

Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and Run Size Estimates, 2013 Run

Klamath River Technical Team
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Summary

The number of Klamath River fall Chinook salmon returning to the Klamath River Basin (Basin) in 2013 was estimated to be:

<i>Age</i>	<i>Run Size</i>	
	<i>Number</i>	<i>Proportion</i>
2	14,416	0.08
3	55,259	0.31
4	108,799	0.61
5	1,067	0.01
Total	179,541	1.00

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

<i>Sector</i>	<i>Adults</i>		
	<i>Preseason Forecast</i>	<i>Postseason Estimate</i>	<i>Pre / Post</i>
<i>Run Size</i>	272,400	165,100	1.65
<i>Fishery Mortality</i>			
Tribal Harvest	114,800	62,800	1.83
Recreational Harvest	40,000	19,700	2.03
Drop-off Mortality	10,800	5,900	1.83
	165,600	88,400	1.87
<i>Escapement</i>			
Hatchery Spawners	33,000	17,100	1.93
Natural Area Spawners	73,800	59,600	1.24
	106,800	76,800	1.39

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 2013. The estimates provided in this report are consistent with the Klamath Basin Megatable (CDFG 2014) and with the 2014 forecast of ocean stock abundance (KRTT 2014).

Age-specific escapement estimates for 2013 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 2014). 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 2014). 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 (Appendix B and C). 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 2013 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.

The specific protocols used to develop estimates of age composition for each sector are provided in Table 3. An alternative method was used to estimate the age composition of escapement to the Shasta River for the 2013 run. The method is described in Appendix H. A summary of the KRTT minutes specific to each sector is given in Appendix B for the Klamath River and Appendix C for the Trinity River.

Results

A total of 9,854 scales from 17 different sectors were aged for this analysis (Table 2). Of these, 698 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 E and F). Overall, the scale-based ages were generally accurate. Accuracy within the Trinity Basin was 100% for age-2 fish, 97% for age-3 fish, and 99% for age-4 fish. Accuracy within the Klamath River Basin was

100% for age-2 fish, 93% for age-3 fish, and 96% for age-4 fish. In both the Trinity and Klamath Basins, no age-5 known-age fish were available for use in the validation matrices and thus 100% accuracy for age-5 scale ages is assumed. 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 F.

The final estimates of the 2012 Klamath Basin age composition were slightly modified from the preliminary age composition. Final estimates are presented in Appendix G.

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
YT	Yurok Tribe
YTFP	Yurok Tribal Fisheries Program

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Klamath River Technical Team Participants

California Department of Fish and Wildlife

Melodie Palmer-Zwahlen
Brett Kormos
Morgan Knechtle
Steve Cannata

Hoopa Valley Tribe

George Kautsky
Billy C. Matilton
Bob Campbell

National Marine Fisheries Service

Michael O'Farrell

U.S. Fish and Wildlife Service

Stephen Gough

Yurok Tribe

Desma Williams

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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 2013 Klamath River fall Chinook run assessment.

Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Iron Gate Hatchery	Direct count. All fish examined for fin-clips, tags, and marks. Bio-data ^a collected from a systematic random sample (1:10). Additionally, all ad-clipped fish were bio-sampled.	CDFW
Trinity River Hatchery	Direct count. All fish examined for fin-clips, tags, and marks. Bio-data collected from a systematic random sample (1:5).	CDFW, HVT
Natural Spawners		
Salmon River Basin	Carcass mark-recapture survey (Schaefer) within the mainstem combined with redd surveys in the lower mainstem and tributaries. Total run based on mark-recapture estimate and expanded redd count (2*total redd count)/(1-proportion of jacks). Jacks estimated from scale-age data for this area. Bio-data collected from all recovered carcasses though scales were obtained only from Path 1 carcasses (one clear eye).	CDFW,USFS,YT, KT, SRRC, SCS
Scott River Basin	Total run based on video count through the weir (at river mile 18) and Cormack-Jolly-Seber mark-recapture estimate below the weir. Bio-data collected from all carcasses recovered.	CDFW, SCS, QVIR, USFS, KT, AC, SRCD
Shasta River Basin	Video count above weir. Bio-data collected from carcasses upstream of video weir site and at a trap located at the weir site.	CDFW, QVIR
Bogus Creek Basin	Video count above weir and twice weekly direct carcass count below weir. Bio-data collected from a systematic random sample (1:4) of all carcasses observed during surveys above and below weir. Additionally, all ad-clipped fish were bio-sampled.	CDFW, SCS
Klamath River mainstem (IGH to Shasta R)	Area under the curve estimate from weekly carcass surveys. Bio-data collected from fresh carcasses.	USFWS, YT
Klamath River mainstem (Ash Cr to Indian Cr)	Weekly redd survey. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from the Klamath River mainstem area scale-age data.	USFWS, KT
Klamath Tributaries above Trinity	Periodic redd surveys, the majority of which were performed weekly. Total run = (2*total redd count)/(1-proportion jacks) + live fish observed on last day surveyed. Jacks estimated from length-frequency data collected during surveys. Bio-data collected from all carcasses recovered.	USFS,CDFW, KT, YT, SRRC, MKWC, SCS
Blue Creek	Weekly snorkel surveys. Jacks and adults estimated as the peak count during surveys. Bio-data collected from all fresh carcasses; additional scale samples collected from gill-net sampled and released fish.	YT
Trinity River (mainstem above WCW)	Mark-recapture (Petersen); marks applied at WCW and recovered at TRH. All fish bio-sampled and scales collected in systematic random sample (1:2). Age composition of total run past WCW based on scale-age data from the weir. 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)	Bi-weekly redd survey. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from the natural area above WCW. Bio-samples from all recovered carcasses.	HVT, USFWS
Trinity Tributaries (above Reservation; below WCW)	Periodic redd survey. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from the upper Trinity River natural spawners. Bio-data collected from all recovered carcasses.	USFS
Hoopa Reservation Tributaries	Periodic redd survey. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from the upper Trinity River natural spawners. 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. 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. 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, 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 tags applied at WCW.	CDFW
Trinity River Basin (below WCW)	Roving access creel survey during three randomly selected days per statistical week stratified by weekdays and weekend days (1 weekday and 2 weekend days). 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	Not directly estimated. Assumed rate relative to fishery impacts = .02; relative to fishery harvest = .02/(1-.02) = 2.04%.	KRTAT
Tribal Net Dropoff Mortality	Not directly estimated. Assumed rate relative to fishery impacts = .08; relative to fishery harvest = .08/(1-.08) = 8.7%.	KRTAT

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

Table 2. Scale sampling locations and numbers of scales collected for the 2013 Klamath Basin fall Chinook age-composition assessment.

Sampling Location	Scales collected			Total	Agency
	Aged		Not aged ^{c/}		
	Unknown-age ^{a/}	Known-age ^{b/}			
<u>Hatchery Spawners</u>					
Iron Gate Hatchery (IGH)	657	75	730	1,462	CDFW
Trinity River Hatchery (TRH)	579	179	10	768	HVT
<u>Natural Spawners</u>					
Salmon River Carcass Survey	243	0	10	253	CDFW
Scott River Carcass Survey	1,024	0	15	1,039	CDFW
Shasta River Carcass	542	0	13	555 ^{d/}	CDFW
Bogus Creek Carcass Survey	730	70	14	814	CDFW
Klamath River mainstem	812	0	13	825	USFWS
Upper Klamath River tributaries	140	0	1	141	USFS
Blue Creek Snorkel	46	0	1	47	YT
Willow Creek Weir	391	7	2	400	CDFW, HVT
Lower Trinity River Carcass	12	0	1	13	HVT
Lower Trinity River tributaries	8	0	0	8	HVT, USFS
<u>Recreational Harvest</u>					
Lower Klamath River Creel	1,526	10	1,579	3,115	CDFW
Lower Trinity River Creel	96	7	2	105	HVT
<u>Tribal Harvest</u>					
Klamath River (below Hwy 101)	821	216	1,036	2,073	YT
Klamath River (Hwy 101 to Trinity R)	620	7	67	694	YT
Trinity River (Hoopa Reservation)	909	127	12	1,048	HVT
TOTAL	9,156	698	3,506	13,360	

a/ Scales from non-ad-clipped fish and ad-clipped fish without CWTs, mounted and aged.

b/ Scales from all mounted and aged ad-clipped CWT fish; non-random CWT fish used for validation but not age composition.

c/ Scales mounted and not aged or scales not mounted.

d/ Includes 53 scales collected from washbacks at Shasta weir that were aged but not used in scale analysis.

Table 3. Age-composition methods used for the 2013 Klamath Basin fall Chinook run assessment.

Sampling Location	Age Composition Method
<u>Hatchery Spawners</u>	
Iron Gate Hatchery (IGH)	Jack/adult structure from scale-age analysis.
Trinity River Hatchery (TRH)	Jack/adult structure from scale-age analysis.
<u>Natural Spawners</u>	
Salmon River Basin	Jack/adult structure from scale-age analysis.
Scott River Basin	Jack/adult structure from scale-age analysis.
Shasta River Basin	Jack/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 (Ash Cr to Indian Cr)	Surrogate: Klamath mainstem (IGH to Shasta R) age-structure.
Klamath tributaries (above Trinity River)	Jack/adult structure from scale-age analysis.
Blue Creek	Jacks estimated by direct observation. Adult age structure from scale-age analysis.
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).
<u>Recreational Harvest</u>	
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 weighted age composition.
Trinity River Basin (above WCW)	Jack component based on estimated jack harvest rate and total jack run estimate. Adult Surrogate: adult age composition from Trinity River Basin Recreational Harvest (below WCW).
Trinity River Basin (below WCW)	Jack/adult structure from scale-age analysis.
<u>Tribal Harvest</u>	
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.

Table 4a. 2013 Klamath River Basin scale validation matrices.

<u>Number</u>		Known Age				
		2	3	4	5	
Read Age	2	46	4	0	0	Total 661
	3	0	183	17	0	
	4	0	9	402	0	
	5	0	0	0	0	
Total		46	196	419	0	

<u>Percentage</u>		Known Age				
		2	3	4	5	
Read Age	2	1.00	0.02	0.00	0.00	Total 1.00
	3	0.00	0.93	0.04	0.00	
	4	0.00	0.05	0.96	0.00	
	5	0.00	0.00	0.00	1.00	
Total		1.00	1.00	1.00	1.00	

Table 4b. 2013 Trinity River Basin scale validation matrices.

<u>Number</u>		Known Age				
		2	3	4	5	
Read Age	2	6	0	0	0	Total 321
	3	0	77	3	0	
	4	0	2	232	0	
	5	0	0	0	1	
Total		6	79	235	1	

<u>Percentage</u>		Known Age				
		2	3	4	5	
Read Age	2	1.00	0.00	0.00	0.00	Total 0.00
	3	0.00	0.97	0.01	0.00	
	4	0.00	0.03	0.99	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 2013 Klamath Basin fall Chinook run.

Escapement & Harvest	AGE				Total Adults	Total Run
	2	3	4	5		
Hatchery Spawners						
Iron Gate Hatchery (IGH)	1,323	6,743	6,670	18	13,431	14,754
Trinity River Hatchery (TRH)	135	1,032	2,682	3	3,717	3,852
Hatchery Spawners subtotal	1,458	7,775	9,352	21	17,148	18,606
Natural Spawners						
Salmon River Basin	240	721	1,519	0	2,240	2,480
Scott River Basin	588	1,517	2,483	36	4,036	4,624
Shasta River Basin	1,096	3,896	3,029	0	6,925	8,021
Bogus Creek Basin	362	2,357	1,563	5	3,925	4,287
Klamath River mainstem (IGH to Shasta R)	388	2,933	4,037	0	6,970	7,358
Klamath River mainstem (Shasta R to Indian Cr)	295	2,212	3,010	0	5,222	5,517
Klamath Tributaries (above Trinity River)	200	718	1,591	0	2,310	2,510
Blue Creek	<u>129</u>	<u>13</u>	<u>282</u>	<u>31</u>	<u>326</u>	<u>455</u>
Klamath Basin subtotal	3,298	14,367	17,514	72	31,954	35,252
Trinity River (mainstem above WCW)	6,598	4,424	20,934	461	25,819	32,417
Trinity River (mainstem below WCW)	371	249	1,177	26	1,452	1,823
Trinity Tributaries (above Reservation; below WCW)	39	26	125	3	154	193
Hoopla Reservation tributaries	<u>61</u>	<u>41</u>	<u>195</u>	<u>4</u>	<u>240</u>	<u>301</u>
Trinity Basin subtotal	7,069	4,740	22,431	494	27,665	34,734
Natural Spawners subtotal	10,367	19,107	39,945	566	59,619	69,986
Total Spawner Escapement	11,825	26,882	49,297	587	76,767	88,592
Recreational Harvest						
Klamath River (below Hwy 101 bridge)	546	3,532	7,681	59	11,272	11,818
Klamath River (Hwy 101 to Weitchpec)	1,135	545	566	3	1,113	2,248
Klamath River (Weitchpec to IGH)	532	3,088	3,149	6	6,243	6,775
Trinity River Basin (above WCW)	0	358	440	10	808	808
Trinity River Basin (below WCW)	48	128	160	3	292	340
Subtotals	2,261	7,651	11,996	81	19,728	21,989
Tribal Harvest						
Klamath River (below Hwy 101)	204	17,378	39,368	348	57,094	57,298
Klamath River (Hwy 101 to Trinity mouth)	41	976	1,672	9	2,656	2,697
Trinity River (Hoopla Reservation)	16	570	2,440	10	3,019	3,035
Subtotals	261	18,924	43,480	367	62,769	63,030
Total Harvest	2,522	26,575	55,476	448	82,497	85,019
Totals						
Harvest and Escapement	14,347	53,457	104,773	1,035	159,264	173,611
Recreational Angling Dropoff Mortality 2.04%	46	156	245	2	403	449
Tribal Net Dropoff Mortality 8.7%	23	1,646	3,781	31	5,458	5,481
Total River Run	14,416	55,259	108,799	1,067	165,125	179,541

Table 6. Age proportion of the 2013 Klamath Basin fall Chinook run.

Escapement & Harvest	AGE			
	2	3	4	5
Hatchery Spawners				
Iron Gate Hatchery (IGH)	0.09	0.46	0.45	0.00
Trinity River Hatchery (TRH)	0.04	0.27	0.70	0.00
Hatchery Spawner subtotal	0.08	0.42	0.50	0.00
Natural Spawners				
Salmon River Basin	0.10	0.29	0.61	0.00
Scott River Basin	0.13	0.33	0.54	0.01
Shasta River Basin	0.14	0.49	0.38	0.00
Bogus Creek Basin	0.08	0.55	0.36	0.00
Klamath River mainstem (IGH to Shasta R)	0.05	0.40	0.55	0.00
Klamath River mainstem (Shasta R to Indian Cr)	0.05	0.40	0.55	0.00
Klamath tributaries (above Reservation)	0.08	0.29	0.63	0.00
Yurok Reservation tributaries	<u>0.28</u>	<u>0.03</u>	<u>0.62</u>	<u>0.07</u>
Klamath Basin subtotal	0.09	0.41	0.50	0.00
Trinity River (mainstem above WCW)	0.20	0.14	0.65	0.01
Trinity River (mainstem below WCW)	0.20	0.14	0.65	0.01
Trinity tributaries (above Reservation)	0.20	0.14	0.65	0.01
Hoopa Reservation tributaries	<u>0.20</u>	<u>0.14</u>	<u>0.65</u>	<u>0.01</u>
Trinity Basin subtotal	0.20	0.14	0.65	0.01
Natural Spawners subtotal	0.15	0.27	0.57	0.01
Total Spawner Escapement	0.13	0.30	0.56	0.01
Recreational Harvest				
Klamath River (below Hwy 101 bridge)	0.05	0.30	0.65	0.00
Klamath River (Hwy 101 to Weitchpec)	0.50	0.24	0.25	0.00
Klamath River (Weitchpec to IGH)	0.08	0.46	0.46	0.00
Trinity River Basin (above WCW)	0.00	0.44	0.54	0.01
Trinity River Basin (below WCW)	<u>0.14</u>	<u>0.38</u>	<u>0.47</u>	<u>0.01</u>
Subtotals	0.10	0.35	0.55	0.00
Tribal Harvest				
Klamath River (below Hwy 101)	0.00	0.30	0.69	0.01
Klamath River (Hwy 101 to Trinity mouth)	0.02	0.36	0.62	0.00
Trinity River (Hoopa Reservation)	<u>0.01</u>	<u>0.19</u>	<u>0.80</u>	<u>0.00</u>
Subtotals	0.00	0.30	0.69	0.01
Total Harvest	0.03	0.31	0.65	0.01
Totals				
Harvest and Escapement	0.08	0.31	0.60	0.01
Recreational Angling Dropoff Mortality 2.04%	0.10	0.35	0.55	0.00
Tribal Net Dropoff Mortality 8.7%	0.00	0.30	0.69	0.01
Total River Run	0.08	0.31	0.61	0.01

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):

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

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. Klamath River – 2013 details.

Iron Gate Hatchery (IGH)

A systematic random bio-sample^a was obtained from every tenth Chinook salmon returning to IGH in 2013. A total of 732 scale samples were aged, of which 75 were from known-age, CWT fish. No non-random scales were sampled from known-age, CWT fish in 2013. 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 (since 2002) above the weir. Bio-samples were obtained using a 1:4 systematic random sample. Additionally, biological data, but no scale samples, were obtained from every (i.e., non-random) ad-clipped fish encountered. A total of 800 scale samples were aged, of which 70 were from known-age, CWT fish. Scale-based age compositions were used to apportion all age classes.

Shasta River

Escapement was estimated by videography (since 1998) while bio-samples were collected from all recovered carcasses during surveys in the lower seven river miles on public and private lands where access is granted. An additional six river miles within the valley area were surveyed on Nature Conservancy property. Bio-samples were also obtained from systematically sampled (1:10) 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 502 (464 from spawning grounds and 38 from a trap at the weir site; excluding 'wash-backs') scale samples were aged, of which none were from known-age CWT fish. Scale-based age compositions from the carcass survey samples were used to apportion adult age classes. Jack proportion was estimated as described in Appendix H.

Scott River

Independent estimates from above and below the weir were combined to produce total escapement. Escapement above the weir was estimated using videography (since 2008). Escapement below the weir was calculated using the Cormack-Jolly-Seber estimator with data from twice weekly mark-recapture carcass surveys. Bio-samples were obtained from all non-deteriorated carcasses recovered above and below the weir. A total of 1,024 scale samples were aged. No ad-clipped fish were observed. Scale-based age compositions were used to apportion all age classes.

Salmon River

Total escapement was estimated by combining the Schaefer estimator from the carcass survey within the main stem, upstream of Nordheimer campground, and a redd count expansion (redds X 2) from tributaries and the lowest three reaches of the main stem. Biological samples and scales were obtained from all recovered "Path 1" carcasses (one clear eye). A total of 243 scale samples were aged, none of which were from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Klamath River Tributaries

Adult escapement was estimated by expanding the total redd count (redds X 2) and adding the number of live fish observed during the final survey in each tributary. A total of 140 scale samples were aged, none of which were from known-age CWT fish. Total escapement (including jacks) was estimated by expanding the adult estimate by the scale-based age-2 proportion. Scale-based age compositions were used to apportion all age classes.

^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.

Klamath River Mainstem

For the upper reach (IGH to Shasta River), weekly counts without removal were used to calculate an area-under-the-curve escapement estimate. Observation efficiency was derived from recapture histories of marked carcasses. Carcass 'life' (residence time) was derived from recapture histories and a 5-point scale for appraisal of carcass condition. A total of 812 scales were aged, of which none 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 from total estimate.

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 1,526 scale samples were aged, of which 10 were taken from known-age CWT fish. Scale-based age proportions for each sub-area were used to apportion all age classes in their respective sub-area.

Upper Klamath River Recreational Fishery

A creel census in this sub-area was not conducted in 2013. 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 2013 lower Klamath River Creel harvest estimate 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 main stem (IGD to Shasta River), Bogus Creek, and Iron Gate Hatchery. These weighted scale-based age compositions were used to apportion all age classes in this fishery.

Yurok Tribal Estuary Fishery (Klamath mouth to Hwy 101)

Yurok harvest in the estuary was estimated by hourly stratified effort and catch-per-effort methods. The fishery was closed on Wednesdays and Thursdays and between the hours of midnight and 10 AM on fishing days. A total of 1,037 scales were aged, of which 216 were from known-age CWT fish. Scale-based age compositions were used to apportion all age classes.

Yurok Tribal Fishery Above 101

Yurok harvest in this sub-area was estimated by daily effort and catch-per-effort analyses. The fishery was closed on Wednesdays and Thursdays and the mid-Klamath fishery was closed between the hours of midnight and 10 AM on fishing days. Yurok harvest in the mid- and upper-Klamath area was segregated into jacks and adults based on scale ages. A total of 627 scale samples were aged, of which 7 came from known-age, CWT fish. Scale-based age compositions were used to apportion all age classes.

Blue Creek

The peak dive count of live fish was used as the estimate of escapement. Jacks were estimated by direct diver count. A total of 46 scale samples (34 collected from carcasses and 12 scales collected from gill-netted fish) were aged. Scale-based age compositions were used to apportion adult age classes.

Appendix C. Trinity River – 2013 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 (no non-random ad-clipped fish scales were collected). A total of 758 scales were aged, of which 179 scales came from known-age CWT fish. Scale samples were used to apportion the hatchery return into age classes.

Upper Trinity River Recreational Harvest

The method for estimating the upper Trinity recreational harvest depends on the application of reward/non-reward program tags at the Willow Creek Weir (WCW) and subsequent returns by anglers. CDFW estimated a 2.7% harvest rate on adult Chinook salmon based on the return of program reward tags (11 of 414) applied at WCW. The jack harvest rate of 0.0% was based on return of no program tags of the combined 136 reward and non-reward tags applied, yielding an estimated harvest of 0 age-2 Chinook. There were no scales recovered from this fishery as no creel survey was implemented in 2013. The adult age proportions estimated for the Lower Trinity River Creel were used to apportion the Upper Trinity River Recreational Harvest adult component.

Lower Trinity River Creel

A roving creel survey was implemented in Trinity River below the location of the WCW. A total of 103 scales were aged, of which 7 were from known-age, CWT fish. Total harvest was apportioned by age using the scale age proportions.

Upper Trinity River Natural Escapement

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 to 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 examined produces a collection of scales for program-marked fish, some of which are 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 398 scales were aged of which 7 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 apportioned by age resulting in an age structure for the natural escapement in the upper Trinity River.

Lower Trinity River Natural Escapement:

The lower Trinity River natural escapement estimate included total spawners estimated in both main stem and tributary sub-areas (redds X 2). In the tributaries, a total of 8 scales were aged, none of which were from known-age fish. In the main stem, a total of 12 scales were aged, none of which were from known-age fish. An insufficient number of scale samples were recovered to generate independent age proportions for both the main stem and tributary sub-areas. Therefore, the upper Trinity River natural age structure was used to apportion all age classes in both tributaries and main stem sub-areas below WCW.

Hoopa Valley Tribal Harvest

Hoopa Valley Tribal harvest is a composite of the gillnet and hook-and-line fisheries prosecuted by Tribal members. A total of 1,036 scales were aged, of which 127 were from known-age fish. The total harvest was apportioned by age using these scale age proportions.

Appendix D. 2013 Klamath age analysis.

Unknown scales age composition as read					
	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	73	391	259	1	724
IGH	65	304	287	1	657
SALMON	25	72	146	0	243
SCOTT	137	336	543	8	1,024
SHASTA	8	245	201	0	454
MAINSTEM	50	322	440	0	812
UR TRIBS	12	41	87	0	140
LRC EST	42	240	499	4	785
LRC UP	381	173	185	1	740
YTFP EST	8	255	548	5	816
YTFP M&U	14	226	378	2	620
BLUE CRK	4	3	35	4	46
	819	2608	3608	26	7061
Unknown scales corrected age proportions (Kimura method)					
	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	0.0893	0.5634	0.3459	0.0014	1.0
IGH	0.0892	0.4768	0.4325	0.0015	1.0
SALMON	0.0969	0.2907	0.6123	0.0000	1.0
SCOTT	0.1271	0.3281	0.5370	0.0078	1.0
SHASTA	0.0062	0.5591	0.4347	0.0000	1.0
MAINSTEM	0.0534	0.4010	0.5456	0.0000	1.0
UR TRIBS	0.0799	0.2861	0.6340	0.0000	1.0
LRC EST	0.0474	0.2993	0.6482	0.0051	1.0
LRC UP	0.5100	0.2396	0.2491	0.0014	1.0
YTFP EST	0.0036	0.3049	0.6854	0.0061	1.0
YTFP M&U	0.0152	0.3636	0.6181	0.0032	1.0
BLUE CRK	0.0862	0.0355	0.7913	0.0870	1.0
Known CWT ages ^{/a}					
	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	7	120	190	0	317
IGH	256	1043	1499	0	2798
SALMON	0	0	0	0	0
SCOTT	0	0	0	0	0
SHASTA	0	0	0	0	0
MAINSTEM	0	17	69	0	86
UR TRIBS	0	0	0	0	0
LRC	14	112	254	0	380
YTFP EST	1	118	572	1	692
YTFP M&U	0	1	14	0	15
BLUE CRK	0	0	0	0	0
	278	1411	2598	1	4288
<u>Breakout within strata</u>					
Bogus1	3	51	112	0	166
Bogus2	4	69	78	0	151
LRC - lo	2	95	237	0	334
LRC - mid	12	17	17	0	46
YTFP MID-UP	0	1	14	0	15

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

Appendix E. 2013 Trinity age analysis.

WCW = Willow Ck. Weir

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	2	0	0	0	0	0	2
2	71	1	0	0	0	0	72
3	63	0	3	0	0	0	66
4	252	0	0	3	0	0	255
5	5	0	0	0	0	0	5
391	393	1	3	3	0	0	400

LOWTRINREC = Lower Trinity Recreational

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	1	0	0	1	0	0	2
2	14	0	0	0	0	0	14
3	36	0	2	1	0	0	39
4	45	0	0	4	0	0	49
8	1	0	0	0	0	0	1
96	97	0	2	6	0	0	105

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

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	10	0	0	2	0	0	12
2	5	0	0	0	0	0	5
3	176	0	22	0	0	0	198
4	725	0	1	104	0	0	830
5	3	0	0	0	0	0	3
129	919	0	23	106	0	0	1048
909							

TRH = Trinity River Hatchery

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	9	0	0	1	0	0	10
2	21	5	0	0	0	0	26
3	161	0	50	2	0	0	213
4	397	0	1	121	0	0	519
5	180	0	0	0	0	0	180
579	588	5	51	124	0	0	768

LOWTRINTRIBS = Lower Trinity Tribs - Includes samples taken by I Cwt Age

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	0	0	0	0	0	0	0
2	1	0	0	0	0	0	1
3	1	0	0	0	0	0	1
4	6	0	0	0	0	0	6
5	0	0	0	0	0	0	0
8	8	0	0	0	0	0	8

UPKLAMREC Upper Klamath Recreational

NO DATA

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

LOWTRINMAINSTEM = Lower Trinity Mainstem

		Cwt Age					
		no cwt age	2	3	4	5	Total
Scale unreadable	1	0	0	0	0	0	1
2	0	0	0	0	0	0	0
3	1	0	0	0	0	0	1
4	10	0	0	0	0	0	10
5	1	0	0	0	0	0	1
12	13	0	0	0	0	0	13

NO DATA

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

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

4x4 VALIDATION MATRIX

	2	3	4	5
2	6	0	0	0
3	0	77	3	0
4	0	2	232	0
5	0	0	0	1

0.98

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

	2	3	4	5
2	1.0000	0.0000	0.0000	0.0000
3	0.0000	0.9747	0.0128	0.0000
4	0.0000	0.0253	0.9872	0.0000
5	0.0000	0.0000	0.0000	1.0000

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

# known scales	7	129	8	180	0	324
unknown scales	391	909	96	579	8	1995

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

	2	3	4	5
2	1.0138	-0.0040	0.0001	0.0000
3	-0.0144	1.0535	-0.0380	0.0000
4	0.0007	-0.0494	1.0378	0.0000
5	0.0000	0.0000	0.0000	1.0000

Age	Willow Creek Weir WCW	Hoopa Tribal NET HARV	Lower Trinity REC HARV	TRH HATCHERY	Lower Trinity Mainstem CARCASS	Upper Trinity REC HARV	Upper Trin NATURAL	Lower Trin Tribs
2	0.1816	0.0055	0.1458	0.0363	0.0000	-	0.2035	0.1250
3	0.1568	0.1881	0.3786	0.2763	0.0745	0.4433	0.1365	0.1183
4	0.6488	0.8031	0.4651	0.6874	0.8422	0.5445	0.6458	0.7567
5	0.0128	0.0033	0.0104	0.0000	0.0833	0.0122	0.0142	0.0000
	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

CWTS Age					(Estimated)		(Estimated)	
	Willow Creek Weir WCW	Hoopa Tribal NET HARV	Lower Trinity REC HARV	TRH HATCHERY	Lower Trinity CARCASS	Upper Trinity REC HARV	Upper Trinity NATURAL	Hoopa Hook&Line
2	1	0	0	30	0	0	15	0
3	3	23	2	231	0	22	558	0
4	3	106	6	690	0	66	1668	0
5	0	0	0	3	0	0	7	0
	7	129	8	954	0	88	2248	0
# unknown ads	0	5	1	22	0	0	0	0
# total ads	7	134	9	976	0	88	2248	0

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

	Total Run	WCW		TRH + Rec above WCW+Natural		Apportioned Natural Escapement	
		Age proportions	Escapement	Escapement	Proportions		
Rec above WCW	808	2	6733	6598	0.2035		
TRH	3852	3	5814	4424	0.1365		
Naturals	32417	4	24056	20934	0.6458		
Total	37077	5	474	461	0.0142		
			37077				

WCW scales

Age	WCW no cwt	known age cwt scales	Total age all scales	WCW age proportions
2	71	1	72	0.1809
3	61	3	64	0.1616
4	254	3	257	0.6449
5	5	5	10	0.0126
	391	7	398	1.0000

Appendix G. Final age composition of the 2012 Klamath Basin fall Chinook run (03/03/14).

Escapement & Harvest	AGE				Total Adults	Total Run
	2	3	4	5		
Hatchery Spawners						
Iron Gate Hatchery (IGH)	1,537	36,485	1,992	0	38,478	40,015
Trinity River Hatchery (TRH)	92	14,965	2,494	2	17,461	17,553
Hatchery Spawner subtotal	1,629	51,450	4,486	2	55,939	57,568
Natural Spawners						
Salmon River Basin	829	2,633	925	4	3,561	4,390
Scott River Basin	1,783	5,608	1,938	23	7,569	9,352
Shasta River Basin	1,944	27,598	2	0	27,600	29,544
Bogus Creek Basin	839	11,390	403	0	11,792	12,631
Klamath River mainstem (IGH to Shasta R)	1156	10379	1091	0	11,469	12,625
Klamath River mainstem (Shasta R to Indian Cr)	703	6153	627	0	6,780	7,483
Klamath Tributaries (above Trinity River)	629	2,813	441	0	3,254	3,883
Blue Creek	<u>406</u>	<u>329</u>	<u>393</u>	<u>39</u>	<u>761</u>	<u>1,167</u>
Klamath Basin subtotal	8,289	66,903	5,820	66	72,786	81,075
Trinity River (mainstem above WCW)	7,152	35,623	11,573	127	47,323	54,475
Trinity River (mainstem below WCW)	90	450	146	2	598	688
Trinity Tributaries (above Reservation; below WCW)	79	391	127	1	520	599
Hoopla Reservation tributaries	<u>48</u>	<u>238</u>	<u>77</u>	<u>1</u>	<u>316</u>	<u>364</u>
Trinity Basin subtotal	7,369	36,702	11,923	131	48,757	56,126
Natural Spawners subtotal	15,658	103,605	17,743	197	121,543	137,201
Total Spawner Escapement	17,287	155,055	22,229	199	177,482	194,769
Recreational Harvest						
Klamath River (below Hwy 101 bridge)	382	2,132	539	25	2,696	3,078
Klamath River (Hwy 101 to Weitchpec)	3,183	4,512	633	30	5,174	8,357
Klamath River (Weitchpec to IGH)	243	3,812	155	0	3,967	4,210
Trinity River Basin (above WCW)	43	1,289	306	0	1,595	1,638
Trinity River Basin (below WCW)	24	359	85	0	444	468
Subtotals	3,875	12,104	1,718	55	13,876	17,751
Tribal Harvest						
Klamath River (below Hwy 101)	68	65,397	20,767	1,583	87,747	87,815
Klamath River (Hwy 101 to Trinity mouth)	54	2,228	1,168	98	3,494	3,548
Trinity River (Hoopla Reservation)	55	2,784	1,350	11	4,145	4,200
Subtotals	177	70,409	23,285	1,692	95,386	95,563
Total Harvest	4,052	82,513	25,003	1,747	109,262	113,314
Totals						
Harvest and Escapement	21,339	237,568	47,232	1,946	286,744	308,083
Recreational Angling Dropoff Mortality 2.04%	79	247	35	1	283	362
Tribal Net Dropoff Mortality 8.7%	15	6,123	2,025	147	8,295	8,310
Total River Run	21,433	243,938	49,292	2,092	295,322	316,755

Appendix H: Shasta River escapement age composition 2013.

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

1. 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 trap located at the weir site,
4. adult scales collected in the spawning survey.

A total of $N = 8,021$ fall Chinook salmon were estimated to have passed the weir in 2013. Data from the spawning ground surveys yielded very few jacks and was deemed by the KRTT to be unrepresentative of the true jack proportion. Much higher jack proportions were observed both in the trap located at the weir site and in carcasses collected at the weir (wash-back 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 trap. The proportion of males among adults, $P(M|A)$, was estimated using the spawning ground survey. There were 162 adult males from the total adult sample of 469 from the spawning ground survey, yielding $P(M|A) = 0.345$. The proportion of jacks among males, $P(J|M)$, was estimated from the weir trap. There were 11 jacks among the 35 male Chinook in the trap sample, yielding $P(J|M) = 0.314$. 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,

$$P(M) = \frac{P(M|A)}{1 - P(J|M)[1 - P(M|A)]} = \frac{0.345}{1 - [0.314 \times (1 - 0.345)]} = 0.435,$$

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:

$$P(J) = P(M) \times P(J|M) = 0.435 \times 0.314 = 0.137.$$

3. Estimate the number of jacks in the run:

$$J = N \times P(J) = 8,021 \times 0.137 = 1,096.$$

4. Estimate the adult run:

$$A = N - J = 8,021 - 1,096 = 6,925.$$

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.