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VIA ELECTRONIC MAIL

Ms. Maria Rea
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Subject: Contingency Plan for Water Year (WY) 2015 Pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3.C of the 2009 Coordinated Long-term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Biological Opinion (NMFS 2009 BiOp) – Lower Klamath River 2015 Fall Augmentation Flows

Dear Ms. Rea:

By letters dated May 18, 2015, and June 25, 2015, the Bureau of Reclamation (Reclamation), in cooperation with the California Department of Water Resources (DWR), submitted and subsequently updated a Contingency Plan for operation of the CVP and SWP from July through November 15, 2015, in accordance with the RPA and conference opinion on the long-term operation of the NMFS 2009 BiOp. An updated Sacramento River Temperature Management Plan for Water Year 2015 prepared pursuant to RPA Action I.2.4 of the NMFS 2009 BiOp was included as part of the June 25, 2015, Contingency Plan request. By letter dated July 1, 2015, NMFS concurred that Reclamation and DWR's Contingency Plan for July – November 15, 2015, as amended by the Revised Sacramento River Temperature Management Plan, is consistent with RPA Action I.2.3.C in NMFS' 2009 BiOp. Reclamation now requests concurrence from NMFS that the Lower Klamath River 2015 Fall Augmentation Flows described in the attached Biological review, which amends the operations described in the previously submitted Updated Project Description dated May 14, 2015, (transmitted through Reclamation's May 18, 2015, letter), are within the limits of the Incidental Take Statement of the NMFS 2009 BiOp and serves as the revised Contingency Plan through November 15, 2015.

The Lower Klamath River 2015 Fall Augmentation Flows consist of the potential release of up to 88 thousand acre-feet (TAF) of water from Lewiston Dam to avert a fish die-off in the Lower Klamath River during the late summer and early fall of 2015. This volume is comprised of a preventative action (51 TAF) and the provision and contingency of an emergency flow augmentation release (37 TAF). The emergency augmentation is formally included in this review although it not believed that it would be required based upon the preventative release schedule. (See USFWS 2015). In addition, a pulse flow for the purpose of flushing any carry over disease organisms that may contribute to elevated background levels of ich entering the 2015 salmon spawning migration season in the lower river may be considered based on review of conditions by the technical team. Implementation of a pulse flow will be within the proposed action volume. The details of water temperature modeling conducted in support of the review are based upon a very similar proposal (previous proposal of 83 TAF) are provided in the attached Biological Review. Reclamation deems these model results to be valid for this review because the volumes only differ by 5 TAF and the general patterns of release are similar. For purposes of the water temperature modeling that was conducted in support of the Biological review of the proposed action, Reclamation evaluated the time period through November 30 to ensure cold water needs of the Trinity River system were reviewed.

Reclamation reviewed the effects of the proposed Lower Klamath River 2015 Fall Augmentation Flows on listed species in the Sacramento River. The resultant *Biological Review: Potential Flow Augmentation Action from Lewiston Dam to Protect Adult Salmon in the Lower Klamath River* is enclosed. This Biological Review and associated modeling output supports the finding that the proposed operation of the CVP and SWP, incorporating the Lower Klamath River 2015 Fall Augmentation Flow proposal, as described above, will not result in any changes in reservoir operations or releases into the Sacramento, American, or Stanislaus rivers, or in Delta outflow conditions (*i.e.*, the Net Delta Outflow Index [NDOI]) from those included in the Contingency Plan for July – November 15, 2015, as amended by the Revised Sacramento River Temperature Management Plan. Based on the enclosed Biological Review, Reclamation believes that the water temperature-related effects of the proposed action on listed salmonids and green sturgeon, and their designated critical habitats in the Sacramento River will not result in violation of the incidental take limit in the NMFS 2009 BiOp, nor will the proposed action jeopardize the continued existence of the listed species or destroy or adversely modify their designated critical habitats.

Reclamation also reviewed the effects of the proposed action to Southern Oregon /Northern California (SONCC) Coho salmon in the Trinity River. Modeling studies were performed to evaluate the influence of removing up to 83 TAF of cold water from Trinity Reservoir. Here again, we believe the new proposal that constitutes up to 88 TAF is close enough to the previous in-depth review conducted on the 83 TAF for the model results to similarly apply. Model results that portray the effects of the proposed action to Coho salmon are provided in the attached Biological Review. Additionally, Reclamation reviewed the proposed action in context of the impacts of the potential flow release magnitude that could occur in the event that the emergency portion of the action is required. The enclosed Biological Review and associated modeling output are being provided to the NMFS Arcata Office as part of the on-going consultation on the Coordinated Long-term Operation of the CVP and SWP regarding effects to SONCC Coho salmon.

As noted in our May 18, 2015, and June 25, 2015, letters specific to operation of the CVP and SWP, further modifications or refinements of the May 14, 2015, Updated Project Description could occur based on new information or additional regulatory requirements. Reclamation and DWR intend to continue to refine operations of the CVP and SWP as hydrological and biological information become available, in coordination with federal and state resources agencies. If further refinements or modifications are necessary that may change the effects to listed species, Reclamation will seek consultation from NMFS to address those potential effects.

The May 18, 2015, letter (transmitting the May 14, 2015, Biological Review), June 25, 2015, Updated Biological Information, and enclosed Biological Review for the Lower Klamath River 2015 Fall Augmentation Flows support Reclamation's conclusion that the effects associated with the proposed July through November 15, 2015, modifications to CVP and SWP operation, as amended by the Lower Klamath River 2015 Fall Augmentation Flows described above, are within what was analyzed in the NMFS 2009 BiOp. Any incidental take resulting from these changes are within the existing incidental take limits in the NMFS 2009 BiOp. Because these actions are contemplated within the drought exception procedures described in the NMFS 2009 BiOp, they do not jeopardize the listed species or adversely modify or destroy designated critical habitats addressed in the NMFS 2009 BiOp. Reclamation seeks NMFS' concurrence in this determination.

We look forward to working with you and your staff as we navigate through another extremely challenging water year and appreciate your willingness to work with us on this time sensitive matter.

Sincerely,

Paul Fujitani

for Ronald Milligan
Operations Manager

Enclosure

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Draft Biological Review: Potential Flow Augmentation Action from Lewiston Dam to Protect Adult Salmon in the Lower Klamath River in 2015; August 14, 2015

Introduction

Reclamation may implement a flow augmentation action (up to 88 thousand acre-feet [TAF]) from Lewiston Dam in August through November 2015 to protect adult salmon in the lower Klamath River. This document is intended to provide the National Marine Fisheries Service with a biological review that evaluates the biological effects of performing a flow augmentation action up to 88 TAF from the Trinity River to the lower Klamath River to help protect adult salmon. Reclamation initially proposed 83 TAF and conducted the biological review on that amount. Based upon public, agency and tribal review of the 83 TAF proposal, the proposed action has been modified to a maximum of 88 TAF. This biological review includes use of water temperature modeling results that are based upon a flow augmentation action of up to 83 TAF. The change in the proposed action from 83 TAF to 88 TAF is not significant to the sensitivity of the model or the results. Thus, the results of the analysis in the biological review are equally applicable to the new action. The comparison of these two alternatives are shown in Figures 1A and 1B. This review also evaluates potential effects of the action on Federally-listed fish species in areas potentially affected by the action including Southern Oregon/Northern California Coast (SONCC) Coho Salmon in the Klamath/Trinity River basin and Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, Central Valley steelhead, and the Southern Distinct Population Segment (DPS) of North American Green Sturgeon in the Sacramento River basin.

Proposed Action

Reclamation proposes to augment flows in the lower Klamath River when conditions are present to suggest the potential for a significant fish die-off event. Continued dry hydrologic conditions and the recent discovery of the presence of *Ich*, the fish disease thought primarily responsible for the fish die-off in 2002, has prompted Reclamation to consider supplementing flows to the lower Klamath River in 2015. The Proposed Action includes supplemental flows to prevent a disease outbreak (preventative flow) and a contingency volume to be used on an emergency basis (Emergency to avoid a significant die-off of adult salmon. An adaptive management approach that incorporates real-time environmental and biological monitoring by federal, state and tribal biologists (technical team) would be used to determine if and when to implement supplemental flows. The technical team would be monitoring flow in the lower Klamath River, water temperature, fish residence time and the overall condition of the fish in the river. In general Reclamation will consider two types of responses to a potential fish-die off

Preventative Flow Augmentation

- Initiate preventative flow augmentation in the lower Klamath River to a target flow of 2,800 cfs at the USGS gage (http://waterdata.usgs.gov/ca/nwis/uv?site_no=11530500) located in the lower Klamath River (RKM 13) when the cumulative harvest of Chinook salmon in the Yurok Tribal fishery in the estuary area meets or exceeds a total of 7,000 fish.

- Initiate preventative flow augmentation by August 22 if the fish harvest metric above is not met.
- Continue flow augmentation to target a flow of 2,800 cfs in the lower Klamath River, as measured at gage #11530500 through September 20. Flow from Lewiston Dam to meet a target of 2,800 cfs in the lower Klamath River is anticipated to reduce average daily water temperatures to below 23°C that may otherwise inhibit adult upstream migration (See USFWS 2015).
- Implement fish pathology monitoring to determine the need for a fish pathology/ mortality emergency release, and
- Monitor conditions to inform need and timing of emergency flow releases based on real-time environmental conditions.

Emergency Flow Augmentation

Initiate emergency flow release to target a flow of 5,000 cfs in the lower Klamath River for up to 5 days if emergency conditions exist as identified below:

- Diagnosis of severe *Ich* (30 or more parasites on a gill arch) infection of gills in 5% or greater of a desired sample of 60 adult salmonids confirmed by the U.S. Fish and Wildlife Service Fish Health Center; or
- Observed mortality of greater than 50 dead adult salmonids in a 20 kilometer reach in 24 hours coupled with the confirmed presence of *Ich* by the U.S. Fish and Wildlife Service Fish Health Center.

Scope of Review

The analysis that follows examines the potential effects of releasing additional flow (augmentation flows) to the Trinity River to protect adult salmon on the lower Klamath River (proposed action) on the availability of cold water for use in the Trinity River during and following implementation of the proposed action in 2015. Because changes to flow through Lewiston Reservoir may also affect water temperatures of diversions through Clear Creek Tunnel to the Sacramento River, the effects of implementing the proposed Action on Sacramento River species are also evaluated. For the Klamath/Trinity basin review, the analysis focuses on water temperatures and availability of cold water reservoir resources to maintain suitable water temperatures for Coho Salmon in the Trinity River downstream of Lewiston Dam from August through November 30, 2015. In addition, the review incorporates an analysis of the effects of a flow augmentation (mainly flow magnitude from Lewiston Dam) to the various life stages of Coho Salmon that may be present in the Trinity River during the action period.

For the Sacramento River basin review, the analysis focuses on potential water temperature impacts, as there are no changes to the volume or timing of diversions to the Sacramento River basin as a result of implementing the proposed action. The areas of interest for water temperature related impacts for the Sacramento River basin include the Sacramento River at Keswick Dam, Clear Creek at the Sacramento River (CDEC station CCR) and Bend Bridge (BND) and Clear Creek itself, which is a tributary to the Sacramento River and is comprised of flow mainly of flow from Whiskeytown dam during the late summer. Clear Creek is included in this review because of the known influence that Trinity River Division operations (i.e., diversions through Clear Creek tunnel) can have on thermal regimes of Whiskeytown Lake and therefore on outflows to Clear Creek.

Modeling Methods

Cold Water Storage Availability and Water Temperatures

Water temperature modeling was performed to estimate water temperatures at various locations (e.g., Lewiston Dam, Clear Creek at Sacramento River, and Bend Bridge) and to examine the availability of suitably cold water in Trinity Reservoir for use this year, up to and including use of this water source to augment flow in the Lower Klamath River in the event a flow augmentation becomes necessary to protect adult salmon. This modeling effort was performed to examine the effects of potentially removing additional water from Trinity Reservoir storage that was not previously anticipated nor modeled to date.

Model simulations were performed on four scenarios (Table 1) using the Sacramento River Temperature Model (SRTM)[1] to: 1) gain an understanding regarding the sensitivity of water temperature responses to releasing water from Trinity Reservoir through either the power outlet (elev. 2160’) or the auxiliary outlet (elev. 1999’); and 2) refine our knowledge of how an augmentation action (up to 88 thousand acre-feet [TAF]) could influence the quantity of remaining cold water resource in Trinity Reservoir through 2015. As alluded to earlier, the model results for the review of an augmentation action for up to 83 TAF are applied here because the increase in volume contemplated (+ 5 TAF) would not amount to a noticeable change in the coldwater pool of Trinity, or water temperatures in Clear Creek or the mainstem Sacramento River. In essence, this modeling effort provided a way to estimate the remaining quantity of suitable cold water to help determine the feasibility of implementing the proposed augmentation action. The 83 TAF (and thus the 88 TAF) volume evaluated in Scenarios 3 and 4 was considered to approximate an upper “book end” of the potential need for a cold water augmentation flow that could be released from Lewiston Dam during late September 2015.

In all scenarios, the ceremonial flows of the Hoopa Valley Tribe and the approved diversion schedules identified in the Sacramento River Temperature Management Plan (Reclamation 2015a) were used. Scenarios 1 and 2 represent baseline flows without or with auxiliary bypass outlets used, respectively. Scenarios 3 and 4 represent implementation of augmentation flows without or with auxiliary bypass outlets used, respectively. Scenarios 1 and 2 provide a basis for flow comparisons with Scenarios 3 and 4 (Figure 2) and also illustrate the sensitivity of water temperatures to releases from the two different outlets under base flow conditions (Figure 2). As indicated above, the auxiliary bypass outlet provides water from a much lower elevation than the

[1] The Sacramento River Temperature Model (SRTM) has been used for water temperature analysis for many years to forecast river temperatures under various operational and meteorological scenarios.

power outlet, allowing access to water in the colder strata of the Trinity Reservoir. As is typical in years of low storage volume such as projected for later this summer either without implementing an action (i.e., End-of-September [EOS] storage projected to be 585 TAF at 90% exceedance) or with implementing an action (i.e. EOS storage projected to be 502 TAF at 90% exceedance), the auxiliary bypass outlet is expected to be used to some degree in order to access the coldest water available for meeting downstream fishery needs. In doing so, there is likely to be an influence on water temperature of diversions to the Sacramento River basin. The auxiliary bypass schedule and the daily volumes used in the model are shown in Table 2. The quantity of water that could be used through the bypass is variable but capacity is estimated at around 2,000 cubic feet per second (cfs), which is much less than the daily volumes used in any of these model scenarios. As this is the case, the outputs from this exercise do not represent a maximum use of the auxiliary outlet works at any point in time and additional influences to water temperature are possible if the auxiliary bypass is used differently.

Winter-run Temperature-Induced Egg Mortality and Approximate Egg-to-Fry Survival

Temperature-induced egg mortality and approximate egg-to-fry survival were estimated using a dynamic simulation framework developed by Cramer Fish Science (CFS 2010a). This model was developed to estimate winter-run Chinook Salmon juvenile production, but provides discretized mortality rate estimates for specific winter-run Chinook Salmon life stages. Relationships for daily temperature-induced mortality of incubating eggs and rearing juveniles (Bartholow and Heasley 2006) are parameterized with results from temperature mortality studies undertaken by the U.S. Fish and Wildlife Service (USFWS 1999). Winter-run Chinook Salmon carcass data from 2014 was used to reflect spawning time, in which the date of egg deposition was shifted 14 days before a carcass was observed (K. Niemela, pers. comm. in CFS 2010a). Daily Cohorts of incubating eggs experience the temperature conditions entered into the model from observations for periods that have already occurred or entered into the model from the Sacramento River Temperature Forecast Model to estimate egg mortality and total egg-to-fry survival.

Differences between estimates of temperature-induced egg mortality and egg-to-fry mortality (presented here as survival) are due to the total egg-to-fry mortality incorporating mortality that occurs ‘naturally’ without high temperature effects over the entire incubation period. The temperature-induced egg mortality estimate reflects effects of extreme temperatures that may be outside the data sets used to derive the egg-to-fry survival function. The function for egg-to-fry survival was based on a stock-recruitment relationship, using escapement and fry production above Red Bluff Diversion Dam from 1996-1999 and 2002-2007. The model runs on a daily time step, and a mean proportional mortality of the incubating eggs is estimated from the mean daily water temperature using a polynomial daily mortality relationship. The model was run for 100 iterations for each scenario and the estimates are reported for the egg only and egg-to-fry stages.

The model was run for all Trinity operational scenarios being considered. The baseline condition was assumed to be the operational scenario with base Trinity River Restoration Program Record of Decision flows (ROD flows) and Hoopa Valley Tribal boat dance flows. Egg mortality and egg-to-fry survival were estimated for the Clear Creek and Bend Bridge temperature nodes on the Sacramento River. Actual mean daily water temperatures for April 1 through July 21[2] were used along with modeled water temperature results from the Sacramento River Water Quality Model for the period July 22 through October 30 (Scenario 2) or November 30 (Scenarios 1, 3-4).

There remains uncertainty with the results from this model for egg-to-fry survival. In recent years, modeled egg-to-fry survival appeared to more closely reflect observed juvenile production and estimated mortality upstream of Red Bluff Diversion Dam when the temperature compliance point was further downstream and poorly reflect the observed juvenile production and mortality estimate when the temperature compliance is further upstream (Reclamation 2015b), as is the case in 2015. These biases suggest that using water temperatures reflecting fry rearing habitat may be important for accurately estimating survival in the reach between Keswick Dam and Red Bluff Diversion Dam. It is not assumed that all mortality of these life stages is directly linked to temperature mortality and this can be seen in the difference between the egg mortality estimates and the egg-to-fry survival estimates for each scenario. Additionally, there is uncertainty due to the potential for actual operations during late summer deviating from the temperature management plan if actual storage and temperature conditions in Trinity and Shasta reservoirs are different from the modeled conditions.

Potential Effects of the Proposed Action

Augmentation Flows and Effects to Cold Water Storage Availability and Water Temperatures from Lewiston Dam

Comparisons of model results for scenarios with and without the use of the auxiliary bypass outlet indicate the use of the auxiliary bypass outlet is an effective way of accessing colder water as compared to using the power outlet (Figure 2). In these examples, the projected temperatures for water released from Lewiston Dam can be markedly reduced by up to as much as 4 to 6 degrees Fahrenheit by use of this outlet. Differences were greatest between Scenarios 3 and 4 when a relatively large volume of water was released from this outlet in late September to mid-October when flow releases were 1,100 cfs (see Figure 2). In contrast, if the auxiliary bypass outlet release volume is lowered, water temperatures can also potentially increase as the powerhouse release is used and water in the reservoir is still relatively warm, such was the case in late October (see Figure 2). The influence of using the auxiliary bypass outlet under the proposed action (i.e., Scenario 4) shows similar results (Figure 3).

When the auxiliary bypass outlet schedule and volumes are the same prior to September 14th, water temperatures at Lewiston Dam are very similar and almost always less than 53ºF between Scenarios 2 and 4 (Figure 3). Comparisons after September 14th reveal some periodic differences between Scenarios 2 and 4 that are readily explained by the different bypass schedule and volumes as shown in Table 2. In comparison of Scenarios 2 and 4 to those without the auxiliary bypass outlet (Scenarios 1 and 3, respectively), it is quite apparent that under the low reservoir storage level this year that the auxiliary bypass outlet will need to be used to assist in meeting

[2] Source: real-time temperature data for Clear Creek (CCR) and Bend Bridge (BND) gages was obtained from the California Data Exchange Center (CDEC) on July 22, 2015, at http://cdec.water.ca.gov/queryTools.html.

downstream temperature needs because water temperatures released through the power outlet would be unsuitably warm.

Further review of the effect of each scenario on the End-of-November storage reveals there would be a substantial quantity of water less than 52°F remaining. In this case, the estimate of volume of available water (above the auxiliary bypass at 1999' elevation) that was less than this temperature threshold for scenarios 1 through 4 are 176, 150, 157 and 102 TAF, respectively. Thus, while the model results are not entirely comparable since the bypass schedules were not entirely similar, the estimates of cold water storage available after November suggest there is cold water to support an augmentation action of up to 88 TAF. Thus, implementing the proposed action would not deplete the cold water resources for immediate use this year or any thermal protection required for Coho Salmon during late September this year.

Augmentation Flows and Effects to Coho Salmon in the Trinity River

The proposed action (i.e., Scenario 4) is not expected to have any measurable impact on water temperatures in the Trinity River and therefore the effects to any lifestage of the Coho salmon. The modeling indicates that water released from Lewiston Dam would be of suitable temperatures in the Trinity River through the action period. After November 30, water temperatures are not believed to be a concern. The estimated volume of the reservoir's cold water resource (i.e., less than 52°F) after 88 TAF is removed) is approximately 100 TAF (at the 90% probability of exceedance) at the end of November, indicating that release temperatures should be suitable.

If the preventative component of the proposed action is implemented, the estimated daily base flow releases from Lewiston Dam to meet the target of 2,800 cfs at KNK from August 19th through September 20th are anticipated to be less than 1,300 cfs. This flow level is anticipated to provide suitable habitat for juvenile Coho salmon and is considered low enough to avoid overtopping of any berms, which would prevent juvenile Coho stranding in downstream reaches (U.S Fish and Wildlife Service and Hoopa Valley Tribe, 1999; D. Goodman pers Comm).

If the emergency release portion of the proposed action is implemented (i.e., Lewiston Dam releases up to 3,500 cfs to meet the target of 5,000 cfs at KNK for 5 days beginning on September 21), riparian berms throughout the upper Trinity River between Lewiston and Junction City would likely be overtopped and juvenile fish may distribute themselves into temporarily inundated areas. As flows from Lewiston Dam recede to a baseline level to 450 cfs, these areas could become disconnected from the mainstem and any juveniles in them have the potential to become stranded. The Trinity River Restoration Program has completed a substantial amount of channel restoration work that has helped to reduce the number of potential stranding locations along the river. Additionally, the potential for stranding will be minimized by implementing conservative flow release changes (ramping rates) that will allow fish to move into the mainstem before connectivity to temporarily inundated areas is lost. Based on the number and location of potential stranding locations and implementation of conservative ramping rates, the proportion of juveniles that may be affected by the proposed action is anticipated to be small and will minimally effect the overall freshwater survival of brood year 2015. There is a high level of uncertainty in this conclusion.

Although impacts to rearing juvenile Coho Salmon may occur during the emergency component of the proposed action is implemented, the augmentation action has the potential to improve the chances of survival of any early arriving adult Coho Salmon that may be migrating through a potentially infectious lower Klamath River to the Trinity River. As an example, 344 adult Coho salmon were associated with the fish die-off in late September 2002. In addition, since the adult Coho salmon spawn in November (See Table 3), and suitable water temperatures are projected through the period of need, the effect of flow manipulations that may occur as part of the proposed action would not affect adult salmon. There is a high level of uncertainty in this conclusion.

Trinity River Division Operations and Effects to Spring-run Chinook Salmon and Steelhead in Clear Creek

Under the proposed action, there will be no changes in water delivery volumes from the Trinity River Basin to the Sacramento River basin, including those to Clear Creek. Therefore, there will be no flow-related effects to species in Clear Creek. However, there is a temperature-related effect related to operations that could occur. Water temperature modeling results indicate that when the auxiliary bypass is used, a commensurate cooling of Lewiston Dam releases occurs that in turn corresponds to lower water temperatures for water diverted through Clear Creek Tunnel to Whiskeytown Reservoir. As stated earlier, this phenomenon occurs because—under low storage conditions such as in 2015—reservoir water accessed from the auxiliary bypass outlet is much colder than reservoir water accessed from the power outlet. The lower temperatures of water delivered to Whiskeytown Dam further translates into cooler water temperatures from the two outlets of Whiskeytown Reservoir, Spring Creek Tunnel and Whiskeytown Dam, which serves as the source water for the anadromous portion of Clear Creek.

Water temperature differences are not expected to have any measurable effect on spring-run Chinook Salmon and steelhead or their designated critical habitats in Clear Creek. During the proposed action period, spring-run Chinook Salmon spawning, egg incubation, and alevins may occur from September through November in Clear Creek downstream of Whiskeytown Dam; while steelhead juvenile rearing may occur throughout the entire period.

Predicted water temperatures in Clear Creek at IGO (river mile 10.9), illustrate the positive influence that the use of the auxiliary bypass is expected to have on water temperatures (Figure 4). Comparisons of Scenarios 1 and 2 and 3 and 4 show very similar trends; whereby water temperatures are generally lower when flows are released through the auxiliary bypass (i.e., Scenarios 2 and 4 compared to Scenarios 1 and 3, respectively). Again, the use of the bypass is not consistent between these scenarios during the entire period so that subtle differences in water temperature predictions should be expected. Regardless, the overall influence of using the auxiliary bypass on temperatures to Clear Creek is likely to be beneficial.

Examination of the differences between Scenarios 2 and 4 show very similar temperature traces throughout the action period (Figure 5) with the exception that Scenario 4 is projected to have slightly higher water temperature in mid- to late August as well as late September through early October. According to modeling runs, water temperatures under both Scenario 2 and 4 would not meet the Igo temperature compliance targets identified in NMFS RPA Action I.1.4. Under both scenarios, the 60ºF at Igo target between August 1 and September 15 is exceeded on 54% of days (up to 62.3ºF) and the 56ºF at Igo target between September 16 and October 31 is exceeded on 93% of days (up to 58.8ºF). These results are consistent with previous poor water temperature patterns related to current drought conditions that were identified by Reclamation in May and June (Reclamation 2015c, d), which indicate that substantial egg and egg-to-fry mortality for spring-run Chinook Salmon in Clear Creek may occur due to an inability to maintain fall cold water temperatures in Clear Creek. Minimal impacts to steelhead rearing are expected since projected water temperatures are less than 63ºF (most conservative maximum temperature criteria identified for analysis by NMFS [ICF 2015] for steelhead rearing) throughout the action period. Although water temperatures under the proposed action may affect spring-run Chinook Salmon spawning and egg incubation in Clear Creek, the effects are consistent with previous poor water temperature patterns related to current drought conditions (Reclamation 2015c), the magnitude of water temperature differences at Igo between Scenarios 2 and 4 are minimal, and water temperatures provided through the auxiliary bypass outlet instead of the power outlet will consequently result in the coolest possible water temperatures delivered from the Trinity River into Clear Creek under the proposed action (Figure 4). The overall influence of the proposed action will have a minimal change in the water temperature-related effects of Trinity River flow operations on spring-run Chinook salmon and steelhead in Clear Creek. There is moderate uncertainty in this conclusion.

Augmentation Flows and Effects to Winter-run Chinook Salmon, Spring-run Chinook Salmon, Steelhead, and Green Sturgeon in the Upper Sacramento River

There will be no changes in water delivery volumes from the Trinity River to the Upper Sacramento River under the proposed action (i.e., Scenario 4); therefore, there will be no flow-related effects to species in the Upper Sacramento River. However, water temperatures in the Sacramento River downstream of Keswick Dam, including below the Clear Creek confluence, may be different under the proposed action (i.e., Scenario 4) as a result of Trinity River flow deliveries being made into Clear Creek from the auxiliary bypass instead of the power outlet at Trinity. As an example, Spring Creek Tunnel temperatures are projected to be reduced when bypass releases are used (Figures 6 and 7). However; these water temperature differences are not expected to have any measurable impacts on winter-run Chinook salmon, spring-run Chinook Salmon and steelhead or their designated critical habitats in the Upper Sacramento River between Keswick Dam and Bend Bridge. In this reach during the proposed action period, winter-run spawning, egg incubation, and alevins typically occurs from August through October, and juvenile rearing and migration typically occurs throughout the entire period. Low densities of spring-run Chinook Salmon are anticipated in the upper Sacramento River mainstem (i.e., a total of 449 redds documented between 2001 and 2014 with an average of 35/year; range= 0-105; no data available for 2009 or 2011; Azat 2014) with spawning, egg incubation, and alevins potentially present from August through November, juvenile rearing potentially present throughout the entire period, and juvenile migration potentially present in October and November. Recent steelhead monitoring data are scarce for the upper Sacramento River system, but some steelhead adults may immigrate and hold and juveniles may rear during the entire period; while, steelhead spawning, egg incubation and smolt emigration may occur in November. Green Sturgeon spawning and incubation may occur as far upstream as Ink's Creek confluence (RM 281; Brown 2007, Poytress et al. 2013), which is approximately 23 miles upstream of Bend Bridge, and generally occurs in August and September; while, juvenile rearing and emigration may occur during the entire period.

Water temperatures in the Sacramento River under Scenario 4 are projected to be generally higher than 56°F until late October at the confluence with Clear Creek (up to 57.9°F) and until early November at Bend Bridge (up to 62.6°F). Conversely, water temperatures under Scenario 2 are projected to be higher than 56°F until early November at the confluence with Clear Creek (up to 57.6°F) and mid-November at Bend Bridge (up to 62.5°F). Water temperatures greater than 56°F (maximum water temperature criterion provided for analysis by NMFS [ICF 2015] for winter- and spring-run spawning and egg incubation applicable during the action period at Bend Bridge from August-September and at Red Bluff from October-November) may adversely affect winter-run and spring-run Chinook Salmon spawning, egg incubation, and alevins. These results are consistent with previous poor water temperature patterns related to current drought conditions that were identified by Reclamation in May and June (Reclamation 2015c, d), which indicate substantial egg and egg-to-fry mortality for winter-run and spring-run Chinook Salmon in the Sacramento River may occur due to an inability to maintain water temperatures less than 56°F through October. Projected water temperatures are generally less than 56°F at the confluence with Clear Creek during November under both Scenarios 2 and 4 (25 and 28 days, respectively) and at Bend Bridge beginning November 12, which indicate that impacts to any steelhead spawning, incubation, or alevins is minimal upstream of Clear Creek with possible egg and egg-to-fry mortality for any early spawning fish between Clear Creek and Bend Bridge. During November, projected water temperatures are less than 57°F (i.e., the EPA [2003] recommended upper temperature for steelhead smoltification); therefore, no effects to steelhead emigration are anticipated. Since projected water temperatures are less than 63°F (i.e., a maximum water temperature criteria provided by NMFS [ICF 2015] for green sturgeon spawning, egg incubation, and rearing applicable during the action period at Bend Bridge from Aug-Sep and for steelhead rearing during the entire action period), no effects to green sturgeon spawning, egg incubation, and rearing, or to salmonid rearing are anticipated.

Additional modeling analysis for winter-run Chinook Salmon is presented in Table 4, which shows the estimated winter-run Chinook Salmon temperature-induced egg mortality and egg-to-fry survival results for each Trinity River operational scenario. Differences in effects on early lifestage survival of winter-run Chinook Salmon between scenarios are very small at both modeled locations (Clear Creek, RM 291; and Bend Bridge, RM 257.8). For temperature-induced egg mortality, the difference between scenarios was ≤1% at Clear Creek and ≤1.1% at Bend Bridge. For egg-to-fry survival, the differences were even smaller with ≤0.3% at Clear Creek and ≤0.2% at Bend Bridge. These differences are within the uncertainty in the model.

Although water temperatures under the proposed action may affect winter-run and spring-run Chinook Salmon and steelhead spawning and egg incubation in the Sacramento River, the effects are consistent with previous poor water temperature patterns related to current drought conditions (Reclamation 2015c), the magnitude of water temperature differences at Clear Creek and Bend Bridge between Scenarios 2 and 4 are minimal. Most importantly, the water provided through the auxiliary bypass outlet instead of the power outlet will result in the coolest possible water temperatures delivered from the Trinity River into the Sacramento River under the proposed action. The overall influence of the proposed action will have a minimal change in the water temperature-related effects of Trinity River flow operations on winter-run and spring-run

Chinook Salmon and steelhead spawning, egg incubation, and rearing in the Sacramento River, and no effect to Green Sturgeon. There is moderate uncertainty in this conclusion.

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Personal Communications

Damon Goodman, Arcata Fish and Wildlife Office, U.S. Fish and Wildlife Service, Aug 8, 2015

Table 1. Water temperature model assumptions

Assumptions for Coldwater Sensitivity Review: Scenarios			
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Flows from Lewiston (Base ROD flows) Aug 1 - Oct 15 = 450 cfs; and Oct 16 to Nov 30 = 300 cfs	Same as Scenario 1	Flow from Lewiston (~ 1,000 cfs) to meet a 2500 target at KNK, plus 7 Days of release (~ 3,500 cfs) to meet a doubling of Flow at KNK (5,000 cfs maximum) as a contingency.	Same as Scenario 3
Additional Volume = 0	Same as Scenario 1	Augmentation Volume 83 TAF	Same as Scenario 3
HV Tribal Dance Flow Included (11 TAF - Peak of 2650 cfs)	Same as Scenario 1	Same as Scenario 1	Same as Scenario 1
No bypass of flow thru the auxiliary bypass would be used	The auxiliary bypass is used extensively through the action period (See Table 2)	No bypass of flow thru the auxiliary bypass would be used	The auxiliary bypass is used extensively through the action period but the schedule and magnitude differs from Scenario 2 (See Table 2).
June hydrological forecast and July 7, 8, 9 profiles	Same as Scenario 1	Same as Scenario 1	Same as Scenario 1
Diversions to Sacramento held constant (See Reclamation 2015d)	Same as Scenario 1	Same as Scenario 1	Same as Scenario 1

Table 2. Auxiliary bypass schedules and daily volumes used in modeling Scenarios 2 and 4. Note: direct comparisons are limited to August and September when daily bypass volumes are similar.

Scenario 2		
Date	Days of Use	Daily Aux Bypass Volume (CFS)
8/3/2015		500
9/8/2015	36	1000
9/14/2015	6	1100
10/15/2015	31	1100
10/16/2015	1	900
10/17/2015	1	500
10/18/2015	1	400
10/19/2015	1	400
10/20/2015	1	400
10/21/2015	1	400
10/30/2015	9	400

Scenario 4		
Date	Days of Use	Daily Aux Bypass Volume (CFS)
8/3/2015		500
9/8/2015	36	1000
9/14/2015	6	1100
10/1/2015	17	800
10/16/2015	15	700
10/17/2015	1	500
10/21/2015	4	300
10/31/2015	10	250
11/1/2015	1	200
11/15/2015	14	100
11/30/2015	15	100

Table 3. Life-history timing of Coho salmon in the Klamath River Basin downstream of Iron Gate Dam. Peak activity is indicated in black. (Table, and associated references, are from Stillwater Sciences, 2009)

Life stage (citations)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Incubation												
Emergence[1,2,3]												
Rearing[4]												
Juvenile redistribution[5]												
Juvenile outmigration[6,7,8,9,10]												
Adult migration[9]												
Spawning[9,11]												

[1] CDFG (2000, unpubl. data, as cited in NRC 2004); [2] CDFG (2001, unpubl. data, as cited in NRC 2004); [3] CDFG (2002, unpubl. data, as cited in NRC 2004); [4] Sandercock (1991);[5] T. Soto, Fisheries Biologist, Yurok Tribe, pers. comm., August 2008; [6]Scheiff et al. (2001); [7] Chesney and Yokel (2003); [8] T. Shaw (USFWS, unpubl. data, 2002, as cited in NRC (2004); [9] NRC (2004); [10]Wallace (2004); [11] Maurer (2002)

Table 4. Sacramento River winter-run Chinook salmon temperature-induced egg mortality and egg-to-fry survival estimated from the Cramer Fish Science model (CFS 2010b). These model runs used actual temperatures from April 1 through July 21 and modeled temperatures from July 22 through October 30 (Scenario 2) or November 30 (Scenarios 1, 3-4). CCR = Clear Creek node on the Sacramento River and BND = Bend Bridge.

	Scenarios*							
	1		**2**		**3**		**4**	
	CCR	**BND**	**CCR**	**BND**	**CCR**	**BND**	**CCR**	**BND**
Temperature-induced egg mortality (%)	5.1	86.6	5.0	86.8	5.1	87.1	6.0	87.7
Approximate egg-to-fry survival (%)	20.1	2.8	20.2	2.8	20.1	2.7	19.9	2.6

*Modeling scenarios include Lewiston Dam releases to meet:

1: Base Trinity River Record of Decision flows (ROD flows) and Hoopa Valley Tribal Dance flows (August 15-August 18)

2: Base ROD flows, Hoopa Valley Tribal Dance (August 15-August 18), and Bypass flows (through October 30)

3: Hoopa Valley Tribal Dance flows from August 15-August 18, and a 2,500 cfs target at KNK from August 19-September 20 followed by seven days of releases to meet a 5,000 cfs target at KNK

4: Hoopa Valley Tribal Dance Flows from August 15-August 18; a 2,500 cfs target at KNK from August 19-September 20, followed by seven days to meet a 5,000 cfs target at KNK; and Bypass flows (through November 30)

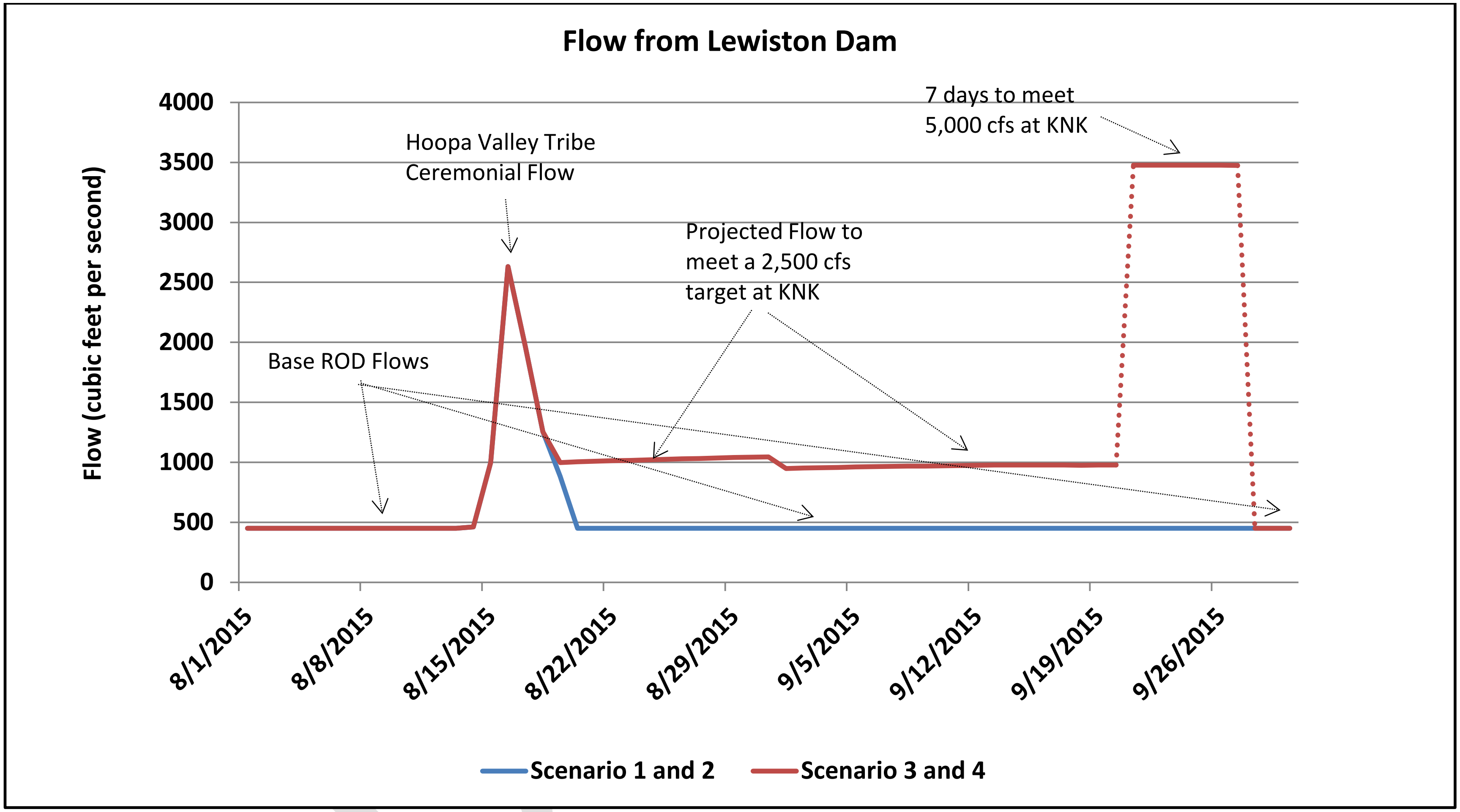

Figure 1A. Draft Proposal and subject to change. Lewiston Dam flow releases for four modeled scenarios. Lewiston Dam releases shown in late September (dotted line area) for Scenarios 3 and 4 are contingent upon an emergency salmon protection need; otherwise, Lewiston Dam releases during this period would remain at approximately 1,000 cfs until September 20, after which they would be reduced to base Trinity River Record of Decision flows (ROD flows).

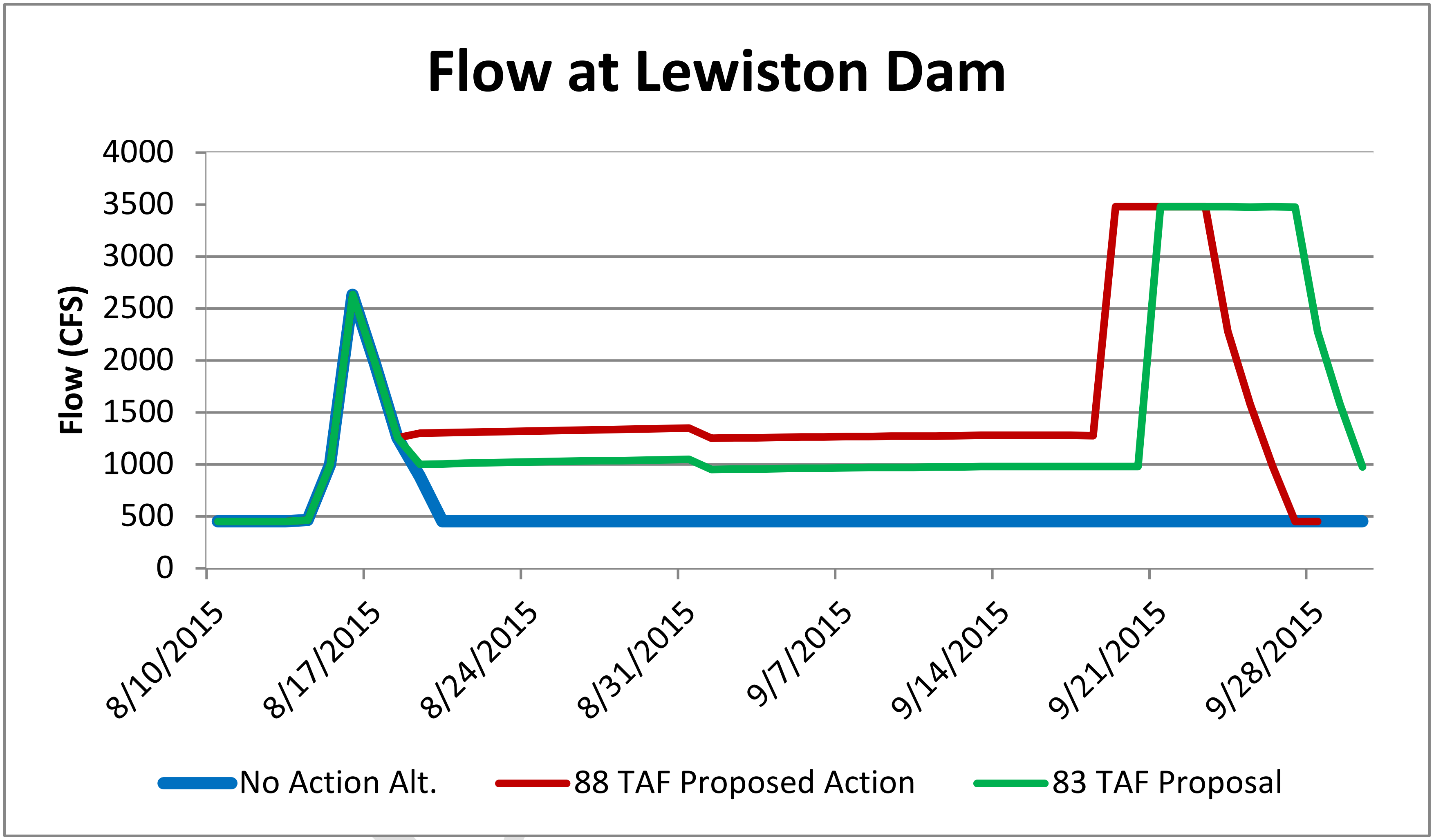

Figure 1B. Illustration of the differences in the prior proposed action (83 TAF) and the new proposed action (88 TAF). The 88 TAF proposal includes preventative flows from Lewiston to meet a target of 2,800 cfs in the lower Klamath River from August 19th thru September 20th rather than 2,500 cfs and a 5 day augmentation to meet a potential emergency need rather than 7 days. It is anticipated that the emergency component of the 88 TAF proposed action would not likely be needed (see USFWS 2015).

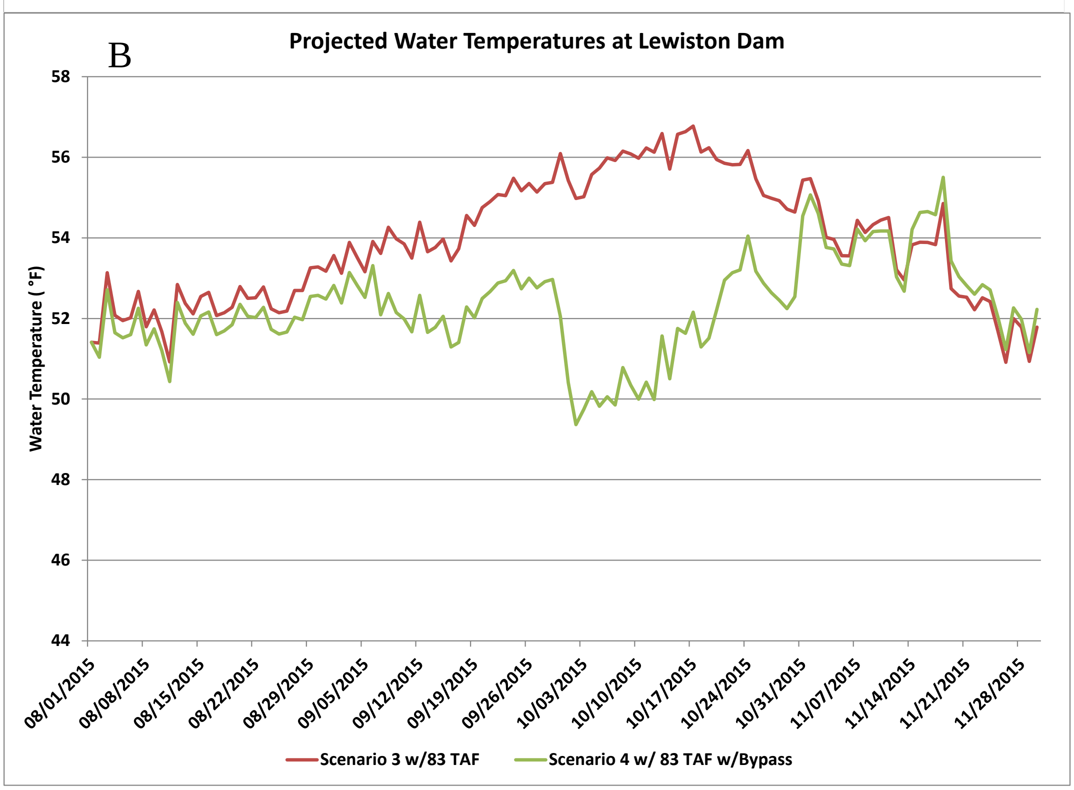

Figure 2. Projected water temperatures released from Lewiston Dam: (A) base flow scenarios with and without the auxiliary bypass outlet; and (B) augmentation flows of 83 TAF with and without the auxiliary bypass outlet. Scenario 4 is the proposed action.

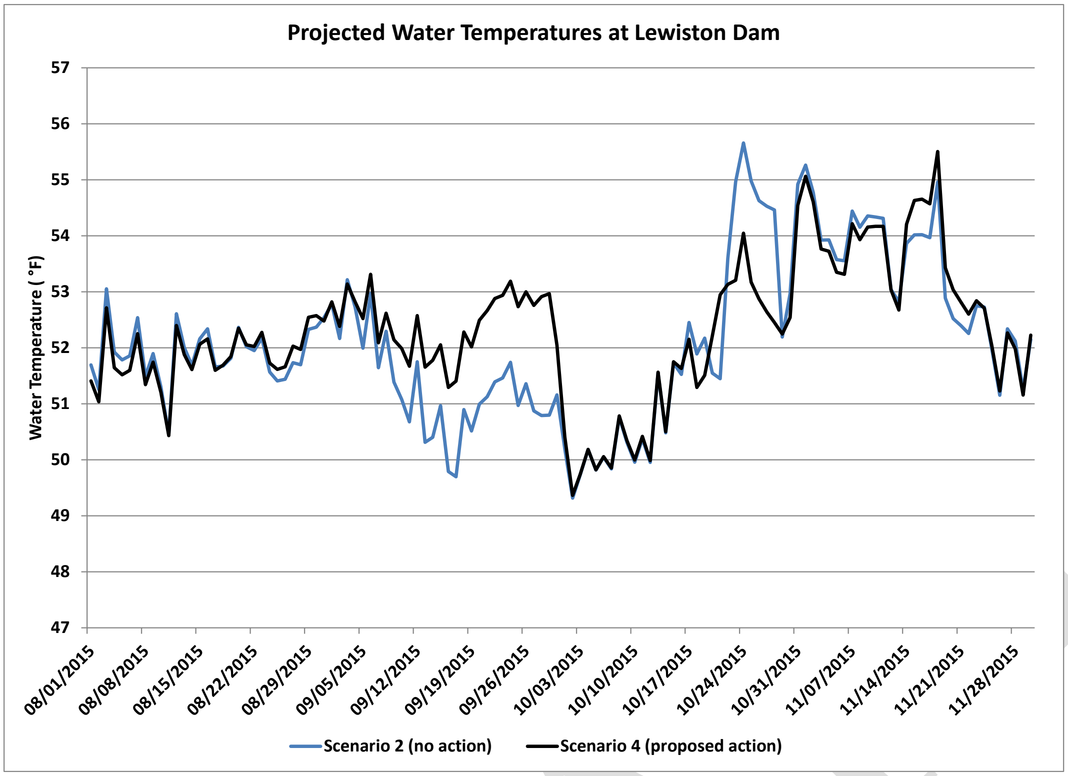

Figure 3. Projected water temperatures released through the auxiliary bypass outlet at Lewiston Dam in Scenario 2 (no action) and Scenario 4 (proposed action).

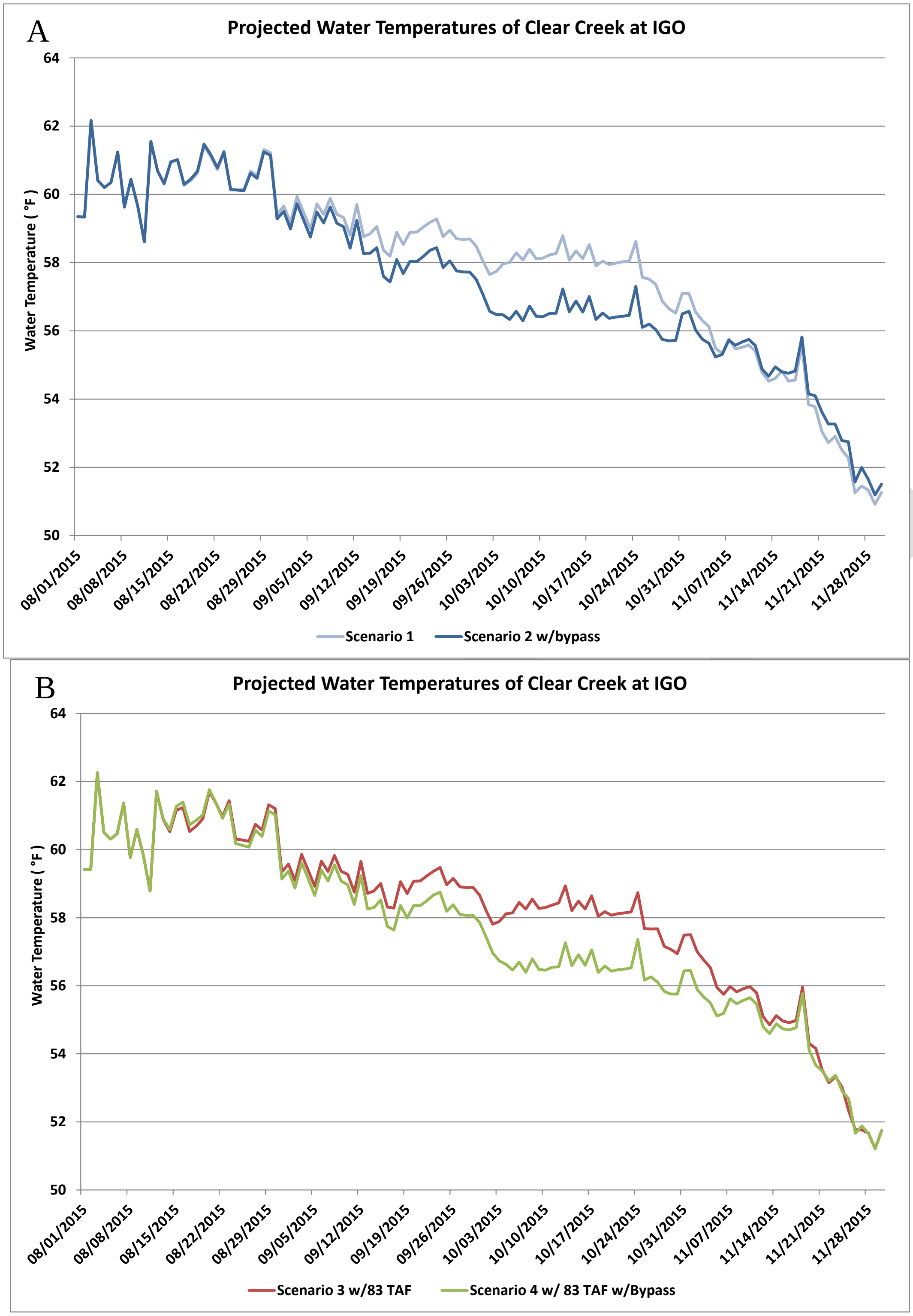

Figure 4. Projected water temperatures in Clear Creek at IGO: (A) Trinity River baseflow scenarios with and without the auxiliary bypass outlet; and by (B) Trinity River augmentation flows of 83 TAF with and without the auxiliary bypass outlet. Scenario 4 is the proposed action.

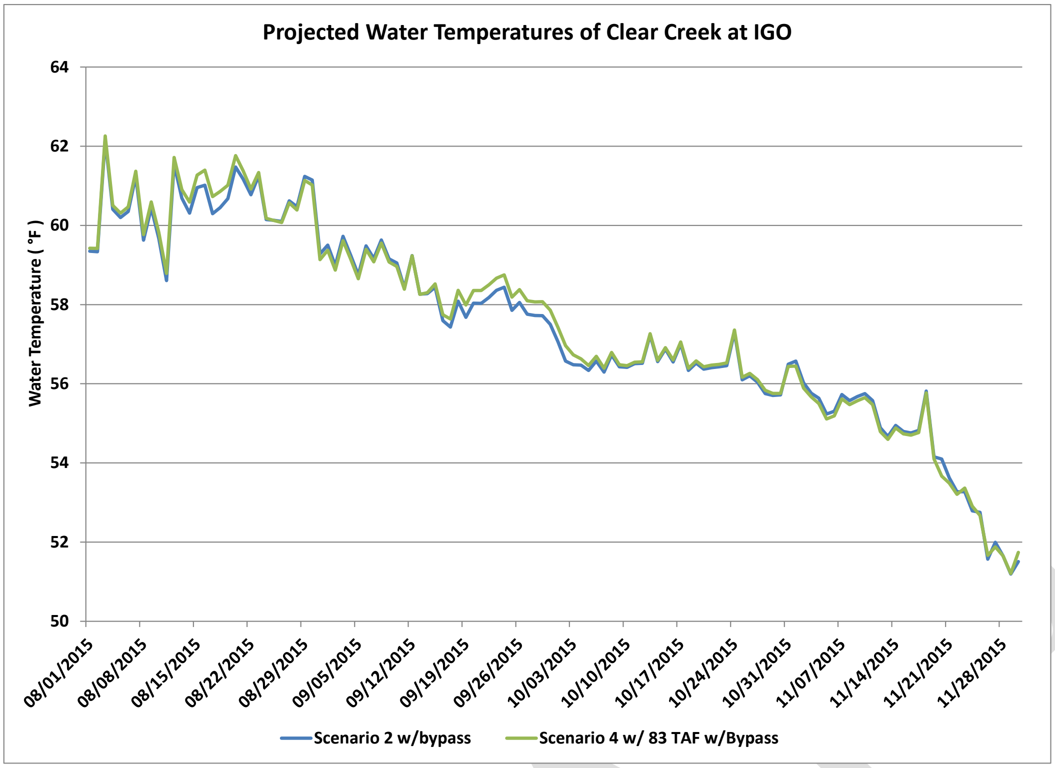

Figure 5. Projected water temperatures in Clear Creek at IGO that are influenced by Lewiston Dam auxiliary bypass releases in Scenario 2 (no action) and Scenario 4 (proposed action).

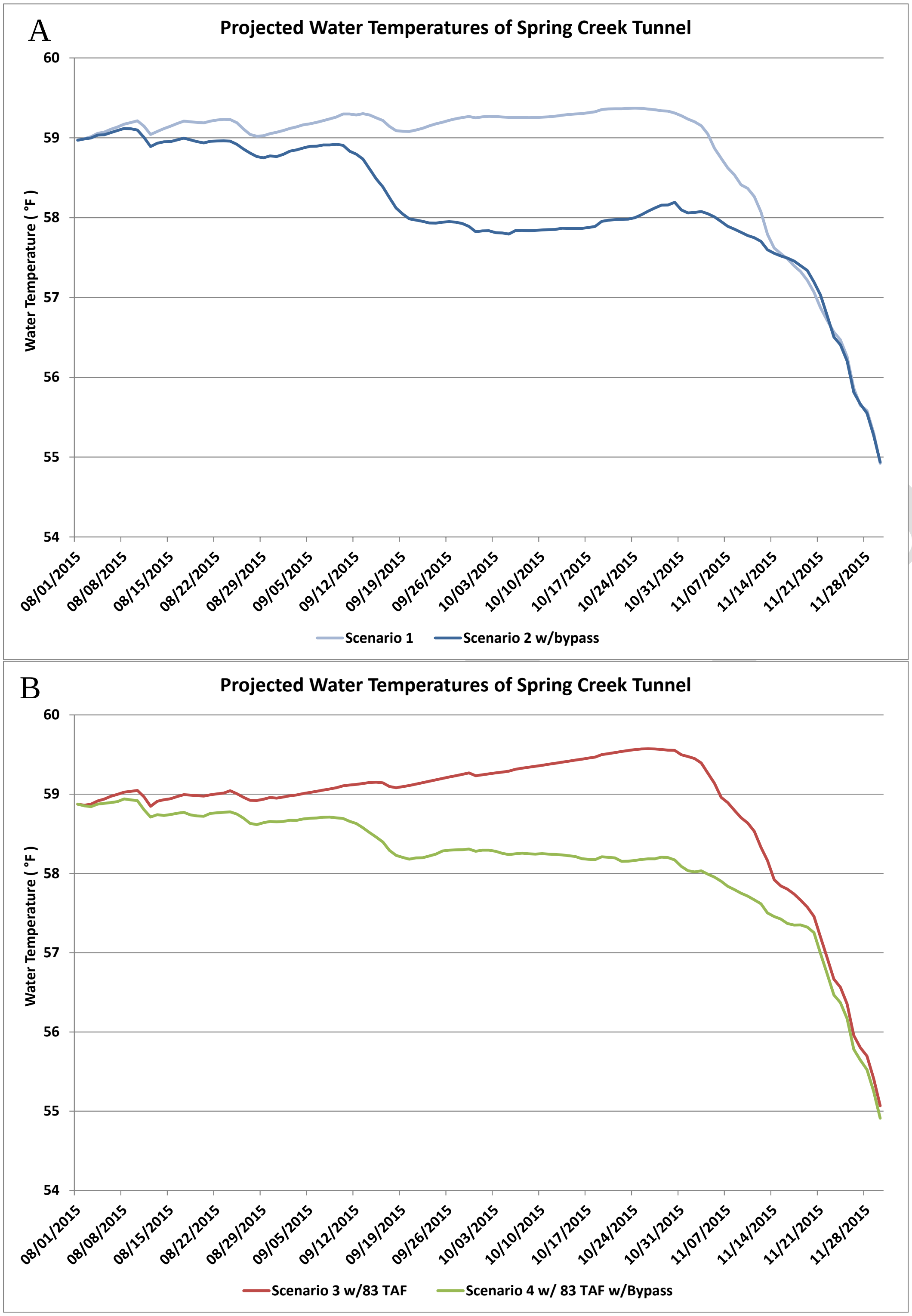

Figure 6. Projected water temperatures in Spring Creek Tunnel : (A) Trinity River baseflow scenarios with and without the auxiliary bypass outlet; and (B) Trinity River augmentation flows of 83 TAF with and without the auxiliary bypass outlet. Scenario 4 is the proposed action.

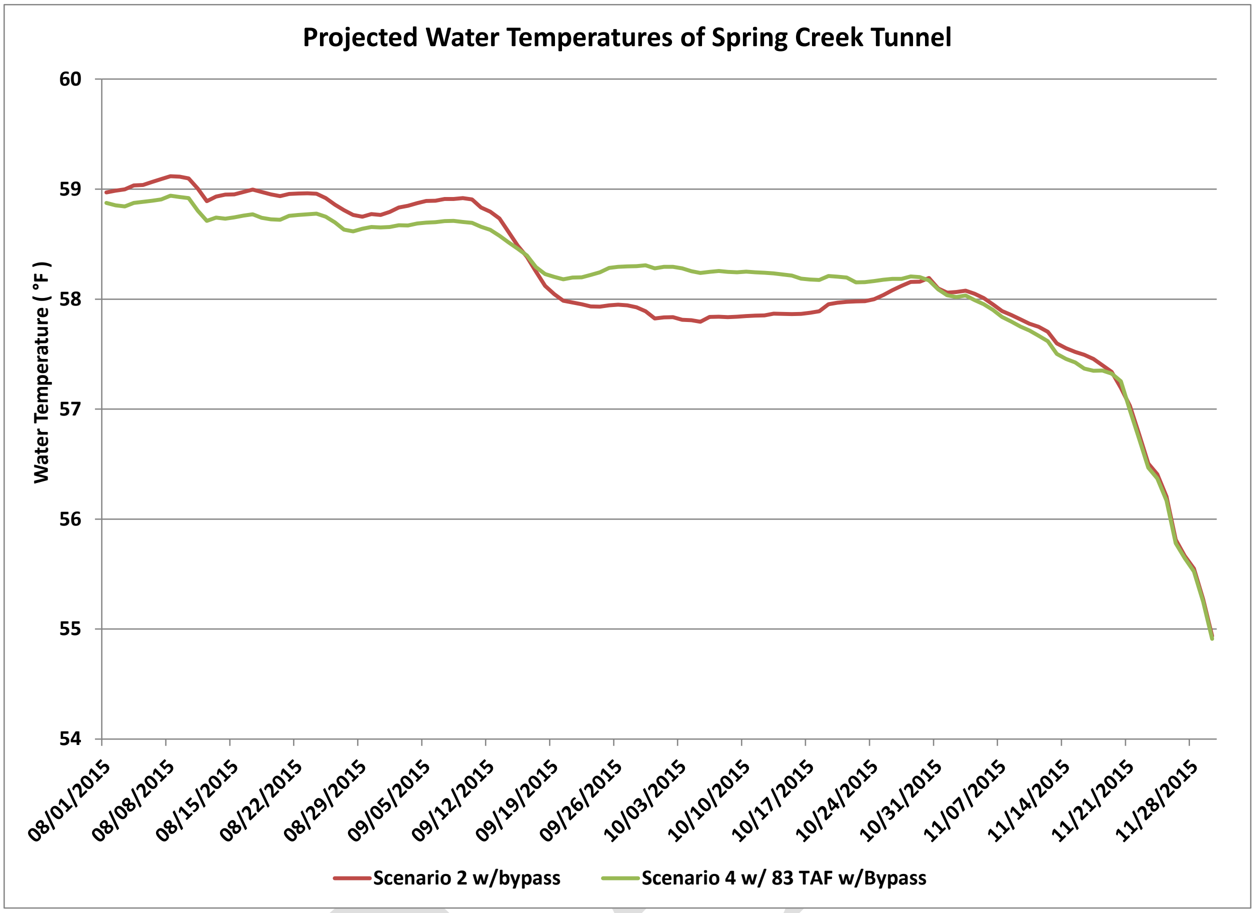

Figure 7. Projected water temperatures in Spring Creek Tunnel that are influenced by Lewiston Dam auxiliary bypass releases in Scenario 2 (no action) and Scenario 4 (proposed action).

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)

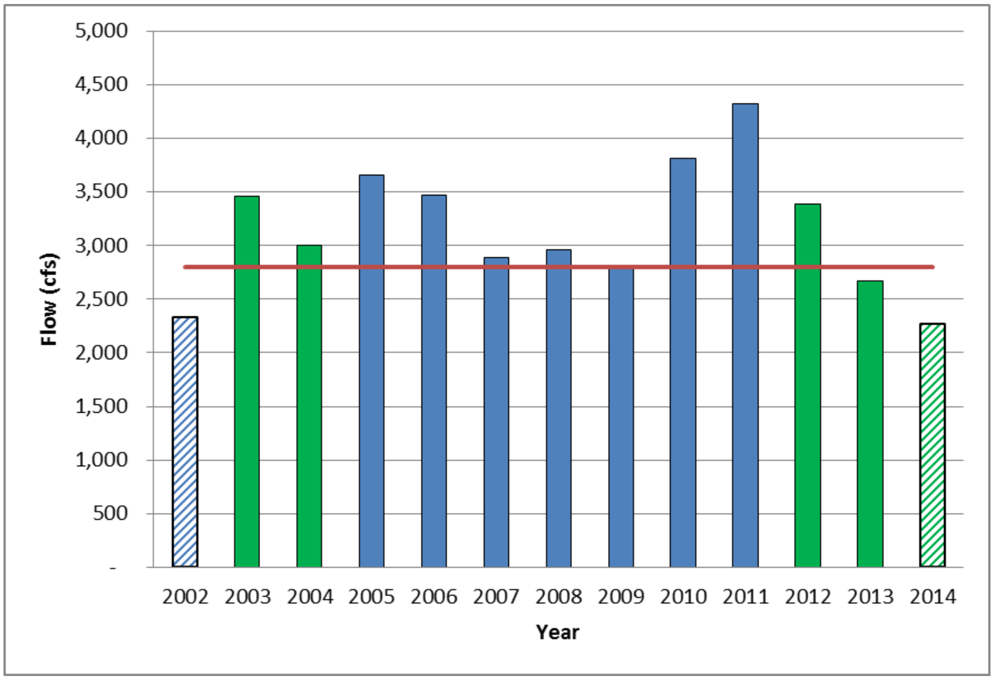

Figure 1. Mean August flow (cfs) in the Lower Klamath River (KNK), 2002-2014. Green bars are years when flow augmentation occurred and hatched bars are years when Ich outbreaks occurred. Horizontal red line represents 2,800 cfs flow.

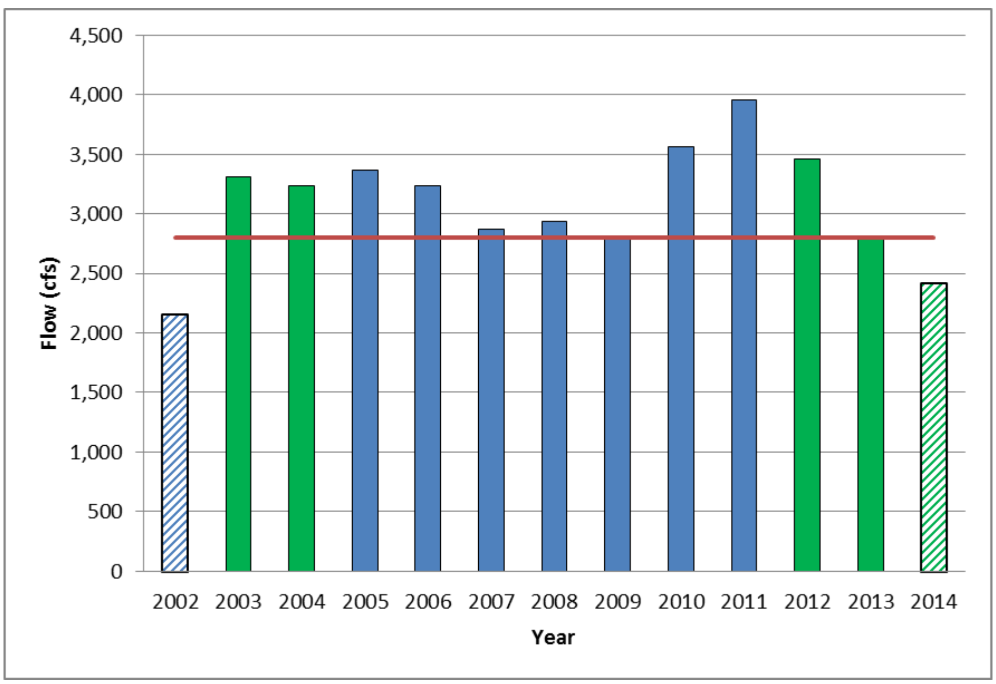

Figure 2. Mean August 15-31 flow (cfs) in the Lower Klamath River (KNK), 2002-2014. Green bars are years when flow augmentation occurred and hatched bars are years when Ich outbreaks occurred. Horizontal red line represents 2,800 cfs flow.

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.

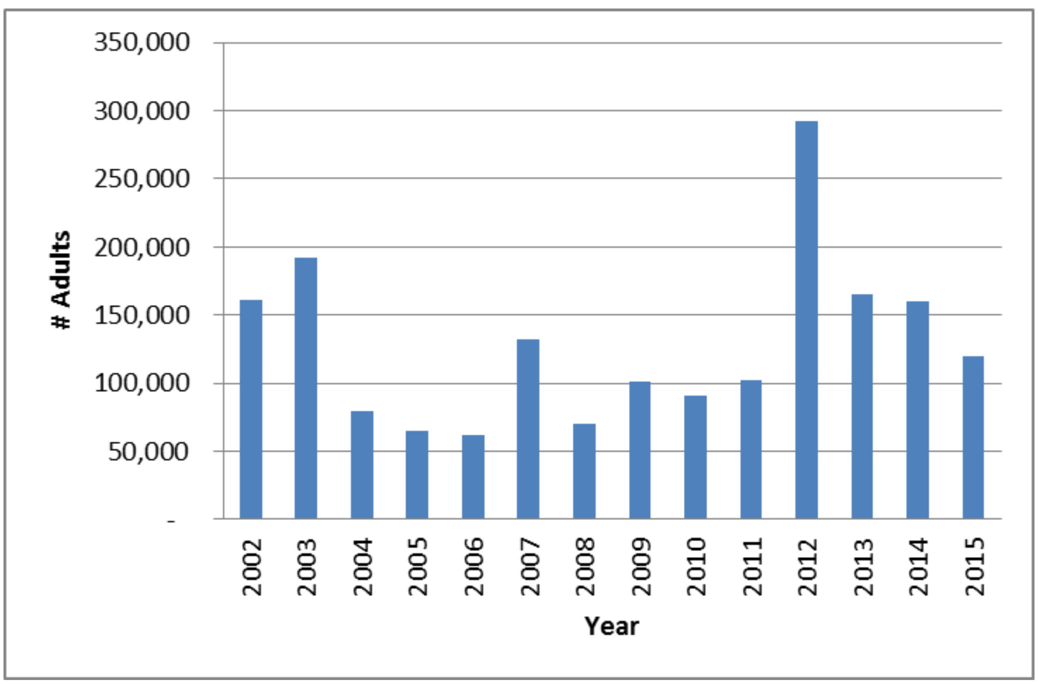

Figure 3. Klamath River adult fall Chinook Salmon in-river run, 2002-2014 and projected 2015 in-river run.

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).

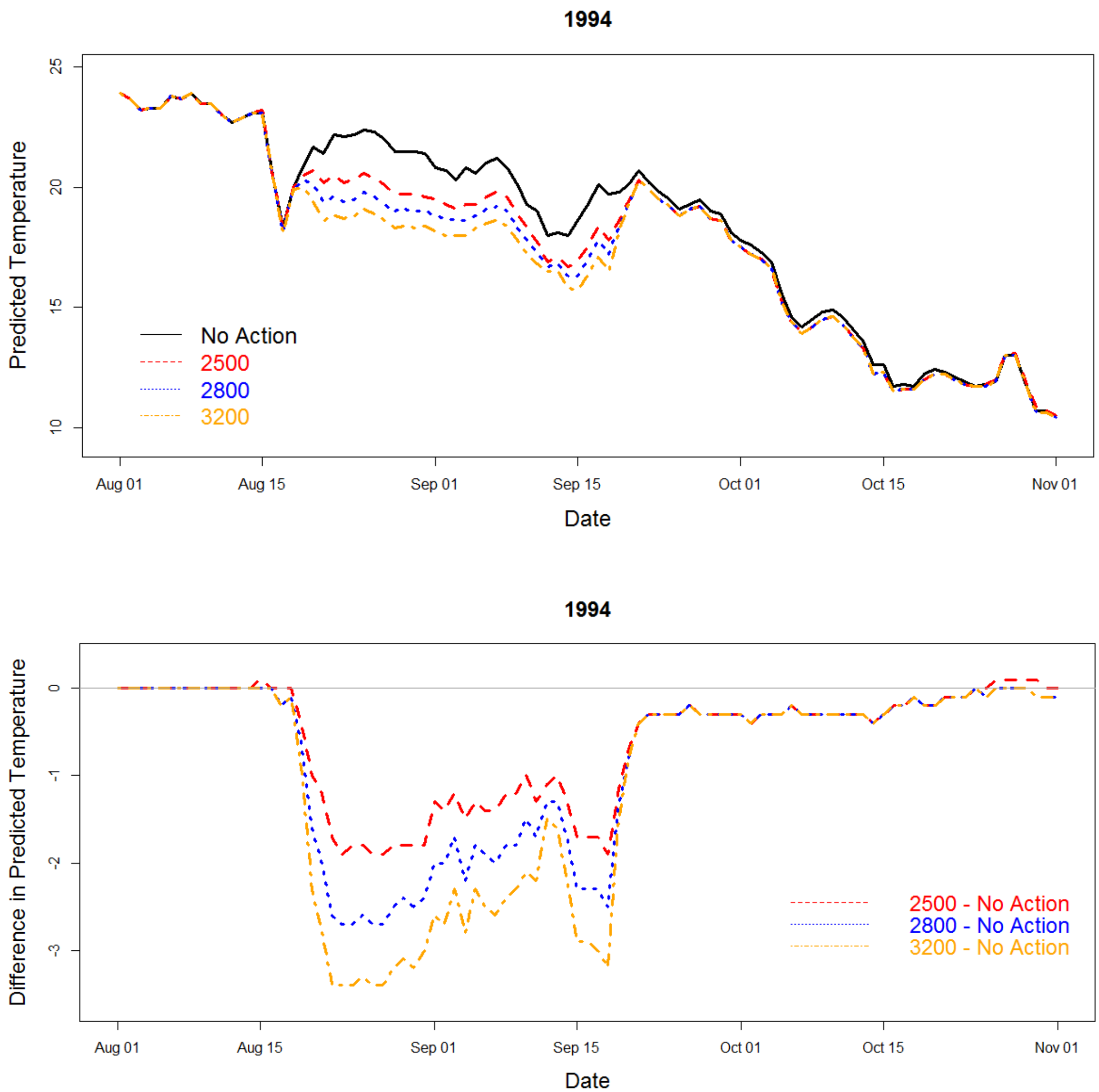

Figure 4. Predicted water temperatures (top) and difference in predicted water temperatures (bottom) in the lower Klamath River near the Klamath gage site, Klamath CA. No action refers to base operation flows from Lewiston Dam without using the bypass facility whereas the three augmented flow release 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.

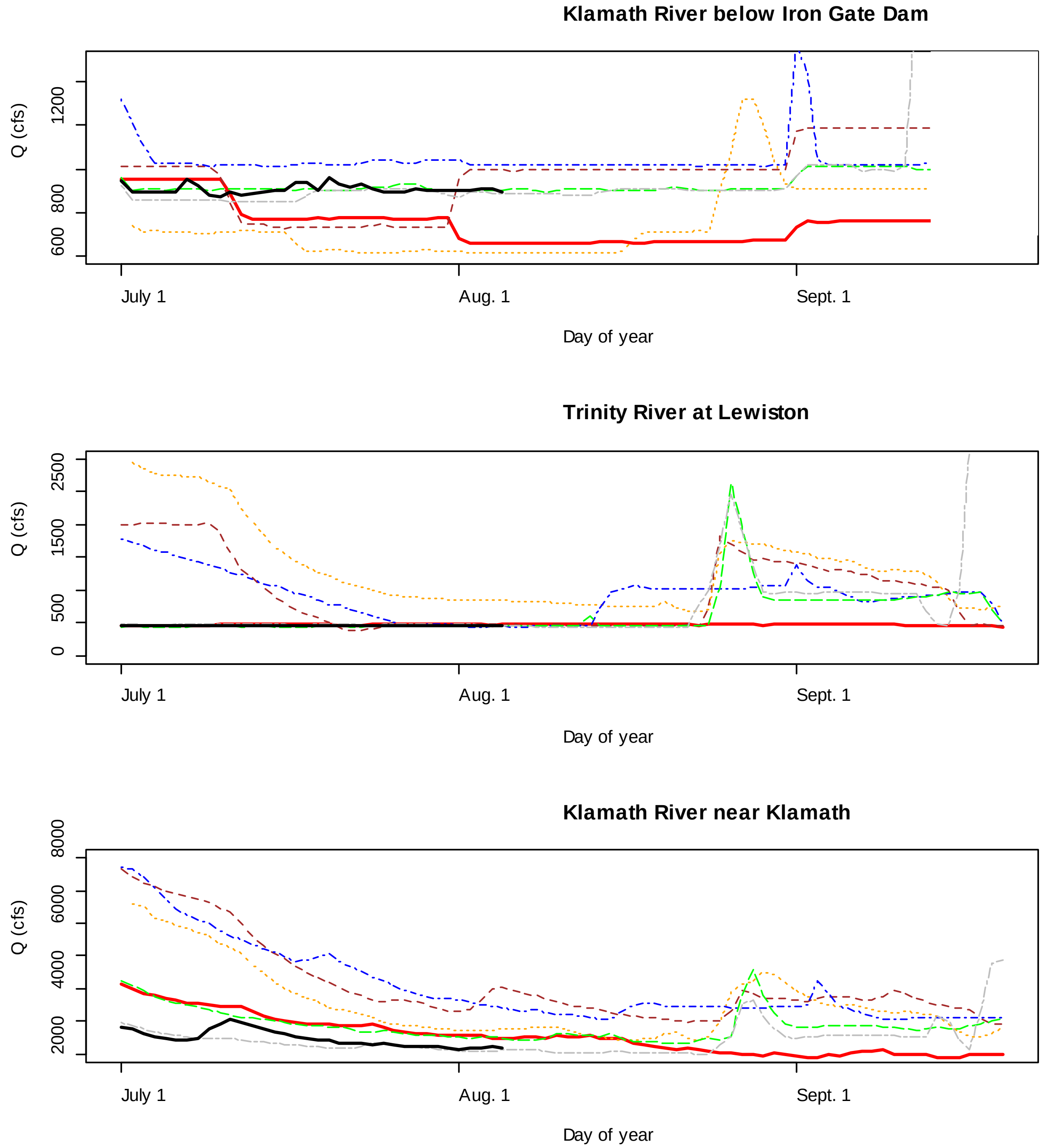

Figure 5. Dam releases and streamflow in the lower Klamath River near Klamath in 2002, 2015 and years with fall streamflow augmentation management actions.

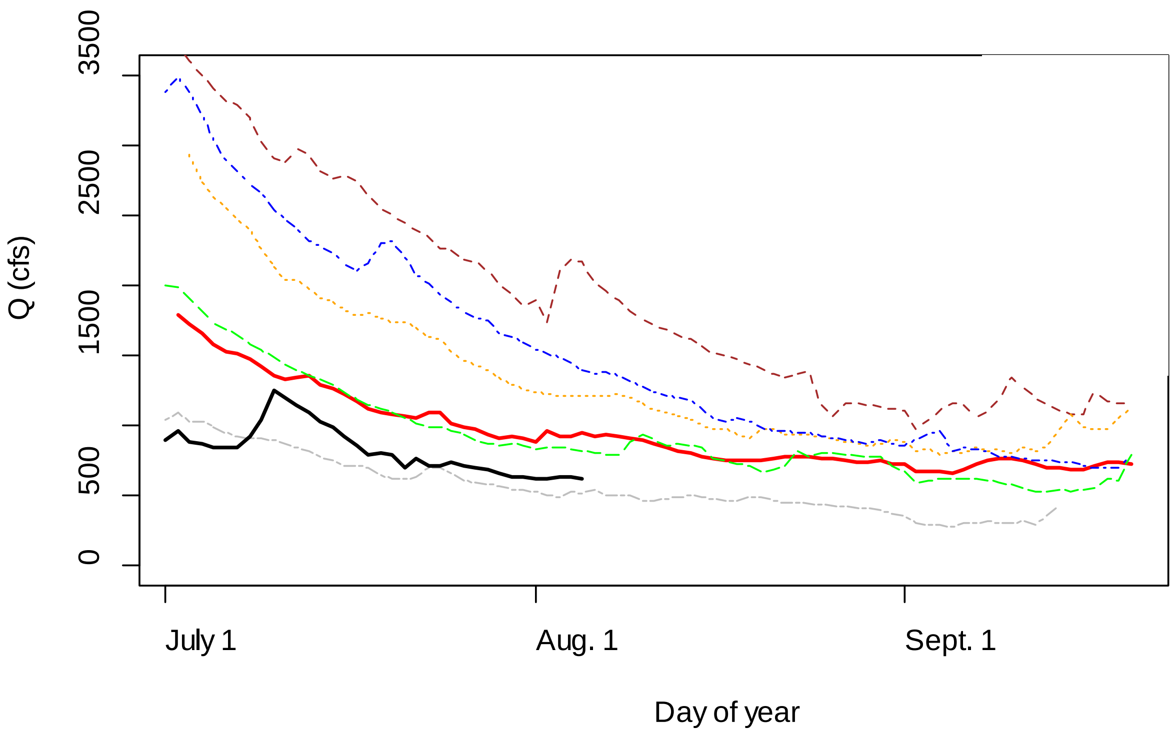

Figure 6. Estimated tributary accretions to the Klamath River downstream of the Trinity River confluence for 2002, 2015 and years where fall flow augmentation actions were implemented. Tributary accretion estimates were developed independently for the Klamath River and Trinity River and then summed. 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 $\geq 23^{o}$ 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.

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.

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MEMORANDUM

TO:	BRIAN PERSON, RECLAMATION NORTHERN CALIFORNIA AREA MANAGER
FROM:	IRMA LAGOMARSINO (NOAA) AND NICHOLAS HETRICK (USFWS)
SUBJECT:	2013 FALL FLOW RELEASE RECOMMENDATION
CC:	ROBIN SCHROCK (TRRP)
DATE:	AUGUST 12, 2013

Background

A significant fish kill occurred in the lower Klamath River in September 2002. Though estimates vary, the US Fish and Wildlife Service (Service) reported that a minimum of 34,000 adult fish, primarily fall-run Chinook salmon, died during the event, (Guillen 2003a). Carcasses were observed between September 18 and October 1, 2002 within the lower 36 miles of the Klamath River, extending from the estuary upstream to Coon Creek Falls. The Service (Guillen 2003b) reported that:

> *"Low river discharges apparently did not provide suitable attraction flows for migrating adult salmon, resulting in large numbers of fish congregating in the warm waters of the lower River. The high density of fish, low discharges, warm water temperatures, and possible extended residence time of salmon created optimal conditions for parasite proliferation and precipitated an epizootic of Ich and columnaris."*

The Yurok Tribe (Belchik et al. 2004) concluded that:

> *"the clinical cause of mortality was massive infections of ich and columnaris. This fact was confirmed by direct observations, as well as pathology reports by USFWS and CDFG."*

California Department of Fish and Game (Turek et al. 2004) concurred with the findings of the Service's and Yurok Tribe's causative factors reports, adding that:

> *"flow is the only controllable factor and tool available in the Klamath Basin... to manage risks against future epizootics and major adult fish kills."*

Several flow-related evaluations and management actions have been implemented in the past to reduce the likelihood of occurrence of an adult fish kill, including the development of criteria for triggering the release of supplemental flows during the fall-run Chinook salmon migration season (Clarke 2010; Hayden 2012; TRRP 2012a) as well as supplemental flow releases from Lewiston Dam on the Trinity River in 2003, 2004, and 2012.

Snowpack and precipitation were below average during the fall/winter 2012-2013 throughout southern Oregon and northern California, resulting in below average river flows in the region. Hydrologic forecasts released by the California Nevada River Forecast Center (CNRFC) predict below average discharge in the lower Klamath River during the 2013 adult fall-run Chinook salmon migration season (Appendix A). Mean monthly discharge for the lower Klamath River is predicted to be 2,168 cfs in August and 2,076 cfs in September, based on inflow predictions and current operation plans that guide managed flow releases from Iron Gate and Lewiston dams. These predicted mean monthly flows are similar to mean monthly flows experienced in the lower Klamath River during the 2002 fish kill (Table 1; Figure 1; Appendix A). Anticipated flow accretions to the lower Klamath River are about 50% of those observed in 2012. Discharges in the lower Klamath River during the 2013 adult fall-run Chinook salmon migration season are predicted to be equivalent to about 90-95% exceedances (Appendix B).

Escapement of fall-run Chinook salmon to the Klamath Basin in 2013 is projected to be the second largest on record. The Pacific Fishery Management Council's Salmon Technical Team estimated that 272,400 adult fall-run Chinook salmon will return to the Klamath River (PFMC 2013); which is about 110,000 fish greater than the adult run size associated with the 2002 fish kill (CDFW 2013). This is important as a large run size combined with low river discharge were reported as the primary contributing factors in the 2002 fish kill (Guillen 2003b; Belchik et al. 2004; Turek et al. 2004). Similarly, below average stream discharge has been associated with Ich outbreaks in fish populations in other rivers (Maceda-Veiga et al. 2009).

Given the concerns described above, the Bureau of Reclamation (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 with the 2013 adult fall-run Chinook salmon migration season in the lower Klamath River, and in developing preventative and emergency measures that would reduce the risk of the occurrence of an adult fish kill, while being conservative of limited water resources given the dry hydrologic conditions. This memorandum contains only technical analyses and recommendations regarding adult fall-run Chinook salmon in the Klamath-Trinity Basin. It does not contain any analyses regarding the potential effects of the fall flow releases on any species listed under the Endangered Species Act (ESA) and does not address, nor is it intended to address, compliance with the ESA or any biological opinions issued under the ESA.

Review of 2012 preventative fall flow releases

During spring 2012, Trinity River Restoration Program (TRRP) staff, TRRP partners and Reclamation's Klamath Basin Area Office jointly developed 1) preventative flow release criteria designed to minimize the risk of a fish disease outbreak and subsequent fish kill (TRRP 2012a), and 2) emergency flow release criteria designed to reduce the severity of a fish kill (TRRP 2012b). The preventative flow release measures identified by the TRRP Fall Flow Subgroup in 2012 were implemented by Reclamation, with supplemental flows originating primarily from Lewiston Dam with a lesser amount of water released from Iron Gate Dam for ceremonial purposes at the request of the Yurok Tribe (Figure 2). Following the recommendations of the Subgroup, BOR targeted a discharge of 3,200 cfs in the lower Klamath River from August 15-September 21 (Figure 2). A fish kill did not occur during the 2012 adult salmon migration season in the lower Klamath River, despite dry hydrologic conditions and an unprecedented return of 302,100 fall-run Chinook salmon to the Klamath Basin (CDFW 2013). While it is not known to what extent the preventative flow releases contributed to averting a fish kill, measures taken in 2012 did contribute to reducing water temperatures by up to 1.4°C in the lower Klamath River (Magneson 2013; Figure 2) and a fish kill did not occur. Similar decreases in water temperatures of about 2.1 °C and 1.6 °C were observed in the lower Klamath River during the 2003 and 2004 fall flow releases (Zedonis 2004, 2005).

Table 1. Discharge (cfs) in the Klamath River near Klamath gage (U.S. Geological Survey Site #11530500) in August and September 2002 and predicted discharge in 2013.

Year	August	September
2002	2,327	1,993
2013 (predicted)	2,168	2,076
Long term average	3,170	3,170

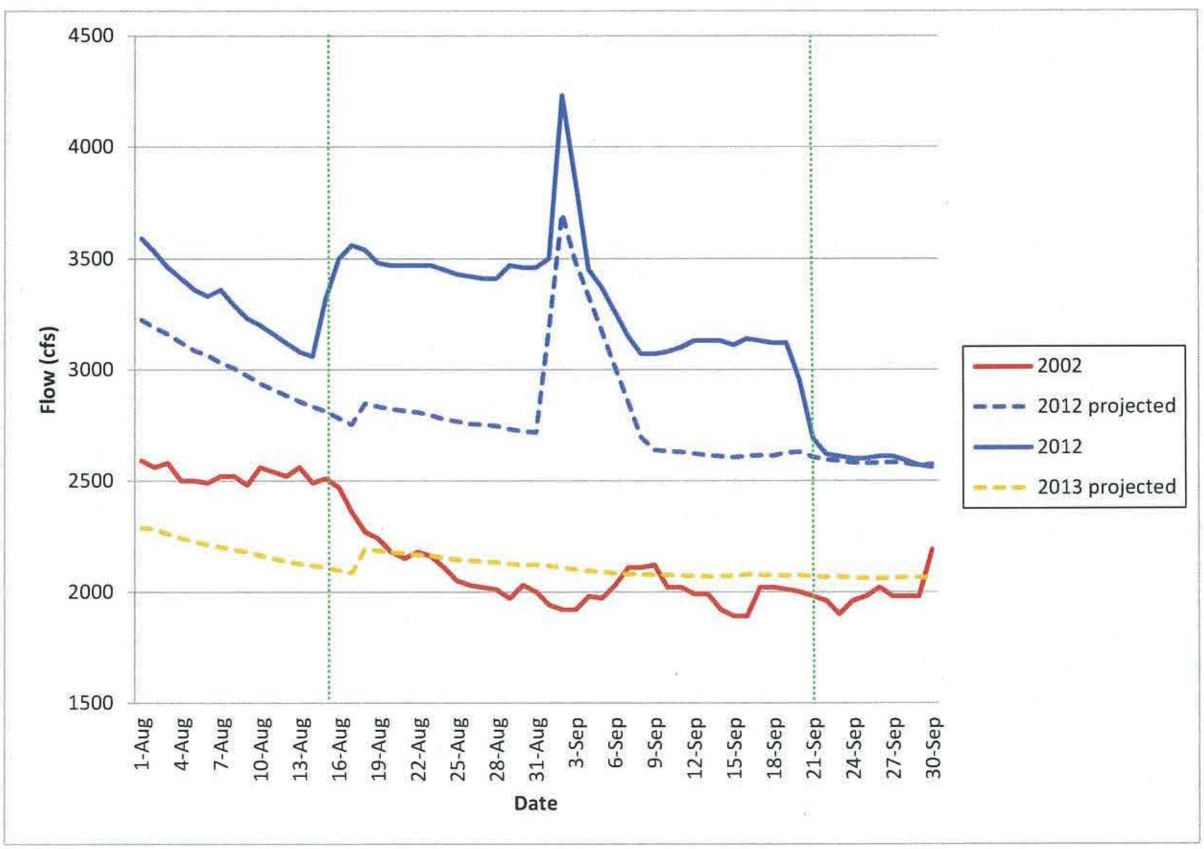


Figure 1. Observed flows in the lower Klamath River (RKM 13) in 2002 and 2012 (includes preventative fall flow augmentation) and preseason flow forecasts for 2012 (includes ceremonial pulse event for the Yurok Tribe released from Iron Gate Dam) and 2013 (without preventative or emergency fall flow augmentation or ceremonial release flow recently requested by the Hoopa Valley Tribe). Vertical green lines depict the primary period of the fall-run Chinook salmon migration season in the lower Klamath, August 15 through September 21.

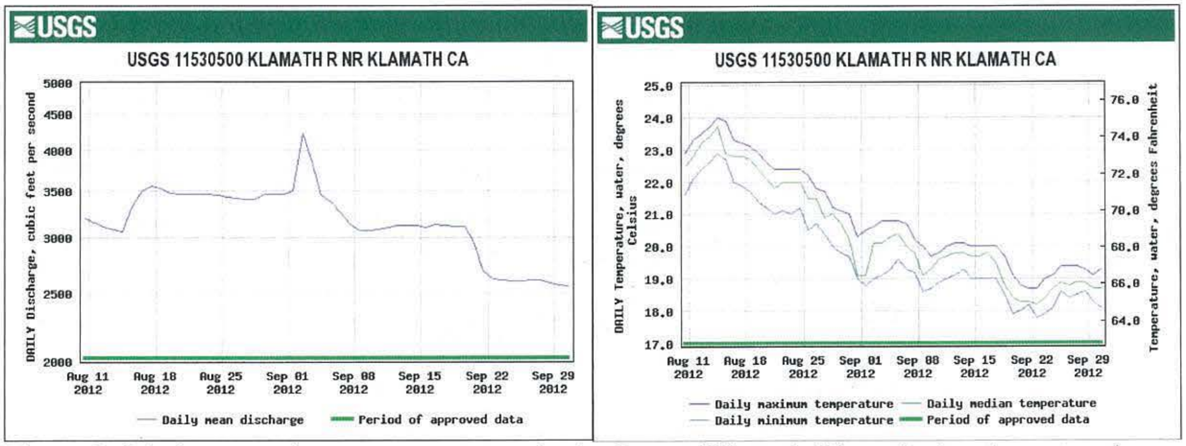


Figure 2. Discharge and water temperature in the Lower Klamath River during August and September of 2012.

Review of past recommendations for preventative fall flow releases

Several minimum flow recommendations for the lower Klamath River have been reported in the literature for the fall time period, ranging from 2,500 cfs to 3,200 cfs (Table 2). Recommendations of Turek et al. (2004) and Strange (2010a), however, were made without consideration of recent run sizes that exceeded previous maximum adult returns observed since comprehensive fall-run Chinook salmon monitoring was initiated in 1978.

While not independent of flow, water temperature can also be a critical parameter in affecting adult salmon behavior (Goniea et al. 2006). Strange (2010b) identified an adult Chinook salmon migration threshold of 23°C in the Klamath River, which is important because thermal migration barriers can lead to crowding of adult migrant fish and therefore, conditions conducive to fish-to-fish disease transmission and fish kills.

Recommendation for 2013 preventative fall flow releases

Given the large forecasted run size for 2013 and that preventative flow measures were taken in 2012 and a fish kill did not occur, implementing the 2012 fall flow plan (TRRP 2012a, 2012b) is likely to pose a lower risk for the occurrence of a fish kill in 2013 than the risk associated with other flow recommendations presented in Table 2. It is not possible, however, to assess if a fish kill would have occurred had discharge in the lower Klamath River been lower than 3,200 cfs experienced in fall 2012. While we do know that a fish kill did not occur in 2012, there is considerable uncertainty with regard to the specific discharge that flow augmentation should target in the lower Klamath River to prevent a fish kill.

We acknowledge that Reclamation has multiple obligations to consider in managing water resources in the Klamath-Trinity Basin. In addition, hydrologic conditions in 2013 are drier than those measured in 2012. For example, the 90% forecasted end of September storage for Trinity Reservoir in 2013 is 1.3 million acre feet (MAF), which is about 28% lower than the 1.8 MAF experienced in 2012. In addition, the 2013 projected end of September carryover storage is similar to that observed in 2009, which contributed to water temperature concerns in the Trinity River and resulted in the use of the auxiliary outlet of Trinity Reservoir. Similarly, the hydrologic conditions in the Upper Klamath Basin are also drier in 2013 than 2012.

Table 2. Review of previous for minimum discharge recommendations for the lower Klamath River during the fall-run Chinook salmon migration season.

Author	Minimum Flow Recommendation	Projected Adult Fall Chinook Salmon Run Size
Turek et al. (2004)	2,200 cfs (Klamath near Orleans +Trinity at Hoopa) ~ 2,500 cfs in Lower Klamath	None specified.
Strange (2010a)	2,500 cfs in Lower Klamath	Less than 170,000
Strange (2010a)	2,800 cfs in Lower Klamath	Greater than 170,000
TRRP (2012a)	3,200 cfs in Lower Klamath	380,000

Given the large fall-run Chinook salmon run size predicted for 2013 and the dry hydrologic conditions being experienced throughout the Klamath Basin, we recognize the need to provide supplemental flows in the Lower Klamath River to prevent a fish kill using a strategy that minimizes risk while conserving limited water resources. We also recommend that an adaptive management approach be taken that incorporates real-time environmental and biological conditions. In general, our joint recommendations are as follows, with more detail following and in the emergency fall flow recommendation section.

- Initiate preventative flow augmentation in the lower Klamath River (RKM 13) to a minimum of 2,800 cfs when the cumulative harvest of Chinook salmon in the Yurok Tribal fishery in the Estuary area meets or exceeds a cumulative total of 7,000 fish (Appendix C). The accounting of harvest should commence starting July 4 and we recommend all Chinook salmon, regardless of race, count toward the cumulative total.
- Fall flow augmentation should be initiated by August 22 if the fish metric is not triggered.
- Fall flow augmentation should continue until September 21 unless mean daily water temperature at rkm 13 is projected to be ≥23°C, in which case flow augmentation to maintain a minimum of 2,800 cfs should continue until daily water temperature at rkm 13 is projected to be < 23°C or until the end of September when seasonal air temperatures typically cool and contribute to water temperatures suitable for upstream migration (Figure 4).
- Implement real-time flow-temperature management using the RBM10 and SN Temp water temperature models developed for the Klamath and Trinity rivers and NOAA Weather Service weather projections to manage flows in assessing the 23°C water temperature migration threshold emergency flow release.
- Implement fish pathology monitoring to determine the need for a fish pathology/mortality emergency release, and
- Monitoring should occur during the fall-run Chinook salmon migration period in the lower Klamath River to inform the need and timing of preventative and emergency flow releases based on real-time environmental conditions (Figure 3; Appendix D).

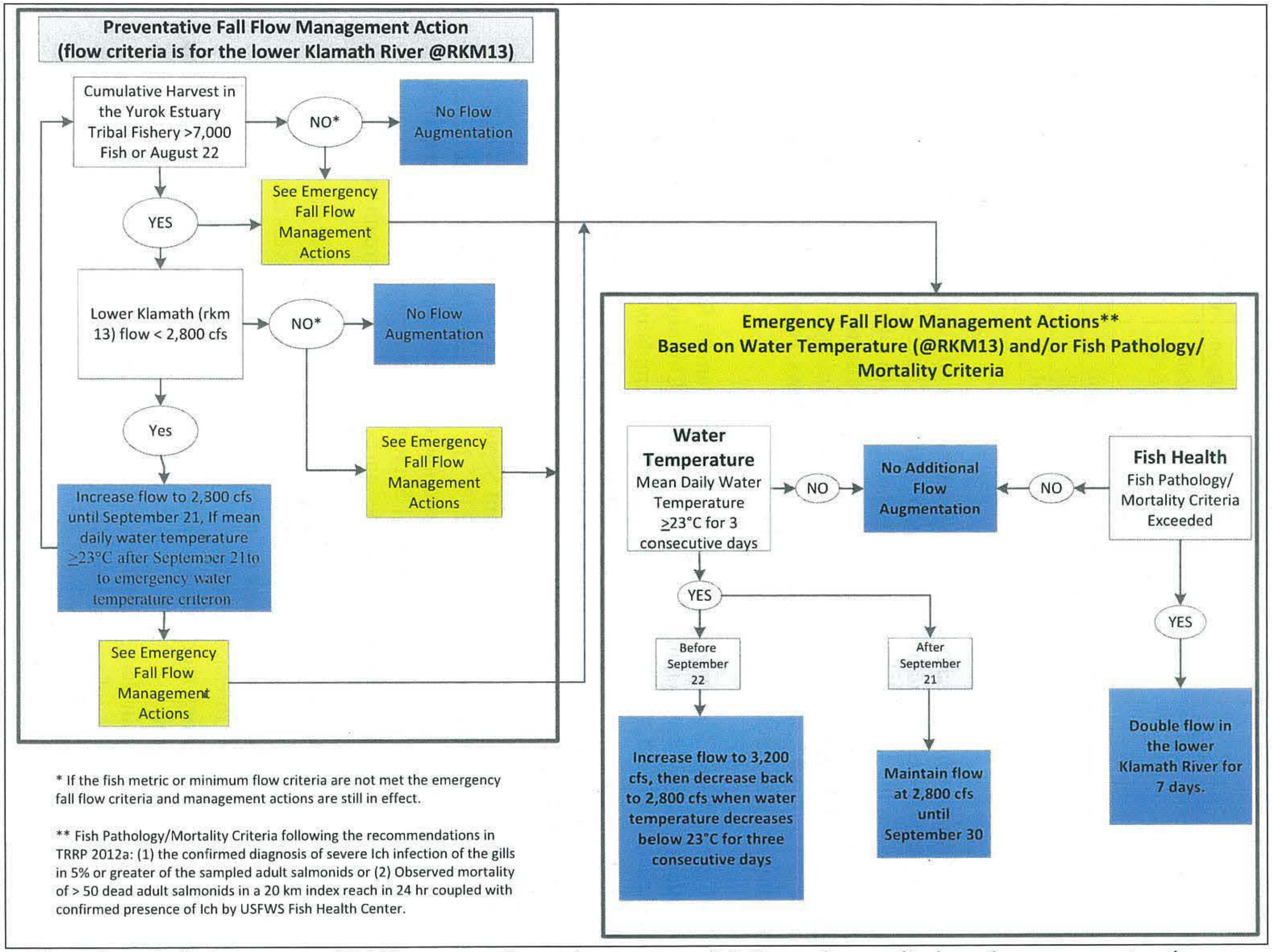
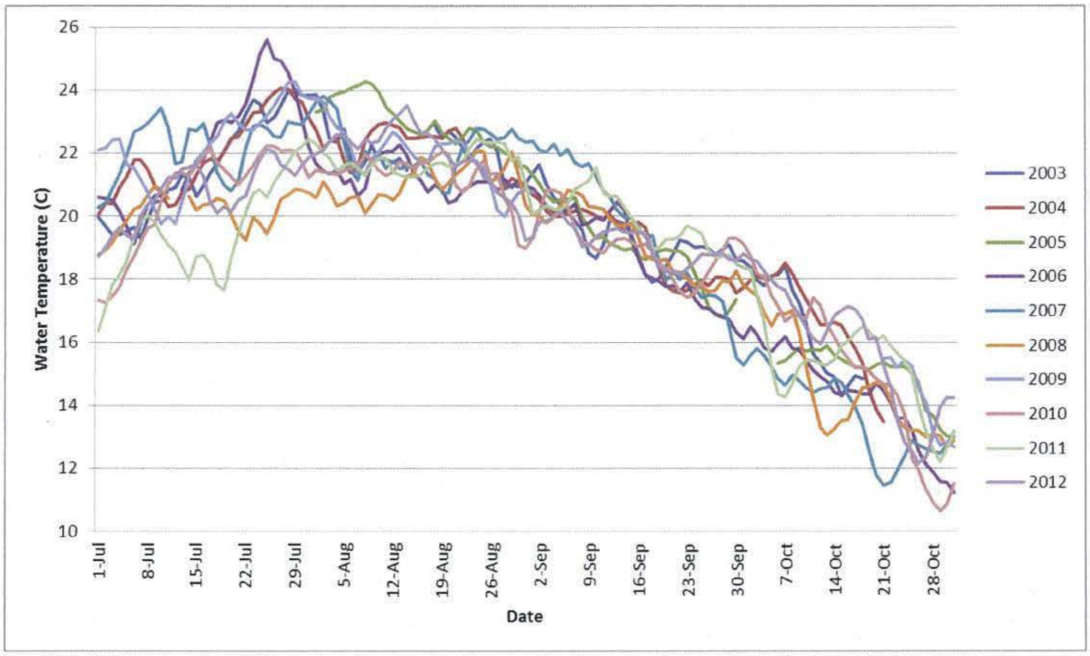


Figure 3. Flow chart depicting proposed 2013 preventative and emergency fall flow release criteria and management actions.



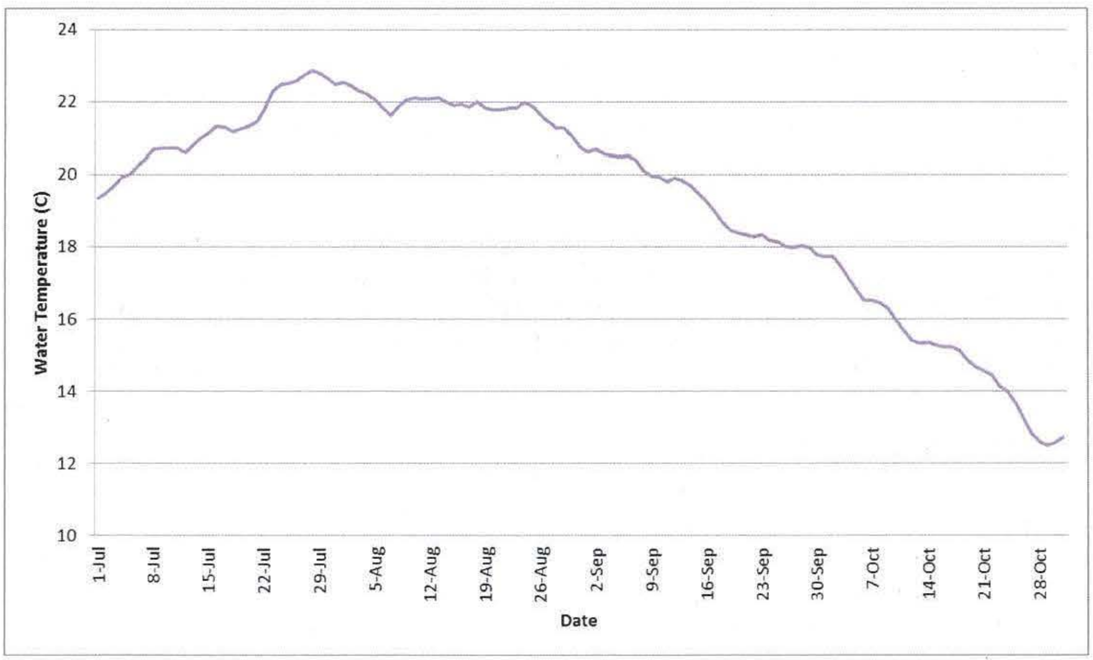


Figure 4. Mean daily water temperature (C) from July through October in the lower Klamath River (rkm 13), 2003-2012 (upper) and mean for all years (lower).

Fish Metric

We recommend that fall flow augmentation should be initiated once the cumulative harvest of Chinook salmon in the Estuary Area by the Yurok Tribal fishery exceeds 7,000 adults. The tallying of the cumulative harvest of Chinook salmon in the Estuary Area to commence on July 4 and the 2013 Yurok Tribal commercial fishery in the estuary will open on August 10. The use of a fish metric as a real-time indicator of the initiation of upriver migration of fall-run Chinook salmon will entail significant coordination among the Yurok Tribe who collect the fishery data and federal managers that will be implementing the fall flow augmentation.

Initiation of Fall Flow Augmentation if Fish Metric Is Not Met

Fall flow augmentation should be initiated by August 22 if the fish metric is not triggered. The reasoning behind this date is as follows:

- The short time period provided to develop the fish-based metric precluded an in-depth evaluation of temperature and flow data, which may have a significant influence on harvest and effort data in the Estuary and Middle Klamath areas. As a result, the metric may not be conservative enough to ensure that flow augmentation will occur.
- It is anticipated that there will be large numbers of fall Chinook salmon in the Estuary Area due to the large projected inriver run. In addition, the 2013 forecast is expected to be more accurate than the 2012 projection and is comprised of a higher proportion of Klamath fall Chinook salmon stocks (Shasta River, Iron Gate Hatchery, Bogus Creek, and mainstem Klamath River) which tend to enter the estuary and river earlier than Trinity River stocks.
- In four of the five years (80%) included in the break point analyses we conducted to define the fish metric, large numbers of fish were harvested in the Estuary Area by August 22 and harvest in the Middle Klamath Area starts to increase in the following weeks, suggesting that the upriver migration of the run had commenced by this date.

Ending of Fall Flow Augmentation

Fall flow augmentation should be continued through September 21 and can end after this date if mean daily water temperature in the lower Klamath River at rkm 13 remains below 23°C (TRRP 2012). See "Recommendation for emergency fall flow releases for 2013 – Water Temperature Criterion" if the mean water temperature in the lower Klamath River exceeds 23°C after September 21.

Recommendation for emergency fall flow releases for 2013

The recommended triggers for emergency flow releases in 2013 are two-tiered, 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. 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).

Water Temperature Criterion

Water temperature is widely known as a critical factor for influencing the upstream migration of adult salmonids (Goniea et al. 2006, Strange 2010b), with Strange (2010b) identifying mean daily water temperature threshold of 23°C for the migration of adult Chinook salmon in the Klamath River.

We recommend the use of a water temperature criterion when the fish metric is met or exceeded and mean daily water temperature (actual and/or predicted) is ≥ 23° C for three consecutive days to trigger the increase of flow in the lower Klamath River (rkm 13) to 3,200 cfs. While it can be expected that water temperatures will occasionally exceed this temperature threshold, prolonged periods of water temperatures above this threshold can lead to large densities of fish in the lower river as they migrate from the estuary. Therefore, we recommend a three consecutive day period for this water temperature trigger to avoid reacting to short (one or two day) temperature increases above the water temperature criterion. Maintaining mean water temperature below this temperature threshold for the following three days will allow adult to migrate upstream and reduce fish density in the lower river. This emergency action is intended to eliminate thermal migration barriers and reinitiate upstream migration of adult fish, thereby reducing the extended residence time of adult fish in thermal refugia and as a result, conditions conducive to fish-to-fish disease transmission and associated fish kills.

We also expect that adult Chinook salmon will resume upstream migration on the onset of periods of declining river temperatures that would result from increasing flows from 2,800 cfs to 3,200 cfs in the lower Klamath River. This real-time management concept is supported by the findings of Strange (2010b) who reported that adult Chinook salmon key into periods of declining river temperature during their upriver migration to take advantage of brief windows of thermal opportunity.

Fall flow augmentation should continue until September 21 unless mean daily water temperature at rkm 13 is projected to be ≥23°C, in which case flow augmentation to maintain a minimum of 2,800 cfs should continue until daily water temperature at rkm 13 is projected to be < 23°C or until the end of September. In early October, mean water temperatures in the lower Klamath River are generally decreasing (Figure 4) due to seasonal decreases in air temperatures and most of the fall-run Chinook salmon have commenced their upstream migration based on harvest data from the Middle Klamath Area (Appendix C, Figure 12)

Fish Pathology/Mortality Criterion

Two primary fish health monitoring efforts will be relied upon to determine the need for a diagnostic Ich survey which could trigger an emergency fall flow release.

1. Adult fish health monitoring will be conducted by the Yurok Tribal Fisheries Program (YTFP) in the lower reach of the Klamath River to determine the presence and severity of Ich and columnaris infection throughout the fall Chinook salmon run. Additionally,

Tribal Fisheries crews will count and examine all pre-spawn mortalities to determine possible cause of death. Pre-spawn mortality due to columnaris, wounds (hook, net, or seal bites), and other causes will be documented but will not be used as diagnostic criteria for identifying an imminent Ich epizootic. Results of these sampling efforts will be used to determine if a more intensive diagnostic Ich survey is needed.

2. In addition to the directed fish health monitoring conducted by the YTFP, the Klamath Fish Health Assessment Team (KFHAT) will implement its response plan if moribund or dead fish are observed in any areas of the Klamath or Trinity rivers. KFHAT response plan documents can be found at the following link: http://www.kbmp.net/images/stories/pdf/KFHAT/FinalResPlan_AppendicesUpdatedMarch2011.pdf

These efforts will provide information on the disease incidence observed in adult salmonids in the lower Klamath River or the numbers/condition of dead or moribund fish throughout the Klamath-Trinity Basin. We recommend that the criteria used to institute a diagnostic Ich survey should be:

1. Prevalence of severe Ich infection in 5% or greater of the weekly adult fish health monitoring samples collected by resource agencies, with Ich infection to be confirmed by the Service's California-Nevada Fish Health Center (CNFHC) from fixed samples, or

2. Observed mortality of > 50 adult salmonids (Chinook and/or coho salmon and steelhead), regardless of cause, in a 20-km reach within a 24-h time period. Recently deceased fish (<24 hours post death) will be differentiated from older mortalities (>24 hours post death) by the presence of at least one clear eye. Data on the presence of hook scars, gill net marks, predator wounds (seal/sea lion, lamprey, otter), and condition of gills (i.e. columnaris) will also be collected to determine other possible causes of mortality.

Diagnostic Ich Survey

If either of the criteria established for the adult fish health monitoring effort are met, an intensive sampling of adult salmonids will be initiated to collect live or recently deceased fish. Ich diagnostic surveys will be performed by the CNFHC that will provide a pathology report documenting the findings of these surveys. These efforts will focus on determining the level and severity of Ich infection or the possible cause of death in the event of large numbers of dead fish are observed. 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. The recommended action is to augment flows in the lower Klamath River to double the preexisting flow for 7 consecutive days.

If possible, a minimum of 60 adult salmonids should be sampled within a consecutive 2-day period. While a sample of 60 fish is desired, it may not always be achievable and the minimum acceptable sample size is set at 30 fish. These fish should be live or recent mortalities (< 3 hours).

Criteria for triggering an emergency flow release and recommended management action based on the level and severity of an Ich infection are as follows.

Fish Pathology/Mortality Emergency Criteria	Management action
1. The confirmed diagnosis of severe Ich infection of the gills in 5% or greater of a desired sample of 60 adult salmonids (3 infected out of a 60-fish sample). Following the 5% threshold criteria, a confirmed diagnosis of 2 or more individuals having a severe Ich infection would meet the criteria for a sample size of less than 60 but greater than the minimum of 30 fish. Or 2. Observed mortality of > 50 dead adult salmonids in a 20 km index reach in 24 hr coupled with confirmed presence of Ich by USFWS Fish Health Center.	Recommend immediate Emergency Fall Flow release with a 7 day duration pulsed spike to double pre-existing flows in the Lower Klamath River.

The Service's CNFHC will provide a pathology report documenting the findings of the diagnostic survey to Brian Person of Reclamation, to other federal, state and tribal co-managers, and to the KFHAT group. It is recommended that an emergency release be implemented immediately upon BOR's receipt of a positive pathology report to limit fish mortalities associated with a potential Ich epizootic.

Additional Considerations

While modest increases of river discharge in the Klamath Basin from summer rainstorms are not uncommon during the adult fall-run Chinook salmon migration period, these rain events are typically short in duration and occur with limited frequency. The sustained release of a substantial volume of water from one or both Klamath Basin dams, as recommended above, would mark a departure from the natural flow regime (Poff et al. 1997, Lytle and Poff 2004) of the Klamath and Trinity rivers because the duration of the elevated flows is unnatural. Modification of flow can be expected to have cascading effects on the ecological integrity of rivers and the organisms that depend on them (Poff et al. 1997). However, both the Klamath and Trinity rivers are extensively managed systems and given existing water withdrawals and conveyances, their hydrology already deviate significantly from the natural conditions.

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Appendices

Appendix A. Predicted discharge for the lower Klamath River (U.S. Geological Survey Site #11530500) with no preventative flow release. (Data from CNFRC downloaded on June 30, 2013).

Date	50% flow forecast river flow without dam releases (from CNRFC)	IGD Flows	Lewiston Flows	Flow estimate at KNK with no supplemental flows
7/30/2013	990	880	450	2,320
7/31/2013	972	880	450	2,302
8/1/2013	957	880	450	2,287
8/2/2013	952	880	450	2,282
8/3/2013	931	880	450	2,261
8/4/2013	913	880	450	2,243
8/5/2013	896	880	450	2,226
8/6/2013	882	880	450	2,212
8/7/2013	871	880	450	2,201
8/8/2013	859	880	450	2,189
8/9/2013	850	880	450	2,180
8/10/2013	834	880	450	2,164
8/11/2013	821	880	450	2,151
8/12/2013	806	880	450	2,136
8/13/2013	796	880	450	2,126
8/14/2013	788	880	450	2,118
8/15/2013	780	880	450	2,110
8/16/2013	766	1,000	450	2,096
8/17/2013	754	1,000	450	2,084
8/18/2013	743	1,000	450	2,193
8/19/2013	734	1,000	450	2,184
8/20/2013	728	1,000	450	2,178
8/21/2013	724	1,000	450	2,174
8/22/2013	716	1,000	450	2,166
8/23/2013	713	1,000	450	2,163
8/24/2013	702	1,000	450	2,152
8/25/2013	694	1,000	450	2,144
8/26/2013	691	1,000	450	2,141
8/27/2013	686	1,000	450	2,136
8/28/2013	682	1,000	450	2,132
8/29/2013	676	1,000	450	2,126
8/30/2013	671	1,000	450	2,121
8/31/2013	671	1,000	450	2,121

Date	50% flow forecast river flow without dam releases (from CNRFC)	IGD Flows	Lewiston Flows	Flow estimate at KNK with no supplemental flows
9/1/2013	667	1,000	450	2,117
9/2/2013	660	1,000	450	2,110
9/3/2013	651	1,000	450	2,101
9/4/2013	644	1,000	450	2,094
9/5/2013	639	1,000	450	2,089
9/6/2013	634	1,000	450	2,084
9/7/2013	630	1,000	450	2,080
9/8/2013	628	1,000	450	2,078
9/9/2013	626	1,000	450	2,076
9/10/2013	627	1,000	450	2,077
9/11/2013	623	1,000	450	2,073
9/12/2013	621	1,000	450	2,071
9/13/2013	619	1,000	450	2,069
9/14/2013	619	1,000	450	2,069
9/15/2013	622	1,000	450	2,072
9/16/2013	628	1,000	450	2,078
9/17/2013	626	1,000	450	2,076
9/18/2013	624	1,000	450	2,074
9/19/2013	623	1,000	450	2,073
9/20/2013	624	1,000	450	2,074
9/21/2013	621	1,000	450	2,071
9/22/2013	616	1,000	450	2,066
9/23/2013	618	1,000	450	2,068
9/24/2013	614	1,000	450	2,064
9/25/2013	611	1,000	450	2,061
9/26/2013	611	1,000	450	2,061
9/27/2013	613	1,000	450	2,063
9/28/2013	615	1,000	450	2,065
9/29/2013	616	1,000	450	2,066
9/30/2013	611	1,000	450	2,061
10/1/2013	608	1,000	450	2,058
10/2/2013	614	1,000	450	2,064
10/3/2013	620	1,000	450	2,070
10/4/2013	609	1,000	450	2,059
10/5/2013	618	1,000	450	2,068

Appendix B. Exceedance table based on monthly average flows, not daily flows, for the Lower Klamath River (U.S. Geological Survey Site #11530500) using years 1911-2012.

Exceedance	July	August	September
0.05	9,646	4,869	4,875
0.10	8,894	4,397	4,247
0.15	7,770	4,326	4,113
0.20	7,352	4,131	3,943
0.25	6,650	3,683	3,773
0.30	6,397	3,532	3,605
0.35	5,455	3,447	3,415
0.40	5,177	3,279	3,346
0.45	4,793	3,170	3,139
0.50	4,477	2,982	3,032
0.55	4,265	2,956	2,968
0.60	4,083	2,901	2,857
0.65	3,924	2,861	2,758
0.70	3,789	2,787	2,691
0.75	3,574	2,672	2,598
0.80	3,313	2,574	2,538
0.85	3,230	2,372	2,501
0.90	2,960	2,200	2,447
0.95	2,518	1,876	2,003

Appendix C. Development of a Fish Metric to Inform the Timing of Fall Flow Augmentation for the Lower Klamath River in 2013.

Introduction

In 2012 the Trinity River Restoration Program Fall-Flow subgroup developed flow recommendations to protect the forecasted large inriver run of fall-run Chinook salmon expected to enter the Klamath/Trinity Basin and prevent a fish-kill (TRRP 2012). Recommendations made by the group included a temporal component (August 15-September 21) based on Yurok Tribal net harvest data collected in the Klamath River estuary, which was used as a proxy for inriver run timing.. With a large fall-run Chinook salmon inriver run forecast for 2013 (PFMC 2013a, Figure 1) and the expected low flows in the lower Klamath River in August and September, the Bureau of Reclamation sought technical assistance from the US Fish and Wildlife Service and National Marine Fisheries Service to develop recommendations for augmenting fall flows, while being conservative of the limited water resources given the dry hydrologic conditions.

One component of the recommendation developed by the Fall-Flow subgroup in 2012 that needed refinement was to better define and support the period when flow augmentation would be implemented. A fish abundance-based metric and associated real-time monitoring was deemed desirable to inform the timing of flow augmentation rather than relying on fixed dates as specified in the 2012 plan.

The projected 2013 inriver run of adult fall-run Chinook salmon is 282,400 fish, approximately 110,000 greater than the 2002 inriver run (Figure 1), of which the majority are predicted to be age-4 fish (PFMC 2013a). The projected age composition of the run is pertinent in that the age-4 predictions are generally more accurate than the age-3 predictions (PFMC 2013b). The 2012 inriver run was 79% of the preseason projection with this error partially attributed to the relatively low precision and accuracy in the preseason forecast for the age-3 component of the run at large stock sizes which comprised 82% of the 2012 run (KRTT 2012). In addition to the age composition of the 2013 run being skewed towards age-4 fish (69%; O'Farrell, pers. com.), the run is expected to be dominated by Klamath stocks (Iron Gate Hatchery, Klamath River mainstem, Bogus Creek, Shasta River, Scott River and Salmon River) based on the distribution of spawners observed in 2012 (CDFW 2013, Figure 2) and these stocks tend to enter the river earlier than Trinity stocks (Polos and Craig 1994, Strange 2007). Therefore, we expect the number of fall-run Chinook salmon that return to the Klamath Basin will be closer to the forecast as compared to 2012 and that many of the fish will return earlier than average.

The goal of this analysis was to develop a fish metric that can be used as an indicator of the first substantial increase of fall-run Chinook salmon in the lower Klamath River, indicating that the inriver run and subsequent upstream migration has commenced. This fish metric is 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 the large predicted return of Klamath Basin fall-run Chinook salmon, rather than relying on fixed dates to start and end flow augmentation.. However, it is critical that an abundance-based metric be conservative so that augmented flows are released in time to protect the run, with the need amplified by the low flows projected for August and September (similar to those in 2002). 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.

An ideal metric for guiding the management decision of when additional water should be released would be based on the density of fish holding above the estuary in the mainstem Klamath River in the reach where the 2002 fish-kill occurred. This is an area where adult and juvenile salmonids often congregate in high densities in thermal refugia when warm mainstem Klamath River water temperatures inhibit migration. Another potential metric would be the abundance of Ich theronts in this reach of the mainstem Klamath River. This information, in combination with the fish density data, could be used to determine the potential for an Ich epizootic. While the development of this fish metric has focused on the abundance of adult fall-run Chinook salmon, the abundance of juvenile salmonids as well as other fish species that may be holding in thermal refugia should be considered because they can also be infected by Ich and can possibly be the source of the initiation of an Ich epizootic. At this time, however, fish and Ich theront density information are not available. As an alternative we chose to use the harvest data from the Yurok Tribal fishery as a proxy for fish density in the mower mainstem river because the historic information were readily available and implementation and tracking of the metric in real-time is feasible.

Methods.

We evaluated the Yurok Tribal net harvest and effort data from the Estuary and Middle Klamath monitoring areas provided by the Yurok Tribal Fisheries Program (Figure 3). These data were selected for exploratory analyses because they: (1) are assumed to provide an indirect measure of fish abundance and run timing, (2) were collected in the area (Middle Klamath) where the 2002 fish-kill occurred, (3) were quickly accessible given the limited time provided to us to develop a fish metric, and (4) the data are updated every 24 hours during the fishery to facilitate a real-time use of the metric to inform flow augmentation decisions. Utilizing harvest data for this task requires two assumptions:

- The number of fall-run Chinook salmon that have escaped estuary harvest is positively associated with the number of estuary harvested fish.
- Fish that escape estuary harvest will soon-after arrive at, and potentially hold in, the section of the Klamath River considered most susceptible to fostering a disease outbreak in returning adult salmon.

The data consisted of weekly estimates of Chinook salmon harvest and fishing effort from July 4 through November 30 for years 2001 through 2012 (Williams, pers. com.). The Estuary Area is an area of intense fishing effort and harvest and rigorous monitoring, especially during years when a commercial fishery is conducted, and can indicate when large numbers of fall–run Chinook salmon have migrated into the estuary. The Middle Klamath Area is the area where the 2002 fish-kill occurred (Guillen 2003), where fall-run Chinook salmon initiate their upstream migration and where they are susceptible to temperature induced migration delays (Strange 2010), potentially leading to high fish densities. These conditions, in combination, can contribute to the initiation of an Ich epizootic (Guillen 2003, Turek et al. 2004, Belchik et al. 2004).

Following discussions with the Yurok Tribal biologists concerning the harvest data, it was decided that the data from five years (2001, 2002, 2003, 2007 and 2009) were most appropriate for analyses for the following reasons:

- the Klamath Basin fall-run Chinook salmon inriver runs during these years were large (Figure 1),
- commercial fisheries occurred in the Estuary Area during these years, and
- the commercial fisheries began between July 29 and August 1.

Data from 2011 and 2012 were not considered because the commercial fisheries started on August 21 and August 19, respectively, which significantly shifts the timing of effort and harvest in the Estuary Area (Figure 4). While weekly data were provided for each year from July 4 through December 4, our analyses focused on the time period from July 4 through November 6 as it encompasses the initiation and the end of the fall-run Chinook salmon migration through the Estuary and Middle Klamath areas. In evaluating catch-effort data, the period was limited from August 1 through October 2 when significant fishery effort and harvest occur and comparable effort data (net-hours) were available. Graphic display of the data used the last day of the week rather than the first day of the week so cumulative data were representative of the sum of weekly data up to that date. While the data are not continuous, line graphs were used for display purposes to facilitate comparative display of the data.

Weekly harvest, effort and catch-effort (CE) data for the Estuary Area and Middle Klamath Area were plotted to evaluate any obvious patterns that could be further evaluated as fish abundance metrics. Weekly values of harvest, effort or CE data were graphed as well as cumulative values of harvest and effort throughout the period. Additionally, proportions and cumulative proportions of each year's harvest and effort were plotted.

Differences in the timing of harvest between the Estuary Area and the Middle Klamath Area were examined to determine potential patterns that could be used to infer run timing into the Middle Klamath Area by the harvest in the Estuary Area. This would allow for flow augmentation to be linked to the fall-run Chinook salmon abundance in both the Estuary and Middle Klamath areas. Yurok Tribal biologists expressed concerns with using the Middle Klamath data for a fish metric because the fishing effort is typically lower during the early part of the run, especially when a commercial fishery is occurring, so the data may not be adequate as an indicator for fish abundance.

The relationship between effort and CE were investigated to see if these variables could be used as indicators of abundance. Ideally, CE data could be used as an indicator of the abundance of fish in the Estuary Area; but due to the intensity of the fishery and the variable removal (via harvest and upstream migration) and addition (via fish moving into the Estuary from the ocean) of fish this in not likely the case. It was speculated that increases in effort could indicate when the large numbers of fish were in the estuary due to fishers reacting the presence of fish or that effort could influence CE, possibly decreasing it with the increase in effort. Harvest was not evaluated for these relationships because of the lack of independence between harvest and effort and harvest and CE since these variables are used to calculate harvest (Equation 1):

$$Harvest_t = \sum_{i=1}^{7}(Effort_i * CE_i) \qquad \text{Equation 1}$$

…where harvest in week *t* is estimated by summing the daily harvest estimates generated by multiplying the effort on day *i* by the catch-effort (CE_i) on day *i*.

The object of the fish metric is to initiate fall flow augmentation so increased flows in the lower Klamath River coincide with large numbers of fish exiting the Estuary and migrating into the lower Klamath River. Following the graphical display of data, it appeared that a fish abundance metric could be developed by looking at the large and abrupt increases in harvest or inflection points of cumulative harvest that occur in the Estuary Area fishery.

The cumulative harvest estimates from all years display a very similar pattern: (1) a period of relatively little harvest before the population of returning salmon arrive en masse, (2) a sharp increase in the amount of harvest that continues for several weeks, and (3) a plateau in harvest during the latter part of the harvest season. Being able to estimate when the cumulative harvest curves begin their quick acceleration would allow us to also estimate when the bulk of the population of returning adult salmon were about to be entering the river. Given the common shape-characteristics of the cumulative harvest curves under consideration, we opted to estimate the beginning of the accelerated arrivals of adults using break-point analysis, applying the model and estimation techniques of Muggeo (2003). Rather than considering a year's cumulative harvest as a single curve, we instead considered each as a set of continuous piece-wise linear segments. Each segment potentially has a unique slope, and changes in slopes occur at break-points. For example, consider the segmented relationship between a response variable (Y) and a single, continuous, explanatory variable (X) with a single break-point (ψ). A model for the mean of Y is:

$$E(Y) = \beta_0 + \beta_1 X + \beta_2 (X - \psi)_+$$

where the "+" is a logical expression indicating a 1 if $X - \psi > 0$, and and 0 if not, According to this parameterization, the slope of the relationships between Y and X is β_1 if $X \leq \psi$ and $(\beta_1 + \beta_2)$ if $X > \psi$. While this model can describe the relationship between the response and explanatory variable, the likelihood is not differentiable at the break points. To combat this issue, likelihood estimation is carried out under an iterative procedure based on a first-order Taylor's expansion (Muggeo, 2003).

Results

Estuary Area – Harvest, Effort and Catch-Effort

Harvest, effort and CE data in the Estuary Area show some general trends among the years evaluated but also substantial variability (Figure 5). Harvest data exhibit some distinct peaks in mid-August and early September, possibly coinciding with the peaks of Klamath origin and Trinity origin fish entry into the estuary. The 2007 data are unique in that the run appeared to enter the river later than in the other years. Fishing effort typically has one peak but it occurs over a five week period from early August through early September. The large CE values that occur in July and October can be attributed to low effort inflating the CE estimates. CE was variable with no consistent trend when the analysis t was limited to August and September, with peaks occurring in late August to mid-September (Figure 6). Data on the proportion of harvest and proportion of effort also showed the similar trends in the timing of peak harvest and effort and the variability throughout the season (Figure 7).

Cumulative and cumulative proportion of harvest and effort showed the same general trends in peaks and timing of harvest and effort data although the relative trends from week to week can be distinguished by changes in the slope of the line segments (Figure 8 and 9). The cumulative proportion of harvest in the Estuary Area show that three years (2001, 2003, and 2009) exhibited similar trends in cumulative harvest through late August while the cumulative harvest line is shifted earlier for 2002 and later for 2007. The later run timing observed in 2007 may have been due to the run being composed of primarily Trinity origin fish (61% based on the distribution spawners) which tend to enter the river later and also the development of a berm at the mouth of the Klamath River which is believed to hinder the migration of salmonids into the estuary (Hilliemier pers. com). The later run timing of fall Chinook salmon was also observed by Strange (2008) and a protracted spawning duration in the upper mainstem Klamath River (Gough, pers. com.).

Middle Klamath Area – Harvest, Effort and Catch-Effort

Harvest and CE in the Middle Klamath Area were highly variable in magnitude and timing of peaks (Figure 10). Effort was relatively stable throughout the period evaluated except for July and the large peaks in August and September in 2009. The proportion of harvest and proportion of effort data exhibited high variability throughout the season (Figure 11).

Cumulative harvest indicates that the pattern of harvest was similar up to mid-September in three years (2001, 2002 and 2003) but increased earlier in 2009 and later in 2007 (Figure 12). Cumulative effort showed similar trends except in 2002 when effort was substantially greater than in other years. Cumulative proportion of total harvest shows that increase in harvest in the Middle Klamath Area was variable, occurring from mid-August to mid-September (Figure 13).

Timing of Harvest in the Estuary and Middle Klamath Areas

The Estuary and Middle Klamath areas show similar trends in cumulative proportion of harvest within years, with harvest occurring in the Estuary Area earlier than in the Middle Klamath Area as is expected (Figure 14). Trends are variable across years, with 2001 exhibiting a desirable trend of almost parallel lines while the lines were virtually the same in 2009 (Figure 15). However, sufficient variability in these data preclude using Estuary Area cumulative harvest data to predict when harvest would be expected to increase in the Middle Klamath Area, which would be used as a surrogate for fish abundance as a trigger for implementing fall flow augmentation.

Trends of Catch-Effort and Effort in the Estuary Area in August and September

The relationship between CE and effort was highly variable when data from all years were analyzed together (Figure 16). CE values had greater variability at values of effort below 2,100. Examining these data for individual years, CE was generally low when effort was high and vise-versa in 2001, 2007, and 2009 (Figure 17). This inverse pattern was not evident in 2002 and 2003 data. Only CE and effort data from 2001were significantly correlated (r=-0.84, p=0.005), with data from 2002 exhibiting a positive relationship (r=0.64, p=0.065, Table 1). Since the relationships between CE and effort were generally not significant and the relationships were not consistent across years, these data were not further evaluated in developing a fish-based metric for guiding fall flow augmentation.

Changes in Trends of Weekly Harvest as a Fish Metric – Break-Point Analysis

Though several break-points exist in the Estuary Area cumulative harvest data for each year, we focused on the estimates of the break-points where cumulative harvest dramatically increases (Figure 18). Estimates of these break-points ranged from 5.3 to (2002) to 8.5 (2007, Table 2). Three of the break-points (2002, 2003, 2009) occur when cumulative harvest transitions past 5,000 fish while the other two occur the following week as cumulative harvest transitions past 10,000 fish (Table 3). Despite variation in the weeks of the harvest season for which these break points are estimated and variation in the total amount of harvest from year to year, the relative consistency of the break point estimates and the similarity of the general shape of the cumulative harvest curves suggest using this methodology for identifying the fish metric to inform fall flow augmentation is creditable.

Estimation of Fish-Metric for Triggering Fall Flow Augmentation

The break-point analysis provided estimates of transition points along the cumulative harvest relationships for each year (Table 2). Since the data were summarized by week, estimates for the break points were rounded to the nearest integer and the cumulative harvest for that week (t) and the following week ($t+1$) were averaged. Calculating the mean for the rounded break-point estimate (t) and the following week ($t+1$) was done because the break-point estimates the transitional point between the shallow sloped early period and the adjacent period of quickly accelerating harvest. The estimated cumulative harvest for each year using the above procedures were then averaged to estimate the recommended cumulative fish metric,

Using this procedure, a cumulative harvest of Chinook salmon in the Estuary Area of the Yurok Tribal fishery of 7,000 (rounded to the nearest 100) fish, with cumulative counts starting on July 4, would trigger the initiation of fall flow augmentation.

Recommendations:

Fish Metric

- Use of a fish metric entails significant coordination among the Yurok Tribe who collect the fishery data and the federal managers that will be implementing the fall flow augmentation.
- Once the cumulative harvest of Chinook salmon in the Estuary Area by the Yurok Tribal fishery exceeds 7,000 adults fall flow augmentation should commence. The releasing of fall flow augmentation does not need to wait until the end of the sampling week.
- The tallying of cumulative harvest of Chinook salmon in the Estuary Area commences on July 4.
- The 2013 Yurok Tribal commercial fishery in the estuary will start on Aug 10.

Initiation of Fall Flow Augmentation if Fish Metric Is Not Met

- Fall flow augmentation should be initiated by August 22.if the fish metric is not triggered. The reasoning behind this date is:
    - The development of this metric in a short time period has precluded an in-depth evaluation of other datasets, including temperature and flow data, which may have influenced harvest and effort data in the Estuary and Middle Klamath areas, therefore the metric may not be conservative enough to ensure that flow augmentation will occur.
    - It should be anticipated that there will be large numbers of fall Chinook salmon in the Estuary Area due to the large projected inriver run, with expected greater accuracy than the 2012 projection, and the expected greater proportion of Klamath fall Chinook salmon stocks (Shasta River, Iron Gate Hatchery, Bogus Creek, and the mainstem Klamath River) which tend to enter the estuary and river earlier than Trinity stock.
    - In four of the five years (80%) large numbers of fish have been harvested in the estuary area by this date and harvest in the Middle Klamath Area starts to increase in the following weeks, suggesting that the upstream migration of the run has commenced.
    - The second week ($t+i$), ending on August 21, used in estimating the fish metric trigger occurs immediately before August 22 in three of the years (2001, 2003, and 2009) and eight days before August 22 in 2002.

Ending of Fall Flow Augmentation

- Fall flow augmentation should be continued through September 21 and augmentation can end after this date if mean daily water temperature in the lower Klamath River at RKM 13 remained below 23°C (TRRP 2012). If mean daily water temperature remains above 23°C then flow augmentation should continue to meet a minimum of 2,800 cfs in the lower Klamath River through the end of September. After this date, mean water temperature in the lower Klamath River is generally decreasing (Figure 19) due to seasonal changes and most of the fall-run Chinook salmon have commenced their upstream migration based on harvest data from the Middle Klamath Area (Figure 12).

Future Efforts

- Define monitoring needs to better inform future fall flow releases.
- Further evaluate data discussed in this document, and include lower Klamath River creel census data from CDFW as well as data from upstream locations such as the harvest in the Hoopa Tribal fishery, Willow Creek and Shasta River weirs, and Iron Gate and Trinity River hatcheries.
- Incorporate the Trinity River into the RBM10 water temperature model that has been developed for the Klamath River to better predict shifts in water

temperatures in the lower Klamath River that would result from flow releases from the Iron Gate or Lewiston dams.

- Develop the upstream migration model that allows water temperatures and flow releases from both the Trinity and the Klamath to be adjusted and tracks the associated response of upstream migrant adults, such as that being proposed by the Service by the Stream Salmonid Simulator of S^3 Model. This model needs to include fish disease component that focuses on Ich and columnaris.
- Allow ample time to conduct these analyses to inform future years in advance of an "emergency" situation.
- Fund a more complete analysis or model that can be used to make fall flow management decisions.

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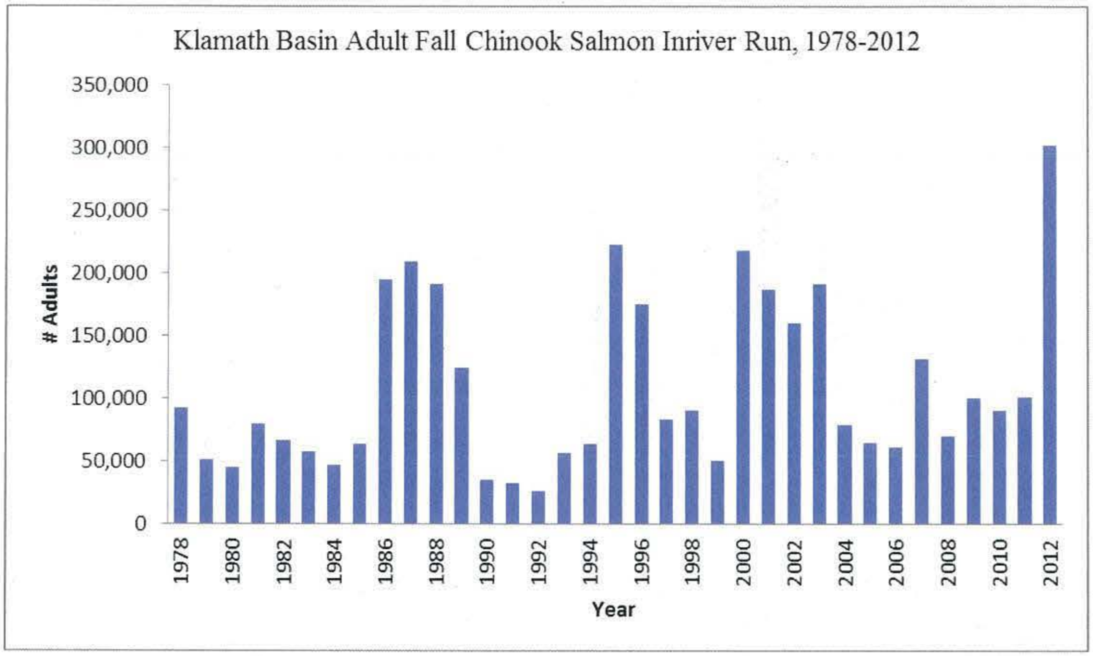


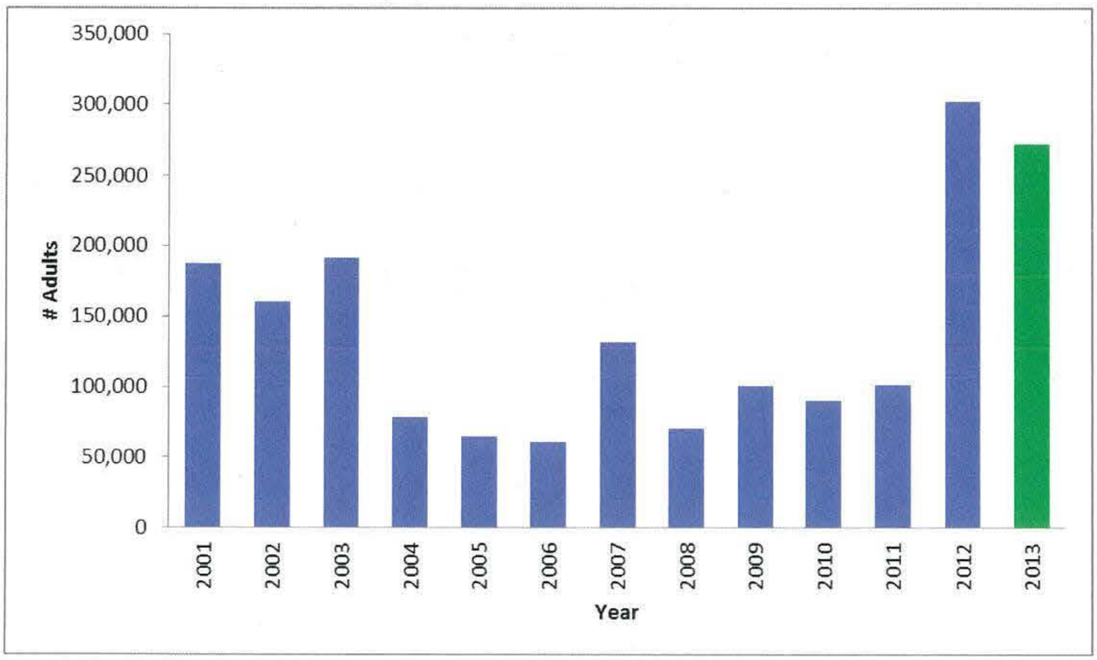


Figure 1. Klamath River adult fall-run Chinook salmon inriver run 1978-2012 (upper) and inriver run for the period 2001-2012 and 2013 projected (green bar) inriver run (lower).

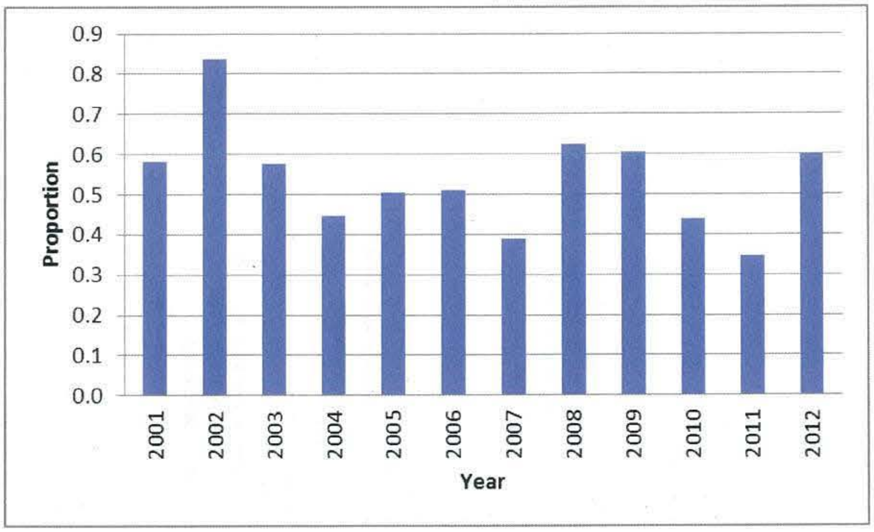


Figure 2. Proportion of Klamath Basin adult fall-run Chinook salmon spawners in the Klamath River, 2001-2012. Klamath River spawners include returns to Iron Gate Hatchery, the mainstem Klamath River and Klamath River tributaries above the confluence of the Klamath and Trinity rivers.

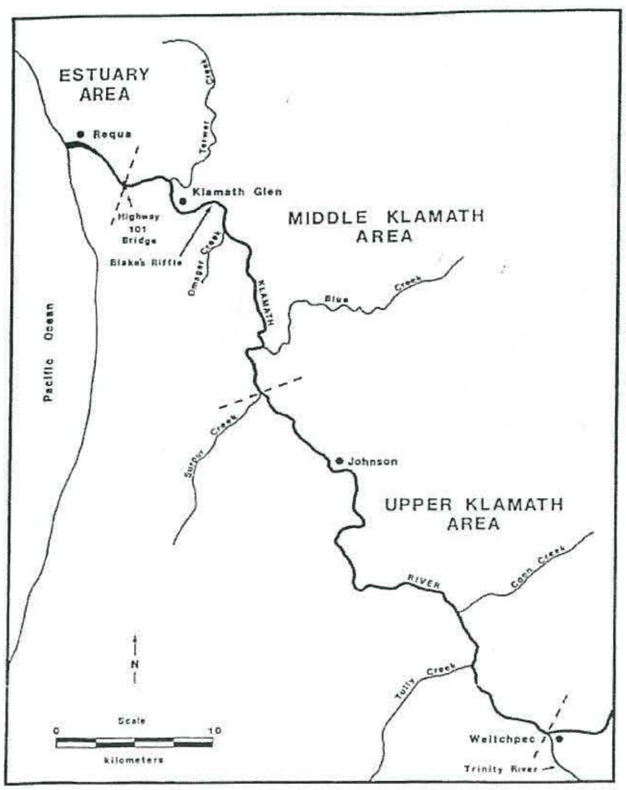


Figure 3. Map of the Yurok Reservation on the lower Klamath River showing harvest monitoring areas.

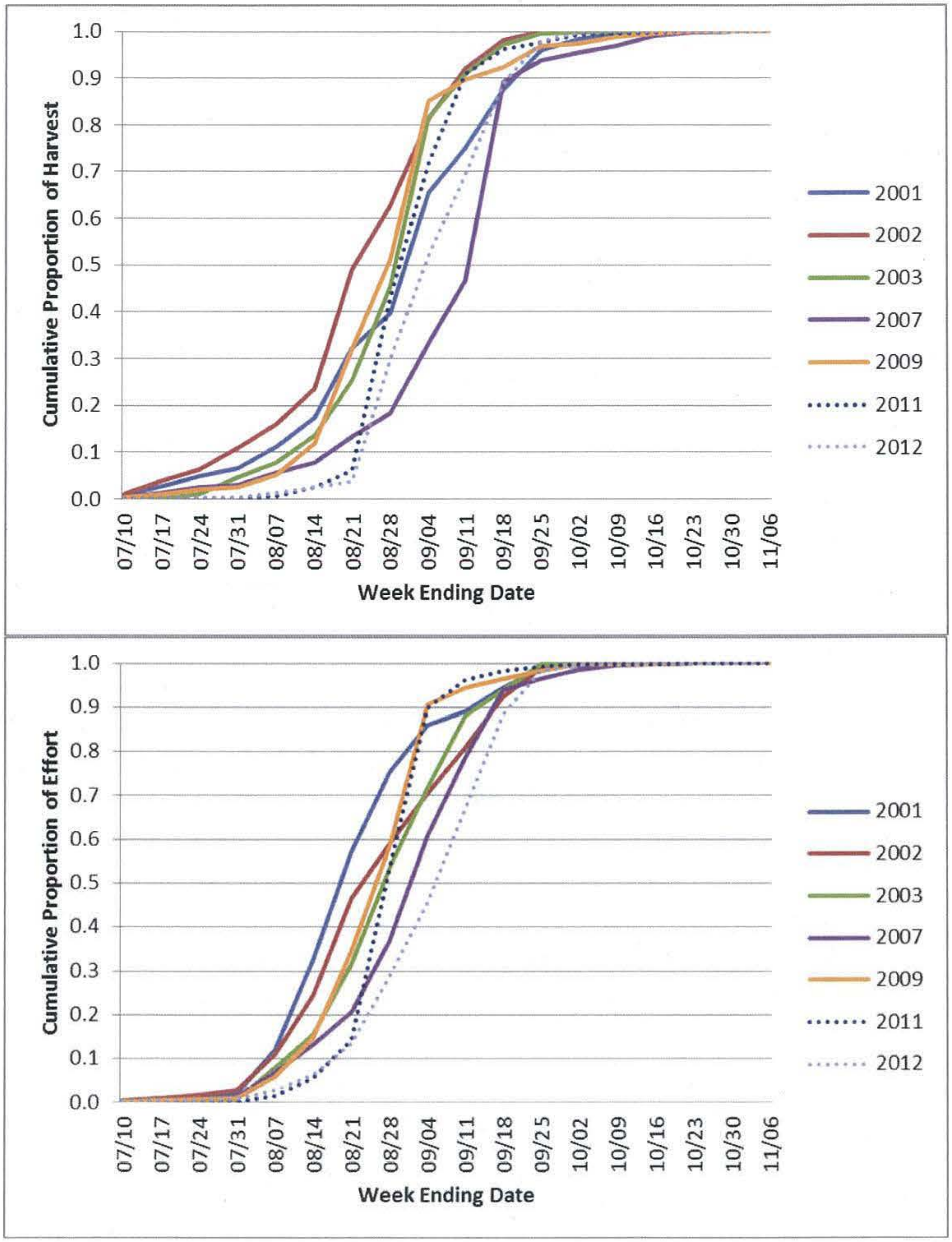


Figure 4. Cumulative fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2012. Lines for 2011 and 2012 are dotted to show the influence of the starting date of the commercial fishery on harvest and effort.

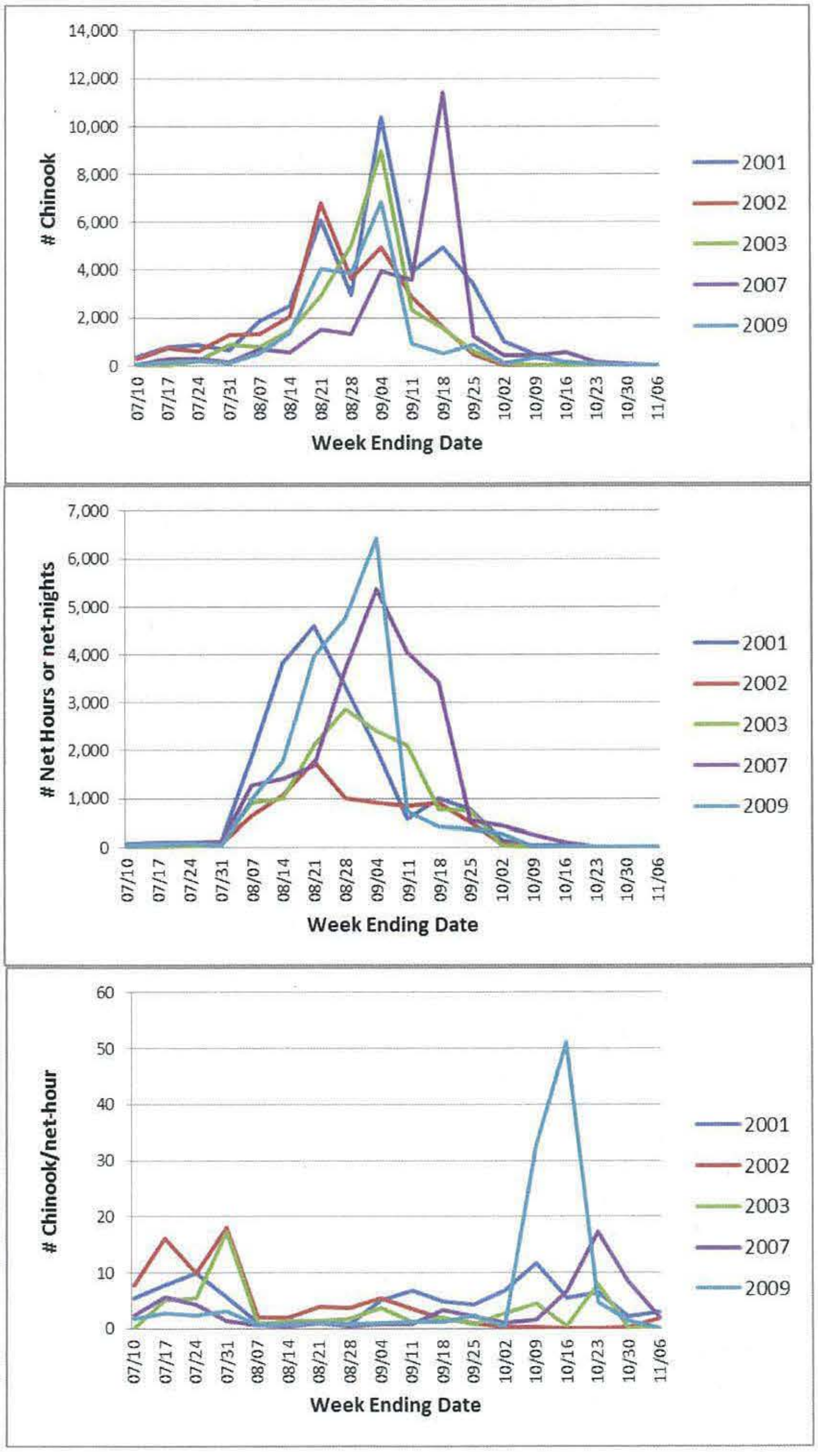


Figure 5. Weekly fall-run Chinook salmon harvest (upper), fishing effort (middle), and catch-effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

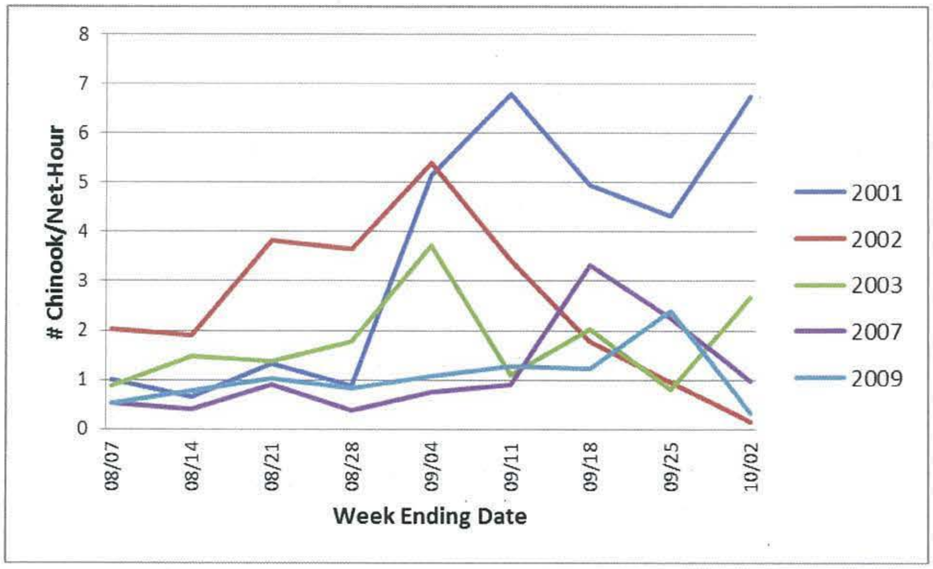


Figure 6. Weekly fall-run Chinook catch-effort for the Yurok Estuary Area fishery for August and September, 2001-2003, 2007, and 2009

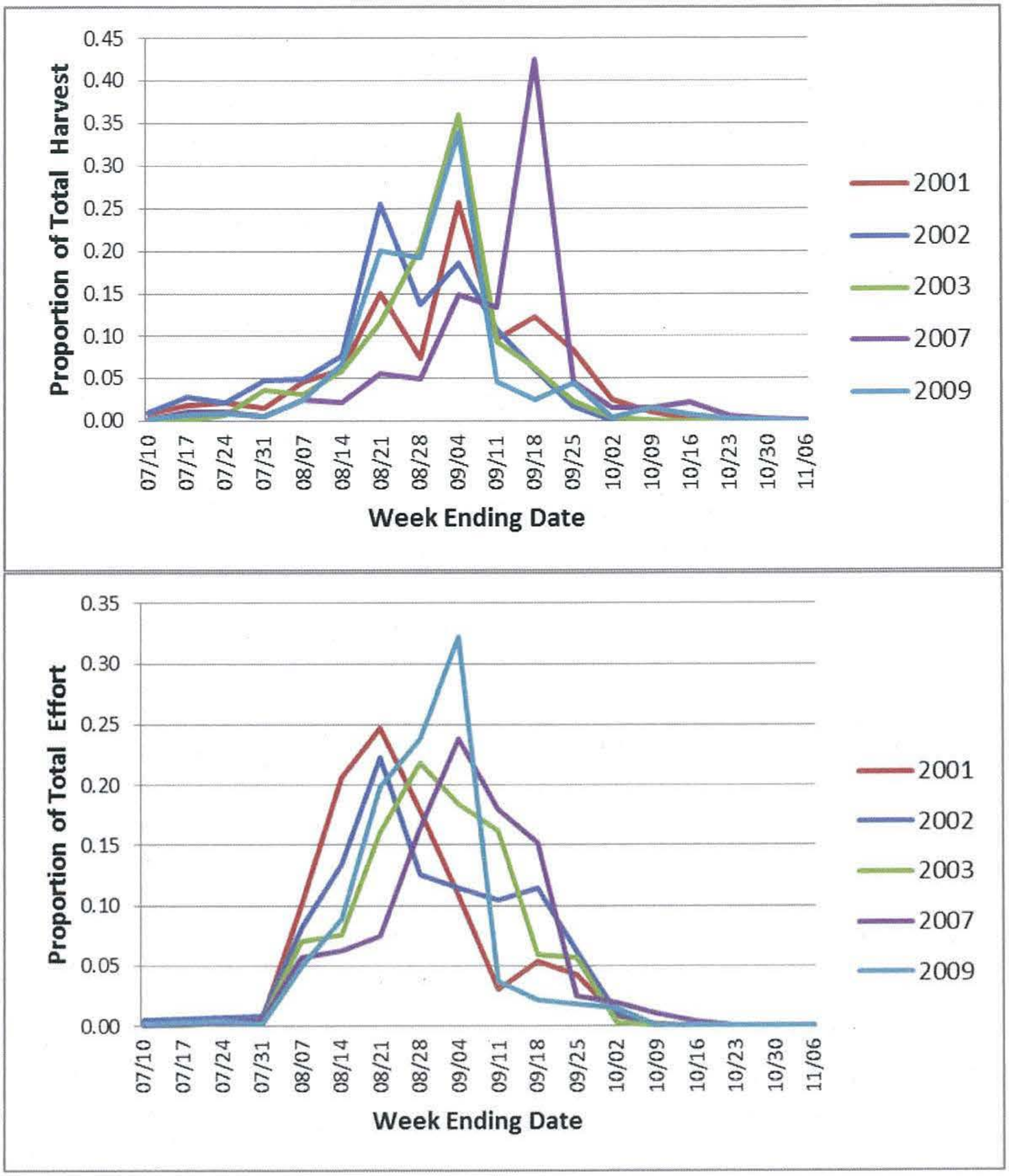


Figure 7. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

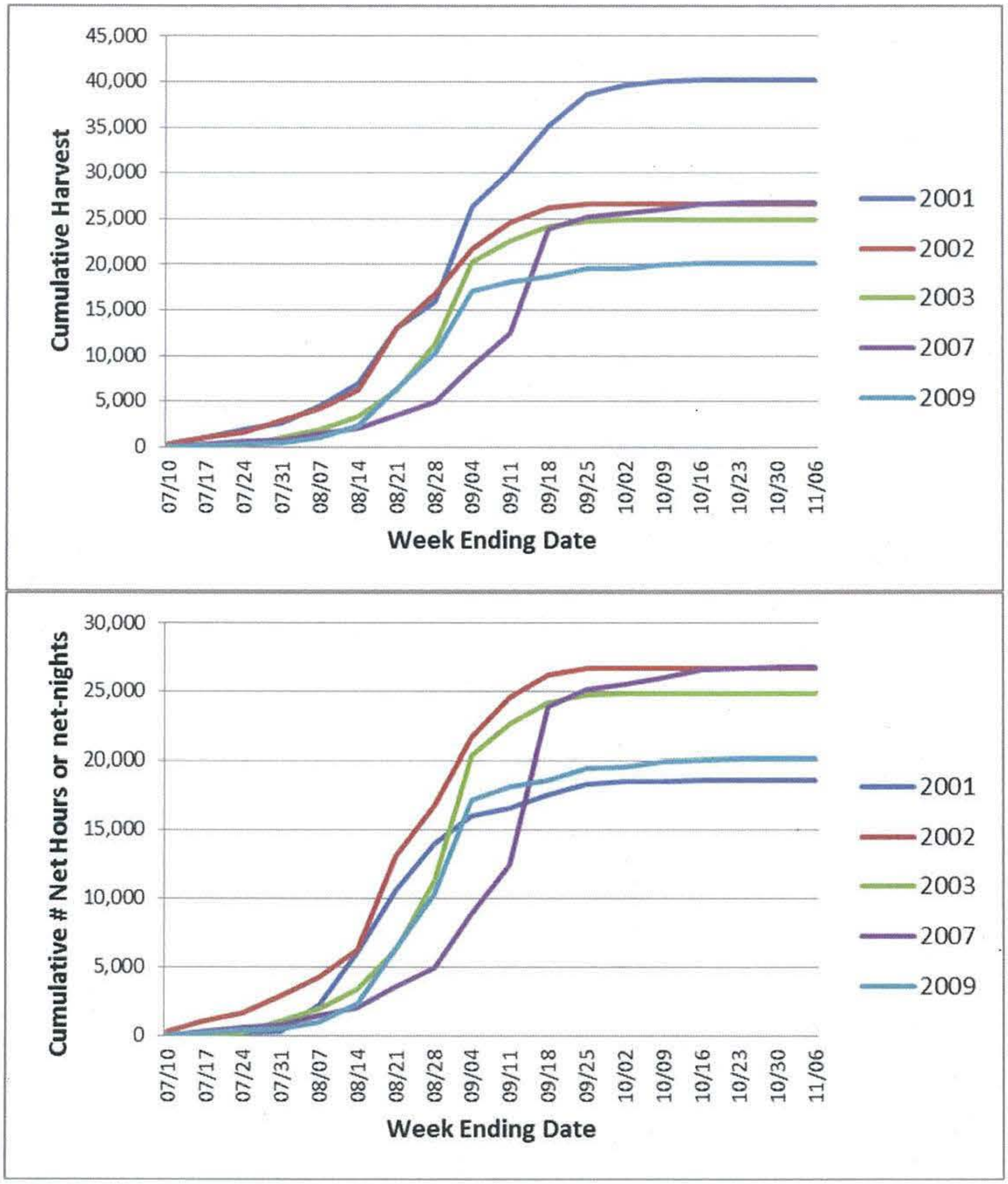


Figure 8. Cumulative weekly fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

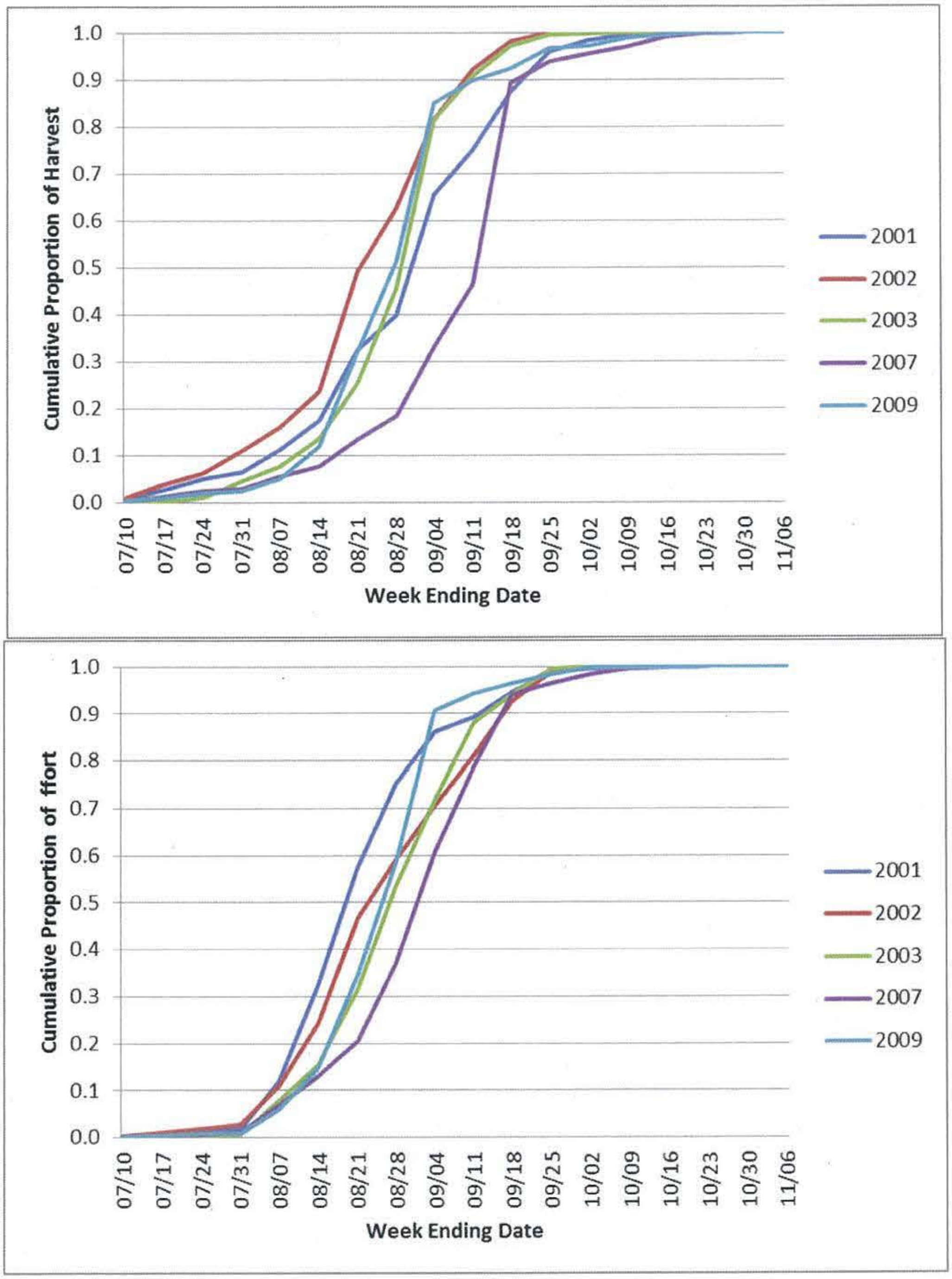


Figure 9. Cumulative proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

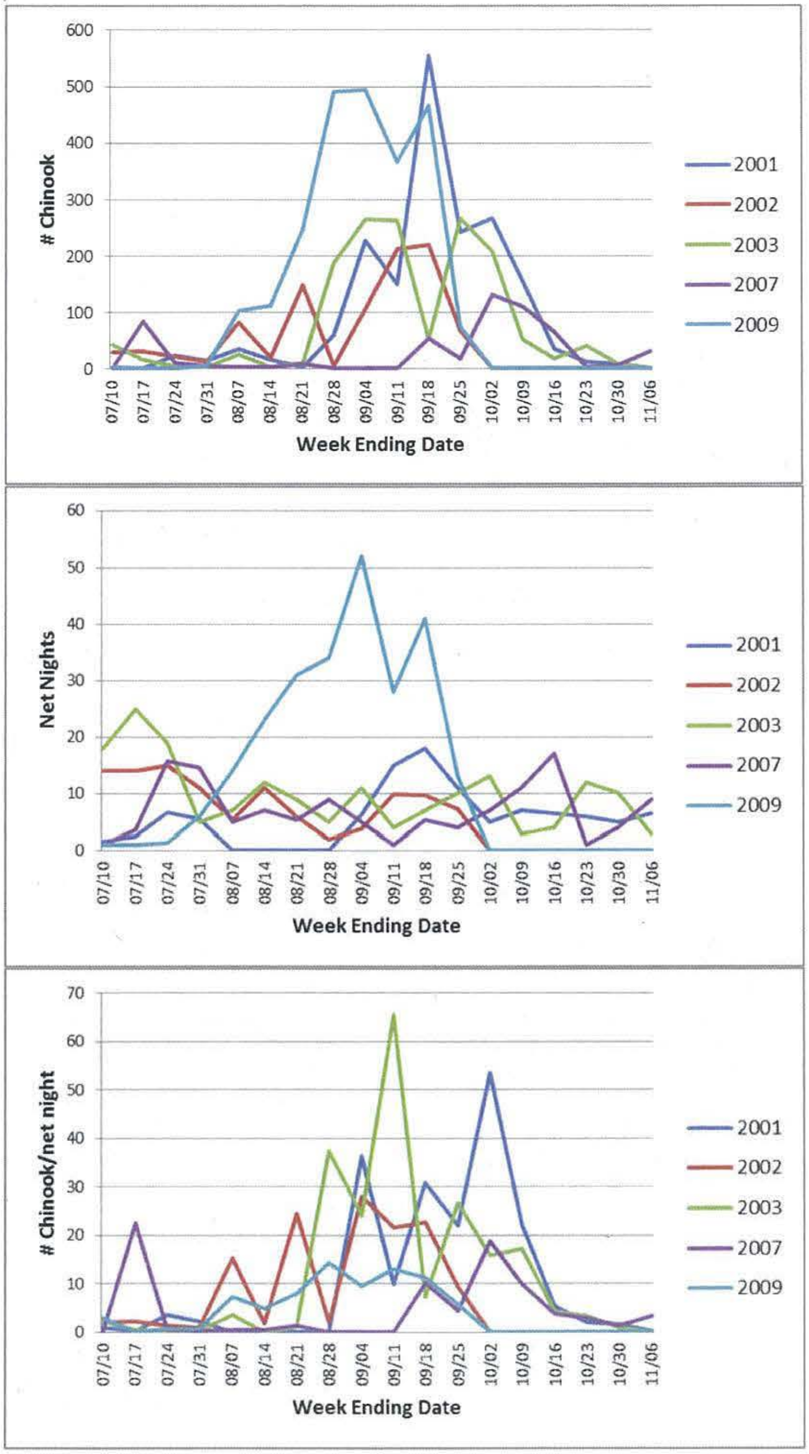


Figure 10. Weekly fall-run Chinook salmon harvest (upper), fishing effort (middle), and catch-effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

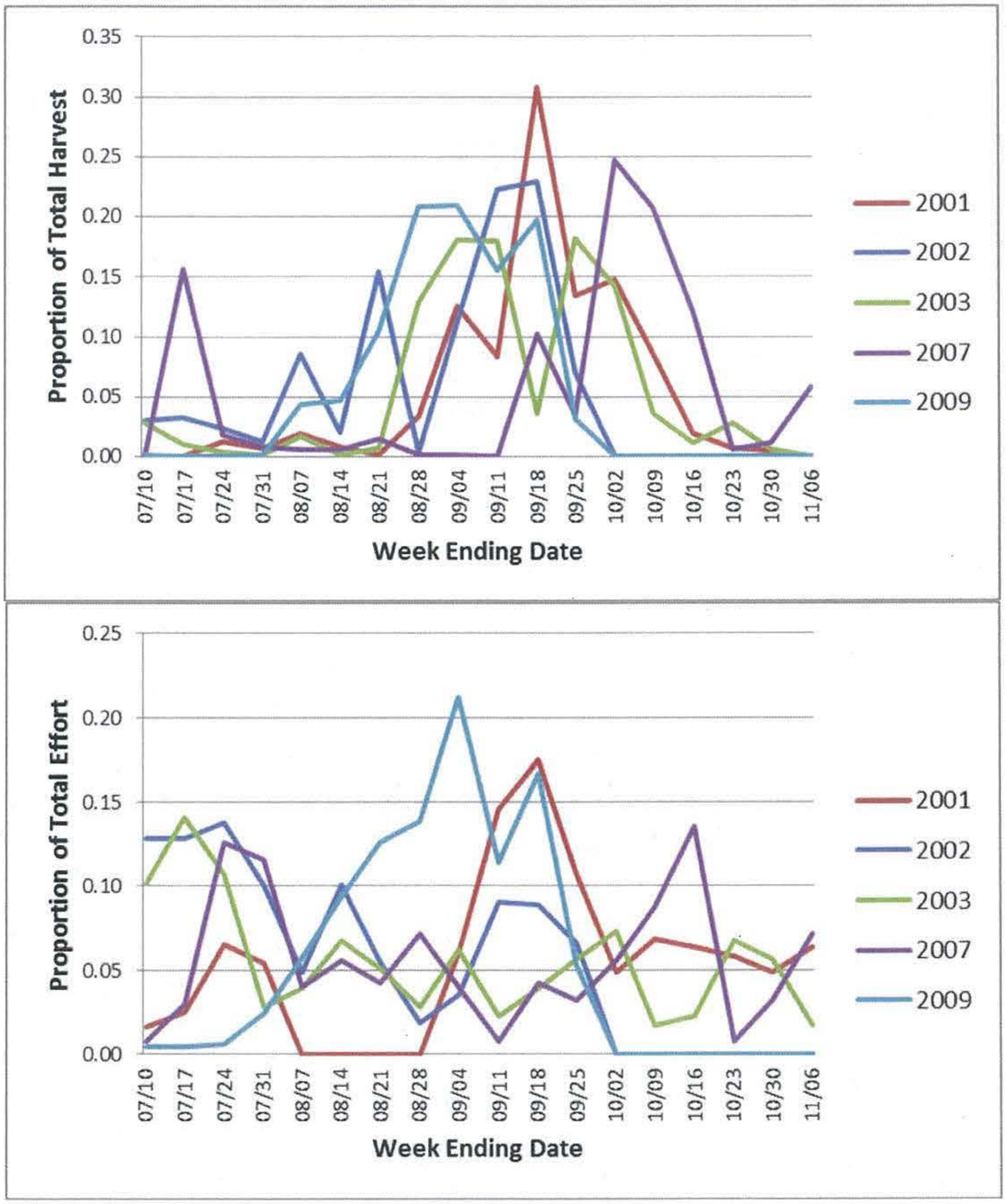


Figure 11. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

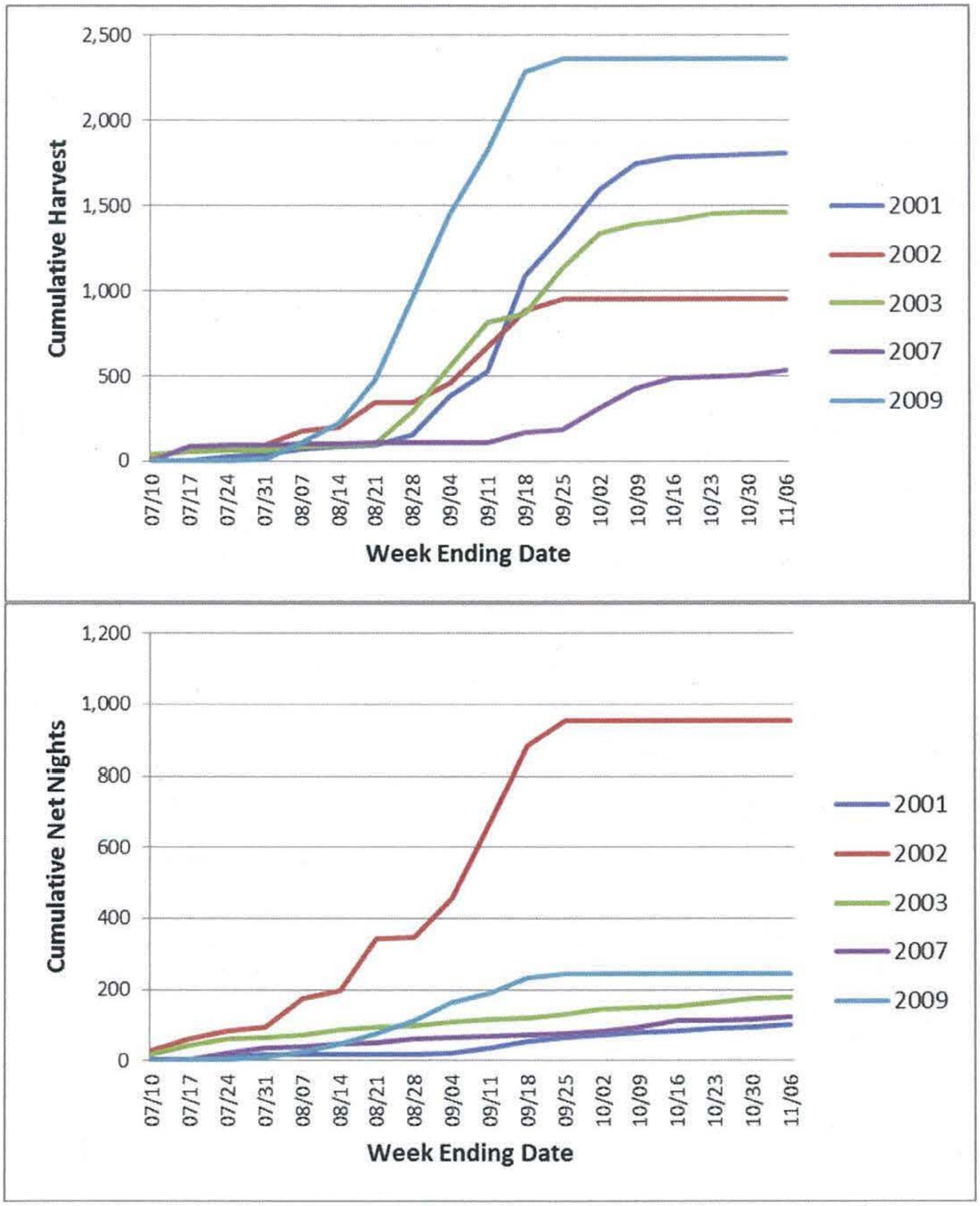
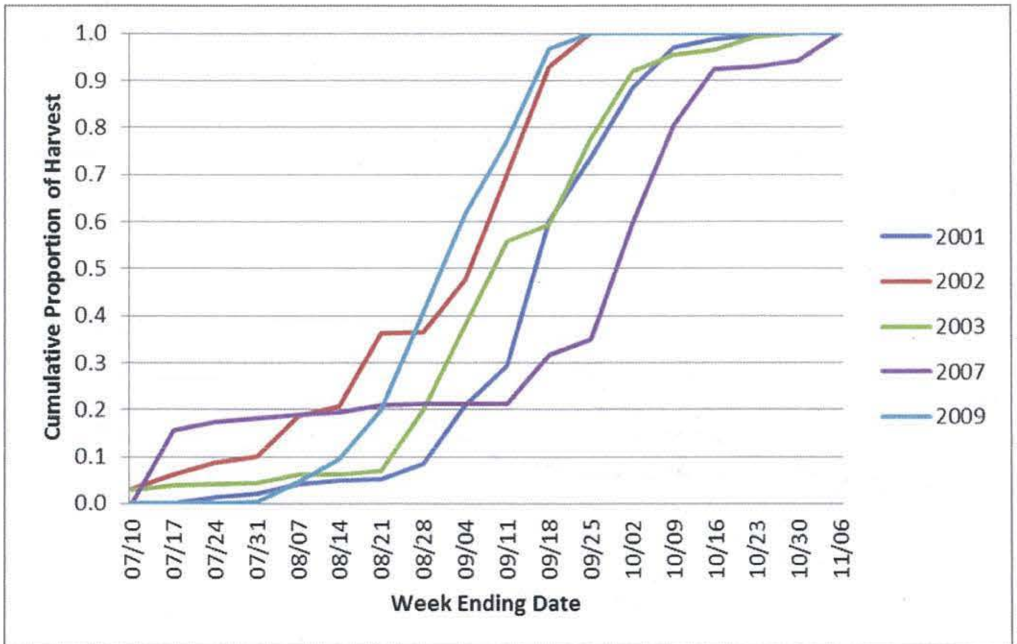


Figure 12. Cumulative weekly fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.



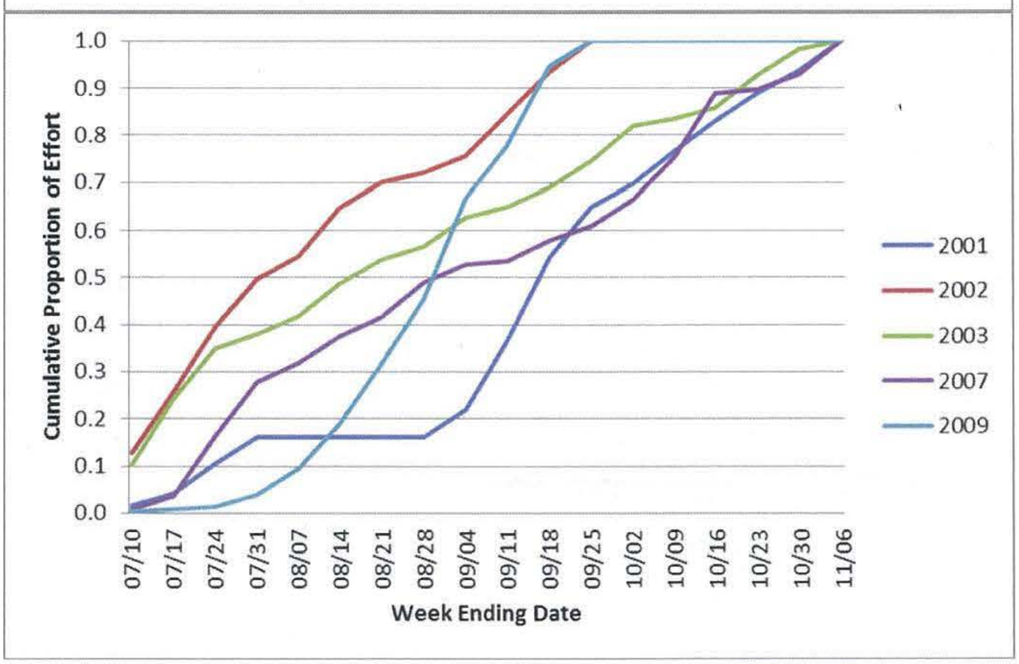


Figure 13. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

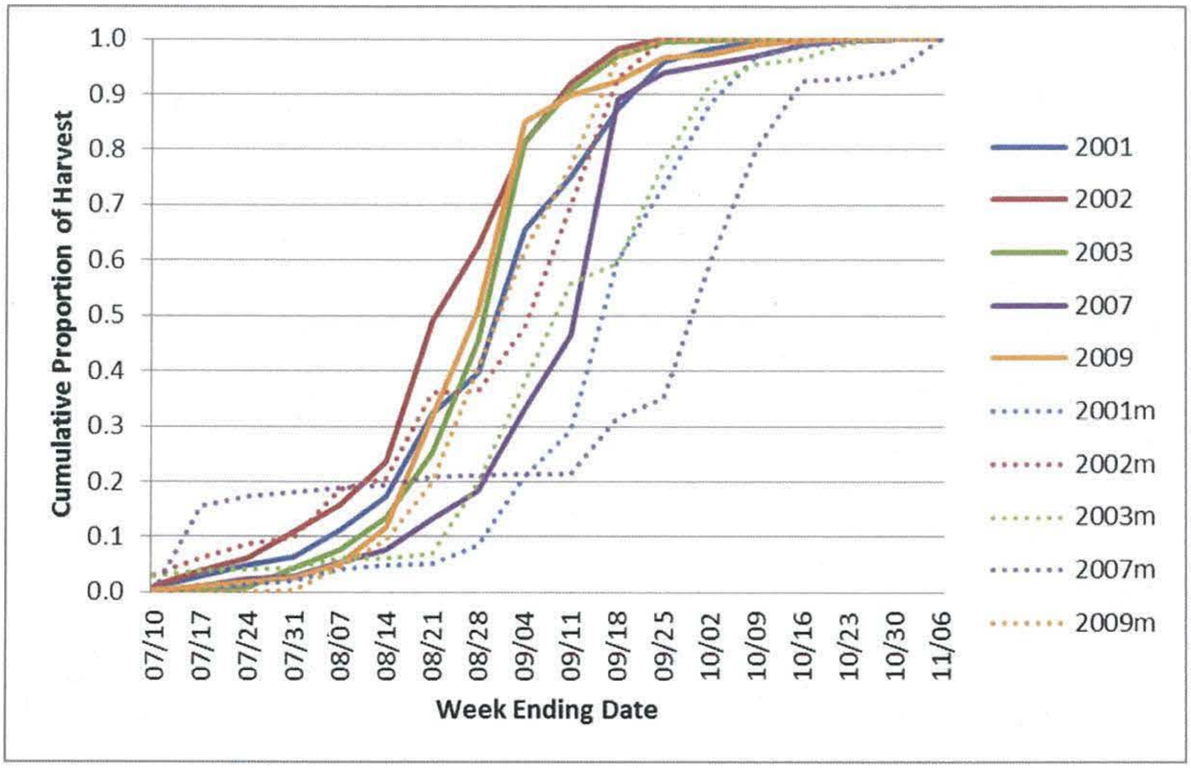


Figure 14. Cumulative weekly fall-run Chinook salmon harvest in the Estuary Area (solid lines) and Middle Klamath Area (dotted lines) of the Yurok fishery, 2001-2003, 2007, and 2009.

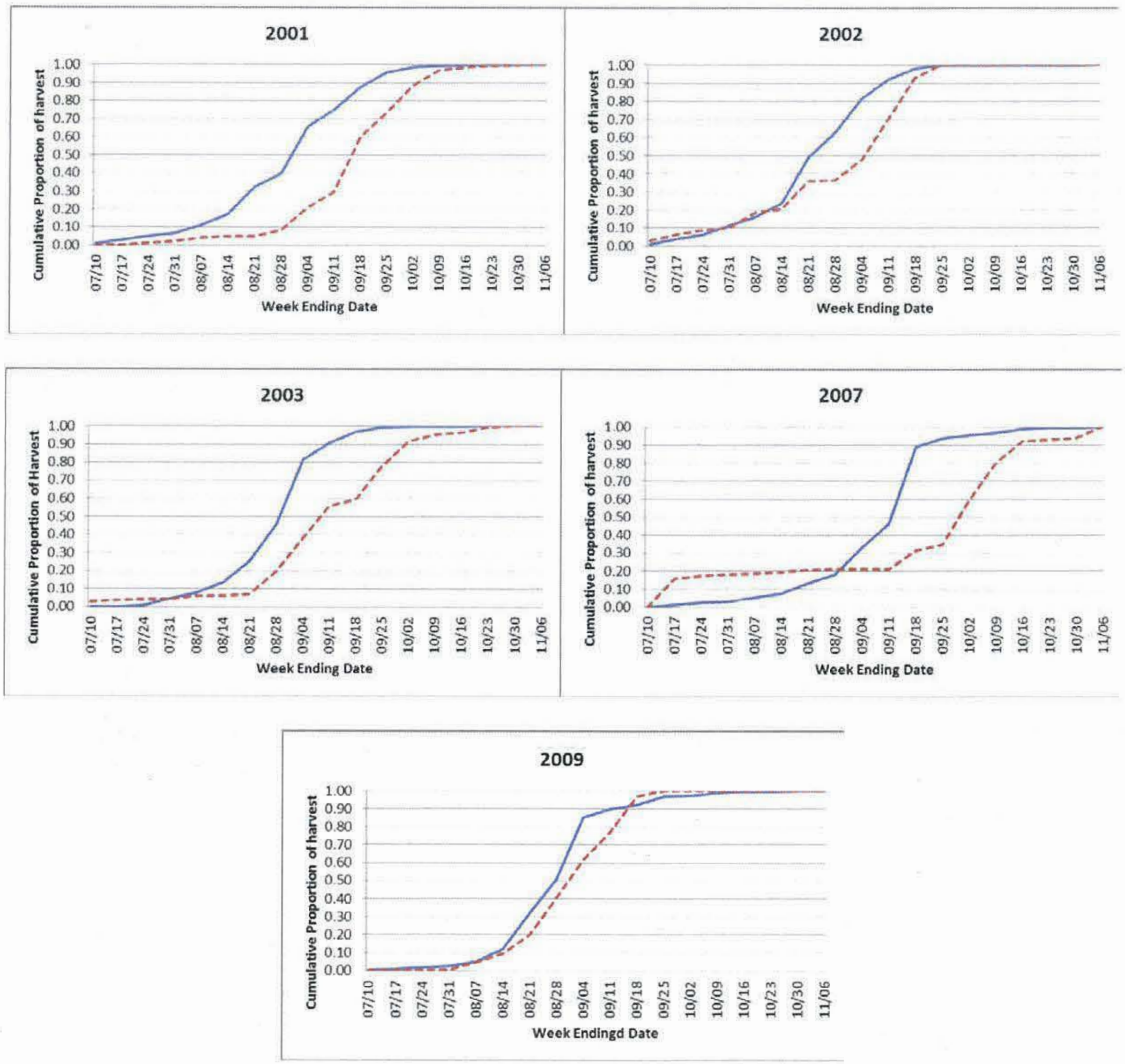


Figure 15. Cumulative weekly fall-run Chinook salmon harvest in the Estuary Area and Middle Klamath Area of the Yurok fishery, for years 2001-2003, 2007, and 2009.

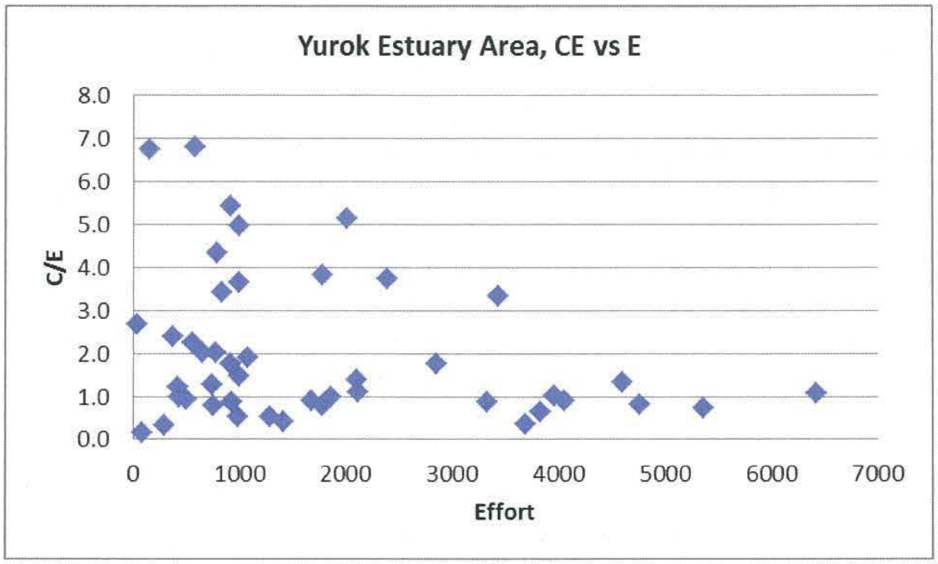


Figure 16. Weekly effort and catch-effort (CE) of fall-run Chinook salmon in the Estuary Area of the Yurok fishery and effort vs. CE for 2001-2003, 2007 and 2009. Data were limited to weeks of August 1 through September 26 when effort (net hours) and catch effort (# fish/net hour) were comparable across years.

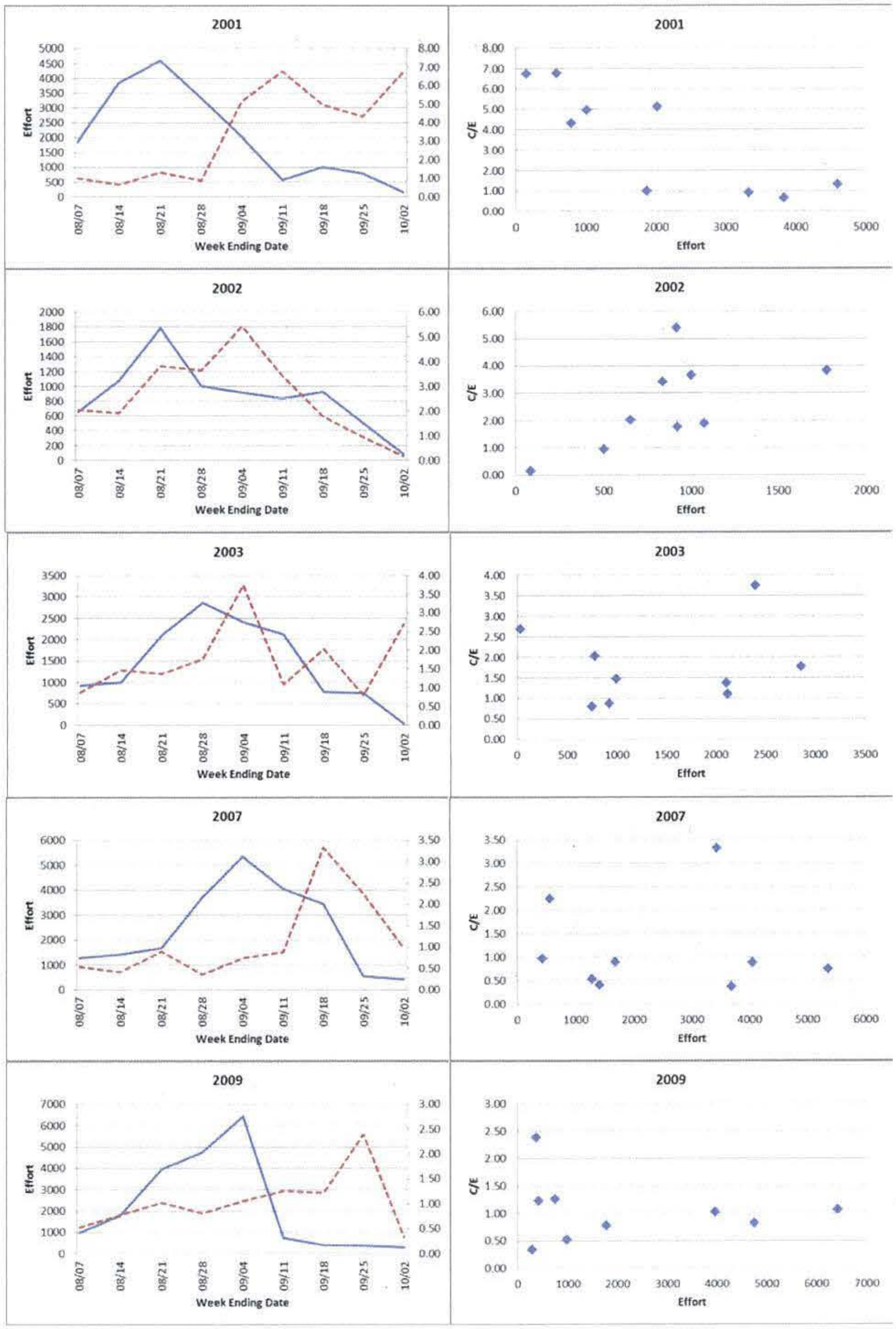


Figure 17. Weekly effort and catch-effort (CE) of fall-run Chinook salmon in the Estuary Area of the Yurok fishery and effort vs. CE for by year, 2001-2003, 2007 and 2009. Data were limited to weeks of August 1 through September 26 when effort (net hours) and catch effort (# fish/net hour) were comparable across years.

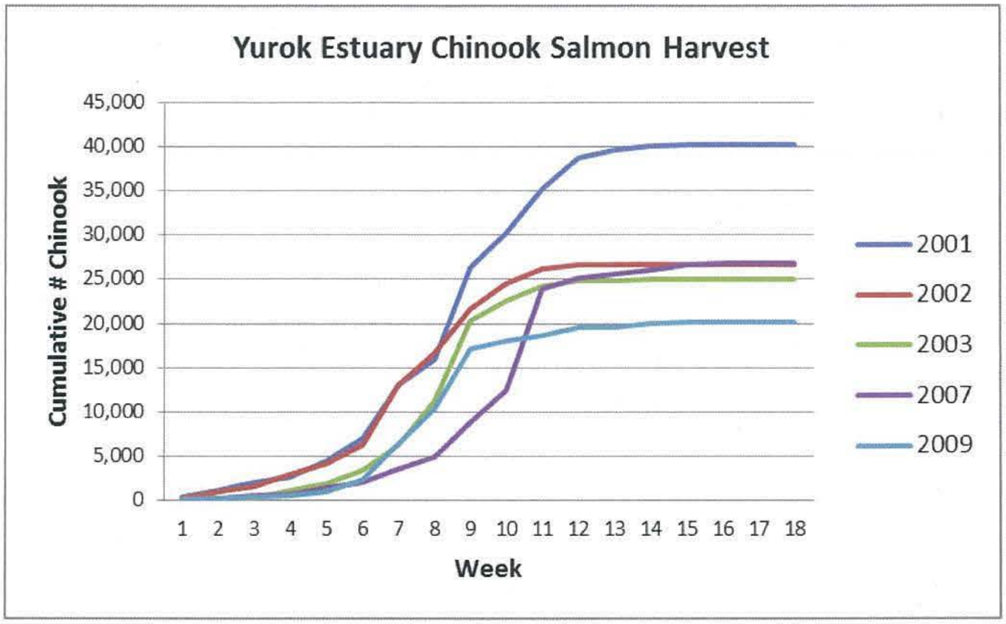


Figure 18. Cumulative harvest of fall-run Chinook salmon in the Estuary Area of the Yurok fishery, 2001-2003, 2007 and 2009.

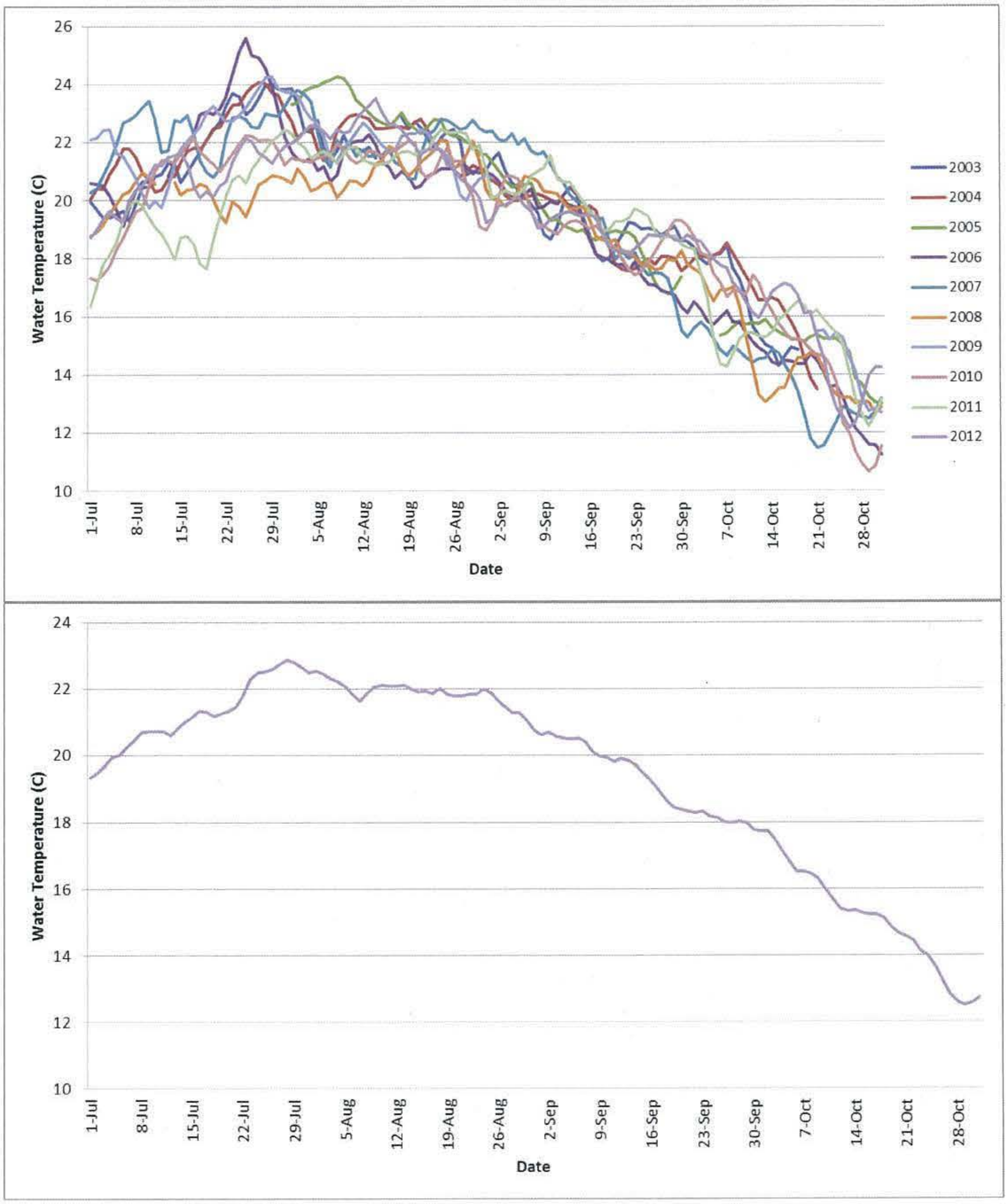


Figure 19. Mean daily later temperature in the lower Klamath River (rkm 13) for 2003-2012 (upper) and mean for all years (lower).

Table 1. Correlation coefficients (r) and significance values (p) for correlation analysis between effort and catch-effort in the Estuary Area fishery by year.

Year	r	N	p
All	-0.28	45	0.062
2001	-0.84	9	0.005
2002	0.64	9	0.065
2003	0.14	9	0.727
2007	-0.04	9	0.927
2009	-0.14	9	0.715

Table 2. Break-point estimates with lower and upper 95% confidence interval bounds.

Year	Break Point	Lower	Upper
2001	5.6	5.1	6.2
2002	5.3	4.9	5.8
2003	5.5	4.6	6.4
2007	8.5	8	9
2009	6.2	5.9	6.6

Table 3. Cumulative harvest of Chinook salmon in the Estuary Area by week, 2001-2003, 2007 and 2009. Highlighted cells were values used to calculate the fish metric. (Mean = 7,047)

Week #	First Day of the Week	Last Day of the Week	Year				
			2001	2002	2003	2007	2009
1	07/04	07/10	358	294	0	58	66
2	07/11	07/17	1,124	1,057	35	334	204
3	07/18	07/24	2,007	1,663	233	638	382
4	07/25	07/31	2,643	2,927	1,129	785	508
5	08/01	08/07	4,500	4,246	1,930	1,472	1,025
6	08/08	08/14	6,985	6,299	3,389	2,053	2,398
7	08/15	08/21	13,045	13,095	6,282	3,570	6,439
8	08/22	08/28	15,995	16,752	11,339	4,917	10,319
9	08/29	09/04	26,361	21,718	20,315	8,890	17,171
10	09/05	09/11	30,270	24,578	22,630	12,495	18,111
11	09/12	09/18	35,230	26,201	24,204	23,927	18,629
12	09/19	09/25	38,626	26,672	24,796	25,178	19,529

Appendix D. Planned monitoring components for Klamath Basin Adult Fall Chinook Salmon Migration 2013.

1. Adult Chinook Salmon Pathology Monitoring (Yurok Tribe)
   - Mid-August through Mid-October 2013
   - Fish will be captured with gill nets from Techtah Creek rkm 38 to Blue Creek rkm 26
   - Goal of 30 adult fish sampled per week
   - External examination of skin and gills for indication of columnaris and ich infections along with digital imaging and video recordings of ich inside gill arches.
   - Conducted every year since 2003
   - USFWS Pathologist Scott Foott on call
   - Further training for field crews in 2012 with CANFHC

2. Harvest Monitoring/Adult Salmon Abundance
   - Yurok Tribal daily count of fish sold in commercial harvest
   - CDFG weekly summaries of creel surveys of sport catches
   - Summer snorkel surveys of thermal refugia at the mouth of Blue Creek (YTFP)
   - Weir summaries from CDFG

3. Water Temperature and Flow
   - USGS site 11530500 Klamath River near Klamath, CA: http://waterdata.usgs.gov/ca/nwis/uv/?site_no=11530500&PARAmeter_cd=00065,00060
   - Yurok Tribal Environmental Program real time monitoring: http://exchange.yuroktribe.nsn.us/lrgsclient/stations/stations.html
   - California Nevada River Forecast Center advanced hydrologic prediction for USGS site 11530500 Klamath River near Klamath, CA http://www.cnrfc.noaa.gov/espTrace.php?id=KLMC1

4. Coordination and Response
   - Klamath Fish Health Assessment Team (KFHAT) Web Portal: http://www.kbmp.net/collaboration/kfhat