



MEMORANDUM

TO: Distribution	DATE: December 5, 2023
FROM: Nick DeCovich, Research Biologist Northern Cook Inlet Area Division of Sport Fish, Region II	SUBJECT: Forecast for the 2024 Deshka River king salmon run, and accuracy of the 2023 forecast

The point estimate of the preseason forecast for the 2024 Deshka River king salmon total run is 6,671 fish (ages 1.1–1.4). The 80% prediction interval, based upon the variability between forecast and actual total run, is 1,984 to 11,358 fish (Table 1). The escapement, without harvest, is forecast to fall below the biological escapement goal of 9,000–18,000 fish. The preseason forecast estimate of age-1.1–1.4 fish is 53% less than the recent ten-year (2014–2023) average run of 14,081 fish and 78% less than the long-term (1979–2023) average of 29,832 fish.

The forecast for 2024 is the sum of individual age class forecasts. We examined estimates for three classes of models: sibling relationships, Ricker spawner-recruit relationships, and moving averages (Table 2). The models chosen were those with statistically significant parameters that have the greatest past reliability (accuracy and precision). The variability among forecasted and actual total runs for each model was assessed by using the mean absolute deviation (MAD) (Table 1) because it is less biased than mean absolute percentage error (MAPE) when some age classes have small returns. The choice of model used for each age class had minimum values of the 5-year MAD in 2019–2023 hindcasts of forecasts, as compared to the actual runs in those years (Table 1). The hindcasts were produced for each return year as one step ahead predictions using the estimates from all prior years.

The 5-year moving average was used for age-1.1 fish, as it is the only applicable model as this age class has no prior years' returns to inform other types of models. The 5-year moving average model was selected for age-1.2 fish. The sibling model (relationship between age-1.2 and age-1.3 fish) was chosen for age-1.3 fish, and the exponential smoothing model was chosen for age-1.4 fish (Table 1). For a description of each model considered, see Table 2.

The preliminary 2023 escapement estimate, which is simply the weir count as no inriver harvest was allowed, was 3,741, which is below the lower end of the escapement goal (9,000–18,000) and is also the lowest escapement on record. The second lowest escapement was 5,440, observed in 2022 (Table 3). The forecast estimate of total run for 2023 for all age classes was 7,243, and the estimated total run (escapement plus marine harvest) was 3,741, a difference of -48% (Table 4).

Worth noting is the absence of age-1.4 (6 year old) fish in the 2023 escapement. Past escapements were comprised by as much as 46% of this age class, although it has averaged 5% over the last 10 years. As such a small percentage of the recent age structure of this run, it is not surprising that sampling efforts in 2023 did not encounter a single age-1.4 fish.

The 2017 brood year return was completed with the 2023 run of age-1.4 fish. The 2017 brood year produced a total return of 8,256 king salmon (return per spawner = 0.75). This was less productive than the 2016 brood year, which had a return-per-spawner of 0.99.

There is considerable uncertainty in the total 2024 Deshka River king salmon forecast estimate. The models used for Deshka River king salmon tend to over-forecast the total run (Table 4). Total run was over-forecasted in 7 of the last 10 years. The forecast was within 5% of the estimated run only once in the last 10 years. The Deshka River king salmon forecast has differed by -53% to +45% from the estimated run in the past 10 years (Table 4).

The best way to consider this salmon forecast is in terms of 3 broad categories: approximately average run (within 25% of the historical average), below average run, or above average run. The 2024 forecast gives the expectation of a run in the below average run category (see footnote Table 4).

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Table 1. – Forecast king salmon total run with 80% prediction interval (PI) for the Deshka River in 2024 using various models, and the relative performance of each model to the previous 5 years of runs as measured by mean absolute deviation (MAD).

Model	Forecast 2024	Model chosen	5-year MAD
Age-1.1			
5-year moving average	1,637	*	N/A
Age-1.2			
5-year moving average	2,233	*	1,915
Exponential smoothing	2,031		3,692
Univariate time series	2,985		3,038
Sibling	^a		
Ricker	4,303		2,822
Age-1.3			
5-year moving average	3,335		4,010
Exponential smoothing	2,375		4,798
Univariate time series	2,824		6,882
Sibling	2,798	*	2,144
Ricker	2,794		6,216
Age-1.4			
5-year moving average	75		343
Exponential smoothing	3	*	94
Univariate time series	5		100
Sibling	2		107
Ricker	^b		
Total forecast	6,671 (1,984 - 11,358 80% PI)		

^aThe sibling relationship between age 1.1 and 1.2 fish was insignificant ($p > 0.05$).

^bThe Ricker model was insignificant ($p > 0.05$) age 1.4 fish.

Table 2. – Brief description of statistical models used to forecast the 2024 Deshka River king salmon run.

<u>Model</u>	<u>Description</u>
5-year moving average	A moving average on the natural log of abundance in each age class.
Exponential smoothing	A weighted moving average on the natural log of abundance in each class.
Univariate time series	AutoRegressive Integrated Moving Average analysis on the natural log of abundance in each age class.
Sibling model	Regression between the natural logs of annual abundance in an age class and the most recent return of siblings from the same brood year.
Ricker Model	Ricker-style regression on the natural log of abundance for each age class.

Table 3. – Estimates of Deshka River king salmon by age class for years 1979–2023.

Run year	Number per age class					Total run	Total run	Escapement
	1.1	1.2	1.3	1.4	1.5	age-1.2 - 1.4	all ages	all ages
1979	0	4,455	38,185	21,002	0	63,642	63,642	60,607
1980	0	3,915	19,967	15,269	0	39,151	39,151	35,096
1981	0	2,626	14,969	8,666	0	26,261	26,261	23,162
1982	0	5,472	18,940	18,098	0	42,510	42,510	37,222
1983	0	10,341	22,620	16,258	0	49,219	49,219	43,871
1984	0	7,681	21,235	16,265	0	45,180	45,180	39,054
1985	0	7,219	20,962	20,337	12	48,518	48,530	41,640
1986	17	18,532	22,480	15,206	46	56,218	56,281	47,657
1987	8	6,877	23,659	12,448	10	42,984	43,002	35,226
1988	494	6,175	12,809	30,545	1,002	49,529	51,025	43,795
1989	510	8,287	8,559	15,311	419	32,157	33,086	23,246
1990	451	8,320	21,394	19,134	155	48,848	49,454	41,671
1991	0	4,753	10,866	15,713	1	31,332	31,333	21,020
1992	3,036	5,733	8,811	10,437	10	24,980	28,026	20,248
1993	3	4,688	10,309	7,294	8	22,292	22,302	16,207
1994	5	1,753	4,620	4,338	102	10,711	10,817	9,832
1995	109	4,070	3,106	3,295	168	10,472	10,749	10,048
1996	11	7,098	5,562	2,007	0	14,667	14,678	14,349
1997	77	6,094	23,652	6,080	0	35,825	35,902	35,587
1998	0	10,682	15,639	10,351	116	36,672	36,788	36,310
1999	0	10,358	14,707	8,560	69	33,625	33,695	29,649
2000	2	4,514	32,807	4,261	0	41,581	41,583	33,965
2001	479	8,038	15,505	9,413	2	32,955	33,436	27,966
2002	534	8,853	18,865	5,272	0	32,991	33,525	28,535
2003	474	16,694	22,575	6,545	0	45,813	46,288	39,257
2004	662	11,916	43,691	9,930	0	65,536	66,198	56,659
2005	541	12,932	25,598	5,247	0	43,778	44,318	36,433
2006	0	8,729	21,153	8,493	0	38,375	38,375	29,922
2007	0	2,166	17,021	4,745	0	23,932	23,932	17,594
2008	0	1,565	3,796	4,635	0	9,996	9,996	7,284
2009	0	8,468	3,052	1,149	0	12,668	12,668	11,641
2010	196	4,573	15,288	1,895	0	21,756	21,952	18,223
2011	508	5,900	14,147	1,523	0	21,569	22,077	18,553
2012	659	8,674	4,117	2,416	0	15,207	15,866	13,952
2013	776	4,229	11,549	3,244	0	19,023	19,799	18,378
2014	1,536	6,996	7,035	2,157	0	16,188	17,724	16,099
2015	2,855	7,089	12,673	3,304	0	23,065	25,920	23,627
2016	4,029	10,858	8,701	1,750	0	21,310	25,339	22,099
2017	1,111	1,564	8,959	1,229	0	11,752	12,863	11,034
2018	3,401	2,180	3,052	87	0	5,319	8,720	8,549
2019	961	1,378	7,266	251	0	8,894	9,855	9,705
2020	2,209	7,253	1,510	295	0	9,057	11,266	10,638
2021	2,912	3,049	13,387	176	0	16,612	19,524	18,652
2022	1,279	1,245	2,999	188	0	4,432	5,711	5,440
2023	1,487	1,464	936	0	0	2,399	3,886	3,741

Table 4. – Accuracy of the Deshka River king salmon forecast for the three major age classes, 1999–2023. Note that this table excludes age-1.1 fish because forecasts for this age class have not been consistently produced.

Return year	Forecast run	Forecast category ^a	Forecast difference by major age class (forecast-estimated)						Relative difference
			Estimated run	Estimated run category ^a	Age-1.2	Age-1.3	Age-1.4	Overall effect	
1999	26,810	average	33,625	above	-4,421	-463	-1,931	underforecast	25%
2000	33,337	above	41,581	above	3,648	-17,550	5,657	underforecast	25%
2001	40,753	above	32,955	above	514	-5,693	12,976	overforecast	-19%
2002	43,805	above	32,991	above	983	5,625	4,207	overforecast	-25%
2003	41,041	above	45,813	above	-8,386	-782	4,395	underforecast	12%
2004	60,833	above	65,536	above	-2,383	-369	-1,952	underforecast	8%
2005	48,687	above	43,778	above	-4,587	3,133	6,364	overforecast	-10%
2006	49,071	above	38,375	above	-611	12,098	-791	overforecast	-22%
2007	37,007	above	23,932	average	6,601	4,188	2,286	overforecast	-35%
2008	20,268	average	9,996	below	6,375	1,931	1,967	overforecast	-51%
2009	20,593	average	12,668	below	1,059	4,161	2,704	overforecast	-38%
2010	30,775	average	21,756	average	4,959	3,059	1,001	overforecast	-29%
2011	21,080	average	21,569	average	401	-3,992	3,101	underforecast	2%
2012	21,665	average	15,207	below	-4,046	9,484	1,020	overforecast	-30%
2013	26,791	average	19,023	average	3,183	6,659	-2,073	overforecast	-29%
2014	19,063	average	16,188	below	-499	1,527	1,846	overforecast	-15%
2015	20,418	average	23,065	average	-862	-2,012	226	underforecast	13%
2016	24,638	average	21,310	average	-4,032	4,132	3,229	overforecast	-14%
2017	17,813	average	11,752	below	5,248	-560	1,373	overforecast	-34%
2018	10,595	below	5,319	below	4,725	-1,788	2,339	overforecast	-50%
2019	8,466	below	8,894	below	2,516	-3,742	797	underforecast	5%
2020	10,570	below	9,057	below	-4,170	5,796	-114	overforecast	-14%
2021	11,464	below	16,612	below	3,283	-8,535	104	underforecast	45%
2022	9,332	below	4,432	below	1,269	3,622	9	overforecast	-53%
2023	7,243	below	3,741	below	938	1,801	185	overforecast	-48%
Average relative difference, 1999-2023									-15%

^a Average category is defined as within +/- 25% of the the 1999-2023 estimated run average of 23,167 age-1.2-1.4 fish.