



THE STATE  
of **ALASKA**  
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### MEMORANDUM

TO: Distribution

DATE: January 23, 2024

SUBJECT: Kenai River late-run  
Chinook salmon  
2024 outlook

FROM: Tony Eskelin, Research Biologist  
Northern Kenai Peninsula  
Division of Sport Fish, Region II

The 2024 forecast for large ( $\geq 75$  cm mideye-to-tail-fork-length [METF] or approximately  $\geq 34$  inches in total length) late-run Chinook salmon in the Kenai River is 13,639 fish with an 80% prediction interval (PI) of 8,366–22,233 fish (Table 1). This forecast is less than the optimum escapement goal range of 15,000 to 30,000 large fish, 67% less than the long-term (1986–2023) average estimated total run of approximately 41,700 large fish, and near the recent 5-year (2019–2023) estimated average total run of approximately 13,400 large fish (Table 2). If realized, the 2024 run would rank 5<sup>th</sup> lowest in the past 38 years and 4<sup>th</sup> 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 for model selection but 5-year MDs and MAPEs were also considered with MADs in aggregate (Table 1).

The age-5 forecast of 5,214 fish is based on the ARIMA time series model, which had the lowest 5-year MAD. This forecast is the same value as the estimated age-5 return in 2023. The age-6 forecast of 8,382 fish is based on the sibling model, which had the lowest 5-year MAD. This forecast is 10% less than the estimated age-6 return in 2023. The age-7 forecast of 43 fish is based on the 5-year geometric mean model. This model was chosen over the exponential smoothing model which had the lowest 5-year MAD. Age-7 fish have not been detected since 2021; however, it is likely that a small number of age-7 fish have returned but have not been sampled due to the

difficulty in detecting a small population in the sampling program. The 5-year geometric mean model generated what was considered a more realistic prediction.

The 2024 forecast is for a run of 5,214 age-5 fish, 8,382 age-6 fish, and 43 age-7 fish (Table 1). Age-4 fish were not considered for this forecast. The return of large age-4 fish is likely to be zero or extremely small. It is important to note that a total run forecast from selecting any of the highest performing models for any age would be less than the optimum escapement goal range.

The 2023 forecast was for a total run of 13,630 large fish, while the estimated total run was 14,537 large fish, which was 907 fish (6%) more than forecasted. It is worth noting that in 2023 the Kenai River Chinook sonar was operated one week past the normal end date of August 20, which accounted for approximately 5% of the run and most of the difference between the 2023 forecast and estimated total run.

There is considerable uncertainty in this forecast. Since 2017, the models have tended to overforecast the run, although the 2023 run was slightly underforecasted (Table 4). The 2024 forecast gives the expectation of a total run that is well below average.

Table 1.—2024 large (>75 cm METF) Kenai River late-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.

Model	Forecast 2024	5-year		
		MD <sup>a</sup>	MAD <sup>b</sup>	MAPE <sup>c</sup>
<b>Age-5</b>				
ARIMA time series	5,214	477	2,241	51%
Exponential smoothing	5,314	840	2,439	60%
5-year geometric mean	4,641	1,962	2,589	72%
<b>Forecast estimate</b>	<b>5,214</b>			
<b>Age-6</b>				
Sibling	8,382	-263	1,723	22%
Exponential smoothing	8,988	402	1,942	25%
ARIMA time series	9,322	250	1,955	25%
5-year geometric mean	8,111	2,277	2,679	35%
<b>Forecast estimate</b>	<b>8,382</b>			
<b>Age-7</b>				
5-year geometric mean	43	192	213	>1,000%
Exponential smoothing	1	59	206	>1,000%
ARIMA time series	1	29	296	>1,000%
Sibling	179	-140	323	>1,000%
<b>Forecast estimate</b>	<b>43</b>			
<b>TOTAL RUN FORECAST</b>	<b>13,639</b>	80% PI 8,366–22,233		

<sup>a</sup> mean deviation, <sup>b</sup> mean absolute deviation, <sup>c</sup> mean average percent error

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

Year	TOTAL AGE IN YEARS			Total run	Escapement
	5	6	7		
1986	34,466	31,223	3,509	69,188	49,197
1987	20,592	54,141	1,097	75,846	48,096
1988	2,562	55,787	12,268	70,691	42,003
1989	4,716	31,749	6,107	42,598	26,852
1990	3,317	27,309	1,821	32,514	24,496
1991	10,505	26,351	2,432	39,342	29,076
1992	7,883	42,345	1,367	51,689	37,788
1993	7,970	52,445	4,096	64,711	38,346
1994	6,355	49,284	3,075	58,798	31,400
1995	10,879	35,163	3,585	49,767	31,022
1996	15,406	28,968	503	44,874	30,453
1997	8,582	34,630	934	44,260	24,734
1998	6,907	34,244	1,644	42,828	33,381
1999	9,641	33,714	2,565	46,006	28,769
2000	12,269	29,152	1,270	42,826	26,331
2001	9,281	34,241	1,465	45,147	27,895
2002	11,468	44,847	2,542	58,965	42,940
2003	17,253	54,445	598	72,422	51,862
2004	23,730	71,804	1,643	97,329	70,617
2005	14,154	67,470	4,058	85,879	55,764
2006	9,983	43,687	6,140	59,872	40,911
2007	13,685	27,832	5,372	46,981	31,276
2008	9,305	31,914	3,937	45,202	30,001
2009	5,012	23,848	1,885	30,785	20,807
2010	9,006	11,689	1,743	22,502	13,425
2011	6,944	18,544	883	26,411	16,541
2012	9,914	12,985	1,099	24,038	23,427
2013	3,556	10,097	846	14,542	12,719
2014	4,799	7,574	390	12,776	11,584
2015	5,789	15,924	1,381	23,139	16,857
2016	11,202	12,562	1,241	25,023	15,652
2017	14,483	14,961	1,271	30,734	20,583
2018	7,597	10,572	146	18,364	17,405
2019	5,435	7,174	711	13,360	11,709
2020	2,716	9,066	401	12,226	11,854
2021	3,930	8,333	504	12,794	12,238
2022	7,126	6,952	0	14,078	13,911
2023	5,214	9,322	0	14,537	14,502
Historical average	9,832	29,535	2,348	41,659	28,590
Recent 5-year average	4,884	8,169	538	13,399	12,843

*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 late-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) late-run Kenai River Chinook salmon forecasts, 2017–2023.

Year	Forecasted total run	Estimated total run	Forecast error	Relative error
2017	33,613	30,734	2,879	-9%
2018	21,508	18,364	3,144	-17%
2019	21,746	13,360	8,386	-63%
2020	22,707	12,226	10,481	-86%
2021	18,406	12,794	5,612	-44%
2022	16,004	14,078	1,926	-14%
2023	13,630	14,537	-907	6%
Average	21,088	16,585	3,939 <sup>a</sup>	34% <sup>a</sup>

<sup>a</sup> Average forecast error and average relative error use absolute values in calculations.

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