Predicting and Monitoring Adult Spring Chinook Salmon Migration on the Columbia River

INTRODUCTION

Continuous predictions of the run size, peak arrival and variability in timing for spring Chinook at Bonneville Dam (BON) on the Columbia River begins in mid-March and continues for each day that new fish are reported at BON dam until June 15.

Before the season begins, estimates of three parameters that define the spring chinook arrival distribution at Bonneville dam (BON) are prepared according to methods described by Anderson and Beer (2009), and CBR (2009). As new observations of passing adult fish are made on a daily basis, these parameters are adjusted according to methods of Beer (2009).

METHODS

On any particular day, the best prediction of the run size, peak arrival and spread of the arrival distribution of the spring Chinook migration is based on historic conditions, current environmental conditions, observations of passage, and mathematical properties of the assumed gaussian (normal) distribution (Beer 2009). Thus, preseason and early predictions rely on historic and current conditions while later predictions are more strongly influenced by observations. As the arrival information becomes available on a daily basis, several methods are used to modify the current prediction.

The ability of the distribution parameters to converge toward the postseason assessment of the parameters is the measure of interest. This is *not* an evaluation of either the preseason or postseason distributions relative to the actual arrivals, both of which are imprecise assessments of the true state of the fish. Conceptually, it is a measure of the transition from the preseason distribution to the postseason.

The sequence of daily predictions of each of the three parameters is treated as a limited time series. The predicted values and the postseason target value are normalized across their range to create daily normalized values for each day (x_i) relative to the target. Convergence on day i is based on the absolute difference between the predicted value and the target: $\Delta x_i = abs(x_i - T)$. The convergence value (C) is the average of these daily values over the days of interest from i to j: $C_{i,j} = \frac{1}{(j-i+1)}\sum_{i}^{j}\Delta x_i$, where days i & j are chosen to be day 80 (March 21) and day 150 (May 30).

Convergence of various hypothetical sequences is demonstrated in Figure 1. It is possible to begin and end the sequence on arbitrary days i and j but for comparative purposes these should be the same within and between seasons. Also, the normalized values (including the target) have mean = 0 and allow comparison of run size convergence to peak day convergence because the values are independent of the units of measure. Smaller values are better.

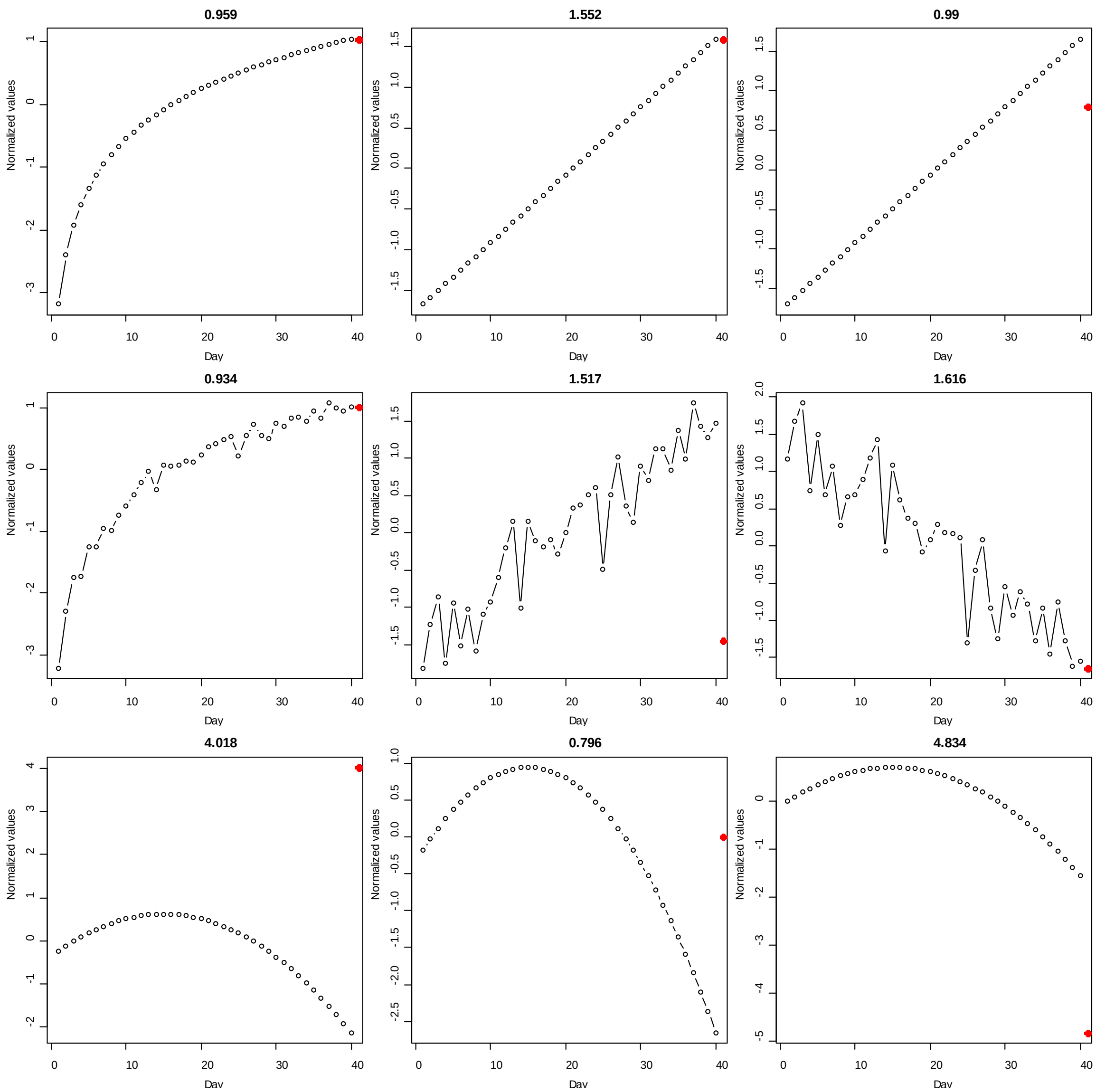


Figure 1 Illustrated convergence over 40 days toward the value shown with the red dot for various hypothetical sequences. The convergence value $C_{1,40}$ depicted in the title is the mean absolute difference between values and target (see text). Smaller values are better.

RESULTS

The postseason distribution of the runs is shown for each year with the "showarrivals" plot. The tri-modal distributions are necessary in order to obtain the target values for the in-season distribution parameters. As a result of fitting the three peaks of the run for a year, the target parameters for the spring adult run were obtained. The distributions of the other two runs are also depicted althoguh not the subject of in-season assessment. In each year, the final in-season parameter set is obtained on ~ Day 150 (May 30) when the spring peak is well passed. The preseason prediction, all in-season predictions (made daily) and the postseason prediction are all shown in the upper-left panel of the "convergence" plot within a year.

DISCUSSION

The challenges of the prediction algorithms to detect these parameters in-season are formidable for several reasons. The daily arrival noise can be quite significant and leads to un-smooth transitions between daily predictions. But more importantly, the runs themselves seem to be changing in fundamental ways. First, the summer run is becoming more significant as evidenced by the ratio of the summer to spring run (See: Compare plots: "ratio.runsize"). Second, the spring mode of the run is moving later (See: Compare plots: "summary.arrivals") which means that the late arriving spring fish are confounded with the early summer fish. Finally, the precocious male "jack" returns, which are the harbingers of the next year's run, have increased dramatically in recent years with record breaking numbers in 2009 that were on par with the adult run itself and has made it more difficult to predict the adult run numbers. While not directly affecting our ability to quickly converge on the distribution parameters for the year, changes in the patterns of abundance and timing suggest that fundamental processes in the ocean have yet to be described completely.

In 2013, we began using a data-driven principal components model for spring Chinook abundance. It is updated annually pre-season (NMFS 2015). The Anderson and Beer (2009) model is used for timing. See http://www.cbr.washington.edu/crisprt/adult_preseason.html. Current methods to assist the model in converging quickly involve deciding when an appropriate estimation method should be applied. Small refinements in the methods (Beer and Anderson 2009) are only implemented at season-outset when weighting schemes are pre-determined for blending of results from the different assessments. For example, testing for the zero-slope point at peak passage is unnecessary and inappropriate in the early weeks of the run.

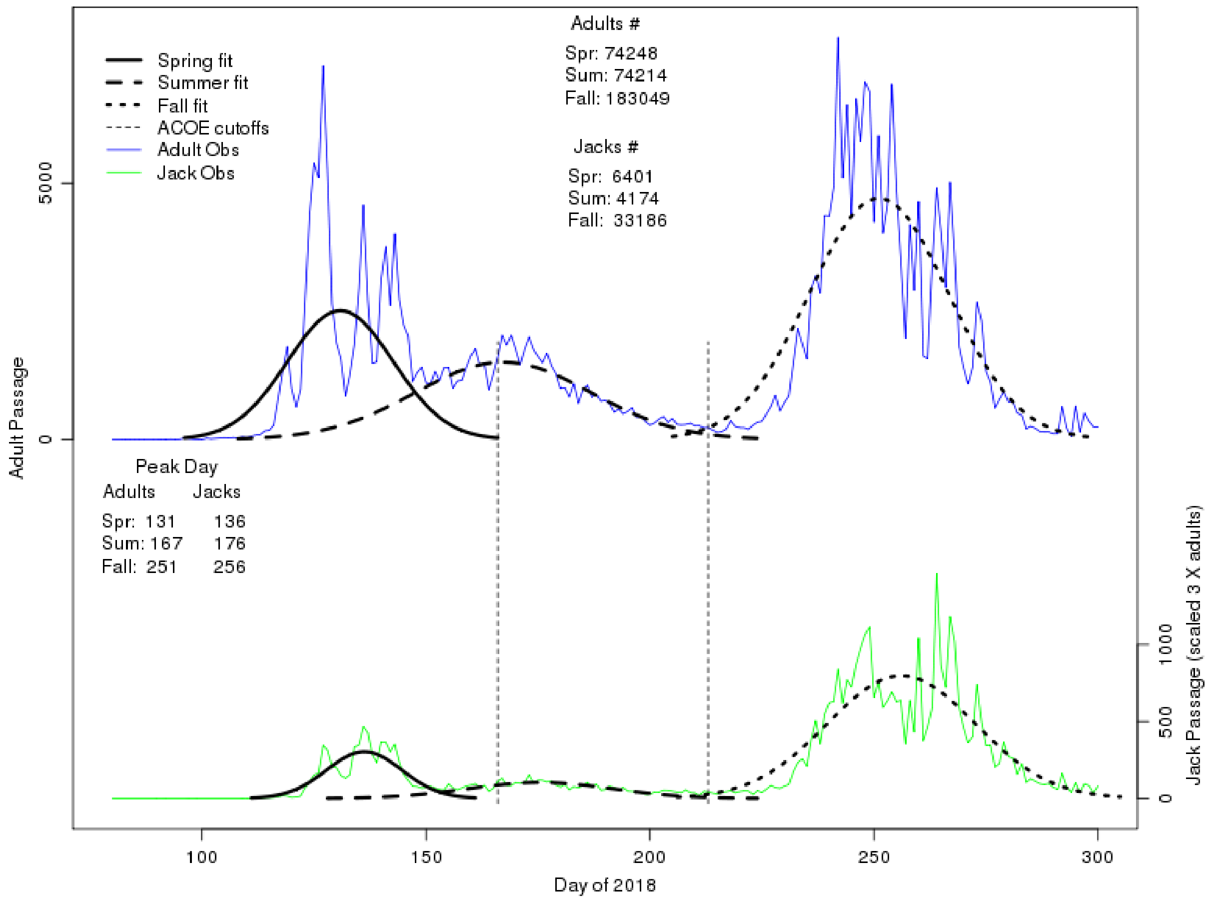


Figure 2 Example of the postseason run assessment for 2018. The spring-summer calendar-based cut-off date was during the peak of the summer arrivals. See the "showarrivals" plot within a year.

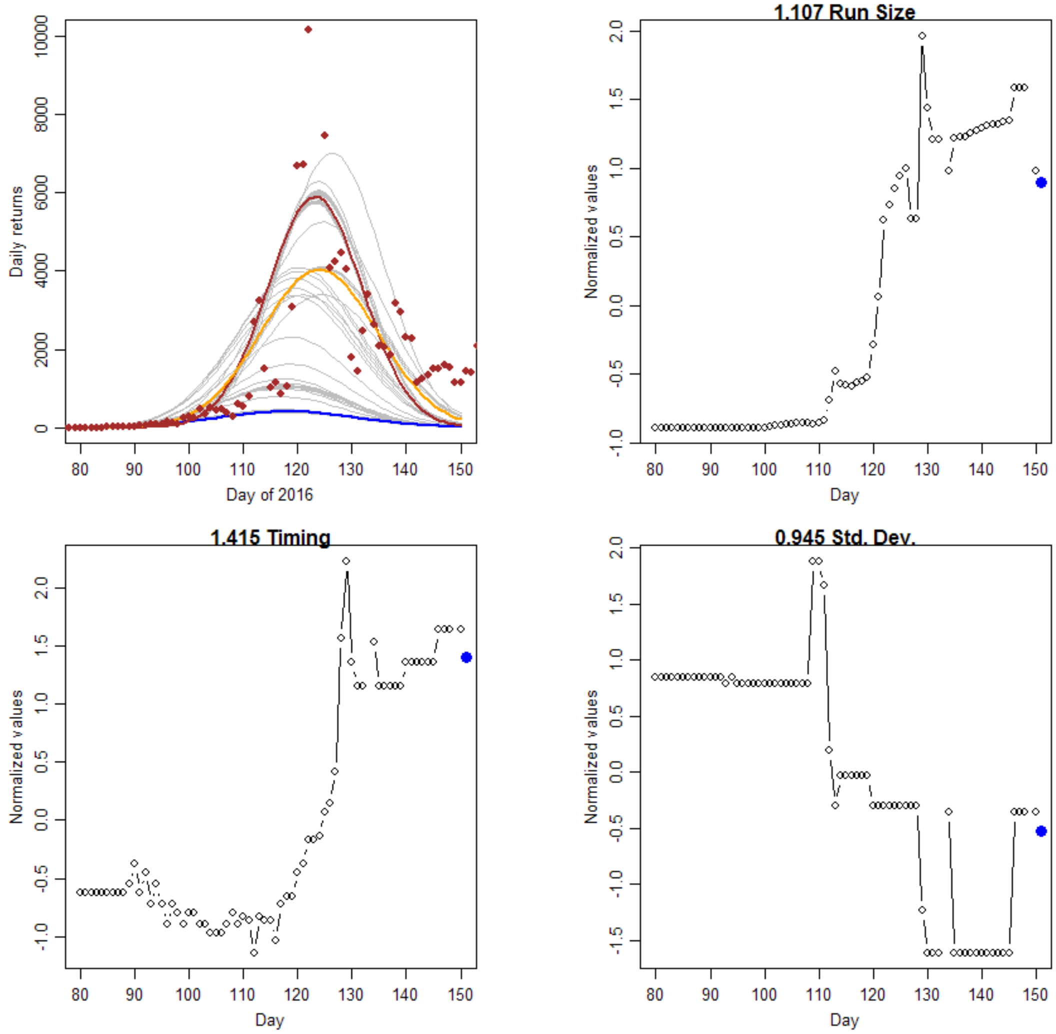
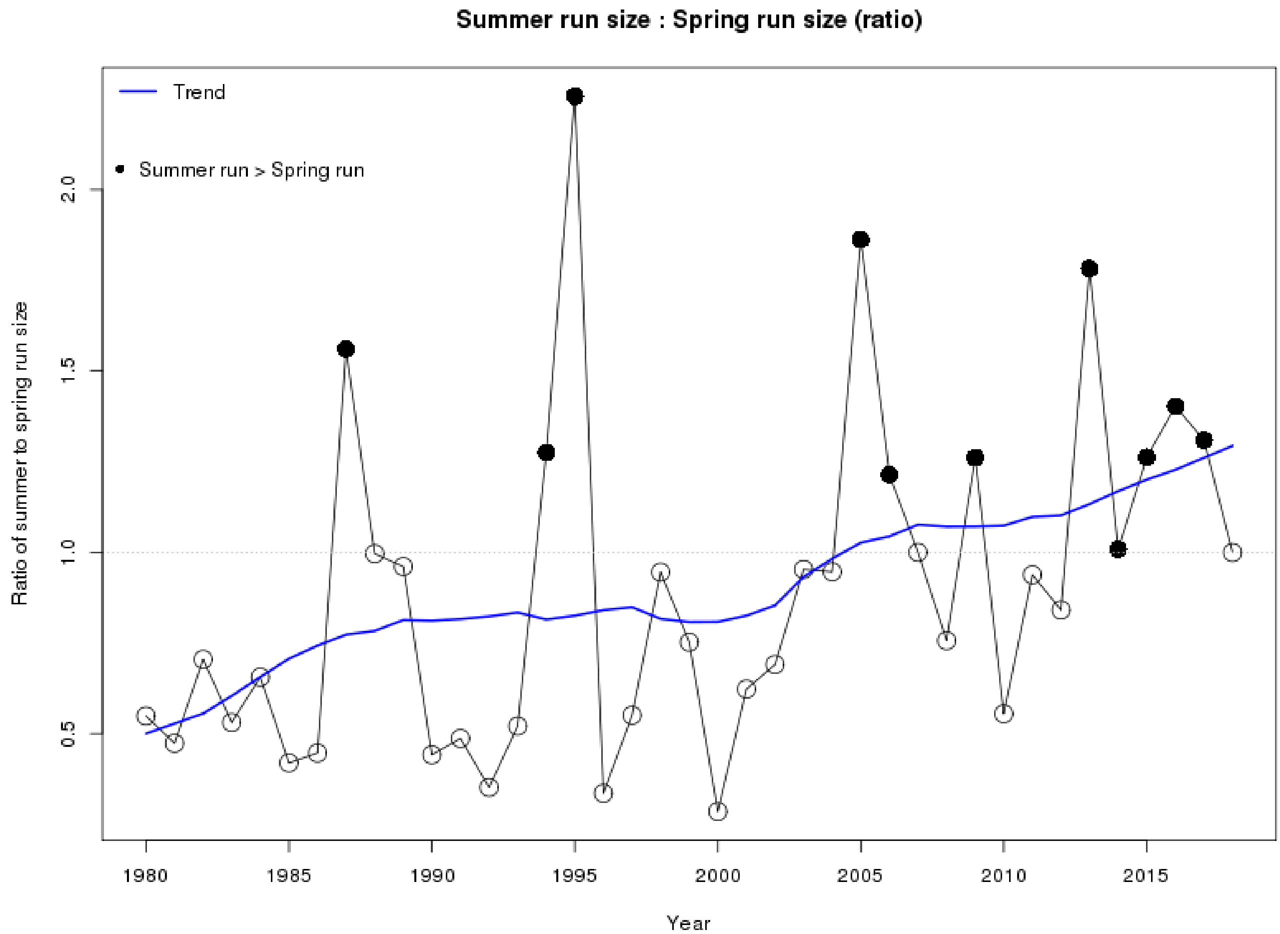
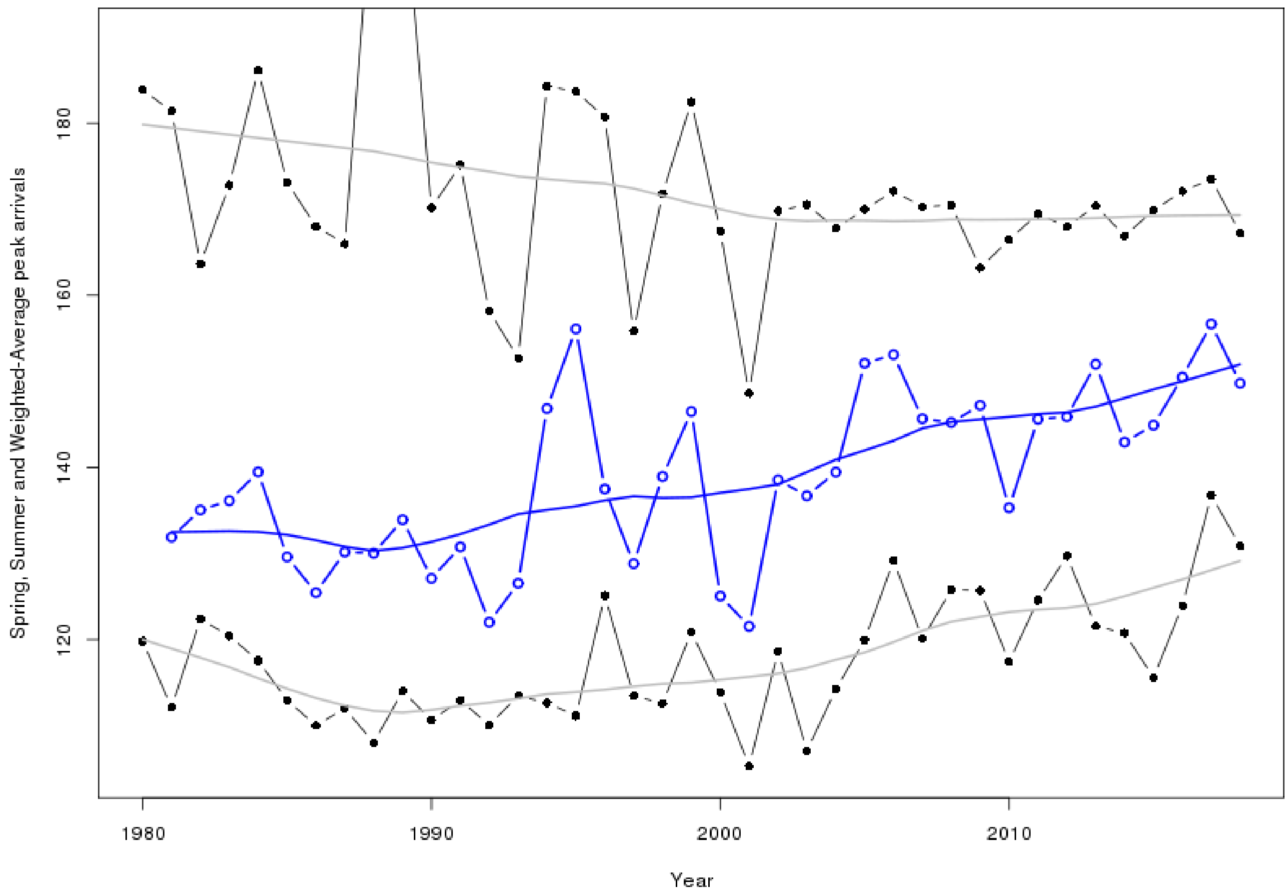


Figure 3 Example of results from 2016. The daily arrivals, in-season and end-of-season predictions (upper left). Normalized convergence for three distribution parameters predicted in-season during the year. Mean anomaly over the time series (days 80 – 150) is in the title. See the "convergence" plot within a year.



Ratio of Summer run to Spring run size based on retrospective fitting with a tri-modal run distribution with data through 2018. Filled points are ≥ 1. Color line shows smoothed trend. See the “ratio.runsize” plot for the Compare page.



Observations (points) and Trends (smoothed lines) in the arrival day of the Spring Peak (bottom), the Fall Peak (top) and Weighted average arrival day of Spring and Summer runs (i.e. pre- August 1) in center.

Figure 4 Example of changes in peak arrival of spring and summer runs with data through 2018. Spring and summer runs are in black (bottom and top respectively). The weighted, average-arrival day for all adult spring and summer Chinook (prior to August 1) is between (in blue). The smoothed trend lines run through time trends. The spring run (below) is getting later and the summer run abundance is increasing rapidly so the run-weighted average (center, with hollow blue circles) has been climbing since 1989.

REFERENCES

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