Fishery Regulation Assessment Model (FRAM): Exploitation Rate Investigation for the Upper Columbia River Summer Chinook Stock

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Summary

The more than 30-year-old Chinook base period of the Fishery Regulation Assessment Model (FRAM) was recently updated with coded wire tag (CWT) recoveries from fishing years 2007–2013 and first used in 2017 preseason planning.

Subsequent years of preseason planning have utilized revised versions of this base period with ongoing data quality improvements. Version 6.2 of the Chinook base period was used in 2019 preseason planning.

The base period integrates fishery catches, stock information, and CWT recovery data to produce a calibrated reference pattern of stock distributions and stock-specific exploitation rates by time-step and fishery.

The Upper Columbia River Summer Chinook stock (referred to as U_CR_Sum) is represented in FRAM with marked (adipose fin clipped) and unmarked (adipose fin intact) components (StockID # 45+46) and is one of 78 stocks included in Chinook FRAM. U_CR_Sum are an early timed Chinook stock spawning upstream of Priest Rapids dam of mixed hatchery/natural origin. Hatchery facilities include Wells Dam, Eastbank, Methow, Similkameen, and Chief Joseph. FRAM uses fingerling and yearling CWT groups from Wells hatchery for its representation. The vast majority of the stock's marine exploitation occurs in Alaska and Canada, with a modest amount of exploitation in Washington and Oregon ocean fisheries. The stock also experiences high freshwater exploitation. U_CR_Sum navigate several Columbia River dams during their migration to their spawning grounds or natal hatchery and are subjected to interdam losses (IDLs) and other sources of pre-spawn mortality along their long journey upriver. Escapement is initially evaluated at Bonneville Dam by allocating all Chinook migrating upstream between June 15 and July 31 to the U_CR_Sum stock.

Recent investigations into FRAM exploitation rates of U_CR_Sum suggests that the updated base period results in significant over-estimates of impacts in marine fisheries, with the magnitude of overestimation in the Central Oregon troll fishery being particularly pronounced.

Methodology

Members of the base period workgroup examined over a dozen different sources of error with the potential to result in an overestimate of base period exploitation rates. An informal summary of this effort is presented in "U_CR_Sum Results Sep 23_2019.docx".

The subset of methods described here, pertains to investigations that resulted in findings or potential causes of an exploitation rate bias.

CWT Recoveries of marked U_CR_Sum in fisheries and escapement

For direct comparisons with FRAM marked landed catch output, adipose marked CWT recoveries (AD+CWT) of U_CR_Sum reported by the Regional Mark Information System (RMIS Standard Reporting; https://www.rmpc.org/) are expanded to the total adipose marked (AD) hatchery stock.

1. Query RMIS for 'Tagged Releases' of U_CR_Sum

Query Parameters

Species: 1
Run: 2
Brood Year: 2002-2011
RMIS Region: UPCR, CRGN

2. Use tag codes from step 1 (appendix table 1) to query RMIS 'Recoveries by Tag Code'.
3. Map recoveries from step 2 to FRAM fisheries.
4. Using release table from step 1, calculate ratio of U_CR_Sum (AD)/(AD+CWT).
5. Filter 'Estimated Number' from step 4 to adipose marked recoveries. Use ratios from step 4 to expand 'Estimated Number' for estimates of 'marked expanded recoveries'.
6. Sum 'marked expanded recoveries' from step 5 over relevant run years, fisheries/escapement, and time steps.

Proportion San Joaquin stock in the Central Oregon Troll Fishery

The Central Valley Fall Chinook stock is an aggregate of fish from the Sacramento River and its tributaries and the San Joaquin River and its tributaries.

The proportion San Joaquin stock in the Central Oregon Troll Fishery was computed in three steps:

1. **Estimate the proportion Central Valley stock (San Joaquin + Sacramento) in the Central Oregon Troll fishery.**
   We used the same Genetic Stock Information (GSI) study (Bellinger, Banks, & Bates, 2015) that is also the source of FRAM's model stock proportion (MSP) for the Central Oregon troll fishery to determine the contribution of Central Valley stock (see "Fishery Model Stock Proportion" chapter below). The Central Oregon troll fishery in FRAM consists of Northern Oregon troll as well as Central Oregon troll. Monthly stock proportions for the months May through September were weighted by monthly catches to obtain an overall (May-Sep, North/Central) stock composition of 22%.

   Table 2. Central Valley Fall Chinook Catch by months in 2010 May-Sep Central Oregon Troll Fishery (Bellinger et al.) and Weighted Central Valley Contribution.

	Central Oregon					Northern Oregon				
	May	June	July	Aug	Sept	May	June	July	Aug	Sept
CV % Contribution	0.27	0.3	0.33	0.4	0.48	0.16	0.13	0.13	0.12	0.27
Central Oregon Troll Catch	453	616	75	601	95	404	1102	403	532	30
CV Catch in Central Oregon Troll	122	185	25	240	46	65	143	52	64	8
Weighted CV Contribution	0.22									

2. **Estimate the proportion San Joaquin stock of Central Valley stock.**
   The proportion San Joaquin stock of Central Valley stock was calculated from 2011-2013 escapement estimates.
   Caveats:

- Some surveys do not collect heads in a standardized manner (e.g., aerial redd surveys, video weirs) were not analyzed for hatchery- vs. natural-origin or included in analyses. However, most of the surveys were included in the analyses, so that the total escapement values here represent the bulk of the escapement.
- These numbers include a small number of non-fall-run Chinook that returned during the fall-run spawning period and were thus considered part of the fall-run escapement. Specifically, there are always some spring- and late fall-run (and sometimes winter-run) Chinook that return during the fall-run spawning period and are counted toward the fall-run escapement.
- Lastly, the natural-origin fish were assumed to not have strayed at all, so they were assigned to Sacramento or San Joaquin based on which basin they entered.

Table 3. 2011-13 Sacramento (Sac) and San Joaquin (SJ) Fall Chinook Escapement by Origin (A. Letvin)

Year	Sac Hat	SJ Hat	Sac Nat	SJ Nat	% SJ
2011	156,696	20,821	41,741	1,321	10.04%
2012	257,301	21,314	49,030	3,188	7.41%
2013	307,355	20,542	102,259	7,453	6.40%
Avg					**7.95%**

3. **Combine values from steps 1 and 2 above for an estimate of the proportion San Joaquin stock in the Central Oregon troll fishery**
   Central Valley Fall Chinook make up 22.04% of the Central Oregon troll fishery. 7.95% of the Central Valley escapement is comprised of San Joaquin origin Chinook, for a San Joaquin contribution to the Central Oregon troll fishery of 1.75%. This proportion is subtracted from the model stock proportion of 87.05% for a new model stock proportion of 85.3%

Note that the MSP used in the updated Chinook base period was derived using Bellinger et al. 2015, which only included GSI data from May–Sept 2010. That particular year had a medium to low run size for the Central Valley stock. An extended GSI data set (2010-2015) indicates that subsequent years likely had a higher contribution to the fishery from Central Valley stock (see appendix table 6).

Results

Evidence of an Error within the FRAM Model

We began our investigation by examining U_CR_Sum FRAM impacts in May–June (time step 2) from the Central Oregon troll fishery, because this fishery had a very large impact on U_CR_Sum relative to other Southern US fisheries (appendix table 4).

We used Chinook CWT recoveries from RMIS to estimate the fishery stock composition in May–June (time step 2) from the Central Oregon troll fishery. The analysis was conducted in "marked" only units (i.e. fish with a clipped adipose fin = marked). This eliminates the need to make estimates for unmarked stock components (hatchery and natural) and thus reduces the uncertainty associated

with unmarked coded wire tag expansions. Marked CWT recoveries were expanded to account for associated marked non-CWT release groups using RMIS' release data (see Methodology chapter).

The average U_CR_Sum contribution of the marked landed catch in FRAM is significantly higher than the RMIS CWT-based estimate (23.9% versus 8.6%). RMIS estimates of total marked catch (average = 5879), summed over all stocks in the fishery, closely approximate the observed marked catch (average = 6240).

Table 5. Marked landed catch observed (2010-2013) and the U_CR_Sum stock contribution to marked landed catch of the Central Oregon troll fishery (during May - June) using two estimation methods: RMIS expanded CWT data versus FRAM modeling.

		RMIS			FRAM		
	Observed		U_CR_Sum			U_CR_Sum	
Year	Total Marked	Total Marked	Number	% of Marked	Total Marked	Number	% of Marked
2010	6744	6340	324	5.1%	8768	1865	21.3%
2011	4305	4323	346	8.0%	9208	2737	29.7%
2012	9758	9019	963	10.7%	9388	2228	23.7%
2013	4155	3836	380	9.9%	6043	1154	19.1%
AVG	**6240**	**5879**	**503**	**8.6%**	**8352**	**1996**	**23.9%**

FRAM estimates of U_CR_Sum impacts in the Central Oregon Troll fishery were also significantly higher than Genetic Stock Identification (GSI) estimates from the Collaborative Research on Oregon Ocean Salmon (CROOS) research project (U_CR_Sum contribution = 11%, appendix table 6).

Identified Causes of Errors

Updated Expansions for Escapement Recoveries in RMIS

In 2018, updates were made to Catch/Sample data in RMIS that resulted in a significant increase to the estimated numbers associated with many escapement recoveries of Wells Hatchery tag codes used to represent Columbia River Summer Chinook in the new FRAM base period. These revised expansions resulted in an increase of the total number of expanded escapement recoveries of Summer Chinook in the base period CWT dataset from ~6,600 to ~8,000. This revised recovery information is not currently included in the FRAM base period CWT data set, as CWT data were last pulled from RMIS in 2015. Incorporating them into the base period calibration will likely result in an ~8% decrease (average 2012–16) in exploitation rates (metric assessed as a relative reduction to the total exploitation rate (ER); i.e. a 50% total ER would decline to 46%).
Note: Addressing this issue requires re-running the FRAM calibration protocol/software and updating the FRAM base period.

Inter-dam Loss

During the cohort analysis that occurs as part of the CTC's exploitation rate analysis process, the stocks that migrate upstream of Bonneville Dam receive expansions to escapement recoveries to account for inter-dam loss (IDL). These stocks include: Columbia Upriver Brights (URB), Hanford

Wild Brights (HAN), Columbia Summers (SUM), Lyons Ferry Fingerling (LYF), Lyons Ferry Yearling (LYY), and Spring Creek Tules (SPR). The IDL estimate represents the proportion of unharvested returning adult fish that survive to spawn, and is calculated as the ratio of the upstream dam count (dam varies by stock) divided by the Bonneville dam count minus known removals due to harvest, escapement to tributaries, and broodstock collection. Although called IDL, this rate does not represent Chinook that are lost, but those that are actually accounted for. In order to accurately represent ocean harvest rates of these stocks, it is critical that all escapement to the river is accounted for. Unlike CTC's exploitation rate analysis, the FRAM base period calibration program currently does not contain algorithms that expand escapement for these stocks to account for IDL. This can be achieved in a different way, however, by imputing a set of auxiliary recoveries. For each escapement recovery that occurs upstream of the location where the stock's IDL value is calculated (usually another dam), a corresponding auxiliary recovery is generated with an estimated number that is equal to:

$$\left(\frac{estimated\ \#\ of\ the\ escapement\ recovery}{IDL_{s,y}}\right) - estimated\ \#\ of\ the\ escapement\ recovery$$

where *s* and *y* represent the stock and return year of the escapement recovery, respectively. The FRAM stocks that correspond to the ERA stock mentioned above are: Unmarked and Marked Columbia R Upriver Brights (Stock IDs 47 and 48, corresponds to URB and HAN), Unmarked and Marked Columbia R Upriver Summer (Stock IDs 45 and 46, corresponds to SUM), Unmarked and Marked Snake River Fall (Stock IDs 53 and 54, corresponds to LYF and LYY), and Unmarked and Marked Bonneville Pool Hatchery (Stock IDs 43 and 44, Corresponds to SPR). Including auxiliary CWT recoveries in the base period CWT data set to account for IDL would likely result in a ~3% exploitation rate reduction (average 2012-16) for Summer Chinook (metric assessed as a relative reduction to the total exploitation rate(ER); i.e. a 50% total ER would decline to 48.5%).
Note: Addressing this issue requires re-running the FRAM calibration protocol and updating the FRAM base period. WDFW proposes addressing this issue for each of the eight FRAM stocks identified above.

Fishery Model Stock Proportion

Currently, Chinook FRAM does not include all Chinook stocks on the US west coast. Thus, a model stock proportion value is used to designate the proportion of total catch in a fishery that is accounted for by modeled stocks. MSP values are fishery specific and remain constant through all time periods. Currently, FRAM uses a MSP of 87.0 % in the Central Oregon troll fishery. This value is derived from GSI estimates of the proportion of the landed catch made up of FRAM stocks (Bellinger, Banks, & Bates, 2015). Examples of stocks not included in the model (i.e. non-model stocks) are all California stocks, with the exception of Sacramento Falls, Oregon stocks south of Elk River, Columbia River and Snake River spring stocks upriver of Bonneville Dam, Washington coastal spring stocks, and any stocks north of the west coast of Vancouver Island (BC). According to GSI data, the primary stocks contributing to the non-model stock aggregate during the May to June time period in the Central Oregon troll fishery are Klamath and Rogue River stocks.

San Joaquin, a non-model stock, was not split from Central Valley stock in the GSI stock grouping in order to match FRAM's stock definition of "Sacramento only" when the 87.05 % MSP parameter was derived. The Central Valley stock made up 22.04% of the total stock composition (including non-model stocks) of the 2010 May-Sep Central Oregon troll fishery. The San Joaquin stock contributes 7.95% to the Central Valley stock aggregate (2011-13 average, person communication with Alex Letvin, Sep 27, 2019). This results in a new model stock proportion of 85.3% (tables 2 and 3). For comparison, the FRAM MSP computed by the calibration program is 74%.

Note: The fishery-specific MSP value can be updated by changing an annual FRAM input and does not require a new round of the FRAM calibration.

Conclusion

During our efforts to investigate potential sources of error in the updated Chinook FRAM base period, we identified three issues. If these issues were corrected, the U_CR_Sum ER may be reduced by ~ approximately 11–12% (metric assessed as a relative reduction to the total exploitation rate(ER); i.e. a 50% total ER would decline to 44%). The Central Oregon troll fishery would experience a reduction of slightly larger magnitude, because the model stock proportion reduction is specific to this fishery (i.e. a 5.0% Central Oregon troll ER would decline to ~4.3%). Based on CWT analyses alone, the potential magnitude of FRAM model bias is significantly higher.

After extensive evaluations, we came to the conclusion that a sizeable portion of the U_CR_Sum freshwater CWT recoveries are not being accounted for in RMIS. Thus, FRAM base period exploitation rates are biased high. Because FRAM models marine, but not freshwater impacts in the Columbia River region, for the U_CR_Sum stocks, all freshwater CWT recoveries (in fisheries, hatchery escapement, on spawning grounds) are considered "ocean escapement" (hereafter referred to as escapement CWTs).

Escapement CWTs are part of the denominator of exploitation rate calculations. Missing CWTs will reduce the denominator and thus increase calculated exploitation rates. CWT recoveries are expanded by the sampling rate to account for total catch or escapement. The sampling rate is calculated as sampled catch or escapement divided by total catch or escapement. If only a portion of the in-river run size is accounted for, the sampling expansion will be smaller, thus reducing estimated CWT recoveries.

Evidence of Missing River Run CWTs

Marked Landed Catch of U_CR_Sum Reconstructed from CWT data (RMIS) versus FRAM

We reconstructed the marked landed catch of the U_CR_Sum stock in FRAM fisheries using CWT recoveries and expanding them by the tag rate of marked Summers. The RMIS-based estimate of U_CR_Sum marked landed catch was approximately 32% of the FRAM estimate in the Central Oregon Troll fishery and 53% of the FRAM estimate in all listed fisheries (fishing years 2010-2013; the table below is missing fisheries with small impacts (<200 total fish during 2010-2013 from RMIS-based estimates).

Since missing escapement CWT recoveries would bias all fisheries equally, it is important to demonstrate that this effect is not restricted to the Central Oregon troll fishery. Additionally, we were able to closely reconstruct the total marked catch in the Central Oregon troll fishery when expanding CWT recoveries of all stocks caught in the fishery, providing support for the general validity of the method.

Table 7. Marked U_CR_Sum Landed Catch by Fishery (all time steps) RMIS versus FRAM

	RMIS					FRAM					RMIS/ FRAM
Fishery	**2010**	**2011**	**2012**	**2013**	**Total**	**2010**	**2011**	**2012**	**2013**	**Total**	
Alaska Troll	2494	2250	5043	2053	**11840**	4276	5607	4232	3284	**17399**	68%
Canada Troll	1860	1028	2375	1455	**6718**	3645	7279	3033	2652	**16610**	40%
Canada Sport	746	1241	1852	1071	**4909**	1341	2044	1687	1209	**6280**	78%
Central Oregon Tr	335	432	1261	718	**2747**	1934	2800	2448	1522	**8705**	32%
Area 4 T Troll	91	114	736	489	**1431**	375	582	1028	851	**2835**	50%
Area 2 NT Troll	564	88	172	502	**1326**	954	651	474	838	**2917**	45%
Area 2 Sport	149	286	556	144	**1136**	441	403	793	212	**1848**	61%
Area 1 Sport	81	216	402	141	**840**	74	235	577	305	**1190**	71%
Alaska Sport	247	152	285	125	**809**	264	298	235	185	**982**	82%
Area 1 Troll	248	60	400	73	**781**	443	449	706	107	**1705**	46%
Area 3-4 NT Troll	79	55	474	109	**718**	335	532	1088	469	**2425**	30%
Area 5 Sport	19	60	180	58	**317**	14	13	11	22	**60**	532%
California Troll		33	152	142	**326**	6	215	257	562	**1040**	31%
Area 3:4 Sport	13	15	107	66	**201**	27	63	141	114	**345**	58%
Central Oregon Sp	10	39	130	60	**239**	61	68	256	293	**679**	35%
California Sport	2	57	120	48	**227**	1	15	38	30	**84**	270%
Alaska Net	22	45	85	48	**200**	69	91	99	74	**333**	60%
Total	**6961**	**6172**	**14330**	**7300**	**34764**	**14260**	**21346**	**17101**	**12729**	**65436**	53%

Marked River Run Size of U_CR_Sum Reconstructed from CWT data (RMIS) versus FRAM

We reconstructed the marked, in-river run size (2010-2013) using CWT recoveries (RMIS) and expanding them by the tag rate of marked Summers. The RMIS-based reconstructed river run was approximately 58% of the estimated river run size.

Table 8. Reported and CWT reconstructed U_CR_Sum marked run to the river

Year	River Run used by FRAM* M	RMIS-Based River Run ESC_M	FW Net_M	FW Sport_M	Tot_M	% Marked River Run Accounted For With CWTs RMIS_Tot_M/FRAM_Tot_M
2010	29814	6555	4954	1990	14699	49%
2011	44890	11128	6524	5898	23550	52%
2012	34122	13265	3271	6506	23042	68%
2013	39567	12617	6701	5072	24390	62%
Total	148393	44764	21451	19467	85682	58%

** River run size from run reconstructions submitted for FRAM post-season model runs*

The two examples above provide support for the hypothesis that a considerable portion of in-river CWTs are missing from exploitation rate calculations. Possible sources of erroneous abundance or missing CWTs could be numerous, such as fish spawning in the mainstem or an incorrect date window at Bonneville Dam (currently June 15 - July 31). Regional experts should be further consulted for ideas on possible steps that could be taken to address this bias.

Appendix

Table 1. U_CR_Sum Tag Codes and Brood Years

Tag Code	BroodYear	Tag Code	BroodYear	Tag Code	BroodYear	Tag Code	BroodYear
631868	2002	633093	2005	634783	2008	635582	2010
631394	2002	633298	2005	634778	2008	055364	2010
631007	2002	633299	2005	635179	2008	051267	2010
631779	2002	633593	2005	635177	2008	635964	2010
631778	2002	633594	2005	635178	2008	635598	2010
631373	2002	633596	2005	634792	2008	635968	2010
631370	2002	633592	2005	635093	2008	635691	2010
631368	2002	633972	2006	635092	2008	635685	2010
631978	2002	633895	2006	634777	2008	635690	2010
631890	2002	633378	2006	635094	2008	635688	2010
631979	2002	633881	2006	634791	2008	635689	2010
631980	2002	633386	2006	635095	2008	635686	2010
632396	2003	633385	2006	634875	2008	635770	2010
632777	2003	633799	2006	634876	2008	635774	2010
632776	2003	634183	2006	635097	2008	635775	2010
631787	2003	634182	2006	635098	2008	635776	2010
631788	2003	634184	2006	190210	2009	190234	2011
632370	2003	634695	2007	190211	2009	190235	2011
632577	2003	634693	2007	190212	2009	190274	2011
632371	2003	634694	2007	190213	2009	190275	2011
632580	2003	632975	2007	053568	2009	190276	2011
632579	2003	634365	2007	635577	2009	190277	2011
632581	2003	634367	2007	635271	2009	190278	2011
619900	2004	633475	2007	635272	2009	635668	2011
632977	2004	634366	2007	635269	2009	636283	2011
632799	2004	632868	2007	053619	2009	055362	2011
632864	2004	632869	2007	635280	2009	636282	2011
632781	2004	632974	2007	635365	2009	055363	2011
633094	2004	634287	2007	635087	2009	636281	2011
632578	2004	633872	2007	635088	2009	636175	2011
632286	2004	634390	2007	635364	2009	636178	2011
632285	2004	633896	2007	635372	2009	636177	2011
633167	2004	634392	2007	635371	2009	636176	2011
633169	2004	633897	2007	635279	2009	636174	2011
633165	2004	633871	2007	635579	2009	635680	2011
633168	2004	634691	2007	635373	2009	636173	2011
633166	2004	190169	2008	635375	2009	636280	2011
633164	2004	190170	2008	635578	2009	636279	2011
633474	2005	613437	2008	190214	2010	635773	2011
633170	2005	635164	2008	053569	2010	636370	2011

Table 4. 2010-13 FRAM AEQ Mortality (marked + unmarked) of U_CR_SUM in Southern US Fisheries

Fishery	2010	2011	2012	2013	Total
Cen OR Trl	**4914**	**5205**	**4369**	**2796**	**17284**
Cen OR Trl Time2	**4730**	**5078**	**3942**	**2080**	**15831**
NT 2 Troll	2425	1222	849	1542	6039
Tr 3:4 Trl	871	1031	1717	1428	5047
NT 3:4 Trl	840	995	1952	855	4642
NT 1 Troll	1264	924	1404	225	3816
Ar 2 Sport	636	549	1004	266	2455
So Cal Trl	22	409	457	1001	1889
Ar 1 Sport	147	359	796	454	1757
Cen OR Spt	150	123	438	501	1213
Ar 3:4 Spt	57	100	187	173	517
So Cal Spt	40	130	115	105	390
Tr 2 Troll	111	92	83	20	307
KMZ Troll	16	67	58	160	300
Tr SPS Net	35	88	43	47	213
KMZ Sport	3	26	63	51	143
Ar 5 Sport	34	26	20	38	119
Ar 7 Sport	10	18	17	40	84
A 11 Sport	7	10	12	8	38
Tr JDF Trl	3	2	5	5	15

Table 6: GSI data on the Central Oregon troll fishery stock composition (May to June) from the CROOS research group.

GSI Data - From CROOS - Stocks making up less than 1% Avg catch omitted						
Stock	**2010**	**2011**	**2012**	**2013**	**2015**	**Average**
Central_Valley_fall	0.28	0.19	0.52	0.63	0.41	0.41
Mid_Columbia_tule	0.25	0.06	0.08	0.04	0.16	0.12
Mid_Oregon_Coast	0.10	0.26	0.04	0.08	0.09	0.12
U_Columbia_summer_fall	0.10	0.13	0.12	0.11	0.07	0.11
L_Columbia_fall	0.06	0.07	0.13	0.04	0.05	0.07
Klamath	0.04	0.07	0.02	0.02	0.08	0.05
Rogue	0.04	0.06	0.01	0.01	0.04	0.03
Snake_fall	0.02	0.02	0.01	0.01	0.01	0.02
L_Fraser	0.03	0.02	0.00	0.01	0.00	0.01
S_Puget_Sound	0.01	0.01	0.01	0.01	0.00	0.01
California_Coast	0.01	0.01	0.00	0.00	0.02	0.01
Deschutes_fall	0.01	0.01	0.00	0.00	0.01	0.01
N_Oregon_Coast	0.00	0.02	0.00	0.00	0.01	0.01
N_California_S_Oregon_Coast	0.01	0.01	0.00	0.00	0.01	0.01
Willamette	0.01	0.01	0.01	0.00	0.00	0.01
Sample Size	1493	1076	2437	410	312	

GSI data were provided by the CROOS research group (Oct 2018, personal communication Nancy Fitzpatrick). Data represent sampling from the Central Oregon troll fishery during the May to June time step only. Note that in table the "U_Col_Summer_Fall" category includes Upriver Fall Chinook (excluding Deschutes Falls) in addition to Columbia River Upriver Summer Chinook (Table 19). Also, note that the "Central_Valley_Fall" aggregate in GSI data includes both Sacramento Falls and San Joaquin Falls. However, in FRAM the "Central Valley Fall" stock only includes Sacramento Falls.

Bibliography

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