Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and Run Size Estimates, 2021 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 2021 was estimated to be:

	Run Size	
Age	*Number*	*Proportion*
2	10,334	0.16
3	36,107	0.56
4	17,648	0.27
5	199	0.00
Total	64,288	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	62,100	54,000	1.15
Fishery Mortality			
Tribal Harvest	8,100	8,100	1.00
Recreational Harvest	1,200	2,300	0.52
Drop-off Mortality	700	700	1.00
	10,000	11,100	0.90
Escapement			
Hatchery Spawners	20,500	12,900	1.59
Natural Area Spawners	31,600	29,900	1.06
	52,100	42,800	1.22

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 2021. The estimates provided in this report are consistent with the Klamath Basin Megatable (CDFW 2022) and with the 2022 forecast of ocean stock abundance (KRTT 2022).

Age-specific escapement estimates for 2021 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 2022). 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 2022). 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 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 is aged independently by two trained readers. In cases of disagreement, a third read is 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 has relied on analysis of length-frequency histograms. In such 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 could vary by sector, and is generally based on location of the length-frequency nadir and, if appropriate, the length-frequency of known-age fish. Scales are then used to estimate the age composition of adults (Appendix A). For the 2021 run, there were no instances where the KRTT relied on a fork length cutoff to determine the number of age-2 fish. Scales were used to apportion all age classes in each sector.

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.

In 2021, as in run years 2018-2020, redd surveys were performed on the mainstem Klamath River from Persido Bar to Big Bar, reaches where surveys generally had not occurred prior to 2018. The KRTT decided to not include results from this survey in 2018 and 2019 because inclusion of this survey would not be consistent with the set of surveys that have contributed to the long term

Klamath River fall Chinook dataset that has been used to inform the estimation of biological reference points and parameterize the Klamath Ocean Harvest Model. However, after further discussion, the KRTT decided to include the results of this survey in 2020, and again for the 2021 run. Justification for this decision included an apparent increase in lower mainstem spawning and the desire to capture this contribution to the run size for future estimation of biological reference points.

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

Results

A total of 8,905 scales from 16 different sectors were aged for this analysis (Table 2). Of these, 1,044 were from known-age CWT fish. Known-age scales provide a direct check, or "validation", of accuracy of the scale-based age estimates (Table 4, Appendices D and E). The scale-based ages were, in general, less accurate in 2021 than prior years. Accuracy within the Trinity Basin was 85% for age-2 fish, 98% for age-3 fish, and 73% for age-4 fish. Accuracy within the Klamath River Basin was 95% for age-2 fish, 86% for age-3 fish, and 71% for age-4 fish (Table 4). 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.

Marking and tagging of Chinook Salmon releases from Trinity River Hatchery did not occur for brood year 2019 due to restrictions related to COVID-19. As such, there were no known-age CWT fish from the Trinity River Hatchery returning to the Basin in 2021. Methods needed to be developed to (1) infer the Trinity River Hatchery proportion of age-2 escapement and catch to the Trinity River and Lower Klamath River (below Weitchpec) and (2) account for a lack of known-age 2 returns to the Trinity River for use in scale validation matrices. Appendix G describes the method used to infer the contribution of Trinity River Hatchery age-2 fish to escapement and harvest sectors in the Trinity and lower Klamath rivers. Appendix H described how known-age CWT fish were included in scale validation matrices for the Klamath and Trinity basins.

Stream surveys in the Salmon River effectively ended early in the 2021 spawning season due to high flow events. In addition, there were no surveys of Wooley Creek in 2021. Methods used to estimate escapement to the Salmon River system, including Wooley Creek, are described in Appendix I.

The final estimates of the 2020 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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Klamath River Technical Team
Participants

California Department of Fish and Wildlife
Morgan Knechtle
Domenic Giudice
Ken Lindke
Dan Troxel
Mary Claire Kier
Grace Easterbrook

Hoopa Valley Tribe
George Kautsky
Bob Campbell
Bryan Lester
Karl Seitz

National Marine Fisheries Service
Michael O'Farrell

U.S. Fish and Wildlife Service
Stephen Gough

U.S. Forest Service
LeRoy Cyr

Yurok Tribe
Desma Williams
Keith Parker

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Table 1. Estimation and sampling methods used for the 2021 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-samples[a] collected from from at a systematic random sample rate of 1:5 (20%). Additionally, ad-clipped males <50 cm FL were bio-sampled opportunistically.	CDFW, WSP
Trinity River Hatchery (TRH)	Direct count. All fish bio-sampled and examined for fin-clips, tags, and marks. Scales collected from fish at a systematic random sample rate of 1:5 (20%).	CDFW, HVT
Natural Spawners		
Salmon River Basin	Redd, carcass, and dive surveys in the upper and lower mainstem and tributaries. Total redds estimated by extrapolating redds counted up through JW 42, 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 and last day live adults (2*total redd count + last day live adults)/(1-proportion of jacks). Bio-samples collected from all carcasses recovered.	CDFW, USFS, USFWS, KT, SRRC, SCS, WSP, MKWC, NCRC
Scott River Basin	Combination ARIS acoustic and video count above Fish Counting Facility at River Mile 18.2 and twice weekly redd and carcass surveys above and below the counting station. Total run estimated by adding ARIS and video count to (2*total redd count)/(1-proportion jacks) downstream of the counting station. Bio-samples collected from all recovered carcasses.	CDFW, QVIR, USFS, KT, NCRC, SRCD, WSP
Shasta River Basin	Video count above weir. Bio-samples collected from carcasses stranded on weir at a systematic random sample rate of (1:5) 20% and from all fish captured in a trap immediately upstream of video chute.	CDFW, WSP
Bogus Creek Basin	Video count above weir and twice weekly direct carcass count below weir. Bio-samples collected opportunisitcally from carcasses observed during surveys above and below weir, including all ad-clipped fish.	CDFW, WSP
Klamath River mainstem (IGH to Shasta R.)	Hierarchical Latent Variable Model from weekly mark-recapture carcass surveys. Bio-samples collected from all fresh carcasses encountered.	USFWS, YT
Klamath River mainstem (Shasta R. to Wingate Bar)	Weekly redd surveys. Total run = (2*total redd count)/(1-proportion jacks). Jacks estimated from Klamath River mainstem (IGH to Shasta R.) scale-age data.	USFWS, KT
Klamath Tributaries above Trinity	Periodic redd surveys. Total run = (2*total redd count + last day live adults)/(1-proportion jacks). Jacks estimated from Klamath tributary scale-age data. Bio-samples collected from all carcasses recovered.	USFS, CDFW, KT, MKWC, WSP
Blue Creek	Total estimated using the maximum count from dive surveys conducted between 16 November and 7 December.	YT
Trinity River (mainstem above WCW)	Mark-recapture (unstratified Petersen); marks applied at WCW and recovered at TRH. All fish bio-sampled and scales collected from every other Chinook in good condition. Natural area spawning escapement estimated by subtracting age-specific estimates of hatchery returns and recreational harvest above WCW from age-specific estimates of the total run upstream of WCW.	CDFW, HVT
Trinity River (mainstem below WCW)	Bi-weekly redd surveys. Total run = (2*total redd count)/(1-proportion jacks) using proportion of jacks in natural area spawning in Trinity River mainstem above WCW.	HVT, USFWS
Trinity Tributaries (above Reservation; below WCW)	Periodic redd surveys. Total run = (2*total redd count + last day live adults)/(1-proportion jacks) using proportion of jacks in natural area spawning in Trinity River mainstem above WCW.	CDFW, USFS, WSP
Hoopa Reservation Tributaries	Periodic redd surveys. Total run = (2*total redd count)/(1-proportion jacks) using proportion of jacks in natural area spawning in Trinity River mainstem above WCW.	HVT
Recreational Harvest		
Klamath River (below Hwy 101 bridge)	Jack and adult estimates based on access point and roving creel survey during 3 randomly selected days per Julian week through JW 39, then 2 days per week starting on JW 40. Bio-samples collected during angler interviews.	CDFW
Klamath River (Hwy 101 to Weitchpec)	Jack and adult estimates based on access point and roving creel survey during 3 randomly selected days per Julian week through JW 39, then 2 days per week starting on JW 40. Bio-samples 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). Jacks estimated from IGH, Klamath mainstem, Shasta River, and Bogus Creek weighted average age compositions.	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-samples collected during angler interviews.	HVT
Tribal Harvest		
Klamath River (below Hwy 101)	Daily harvest estimates based on effort and catch-per-effort surveys. Bio-samples collected during harvest surveys.	YT
Klamath River (Hwy 101 to Trinity mouth)	Daily harvest estimates based on effort and catch-per-effort surveys. Bio-samples collected during harvest surveys.	YT
Trinity River (net and hook-and-line)	Roving effort and catch-per-effort surveys during four randomly selected days per statistical week for the net fishery, and three randomly selected days for the hook-and-line fishery, plus census count of hook-and-line and net fishery downstream of harvest weir to Tish Tang Creek. Bio-samples collected during harvest surveys.	HVT
Trinity River (harvest weir)	Direct count of all harvested fish. Bio-samples collected from all harvested fish.	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-samples 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 2021 Klamath Basin fall Chinook age-composition assessment.

Sampling Location	Aged			Total Collected[c/]	Agency
	Unknown-age [a/] [d/]	Known-age [b/]	Total		
Hatchery Spawners					
Iron Gate Hatchery (IGH)	725	157	882	1,457	CDFW
Trinity River Hatchery (TRH)	896	265	1161	1,189	HVT
Natural Spawners					
Salmon River Carcass Survey	22	0	22	22	CDFW
Scott River Carcass Survey	146	0	146	148	CDFW
Shasta River Carcass	355	3	358	385	CDFW
Bogus Creek	517	61	578	600	CDFW
Klamath River mainstem	608	25	633	662	USFWS
Upper Klamath River tributaries	40	0	40	43	USFS
Blue Creek Snorkle	8	0	8	8	YT
Willow Creek Weir	1,377	74	1451	1,652	HVT
Lower Trinity River Carcass	0	0	0	0	HVT
Lower Trinity River tributaries	0	0	0	0	HVT
Recreational Harvest					
Lower Klamath River Creel	681	56	737	753	CDFW
Lower Trinity River Creel	15	1	16	40	HVT
Tribal Harvest					
Klamath River (below Hwy 101)	449	61	510	617	YT
Klamath River (Hwy 101 to Trinity R)	668	84	752	753	YT
Trinity River (Hoopa Reservation)	1,017	201	1218	1,611	HVT
Hoopa Weir	337	56	393	453	HVT
TOTAL	7,861	1,044	8,905	9,940	

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.
d/ Weir washback collected scales were read but not used.

Table 3. Age-composition methods used for the 2021 Klamath Basin Chinook Salmon fall 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	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 (Shasta R. to Wingate Bar)	Surrogate: Klamath mainstem (IGH to Shasta R.) age structure.
Klamath River mainstem (Persido Bar to Big Bar)	Surrogate: Klamath mainstem (Persido Bar to Big Bar) and tributaries (Rock, Red Cap, and Camp creeks) age structure.
Klamath tributaries (above Trinity R.)	Jack/adult structure from scale-age analysis.
Blue Creek	Jacks estimated through direct observation. Unweighted average of scale-based adult age structure from Blue Creek in 2007-2009, 2011-2015, 2017, and 2020.
Trinity River Basin (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)	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: jack/adult weighted average age proportions from Shasta River, IGH, Bogus Creek, and mainstem Klamath (IGH to Shasta R.).
Trinity River Basin (above WCW)	Jack component based on estimated jack harvest rate and total jack run estimate. Adult age structure surrogate 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 (net and hook-and-line)	Jack/adult structure from scale-age analysis.
Trinity River (harvest weir)	Jack/adult structure from scale-age analysis.
Ich Disease Monitoring	
Klamath-Trinity Basin	Jack/adult structure from scale-age analysis.

Table 4a. 2021 Klamath River Basin scale validation matrices

Number

		Known Age 2	3	4	5	
	2	41	17	0	0	
Read	3	2	249	25	0	
Age	4	0	25	61	0	
	5	0	0	0	0	Total
	Total	43	291	86	0	420

Percentage

		Known Age 2	3	4	5
	2	0.95	0.06	0.00	0.00
Read	3	0.05	0.86	0.29	0.00
Age	4	0.00	0.09	0.71	0.00
	5	0.00	0.00	0.00	1.00
	Total	1.00	1.00	1.00	1.00

Table 4b. 2021 Trinity River Basin scale validation matrices.

Number

		Known Age 2	3	4	5	
	2	29	7	0	0	
Read	3	5	501	14	0	
Age	4	0	4	37	0	
	5	0	0	0	1	Total
	Total	34	512	51	1	598

Percentage

		Known Age 2	3	4	5
	2	0.85	0.01	0.00	0.00
Read	3	0.15	0.98	0.27	0.00
Age	4	0.00	0.01	0.73	0.00
	5	0.00	0.00	0.00	1.00
	Total	1.00	1.00	1.00	1.00

Table 5. Age composition of the 2021 Klamath Basin fall Chinook run.

1/16/2022

Escapement & Harvest	AGE 2	3	4	5	Total Adults	Total Run
Hatchery Spawners						
Iron Gate Hatchery (IGH)	494	4,862	2,096	54	7,012	7,506
Trinity River Hatchery (TRH)	129	5,523	315	0	5,838	5,967
Hatchery Spawner subtotal	**623**	**10,385**	**2,411**	**54**	**12,850**	**13,473**
Natural Spawners						
Salmon River Basin	263	738	1,152	0	1,890	2,153
Scott River Basin	655	344	962	0	1,307	1,962
Shasta River Basin	927	1,676	4,273	23	5,972	6,899
Bogus Creek Basin	423	961	1,281	11	2,253	2,676
Klamath River mainstem (IGH to Shasta R.)	343	946	809	7	1,762	2,105
Klamath River mainstem (Ash Cr. to Wingate Bar)	468	1,280	1,095	9	2,384	2,852
Klamath Tributaries (above Trinity River)	179	620	383	0	1,003	1,182
Blue Creek	25	32	79	8	119	144
Klamath Basin subtotal	3,283	6,597	10,034	58	16,690	19,973
Trinity River (mainstem above WCW)	3,256	12,058	870	0	12,928	16,184
Trinity River (mainstem below WCW)	18	66	5	0	70	88
Trinity Tributaries (above Reservation; below WCW)	33	121	9	0	130	163
Hoopa Reservation tributaries	32	116	8	0	124	156
Trinity Basin subtotal	3,339	12,361	892	0	13,252	16,591
Natural Spawners subtotal	**6,622**	**18,958**	**10,926**	**58**	**29,942**	**36,564**
Total Spawner Escapement	**7,245**	**29,343**	**13,337**	**112**	**42,792**	**50,037**
Recreational Harvest						
Klamath River (below Hwy 101 bridge)	138	100	147	2	249	387
Klamath River (Hwy 101 to Weitchpec)	2,161	728	166	6	900	3,061
Klamath River (Weitchpec to IGH)	74	287	288	4	579	653
Trinity River Basin (above WCW)	8	479	3	0	482	490
Trinity River Basin (below WCW)	16	55	0	0	55	71
Subtotals	**2,397**	**1,649**	**604**	**12**	**2,265**	**4,662**
Tribal Harvest						
Klamath River (below Hwy 101)	17	1,089	1,496	13	2,598	2,615
Klamath River (Hwy 101 to Trinity mouth)	144	1,540	1,249	53	2,842	2,986
Trinity River (net and hook-and-line)	136	1,591	566	0	2,156	2,292
Trinity River (harvest weir)	315	428	42	0	470	785
Subtotals	**612**	**4,648**	**3,353**	**66**	**8,066**	**8,678**
Total Harvest	**3,009**	**6,297**	**3,957**	**78**	**10,331**	**13,340**
Totals						
Harvest and Escapement	10,253	35,640	17,294	190	53,124	63,377
Recreational Angling Dropoff Mortality 2.04%	49	34	12	0	46	95
Tribal Net Dropoff Mortality 8.7%	26	372	292	7	671	697
Klamath-Trinity Basin Ich disease testing	6	61	50	2	113	119
Total River Run	**10,334**	**36,107**	**17,648**	**199**	**53,954**	**64,288**

Table 6. Age proportion of the 2021 Klamath Basin fall Chinook run.

Escapement & Harvest	AGE 2	3	4	5
Hatchery Spawners				
Iron Gate Hatchery (IGH)	0.07	0.65	0.28	0.01
Trinity River Hatchery (TRH)	0.02	0.93	0.05	0.00
Hatchery Spawner subtotal	0.05	0.77	0.18	0.00
Natural Spawners				
Salmon River Basin	0.12	0.34	0.54	0.00
Scott River Basin	0.33	0.18	0.49	0.00
Shasta River Basin	0.13	0.24	0.62	0.00
Bogus Creek Basin	0.16	0.36	0.48	0.00
Klamath River mainstem (IGH to Shasta R.)	0.16	0.45	0.38	0.00
Klamath River mainstem (Ash Cr. to Wingate Bar)	0.16	0.45	0.38	0.00
Klamath tributaries (above Trinity River)	0.15	0.52	0.32	0.00
Yurok Reservation tributaries	0.17	0.22	0.55	0.06
Klamath Basin subtotal	0.16	0.33	0.50	0.00
Trinity River (mainstem above WCW)	0.20	0.75	0.05	0.00
Trinity River (mainstem below WCW)	0.20	0.75	0.05	0.00
Trinity tributaries (above Reservation)	0.20	0.75	0.05	0.00
Hoopa Reservation tributaries	0.21	0.74	0.05	0.00
Trinity Basin subtotal	0.20	0.75	0.05	0.00
Natural Spawners subtotal	0.18	0.52	0.30	0.00
Total Spawner Escapement	0.14	0.59	0.27	0.00
Recreational Harvest				
Klamath River (below Hwy 101 bridge)	0.36	0.26	0.38	0.01
Klamath River (Hwy 101 to Weitchpec)	0.71	0.24	0.05	0.00
Klamath River (Weitchpec to IGH)	0.11	0.44	0.44	0.01
Trinity River Basin (above WCW)	0.02	0.98	0.01	0.00
Trinity River Basin (below WCW)	0.23	0.77	0.00	0.00
Subtotals	0.51	0.35	0.13	0.00
Tribal Harvest				
Klamath River (below Hwy 101)	0.01	0.42	0.57	0.00
Klamath River (Hwy 101 to Trinity mouth)	0.05	0.52	0.42	0.02
Trinity River (net and hook-and-line)	0.06	0.69	0.25	0.00
Trinity River (harvest weir)	0.40	0.55	0.05	0.00
Subtotals	0.07	0.54	0.39	0.01
Total Harvest	0.23	0.47	0.30	0.01
Totals				
Harvest and Escapement	0.16	0.56	0.27	0.00
Recreational Angling Dropoff Mortality 2.04%	0.52	0.36	0.13	0.00
Tribal Net Dropoff Mortality 8.7%	0.04	0.53	0.42	0.01
Total River Run	0.16	0.56	0.27	0.00

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: Klamath River – 2021 methodology details.

Iron Gate Hatchery (IGH)
Escapement to IGH is a direct count of the number of fall Chinook Salmon entering the hatchery over the duration of the spawning season. A systematic random bio-sample was obtained from every fifth Chinook Salmon returning to IGH. Heads were also collected for CWT analysis from all ad-clipped fish. Scale-based age compositions were used to apportion all age classes.

Bogus Creek
Escapement was estimated by summing carcasses encountered during spawning ground surveys below the video weir and videography counts above the weir. Spawning ground surveys were also conducted upstream of the weir. Bio-samples were collected from every carcass encountered downstream of the weir. Bio-samples were collected opportunistically upstream of the weir. Scale-based age compositions were used to apportion all age classes.

Shasta River
Escapement was estimated by videography as the net count of fish moving upstream (total observed moving upstream minus total moving downstream). Bio-samples were obtained from a 1:5 systematic sample of carcasses that washed back onto the counting weir. A trap was also installed on the upstream end of the video flume to bolster scale sample collection for a total of 97.5 hours of effort between September 16 and October 21. Every fish was bio-sampled from the video flume trap. Three ad-clipped fish were recovered as washbacks, two of which were decoded. Scale-based age compositions from samples collected from the trap were used to apportion all age classes.

Scott River
Independent estimates from above and below the weir were combined to estimate total escapement. Escapement above the weir was estimated using SONAR and videography as the net count of fish moving upstream. During periods when the monitoring station was inoperable (18.25 hours in total), fish passage was interpolated by averaging the two days prior and two days following the outage. Escapement below the weir was calculated by expanding total redd counts (redds X 2) from twice weekly surveys. Total escapement below the weir was then estimated by expanding adult escapement by the scale-based age-2 proportion from the upper reach. Bio-samples were obtained from all non-deteriorated carcasses recovered above and below the weir. Scale-based age compositions were used to apportion all age classes.

Salmon River
Adult escapement estimated using a redd ratio estimator. Total redds were estimated by utilizing observed redd deposition through Julian Week 42 and expanding by the mean annual proportion observed though Julian Week 42 from years 1998 through 2020 (excluding 2005, 2010, 2013, 2016, 2017 and 2020), then applying the standard redd-based population estimator (total # of redds X 2, then adding the number of live adult fish observed on the last survey). Additionally, Wooley Creek redd counts were estimated by using the historical ratio of redd counts in the entire Salmon River Basin (inclusive of Wooley Creek) and the Salmon River Basin excluding Wooley Creek (Appendix I). Total escapement was then estimated by expanding adult escapement by the scale-based age-2 proportion. Bio-samples were obtained from recovered carcasses. 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 then adding the number of live adult fish observed on the last survey. Total escapement was then estimated by expanding adult escapement by the scale-based age-2 proportion. Scale-based age compositions were used to apportion all age classes.

Klamath River Mainstem (IGH to Shasta River)
A hierarchical latent variables model based on weekly carcass counts and mark-recapture data was used to estimate escapement. All surveyed fresh carcasses were bio-sampled. Scale-based age proportions were used to assign all age classes.

Klamath River Mainstem (Ash Creek to Wingate Bar)
Adult escapement was estimated by expanding total redd counts (redds X 2) from weekly surveys. Total escapement was then estimated by expanding adult escapement by the scale-based age-2 proportion from the upper reach. Age assignments were based on age proportions from scales collected in the IGH-Shasta reach.

Klamath River Mainstem (Persido Bar to Big Bar)
Adult escapement was estimated by expanding total redd counts (redds X 2) from single pass survey. Total escapement was then estimated by expanding adult escapement by the scale-based age-2 proportion from mainstem (Persido Bar to Big Bar) and tributaries (Rock, Camp and Red Cap Creeks). Age assignments were based on age proportions from scales collected in the same areas.

Lower Klamath River Creel
Total harvest was estimated by combining creel estimates from the two sub-areas (above the Highway 101 Bridge to Weitchpec and below the Highway 101 Bridge to the mouth). In each sub-area, jack and adult estimates were based on access point and roving creel surveys during three randomly selected days per Julian week (JW) through JW 39, then two days per week starting on JW 40. Bio-samples were collected from every fish possible during angler interviews. Scale-based age proportions from scale samples were used to apportion all age classes in each sub-area.

Upper Klamath River Recreational Fishery
A creel survey in this sub-area was not conducted in 2021. Creel data were available for the lower and upper river fisheries from 1999 to 2002. The ratio of average adult harvest in the entire Klamath mainstem to average harvest in the lower Klamath River creel area from these years was applied to the 2021 lower Klamath River creel harvest to estimate total adult harvest in the Klamath River mainstem. Adult harvest for the upper Klamath River recreational fishery was then estimated by subtracting the estimated lower Klamath River creel estimate from the Klamath mainstem 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), Shasta River, Bogus Creek, and IGH. 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)
Subsistence Yurok harvest in this sub-area was estimated by hourly net-fishing effort and catch-per-effort (fish per net-hour) analyses, stratified by day and night. 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 net-fishing effort and catch-per-effort (fish per net-day) analyses. Scale-based age composition was used to apportion all age classes.

Blue Creek
Total escapement was estimated using the maximum single-day count from dive surveys conducted between November 16 and December 7. Bio-samples were collected from eight recovered carcasses. Jacks were identified by visual determination during dive surveys and apportioned from the total count. Adult age proportions were estimated as the unweighted average of age-specific proportions in Blue Creek from years when scales were used to apportion adult age classes (2007-2009, 2011-2015, 2017 and 2020).

Appendix C: Trinity River – 2021 methodology details.

Trinity River Natural Escapement (above WCW)
Escapement was estimated using a Petersen mark-recapture estimator. The methods used for estimating age structure within the Trinity River run above WCW was similar to those used in the population estimate, apportioned into three general recovery areas: TRH, Trinity basin natural spawning escapement above WCW, and recreational harvest. Scales were collected from every other Chinook Salmon at WCW.

The age structure for fish passing above WCW was estimated using scales collected at WCW and TRH. Age-specific abundances for all fish passing above WCW were estimated from scales collected at WCW. Next, age-specific abundances of fish returning to TRH and fish harvested in the recreational fishery were estimated. Finally, age-specific abundances from TRH and the recreational fishery were subtracted from age-specific abundances of fish passing above WCW to yield age-specific abundances of fish returning to natural spawning areas above WCW.

Trinity River Hatchery (TRH)
Escapement to TRH is a direct count of the number of fall Chinook Salmon entering the hatchery over the duration of the spawning season. Scales were sampled systematically (1:5), ad-clipped and non-ad-clipped fish included. Scale samples were used to apportion the hatchery return into age classes.

Upper Trinity River Recreational Harvest
The method for estimating the upper Trinity River recreational harvest depends on the application of program tags at WCW and subsequent returns by anglers. In 2021 CDFW estimated a 2.42% harvest rate on adult Chinook Salmon based on the return of program reward tags (32 of 1,320) applied at WCW. An estimated 0.68% (1 of 147 tag returns) jacks were estimated to have been harvested in 2021. No scales were recovered from this fishery since no creel survey was implemented in 2021. 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 downstream of WCW. Sampling was temporally stratified by weekend (Friday-Sunday) and weekday, with sampling occurring on 2 and 1 randomly selected days per stratum, respectively. Scale samples were used to apportion all age classes.

Trinity Mainstem Natural Escapement (below WCW)
Total escapement was estimated by expanding total redd counts (redds X 2) from surveys conducted biweekly as conditions allowed and applying the jack proportion from the upper Trinity River natural escapement. No scales were collected in this sector. The upper Trinity River natural escapement age structure was used as a surrogate to apportion all ages.

Trinity Tributaries (above Reservation; below WCW)
Adult escapement was estimated by expanding total redd counts (redds X 2) and then adding the number of live adult fish observed on the last survey. Total escapement was then estimated by expanding adult escapement by the scale-based age-2 proportion from scales collected in Trinity Tributaries and Hoopa Reservation Tributaries combined. All age classes were apportioned using combined set of scales from Trinity Tributaries and Hoopa Reservation Tributaries.

Hoopa Reservation Tributaries
Total escapement was estimated by expanding total redd counts (redds X 2) and applying the jack proportion from scales collected in Trinity Tributaries and Hoopa Reservation Tributaries combined. All age classes were apportioned using combined set of scales from Trinity Tributaries and Hoopa Reservation Tributaries.

Hoopa Valley Tribal Harvest (net and hook-and-line)

Hoopa Valley Tribal member gill net and hook-and-line harvest is monitored by estimating effort and catch from three (hook-and-line) or four (gill net) randomly selected days per week. Total harvest was estimated by expanding randomly selected days and effort to weekly totals. A census of the Tribal net and hook-and-line fisheries was also implemented in the area immediately downstream of the Hoopa selective harvest weir to Tish Tang Creek. Scale-age proportions were used to apportion all ages.

Hoopa Valley Tribal Harvest (harvest weir)

Total harvest was a direct count of all Chinook Salmon taken at the weir. Scale samples were attempted to be taken from every other harvested fish. Scale-age proportions were used to apportion all ages.

Appendix D. 2021 Klamath age analysis.

Unknown scales age composition as read

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	90	233	192	2	517
IGH	71	460	188	6	725
SALMON	3	10	9	0	22
SCOTT	48	45	53	0	146
SHASTA	43	119	139	1	302
MAINSTEM	111	306	189	2	608
UR TRIBS	7	22	11	0	40
LRC EST	49	48	40	1	138
LRC UP	375	135	32	1	543
YTFP EST	13	225	194	2	434
YTFP M&U	51	376	229	12	668
BLUE CRK	1	1	6	0	8
	862	1,980	1,282	27	4,151

Unknown scales corrected age proportions (Kimura method)

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	0.1608	0.3547	0.4806	0.0039	1.0
IGH	0.0635	0.6402	0.2880	0.0083	1.0
SALMON	0.1220	0.3427	0.5352	0.0000	1.0
SCOTT	0.3341	0.1754	0.4905	0.0000	1.0
SHASTA	0.1345	0.2427	0.6195	0.0033	1.0
MAINSTEM	0.1640	0.4488	0.3839	0.0033	1.0
UR TRIBS	0.1514	0.5244	0.3242	0.0000	1.0
LRC EST	0.3565	0.2589	0.3773	0.0072	1.0
LRC UP	0.7100	0.2333	0.0548	0.0018	1.0
YTFP EST	0.0064	0.4082	0.5808	0.0046	1.0
YTFP M&U	0.0487	0.5120	0.4213	0.0180	1.0
BLUE CRK	0.2313	0.2067	0.5107	0.0512	1.0

Known CWT ages [a/]

	AGE 2	AGE 3	AGE 4	AGE 5	TOTAL
BOGUS	0	29	17	1	47
IGH	91	803	270	1	1,165
SALMON	0	0	0	0	0
SCOTT	0	0	0	0	0
SHASTA	0	2	0	0	2
MAINSTEM	0	8	7	0	15
UR TRIBS	0	0	0	0	0
LRC	10	21	1	0	32
YTFP EST	1	43	8	0	52
YTFP M&U	0	26	4	0	30
BLUE CRK	0	0	0	0	0
	102	932	307	2	1,343
Breakout within strata					
Bogus1	0	21	16	1	38
Bogus2	0	8	1	0	9
LRC - lo	0	0	1	0	1
LRC - mid	10	21	0	0	31
YTFP MID	1	1	1	1	4
YTFP UP	0	0	0	0	0

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

Appendix E. 2021 Trinity age analysis.

WCW = Willow Ck. Weir

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable	67	0	7	1	0	75
2	191	4	0	0	0	195
3	1125	0	67	2	0	1194
4	61	0	0	1	0	62
5	0	0	0	0	0	0
	1444	4	74	4	0	1526

82		
1377		

LOWTRINREC = Lower Trinity Recreational

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable	3	0	0	0	0	3
2	3	0	0	0	0	3
3	12	0	1	0	0	13
4	0	0	0	0	0	0
5	0	0	0	0	0	0
	18	0	1	0	0	19

1		
15		

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

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable	50	0	7	0	0	57
2	66	0	2	0	0	68
3	756	0	165	7	0	928
4	195	0	4	23	0	222
5	0	0	0	0	0	0
	1067	0	178	30	0	1275

208		
1017		

TRH = Trinity River Hatchery

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable	42	0	6	0	0	48
2	32	16	5	0	0	53
3	822	4	226	4	0	1056
4	42	0	0	10	0	52
5	0	0	0	0	0	0
	938	20	237	14	0	1209

271		
896		

LOWTRINTRIBS = Lower Trinity Tribs - Includes samples taken by l

Scale Ages	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
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
	0	0	0	0	0	0

0		
0		

NO DATA

0

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

0		
0		

HVTSELECTHARV = Hoopa Tribal Weir Harvest

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable	10	0	0	0	0	10
2	130	9	0	0	0	139
3	193	1	42	1	0	237
4	14	0	0	3	0	17
5	0	0	0	0	0	0
	347	10	42	4	0	403

56		
337		

NO DATA

0

Scale Ages	no cwt age	Cwt Age 2	3	4	5	Total
Scale unreadable						
2						
3						
4						
5						
	0	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	29	7	0	0
3	5	501	14	0
4	0	4	37	0
5	0	0	0	1

4x4

0.95

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

	2	3	4	5
2	0.8529	0.0137	0.0000	0.0000
3	0.1471	0.9785	0.2745	0.0000
4	0.0000	0.0078	0.7255	0.0000
5	0.0000	0.0000	0.0000	1.0000

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

	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	
# known scales	82	208	1	271				0	56
# unknown scales	1377	1017	15	896				0	337
Age									
2	0.1498	0.0652	0.2223	0.0272	0.0000	0.0158	0.2012	0.2014	
3	0.7977	0.6778	0.7777	0.9181	0.0000	0.9782	0.7451	0.7448	
4	0.0525	0.2570	0.0000	0.0547	0.0000	0.0059	0.0538	0.0538	
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
	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	1.1753	-0.0165	0.0062	0.0000
3	-0.1772	1.0275	-0.3888	0.0000
4	0.0019	-0.0111	1.3826	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	0	0	1	1	0
3	0	178	1	1175	0	1	1	0
4	0	30	0	56	0	1	1	0
5	0	0	0	0	0	1	1	0
	0	208	1	1231	0	4	4	0
# unknown ads	0	6	0	35	0	0	0	0
# total ads	0	214	1	1266	0	paper CWTs		0

WCW scales

Age	WCW no cwts	known age cwts scales	Total age all scales	WCW age proportions
2	206	0	206	0.1498
3	1098	0	1098	0.7977
4	72	0	72	0.0525
5	0	0	0	0.0000
	1377	0	1377	1.0000

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

	Total Run
Rec above WCW	490
TRH	5967
Naturals	16184
Total	22641

Age	WCW proportions	TRH + Rec above WCW+Natural Escapement	Apportioned Natural Escapement minus TRH #s minus above WCW creel #s	Proportions
2	0.1498	3392	3255	0.2012
3	0.7977	18061	12059	0.7451
4	0.0525	1188	870	0.0538
5	0.0000	0	0	0.0000
		22641		

Appendix F. 2021 Klamath Basin fall Chinook age-composition calculation worksheet.

1/16/2022

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	Redd Surveys Redds	Live	Video	Carcass
Iron Gate Hatchery (IGH)	494	7012	7506	494	4862	2096	54	7506	scales	0.06348	0.64020	0.28804	0.00828	1.0	725				
									IGH cwts	91	803	270	1	1165					
Trinity River Hatchery (TRH)	129	5838	5967	129	5523	315	0	5967	scales	0.02716	0.91812	0.05472	0.00000	1.0	896				
Hatchery spawner subtotal:	623	12850	13473	623	10385	2411	54	13473	TRH cwts	0	1175	56	0	1231					
	prop. hatchery grilse		0.046			proportion hatchery		21%											
Natural Spawners																LAST DAY LIVES ARE ADULTS ONLY			
Trinity River mainstem above WCW	3256	12928	16184	3256	12058	870	0	16184	WCW w/ age correction	0.20117	0.74507	0.05376	0.00000	1.0	1377				
Trinity River mainstem below WCW	18	70	88	18	66	5	0	88	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	35			
Salmon River Basin (includes Wooley Cr)	263	1890	2153	263	738	1152	0	2153	scales	0.12202	0.34275	0.53524	0.00000	1.0	22	944	2		0
Scott River	655	1307	1962	655	344	962	0	1962	scales	0.33406	0.17540	0.49055	0.00000	1.0	146	187		1400	0
				30%	16%	45%	0%		Scott CWT	0	0	0	0	0					
Shasta River	927	5972	6899	927	1676	4273	23	6899	scales	0.13446	0.24273	0.61950	0.00331	1.0	302			6899	0
									Shasta CWT	0	2	0	0	2					
Bogus Creek	423	2253	2676	423	961	1281	11	2676	scales	0.16084	0.35467	0.48062	0.00387	1.0	517			2232	444
									Bogus CWT	0	29	17	1	47					
Mainstem Klamath (IGH to Shasta R)	343	1762	2105	343	946	809	7	2105	scales	0.16397	0.44885	0.38389	0.00329	1.0	608				
									KR main CWT	0	8	7	0	15					
Mainstem Klamath (Ash Cr to Wingate Bar)	468	2384	2852	468	1280	1095	9	2852	Up K main	0.16397	0.44885	0.38389	0.00329	1.0	surrogate IGH t	1192			
Mainstem Klamath (Persido Bar to Big Bar)	49	254	303	49	141	99	14	303		0.16226	0.46398	0.32830	0.04545	1.0	Surrogate	127			
Main basin subtotals:	6,353	28,566	34,919	6,353	18,069	10,447	50	34,919	scale age proportions based on Persido Bar to Big bar+ Camp+Red Cap+Rock- see tab										
Klamath Tributaries																			
Aiken Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Beaver Cr	22	125	147	22	77	48	0	147	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	59	7		
Bluff Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Boise Cr	5	30	35	5	18	11	0	35	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	15	0		
Camp Cr	42	235	277	42	145	90	0	277	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	115	5		
China Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Clear Cr	26	144	170	26	89	55	0	170	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	72	0		
Clear SF	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Dillon Cr	7	40	47	7	25	15	0	47	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	20	0		
Elk Cr	14	77	91	14	48	30	0	91	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	37	3		
Ft. Goff Cr	0	2	2	0	1	1	0	2	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	1	0		
Grider Cr	7	40	47	7	25	15	0	47	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	20	0		
Horse Cr	4	24	28	4	15	9	0	28	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	12	0		
Independence Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Indian Cr	7	38	45	7	24	15	0	45	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	17	4		
Indian SF	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40		0		
Irving Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Pearch Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Red Cap Cr	23	127	150	23	79	49	0	150	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	61	5		
Rock Cr	7	42	49	7	26	16	0	49	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	21	0		
Rogers Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Slate Cr	1	8	9	1	5	3	0	9	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	4	0		
Swillup Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Thompson Cr	12	69	81	12	42	26	0	81	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	34	1		
Ti Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Ukonom Cr	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0	0		
Other	1	3	4	1	2	1	0	4	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	1	1		
Pine Cr (fmoved to Hoopa tribs)	0	0	0	0	0	0	0	0	scales	0.15141	0.52440	0.32419	0.00000	1.0	40	0			
Klamath trib subtotal:	178	1004	1182	179	620	383	0	1182								489	26		
Trinity Tributaries																			
Horse Linto Cr	11	44	55	11	41	3	0	55	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	21	2		
Cedar Cr (trib to Horse Linto)	6	22	28	6	21	2	0	28	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	11	0		
Willow Cr	16	64	80	16	60	4	0	80	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	32	0		
Other (Madden creeks in Up TR nat estim)	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0				
Trinity trib subtotal:	33	130	163	33	121	9	0	163								64			
Non-reservation trib subtotal:	211	1134	1345	212	741	392	0	1345											
Reservation Tributaries-Hoopa Valley																			
Campbell Cr	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	0			
Hostler Cr	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	0			
Mill Cr	20	78	98	20	73	5	0	98	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	39			
Pine Cr (formerly included in klam tribs)	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	0			
Soctish Cr	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	0			
Supply Cr	7	28	35	7	26	2	0	35	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	14			
Tish Tang Cr	5	18	23	5	17	1	0	23	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	9			
Other (Hospital Cr.)	0	0	0	0	0	0	0	0	Up T main	0.20117	0.74507	0.05376	0.00000	1.0	0	0			
HVT reservation trib subtotal:	32	124	156	32	116	8	0	156								62			
							0												
Reservation Tributaries-Yurok									**SURROGATE** - Unweighted avg of Blue Ck adults from 2007-09, 11-15, 17, 20 (years w/ surrogates omitted)										
Blue Cr	25	119	144	25	32	79	8	144	**count**	0.26895	0.66439	0.06666	1.0	7					
									0.174										
Reservation tributaries subtotal:	57	243	300	57	148	87	8	300											
Natural spawner subtotal:	6621	29943	36564	6622	18958	10926	58	36564											
Total spawners:	**7244**	**42793**	**50037**	**7245**	**29343**	**13337**	**112**	**50037**											
Angler Harvest																			
Klamath River (below Hwy 101)	138	249	387	138	100	147	2	387	scales	0.35653	0.25894	0.37729	0.00725	1.0	138				
									est-LRC CWT	0	0	1	0	1					
Klamath River (Hwy 101 to Weitchpec)	2161	900	3061	2161	728	166	6	3061	scales	0.71000	0.23334	0.05482	0.00184	1.0	543				
									mid-LRC CWT	10	21	0	0	31					
		Upper Klam ratio estimator							**SURROGATE** - IGH+Bogus+Klamath Mainstem+Shasta Weighted Totals							IGH+BOG+Kmain+Shasta			
									IGH+Bog+Klam+Sha	2187	8445	8459	95	19186		19186			
Klamath River (Weitchpec to IGH)	74	579	653	74	287	288	4	653		0.1140	0.4402	0.4409	0.0050	1.0		653	0.034		
									SURROGATE scales Lower TR sport										
Trinity River (above Willow Cr. Weir)	8	482	490	8	479	3	0	490	rtions provided by Hoopa	0.01584	0.97822	0.00594	0.00000	1.0					
									don't use paper TR CWTs in age calculations										
Trinity River (below Willow Cr. Weir)	16	55	71	16	55	0	0	71	scales	0.22234	0.77766	0.00000	0.00000	1.0	15				
									TR-low CWT	0	1	0	0	1					
Angler harvest subtotal:	2,397	2265	4,662	2,397	1,649	604	12	4662											
Tribal Harvest																			
Klamath River (Estuary)	17	2598	2615	17	1089	1496	13	2615	scales	0.00640	0.40823	0.58076	0.00461	1.0	434				
									YTFP EST CWT	1	43	8	0	52		Yurok harvest			
Klamath River (101 to Trinity R)	144	2842	2986	144	1540	1249	53	2986	scales	0.04870	0.51204	0.42129	0.01796	1.0	668	2243	MidKlm		
									YTFP MU CWT	0	26	4	0	30		743	UpKlm		
Trinity River (net and hook-and-line)	136	2156	2292	136	1591	566	0	2292	net scales	0.0652	0.6778	0.2570	0.0000	1.0	1,017				
									HVT net CWT	0	178	30	0	208					
Trinity River (harvest weir)	315	470	785	315	428	42	0	785	weir scales	0.44419	0.50398	0.05183	0.00000	1.0	337				
									HVT weir CWT	0	70	5	0	75					
Tribal harvest subtotal:	612	8066	8678	612	4648	3353	66	8678											
Total harvest:	**3009**	**10331**	**13340**	**3009**	**6297**	**3957**	**78**	**13340**											
Totals																			
Harvest and Escapement	10253	53124	63377	10253	35640	17294	190	63377											
Angling drop-off mortality (2.04%)	49	46	95	49	34	12	0	95	0.0204 angling drop-off mortality rate on harvest										
Net drop-off mortality (8.7%)*	26	671	697	26	372	292	7	697	0.0870 net drop-off mortality rate on harvest										
Ich Disease Testing (Tribal)									Klam CWTs	0	0	0	0	0					
Klamath River	6	113	119	6	61	50	2	119	YTFP MU scales	0.0487	0.5120	0.4213	0.0180	1.0000					
Trinity River	0	0	0	0	0	0	0	0	HVT scales	0.0652	0.6778	0.2570	0.0000	1.0000					
Total disease testing:	**6**	**113**	**119**	**6**	**61**	**50**	**2**	**119**	Trin CWTs	0	0	0	0	0					
Total in-river run	**10334**	**53954**	**64288**	**10334**	**36107**	**17648**	**199**	**64288**											

Appendix G: Estimation of age-2 Trinity River hatchery-origin abundances in the absence of coded-wire tag recoveries.

Fall Chinook Salmon reared at and released from Trinity River hatchery are marked by the removal of the adipose fin and implanted with coded wire tags at an approximate 25% rate annually for subsequent recovery in fisheries, freshwater escapement, and in hatchery returns. Tag recoveries are used to estimate the age-specific number of hatchery-origin fish in each recovery sector. No Chinook Salmon from brood year 2019 were marked or tagged at Trinity River hatchery due to travel and physical distancing limitations associated with the COVID-19 global pandemic. Consequently, Trinity River hatchery origin (TRH-origin) age-2 fish caught in ocean fisheries and returning to the Klamath River basin in 2021 were indistinguishable from natural-origin fish, and hatchery contributions to this age class could not be estimated using established methods. Accurate estimates of hatchery contributions to age classes 2-4 are necessary for estimation of fishery impact rates on hatchery and natural-origin stocks in ocean and terminal fisheries via cohort reconstructions. These estimates are also relevant to future fishery planning using the Klamath Ocean Harvest Model.

Estimation of the TRH-origin contribution to age-2 harvest or escapement in each relevant sector was estimated for the 2021 run year by multiplying the long-term un-weighted average proportion of TRH-origin fish among the total within each sector by the estimated total age-2 numbers within the same sector. Specifically, the number of age-2 TRH-origin fish within a given sector was estimated as:

$$TRH_{2021} = \tau_{2021} * \frac{\sum_{i=1}^{n} {TRH_i}/{\tau_i}}{n}$$

Where

$TRH_i =$ number of age-2 TRH-origin fall Chinook Salmon estimated within a given sector in year i,

$\tau_i =$ total number of age-2 fall Chinook Salmon estimated within a given sector in year i, irrespective of origin (hatchery or natural), and

$n =$ number of years for which estimates of TRH_i and τ_i were available from 2001 to 2019.

Members of the Klamath River Technical Team (KRTT) agreed on the simplifying assumption that no age-2 TRH-origin fish strayed to natural spawning areas in the Klamath River or its tributaries (excluding the Trinity River), Iron Gate hatchery, or to rivers outside the Klamath basin. Consequently, age-2 TRH-origin fish were estimated only for the six sectors summarized in Table 1. The quantities TRH_i for fishery sectors were derived from the Klamath cohort reconstruction input table kohminland.dbf, and quantities τ_i were obtained from historic KRTT reports. These data were available starting in the 2001 run year. The quantities TRH_i and τ_i for Trinity River natural area escapement and returns to Trinity River hatchery were obtained from the 2020 CDFW annual run size report (Kier et al. 2021). These data were available starting in the 2002 run year. Run year 2020 was excluded from all analyses because the proportion of TRH-origin fish was a considerable outlier in several sectors. For example, more than 80% of age-2 harvest in the lower Klamath River recreational fishery was estimated to be TRH-origin in 2020, whereas the next highest percent since 2001 was less than 24% (Figure 1). All data points shown in Figure 1 were used to calculate the values presented in Table 1.

Table 1. Mean proportions of age-2 Trinity River hatchery-origin fish among total age-2 fish in six sectors of harvest or escapement in the Klamath River basin based on data from 2001 (fishery sectors) or 2002 (escapement sectors) to 2019.

Sector		Proportion TRH
lower Klamath River	recreational fishery	0.040
	tribal fishery	0.030
Trinity River	recreational fishery	0.125
	tribal fishery	0.029
	natural area escapement	0.164
	hatchery escapement	0.845

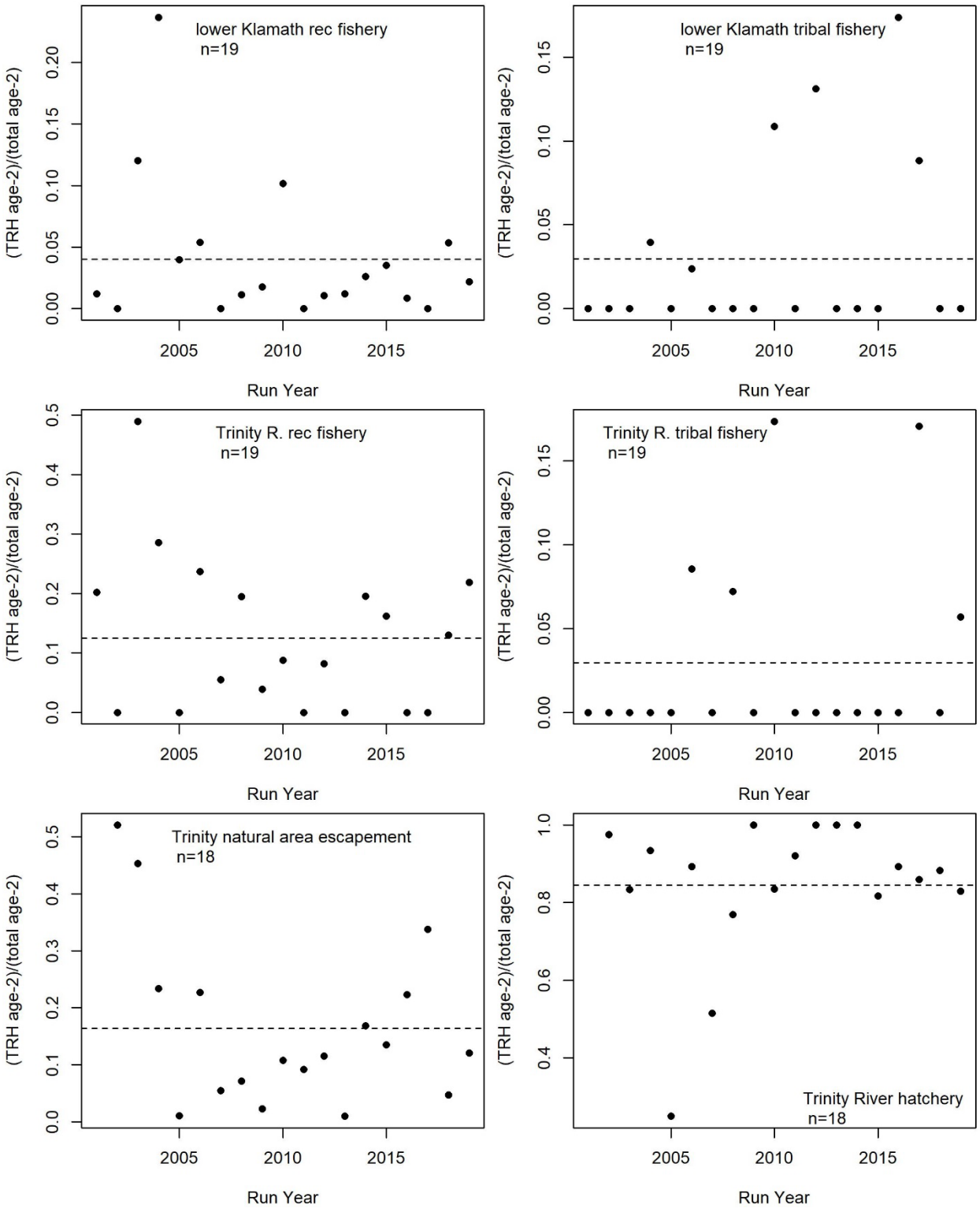

Figure 1. Time series of the proportion of age-2 Trinity River hatchery-origin fall Chinook Salmon among total age-2 fall Chinook Salmon in various harvest and escapement sectors in the Klamath River basin. Sample sizes (n) and estimated mean proportions (dashed lines) are shown for each sector.

Reference

Kier, M. C., J. Hileman, and K. Lindke. 2021. Annual report Trinity River basin salmon and steelhead monitoring project: Chinook Salmon, Coho Salmon, and fall-run steelhead run-size estimates using mark-recapture methods. California Department of Fish and Wildlife, Northern Region, Klamath-Trinity Program, Arcata, CA.

Appendix H: Inclusion of known-age-2 CWT fish in scale validation matrices in 2021

Due to complications associated with Covid-19, no Trinity River Hatchery (TRH) Chinook were coded-wire-tagged in 2020, which has resulted in there being no CWT known age-2 fish in the Trinity River Basin in 2021, and significantly reduced the number of CWT known age-2 fish in the Klamath River, which are used to bias correct reader scale ages. In order to account for this lack of CWT known age-2 samples to validate reader produced values, the Hoopa Valley Tribe (HVT), following the methods described in Satterthwaite et al. (2013), inserted CWT known age-2 scale samples from collection years 2019 and 2020 into the 2021 collection year to provide sufficient samples to validate age-2 reads. Satterthwaite et al. (2013) suggested that at least 20 known age archived scales should be incorporated into validation matrices for each age class lacking an adequate sample size of known -age scales from the current year. HVT incorporated a total of 34 CWT known age-2 fish from archived samples into the 2021 collection. As there are typically low numbers of age-2 fish captured in the HVT individual Tribal member fisheries as a result of the capture methods employed, it was decided that archived scales would be taken from and incorporated into sectors of only the weirs and the hatchery. Archived samples from the Willow Creek Weir (WCW) (4) and the Hoopa Selective Harvest Weir (HW) (10) were from return year 2019 and archived samples from TRH (20) were from the 2020 return year. Archived samples were randomly incorporated into the current year's collection, but sectors were not mixed. Once reader validation was completed, these CWT known age-2 were removed from the dataset prior to further calculations. For ageing in the Klamath River, the Yurok Tribe did not utilize this method but instead relied solely on Iron Gate Hatchery (IGH) fish, which were coded-wire-tagged in 2020 and used for age-2 validation in 2021.It should be noted that the overall number of CWT known age-2 fish returning to the Klamath River was significantly lower than normal.

Reference

Satterthwaite, W.H., O'Farrell, M.R., and M.S. Mohr. 2013. Klamath-Trinity Basin fall run Chinook Salmon scale age analysis evaluation. U. S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-522.

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

Limited survey in the Salmon River Basin

In 2021, the initial Salmon River redd survey was conducted during the first two weeks of the season (through week ending October 23). A large flow event began as of Friday October 22 (the first day of Julian Week 43), following two survey days on the lower Salmon River (October 14 and 21) and 2 survey days on the upper Salmon River (October 15 and 19). Although successful survey efforts were conducted following the high flow period (sampling resumed November 16 and ran through December 3), there was evidence of flattening of pre-existing redds, which likely indicates that spawning activity that occurred during the high flow period, were difficult to recognize (or possibly not at all recognizable) in the surveys during the latter part of the season. Although some new redds were located after the flow event, this impact likely led to an underestimate of spawning activity.

In the Salmon River system, substantial spawning typically occurs after Julian week 42, and this spawning activity was insufficiently sampled, with surveys unable to resume until late November. Additionally, no sampling was performed on Wooley Creek in 2021, 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, 2017, 2018).

To account for the lack of sampling after Julian week 42 in the Salmon River, 2021 redd deposition data up to and including Julian week 42, and the cumulative distributions of redd deposition from past years were used to estimate redds in 2021 (KRTT 2009, 2011, 2017, 2018). Redd deposition data for years 1998-2020 (excluding 2005, 2010, 2013, 2016, 2017 and 2020, where survey effort was also low, or had a delayed start of the survey season) indicated that the mean proportion of new redds counted up to, and including, Julian week 42 was p = 0.356169. The KRTT discussed whether a mean, minimum, or maximum proportion of redd deposition (across years with appropriate data) at Julian week 42 would be most representative of 2021 conditions. The team decided that the mean proportion would be most appropriate because observations from other neighboring sectors (including the upper Klamath tributaries and the Scott River) suggested average run timing and spawning in 2021.

In 2021, 309 redds were enumerated through Julian week 41 (R_{inc} = 309) and the total number of redds in the Salmon River (R), not including Wooley Creek, was estimated to be:

$$R = \frac{R_{inc}}{p} = \frac{309}{0.356169} = 867.566$$

Lack of sampling in Wooley Creek

To account for the lack of sampling in Wooley Creek, we applied a method previously described in KRTT (2009, 2017, 2018). The ratio of the mean number of total redds in the Salmon River basin (including Wooley Creek, $\bar{T}$) to the mean number of redds in the Salmon River (excluding Wooley Creek $\bar{S}$) was computed using data from 1996-2020 (but excluding appropriate years as indicated above):

$$\lambda = \frac{\bar{T}}{\bar{S}} = \frac{1041.727}{957.2727} = 1.0882244$$

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:

$$R_{tot} = R\ x\ \lambda = 867.566\ x\ 1.0882244 = 944$$

With an estimated total of 944 redds, we apply the standard redd estimator (redds x 2 + Last Day Lives), resulting in:

(944 x 2) + 2 = 1,890 adult fall Chinook salmon in the Salmon River Basin, including Wooley Creek.

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.

KRTT (Klamath River Technical Team). 2017. Klamath River fall Chinook age-specific escapement, river harvest, and run size estimates, 2016 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

KRTT (Klamath River Technical Team). 2018. Klamath River fall Chinook age-specific escapement, river harvest, and run size estimates, 2017 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Appendix J. Final age composition of the 2020 Klamath Basin fall Chinook run.

2/8/2022

Escapement & Harvest	AGE 2	3	4	5	Total Adults	Total Run
Hatchery Spawners						
Iron Gate Hatchery (IGH)	413	3,198	843	1	4,042	4,455
Trinity River Hatchery (TRH)	2,815	4,070	219	0	4,289	7,104
Hatchery Spawner subtotal	**3,228**	**7,268**	**1,062**	**1**	**8,331**	**11,559**
Natural Spawners						
Salmon River Basin	122	862	110	0	972	1,094
Scott River Basin	43	564	248	0	812	855
Shasta River Basin	393	2,948	827	0	3,775	4,168
Bogus Creek Basin	88	1,909	324	0	2,233	2,321
Klamath River mainstem (IGH to Shasta R.)	55	1,087	83	0	1,170	1,225
Klamath River mainstem (Ash Cr. to Wingate Bar)	75	1,474	110	0	1,584	1,659
Klamath River mainstem (Persido Bar to Big Bar)	20	249	25	0	274	294
Klamath tributaries (above Trinity River)	34	836	38	0	874	908
Blue Creek	99	46	78	0	124	223
Klamath Basin subtotal	929	9,975	1,843	0	11,818	12,747
Trinity River Basin (above WCW)	3,792	12,182	1,553	0	13,735	17,527
Trinity River mainstem (below WCW)	93	298	38	0	336	429
Trinity tributaries (above Reservation, below WCW)	97	139	75	0	214	311
Hoopa Reservation tributaries	37	53	29	0	82	119
Trinity Basin subtotal	4,019	12,672	1,695	0	14,367	18,386
Natural Spawners subtotal	**4,948**	**22,647**	**3,538**	**0**	**26,185**	**31,133**
Total Spawner Escapement	**8,176**	**29,915**	**4,600**	**1**	**34,516**	**42,692**
Recreational Harvest						
Klamath River (below Hwy 101)	39	168	38	0	206	245
Klamath River (Hwy 101 to Weitchpec)	343	2,718	228	0	2,946	3,289
Klamath River (Weitchpec to IGH)	134	1,294	294	1	1,589	1,723
Trinity River Basin (above WCW)	0	322	6	0	328	328
Trinity River Basin (below WCW)	17	52	2	0	54	71
Subtotals	**533**	**4,554**	**568**	**1**	**5,123**	**5,656**
Tribal Harvest						
Klamath River (below Hwy 101)	85	915	809	6	1,730	1,815
Klamath River (Hwy 101 to Weitchpec)	156	1,433	1,070	0	2,503	2,659
Trinity River	87	649	330	0	979	1,066
Trinity River (harvest weir)	0	0	0	0	0	0
Subtotals	**328**	**2,997**	**2,209**	**6**	**5,212**	**5,540**
Total Harvest	**861**	**7,551**	**2,777**	**7**	**10,335**	**11,196**
Totals						
Harvest and Escapement	9,037	37,466	7,377	8	44,851	53,888
Recreational Angling Dropoff Mortality 2.04%	11	93	12	0	105	116
Tribal Net Dropoff Mortality 8.7%	29	261	192	0	453	482
Total River Run	**9,077**	**37,820**	**7,581**	**8**	**45,409**	**54,486**