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MEMORANDUM

TO: Distribution

DATE: March 2, 2023

SUBJECT: Kenai River early run  
Chinook salmon 2023  
outlook

FROM: Robert Begich, Tony Eskelin  
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The 2023 forecast for the stock of large ( $\geq 75$  cm mideye-to-tail-fork-length [METF] or approximately  $\geq 34$  inches in total length) early-run Chinook salmon in the Kenai River is 2,914 fish. This total run forecast is less than the optimum escapement goal range of 3,900 to 6,600 fish. The forecast is well below the 1986–2022 average run of approximately 8,700 fish and is slightly less than the recent 5-year average run of approximately 3,200 fish (Table 1). If realized, this forecast would be the 3<sup>rd</sup> largest run in the past five years but rank as the 5<sup>th</sup> lowest run in the past 38 years.

This forecast is the sum of individual age-specific (total age 5, 6, and 7) forecasts of abundance calculated from models based on historical adult returns by age class (mean, median, geometric mean), recent age-specific run size (5-year mean, 5-year geometric mean), or sibling ratios from previous years (mean sibling, 5-year mean sibling, median sibling, most recent sibling; Table 2). The difference between forecasted and estimated total returns for each model was assessed by calculating the mean absolute deviation (MAD), mean absolute percent error (MAPE) and mean deviation (MD) (Tables 3 and 4). The choice of model used for each age class had minimum values of the 5-year MAPE (Table 4). In recent years, we have selected models based on the minimum MAPE as this criterion has provided the best accuracy between observed and forecasted runs by age.

The age-5 large fish forecast of 1,489 fish is based on the 5-year geometric mean model from returns for the 2013–2017 brood years (Table 4). This forecast is nearly twice as large as the 2022 run of 899 age-5 fish from the 2017 brood year (Table 1). Although the 5-year geometric mean forecast model was selected because it performed better than the other models, the difference of the forecasted run size for the two next best models (median 2,621 fish and geometric mean 2,499 fish) are large with a difference of approximately 1,000 fish (Table 4). Returns forecasted by the two next best models would approximate the larger returns of age-5 early-run fish observed every other year, such as those estimated during 2019 and 2021 (Table 1).

The 5-year geometric mean model from returns for the 2012–2016 brood years of age-6 large fish was selected for a forecast of 1,423 fish (Table 4). This forecast of age-6 fish is larger than the preliminary estimate of the 2022 run of 1,153 age-6 fish (Table 1). The 5-year mean model was the second-best model and estimated a similar sized run of 1,441 age-6 fish (difference of approximately 18 fish; Table 4). The 5-year mean sibling model was the third best model and estimated a much smaller run of 800 age-6 fish (Table 4). The reason the 5-year mean sibling model estimated a much smaller run was due to the observed variation in the sibling ratio of age-5 fish to age-6 fish, which has varied from 0.25 to 2.23 (mean=0.89) from the 2012–2016 brood years (Tables 1 and 4).

The 5-year geometric mean model from the returns for the 2011–2015 brood years was selected to forecast the return of age-7 large fish (2 fish) (Table 4). Age-7 early-run Chinook salmon have been detected in samples in 2 of the past 5 years (Table 1).

The 2022 forecast was for a total run of 4,272 large fish while the preliminary estimated total run was 2,052, a difference of 2,220 fish or approximately 108% less than forecasted (Table 5). It is worth noting that in four of the last 6 years the run has been less than forecast (Table 5). The error in the 2022 forecast was due to a large difference in observed versus forecasted returns for the age-5 large fish age class.

The 2023 forecast gives the expectation of a run that will be below the historical average and slightly less than the recent 5-year total run average of approximately 3,200 large fish (Table 1).

Table 1.—Estimated number of large ( $\geq 75$  cm METF) early-run Kenai River Chinook salmon by age class and year, 1986–2022.

| Year                  | Total Age in Years |       |        |       | Total Run | Escapement |
|-----------------------|--------------------|-------|--------|-------|-----------|------------|
|                       | 4                  | 5     | 6      | 7     |           |            |
| 1986                  |                    | 6,648 | 6,108  | 1,387 | 14,143    | 6,562      |
| 1987                  |                    | 6,874 | 11,037 | 437   | 18,348    | 4,660      |
| 1988                  |                    | 2,226 | 13,367 | 1,944 | 17,537    | 2,668      |
| 1989                  |                    | 1,267 | 8,020  | 1,072 | 10,359    | 2,663      |
| 1990                  |                    | 1,901 | 5,354  | 570   | 7,825     | 5,523      |
| 1991                  |                    | 2,042 | 6,556  | 526   | 9,124     | 6,830      |
| 1992                  |                    | 2,624 | 7,243  | 647   | 10,514    | 7,902      |
| 1993                  |                    | 3,235 | 8,824  | 509   | 12,568    | 3,108      |
| 1994                  |                    | 1,873 | 9,349  | 555   | 11,777    | 3,448      |
| 1995                  |                    | 2,268 | 9,570  | 609   | 12,447    | 1,692      |
| 1996                  |                    | 2,099 | 6,157  | 229   | 8,485     | 1,940      |
| 1997                  |                    | 3,139 | 6,429  | 131   | 9,699     | 2,898      |
| 1998                  |                    | 3,188 | 4,214  | 317   | 7,719     | 5,918      |
| 1999                  |                    | 5,846 | 4,566  | 59    | 10,471    | 2,808      |
| 2000                  |                    | 3,791 | 4,956  | 65    | 8,812     | 6,580      |
| 2001                  |                    | 2,754 | 5,943  | 240   | 8,937     | 6,455      |
| 2002                  |                    | 4,108 | 4,902  | 432   | 9,442     | 8,489      |
| 2003                  |                    | 3,783 | 10,469 | 229   | 14,481    | 11,735     |
| 2004                  |                    | 6,249 | 11,092 | 994   | 18,335    | 15,319     |
| 2005                  |                    | 4,131 | 10,672 | 611   | 15,414    | 11,529     |
| 2006                  |                    | 2,709 | 7,331  | 565   | 10,605    | 6,072      |
| 2007                  |                    | 3,923 | 4,412  | 150   | 8,485     | 5,151      |
| 2008                  |                    | 3,457 | 4,012  | 135   | 7,604     | 4,138      |
| 2009                  |                    | 1,474 | 3,835  | 126   | 5,435     | 4,034      |
| 2010                  |                    | 2,534 | 1,648  | 73    | 4,255     | 3,012      |
| 2011                  |                    | 2,621 | 3,812  | 110   | 6,543     | 5,196      |
| 2012                  |                    | 1,138 | 2,168  | 70    | 3,376     | 2,977      |
| 2013                  |                    | 548   | 1,069  | 71    | 1,688     | 1,601      |
| 2014                  |                    | 1,881 | 754    | 55    | 2,690     | 2,621      |
| 2015                  |                    | 2,324 | 1,897  | 82    | 4,303     | 4,198      |
| 2016                  |                    | 4,243 | 2,244  | 80    | 6,567     | 6,478      |
| 2017                  | 123                | 4,898 | 2,380  | 0     | 7,401     | 6,725      |
| 2018                  |                    | 1,837 | 1,212  | 0     | 3,050     | 2,909      |
| 2019                  |                    | 2,497 | 1,478  | 233   | 4,208     | 4,128      |
| 2020                  |                    | 725   | 1,744  | 0     | 2,469     | 2,439      |
| 2021                  |                    | 2,451 | 1,617  | 91    | 4,159     | 4,036      |
| 2022                  |                    | 899   | 1,153  | 0     | 2,052     | 2,047      |
| Average               |                    | 2,979 | 5,340  | 362   | 8,685     | 5,040      |
| Recent 5-Year Average |                    | 1,682 | 1,441  | 65    | 3,188     | 3,112      |

Table 2.—Description of models used in forecasting the 2023 large ( $\geq 75$  cm METF) early-run Kenai River Chinook salmon run.

| Model                 | Description  |
|-----------------------|--|
| Mean                  | Mean return for the specified age class using all available return years. <sup>a</sup>   |
| 5-year mean           | Mean of the 2018–2022 return for the specified age class.  |
| Median                | Median return for the specified age class using all available return years.  |
| Mean sibling          | Mean of sibling ratios (returns of age x/returns of age x-1) for all returns multiplied by the return of age x-1 siblings.         |
| 5-year mean sibling   | Mean of sibling ratios (returns of age x /returns of age x-1) for previous 5 returns multiplied by the return of age x-1 siblings. |
| Median sibling        | Median of sibling ratios (returns of age x/returns of age x-1) for all returns multiplied by return of age x-1 siblings.           |
| Most recent sibling   | Most recent sibling ratio (return age x/return age x-1), multiplied by the return of age x-1 siblings.                             |
| Geometric mean        | Geometric mean of the return for the specified age class using all available return years.   |
| 5-year geometric mean | Geometric mean of the 2018–2022 return for the specified age class.  |

<sup>a</sup>1981–2017 for age-5 fish, 1980–2016 age-6 fish, 1979–2015 for age-7 fish.

Table 3.—Description of statistics used to assess model fit for the 2023 Kenai River early-run Chinook salmon forecasts for large ( $\geq 75$  cm METF) fish.

| Statistic                          | Description  |
|------------------------------------|--|
| Mean Absolute Deviation (MAD)      | Sum of the absolute values of the deviations in the estimated total return from the sum of actual total returns for each model divided by the sample size (5 years).   |
| Mean Deviation (MD)                | Sum of the deviations in the estimated total return from the sum of actual total returns for each model divided by the sample size (5 years).  |
| Mean Absolute Percent Error (MAPE) | Sum of the absolute values of the deviations of the estimated total return from the sum of actual returns for each model divided by the sample size (5 years) expressed as a percentage of the actual returns. |

Table 4.—2023 Kenai River early run Chinook salmon forecasts for large ( $\geq 75$  cm METF) fish using several models, and the fit of each model to the previous 5 years of actual returns. Transparent boxes indicate the lowest MAPE for each age class forecast. Shaded boxes indicate forecasts that were selected to be part of the total run forecast for each age class. See Table 2 for a description of each model.

| Model                     | Forecast     | 5-year           |                   |                 |
|---------------------------|--------------|------------------|-------------------|-----------------|
|                           | 2023         | MAD <sup>a</sup> | MAPE <sup>b</sup> | MD <sup>c</sup> |
| <b>Age-5</b>              |              |                  |                   |                 |
| Mean                      | 2,877        | 1,446            | 139%              | 1,446           |
| 5-year mean               | 1,682        | 1,178            | 120%              | 1,178           |
| Median                    | 2,621        | 989              | 105%              | 989             |
| Geometric mean            | 2,499        | 1,022            | 108%              | 1,022           |
| 5-year geometric mean     | 1,489        | 833              | 95%               | 785             |
| <b>Forecast estimate</b>  | <b>1,489</b> |                  |                   |                 |
| <b>Age-6</b>              |              |                  |                   |                 |
| Mean                      | 5,340        | 4,251            | 305%              | 4,251           |
| 5-year mean               | 1,441        | 300              | 23%               | 300             |
| Median                    | 4,902        | 3,768            | 272%              | 3,768           |
| Mean sibling              | 1,698        | 3,593            | 276%              | 3,503           |
| 5-year mean sibling       | 800          | 1,170            | 92%               | 714             |
| Median sibling            | 1,437        | 2,817            | 217%              | 2,633           |
| Most recent sibling       | 423          | 1,649            | 131%              | 796             |
| Geometric mean            | 1,264        | 3,114            | 225%              | 3,114           |
| 5-year geometric mean     | 1,423        | 213              | 17%               | 213             |
| <b>Forecast estimate</b>  | <b>1,423</b> |                  |                   |                 |
| <b>Age-7</b>              |              |                  |                   |                 |
| Mean                      | 362          | 325              | 3,842%            | 325             |
| 5-year mean               | 65           | 84               | 668%              | -3              |
| Median                    | 229          | 167              | 2,348%            | 166             |
| Mean sibling              | 63           | 96               | 943%              | 29              |
| 5-year mean sibling       | 56           | 97               | 839%              | 20              |
| Median sibling            | 58           | 91               | 869%              | 21              |
| Most recent sibling       | 0            | 138              | 925%              | 9               |
| Geometric mean            | 113          | 128              | 1,519%            | 103             |
| 5-year geometric mean     | 2            | 70               | 55%               | -54             |
| <b>Forecast estimate</b>  | <b>2</b>     |                  |                   |                 |
| <b>TOTAL RUN FORECAST</b> |              | <b>2,914</b>     |                   |                 |

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

Table 5.—Accuracy of the Kenai River early-run Chinook salmon forecasts for large ( $\geq 75$  cm METF) fish, 2017–2022.

| Year    | Forecasted total run | Estimated total run | Difference         | Relative difference | Overall effect |
|---------|----------------------|---------------------|--------------------|---------------------|----------------|
| 2017    | 6,526                | 7,401               | -875               | 12%                 | underforecast  |
| 2018    | 5,499                | 3,050               | 2,449              | -80%                | overforecast   |
| 2019    | 3,168                | 4,208               | -1,040             | 25%                 | underforecast  |
| 2020    | 4,794                | 2,469               | 2,325              | -94%                | overforecast   |
| 2021    | 4,391                | 4,159               | 232                | -6%                 | overforecast   |
| 2022    | 4,272                | 2,052               | 2,220              | -108%               | overforecast   |
| Average | 4,775                | 3,890               | 1,523 <sup>a</sup> | 54% <sup>a</sup>    |                |

<sup>a</sup> Average absolute difference and relative difference.

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