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MEMORANDUM

TO: Distribution

DATE: January 23, 2024

SUBJECT: Kenai River early-run Chinook salmon 2024 outlook

FROM: Tony Eskelin, Research Biologist
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The 2024 forecast for large (≥75 cm mideye-to-tail-fork-length [METF] or approximately ≥34 inches in total length) early-run Chinook salmon in the Kenai River is 2,630 fish with an 80% prediction interval (PI) of 1,333–5,188 fish (Table 1). This forecast is less than the optimum escapement goal range of 3,900 to 6,600 large fish, 73% less than the long-term (1986–2023) average estimated total run of approximately 9,600 large fish, and 11% less than the recent 5-year (2019–2023) average estimated total run of approximately 3,000 large fish (Table 2). If realized, the 2024 run would rank 6th lowest in the past 38 years and 4th lowest in the past 10 years (Table 2).

This forecast is the sum of individual age-specific (total age 5, 6, and 7) forecasts of abundance calculated from three models based on recent age-specific run sizes (5-year geometric mean, ARIMA time series, exponential smoothing) and one model that also incorporated sibling ratios (Sibling; Table 3). The variability among forecasted and estimated total runs for each model was assessed using the mean deviation (MD), mean absolute deviation (MAD), and mean absolute percent error (MAPE) (Tables 1 and 3). Hindcasts by age were produced for each return year as one-step-ahead predictions (forecasts) using the estimates from prior years. The 5-year MAD for each age in the 2019–2023 hindcasts, as compared to the estimated run size by age in those years, was the primary diagnostic used for model selection, but 5-year MDs and MAPEs were also considered with MADs in aggregate (Table 1).

The age-5 forecast of 1,342 fish is based on the ARIMA time series model. The 5-year geometric mean model had the lowest 5-year MAD for age-5 fish, but the ARIMA time series model had the lowest 5-year MD. The ARIMA time series model was chosen as the forecast model because the 5-year geometric mean model had the highest 5-year MAPE and the highest MD by far because it consistently overforecast age-5 fish. All three age-5 models predicted similar abundance, so model selection was relatively inconsequential for age-5 fish. The age-6 forecast of 1,275 fish is based on the 5-year geometric mean model, which had the lowest 5-year MAD. It is worth noting that two other models performed similar to the 5-year geometric mean model. The exponential smoothing

and ARIMA time series models had slightly higher MADs, lower MDs, and similar MAPEs, yet predicted considerably fewer age-6 fish. The estimated age-6 fish run in 2023 was the historical low (585 fish) and runs of age-6 fish prior to 2023 were considerably larger. The age-6 fish forecast is for a run closer to the recent 5-year average than the historical low observed in 2023. The age-7 forecast of 13 fish is based on the 5-year geometric mean model, which had the lowest 5-year MAD. None of the models predicted many age-7 fish, and no age-7 fish have been sampled since 2021.

The 2024 forecast is for a total large fish run of 1,342 age-5 fish, 1,275 age-6 fish, and 13 age-7 fish (Table 1). Age-4 fish were not considered for this forecast and the return of large age-4 fish is likely to be zero or extremely small. It is important to note that the total run forecast from selecting any of the highest performing models for any age is still considerably less than the optimum escapement goal range.

The 2023 forecast was for a total run of 2,914 large fish. The preliminary estimated total run was 1,975 large fish, 939 fish (48%) fewer than forecasted (Table 4). Most of the difference between the forecast and estimated total run was due to overforecasting age-6 fish.

There is considerable uncertainty in the 2024 forecast. Since 2017, the models used to forecast the early run have tended to overforecast. Total run size was overforecasted the past 4 years, and 5 of the past 7 years. The 2024 forecast gives the expectation of a total run that is well below average; because of the tendency to overforecast, this should be considered the most optimistic scenario.

Table 1.–2024 large (>75 cm METF) Kenai River early-run Chinook salmon forecast, and the relative fit of each model to the previous 5 years of estimated runs by age. Boxes indicate the chosen model and forecast for each age. See Table 3 for model descriptions.

	Forecast	5-year		
Model	**2024**	**MD[a]**	**MAD[b]**	**MAPE[c]**
Age-5				
ARIMA time series	1,342	261	818	75%
Exponential smoothing	1,352	285	820	75%
5-year geometric mean	1,396	766	766	84%
Forecast estimate	**1,342**			
Age-6				
5-year geometric mean	1,275	262	323	39%
Exponential smoothing	727	142	375	40%
ARIMA time series	608	92	387	38%
Sibling	1,793	-48	639	53%
Forecast estimate	**1,275**			
Age-7				
5-year geometric mean	13	-17	69	>1,000%
Exponential smoothing	2	-18	82	>1,000%
ARIMA time series	1	-11	85	>1,000%
Sibling	11	-32	75	>1,000%
Forecast estimate	**13**			
TOTAL RUN FORECAST	**2,630**	80% PI 1,333–5,188		

[a] mean deviation, [b] mean absolute deviation, [c] mean average percent error

Table 2.–Estimated number of large (>75 cm METF) early-run Kenai River Chinook salmon by age class and return year, 1986–2023.

	TOTAL AGE IN YEARS				
Year	5	6	7	Total run	Escapement
1986	7,598	6,823	1,574	16,013	8,320
1987	7,771	12,457	576	20,808	7,109
1988	2,586	15,740	2,352	20,673	5,773
1989	1,513	9,647	1,282	12,430	4,184
1990	3,248	9,124	970	13,401	11,344
1991	4,648	9,968	819	15,495	13,475
1992	3,484	9,839	879	14,266	11,881
1993	4,401	12,382	690	17,577	8,442
1994	2,009	10,272	704	12,970	4,792
1995	2,319	9,943	706	12,947	3,228
1996	2,033	6,038	217	8,279	1,853
1997	3,337	6,699	128	10,171	3,433
1998	2,833	3,677	277	6,827	5,269
1999	6,769	5,199	56	12,048	4,617
2000	5,361	6,457	72	11,974	9,917
2001	4,534	9,738	375	14,738	12,306
2002	3,719	4,494	390	8,649	7,776
2003	3,911	10,803	229	14,976	12,168
2004	7,251	12,817	1,140	21,328	18,323
2005	4,345	11,120	639	16,153	12,545
2006	2,505	6,702	519	9,785	5,780
2007	3,500	3,658	115	7,305	4,493
2008	3,125	3,463	158	6,799	3,539
2009	1,460	3,500	108	5,098	3,835
2010	2,591	1,607	62	4,278	3,082
2011	2,601	3,652	104	6,385	5,212
2012	1,168	1,984	58	3,232	2,948
2013	620	872	48	1,556	1,541
2014	1,810	679	47	2,552	2,541
2015	2,450	1,601	126	4,197	4,172
2016	4,017	2,275	82	6,399	6,328
2017	4,542	2,724	37	7,333	6,678
2018	1,975	1,066	26	3,088	2,934
2019	2,299	1,604	228	4,162	4,055
2020	796	1,656	20	2,495	2,443
2021	2,243	1,805	94	4,171	4,024
2022	896	1,155	0	2,051	2,047
2023	1,390	585	0	1,975	1,975
Historical average	3,254	5,890	419	9,594	6,168
Recent 5-year average	1,525	1,361	68	2,971	2,909

Note: Run size by age does not sum to total run for 1986–2021 because the numbers given by age and total run are the medians of the posterior distribution of the state-space model. 2022 and 2023 are point estimates and are not based on the state-space model.

Table 3.–Description of models used for the 2024 large (>75 cm METF) Kenai River early-run Chinook salmon forecast.

Model	Description
5-year geometric mean	Geometric mean of the 2019–2023 returns for the specified age class.
Sibling	A regression between the natural logs of abundance in an age class and the most recent return of siblings from the same brood year.
ARIMA time series	Autoregressive integrated moving average (ARIMA) analysis on the natural log of abundance for the specified age class.
Exponential smoothing	Weighted moving average on the natural log of abundance for the specified age class.

Table 4.– Accuracy of large (>75 cm METF) early-run Kenai River Chinook salmon forecasts, 2017–2023.

Year	Forecasted total run	Estimated total run	Forecast error	Relative error
2017	6,526	7,401	-875	12%
2018	5,499	3,067	2,432	-79%
2019	3,168	4,131	-963	23%
2020	4,794	2,472	2,322	-94%
2021	4,391	4,142	249	-6%
2022	4,272	2,052	2,220	-108%
2023	2,914	1,975	939	-48%
Average	4,509	3,606	1,429[a]	53%[a]

[a] Average forecast error and average relative error use absolute values in calculations.

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