Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and Run Size Estimates, 2016 Run

Klamath River Technical Team
16 February 2017

Summary

The number of Klamath River fall Chinook Salmon returning to the Klamath River Basin (Basin) in 2016 was estimated to be:

	Run Size	
Age	*Number*	*Proportion*
2	2,786	0.10
3	8,615	0.31
4	15,443	0.56
5	509	0.02
Total	27,353	1.00

Preseason forecasts of the number of fall Chinook Salmon adults returning to the Basin and the corresponding post-season estimates are:

	Adults		
Sector	*Preseason Forecast*	*Postseason Estimate*	*Pre / Post*
Run Size	52,100	24,600	2.12
Fishery Mortality			
Tribal Harvest	7,400	5,200	1.42
Recreational Harvest	1,100	1,300	1.85
Drop-off Mortality	700	500	1.40
	9,200	7,000	1.31
Escapement			
Hatchery Spawners	12,000	3,600	3.33
Natural Area Spawners	30,900	13,900	2.22
	42,900	17,500	2.45

Introduction

This report describes the data and methods used by the Klamath River Technical Team (KRTT) to estimate age-specific numbers of fall Chinook Salmon returning to the Basin in 2016. The estimates provided in this report are consistent with the Klamath Basin Megatable (CDFW 2017) and with the 2017 forecast of ocean stock abundance (KRTT 2017).

Age-specific escapement estimates for 2016 and previous years, coupled with the coded-wire tag (CWT) recovery data from Basin hatchery stocks, allow for a cohort reconstruction of the hatchery and natural components of Klamath River fall Chinook Salmon (Goldwasser et al. 2001, Mohr 2006a, KRTT 2017). Cohort reconstruction enables forecasts to be developed for the current year's ocean stock abundance, ocean fishery contact rates, and percent of spawners expected in natural areas (KRTT 2017). These forecasts are necessary inputs to the Klamath Ocean Harvest Model (Mohr 2006b), the model used by the Pacific Fishery Management Council to forecast the effect of fisheries on Klamath River fall Chinook Salmon.

Methods

The KRTT obtained estimates of abundance and age composition separately for each sector of harvest and escapement. Random and nonrandom sampling methods of various types were used throughout the Basin (Table 1) to estimate the numbers of fall Chinook Salmon in the 2016 run and to obtain the data from which the Klamath Basin Megatable totals and estimates of age composition were derived. The KRTT relied on surrogate data for estimating age composition where the sample of scales was insufficient, or altogether lacking, within a particular sector.

Estimates of age composition were based on random samples of scales (Table 2) whenever possible. Generally, each scale was aged independently by two trained readers. In cases of disagreement, a third read was used to arbitrate. Statistical methods (Cook and Lord 1978, Cook 1983, Kimura and Chikuni 1987) were used to correct the reader-assigned age composition estimates for potential bias based on the known-age vs. read-age validation matrices. The method used to combine the random sample's known ages (for CWT fish) and unknown read ages for estimation of the escapement or harvest age composition is described in Appendix A.

For cases in which scales were believed to be non-representative of the age-2 component, the KRTT relied on analysis of length-frequency histograms. In these cases, all fish less than or equal to a given fork-length "cutoff" were assumed to be age-2, and all fish greater than the cutoff length were assumed to be adults. The cutoff value varied by sector, and was based on location of the length-frequency nadir and, if appropriate, the length-frequency of known-age fish. As before, scales were used to estimate the age composition of adults (Appendix A).

An indirect method was used to estimate age composition for natural spawners in the Trinity River above the Willow Creek Weir (WCW). Age-specific numbers of fall Chinook Salmon that immigrated above WCW were estimated by applying the age composition from scales collected at the weir to the estimate of total abundance above the weir. Next, the age composition of returns to Trinity River Hatchery and the harvest above WCW were estimated. The age composition of natural spawners above the weir was then estimated as the age-specific abundances above the WCW, minus the age-specific hatchery and harvest totals.

An alternative method was used to estimate the age structure of escapement to the Shasta River in 2016. This method is described in Appendix B.

Stream surveys in the Salmon River effectively ended early in the 2016 spawning season due to high flow events. Also because of these high flows, sampling of Wooley Creek was not possible. The alternative method used for estimation of adult escapement to the Salmon River Basin in 2016 is described in Appendix C.

A new method, applied by USFWS, was used to estimate the Klamath River mainstem escapement in the area from IGH to the Shasta River. This method is described in Appendix D.

The specific protocols used to develop estimates of age composition for each sector are provided in Table 3. A summary of the KRTT minutes specific to each sector is given in Appendix E for the Klamath River and Appendix F for the Trinity River.

Results

A total of 3,500 scales from 16 different sectors were aged for this analysis (Table 2). Of these, 221 were from known-age CWT fish. Known-age scales provide a direct check, or "validation", of accuracy of the scale-based age estimates (Tables 4a and 4b, Appendices G and H). Overall, the scale-based ages were generally accurate. Accuracy within the Trinity Basin was 96% for age-2 fish, 87% for age-3 fish, 100% for age-4 fish, and 100% for age-5 fish. Accuracy within the Klamath River Basin was 100% for age-2 fish, 96% for age-3 fish, 93% for age-4 fish, and 67% for age-5 fish. The statistical bias-adjustment methods employed are intended to correct for scale-reading bias, but the methods assume that the known-age versus read-age validation matrices are themselves well estimated (Kimura and Chikuni 1987).

Table 5 presents estimates of age-specific returns to Basin hatcheries and spawning grounds, as well as Basin harvest by tribal and recreational fisheries and the drop-off mortality associated with those fisheries. Table 6 displays the Table 5 estimates as proportions. Calculations underlying the results summarized in Table 5 are presented in Appendix I.

In 2016, sampling was conducted by the Yurok Tribe in the Klamath River to assess the incidence of *Ichthyophthirius multifiliis* (often referred to as Ich) in returning fish. Sampling was conducted using gill nets in a manner similar to the prosecution of their tribal fisheries. All fish caught as part of this effort were examined and killed and therefore no sampling expansion was necessary. Estimated impacts from Ich sampling include net dropoff mortality. The age structure of fish caught in Ich sampling programs in the Klamath River is reported in Table 5.

The final estimates of the 2015 Klamath Basin age composition are presented in Appendix J.

List of Acronyms and Abbreviations

ad-clipped	adipose fin removed
CDFW	California Department of Fish and Wildlife
CWT	coded-wire tag
EST	Klamath River estuary
FL	fork length
HVT	Hoopa Valley Tribe
IGH	Iron Gate Hatchery
KRTAT	Klamath River Technical Advisory Team
KRTT	Klamath River Technical Team
KT	Karuk Tribe
LRC	Lower Klamath River Creel
MKWC	Mid-Klamath Watershed Council
M&U	Klamath River below Weitchpec: "middle" section (Hwy 101–Surpur Cr.) and "upper" section (Surpur Cr.—Trinity River)
NCRC	Northern California Resource Center
QVIR	Quartz Valley Indian Reservation
SCS	Siskiyou County Schools

SRCD	Siskiyou Resource Conservation District
SRRC	Salmon River Restoration Council
TRH	Trinity River Hatchery
UR TRIBS	Upper Klamath River Tributaries
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WCW	Willow Creek Weir
WSP	AmeriCorps Watershed Stewards Program
YT	Yurok Tribe
YTFP	Yurok Tribal Fisheries Program

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Acknowledgements

The Klamath River Technical Team thanks the following individuals for their expert assistance in compiling and reviewing the data for this report: Wade Sinnen, Sara Borok, Mary Claire Kier, Diana Chesney, Melodie Palmer-Zwahlen, Jennifer Simon, and Barry Miller of the California Department of Fish and Wildlife; LeRoy Cyr of the U.S. Forest Service; Billy Matilton of the Hoopa Valley Tribe; and Aaron David of the U.S. Fish and Wildlife Service. The Yurok Tribe and U.S. Fish and Wildlife Service performed the scale reading analysis for the Klamath River while the Hoopa Valley Tribe performed the scale reading analysis for the Trinity River. Scale collections were provided by the California Department of Fish and Wildlife, Hoopa Valley Tribe, U.S. Fish and Wildlife Service, U.S. Forest Service, and Yurok Tribe.

Table 1. Estimation and sampling methods used for the 2016 Klamath River fall Chinook run assessment.

Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Iron Gate Hatchery (IGH)	Direct count. All fish examined for fin-clips, tags, and marks. Bio-data[a] collected from a systematic random sample of 10% of the fish. Additionally, all ad-clipped fish were bio-sampled.	CDFW, WSP
Trinity River Hatchery (TRH)	Direct count. All fish examined for fin-clips, tags, and marks. Bio-data collected from a systematic random sample of 20% of the fish.	CDFW, HVT
Natural Spawners		
Salmon River Basin	Redd surveys of the upper and lower mainstem and tributaries. Total redds estimated by extrapolating redds counted from the first and only survey day based on historical redd deposition rate since 1998. Additionally, the Wooley Creek redd count was estimated using the historical ratio of redds there versus the rest of the Salmon River basin (Appendix C). Total run based on expanded redd count (2*total redd count)/(1-proportion of jacks). Bio-data collected from all carcasses recovered.	CDFW,USFS,YT, KT, SRRC, SCS, WSP
Scott River Basin	Combination ARIS acoustic and video count above weir at river mile 18 and redd survey below the weir. Total run based on ARIS acoustic and video count through the weir and redd survey (Total run below the weir = (2*total redd count)/(1-proportion jacks)). Bio-data collected from all carcasses recovered.	CDFW, QVIR, USFS, KT, NCRC, SRCD, WSP
Shasta River Basin	Video count above weir. Bio-data collected from all carcasses upstream of video weir site, and a systematic random sample of carcasses stranded on weir.	CDFW, WSP
Bogus Creek Basin	Video count above weir and twice weekly direct carcass count below weir. Bio-data collected from a systematic random sample (1:2) of all carcasses observed during surveys above and below weir. Additionally, all ad-clipped fish were bio-sampled.	CDFW, WSP
Klamath River mainstem (IGH to Shasta R.)	Hierarchical Latent Variable Model from weekly carcass surveys (Appendix D). Bio-data collected from fresh carcasses.	USFWS, YT
Klamath River mainstem (Shasta R. to Indian Cr.)	Weekly redd survey. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from the Klamath River mainstem (IGH to Shasta R.) area scale-age data.	USFWS, KT
Klamath Tributaries above Trinity	Periodic redd surveys. High flows precluded repeated surveys in some areas. Total run = (2*total redd count)/(1-proportion jacks) + live fish observed on last day surveyed. Jacks estimated from Klamath tributary scale-age data. Bio-data collected from all carcasses recovered.	USFS,CDFW, KT, YT, SRRC, MKWC, SCS, WSP
Blue Creek	Total estimated using the single diver count completed for this year. No bio-data was collected as conditions prevented recovery of any carcasses.	YT
Trinity River (mainstem above WCW)	Mark-recapture (non-stratified Peterson); marks applied at WCW and recovered at TRH. All fish bio-sampled and scales collected in systematic random sample (1:2). Natural spawning escapement estimated by subtracting age specific estimates of hatchery returns and recreational harvest above WCW from the total run.	CDFW, HVT
Trinity River (mainstem below WCW)	No redd survey was possible due to flow conditions in 2016. Adult escapement estimated by applying the average ratio of this sector to the upper Trinity River adult natural escapement for years 2001-2015 to the 2016 upper Trinity River adult escapement.	HVT, USFWS
Trinity Tributaries (above Reservation; below WCW)	Periodic redd surveys. Total run = (2*total redd count)/(1-proportion jacks) + live fish observed on last day surveyed. Bio-data collected from all recovered carcasses.	CDFW, USFS, WSP
Hoopa Reservation Tributaries	Periodic redd surveys. Total run = (2*total redd count)/(1-proportion jacks). Bio-data collected from all recovered carcasses.	HVT
Recreational Harvest		
Klamath River (below Hwy 101 bridge)	Jack and adult estimates based on access point creel survey during three randomly selected days per statistical week (two weekdays and one weekend day). Bio-data collected during angler interviews.	CDFW
Klamath River (Hwy 101 to Weitchpec)	Jack and adult estimates based on access point creel survey during three randomly selected days per statistical week (two weekdays and one weekend day). Bio-data collected during angler interviews.	CDFW
Klamath River (Weitchpec to IGH)	No survey. Upper Klamath adult harvest estimated using the ratio of lower river to total adult river harvest during the years 1999-2002 (Appendix B). Upper river adult harvest = total adult harvest minus lower river adult harvest. Total harvest = adults/(1-proportion jacks). Jacks estimated from the weighted IGH, Klamath mainstem (IGH to Shasta R.), and Bogus Creek age composition data.	CDFW
Trinity River Basin (above WCW)	Jack and adult harvest estimates based on estimated harvest rates from angler return of reward and non-reward tags applied at WCW.	CDFW, HVT
Trinity River Basin (below WCW)	Roving access creel survey during three randomly selected days per statistical week stratified by weekdays (M-Th) and weekend (F-Su) days (1 weekday and 2 weekend). Bio-data collected during angler interviews.	HVT
Tribal Harvest		
Klamath River (below Hwy 101)	Daily harvest estimates based on effort and catch-per-effort surveys. Bio-data collected during net harvest and buying station interviews.	YT
Klamath River (Hwy 101 to Trinity mouth)	Daily harvest estimates based on effort and catch-per-effort surveys. Bio-data collected during net harvest interviews.	YT
Trinity River (Hoopa Reservation)	Effort and catch-per-effort surveys during four randomly selected days per statistical week. Bio-data collected during net harvest interviews.	HVT
Fishery Dropoff Mortality		
Recreational Angling Dropoff Mortality 2.04%	Not directly estimated. Assumed rate relative to fishery impacts = .02; relative to fishery harvest = .02/(1-.02).	KRTAT
Tribal Net Dropoff Mortality 8.7%	Not directly estimated. Assumed rate relative to fishery impacts = .08; relative to fishery harvest = .08/(1-.08).	KRTAT

[a] Bio-data generally includes: fork length, scale, sex, tags or marks, and CWT recovery from dead ad-clipped fish.

Table 2. Scale sampling locations and numbers of scales collected for the 2016 Klamath Basin fall Chinook age-composition assessment.

Sampling Location	Aged: Unknown-age [a/]	Aged: Known-age [b/]	Aged: Total	Total Collected[c/]	Agency
Hatchery Spawners					
Iron Gate Hatchery (IGH)	203	24	227	285	CDFW
Trinity River Hatchery (TRH)	220	82	302	306	HVT
Natural Spawners					
Salmon River Carcass Survey	21	0	21	22	CDFW
Scott River Carcass Survey	153	0	153	163	CDFW
Shasta River Carcass	53	1	54	54	CDFW
Bogus Creek	103	13	116	126	CDFW
Klamath River mainstem	228	13	241	250	USFWS
Upper Klamath River tributaries	33	0	33	33	USFS
Blue Creek Snorkel	0	0	0	0	YT
Willow Creek Weir	147	9	156	158	CDFW, HVT
Lower Trinity River Carcass	0	0	0	0	HVT
Hoopa Reservation tributaries	1	0	1	1	HVT
Other Trinity River tributaries	1	0	1	1	USFS
Recreational Harvest					
Lower Klamath River Creel	219	1	220	221	CDFW
Lower Trinity River Creel	6	0	6	6	HVT
Tribal Harvest					
Klamath River (below Hwy 101)	1,151	50	1,201	1,225	YT
Klamath River (Hwy 101 to Trinity R)	546	10	556	580	YT
Trinity River (Hoopa Reservation)	194	18	212	213	HVT
TOTAL	3,279	221	3,500	3,644	

a/ Scales from non-ad-clipped fish and ad-clipped fish without CWTs, mounted and read.
b/ Scales from all mounted and aged ad-clipped CWT fish; non-random CWT fish used for validation but not age composition.
c/ Scales collected from the area.

Table 3. Age-composition methods used for the 2016 Klamath Basin fall Chinook run assessment.

Sampling Location	Age Composition Method
Hatchery Spawners	
Iron Gate Hatchery (IGH)	Jack/adult structure from scale-age analysis.
Trinity River Hatchery (TRH)	Jack/adult structure from scale-age analysis.
Natural Spawners	
Salmon River Basin	Surrogate: jacks estimated from Klamath tributaries (above Trinity R.). Adults estimated using scale-age analysis from this area.
Scott River Basin	Jack/adult structure from scale-age analysis.
Shasta River Basin	Jacks estimated as per Appendix B. Adult structure from scale-age analysis.
Bogus Creek Basin	Jack/adult structure from scale-age analysis.
Klamath River mainstem (IGH to Shasta R.)	Jack/adult structure from scale-age analysis.
Klamath River mainstem (Shasta R. to Indian Cr.)	Surrogate: Klamath mainstem (IGH to Shasta R.) age structure.
Klamath tributaries (above Trinity R.)	Jack/adult structure from scale-age analysis.
Blue Creek	Jacks estimated through direct observation. Adult surrogate: structure from un-weighted average estimated for this sector in years 2011-2015.
Trinity River (above WCW)	Jack/adult structure derived from subtracting age-specific TRH counts and recreational harvest estimate above WCW from the age-specific total run estimate above WCW derived from scale-age analysis.
Trinity River (mainstem below WCW)	Surrogate: jack/adult structure from Trinity River (above WCW).
Trinity Tributaries (above Reservation to WCW)	Surrogate: jack/adult structure from Trinity River (above WCW).
Hoopa Reservation Tributaries	Surrogate: jack/adult structure from Trinity River (above WCW).
Recreational Harvest	
Klamath River (below Hwy 101 bridge)	Jack/adult structure from scale-age analysis.
Klamath River (Hwy 101 to Weitchpec)	Jack/adult structure from scale-age analysis.
Klamath River (Weitchpec to IGH)	Surrogate: IGH, Bogus Creek, and Klamath River mainstem (IGH to Shasta R.) weighted age composition.
Trinity River Basin (above WCW)	Jack component based on estimated jack harvest rate and total jack run estimate. Adult surrogate: age composition from Trinity River recreational harvest below WCW.
Trinity River Basin (below WCW)	Jack/adult structure from scale-age analysis.
Tribal Harvest	
Klamath River (below Hwy 101)	Jack/adult structure from scale-age analysis.
Klamath River (Hwy 101 to Trinity mouth)	Jack/adult structure from scale-age analysis.
Trinity River (Hoopa Reservation)	Jack/adult structure from scale-age analysis.
Ich Disease Monitoring	
Klamath River (Yurok Reservation)	Surrogate: jack/adult structure from Tribal harvest Klamath River (Hwy 101 to Trinity mouth).

Table 4a. 2016 Klamath River Basin scale validation matrices.

Number

		Known Age				
		2	3	4	5	
	2	14	2	0	0	
Read	3	0	132	10	1	
Age	4	0	3	127	0	
	5	0	0	0	2	Total
	Total	14	137	137	3	291

Percentage

		Known Age			
		2	3	4	5
	2	1.00	0.01	0.00	0.00
Read	3	0.00	0.96	0.07	0.33
Age	4	0.00	0.02	0.93	0.00
	5	0.00	0.00	0.00	0.67
	Total	1.00	1.00	1.00	1.00

Table 4b. 2015 Trinity River Basin scale validation matrices.

Number

		Known Age				
		2	3	4	5	
	2	27	0	0	0	
Read	3	1	47	0	0	
Age	4	0	7	27	0	
	5	0	0	0	1	Total
	Total	28	54	27	1	110

Percentage

		Known Age			
		2	3	4	5
	2	0.96	0.00	0.00	0.00
Read	3	0.04	0.87	0.00	0.00
Age	4	0.00	0.13	1.00	0.00
	5	0.00	0.00	0.00	1.00
	Total	1.00	1.00	1.00	0.00

Table 5. Age composition of the 2016 Klamath Basin fall Chinook run.

Escapement & Harvest	2	3	AGE 4	5	Total Adults	Total Run
Hatchery Spawners						
Iron Gate Hatchery (IGH)	151	1,683	715	38	2,436	2,587
Trinity River Hatchery (TRH)	401	722	412	8	1,142	1,543
Hatchery Spawner subtotal	**552**	**2,405**	**1,127**	**46**	**3,578**	**4,130**
Natural Spawners						
Salmon River Basin	26	676	356	0	1,032	1,058
Scott River Basin	139	1	1,375	0	1,376	1,515
Shasta River Basin	135	536	2,218	0	2,754	2,889
Bogus Creek Basin	38	245	585	0	830	868
Klamath River mainstem (IGH to Shasta R)	38	236	471	1	708	746
Klamath River mainstem (Shasta R to Indian Cr)	121	732	1,462	0	2,194	2,315
Klamath Tributaries (above Trinity River)	30	234	919	52	1,205	1,235
Blue Creek	27	42	210	12	264	291
Klamath Basin subtotal	554	2,702	7,596	65	10,363	10,917
Trinity River (mainstem above WCW)	1,260	1,936	1,340	76	3,352	4,612
Trinity River (mainstem below WCW)	35	53	37	2	92	127
Trinity Tributaries (above Reservation; below WCW)	21	31	22	2	55	76
Hoopa Reservation tributaries	24	36	25	1	62	86
Trinity Basin subtotal	1,340	2,056	1,424	81	3,561	4,901
Natural Spawners subtotal	**1,894**	**4,758**	**9,020**	**146**	**13,924**	**15,818**
Total Spawner Escapement	**2,446**	**7,163**	**10,147**	**192**	**17,502**	**19,948**
Recreational Harvest						
Klamath River (below Hwy 101 bridge)	31	129	672	0	801	832
Klamath River (Hwy 101 to Weitchpec)	91	15	3	6	24	115
Klamath River (Weitchpec to IGH)	24	227	185	4	416	440
Trinity River Basin (above WCW)	0	34	6	0	40	40
Trinity River Basin (below WCW)	15	25	4	0	29	44
Subtotals	**161**	**430**	**870**	**10**	**1,310**	**1,471**
Tribal Harvest						
Klamath River (below Hwy 101)	121	413	2,611	161	3,185	3,306
Klamath River (Hwy 101 to Trinity mouth)	19	163	977	84	1,224	1,243
Trinity River (Hoopa Reservation)	20	341	378	31	750	770
Subtotals	**160**	**917**	**3,966**	**276**	**5,159**	**5,319**
Total Harvest	**321**	**1,347**	**4,836**	**286**	**6,469**	**6,790**
Totals						
Harvest and Escapement	2,767	8,510	14,983	478	23,971	26,738
Recreational Angling Dropoff Mortality 2.04%	3	9	18	0	27	30
Tribal Net Dropoff Mortality 8.7%*	14	81	353	24	458	472
Klamath River Ich disease testing (Yurok Tribe)	2	15	89	7	111	113
Total River Run	**2,786**	**8,615**	**15,443**	**509**	**24,567**	**27,353**

* Net drop-off mortality includes fish collected by tribes for Ich testing.

Table 6: Age proportion of the 2016 Klamath Basin fall Chinook run.

	AGE			
Escapement & Harvest	2	3	4	5
Hatchery Spawners				
Iron Gate Hatchery (IGH)	0.06	0.65	0.28	0.01
Trinity River Hatchery (TRH)	0.26	0.47	0.27	0.01
Hatchery Spawner subtotal	0.13	0.58	0.27	0.01
Natural Spawners				
Salmon River Basin	0.02	0.64	0.34	0.00
Scott River Basin	0.09	0.00	0.91	0.00
Shasta River Basin	0.05	0.19	0.77	0.00
Bogus Creek Basin	0.04	0.28	0.67	0.00
Klamath River mainstem (IGH to Shasta R)	0.05	0.32	0.63	0.00
Klamath River mainstem (Shasta R to Indian Cr)	0.05	0.32	0.63	0.00
Klamath tributaries (above Reservation)	0.02	0.19	0.74	0.04
Yurok Reservation tributaries	0.09	0.14	0.72	0.04
Klamath Basin subtotal	0.05	0.25	0.70	0.01
Trinity River (mainstem above WCW)	0.27	0.42	0.29	0.02
Trinity River (mainstem below WCW)	0.28	0.42	0.29	0.02
Trinity tributaries (above Reservation)	0.28	0.41	0.29	0.03
Hoopa Reservation tributaries	0.28	0.42	0.29	0.01
Trinity Basin subtotal	0.27	0.42	0.29	0.02
Natural Spawners subtotal	0.12	0.30	0.57	0.01
Total Spawner Escapement	0.12	0.36	0.51	0.01
Recreational Harvest				
Klamath River (below Hwy 101 bridge)	0.04	0.16	0.81	0.00
Klamath River (Hwy 101 to Weitchpec)	0.79	0.13	0.03	0.05
Klamath River (Weitchpec to IGH)	0.05	0.52	0.42	0.01
Trinity River Basin (above WCW)	0.00	0.85	0.15	0.00
Trinity River Basin (below WCW)	0.34	0.57	0.09	0.00
Subtotals	0.11	0.29	0.59	0.01
Tribal Harvest				
Klamath River (below Hwy 101)	0.04	0.12	0.79	0.05
Klamath River (Hwy 101 to Trinity mouth)	0.02	0.13	0.79	0.07
Trinity River (Hoopa Reservation)	0.03	0.44	0.49	0.04
Subtotals	0.03	0.17	0.75	0.05
Total Harvest	0.05	0.20	0.71	0.04
Totals				
Harvest and Escapement	0.10	0.32	0.56	0.02
Recreational Angling Dropoff Mortality 2.04%	0.10	0.30	0.60	0.00
Tribal Net Dropoff Mortality 8.7%	0.03	0.17	0.75	0.05
Total River Run	0.10	0.31	0.56	0.02

Appendix A: Estimation of escapement age-composition from a random sample containing known-age (CWT) and unknown read-age fish.

Denote the escapement at age as $\{N_a, a = 2,3,4,5\}$, $N = \sum N_a$, and for the random sample of size $(n+m)$ fish, denote the following quantities:

- known-age fish: number at age $\{n_a, a = 2,3,4,5\}$, $n = \sum n_a$, $p_a = n_a / n$.
- unknown read-age fish: number at age $\{m_a, a = 2,3,4,5\}$, $m = \sum m_a$, $r_a = m_a / m$.
- bias-corrected unknown read-age proportions: $\{r_a^*, a = 2,3,4,5\}$, $r_A^* = r_3^* + r_4^* + r_5^*$.
- age-2 proportion as estimated by size-frequency: s_2.

1. Age 2–5 escapement by scales. Estimate N_a as the sample of known-age *a* fish plus the unknown age portion of the escapement times the estimated age *a* proportion (bias-corrected):

$$N_a = np_a + (N-n)r_a^*, \ a = 2,3,4,5.$$

2. Age-2 escapement by size-frequency; age 3–5 escapement by scales. Estimate N_2 as the total escapement times the size-frequency based estimated age-2 proportion. Estimate N_a for $a = 3,4,5$ as the sample known-age *a* fish plus the unknown age portion of the adult escapement times the age *a* proportion among adults (bias-corrected):

$$N_a = \begin{cases} Ns_2, & a = 2 \\ np_a + [N(1-s_2) - n(1-p_2)](r_a^* / r_A^*), & a = 3,4,5 \end{cases}$$

Appendix B: Shasta River escapement age composition 2016.

Age structure of the Shasta River fall Chinook Salmon run was determined using:

1. the estimated total number of fish passing the video weir [jacks (J) and adults (A) combined],
2. proportion of males among adults in the spawning ground survey,
3. proportion of jacks among males in the "washback" samples taken at the weir site,
4. adult scales collected in the spawning survey.

A total of N = 2,889 fall Chinook salmon were estimated to have passed the weir in 2016. Data from the spawning ground surveys included no jacks and was deemed by the KRTT to be unrepresentative of the true number of jacks in the Shasta River. A single jack carcass was sampled at the weir from carcasses that accumulated at the upstream side (washback samples).

The KRTT elected to utilize an age composition estimation method, developed in 2006 (KRTAT 2007), to partition the run using data collected from the spawning ground survey and weir washbacks. The proportion of males among adults, $P(M|A)$, was estimated using the spawning ground survey. There were 20 adult males from the total adult sample of 37 taken in the spawning ground survey, yielding $P(M|A)$ = 0.5405. The proportion of jacks among males, $P(J|M)$, was estimated from the sampled washbacks. There was 1 jack among the 12 male Chinook in the sampled washbacks, yielding $P(J|M)$ = 0.0833. The equations below were then used to partition the total run (N) into jacks and adults. Following that, the age composition of adults was estimated using the age proportions derived from the spawning ground survey.

1. Estimate the proportion of males in the run,

$$P(M) = \frac{P(M|A)}{1 - P(J|M)[1 - P(M|A)]} = \frac{0.5405}{1 - [0.0833 \times (1 - 0.5405)]} = 0.5620,$$

   based on the following relationship:

$$P(M|A) = \frac{P(M,A)}{P(A)} = \frac{P(M) - P(J)}{1 - P(J)} = \frac{P(M) - P(J|M)P(M)}{1 - P(J|M)P(M)}.$$

2. Estimate the proportion of jacks in the run:

$$P(J) = P(M) \times P(J|M) = 0.5620 \times 0.0833 = 0.0468.$$

3. Estimate the number of jacks in the run:

$$J = N \times P(J) = 2{,}889 \times 0.0468 = 135.$$

4. Estimate the adult run:

$$A = N - J = 2{,}889 - 135 = 2{,}754.$$

Reference

KRTAT (Klamath River Technical Advisory Team). 2007. Klamath River fall Chinook age-specific escapement , river harvest, and run size estimates, 2006 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Appendix C: Estimation of Salmon River adult escapement, accounting for a shortened survey and a lack of sampling in Wooley Creek.

In 2016, the initial Salmon River redd survey was conducted during Julian week 41 (the week ending on 14 October 2016). Large flow events following this initial survey resulted in very sparse additional surveys. In the Salmon River system, substantial spawning typically occurs after Julian week 41, and this spawning activity was insufficiently sampled. Additionally, no sampling was performed on Wooley Creek in 2016, and the total Salmon River escapement estimate reported annually includes fish spawning in Wooley Creek. To derive an adult spawner estimate given these sampling shortfalls in the Salmon River watershed, we employed methods previously developed by the KRTT to account for scenarios when sampling effort was either low or lacking altogether (KRTT 2009, 2011).

To account for the lack of sampling after Julian week 41 in the Salmon River, 2016 redd deposition data up to and including Julian week 41, and the cumulative distributions of redd deposition from past years were used to estimate redds in 2016 (KRTT 2011). Redd deposition data for years 1998-2015 (but excluding 2010, where survey effort was also low) indicated that the maximum proportion of new redds counted up to, and including, Julian week 41 was $p = 0.3237$. The KRTT discussed whether a mean, minimum, or maximum proportion of redd deposition (across years with appropriate data) at Julian week 41 would be most representative of 2016 conditions. The team decided that the maximum proportion would be most appropriate because observations from other neighboring sectors (including the upper Klamath tributaries and the Scott River) suggested early run timing and spawning in 2016.

In 2016, 153 redds were enumerated through Julian week 41 ($R_{inc} = 153$) and the total number of redds in the Salmon River (R), not including Wooley Creek, was estimated to be:

$$R = \frac{R_{inc}}{p} = \frac{153}{0.3237} = 473.$$

To account for the lack of sampling in Wooley Creek, we applied a method previously described in KRTT (2009). The ratio of the mean number of total redds in the Salmon River basin (including Wooley Creek $\overline{T}$) to the mean number of redds in the Salmon River (excluding Wooley Creek $\overline{S}$) was computed using data from 1996-2015 (but excluding 2008 when Wooley Creek was not sampled):

$$\lambda = \frac{\overline{T}}{\overline{S}} = \frac{1124.95}{1030.63} = 1.09.$$

The total number of redds in the Salmon River Basin (R_{tot}), accounting for both a shortened survey and a lack of sampling in Wooley Creek, is therefore

$$R_{tot} = R \times \lambda = 473 \times 1.09 = 516,$$

which allows for estimate of adult escapement (E) to the Salmon River basin, assuming two adult fish per redd:

$$E = R_{tot} \times 2 = 516 \times 2 = 1{,}032.$$

References

KRTT (Klamath River Technical Team). 2009. Klamath River fall Chinook age-specific escapement, river harvest, and run size estimates, 2008 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

KRTT (Klamath River Technical Team). 2011. Klamath River fall Chinook age-specific escapement, river harvest, and run size estimates, 2010 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Appendix D: Description of the hierarchical latent variable model used to estimate fall Chinook Salmon escapement in the mainstem Klamath River from Iron Gate Dam to the Shasta River, 2016.

Carcass abundance estimates of Chinook Salmon in the mainstem Klamath River between Iron Gate Dam and the Shasta River confluence were generated via a hierarchical latent variable model in 2016. This model assumes a latent (unobservable) ecological process interacts with a detection process to produce the observed counts of carcasses (Kery and Schaub 2012). For this survey, the latent process is the true abundance of carcasses. As not all carcasses are observed (imperfect detection), a separate observation process links the unobserved latent process to the observed data.

The general model described above was executed with counts of fresh Chinook Salmon carcasses (C_i, and hereafter *i* indexes week; i.e., those arriving since the prior survey) and weekly detection probabilities (p_i) estimated from mark–recapture data. Detection probability (p_i) is estimated via the count of recovered carcasses (R_i) that had been marked the previous week (M_{i-1}). Weekly abundances (N_i) are estimated by assuming that the weekly counts of fresh Chinook Salmon carcasses (C_i) arise from a binomial distribution (index parameter = N_i, probability of detection = p_i; Kery and Schaub 2012). Finally, weekly estimates were summed to create an annual abundance estimate of carcasses (*N*) as a derived parameter (Kery and Schaub 2012). The assumptions of this modeling framework include: 1) crews correctly identify fresh Chinook Salmon carcasses among all other carcasses (e.g., decaying carcasses or carcasses of other species), 2) marked carcasses remain in the study area for at least one week, and 3) the detection probability of all carcasses is equal within a given week.

$$R_i \sim binomial(M_{i-1}, p_i);\ C_i \sim binomial(N_i, p_i)$$

$$N = \sum_i N_i$$

Implementing our abundance model in a Bayesian framework and estimating parameters via Markov Chain Monte-Carlo (MCMC) methods allowed us to propagate all sources of estimation uncertainty (over all detection probabilities and weeks) and generate confidence intervals for each annual abundance estimate (Kery and Schaub 2012). A requirement of Bayesian implementation is specifying prior distributions for all estimated parameters. In all cases, we implemented non-informative priors, and commenced with MCMC sampling via JAGS software (Plummer 2014) implemented with R statistical software (R Core Team 2016).

References

Kery, M., and M. Schaub. 2012. Bayesian Population Analysis Using WinBUGS. Academic Press. Oxford, United Kingdom.

Plummer, M. 2014. JAGS: A program for analysis of Bayesian graphical model using Gibbs sampling.

R Core Team. 2016. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Appendix E: Klamath River – 2016 details.

Iron Gate Hatchery (IGH)
A systematic random bio-sample[a] was obtained from every tenth Chinook Salmon returning to IGH in 2016. A total of 227 scale samples were aged, of which 24 were from known-age CWT fish. Additionally, 21 non-random scales were collected from known-age CWT fish <55 cm FL to assist in validation. Scale-based age compositions were used to apportion all age classes.

Bogus Creek
Escapement was estimated by summing carcasses encountered below the video weir and videography counts above the weir. Bio-samples were obtained at a 1:2 systematic random sampling rate. Additionally, biological data (including scales), were obtained from every (i.e., non-random) ad-clipped fish encountered. A total of 116 scale samples were aged, of which 13 were from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Shasta River
Escapement was estimated by videography while bio-samples were collected from all recovered carcasses during surveys in the lower seven miles on public and private lands where access is granted. Bio-samples were also obtained from systematically sampling carcasses that washed back onto the counting weir. Additionally, all ad-clipped fish not falling within the systematic sample were bio-sampled. A total of 54 scales were aged, of which only one was from a known-age fish. Scale-based age compositions collected from the spawning ground surveys were used to apportion adult age classes. Due to no recovery of fish <59 cm FL (presumed jacks), jacks were estimated using methods described in Appendix B.

Scott River
Independent estimates from above and below the weir were combined to estimate total escapement. Escapement above the weir was estimated using videography supplemented by ARIS acoustic counts during multiple high flow events. Species proportions observed by videography prior to and after ARIS deployment were used to estimate Chinook Salmon counts by ARIS. Escapement below the weir was attempted using the Cormack-Jolly-Seber estimator with data from twice weekly mark-recapture carcass surveys. However, multiple surveys were cancelled due to high flows. Adult escapement below the weir was estimated by total redd count (redds X 2). Bio-samples were obtained from all non-deteriorated carcasses recovered above and below the weir. A total of 153 scale samples were aged of which none were from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Salmon River
River flows were too excessive in most weeks to conduct comprehensive mark recapture estimates, and inhibited redd surveys on several occasions. A comprehensive survey of the mainstem was completed only for Julian week 41. Wooley Creek was excluded entirely from redd surveys due to high flows. To account for incomplete sampling, adult escapement was estimated using methods described in Appendix C. Bio-samples and scales were obtained from all recovered carcasses. A total of 21 scale samples were aged, none of which were from known-age CWT fish. Scale-based age compositions were used to apportion adult age classes. The jack proportion from the upper Klamath River tributaries was used as a surrogate.

Klamath River Tributaries
Typically, streams are surveyed every other week for counting redds. In 2016 high flow events precluded repeated surveys. Total escapement was estimated by expanding the total redd count (redds X 2), applying the scale-based age-2 proportion to the expanded redd count, and then adding the number of live fish observed during the final survey in each tributary. A total of 33 scale samples were aged, none

[a] Biological samples ("bio-samples") of live fish or carcasses generally included: sex, fork length, tags or marks, a scale sample, and CWT recovery codes from adipose fin-clipped fish.

of which were from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Klamath River Mainstem
For the upper reach (IGH to Shasta River), weekly carcass counts were input into a hierarchical latent variable model to estimate escapement (Appendix D). Weekly observation efficiency was derived from recapture histories of marked carcasses. Only fresh carcasses were marked for this estimation method. A total of 241 scales were aged, 13 of which were from known-age CWT fish. Scale-based age proportions were used to assign all age classes.

For the lower reach (Shasta River to Indian Creek), adult escapement was estimated by expanding the total redd count (redds X 2). Total escapement was estimated by expanding the adult estimate by the scale-based age-2 proportion from the upper reach. Scale-based age proportions from the upper reach were used as surrogate to assign all age classes.

Lower Klamath River Creel
Total harvest was estimated by combining creel census estimates from the two sub-areas (above the Highway 101 Bridge to Weitchpec and below the Highway 101 Bridge to the mouth). A total of 220 scale samples were aged, of which 1 was taken from a known-age CWT fish. Scale-based age proportions for each sub-area were used to apportion all age classes in their respective sub-areas.

Upper Klamath River Recreational Fishery
A creel census in this sub-area was not conducted in 2016. Creel census data were available for the lower and upper river fisheries in 1999 through 2002. The ratio of average adult harvest in the entire Klamath main stem to the average harvest in the lower Klamath River Creel area from these years was applied to the 2016 lower Klamath River Creel harvest to estimate the total adult harvest in the Klamath River main stem. Adult harvest for the upper Klamath River recreational fishery was then estimated by subtracting the estimated lower Klamath River Creel estimate from the Klamath main stem total harvest. Finally, the combined adult and jack harvest was obtained by dividing the adult harvest by the proportion of adults from the weighted average scale age composition of the Upper Klamath River mainstem (IGH to Shasta River), Bogus Creek, and Iron Gate Hatchery. This weighted scale-based age composition was used to apportion all age classes in this fishery.

Yurok Tribal Estuary Fishery (Klamath mouth to Hwy 101)
Yurok harvest in this sub-area was estimated by hourly effort and catch-per-effort analyses. A total of 1,201 scales were aged, of which 50 were from known-age CWT fish. Scale-based age composition was used to apportion all age classes.

Yurok Tribal Fishery Above Hwy 101
Yurok harvest in this sub-area was estimated by daily effort and catch-per-effort analyses. A total of 556 scale samples were aged, of which 10 came from known-age CWT fish. Scale-based age composition was used to apportion all age classes.

Blue Creek
Total run was estimated from the single diver (assumed peak) count completed on November 9, 2016. No scales were obtained from this sector. Age-2 composition was estimated through direct observation from the single diver survey. Adult age proportions were estimated using the un-weighted average proportions estimated for this sector from years 2011-2015.

Appendix F: Trinity River – 2016 details.

Trinity River Hatchery (TRH)
Sampling for scales was conducted in a systematic (1:5) random manner including ad-clipped and non-ad-clipped fish. A total of 302 scales were aged, of which 82 scales came from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Upper Trinity River Recreational Harvest
The method for estimating the upper Trinity River recreational harvest depends on the application of reward and non-reward program tags at the Willow Creek Weir (WCW) and subsequent returns by anglers. In 2016, only non-reward tags were recovered. CDFW estimated a 0.893% harvest rate on adult Chinook Salmon based on the return of program tags (2 of 224) applied at WCW. The jack harvest rate of 0.0% was based on return of program tags (0 of 88), yielding an estimated harvest of no age-2 Chinook Salmon. There were no scales recovered from this fishery as no creel survey was implemented in 2016. The adult age proportions were determined using surrogate scales aged from recreational harvest below WCW.

Lower Trinity River Creel
A roving creel survey was implemented in the Trinity River below the location of the WCW. A total of six scales were aged, of which none came from known-age CWT fish. Scale age proportions were used to apportion age structure in this sector.

Trinity River Natural Escapement (above WCW)
Total run was estimated using a non-stratified Petersen mark-recapture estimator. The methods used for estimating age structure within the Trinity River run above WCW were similar to those used in the population estimate, apportioned into three general recovery areas: Trinity River Hatchery, Trinity upper basin natural spawning escapement, and recreational harvest. At WCW a systematic random sample (1:2) of all Chinook Salmon examined yielded a collection of scales for program-marked fish, some of which were ad-clipped (Trinity River Hatchery origin). Validation of WCW scales is accomplished with known-age fish recovered throughout all sectors of the Trinity River. A total of 156 scales were aged of which 9 were from known-age CWT fish subsequently recovered at TRH.

The age structure for fish passing above WCW was estimated using scales collected at WCW minus those from known-age fish later recovered at TRH. Next, specific age structures were estimated for fish returning to TRH and the recreational fishery. These proportions were applied to the total hatchery escapement and estimated fishery harvest, respectively, providing totals by age within area. These totals were then deducted from the WCW run and apportioned by age, resulting in an age structure for the natural escapement in the upper Trinity River.

Trinity Mainstem Natural Escapement (below WCW)
No successful redd surveys were completed in this sector. Adult escapement was estimated by multiplying the ratio of this sector to the upper Trinity River adult natural escapement for years 2001–2015 (0.0274), by the 2016 estimated adult run size in the upper Trinity River natural escapement sector. This product was then divided by the adult proportion of the upper Trinity River natural escapement sector to produce the total run. The upper Trinity River natural escapement age structure was used to apportion all ages.

Trinity Tributaries (above Reservation; below WCW)
Total escapement was estimated by expanding the total redd count (redds X 2), applying the age-2 proportion from the upper Trinity River natural escapement sector to the expanded redd count, and then adding the number of live fish observed during the final survey in each tributary. One scale was recovered from an unknown-age carcass. The upper Trinity River natural escapement age structure was used to apportion all ages.

Hoopa Reservation Tributaries

Total escapement was estimated by expanding the total redd count (redds X 2) and applying the age-2 proportion from the upper Trinity River natural escapement sector to the expanded redd count. One scale was recovered from an unknown-age carcass. The upper Trinity River natural escapement age structure was used to apportion all ages.

Hoopa Valley Tribal Harvest

Hoopa Valley Tribal harvest is a composite of the gill net and hook-and-line fisheries prosecuted by Tribal members. A total of 212 scales were aged, of which 18 were from known-age fish. Scale age proportions were used to apportion the age structure in this sector.

Appendix G: 2016 Klamath age analysis.

Unknown scales age composition as read

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	5	33	65	0	103
IGH	15	132	54	2	203
SALMON	0	14	7	0	21
SCOTT	14	7	132	0	153
SHASTA	0	10	30	0	40
MAINSTEM	13	80	135	0	228
UR TRIBS	1	9	25	1	36
LRC EST	7	37	134	0	178
LRC UP	27	5	1	1	34
YTFP EST	44	218	851	38	1,151
YTFP M&U	9	112	400	25	546
BLUE CRK	0	0	0	0	0
	135	657	1834	67	2693

Unknown scales corrected age proportions (Kimura method)

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	0.0444	0.2815	0.6741	0.0000	1.0
IGH	0.0644	0.6492	0.2716	0.0148	1.0
SALMON	0.0000	0.6555	0.3445	0.0000	1.0
SCOTT	0.0915	0.0000	0.9085	0.0000	1.0
SHASTA	0.0000	0.1946	0.8054	0.0000	1.0
MAINSTEM	0.0524	0.3163	0.6313	0.0000	1.0
UR TRIBS	0.0250	0.1886	0.7447	0.0417	1.0
LRC EST	0.0371	0.1545	0.8084	0.0000	1.0
LRC UP	0.7921	0.1352	0.0285	0.0441	1.0
YTFP EST	0.0365	0.1192	0.7948	0.0495	1.0
YTFP M&U	0.0146	0.1295	0.7872	0.0687	1.0
BLUE CRK	0.0928	0.1433	0.7221	0.0417	1.0

Known CWT ages [a/]

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	0	7	15	0	22
IGH	17	332	150	7	506
SALMON	0	0	0	0	0
SCOTT	0	1	0	0	1
SHASTA	0	0	1	0	1
MAINSTEM	0	5	10	1	16
UR TRIBS	0	0	0	0	0
LRC	1	0	0	0	1
YTFP EST	2	25	23	0	50
YTFP M&U	1	3	6	0	10
BLUE CRK	0	0	0	0	0
	21	373	205	8	607
<u>Breakout within strata</u>					
Bogus1	0	3	6	0	9
Bogus2	0	4	9	0	13
LRC - lo	0	0	0	0	0
LRC - mid	1	0	0	0	1
YTFP MID-UP	0	1	3	0	4

a/ Table includes known-age fish whose scales were not mounted / read.

Appendix H: 2016 Trinity age analysis.

WCW = Willow Ck. Weir

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	2	0	0	0	0	2
	2	38	2	0	0	0	40
Scale	*3*	57	0	4	0	0	61
Ages	*4*	50	0	1	2	0	53
9	*5*	2	0	0	0	0	2
147		149	2	5	2	0	158

LOWTRINREC = Lower Trinity Recreational

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	0	0	0	0	0	0
	2	2	0	0	0	0	2
Scale	*3*	3	0	0	0	0	3
Ages	*4*	1	0	0	0	0	1
0	*5*	0	0	0	0	0	0
6		6	0	0	0	0	6

HUPAHARV = Hoopa Tribal Net Harvest plus Tribal Hook-and-Line

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	0	0	1	0	0	1
	2	5	0	0	0	0	5
Scale	*3*	74	0	10	0	0	84
Ages	*4*	107	0	2	6	0	115
19	*5*	8	0	0	0	0	8
194		194	0	13	6	0	213

TRH = Trinity River Hatchery

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	4	0	0	0	0	4
	2	55	25	0	0	0	80
Scale	*3*	93	1	33	0	0	127
Ages	*4*	71	0	4	19	0	94
82	*5*	1	0	0	0	0	1
220		224	26	37	19	0	306

LOWTRINTRIBS = Lower Trinity Tribs - Includes samples taken by U

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	0	0	0	0	0	0
	2	0	0	0	0	0	0
Scale	*3*	0	0	0	0	0	0
Ages	*4*	1	0	0	0	0	1
0	*5*	1	0	0	0	0	1
2		2	0	0	0	0	2

UPKLAMREC Upper Klamath Recreational

NO DATA

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable						
	2						
Scale	*3*						
Ages	*4*						
0	*5*						
0		0	0	0	0	0	0

LOWTRINMAINSTEM = Lower Trinity Mainstem

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable	0	0	0	0	0	0
	2	0	0	0	0	0	0
Scale	*3*	0	0	0	0	0	0
Ages	*4*	0	0	0	0	0	0
0	*5*	0	0	0	0	0	0
0		0	0	0	0	0	0

0

NO DATA

		no cwt age	*Cwt Age* 2	3	4	5	Total
	Scale unreadable						
	2						
Scale	*3*						
Ages	*4*						
0	*5*						
0		0	0	0	0	0	0

POOLED data from all areas: Scale age-CWT age matrix.
(Includes only fish with both scale age and CWT known age.)

	VALIDATION MATRIX	**2**	**3**	**4**	**5**	
	2	27	0	0	0	
	3	1	47	0	0	
4x4	**4**	0	7	27	0	
	5	0	0	0	1	**0.93**

(B)
Scale-CWT age matrix of proportions of column sums.

	2	**3**	**4**	**5**
2	0.9643	0.0000	0.0000	0.0000
3	0.0357	0.8704	0.0000	0.0000
4	0.0000	0.1296	1.0000	0.0000
5	0.0000	0.0000	0.0000	1.0000

Corrected Scale age proportion vectors for scale-aged 2 - 5 fish.

# known scales	9	19	0	82				0	110
# unknown scales	147	194	6	220				2	569
Age	Willow Creek Weir WCW	Hoopa Tribal NET HARV	Lower Trinity REC HARV	TRH HATCHERY	Lower Trinity Mainstem	Upper Trinity REC HARV	Upper Trin NATURAL	Lower Trin Tribs	
2	0.2681	0.0267	0.3457	0.2593	0.0000	-	0.2731	0.0000	
3	0.4345	0.4372	0.5603	0.4750	0.0000	0.8563	0.4197	0.0000	
4	0.2838	0.4949	0.0940	0.2611	0.0000	0.1437	0.2906	0.5000	
5	0.0136	0.0412	0.0000	0.0045	0.0000	0.0000	0.0165	0.5000	
	1.00000	1.00000	1.00000	1.00000	0.00000	1.00000	1.00000	1.00000	

Correction Matrix for ages 2,3,4,5.
(Inverse of Scale-CWT age proportion matrix.)

	2	**3**	**4**	**5**
2	1.0370	0.0000	0.0000	0.0000
3	-0.0426	1.1489	0.0000	0.0000
4	0.0055	-0.1489	1.0000	0.0000
5	0.0000	0.0000	0.0000	1.0000

CWTS Age	Willow Creek Weir WCW	Hoopa Tribal NET HARV	Lower Trinity REC HARV	TRH HATCHERY	Lower Trinity CARCASS	(Estimated) Upper Trinity REC HARV	(Estimated) Upper Trinity NATURAL	Hoopa Hook&Line
2	0	0	0	86	0	0	68	0
3	0	13	0	145	0	2	71	0
4	0	6	0	95	0	1	46	0
5	0	0	0	2	0	0	1	0
	0	19	0	328	0	3	186	0
# unknown ads	0	1	2	11	0	0	0	0
# total ads	0	20	2	339	0	paper CWTs		0

WCW scales

Age	WCW no cwts	known age cwts scales	Total age all scales	WCW age proportions
2	39	0	39	0.2681
3	64	0	64	0.4345
4	42	0	42	0.2838
5	2	0	2	0.0136
	147	0	147	1.0000

Natural Escapement, Trinity basin above WCW: Apportioned to age structure.

	Total Run
Rec above WCW	40
TRH	1543
Naturals	4612
Total	6195

Age	WCW proportions	TRH + Rec above WCW+Natural Escapement	minus TRH #s minus above WCW creel #s Escapement	**Apportioned Natural Escapement** Proportions
2	0.2681	1661	1260	0.2731
3	0.4345	2692	1936	0.4197
4	0.2838	1758	1340	0.2906
5	0.0136	84	76	0.0165
		6195		

Appendix I: 2016 Klamath Basin fall Chinook age-composition calculation worksheet.

2/10/2017

Hatchery spawners	# Grilse	# Adults	Total Run	CALCULATED AGE 2	3	4	5	Total	SCALE AGE PROPORTIONS (unknowns)	2	3	4	5	Total	Unk. Age Scales Read	Length Freq or Redds	Live
Iron Gate Hatchery (IGH)	151	2436	2587	151	1683	715	38	2587	scales	0.06441	0.64919	0.27162	0.01478	1.0	203		
									IGH cwts	17	332	150	7	506			
Trinity River Hatchery (TRH)	401	1142	1543	401	722	412	8	1543	scales	0.25926	0.47505	0.26115	0.00455	1.0	220		
Hatchery spawner subtotal:	552	3578	4130	552	2405	1127	46	4130	TRH cwts	86	145	95	2	328			
	prop. hatchery grilse		0.134			proportion hatchery		0									
Natural Spawners																	
Trinity River mainstem above WCW	1260	3352	4612	1260	1936	1340	76	4612	scales	0.27314	0.41972	0.29059	0.01654	1.0	147		
Trinity River mainstem below WCW	35	92	127	35	53	37	2	127	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	0		carcass
Salmon River Basin (includes Wooley Cr)	26	1032	1058	26	676	356	0	1058	Up K tribs	0.02502	0.65547	0.34453	0.00000	1.0	21	516	0
Scott River	139	1376	1515	139	1	1375	0	1515	scales	0.09150	0.00000	0.90850	0.00000	1.0	153	165	1152
									Scott CWT	0	1	0	0	1			video
Shasta River	135	2754	2889	135	536	2218	0	2889	Adult scales only		0.19457	0.80543	0.00000	1.0	40		
									Shasta CWT	0	0	1	0	1			
Bogus Creek	38	830	868	38	245	585	0	868	scales	0.04443	0.28146	0.67411	0.00000	1.0	103		
									Bogus CWT	0	7	15	0	22			
Mainstem Klamath (IGH to Shasta R)	38	708	746	38	236	471	1	746	scales	0.05240	0.31635	0.63125	0.00000	1.0	228		
									KR main CWT	0	5	10	1	16			
Mainstem Klamath (Ash Cr to Indian Cr)	121	2194	2315	121	732	1462	0	2315	Up K main	0.05240	0.31635	0.63125	0.00000	1.0	IGH to Shasta	1097	
Main basin subtotals:	1,792	12338	14,130	1,792	4,415	7,844	79	14130									
Klamath Tributaries																	
Aiken Cr	0	8	8	0	2	6	0	8	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	4	0
Beaver Cr	4	156	160	4	30	119	7	160	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	78	0
Bluff Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Boise Cr	0	8	8	0	2	6	0	8	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	4	0
Camp Cr	11	443	454	11	86	338	19	454	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	219	5
Clear Cr	1	28	29	1	5	22	1	29	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	14	0
Dillon Cr	1	51	52	1	10	39	2	52	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	23	5
Elk Cr	2	64	66	2	12	49	3	66	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	32	0
Ft. Goff Cr	1	30	31	1	6	23	1	31	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	15	0
Grider Cr	1	36	37	1	7	27	2	37	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	18	0
Horse Cr	0	12	12	0	2	9	1	12	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	6	0
Independence Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	0	0
Indian Cr	1	36	37	1	7	27	2	37	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	18	0
Irving Cr	0	6	6	0	1	5	0	6	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	3	0
Perch Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Red Cap Cr	3	118	121	3	23	90	5	121	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	59	0
Rock Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Slate Cr	1	44	45	1	8	34	2	45	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	20	4
Swillup Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Seiad Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Thompson Cr	4	142	146	4	28	108	6	146	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	71	0
Ti Cr	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	0	0
Unkonom Cr	0	9	9	0	2	7	0	9	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	2	5
Other (China Cr, Rogers Cr)	0	14	14	0	3	10	1	14	scales	0.02502	0.18864	0.74467	0.04167	1.0	36	7	0
Pine Cr (formerly in Hoopa tribs)	0	0	0	0	0	0	0	0	scales	0.02502	0.18864	0.74467	0.04167	1.0	36		
Klamath trib subtotal:	30	1205	1235	30	234	919	52	1235								593	19
Trinity Tributaries																	
Horse Linto Cr	9	23	32	9	13	9	1	32	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	11	2
Cedar Cr (trib to Horse Linto)	12	32	44	12	18	13	1	44	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	16	0
Other (Willow & Madden creeks in Up TR nat estim)	0	0	0	0	0	0	0	0	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	0	0
Trinity trib subtotal:	21	55	76	21	31	22	2	76								27	
Non-reservation trib subtotal:	51	1260	1311	51	265	941	54	1311									
Reservation Tributaries-Hoopa Valley																	
Campbell Cr	0	0	0	0	0	0	0	0	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	0	
Hostler Cr	2	4	6	2	3	1	0	6	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	2	
Mill Cr	7	18	25	7	10	8	0	25	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	9	
~~Pine Cr.~~ (moved in 2007 to Klam tribs)																	
Sotish Cr	0	0	0	0	0	0	0	0	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	0	
Supply Cr	12	32	44	12	18	13	1	44	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	16	
Tish Tang Cr	3	8	11	3	5	3	0	11	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	4	
Other (Hospital Cr.)	0	0	0	0	0	0	0	0	Up T main	0.27314	0.41972	0.29059	0.01654	1.0	2	0	
HVT reservation trib subtotal:	24	62	86	24	36	25	1	86								31	
							1										
Reservation Tributaries-Yurok																	
Blue Cr	27	264	291	27	42	210	12	291	scales	count	0.15800	0.79600	0.04600	1.0	0		
										0.093	Proportions this year based on 5-yr avg						
Reservation tributaries subtotal:	51	326	377	51	78	235	13	377									
Natural spawner subtotal:	1894	13924	15818	1894	4758	9020	146	15818									
Total spawners:	**2446**	**17502**	**19948**	**2446**	**7163**	**10147**	**192**	**19948**									
Angler Harvest																	
Klamath River (below Hwy 101)	31	801	832	31	129	672	0	832	scales	0.03707	0.15449	0.80844	0.00000	1.0	178		
									est-LRC CWT	0	0	0	0	0			
Klamath River (Hwy 101 to Weitchpec)	91	24	115	91	15	3	6	115	scales	0.79214	0.13520	0.02853	0.04412	1.0	34		
									mid-LRC CWT	1	0	0	0	1			
		Upper Klam ratio estimator							SURROGATE - Iron Gate+Bogus+Klamath Mainstem Weighted Totals							IGH+BOG+Kmain	
									IGH+Bog+Klam	227	2164	1771	39	4201		4201	
Klamath River (Weitchpec to IGH)	24	416	440	24	227	185	4	440		0.0540	0.5151	0.4216	0.0093	1.0		440	0.1047
									SURROGATE - Trinity Rec. Harvest below WCW - adults only								
Trinity River (above Willow Cr. Weir)	0	40	40	0	34	6	0	40	TR LRC	count	0.85628	0.14372	0.00000	1.0			
									don't use paper TR CWTs in age calculations								
Trinity River (below Willow Cr. Weir)	15	29	44	15	25	4	0	44	scales	0.34568	0.56028	0.09404	0.00000	1.0	6		
									TR-low CWT	0	0	0	0	0			
Angler harvest subtotal:	161	1310	1,471	161	430	870	10	1471									
Tribal Harvest																	
Klamath River (Estuary)	121	3185	3306	121	413	2611	161	3306	scales	0.0365	0.1192	0.7948	0.0495	1.0	1,151		
									YTFP EST CWT	2	25	23	0	50	0.0151	Yurok harvest	
Klamath River (101 to Trinity R)	19	1224	1243	19	163	977	84	1243	scales	0.0146	0.1295	0.7872	0.0687	1.0	546	412	MidKlm
									YTFP MU CWT	1	3	6	0	10	0.0080	831	UpKlm
Trinity River	20	750	770	20	341	378	31	770	scales	0.02673	0.43716	0.49488	0.04124	1.0	194		
									HVT CWT	0	13	6	0	19			
Tribal harvest subtotal:	160	5159	5319	160	917	3966	276	5319									
Total harvest:	**321**	**6469**	**6790**	**321**	**1347**	**4836**	**286**	**6790**									
Totals																	
Harvest and Escapement	2767	23971	26738	2767	8510	14983	478	26738									
Angling drop-off mortality (2.04%)	3	27	30	3	9	18	0	30	0.0204 angling drop-off mortality rate on harvest								
Net drop-off mortality (8.7%)*	14	458	472	14	81	353	24	472	0.0870 net drop-off mortality rate on harvest								
ICH Disease Testing (Tribal)									Klam CWTs	0	0	1	0	1			
Klamath River	2	111	113	2	15	89	7	113	YTFP MU sc	0.0146	0.1295	0.7872	0.0687	1.0000			
Trinity River	0	0	0	0	0	0	0	0	HVT scales	0.0267	0.4372	0.4949	0.0412	1.0000			
Total disease testing:	**2**	**111**	**113**	**2**	**15**	**89**	**7**	**113**	Trin CWTs	0	0	0	0	0			
Total in-river run	**2786**	**24567**	**27353**	**2786**	**8615**	**15443**	**509**	**27353**									
				10.2%	31.5%	56.5%	1.9%										

* Net drop-off mortality includes fish collected by tribes for ICH testing.

Appendix J: Final age composition of the 2015 Klamath Basin fall Chinook run.

Escapement & Harvest	AGE 2	3	4	5	Total Adults	Total Run
<u>Hatchery Spawners</u>						
Iron Gate Hatchery (IGH)	220	3,657	4,073	226	7,956	8,176
Trinity River Hatchery (TRH)	224	1,832	1,258	39	3,129	3,353
Hatchery Spawner subtotal	**444**	**5,489**	**5,331**	**265**	**11,085**	**11,529**
<u>Natural Spawners</u>						
Salmon River Basin	92	847	982	149	1,978	2,070
Scott River Basin	21	1,053	829	210	2,092	2,113
Shasta River Basin	133	5,752	658	202	6,612	6,745
Bogus Creek Basin	45	1,314	974	20	2,308	2,353
Klamath River mainstem (IGH to Shasta R)	84	1,040	1,261	122	2,423	2,507
Klamath River mainstem (Shasta R to Indian Cr)	175	2,131	2,601	252	4,984	5,159
Klamath Tributaries (above Trinity River)	49	1,262	871	111	2,244	2,293
Blue Creek	149	141	491	0	632	781
Klamath Basin subtotal	748	13,540	8,667	1,066	23,273	24,021
Trinity River (mainstem above WCW)	2,505	1,421	2,598	432	4,451	6,956
Trinity River (mainstem below WCW)	155	88	161	27	276	431
Trinity Tributaries (above Reservation; below WCW)	26	15	27	4	46	72
Hoopa Reservation tributaries	38	22	39	5	66	104
Trinity Basin subtotal	2,724	1,546	2,825	468	4,839	7,563
Natural Spawners subtotal	**3,472**	**15,086**	**11,492**	**1,534**	**28,112**	**31,584**
Total Spawner Escapement	**3,916**	**20,575**	**16,823**	**1,799**	**39,197**	**43,113**
<u>Recreational Harvest</u>						
Klamath River (below Hwy 101 bridge)	292	1,396	1,118	400	2,914	3,206
Klamath River (Hwy 101 to Weitchpec)	1,224	1,492	602	164	2,258	3,482
Klamath River (Weitchpec to IGH)	65	1,589	941	77	2,607	2,672
Trinity River Basin (above WCW)	21	18	17	0	35	56
Trinity River Basin (below WCW)	3	14	14	0	28	31
Subtotals	**1,605**	**4,509**	**2,692**	**641**	**7,842**	**9,447**
<u>Tribal Harvest</u>						
Klamath River (below Hwy 101)	405	8,955	9,934	3,619	22,508	22,913
Klamath River (Hwy 101 to Trinity mouth)	44	1,035	1,932	553	3,520	3,564
Trinity River (Hoopa Reservation)	47	614	1,294	112	2,020	2,067
Subtotals	**496**	**10,604**	**13,160**	**4,284**	**28,048**	**28,544**
Total Harvest	**2,101**	**15,113**	**15,852**	**4,925**	**35,890**	**37,991**
<u>Totals</u>						
Harvest and Escapement	6,017	35,688	32,675	6,724	75,087	81,104
Recreational Angling Dropoff Mortality 2.04%	33	92	55	13	160	193
Tribal Net Dropoff Mortality 8.7%*	43	926	1,151	374	2,451	2,494
Klamath River Ich disease testing (Yurok Tribe)	1	30	57	16	103	104
Trinity River Ich disease testing (Hoopa Valley Tribe)	0	6	13	1	20	20
Total River Run	**6,094**	**36,742**	**33,951**	**7,128**	**77,821**	**83,915**

* Net drop-off mortality includes fish collected by tribes for Ich testing.