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

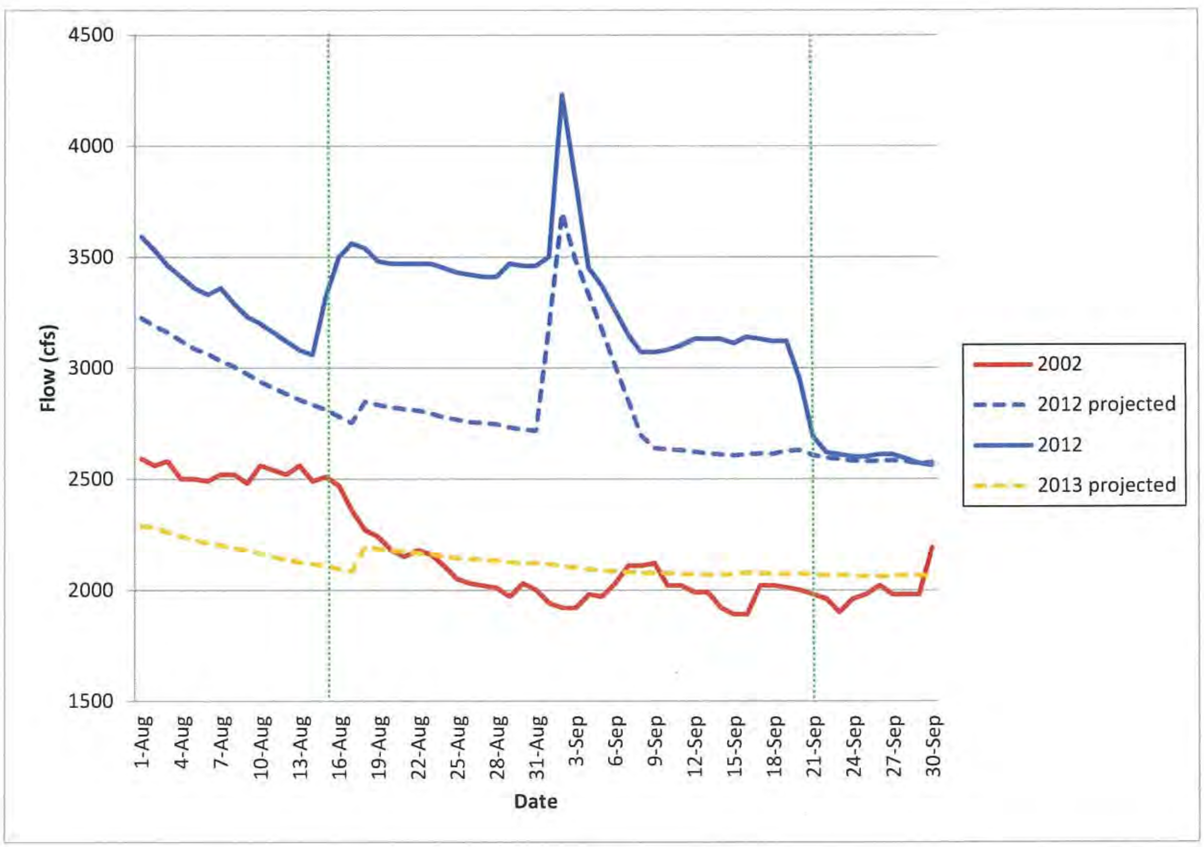

Figure 1. Observed flows in the lower Klamath River (RKM 13) in 2002 and 2012 (includes preventative fall flow augmentation) and preseason flow forecasts for 2012 (includes ceremonial pulse event for the Yurok Tribe released from Iron Gate Dam) and 2013 (without preventative or emergency fall flow augmentation 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.

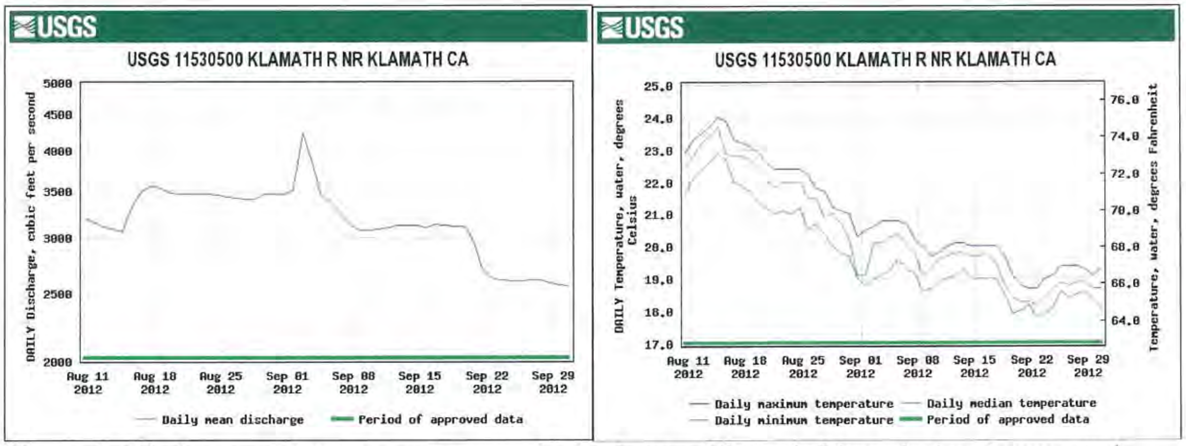

Figure 2. Discharge and water temperature in the Lower Klamath River during August and September of 2012.

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).

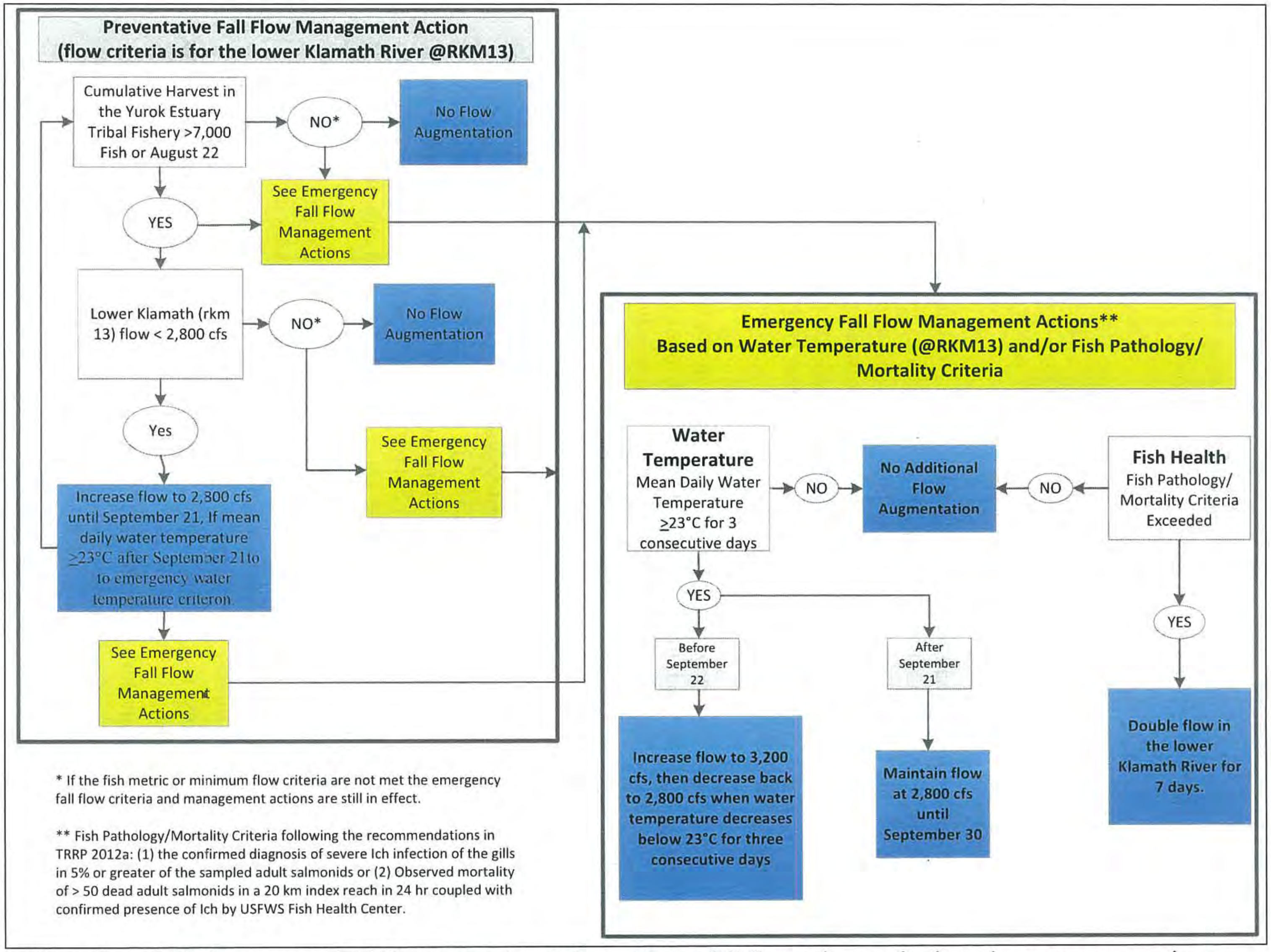

Figure 3. Flow chart depicting proposed 2013 preventative and emergency fall flow release criteria and management actions.

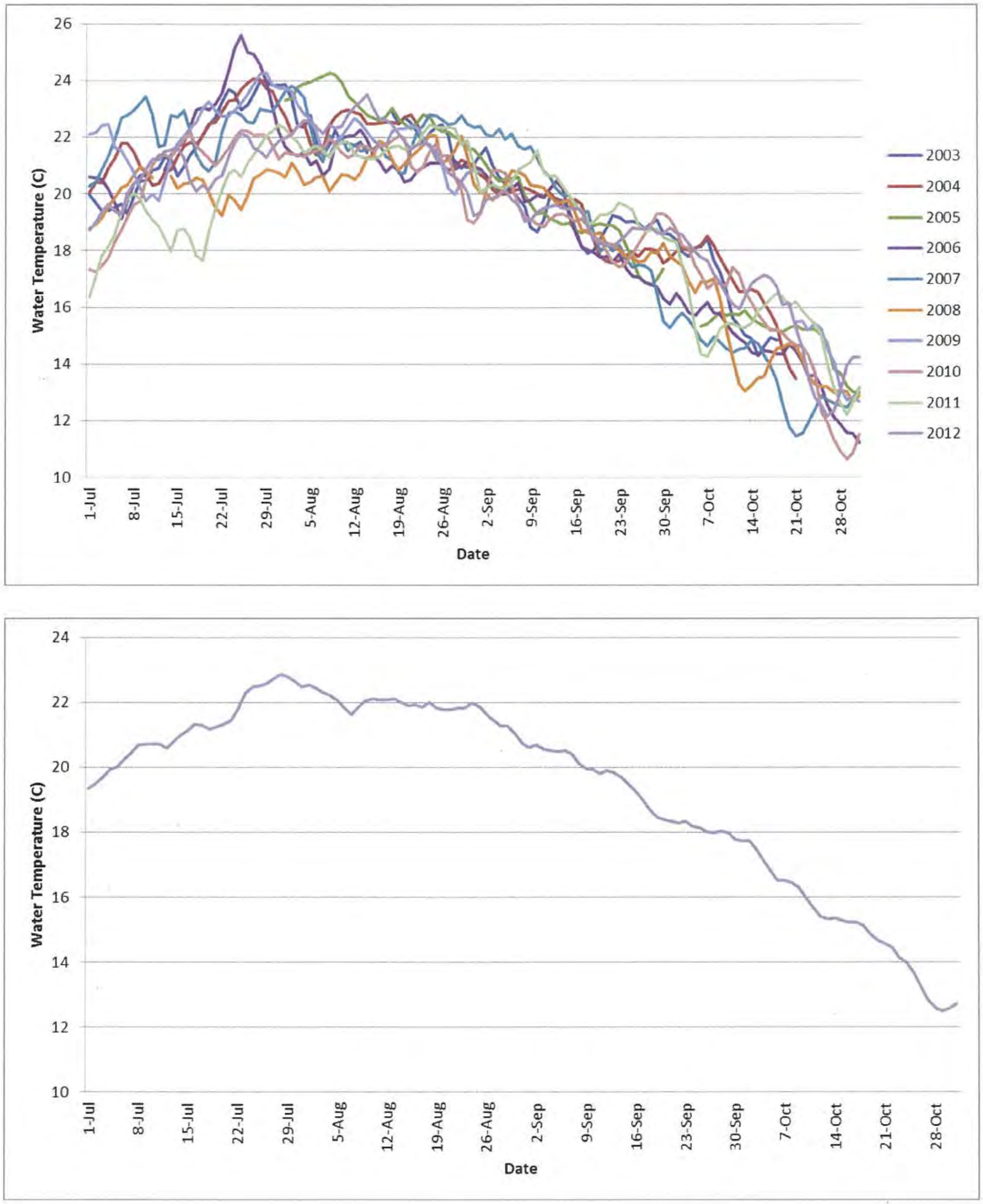

Figure 4. Mean daily water temperature (C) from July through October in the lower Klamath River (rkm 13), 2003-2012 (upper) and mean for all years (lower).

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

<u>Estuary Area – Harvest, Effort and Catch-Effort</u>

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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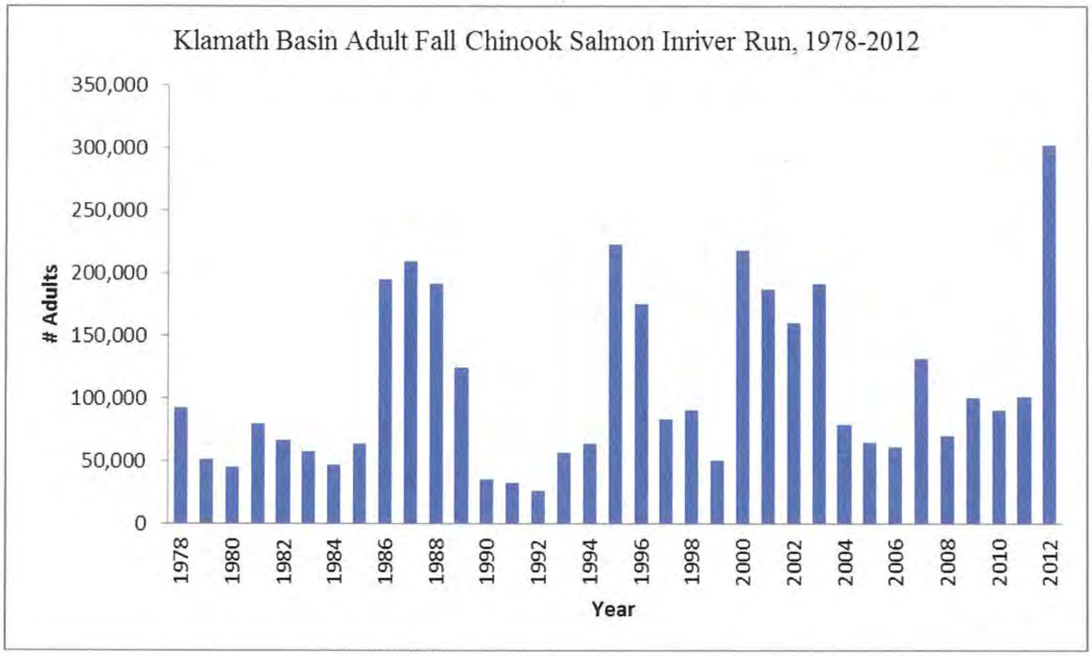

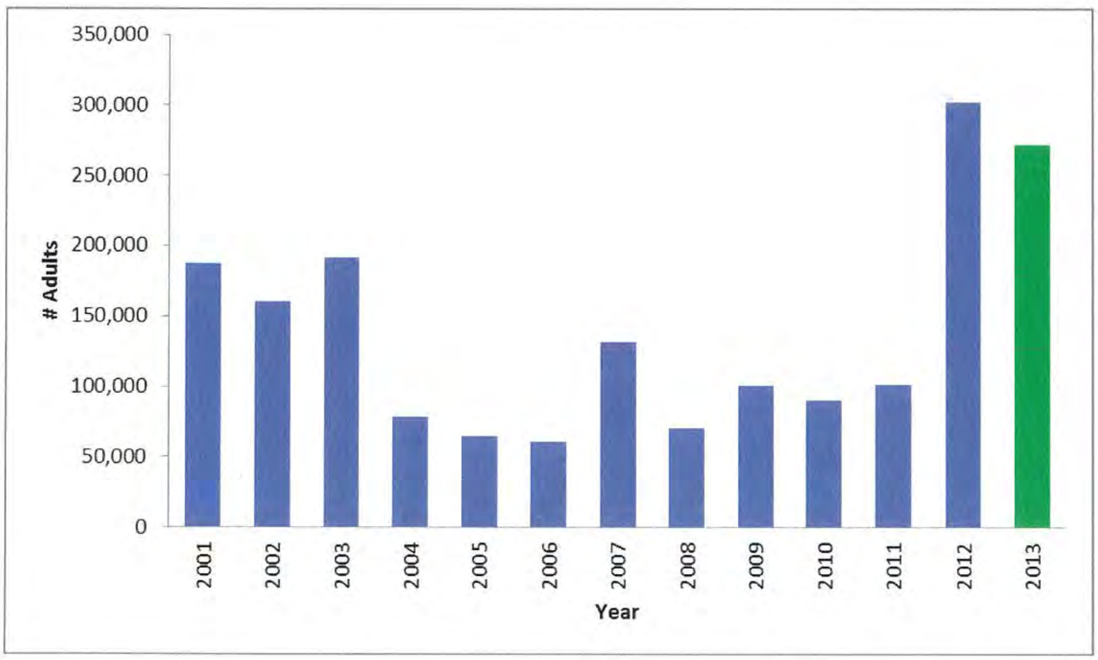

Figure 1. Klamath River adult fall-run Chinook salmon inriver run 1978-2012 (upper) and inriver run for the period 2001-2012 and 2013 projected (green bar) inriver run (lower).

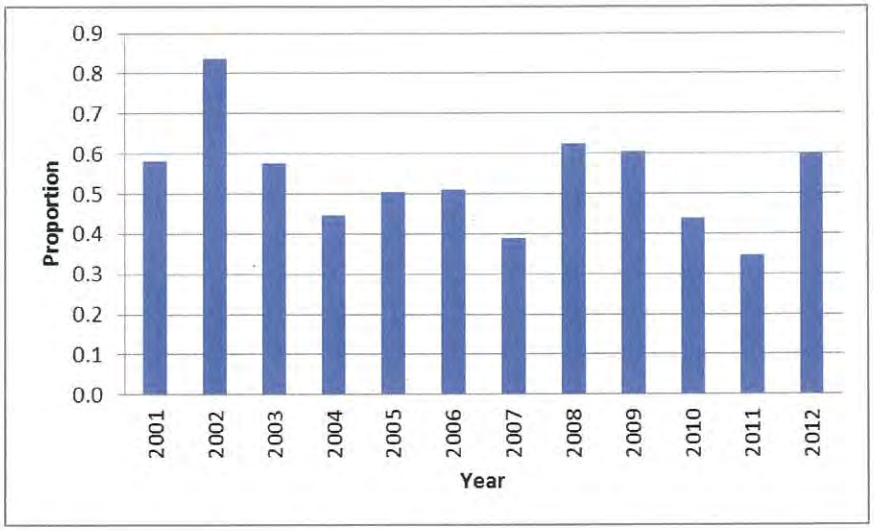

Figure 2. Proportion of Klamath Basin adult fall-run Chinook salmon spawners in the Klamath River, 2001-2012. Klamath River spawners include returns to Iron Gate Hatchery, the mainstem Klamath River and Klamath River tributaries above the confluence of the Klamath and Trinity rivers.

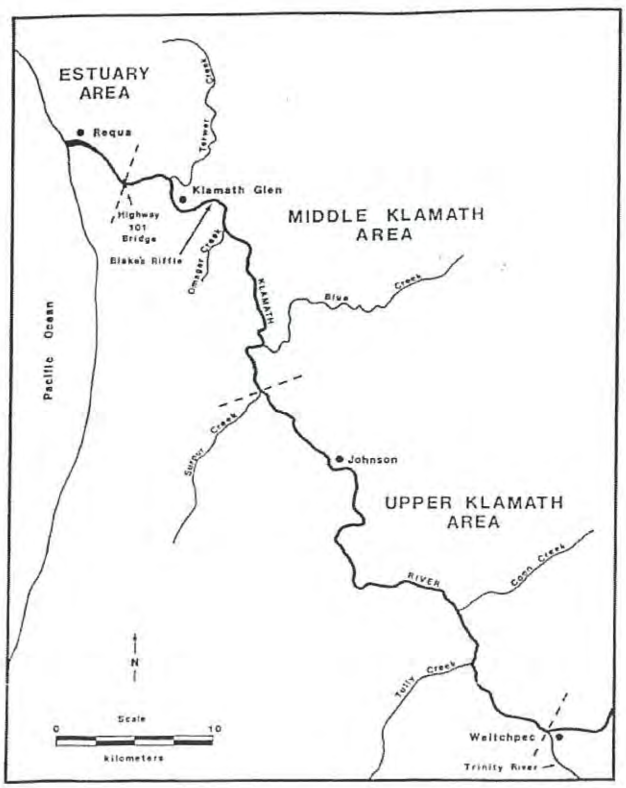

Figure 3. Map of the Yurok Reservation on the lower Klamath River showing harvest monitoring areas.

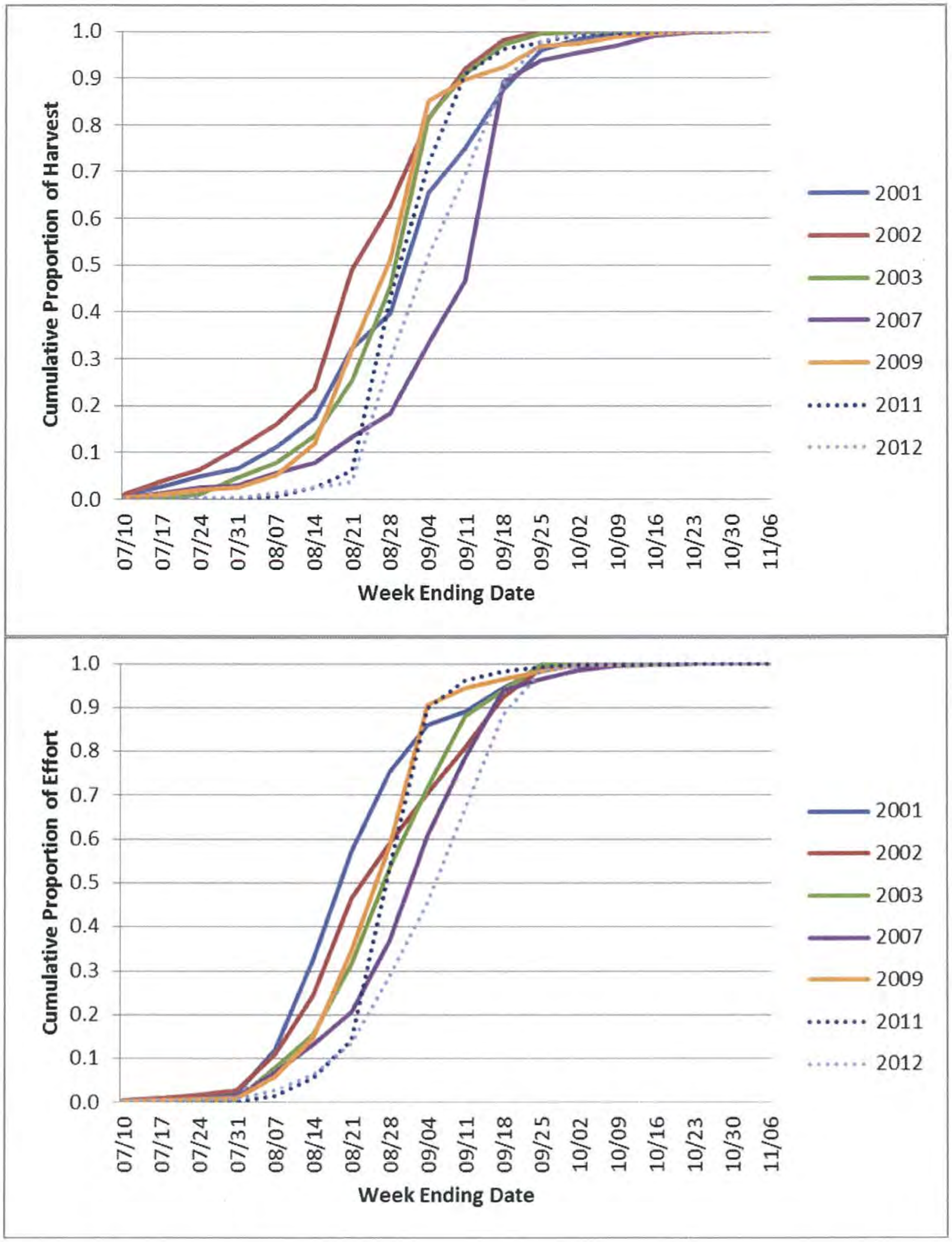

Figure 4. Cumulative fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2012. Lines for 2011 and 2012 are dotted to show the influence of the starting date of the commercial fishery on harvest and effort.

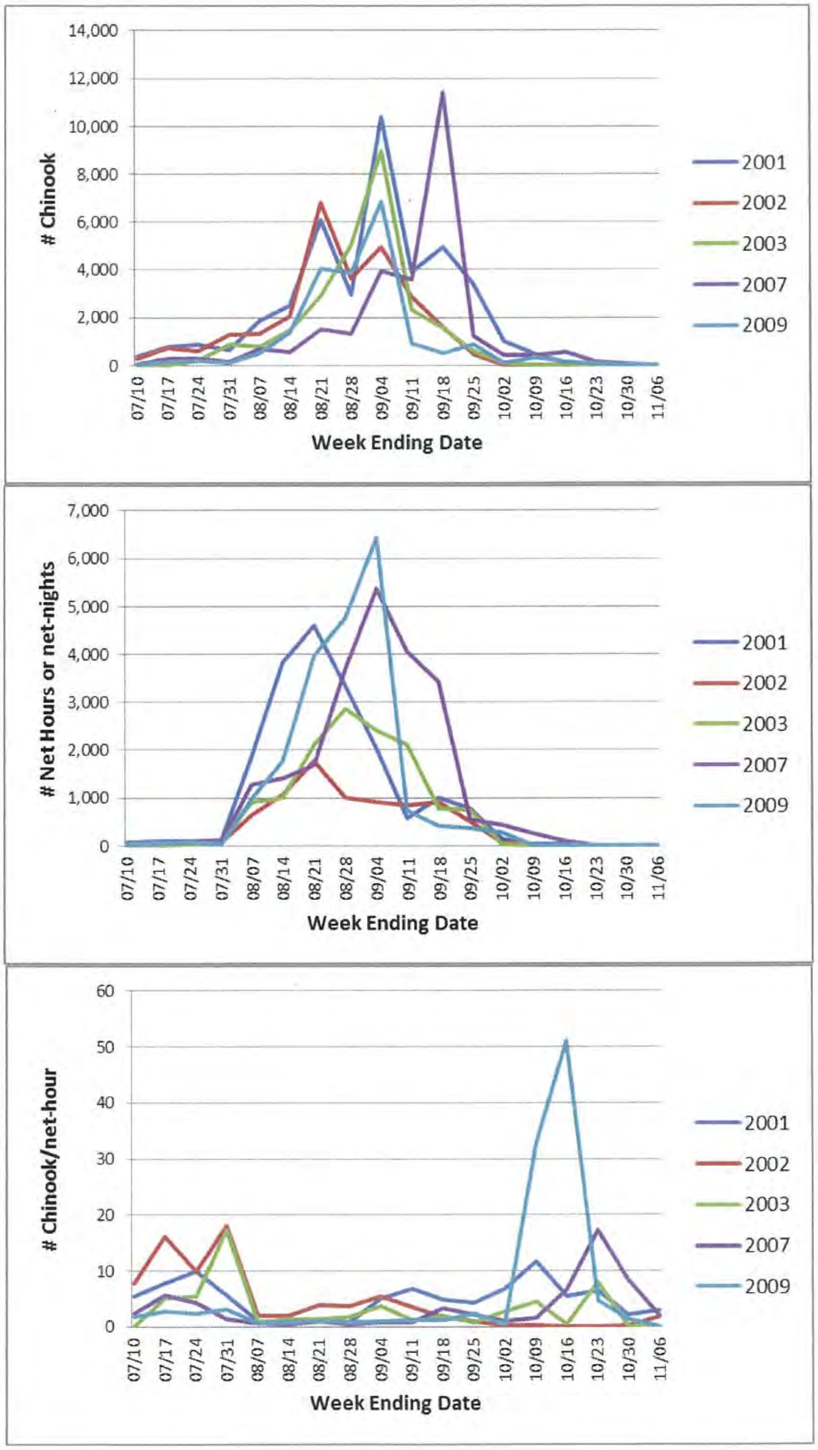

Figure 5. Weekly fall-run Chinook salmon harvest (upper), fishing effort (middle), and catch-effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

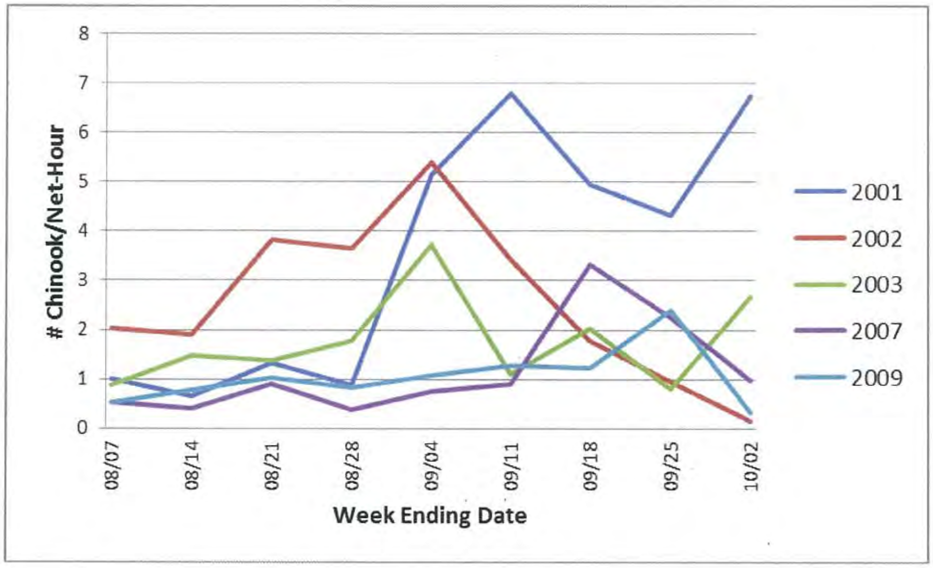

Figure 6. Weekly fall-run Chinook catch-effort for the Yurok Estuary Area fishery for August and September, 2001-2003, 2007, and 2009

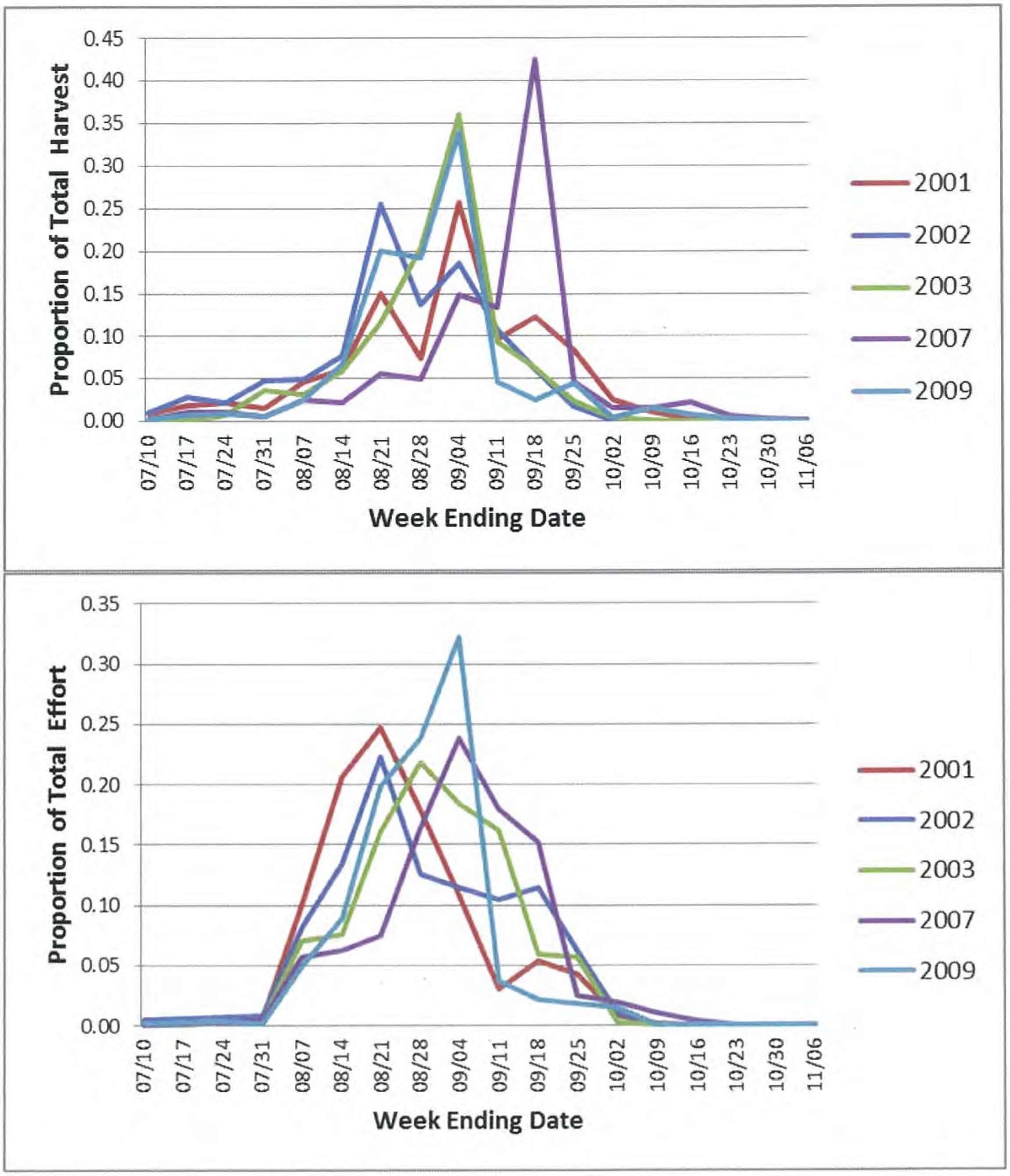

Figure 7. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

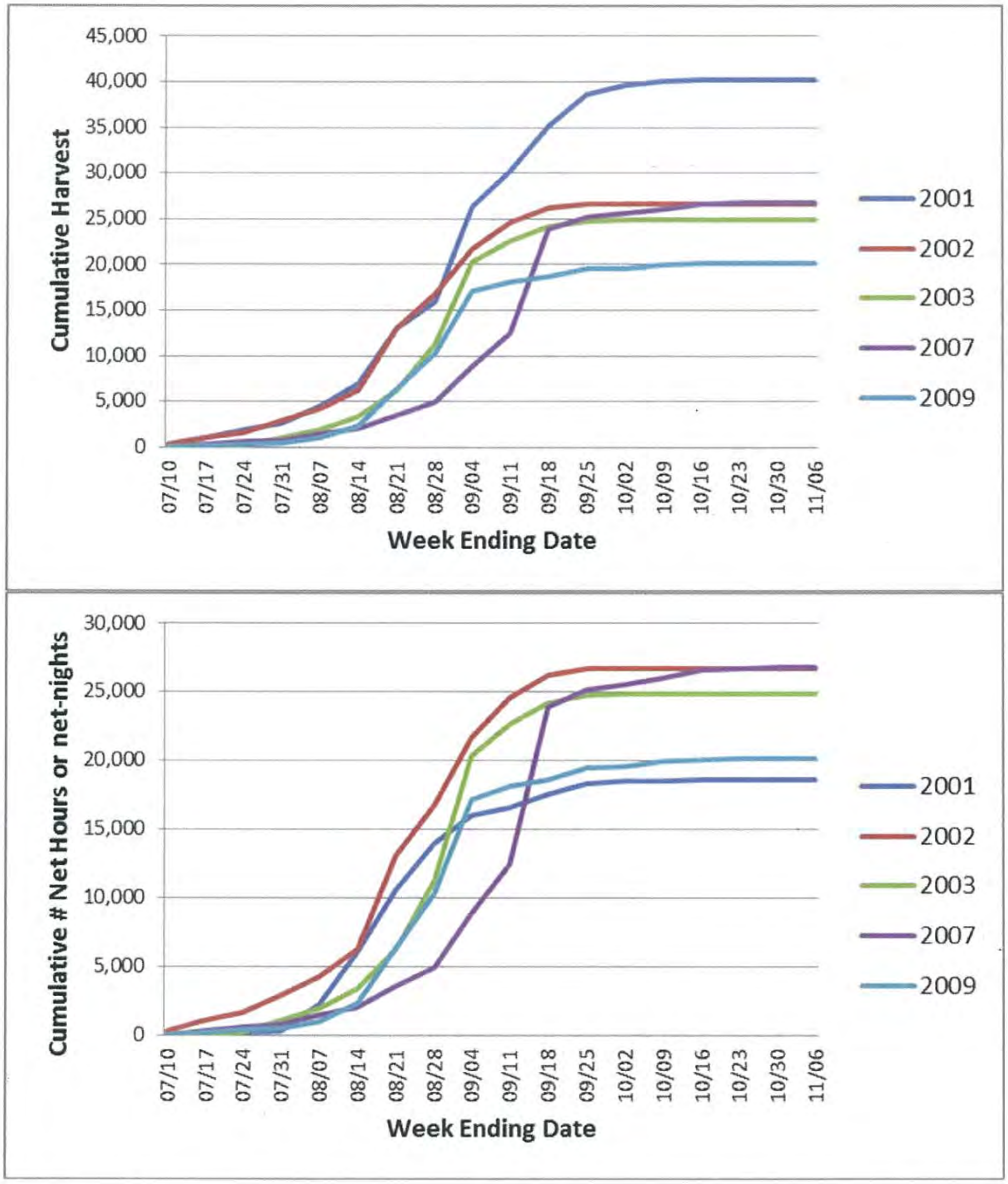

Figure 8. Cumulative weekly fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

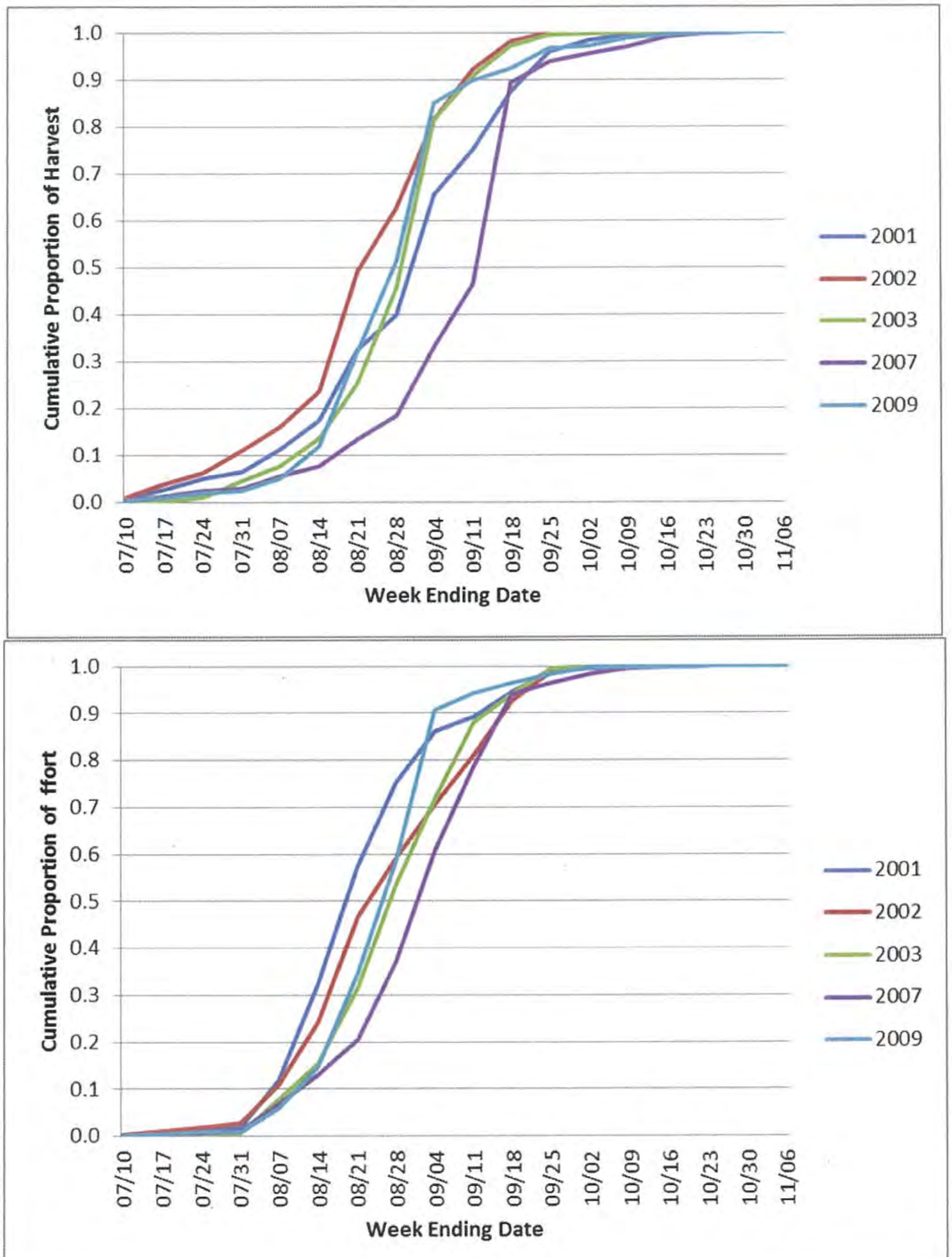

Figure 9. Cumulative proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Estuary Area fishery, 2001-2003, 2007, and 2009.

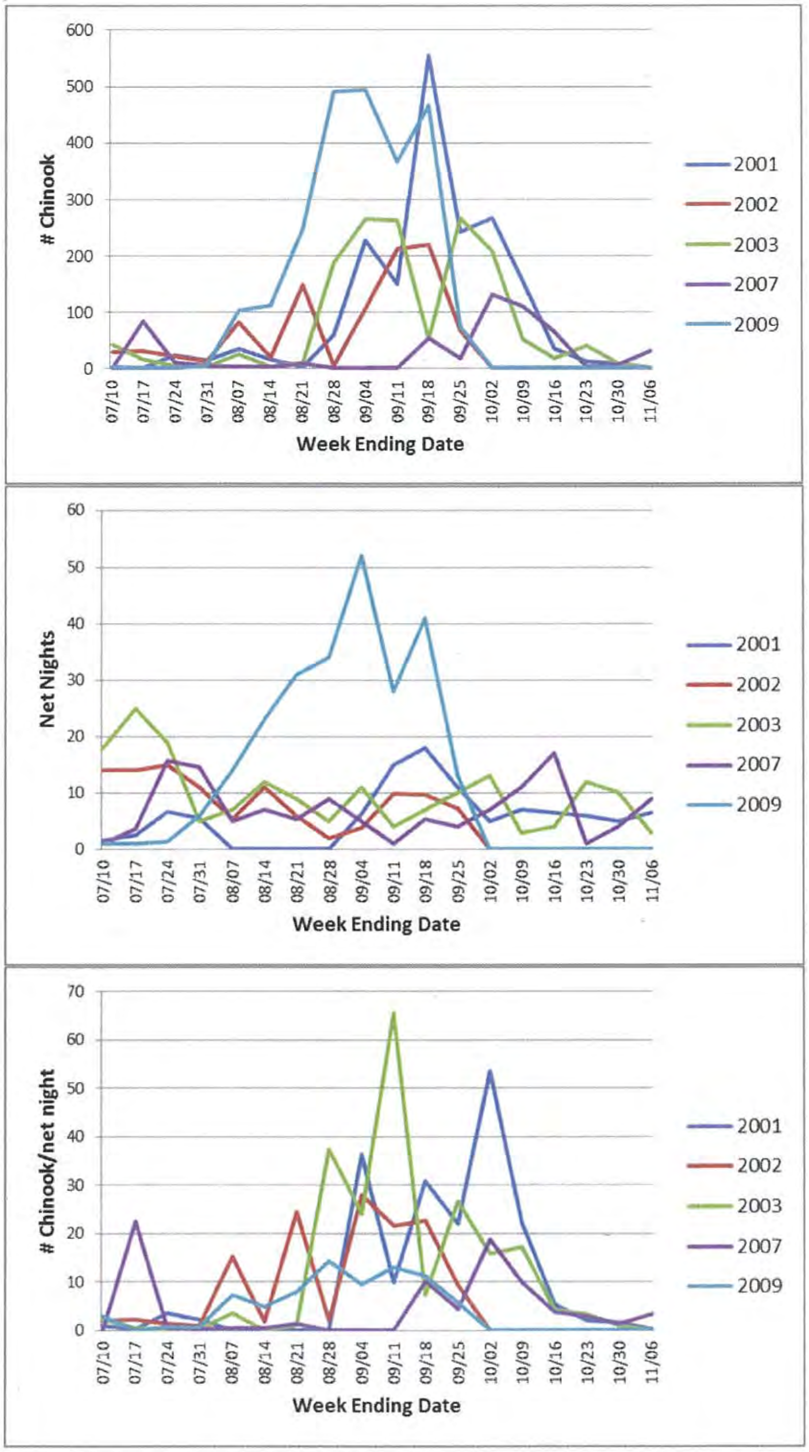

Figure 10. Weekly fall-run Chinook salmon harvest (upper), fishing effort (middle), and catch-effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

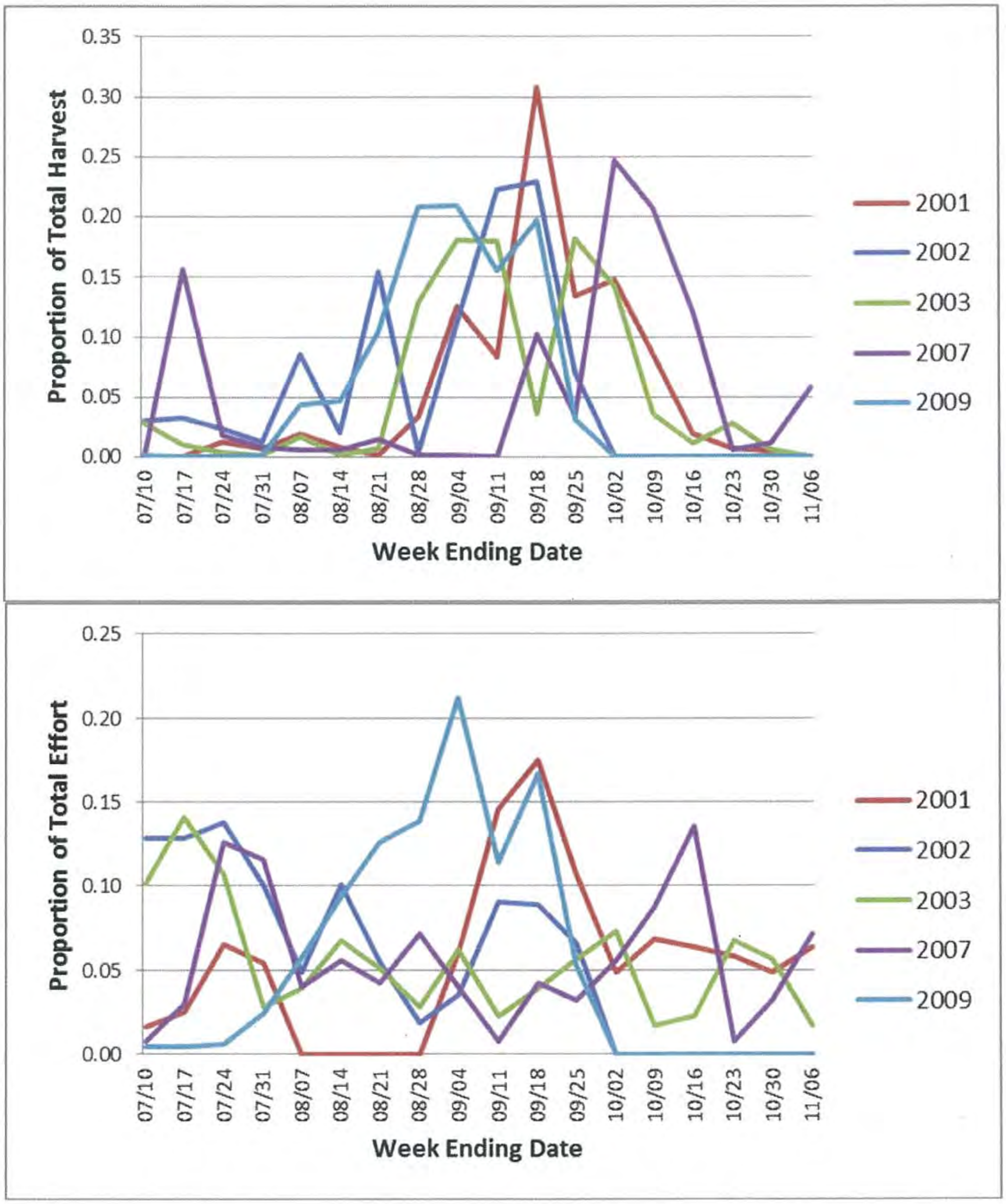

Figure 11. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

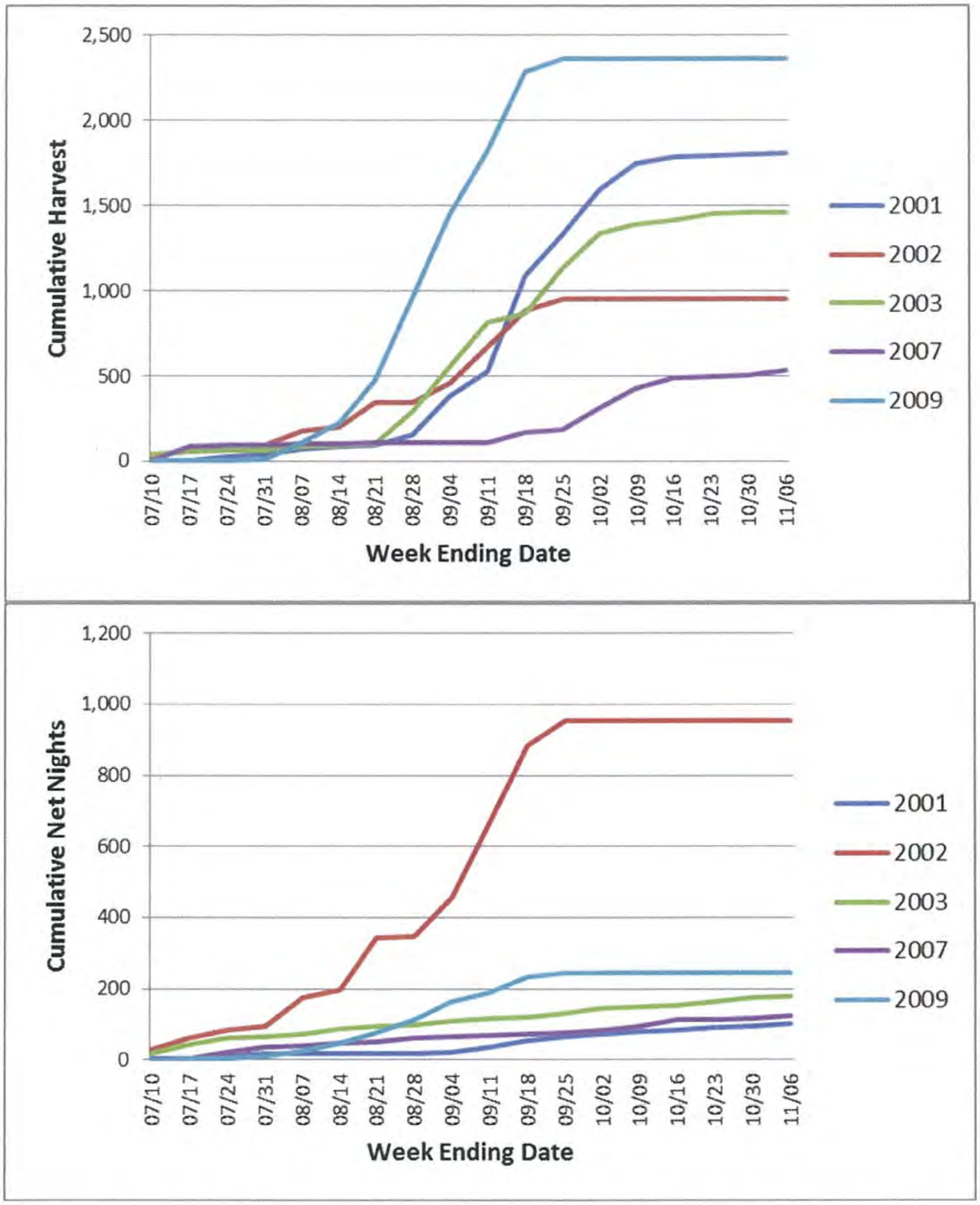

Figure 12. Cumulative weekly fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

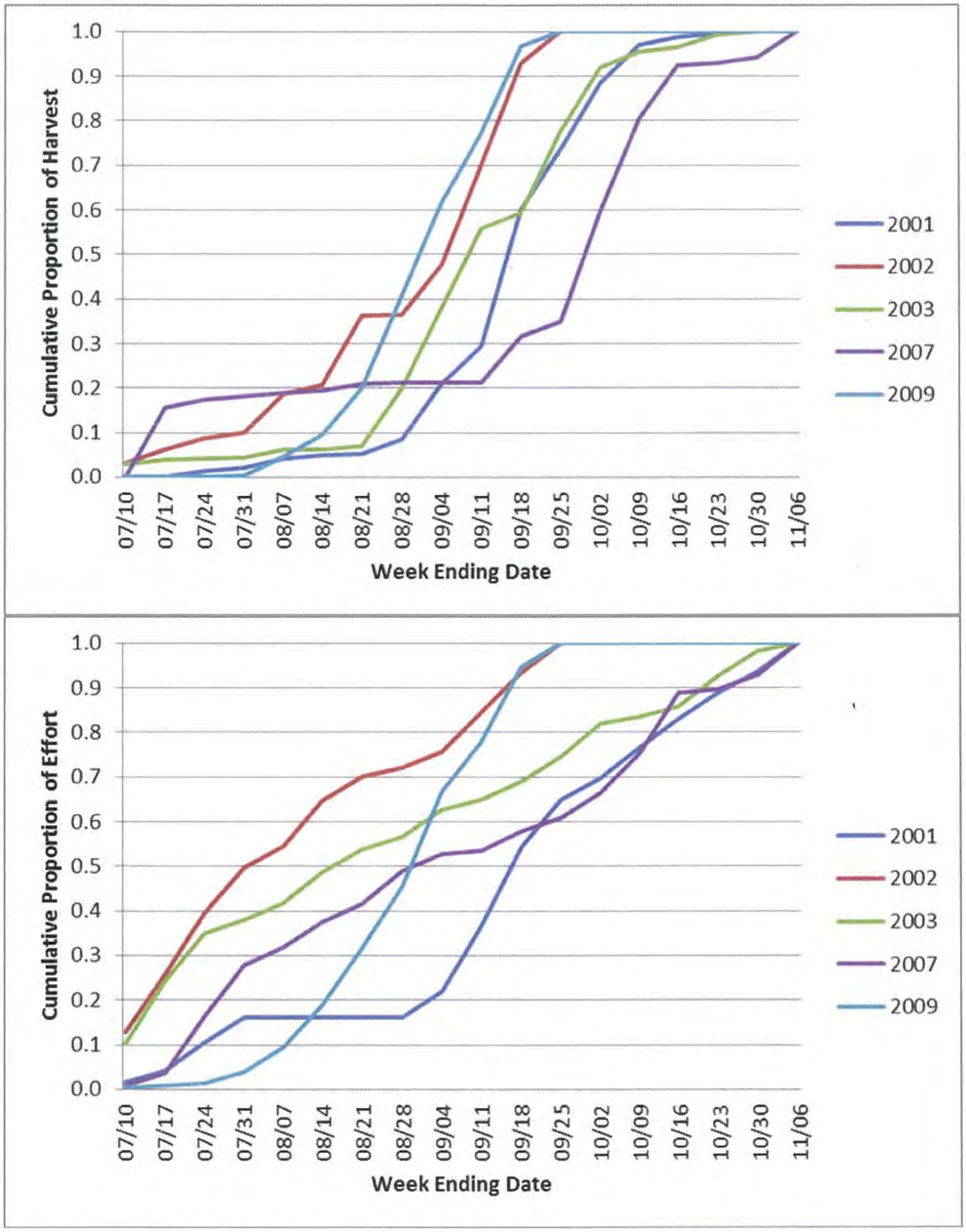

Figure 13. Proportion of annual fall-run Chinook salmon harvest (upper) and fishing effort (lower) for the Yurok Middle Klamath Area fishery, 2001-2003, 2007, and 2009.

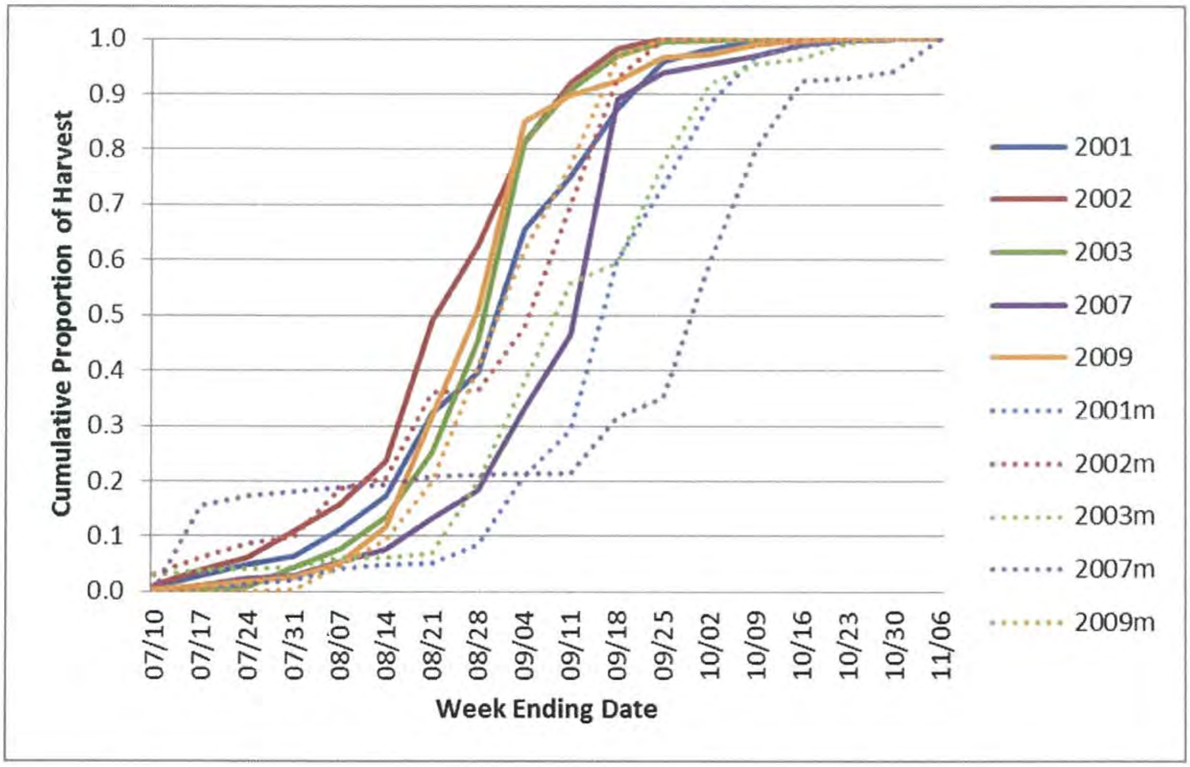

Figure 14. Cumulative weekly fall-run Chinook salmon harvest in the Estuary Area (solid lines) and Middle Klamath Area (dotted lines) of the Yurok fishery, 2001-2003, 2007, and 2009.

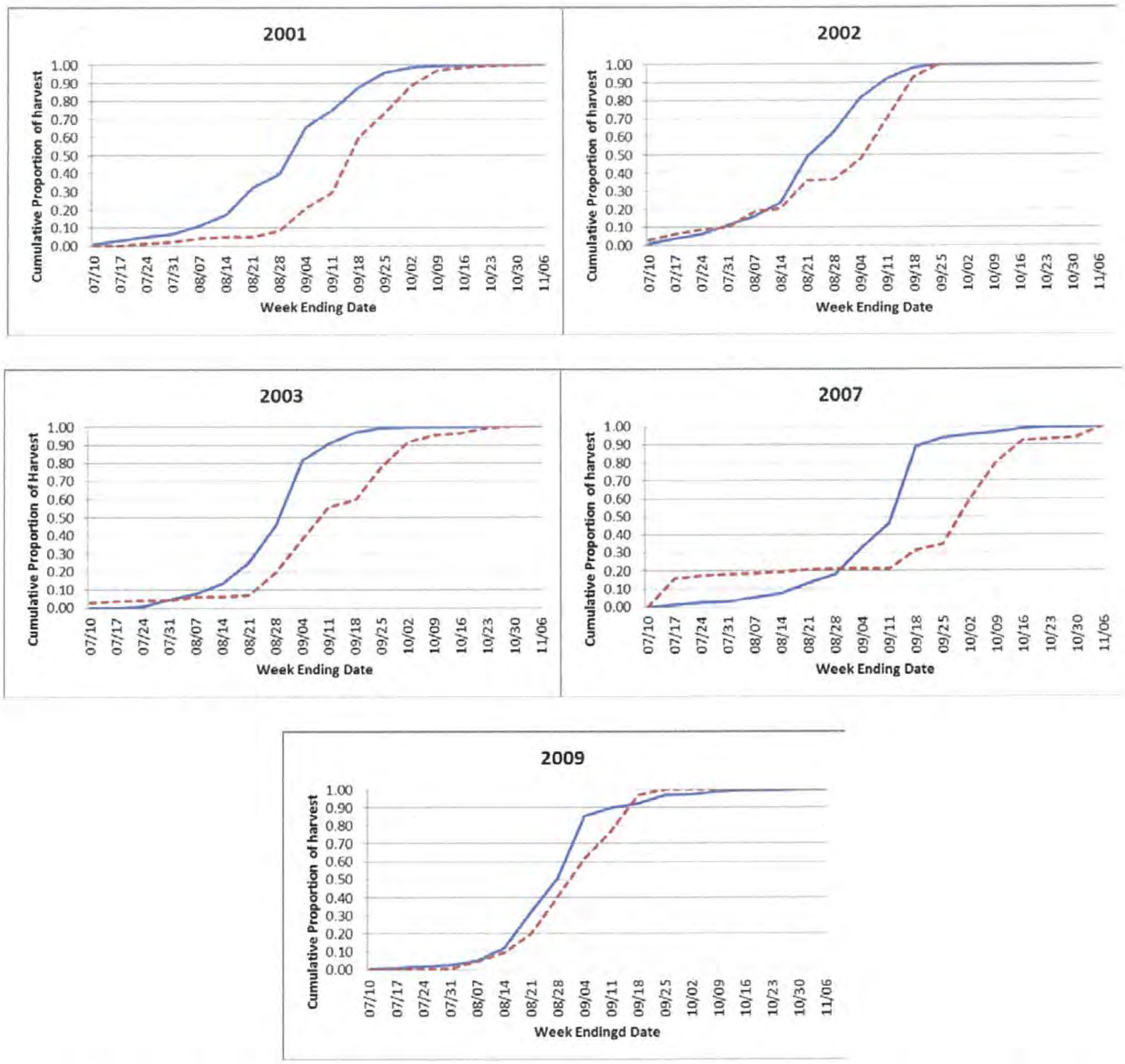

Figure 15. Cumulative weekly fall-run Chinook salmon harvest in the Estuary Area and Middle Klamath Area of the Yurok fishery, for years 2001-2003, 2007, and 2009.

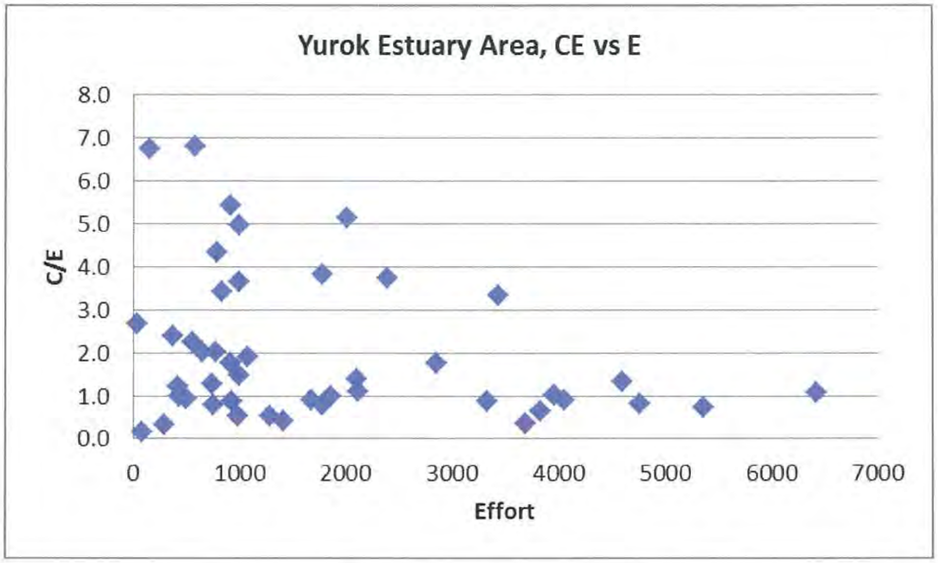

Figure 16. Weekly effort and catch-effort (CE) of fall-run Chinook salmon in the Estuary Area of the Yurok fishery and effort vs. CE for 2001-2003, 2007 and 2009. Data were limited to weeks of August 1 through September 26 when effort (net hours) and catch effort (# fish/net hour) were comparable across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

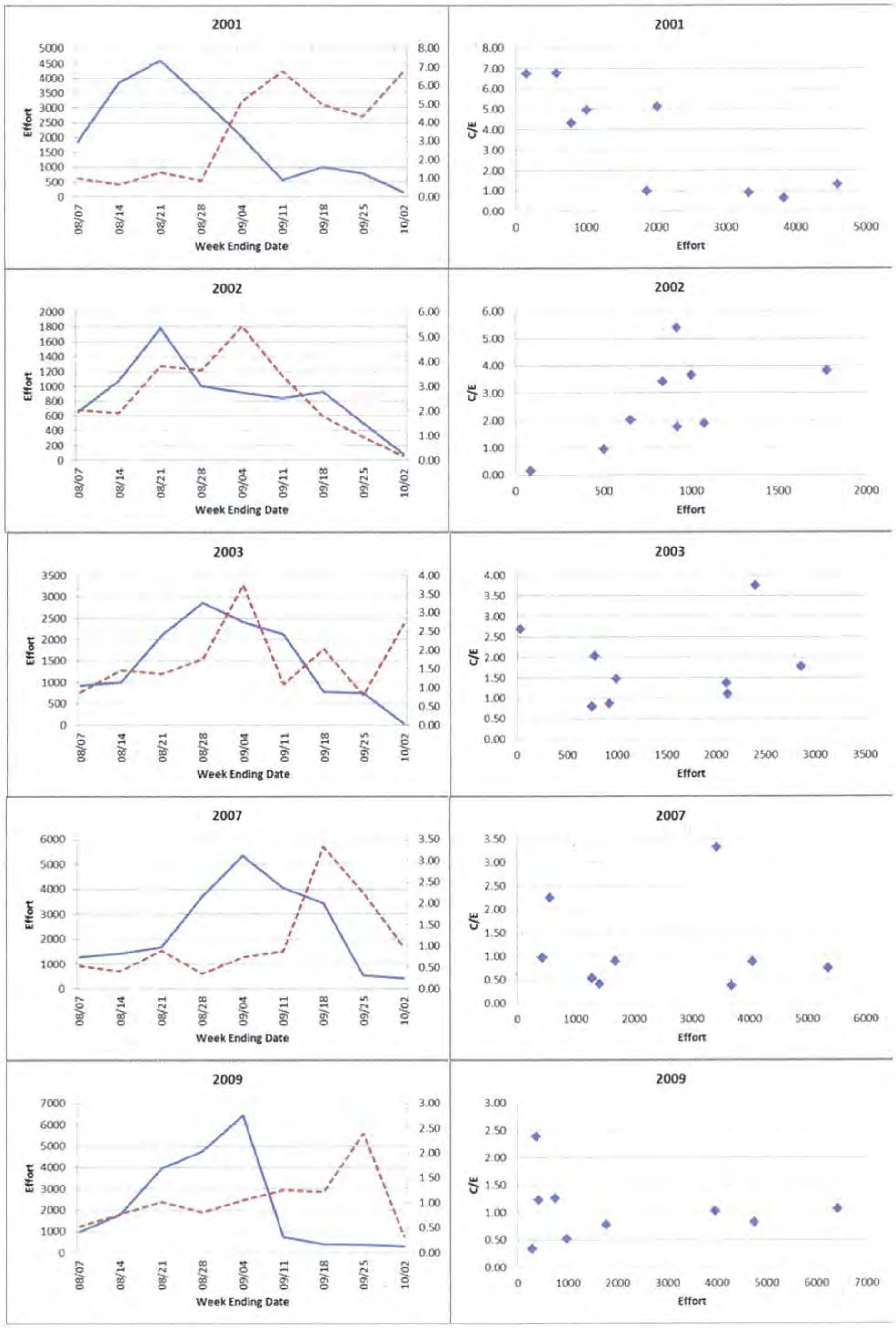

Figure 17. Weekly effort and catch-effort (CE) of fall-run Chinook salmon in the Estuary Area of the Yurok fishery and effort vs. CE for by year, 2001-2003, 2007 and 2009. Data were limited to weeks of August 1 through September 26 when effort (net hours) and catch effort (# fish/net hour) were comparable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

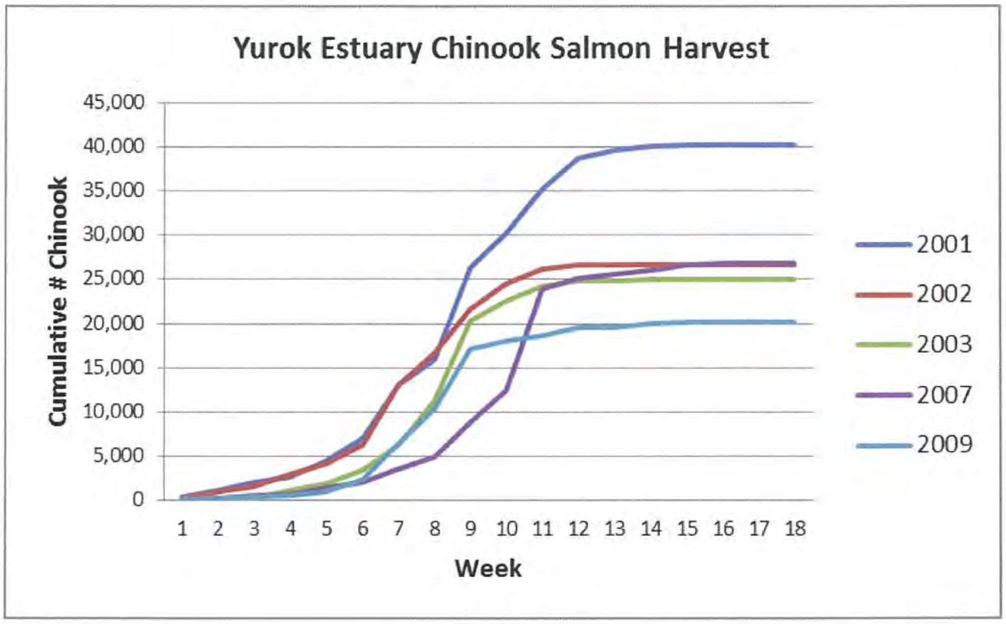

Figure 18. Cumulative harvest of fall-run Chinook salmon in the Estuary Area of the Yurok fishery, 2001-2003, 2007 and 2009.

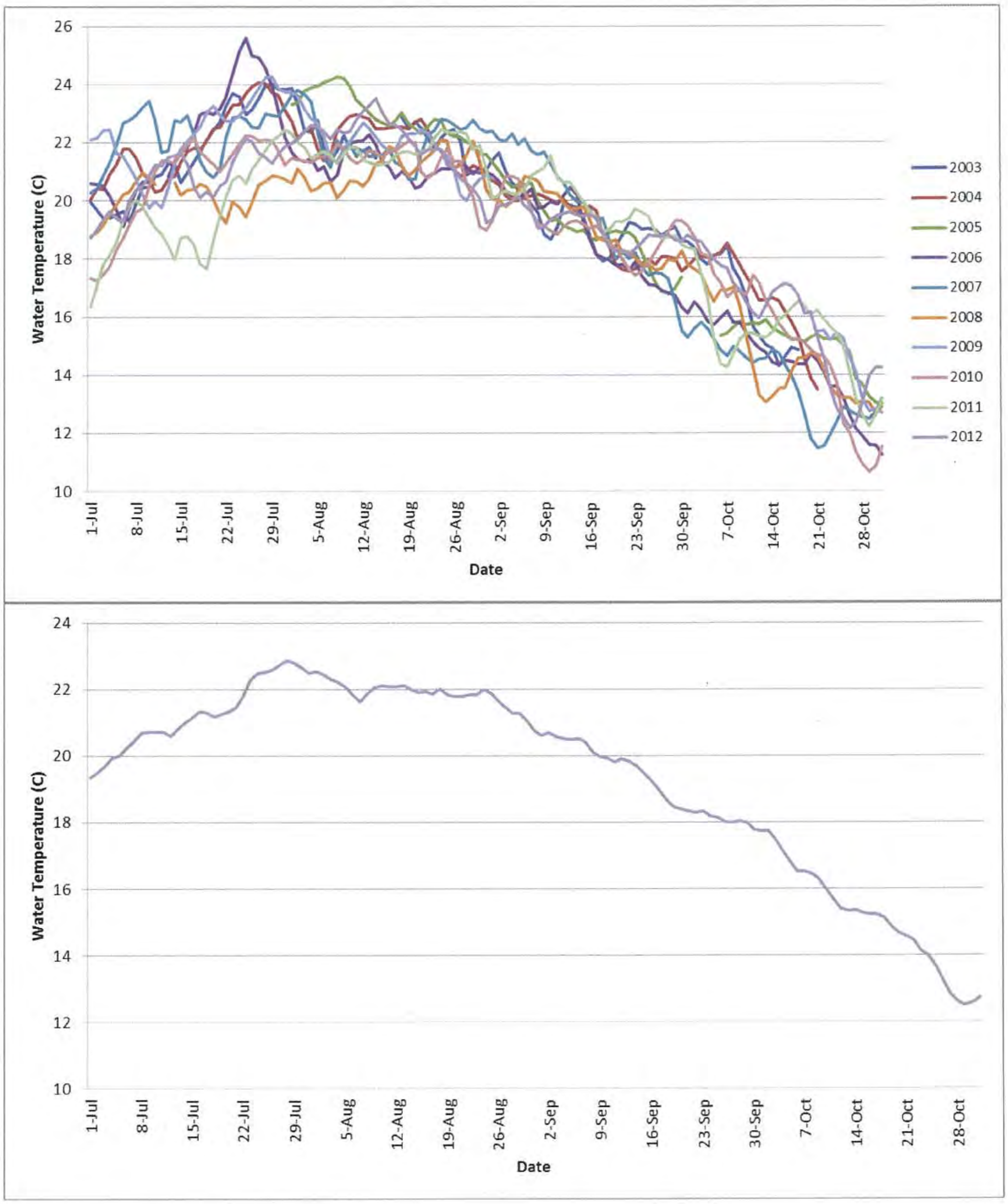

Figure 19. Mean daily later temperature in the lower Klamath River (rkm 13) for 2003-2012 (upper) and mean for all years (lower).

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