MEMORANDUM

TO: Distribution

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DATE: January 29, 2021

SUBJECT: Outlook for the 2021 Deshka River king salmon run, and accuracy of the 2020 forecast

The point estimate of the preseason forecast for the 2021 Deshka River king salmon total run is 11,464 fish (ages 1.2–1.4), which is within the biological escapement goal of 9,000 –18,000. Inclusion of the five-year average number of age-1.1 fish would add 2,361 to the total of the 2021 Deshka king salmon forecast. The best way to consider this salmon forecast is in terms of 3 broad categories: average run, below average run, or above average run. The 2021 forecast gives the expectation of a run in the below average category. The 80% prediction interval for the total run forecast is 3,041 to 19,887 fish. This interval is calculated based on the previous five years of returns for each age class and the models chosen (see below) for this year's forecast, and is provided as the expected range in which the 2021 run will fall with an 80% probability (Table 1). The preseason forecast estimate is 25% less than the recent ten-year (2011 – 2020) average run of 15,276 age 1.2 – 1.4 fish, 63% less than the long-term (1979 – 2020) average of 30,770 fish, and 8% more than the forecast for the 2020 run (10,570).

The forecast for 2021 is the sum of individual age class forecasts. We examined estimates from three classes of models: sibling relationships, Ricker spawner-recruit relationships, and recent year moving averages (Table 2). The models chosen were those with statistically significant parameters that have the greatest past reliability (accuracy and precision). Specifically, the model estimate selected for each age class for inclusion in the 2021 forecast were those with the lowest recent five year mean absolute deviation (MAD). We calculated the MAD as the mean of the absolute difference between hindcasted estimates for each of the previous five years and the actual returns for each age class. The hindcasts were produced for each return year as one step ahead predictions using the estimates from all prior years.

For each age specific forecast, we chose a model from the moving average class. The univariate time series model was selected for age-1.2 fish, the five-year moving average was selected for age-1.3 fish, and the univariate time series model also selected for age-1.4 fish (Table 1). Note that three models, the five-year moving average, the exponential smoothing, and the sibling model all have similar MAD scores for the age-1.3 fish: 2,762, 2,960, and 3,027, respectively. The exponential smoothing model results in a reduced forecast estimate (2,966), and the sibling model a much larger estimate (11,244; Table 1). This is worth noting because it highlights the uncertainty in this forecast. The age-1.3 fish will be returns from the 2016 brood year, which had the largest escapement in the last five years (Table 3). For a description of each model considered see Table 2.

Weir counts of age- 1.1 'jack' king salmon are considered a minimum because an unknown number likely pass through the gaps between weir pickets and go uncounted. And in many years zero to only a few hundred fish of this age class are counted thru the weir. However, those enumerated do count toward the escapement goal. The recent five-year average of age-1.1 fish is 2,361. In recent years, there has been an increase in the number of jacks counted at the weir, and efforts are underway to evaluate how this phenomenon could impact future production (Table 3).

The complete 2020 escapement estimate, including age-1.1 fish, was 10,638, which is within the escapement goal range. The preliminary estimate of last year's (2020) Deshka River king salmon total run of fish age-1.2 – 1.4 is 8,968. The forecast estimate of total run for 2020 for these age classes was 10,570, a difference of -15%. The average difference between the forecast total run and actual total run, for years 1999–2020 was -14% (Table 4). The 2020 total run was 65% less than the average run of 25,507 age 1.2 – 1.4 fish during the same timeframe.

The 2020 run completed the return of the 2014 brood year (BY). The 2014 BY produced a total return of 10,863 king salmon (return per spawner = 0.68). This was more productive than the 2013 brood year, which had a return-per-spawner of 0.49.

There is considerable uncertainty in the total 2021 Deshka River king salmon forecast estimate. The models used for Deshka River king salmon tend to over-forecast: over-forecasting occurred in15 of 22 years, under-forecast occurred in 5 of 22 years, and the forecast was within 5% of the actual run in 2 years (Table 4). The Deshka king salmon forecast has differed by 3% to -50% from the actual run in the past ten years (-16% average).

The best way to consider this salmon forecast is in terms of 3 broad categories: approximately average run, below average run, or above average run. The 2021 forecast gives the expectation of a run in the below average category (Table 4).

Distribution:

Anchorage: Tom Vania, Tim McKinley, Matt Miller, Jason Dye, Jay Baumer, Brittany Blaine-Roth, Bert Lewis, Jack Erickson, Aaron Poetter, Jim Hasbrouck, Bill Templin, Andrew Munro

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Table 1. – Forecast king salmon abundance of major age classes and total run with 80% prediction interval (PI) for the Deshka River in 2021 using various models, and the relative performance of each model to the previous 5 years of runs as measured by MAD (mean absolute deviation).

Model	Forecast 2021	Model chosen	5-year MAD	5-year MD
Age 1.2				
5-year moving average	3,282		4,093	669
Exponential smoothing	5,876		5,109	1,137
Univariate time series	6,332	*	3,925	521
Sibling	[a]			
Ricker	5,826		4,217	1,076
Age 1.3				
5-year moving average	4,852	*	2,762	2,426
Exponential smoothing	2,966		2,960	2,129
Univariate time series	3,621		4,805	4,272
Sibling	11,244		3,027	1,141
Ricker	3,869		5,262	4,700
Age 1.4				
5-year moving average	427		1,057	1,057
Exponential smoothing	274		733	666
Univariate time series	280	*	726	648
Sibling	312		1,146	1,084
Ricker	[b]			
Total forecast	11,464 (3,041 - 19,887, 80% PI)			

[a] There was no signinficant sibling relationship with 1.2 age fish.

[b] The Ricker model was insignificant (p-value > 0.05) for 1.4 age fish.

Table 2. – Brief description of statistical models used in forecasting the Deshka River king salmon run for 2021.

Model	Description
5-year moving average	A moving average on the natural log of abundance in each age class.
Expontential 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. – Estimate of Deshka River king salmon by age class for years 1979 – 2020.

Run Year	Number per Age Class 1.1	1.2	1.3	1.4	1.5	Total Run age 1.2 - 1.4	Total Run all ages	Escapement 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	4,621	33,600	4,362	0	42,583	42,585	34,967
2001	489	8,212	15,849	9,621	2	33,683	34,174	28,704
2002	542	8,988	19,154	5,352	0	33,495	34,037	29,047
2003	477	16,780	22,691	6,579	0	46,050	46,527	39,496
2004	669	12,037	44,134	10,030	0	66,201	66,869	57,330
2005	550	13,153	26,036	5,337	0	44,525	45,075	37,190
2006	0	8,810	21,350	8,572	0	38,732	38,732	30,279
2007	0	2,217	17,419	4,856	0	24,492	24,492	18,154
2008	0	1,602	3,884	4,743	0	10,228	10,228	7,516
2009	0	8,680	3,128	1,178	0	12,986	12,986	11,959
2010	196	4,582	15,318	1,898	0	21,798	21,995	18,266
2011	511	5,943	14,250	1,534	0	21,726	22,238	18,714
2012	662	8,717	4,138	2,427	0	15,282	15,944	14,030
2013	779	4,244	11,590	3,256	0	19,090	19,869	18,448
2014	1,534	6,988	7,027	2,154	0	16,169	17,703	16,078
2015	2,915	7,240	12,945	3,374	0	23,559	26,474	24,181
2016	4,124	11,112	8,902	1,791	0	21,806	25,930	22,690
2017	1,131	1,590	9,117	1,249	0	11,956	13,087	11,258
2018	3,401	2,180	3,052	87	0	5,319	8,720	8,549
2019	960	1,377	7,260	251	0	8,888	9,848	9,705
2020	2,187	7,181	1,495	292	0	8,968	11,155	10,638

Table 4. – Accuracy of the Deshka River king salmon outlook for the three major age classes, 1999–2020.

Return year	Forecast run	Forecast category[a]	Actual run	Actual run category[a]	Forecast difference by major age class (forecast-actual) Age 1.2	Age 1.3	Age 1.4	Overall effect	Relative difference
1999	26,810	average	33,625	above	-4,421	-463	-1,931	underforecast	25%
2000	33,337	above	42,583	above	3,541	-18,343	5,556	underforecast	28%
2001	40,753	above	33,683	above	340	-6,037	12,768	overforecast	-17%
2002	43,805	above	33,495	above	848	5,336	4,127	overforecast	-24%
2003	41,041	above	46,050	above	-8,472	-898	4,361	underforecast	12%
2004	60,833	above	66,201	above	-2,504	-812	-2,052	underforecast	9%
2005	48,687	above	44,525	above	-4,808	2,695	6,274	overforecast	-9%
2006	49,071	above	38,732	above	-692	11,901	-870	overforecast	-21%
2007	37,007	above	24,492	average	6,550	3,790	2,175	overforecast	-34%
2008	20,268	average	10,228	below	6,338	1,843	1,859	overforecast	-50%
2009	20,593	average	12,986	below	847	4,085	2,675	overforecast	-37%
2010	30,775	average	21,798	average	4,950	3,029	998	overforecast	-29%
2011	21,080	average	21,726	average	358	-4,095	3,090	underforecast	3%
2012	21,665	average	15,282	below	-4,089	9,463	1,009	overforecast	-29%
2013	26,791	average	19,090	below	3,168	6,618	-2,085	overforecast	-29%
2014	19,063	below	16,169	below	-491	1,535	1,849	overforecast	-15%
2015	20,418	average	23,559	average	-1,013	-2,284	156	underforecast	15%
2016	24,638	average	21,806	average	-4,286	3,931	3,188	overforecast	-11%
2017	17,813	below	11,956	below	5,222	-718	1,353	overforecast	-33%
2018	10,595	below	5,319	below	4,725	-1,788	2,339	overforecast	-50%
2019	8,466	below	8,888	below	2,517	-3,736	797	underforecast	5%
2020	10,570	below	8,968	below	-4,098	5,811	-111	overforecast	-15%
							Average relative difference, 1999-2020		-14%

[a]Average category is defined as within +/- 25% of the the 1999-2020 actual run average of 25,507 age 1.2-1.4 fish.