Agenda Item D.1.a
Supplemental NMFS Report 2
November 2023

NATIONAL MARINE FISHERIES SERVICE REPORT: PERIODIC REVIEW OF THE LOWER COLUMBIA RIVER TULE FALL CHINOOK ABUNDANCE-BASED HARVEST MATRIX

DRAFT
November 3, 2023

In November 2011, the Pacific Fishery Management Council (PFMC) passed a motion recommending that NOAA's National Marine Fisheries Service (NMFS) consider an abundance-based management (ABM) matrix as the harvest control rule (HCR) for lower Columbia River (LCR) tule fall Chinook salmon for management of salmon fisheries in 2012 and beyond (NMFS 2012). The HCR identifies exploitation rate (ER) limits based on four levels of abundance of LCR hatchery tule (LRH) Chinook salmon (Table 1). The LRH stock management unit is the indicator stock surrogate for the tule component of the LCR Chinook Salmon Evolutionarily Significant Unit (ESU) (PFMC 2023a). Although LRH is often considered a hatchery stock, the LRH run does include a small proportion of naturally-produced LCR tule (LCR natural tule) fall Chinook salmon (WDFW and ODFW 2023).

Table 1. Variable fishing exploitation rate limits based on the ABM matrix as proposed by the PFMC and adopted by NMFS (NMFS 2012).

Lower River Hatchery (LRH) Abundance Forecast	Total Exploitation Rate Limit
0 – 30,000	0.30
30,000 – 40,000	0.35
40,000 – 85,000	0.38
>85,000	0.41

In 2012, acting on the PFMC recommendation, NMFS issued a biological opinion on the management of the ocean fisheries subject to the Pacific Coast Salmon Fishery Management Plan for salmon fisheries off the coasts of Washington, Oregon and California. The opinion evaluated the impacts to the Endangered Species Act (ESA)-listed LCR Chinook Salmon Evolutionarily Significant ESU from the proposed action including the ABM matrix for the tule fall Chinook salmon component (Table 1). NMFS (2012) concluded that the HCR, combined with the management objectives for the spring and bright components of the LCR Chinook Salmon ESU, would not jeopardize the continued existence of the ESU (NMFS 2012).

As part of the HCR, NMFS agreed to review the ABM framework every three to five years. The purpose of the review would be to assess the assumptions and expectations described by Beamesderfer et al. (2011), and performance of the ABM framework (NMFS 2012). The risk metrics for the proposed abundance-based framework are equivalent to those of a fixed exploitation rate of 36 percent (NMFS 2012). As described in NMFS (2012), the review should include, but is not limited to, forecast methods, the relationship between Lower Columbia River hatchery and natural-origin fish, and population specific information used by Beamesderfer et al. (2011) such as population specific hatchery contribution.

This report comprises our draft review and recommendations, which we expect to finalize by March 2024. We invite comments on this draft. Comments, due by February 1, should be submitted to:

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In the sections below, we review the performance of the ABM and review information received in response to questions posed by NMFS since the last review.

Performance

The effectiveness of this HCR depends, in part, on whether abundance of LRH can be predicted with reasonable accuracy. When the ABM matrix was proposed, LCR tule fall Chinook salmon run sizes were predicted using sibling models based on reconstructed runs of the aggregate LRH (LCR natural tules are a small component of LRH). LCR natural tules could not be forecasted independently because of the lack of reliable age and escapement data for most wild populations. Correlations between the LRH return and the abundance of LCR natural tule between 1964 and 2010 suggested that the LRH forecast provided a suitable surrogate for LCR natural tules due to common effects of marine and freshwater conditions to which both hatchery and wild fish are subject (Beamesderfer et al. 2011).

Since implementation of the ABM matrix (2012 to 2023), the LRH forecast (pre-season run size forecast) has averaged 86,400 (range 51,000 to 133,700) and has been high enough to allow fisheries to operate at the highest two tiers (Table 2). During the same time period, the actual LRH return (post-season reconstructed run) has averaged 82,200 (range 48,900 to 128,700) and the ER achieved has averaged 36 percent (Table 3). While the average return has been slightly over-forecast, the ABM tier was correctly forecast in seven out of eleven years (Table 3). In 2012, 2016, and 2017 the forecast allowed for a higher ER limit (41 percent compared to 38 percent) than what would have been appropriate given the return. In 2022, the forecast set a lower ER limit (38 percent compared to 41 percent) than what would have been appropriate given the return. The post-season ERs were below the allowable limit for 9 out of 11 years but exceeded the allowable ER in 2012 and 2014.

Based on this information, NMFS concludes that (1) fisheries over the past review period have been managed consistent with the control rule long-term expectation of risk levels equal to a fixed ER of 36 percent (Table 3); (2) updates to forecast methodology have retained the ability to forecast abundances of the LRH correctly (Table 3); and (3) fisheries managed under the LCR tule fall Chinook salmon HCR continue to be consistent with the outcomes and expectations of NMFS (2012). NMFS may re-evaluate these conclusions after review and consideration of new information, as described below, and comments received on this report.

Table 2. Forecast and allowable exploitation rate (based on ABM framework) for LRH Chinook salmon for years 2012 to 2023 (PFMC 2023a).

Year	LRH Forecast	Allowable Exploitation Rate
2012	127,000	0.41
2013	88,000	0.41
2014	110,000	0.41
2015	94,900	0.41
2016	133,700	0.41
2017	92,400	0.41
2018	62,400	0.38
2019	54,500	0.38
2020	51,000	0.38
2021	73,100	0.38
2022	73,000	0.38
2023	77,100	0.38
Average	86,400	0.40

Table 3. Post-season returns and exploitation rates for LRH Chinook salmon for years 2012 to 2022 (PFMC 2023b).

Year	LRH Return	Percent of Forecast	Exploitation Rate achieved[1]
2012	85,000	66.9%	0.430
2013	104,800	119.1%	0.349
2014	101,900	92.6%	0.444
2015	128,700	135.6%	0.360
2016	81,900	61.3%	0.374
2017	64,600	69.9%	0.367
2018	53,000	84.9%	0.359
2019	48,900	89.7%	0.324
2020	77,900	152.7%	0.267
2021	74,700	102.2%	0.377
2022	87,500	119.9%	0.306
Average	82,600	99.5%	0.360

[1] Calculated total exploitation on LCR tule Chinook salmon in all fisheries in the ocean and in the Columbia River below Bonneville Dam. These are estimated using the Fisheries Regulation Assessment Model and the Columbia River Fall Chinook Fishery Model.

Additional Information Requested/Received

Changes in the escapement datasets and forecast methodology emerged since our last review of the HCR. In order for NMFS to evaluate the effect of these changes to the HCR, NMFS requested more information from Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW). The following subsections summarize the information and analyses provided by ODFW and WDFW. Additional documentation is compiled in a memorandum based on the communications received. (Siniscal 2023).

1) What was the effect of changes to the methodology for estimating escapement on escapement trends relative to the estimates used in the biological opinion?

In 2010, WDFW modified and expanded their escapement monitoring program to improve estimates of LCR Chinook salmon and to include Viable Salmonid Population parameters and other population demographic metrics (i.e., proportion of hatchery-origin spawners, age structure, percent females, spawn timing, and spatial distribution). The implementation of this intensive monitoring programs for fall Chinook salmon has resulted in robust abundance estimates for most populations of LCR fall Chinook salmon since 2010 (Wilson et al., 2020b; Dammerman et al., 2022).

In 2020, WDFW paired the robust abundance estimates with historical peak (pre-2010) counts to inform new peak count expansion factors. The revised expansion factors were then applied to peak counts across the historical time series to update the historical escapement estimates and compute associated estimates of uncertainty (Wilson et al., 2020b; Dammerman et al., 2022). The revised abundance estimates for the historical fall Chinook escapement follow the same trends as the historical estimates and are higher than the historical estimates for most populations despite not including jacks (the original estimates included jacks). The original historical estimates numbers are also within the confidence intervals of the new abundance estimates (Wilson et al., 2020a). Thus, we do not have reason to expect this would change the underlying relationship between LRH and LCR natural tules that is foundational to the HCR. Escapement data for LRH populations in the Coast and Cascade Major Population Groups (MPG) are provided in Table 4 and Table 5. Data for years prior to 2010 have been updated from Beamesderfer et al. (2011) to reflect the new abundance estimates. Methodology for the Oregon LRH populations has not changed from previous methods.

As monitoring and estimation methods continue to improve, historical abundance estimates could undergo further revision. We will continue to evaluate the effects of future changes to escapement methods in subsequent periodic performance reviews of the LCC tule ABM matrix.

Table 4. Escapement information (total spawners (#) and proportion wild) for Coast MPG populations of Lower Columbia River tule Chinook Salmon for years 1995 through 2021 (Source: https://www.streamnet.org/home/data-maps/fish-hlis/).

Year	**Grays / Chinook**		**Big Creek**		**Elochoman / Skamokawa**		**Clatskanie**		**Mill / Abernathy / Germany**	
	Spawners	Prop. Wild	Spawners	Prop. Wild	Spawners	Prop. Wild	Spawners	Prop. Wild	Spawners	Prop. Wild
1995	24	39.0			388	0.50	194	0.10	1,743	0.51
1996	307	17.0			944	0.66	1,069	0.10	652	0.54
1997	6	12.0			640	0.11	155	0.10	598	0.23
1998	852	24.0			455	0.25	214	0.10	456	0.60
1999	176	68.0			1,241	0.25	233	0.10	666	0.69
2000	401	70.0			221	0.62	607	0.10	1,050	0.58
2001	714	43.0			3,282	0.82	607	0.10	3,976	0.39
2002	281	47.0			9,640	0.00	894	0.10	3,301	0.05
2003	319	39.0			4,929	0.65	1,088	0.10	2,977	0.56
2004	626	25.0			8,737	0.01	401	0.10	2,512	0.02
2005	103	41.0			2,985	0.05	370	0.10	2,072	0.13
2006	319	100.0			391	1.00	212	0.10	575	0.62
2007	88	100.0			284	1.00	93	0.10	326	0.48
2008	95	34.7			1,730	0.10	94	0.10	745	0.49
2009	555	37.8	7,196	0.00	1,254	0.18	167	0.56	712	0.93
2010	170	48.8	14,768	0.06	1,260	0.11	103	0.12	2,410	0.06
2011	416	14.9	2,709	0.05	1,083	0.06	152	0.09	1,192	0.08
2012	160	21.9	1,096	0.05	206	0.30	80	0.10	147	0.14
2013	1,644	5.5	946	0.00	448	0.18	39	0.08	657	0.19
2014	969	19.1	2,583	0.02	680	0.22	76	0.09	554	0.06
2015	762	28.7	2,586	0.00	989	0.23	76	0.09	989	0.08
2016	356	22.5	582	0.08	368	0.25	76	0.07	397	0.22
2017	565	52.2	1,279	0.00	114	0.68	n/a	n/a	95	0.18
2018	734	70.2	12,301	0.01	77	0.35	76	0.01	14	0.43
2019	591	58.2	936	0.02	163	0.23	49	0.02	263	0.05
2020	581	34.9	1,256	0.02	178	0.33	n/a	n/a	85	0.28
2021	343	49.0	6,173	0.05	275	0.31	n/a	n/a	93	0.27
2012-2021 average	671	36.22	2,974	0.02	350	0.31	67	0.07	329	0.19
Long term average	450	41.61	4,185	0.03	1,591	0.35	297	0.11	1,084	0.33

Table 5. Escapement information (total spawners (#) and proportion wild) for Cascade MPG populations of Lower Columbia River tule Chinook Salmon for years 1995 through 2021 (Source: https://www.streamnet.org/home/data-maps/fish-hlis/).

Year	**Lower Cowlitz**[1]		**Coweeman**		**Toutle**		**Upper Cowlitz**		**Kalama**		**Lewis**[2]		**Clackamas**		**Washougal**		**Sandy**	
	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild	#	Prop. Wild
1995	2,231	0.13	1,501	1.00	405				2,734	0.69	200	1.00			2,464	0.39		
1996	1,602	0.58	2,454	1.00	1,376		437		8,353	0.44	1,256	1.00			2,992	0.17		
1997	2,710	0.72	524	1.00	560		27		2,525	0.40	1,737	1.00			3,505	0.12		
1998	2,108	0.37	340	1.00	1,353		257		3,062	0.69	1,329	1.00			3,043	0.24		
1999	997	0.16	227	1.00	720		1		3,006	0.03	1,249	1.00			3,205	0.68		
2000	2,363	0.10	184	1.00	879		1		1,529	0.21	1,689	1.00			2,207	0.70		
2001	4,652	0.44	698	0.73	4,971		3,646		2,861	0.18	4,132	0.70			3,483	0.43		
2002	13,514	0.76	756	0.97	7,896		6,113		18,950	0.01	5,224	0.77			6,139	0.47		
2003	10,048	0.88	1,052	0.89	13,943		4,165		37,885	0.00	6,518	0.98			3,527	0.39		
2004	4,466	0.70	1,513	0.91	4,711		2,145		7,250	0.11	2,171	0.29			10,795	0.25		
2005	2,870	0.17	661	0.60	3,303		2,901		8,633	0.03	2,536	1.00			2,735	0.41		
2006	2,944	0.47	632	1.00	5,752		1,782		9,481	0.01	1,332	0.82			2,765	0.14		
2007	1,847	0.53	455	1.00	1,149		1,325		3,101	0.06	1,012	0.73			1,657	0.87		
2008	1,828	0.90	369	0.52	1,725		1,845		3,466	0.04	1,256	0.87			1,870	0.93	2,549	0.80
2009	2,602	0.45	666	0.63	539		7,491		6,907	0.10	2,437	1.00	489	0.49	3,139	0.30	2,057	0.97
2010	3,734	0.68	584	0.71	1,917	0.21	9,808	0.21	5,315	0.11	2,490	0.64	n/a	n/a	5,530	0.11	2,304	1.00
2011	3,685	0.74	707	0.88	1,498	0.33	12,914	0.33	7,591	0.06	2,364	0.71	118	0.29	3,224	0.15	6,731	0.93
2012	2,725	0.57	526	0.88	907	0.35	5,564	0.35	7,477	0.04	1,950	0.68	321	0.19	965	0.27	314	0.70
2013	4,320	0.80	2,322	0.68	1,754	0.50	6,488	0.50	8,487	0.10	5,872	0.71	422	0.92	3,612	0.33	9,615	0.97
2014	4,347	0.67	830	0.96	783	0.36	6,231	0.36	9,451	0.08	5,553	0.55	183	0.69	1,529	0.65	2,725	0.91
2015	5,981	0.70	1,391	0.98	598	0.60	5,647	0.60	6,423	0.45	7,489	0.45	308	0.62	2,925	0.46	n/a	n/a
2016	3,885	0.74	439	0.94	803	0.77	3,959	0.77	4,226	0.60	4,769	0.46	910	0.78	2,198	0.40	4,773	0.99
2017	3,630	0.81	841	0.86	594	0.98	1,520	0.98	3,041	0.57	3,762	0.53	90	0.38	1,112	0.59	6,229	1.00
2018	3,553	0.84	244	0.89	244	0.92	674	0.92	2,548	0.64	2,087	0.63	709	0.95	1,019	0.89	12,622	0.99
2019	5,072	0.89	366	0.78	466	1.00	544	1.00	2,763	0.53	2,033	0.74	928	0.95	1,817	0.87	8,014	0.99
2020	4,863	0.92	807	0.92	708	0.88	2,265	0.88	4,700	0.68	4,442	0.68	111	1.00	5,042	0.75	20,824	1.00
2021	4,756	0.85	669	0.91	819	0.79	863	0.79	4,195	0.47	3,827	0.52	40	0.90	1,956	0.74	8,927	0.95
2012-2021 average	4,313	0.78	844	0.88	768	0.72	3,376	0.72	5,331	0.42	4,178	0.59	402	0.74	2,218	0.59	8,227	0.94
Long term average	3,975	0.61	806	0.87	2,236	0.64	3,408	0.64	6,887	0.27	2,989	0.76	386	0.68	3,128	0.47	6,745	0.94

[1] *Tule Chinook salmon in the Cowlitz River were previously a conglomerate estimate.*

[2] *Tule Chinook salmon estimates from both East and North Fork Lewis Rivers.*

(2) How have the forecasting methodologies evolved since Beamesderfer et al. (2011)?

As mentioned above, the performance of the HCR depends on whether LRH stock abundance can be predicted with reasonable accuracy and precision. Beamesderfer et al. (2011) described and evaluated the precision and potential use of both LRH and LCR natural tules for forecasting methods and determined that the sibling models in use at the time were the best scientific information available. The forecast methodology for LRH abundance has evolved from the methods described by Beamesderfer et al. (2011). The current forecasting methodology is described briefly here[1]. Forecasts for LRH are computed, using an ensemble model, which fits eight different models (Table 6) to observed returns in the historical time series, makes predictions for the upcoming year, and averages the predictions based on a weighting criterion described by Dormann et al. (2018).

Table 6. A suite of 8 models run for each brood. The 8 models are variants of sibling regressions, cohort ratios, and average returns. A weighted average of the predictions of each of the 8 models is used as the forecast for an upcoming year.

Description
Sibling regression with constant slope and intercept.
Sibling regression with time-varying intercept.
Sibling regression with time-varying slope.
Sibling regression with time-varying slope and intercept.
Time varying "cohort ratio" model. Time varying slope, Intercept=0.
Constant "cohort ratio" model. Constant slope, Intercept=0
Time-varying Intercept-only model. Random walk on return, no sibling predictor.
Constant Intercept-only model. Long-term average, no sibling predictor.

(3) Are the available data sufficient to forecast natural LCR tule abundance?

The available time series of LCR natural tules since implementing the HCR is now over 10 years long. In prior reviews of the HCR, NMFS had determined that data were insufficient for forecasting abundance of LCR natural tules (NMFS 2015; 2019). As mentioned above, methodologies to forecast LRH abundance have continued to evolve since 2012. NMFS (2012) recommended continuing to examine forecast methods, the relationship between LRH and natural-origin fish, and population specific information used in the risk analysis. Consistent with this expectation, NMFS recommends an evaluation of whether:

- sufficient data exist to forecast LCR natural tules and, if so, an assessment of the accuracy of such forecasts and the feasibility of producing them in a time and manner that would be informative for managing fisheries.

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[1] WDFW and ODFW are the agencies responsible for producing the forecasts and the following description is based on information provided by these agencies.

- the available information indicates that the LRH abundance remains a suitable surrogate for natural LCR abundance going forward.

NMFS requests a discussion of the feasibility and the timeline for this work with the state and tribal comanagers prior to finalizing this report in March 2024.

(4) Does the reduction in Mitchell Act production affect the HCR matrix?

The abundance of LRH is used as a surrogate for the abundance of LCR natural tule in the HCR (Beamesderfer et al. 2011; NMFS 2012). Beamesderfer et. al. (2011) estimated that annual hatchery releases from lower Columbia River programs averaged approximately 22 million LRH juveniles per year from 1998 through 2008. This production level reflects program changes that were implemented in the mid-90's to reduce production costs and eliminate programs with lower success rates. The level of releases (22 million) was used to set the breakpoints for the ABM matrix, but did not reflect any future changes to hatchery production. As described by Beamesderfer et. al. (2011), tier frequencies in the future will depend on average size and variability in the LRH run size which in turn is affected by hatchery production, ocean survival patterns, and ocean exploitation rates. If parameters changed significantly in the future, then the tier break points could change as well (Beamesderfer et. al. 2011).

In 2017, NMFS reviewed the effects of the Mitchell Act funded hatcheries on ESA-listed species and completed a biological opinion (NMFS 2017). The majority of the hatcheries that produce tule Chinook salmon in the LCR are funded by the Mitchell Act. The opinion reduced the maximum amount of LRH juveniles that could be released from Mitchell Act hatchery programs substantially (NMFS 2017). The overall production goal as of release year 2022 (brood year 2021) inclusive of the Mitchell Act programs and including the Cowlitz Hatchery, which is not funded by Mitchell Act, will be approximately 17.3 million LRH juveniles. This represents a substantial reduction in hatchery production from the 22 million used to set the breakpoints in the ABM matrix. Since the majority of the LCR tule Chinook abundance is comprised of returns from these hatchery programs, we anticipate that the abundance of adult LRH will be lower when fish from those programs return. The reductions were realized with the juveniles released in 2022 (i.e., brood year 2021 for tule fall Chinook) (NMFS 2017). Tule fall Chinook adults mature starting at age three, therefore the reductions in hatchery production will result in fewer hatchery adult returns starting in 2024.

In the 2019 review of the tule harvest matrix, NMFS recommended that once the production changes were final and the adults from the reduced production had recruited to fisheries, the abundance tiers should be adjusted to reflect the reduced production (NMFS 2019). While actual releases of hatchery fish fluctuate from year to year and are typically less than program goals, using the production goal of approximately 17.3 million as the basis for the adjustment to the breakpoints acknowledges the production levels evaluated in the Mitchell Act opinion and the potential that those goals could be attained, while adjusting the breakpoints in the matrix to account for reduced production. As part of the adaptive management strategy developed through the ABM matrix and based on the 2019 review, NMFS recommends an adjustment to the abundance tiers to reflect the reductions in hatchery production and the resulting abundance of adult LRH. The program production goal of 17.3 million represents a reduction of approximately 21.4 percent from the 22 million reference level. After applying this reduction to the ABM matrix, the corresponding abundance breakpoints are shown in Table 7.

Table 7. Variable fishing exploitation rate limits based on reduced hatchery releases of LRH Chinook salmon implemented by the Mitchell Act opinion (numbers are rounded to the nearest 1,000) (NMFS 2017).

LRH Abundance Forecast	Total Exploitation Rate Limit
0 – 24,000	0.30
24,000 – 31,000	0.35
31,000 – 67,000	0.38
>67,000	0.41

NMFS is aware that LRH release goals may change again in the future and may revise the ABM matrix as needed once changes have been realized and the adult fish have recruited to the fishery.

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