# MEMORANDUM

TO: Distribution

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DATE: January 18, 2022

SUBJECT: Outlook for the 2022 Deshka River king salmon run, and accuracy of the 2021 forecast

The point estimate of the preseason forecast for the 2022 Deshka River king salmon total run is 9,332 fish (ages 1.2 – 1.4). The 80% prediction interval, based upon the variability between forecast and actual total runs from 1985 –2021, is 5,637 to 15,450 fish (Table 1). Inclusion of the five-year average number of age-1.1 fish would add 2,103 fish to this forecast. Some number of fish of age-1.1 are thought to pass between the pickets of the Deshka weir and go uncounted, the fact of which reduces the viability of forecasting this age class. The run is predicted to be within the biological escapement goal of 9,000 – 18,000 fish. The preseason forecast estimate is 36% less than the recent ten-year (2012 – 2021) average run of 14,609 age 1.2 – 1.4 fish, and 69% less than the long-term (1979 – 2021) average of 30,275 fish.

The forecast for 2022 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). The variability among forecasted and actual total returns for each model was assessed by using the mean absolute deviation (MAD) and mean absolute percent error (MAPE) (Table 1). The choice of model used for each age class had minimum values of the 5–year MAD in 2017 – 2021 hindcasts of forecasts, as compared to the actual runs in those years (Tables 1). Choosing age class models with the minimum MAPE would produce a near-identical forecast (Table 1). The hindcasts were produced for each return year as one step ahead predictions using the estimates from all prior years.

For age-1.2 fish, the 5-year moving average model was selected. 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.

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 through the weir. However, those enumerated do count toward the escapement goal. The recent five-year average of age-1.1 fish is 2,103. 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 preliminary 2021 escapement estimate, including age-1.1 fish, was 18,524 (weir count minus estimated sport harvest above the weir of 150 fish), which is above the 18,000 fish upper bound of the escapement goal. The preliminary estimate of the 2021 Deshka River king salmon total run of fish age-1.2 – 1.4 is 16,530. The forecast estimate of total run for 2021 for these age classes was 11,464, a difference of 44%. For comparison, the average difference between the forecast total run and estimated total run, for years 1999 – 2021 was -12% (Table 4). The estimated 2021 total run was 33% less than the historical average run of 24,812 age 1.2 – 1.4 fish during the same timeframe.

The difference between the forecast and estimated total run in 2021 was driven by the return of 13,321 age-1.3 fish. It was noted in the 2021 forecast memo that the sibling model forecasted a return of 11,244 age-1.3 fish, much larger than the 4,852 fish predicted by the 5-year moving average. The smaller number predicted by the 5-year moving average was chosen in 2021 because it had the lowest MAD (2,762), but the sibling model had a MAD that was close at 3,027. The 2022 forecast for this age class is based on the sibling model which has the lowest MAD.

The 2015 brood year) return was completed with the 2021 run of age-1.4 fish. The 2015 brood year produced a total return of 6,421 king salmon (return per spawner = 0.27). This was less productive than the 2014 brood year, which had a return-per-spawner of 0.67.

There is considerable uncertainty in the total 2022 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 15 of 23 years and under-forecasted in 8 of 23 years. The forecast was within 5% of the estimated run in only 2 years (Table 4). The Deshka king salmon forecast has differed by 5% to -50% from the estimated run in the past ten years (-13% average).

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 2022 forecast gives the expectation of a run in the below average run 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, Sarah Webster, Bill Templin, Andrew Munro

Palmer: Samuel Ivey, Samantha Oslund, Johnathon Campbell, Adam St. Saviour, Dave Rutz

Homer: Mike Booz, Holly Dickson

Soldotna: Colton Lipka, Jenny Gates, Brian Marston, Robert Begich, Alyssa Frothingham, Adam Reimer, Robert DeCino

Juneau: Forrest Bowers, Tom Taube, Sam Rabung

Table 1. – Forecast king salmon abundance of major age classes and total run with 80% prediction interval (PI) for the Deshka River in 2022 using various models, and the relative performance of each model to the previous 5 years of runs as measured by mean absolute deviation (MAD) and mean absolute percent error (MAPE).

| Model | Forecast 2022 | Model chosen | 5-year MAD | 5-year MAPE |
|---|---|---|---|---|
| Age 1.2 | | | | |
| 5-year moving average | 2,514 | * | 3,151 | 1.57 |
| Exponential smoothing | 5,753 | | 4,637 | 2.21 |
| Univariate time series | 4,587 | | 3,631 | 1.71 |
| Sibling | [a] | | | |
| Ricker | 4,218 | | 3,742 | 2.16 |
| Age 1.3 | | | | |
| 5-year moving average | 5,222 | | 4,359 | 1.38 |
| Exponential smoothing | 6,002 | | 4,741 | 1.27 |
| Univariate time series | 12,805 | | 5,810 | 1.85 |
| Sibling | 6,621 | * | 3,977 | 0.73 |
| Ricker | 9,970 | | 6,087 | 2.08 |
| Age 1.4 | | | | |
| 5-year moving average | 266 | | 965 | 6.24 |
| Exponential smoothing | 197 | * | 502 | 3.55 |
| Univariate time series | 201 | | 517 | 3.41 |
| Sibling | 385 | | 555 | 3.34 |
| Ricker | [b] | | | |
| Total forecast | 9,332 (5,637 - 15,450 80% PI) | | | |

[a]The sibling relationship between age 1.1 and 1.2 fish was insignificant.

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

Table 2. – Brief description of statistical models used in forecasting the Deshka River king salmon run for 2022.

| 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. – Estimates of Deshka River king salmon by age class for years 1979 – 2021. All values for 2021 are preliminary until Statewide Harvest Survey estimates are available.

| Run Year | 1.1 | Number per Age Class 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 | 4,514 | 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 | 960 | 1,377 | 7,260 | 251 | 0 | 8,888 | 9,848 | 9,705 |
| 2020 | 2,148 | 7,053 | 1,468 | 286 | 0 | 8,807 | 10,955 | 10,638 |
| 2021 | 2,898 | 3,034 | 13,321 | 175 | 0 | 16,530 | 19,428 | 18,524 |

Table 4. – Accuracy of the Deshka River king salmon outlook for the three major age classes, 1999–2021.

| Return year | Forecast run | Forecast category[a] | Estimated run | Estimated run category[a] | Age 1.2 | Age 1.3 | Age 1.4 | Overall effect | Relative difference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Forecast difference by major age class (forecast-estimated) | | | | | |
| 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 | below | 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 | 8,888 | below | 2,517 | -3,736 | 797 | underforecast | 5% |
| 2020 | 10,570 | below | 8,807 | below | -3,970 | 5,838 | -105 | overforecast | -17% |
| 2021 | 11,464 | below | 16,530 | below | 3,298 | -8,469 | 105 | underforecast | 44% |
| | | | | | | | Average relative difference, 1999-2021 | | -12% |

[a]Average category is defined as within +/- 25% of the the 1999-2021 estimated run average of 24,812 age 1.2-1.4 fish.