

Predicting and Monitoring Migration

**PREDICTING AND MONITORING ADULT SPRING CHINOOK SALMON  
MIGRATION ON THE COLUMBIA RIVER IN 2010**

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 1.43, 0.87, and 4.75, 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 reiew 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 are 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.

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Convergence on day  $i$  is based on the absolute difference between the predicted value and the target:  $\Delta x_i = \text{abs}(x_i - T)$ . 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 are 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.

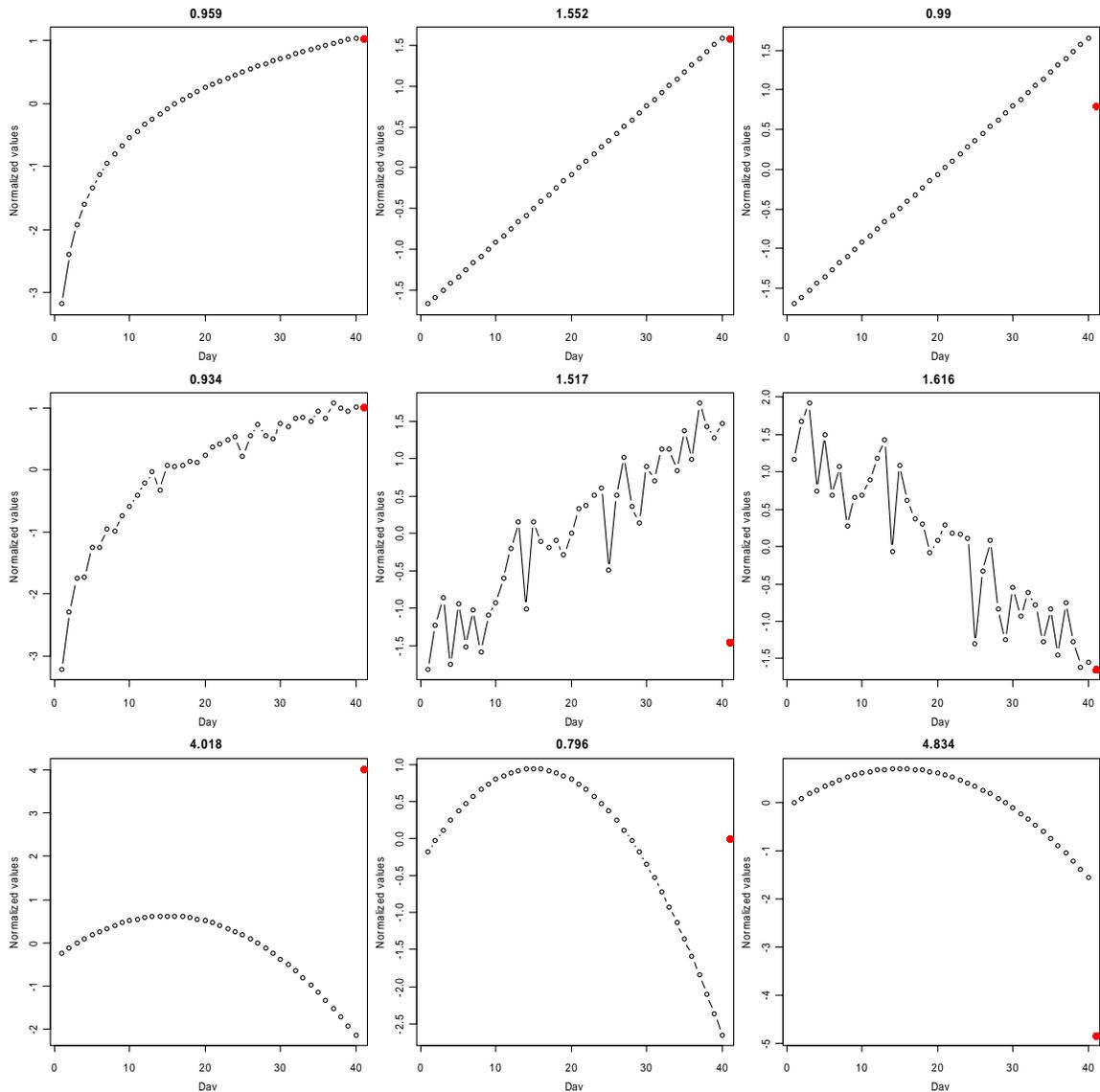


Figure 1 Illustrated convergence over 40 days toward the value shown with the red dot

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 distributions of the runs is shown in Figure 2. 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 2010, the target parameters for the spring adult run were obtained: Run Size = 221924, Peak Day = 117 and Standard Deviation = 11.2 (not explicitly printed on graph).

The final parameter set was unchanged after day 125 (May 5) with run size == 190500, peak day = 115 (April 25) and standard deviation = 9. Errors of 14%, 2 days and 2 days, respectively.

Convergence was 0.964 for run size, 0.766 for run timing, and 1.25 for standard deviation. These are collectively lower (better) than in 2009 (1.43 for run size, 0.87 for peak day timing and 4.8 for the standard deviation).

The preseason prediction, all in-season predictions (made daily) and the postseason prediction are all shown in the upper-left panel of Figure 3. There is also a depiction of the relative convergence (in normalized-value space) of each parameter. They can be compared to each other, so the run timing convergence was better than the run size convergence and these in turn better than the standard deviation convergence.

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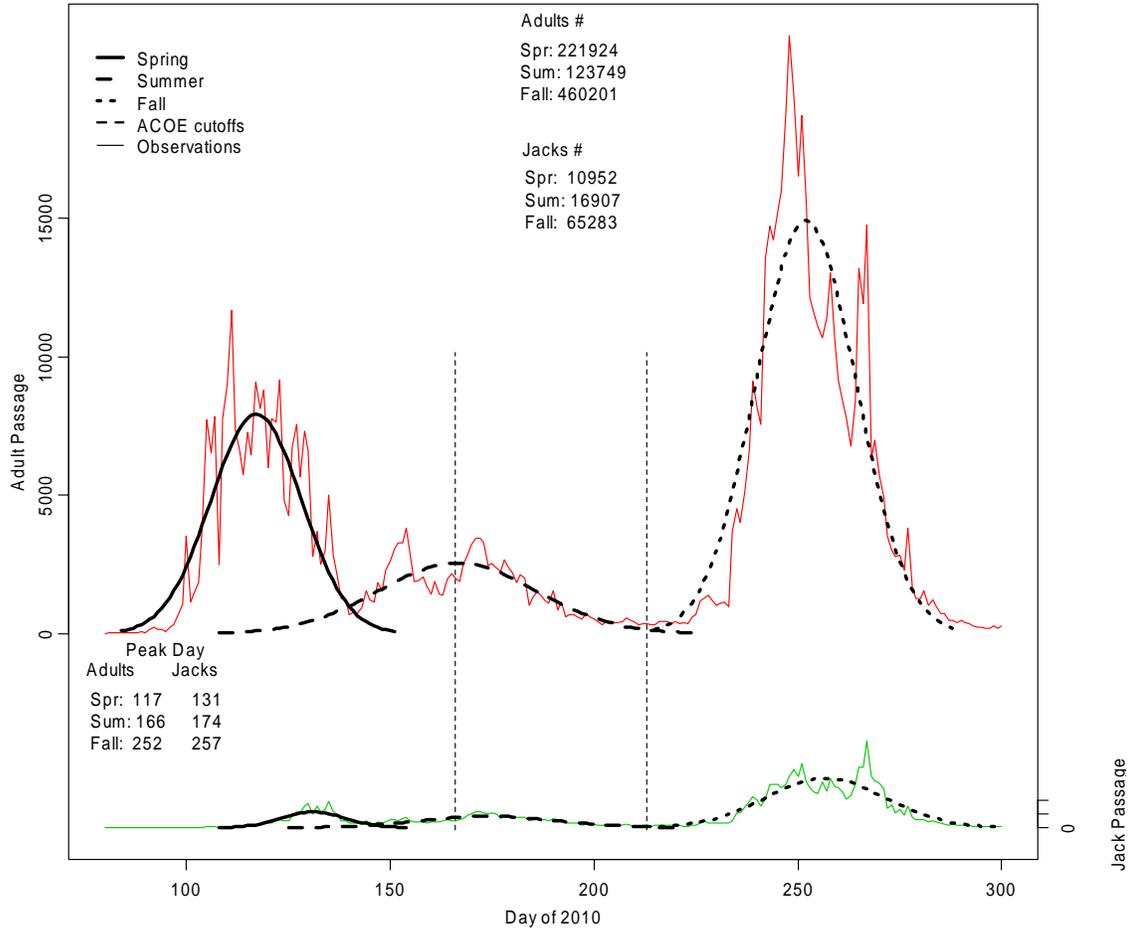


Figure 2 Postseason run assessment. Note that the spring and summer runs are very difficult to distinguish with either distributions or the calendar-based run date cutoffs.

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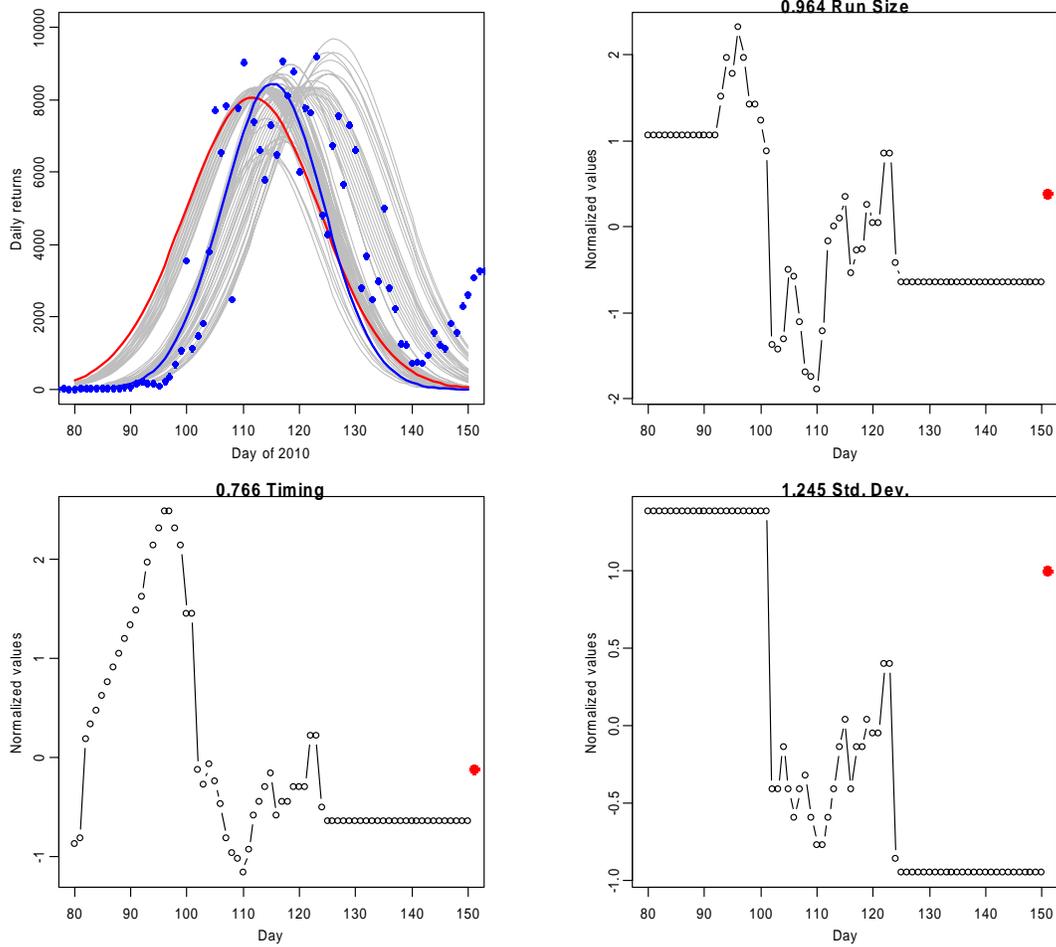


Figure 3 Daily arrivals, in-season and postseason predictions (upper left) and normalized convergence for three distribution parameters predicted in-season during 2010.

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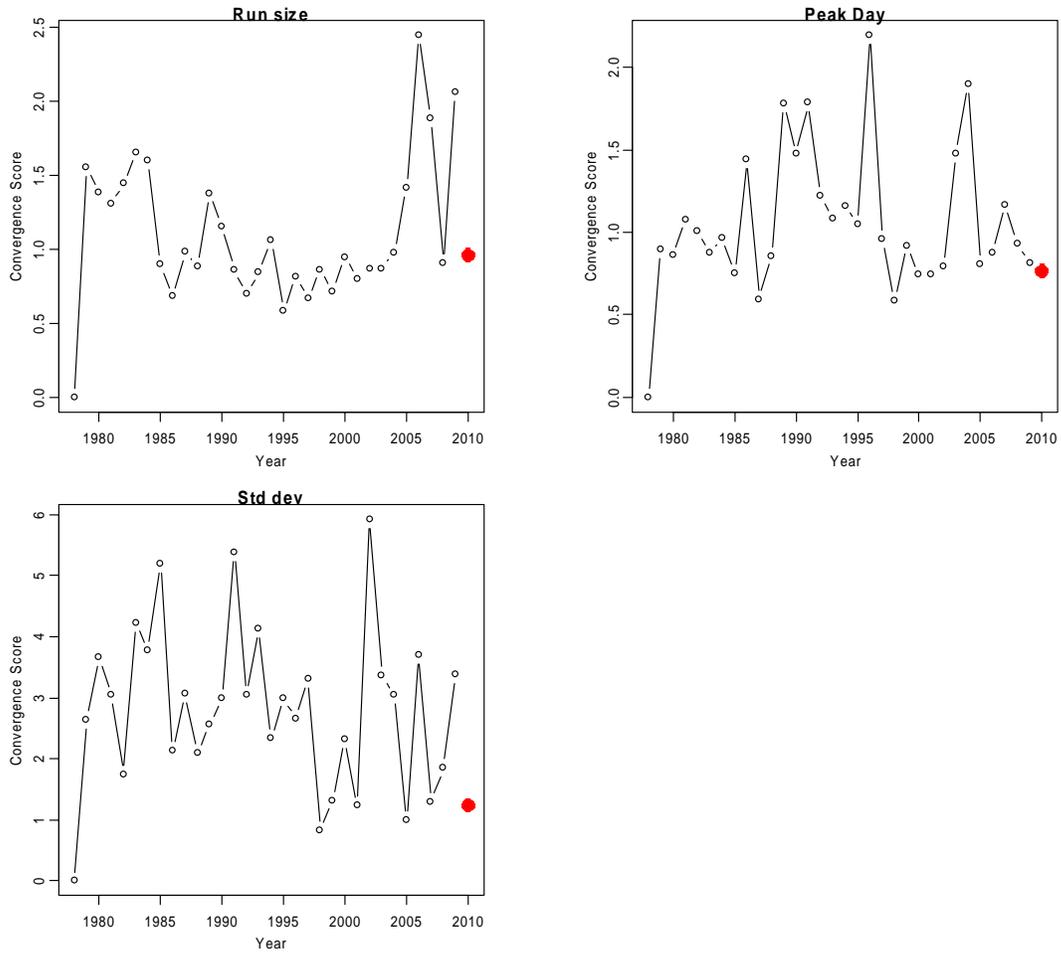


Figure 4 Retrospective convergence of the three parameters for the spring mode of the tri-modal arrival distribution in historic years. The points for 2010 based on the hybrid prediction used in-season, and the postseason targets are marked in red.

## DISCUSSION

The convergence values of the parameters are all better (i.e. lower) than last year (Figure 4), and all three parameters converged about as well as any previous year. The measure of convergence is not the same as the accuracy of the point estimates of the parameters, but rather the ability of the model to determine the true parameters as the data becomes available.

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 2), 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 less than 2 days away from the in-season, final assessment and thus the convergence was good and the final prediction for peak arrival was good.

The challenge 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 greater each year as evidenced by the ratio of the summer to spring run (Figure 5). Second, the spring mode of the run is moving later (Figure 6) 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. While not directly affecting our ability to quickly converge on the distribution parameters for the year, this does suggest that fundamental processes controlling the populations in the ocean are changing in ways that we have yet to understand.

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](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. The current scheme is not expected to be significantly different in 2011.

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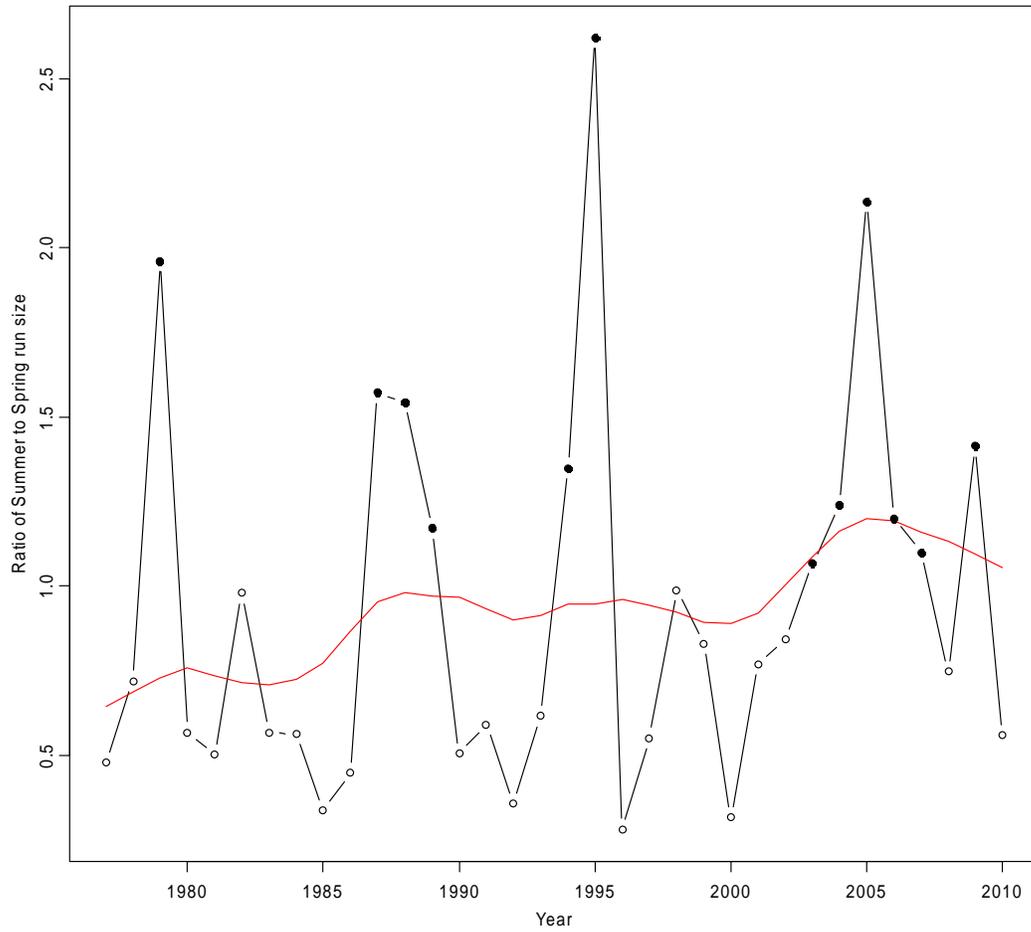


Figure 5 Ratio of Summer run to Spring run size based on retrospective fits of tri-modal run distributions. Filled points are  $>1$  (6 out of last 8 years). Red line shows smoothed trend.

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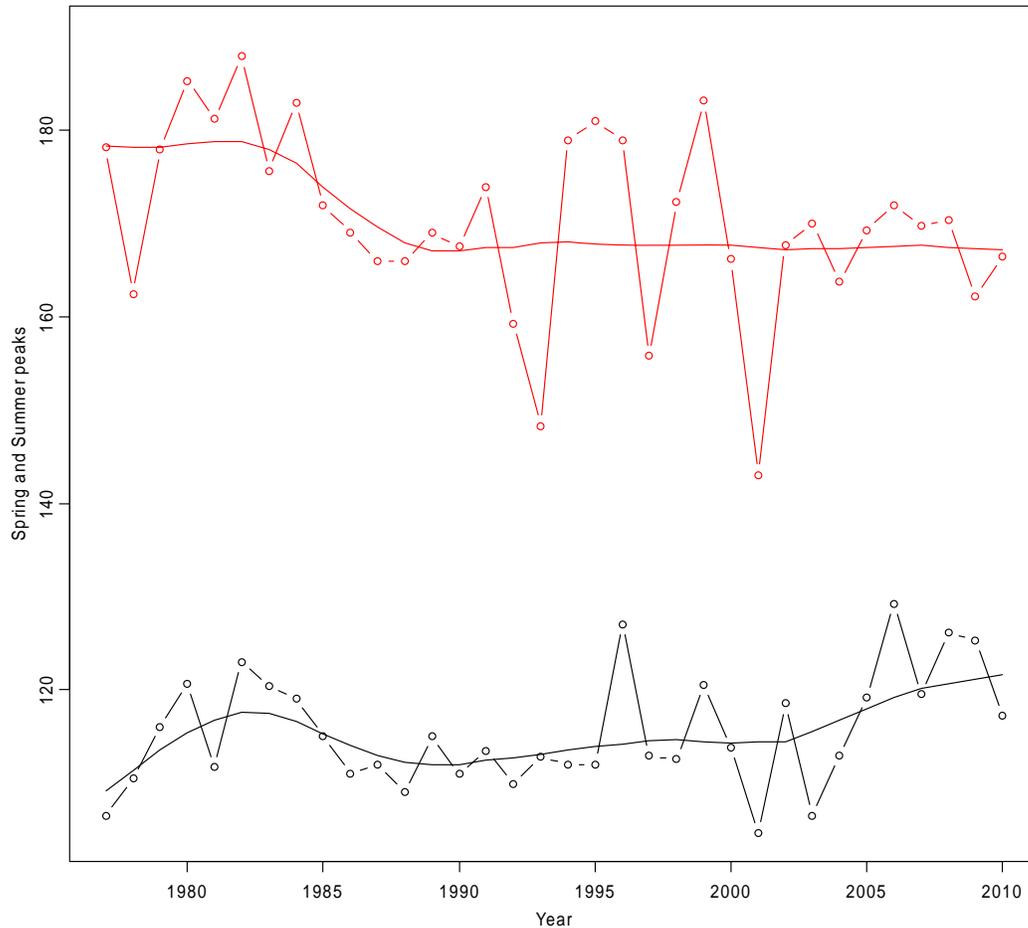


Figure 6 Changes in peak arrival of spring and summer runs. Summer in red above and spring in black below. The smoothed trend runs through the fitted points from the tri-modal distributions.

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