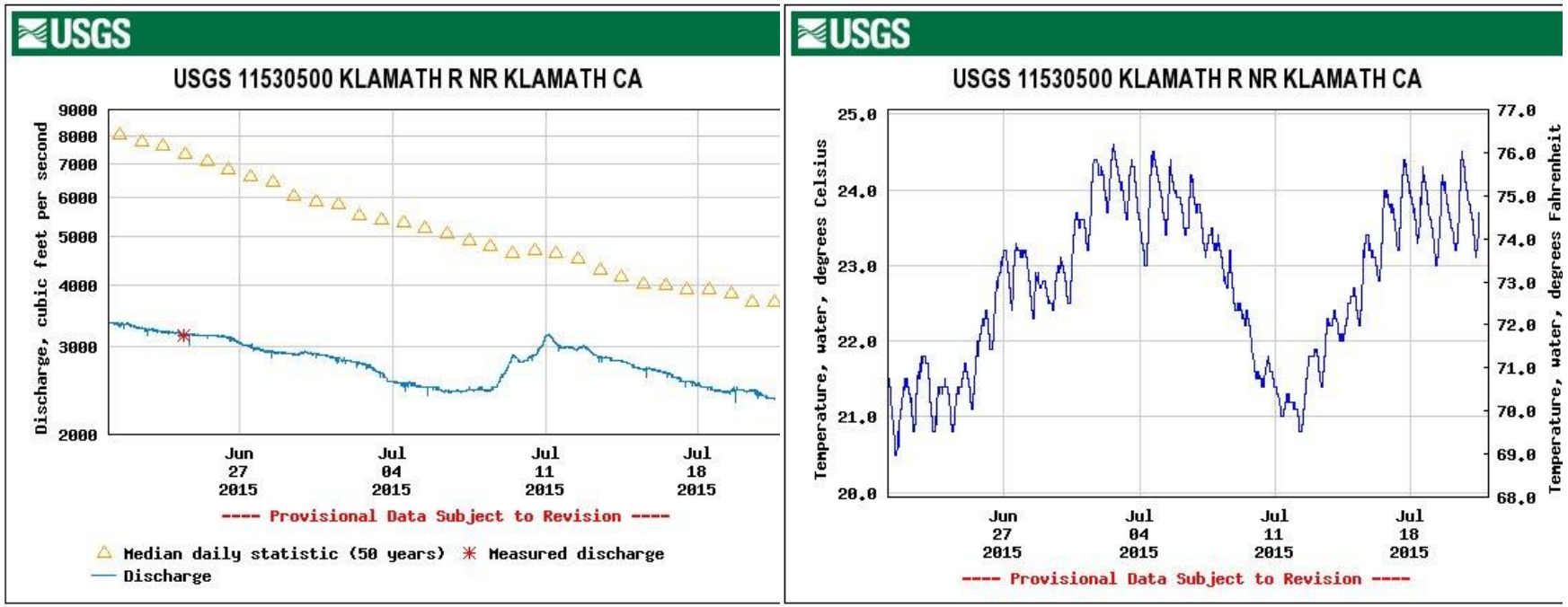

Figure 2. Flows and temperatures in the lower Klamath River in 2015 over the last 30 days. Mean daily temperatures ≥ 22°C are generally in excesses of the upper thermal limit to migration for adult Chinook salmon.

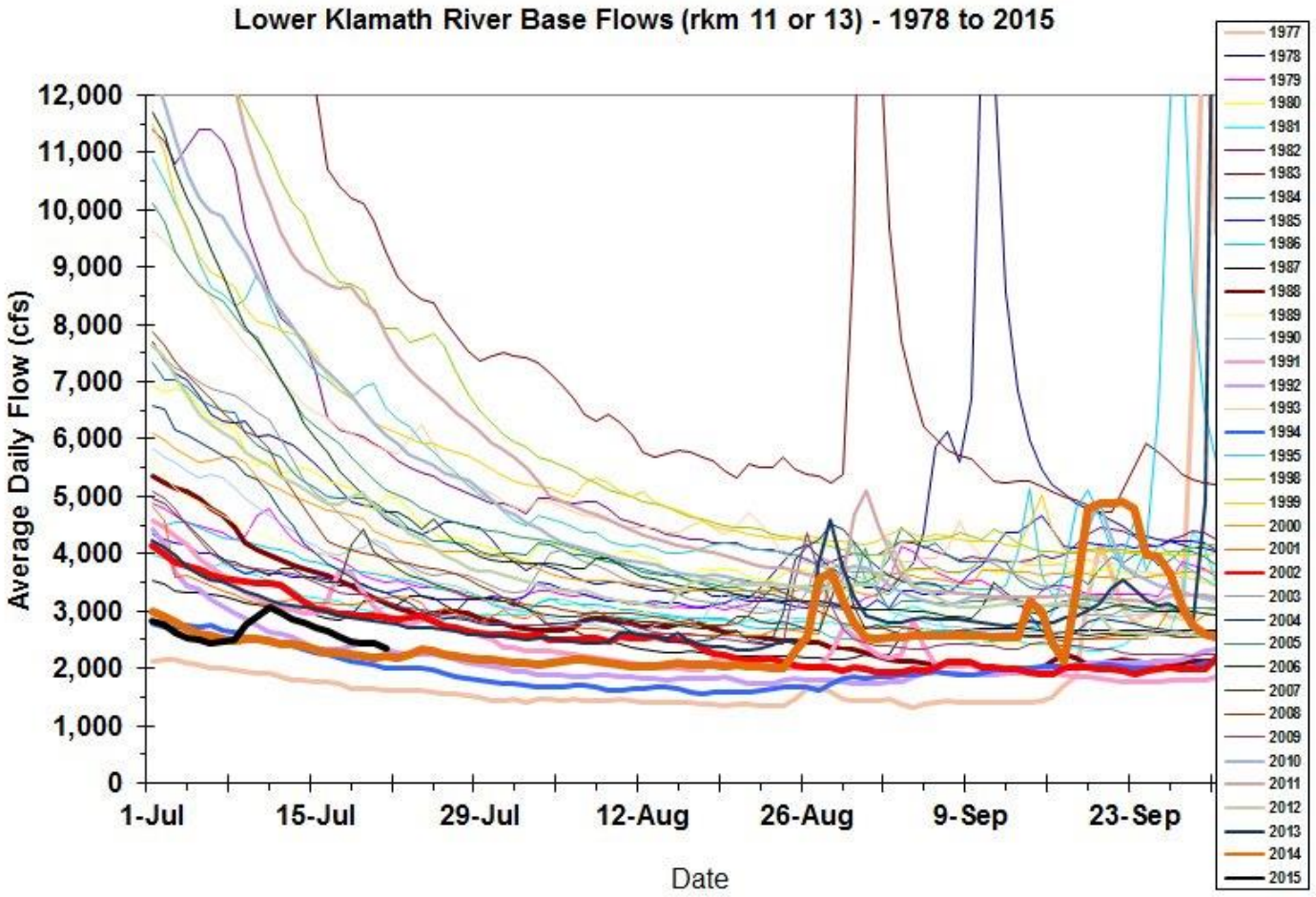

Figure 3. Flows in the lower Klamath River during July, August, and September from 1997 to 2014 and thus far in 2015. USGS #11530500.

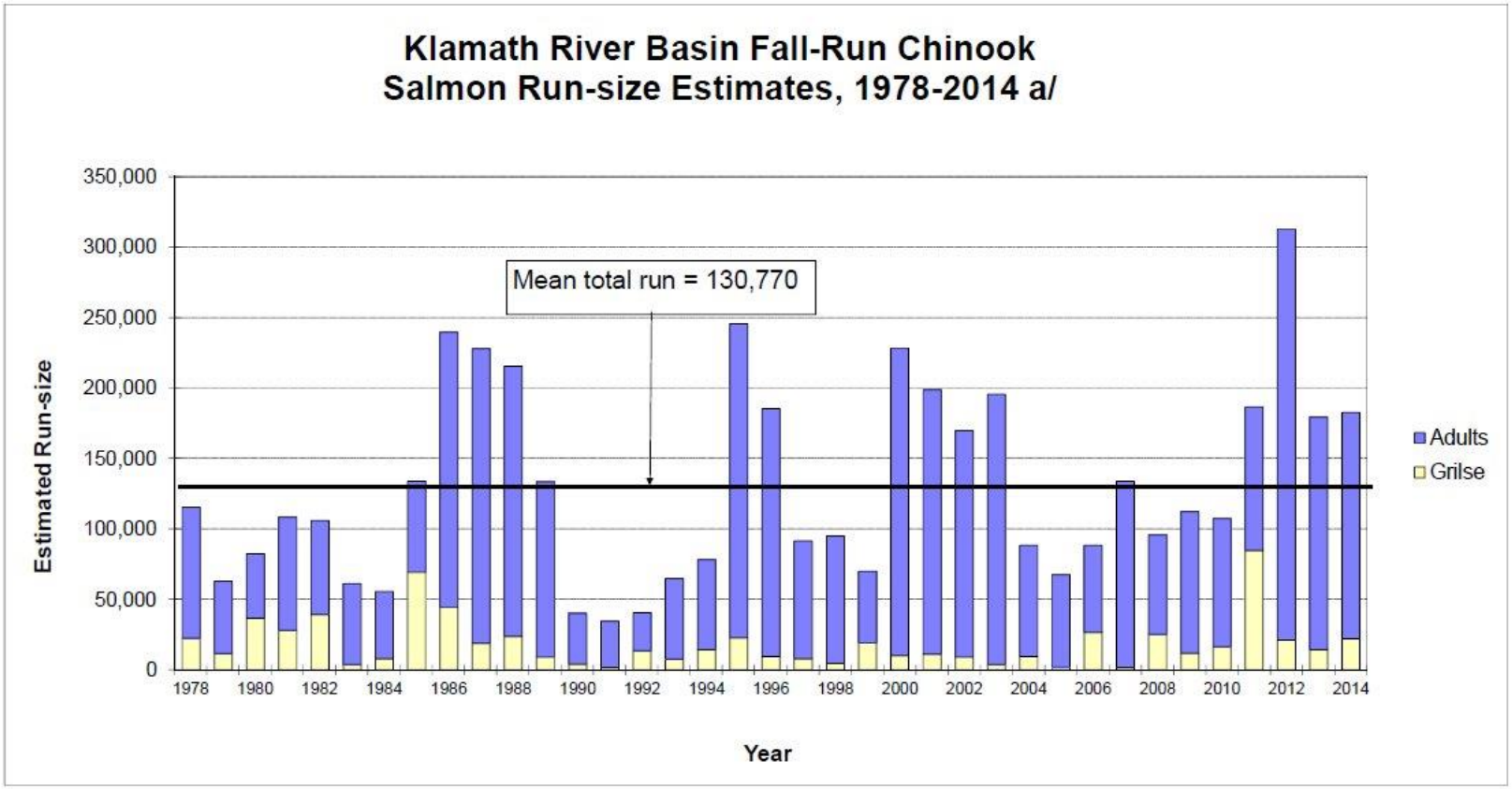

Figure 4. Klamath River Basin fall-run Chinook salmon in-river run-size estimates for the period of record from 1978 to 2014 (source: CDFW mega-table).

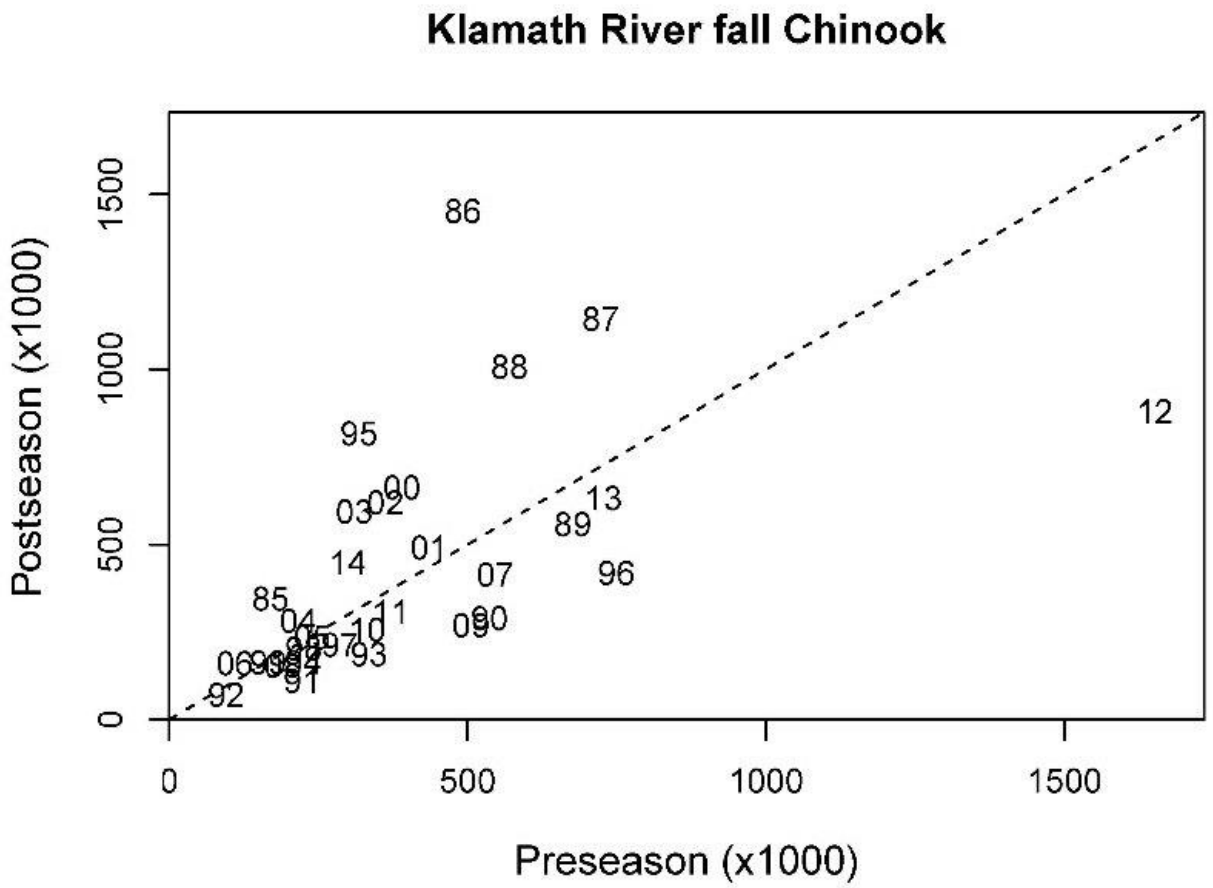

Figure 5. Postseason vs. preseason fall-run Chinook salmon in-river run-size forecasts and estimates for the Klamath River basin (source: PFMC).

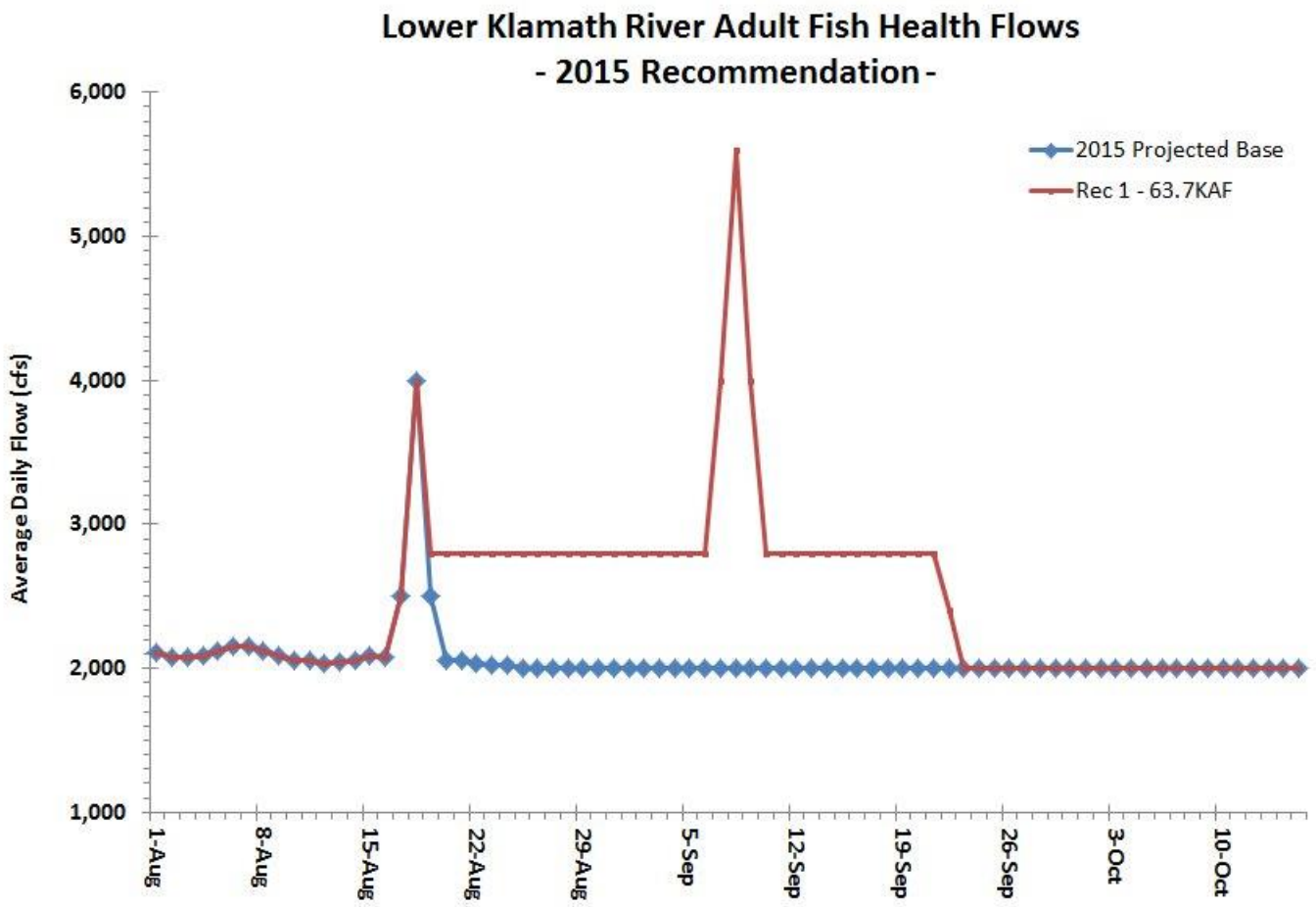

Figure 6. Recommended proactive flows for the lower Klamath River for the 2015 fall Chinook salmon run. With the Hoopa ceremonial boat dance flows excluded, and assuming a base flow of 2,000 cfs, this would require approximately 63,729 AF. In 2014, total supplemental flow released for adult fish health totaled approximately 80,000 AF.

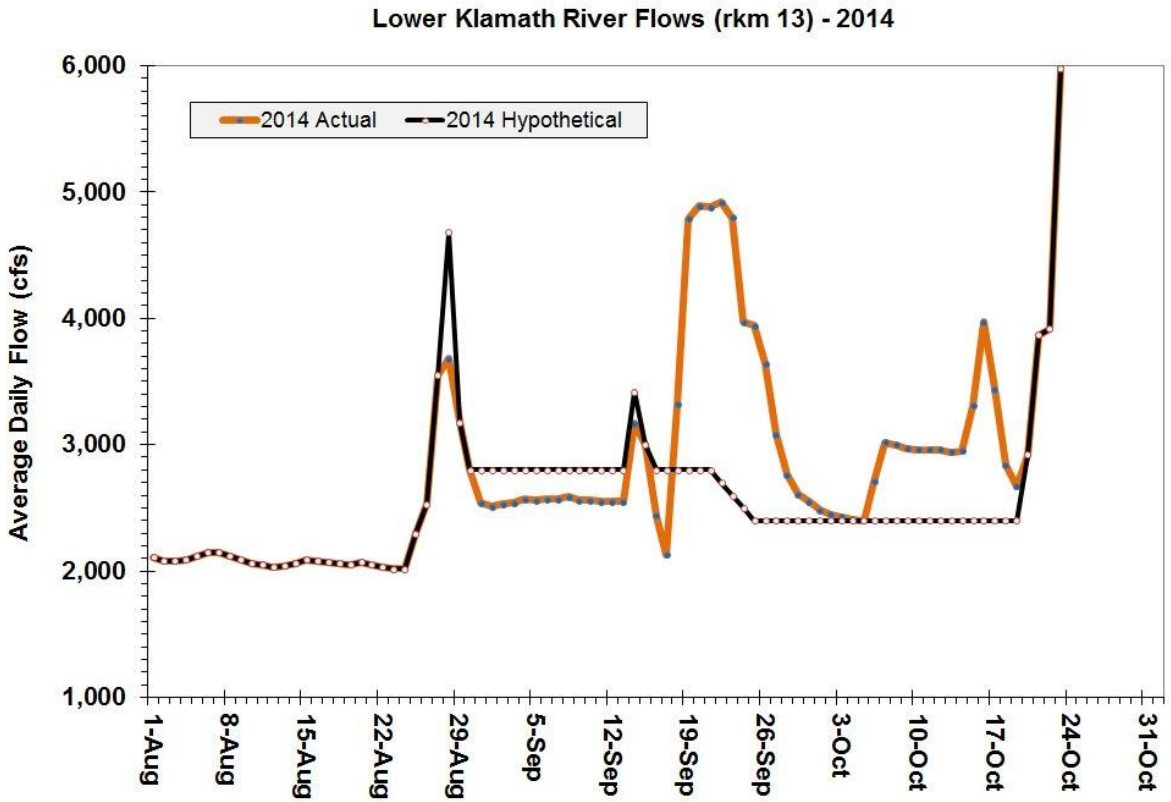

Figure 7. Actual flows in the lower Klamath River during Aug-Oct 2014 with emergency flow releases compared to a hypothetical flow release that would have been consistent with proactive flow recommendations. The emergency flow releases that occurred used 64,000 AF of water from Trinity Reservoir and an additional 16,000 AF releases from Iron Gate Dam for a total of 80,000 AF, whereas the hypothetical proactive release would have used approximately 42,000 AF. The Yurok Tribe's ceremonial release from Iron Gate Dam used approximately 3,750 AF. Precipitation from fall storms increased flows starting on October 20th 2014.

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http://www.kbmp.net/maps-data/blue-green-algae-tracker