PREDICTING AND MONITORING ADULT SPRING CHINOOK SALMON MIGRATION ON THE COLUMBIA RIVER IN 2012

Technical Report

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SUMMARY

Preseason predictions of run size and migration timing are modified by inseason conditions and passage observations to monitor the run size and migration timing of spring Chinook salmon (*Oncorhynchus tshawytscha*) at Bonneville Dam on the Columbia River. As the season progresses, patterns in the arrival of the fish dictate modification of the size and timing parameters. The convergence of predictions for normalized run size, peak arrival day and variance parameters are 1.82, 0.81, and 1.5, respectively over the days 80-150 (March 21 – May 30).

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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 the end of May.

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).

This report is a review of the ability of the in-season peak predictor to estimate the true parameters of the spring distribution before the run is completed.

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.

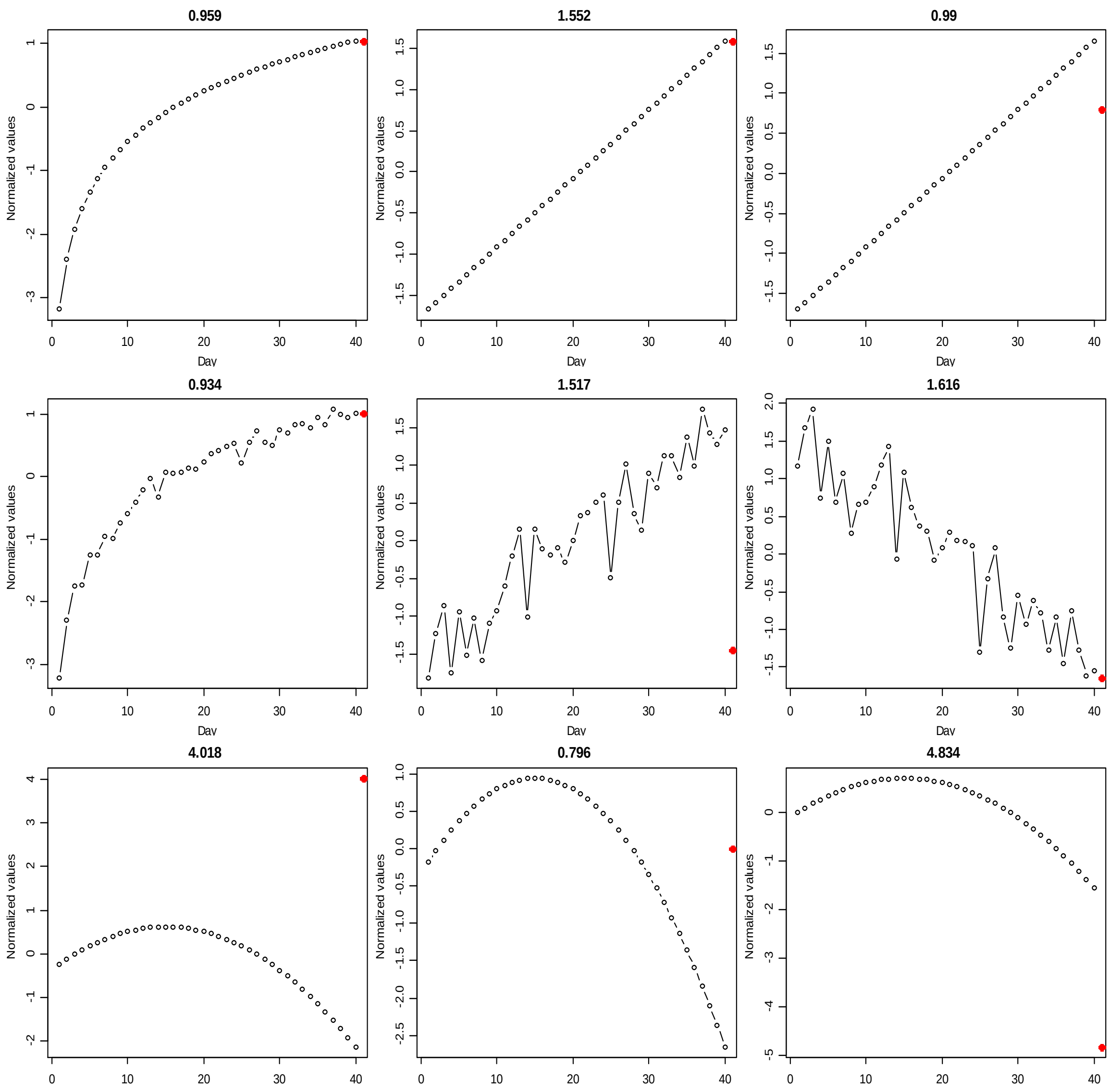

Figure 1 Illustrated convergence over 40 days toward the value shown with the red dot for various hypothetical sequences. The convergence value $C_{1,40}$ depicted in the title is the mean absolute difference between values and target (see text). Smaller values are better.

RESULTS

The postseason distribution of the runs is shown in Figure 3. 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 2012, the target parameters for the spring adult run were obtained: Run Size = 131182, Peak Day = 130 and Standard Deviation = 10.9 which is the postseason estimate of the passage profile. The final in-season parameter set was: Run Size == 179130, peak day = 131 (May 10) and standard deviation = 12.7. The preseason prediction, all in-season predictions (made daily) and the postseason prediction are all shown in the upper-left panel of Figure 2.

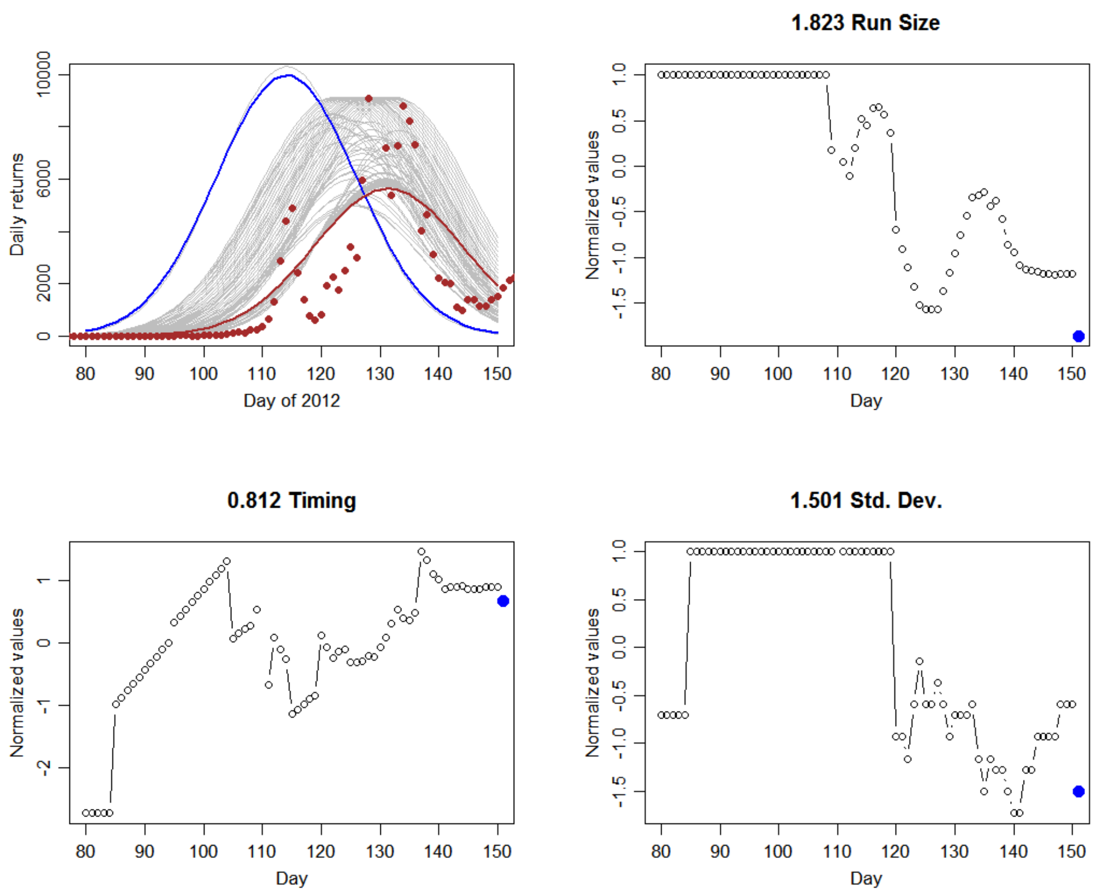

Figure 2 Daily arrivals, in-season and end-of-season predictions (upper left). Normalized convergence for three distribution parameters predicted in-season during 2012. Mean anomaly over the time series (days 80 – 150) is in the title.

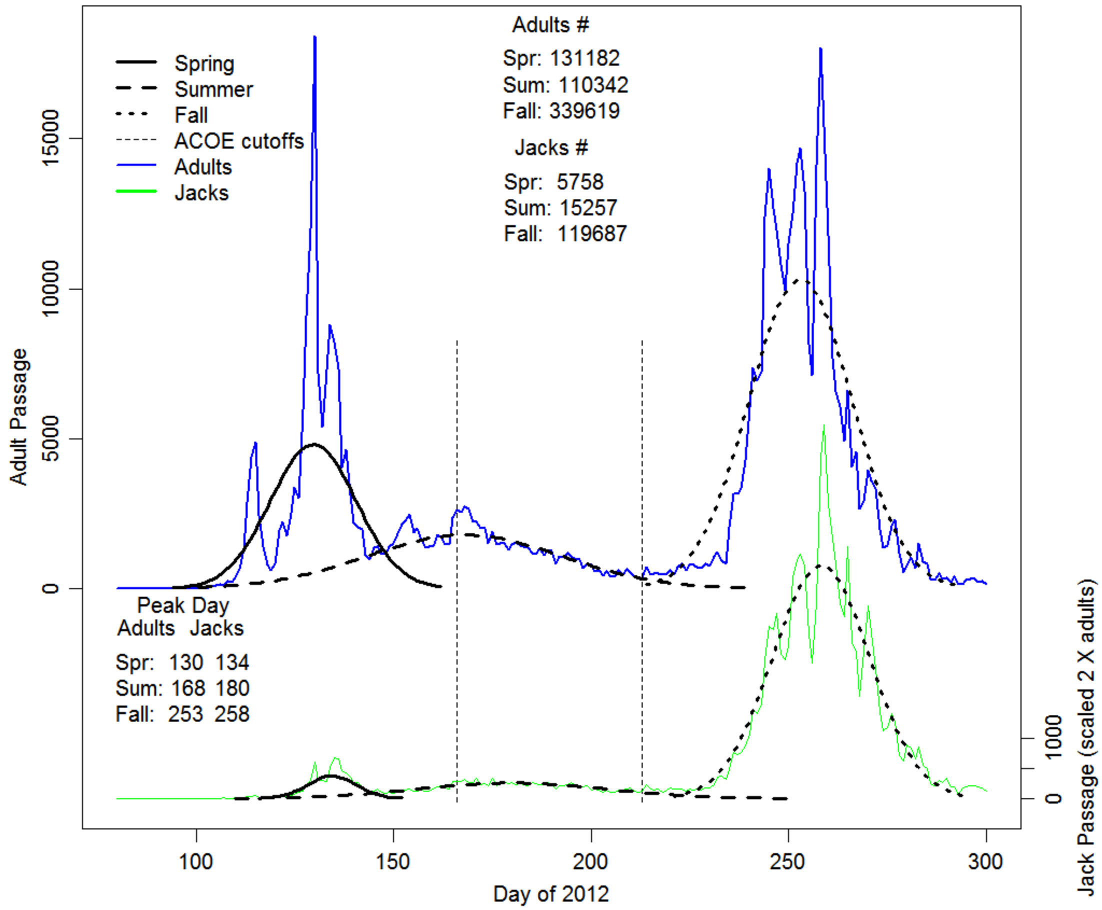

Figure 3 Postseason run assessment. The spring-summer calendar-based cut-off date was during the peak of the summer arrivals.

PRESEASON 2013

At the time of writing, the 2013 run is complete, and it has used the NMFS (2013) abundance model based on a principle component analysis of ocean conditions.

DISCUSSION

This year, as in previous years, there was some difficulty in defining the spring distribution in-season, and the distinction between the end of the spring run and the beginning of the summer run was unclear both mathematically and phenomenologically (see Figure 3), so the "truth" of the target as the actual state of the population is not guaranteed. However, the post-season assessment of the peak arrival day was essentially the same as the in-season, final assessment (one day different).

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, as it was this year 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 (Figure 4). Second, the spring mode of the run is moving later (Figure 5) 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 prediction of the adult run strength more difficult. 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 2010, we began using a modified model for estimating the pre-season abundance which included cohort relations and environmental indices. See http://www.cbr.washington.edu/crisprt/adult_preseason.html. This refinement was required after the unprecedented return of Jack Chinook in 2009. 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 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.

For 2013, we are using a data-driven principal components model for spring abundance (NMFS 2013) and the Anderson and Beer (2009) model for timing.

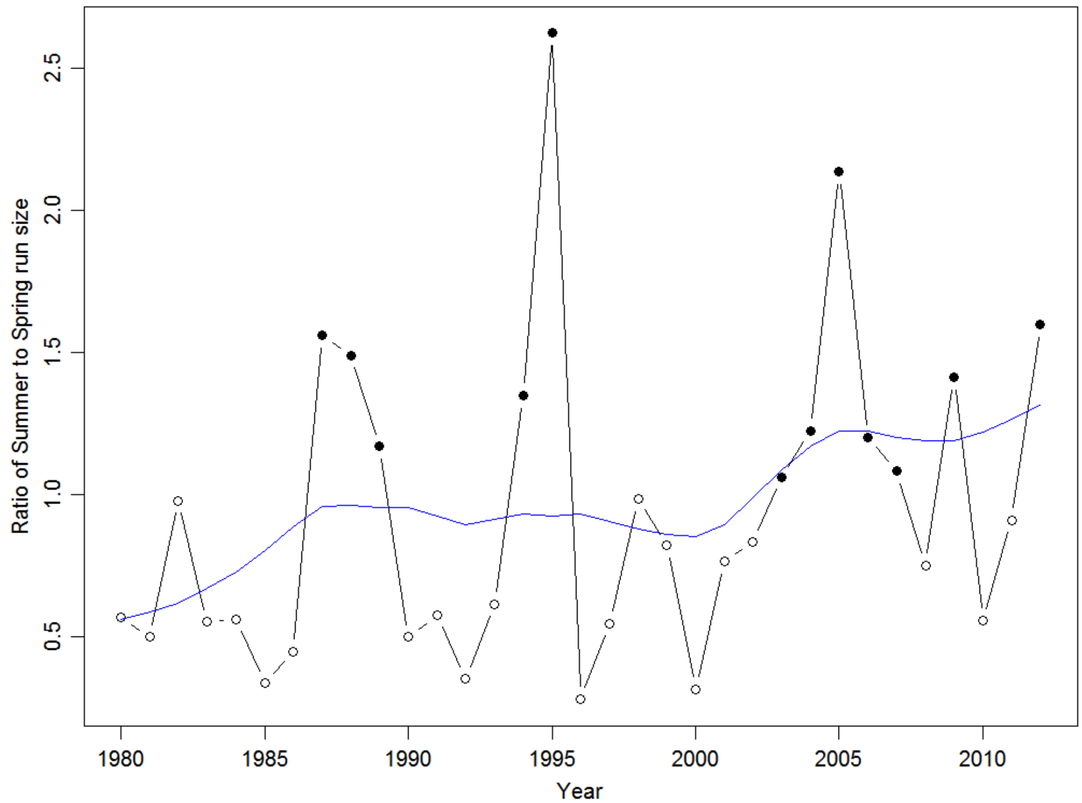

Figure 4 Ratio of Summer run to Spring run size based on retrospective fitting with a tri-modal run distribution. Filled points are >1 (7 out of last 10 years). Blue line shows smoothed trend. There is an increasing “summer” Chinook population in the system.

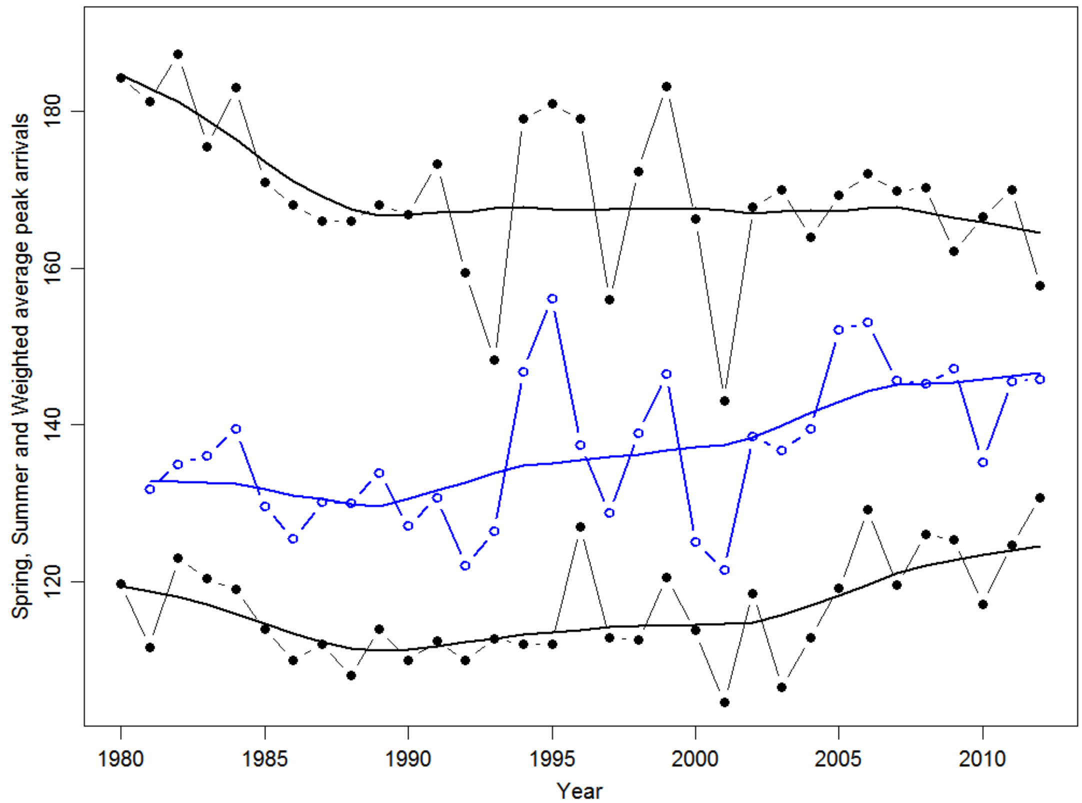

Figure 5 Changes in peak arrival of spring and summer runs. Spring and summer runs are in black (bottom and top respectively). The weighted average arrival day for all adult Chinook between March 15 and August 1 is between (in blue). The smoothed trend lines run through time trends. The spring run is gettting later and the summer run earlier.

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