

1% Weir Escapement Rule

Chilkoot Lake Sockeye Salmon

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1 Background

The objectives of this analysis were to:

1. Model the tails of the run to quantify a hard ending date for weir operations – the date to which the weir would be required to be operated (e.g., would capture 95% of the escapement 95% of the time on average, based on the most recent 10 years of data).
2. Estimate the % of counts missed if the project was operated past the hard ending date until daily counts equaled less than 1% of the cumulative count for 1, 2, 3, 4, or 5 days in a row.

All associated files, data, and code are located at <https://github.com/commfish/weiRends>. This work is based upon efforts originally developed by Scott Raborn. The code was originally written by Ben Williams and then adapted by Sara Miller.

2 Data Inputs

The input data format is four columns with date (preferably in year-mm-dd format), weir count data, species, and year.

An example is:

```
date count species year
2019-07-20 20 Sockeye 2019
```

This is for a single species at a single weir. No other values or comments should be included in the file. Data should be provided in .csv format.

3 Analysis

Two models were considered:

The Gompertz model

$$pe^{-e^{-k(t-t_0)}},$$

and the logistic model

$$\frac{p}{1 + e^{-k(t-t_0)}}.$$

The variable p represents the asymptote of the cumulative escapement, k is the steepness of the curve, and t_0 is the inflection point of the curve.

The evaluation process starts by fitting both models, and then the model with the least total variance is chosen for the analysis. *Note that this is a coarse approach and is not a meaningful model comparison.* Cumulative run is predicted from the selected model and then this is converted into the number of estimated fish past the weir for a given day. A reconstructed run is estimated using observed daily data, filling in any data gaps with estimated daily escapement numbers. This reconstructed run is then used to compute a cumulative sum of escapement. The date that a weir should remain in place to capture 95% of the escapement, on average, is calculated using the reconstructed cumulative sum.

3.1 95% Mean Passage Weir Removal Date (Base Removal Date)

Based on the model deviance, the logistic model provided an overall better fit to the data than the Gompertz model. None of the parameter estimates had substantial error bars (Figure 2) and the models converged for all years. The predicted data showed a reasonable model fit for most years (Figures 3 and 4); although in some years there was a substantial difference between the cumulative sums and the fitted cumulative sums (Figure 1). Using only the 10 most recent years of data, the 95% mean passage weir removal date is 2021-08-25 (i.e., 95% of the run will have passed the weir, on average, by this date, using on the most recent 10 years of data; Julian date 237). This is the date that the weir must be operated through, i.e., removal could occur on the following day. In 32 of the data years, 95% of the run had passed the weir at a Julian date greater than the mean passage weir removal date (Julian date 237; Figure 3, Figure 4, and the Appendix).

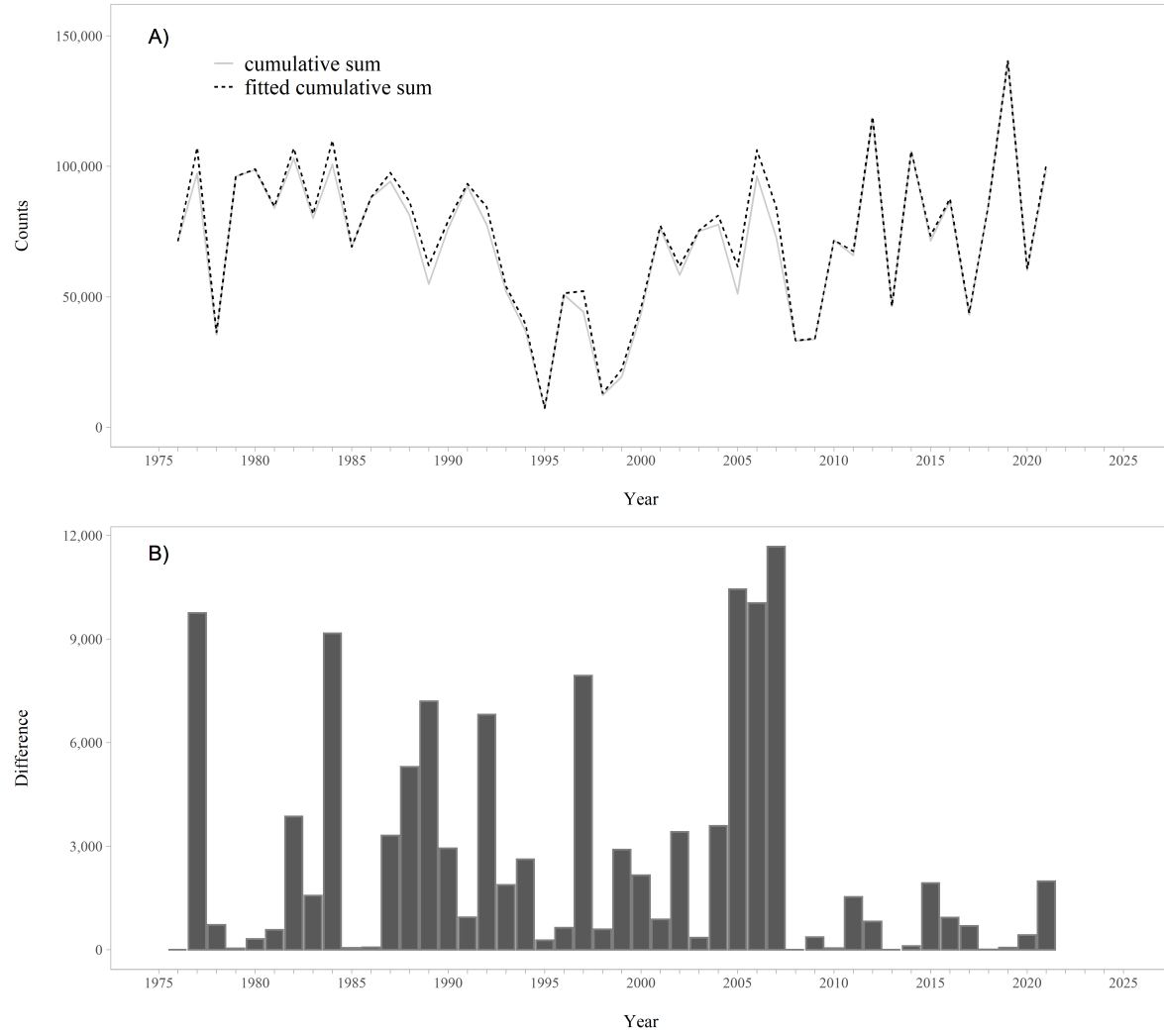


Figure 1: A. Raw and fitted cumulative sums of the weir counts by year, based on the logistic model. B. Difference between the raw and fitted cumulative sums of the weir counts by year. The difference between the raw and fitted cumulative sums is the modeled tails.

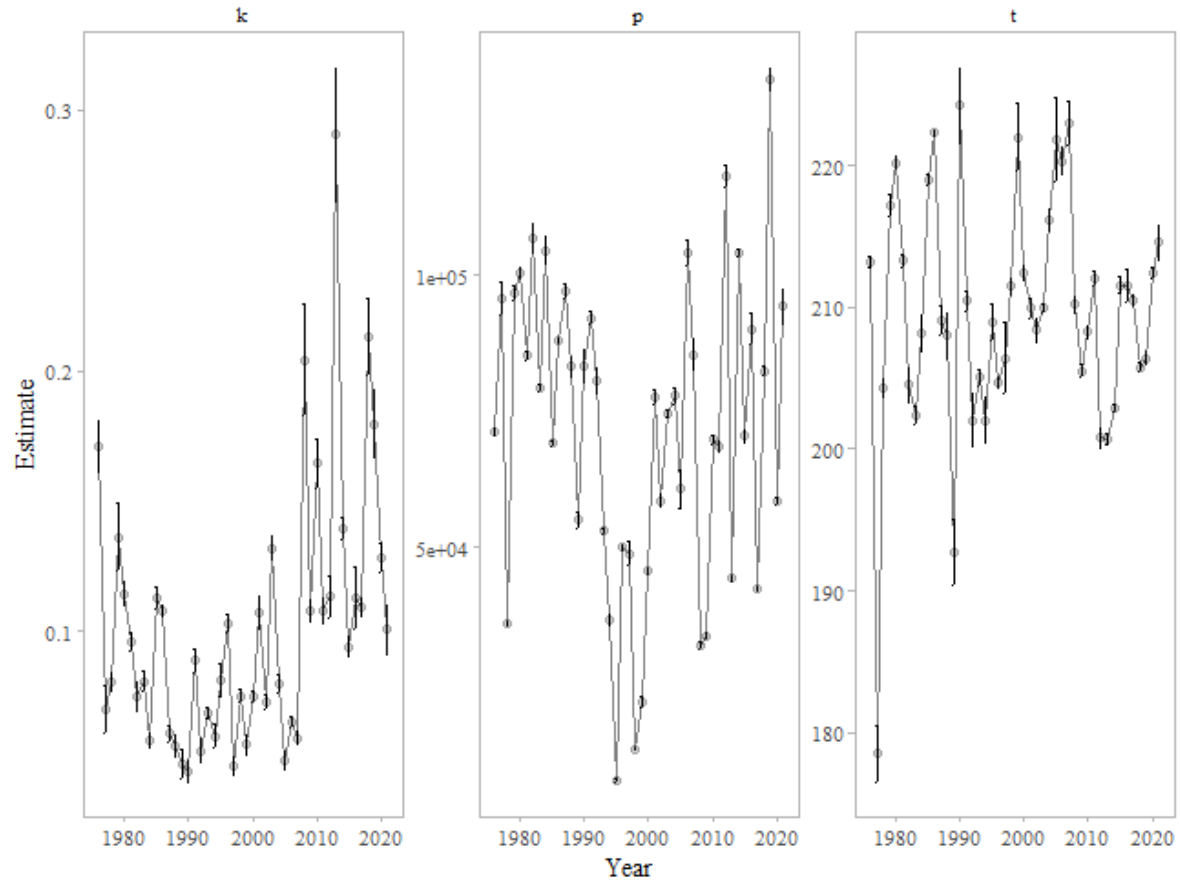


Figure 2: Parameter estimates from the logistic model for the Chilkoot River.

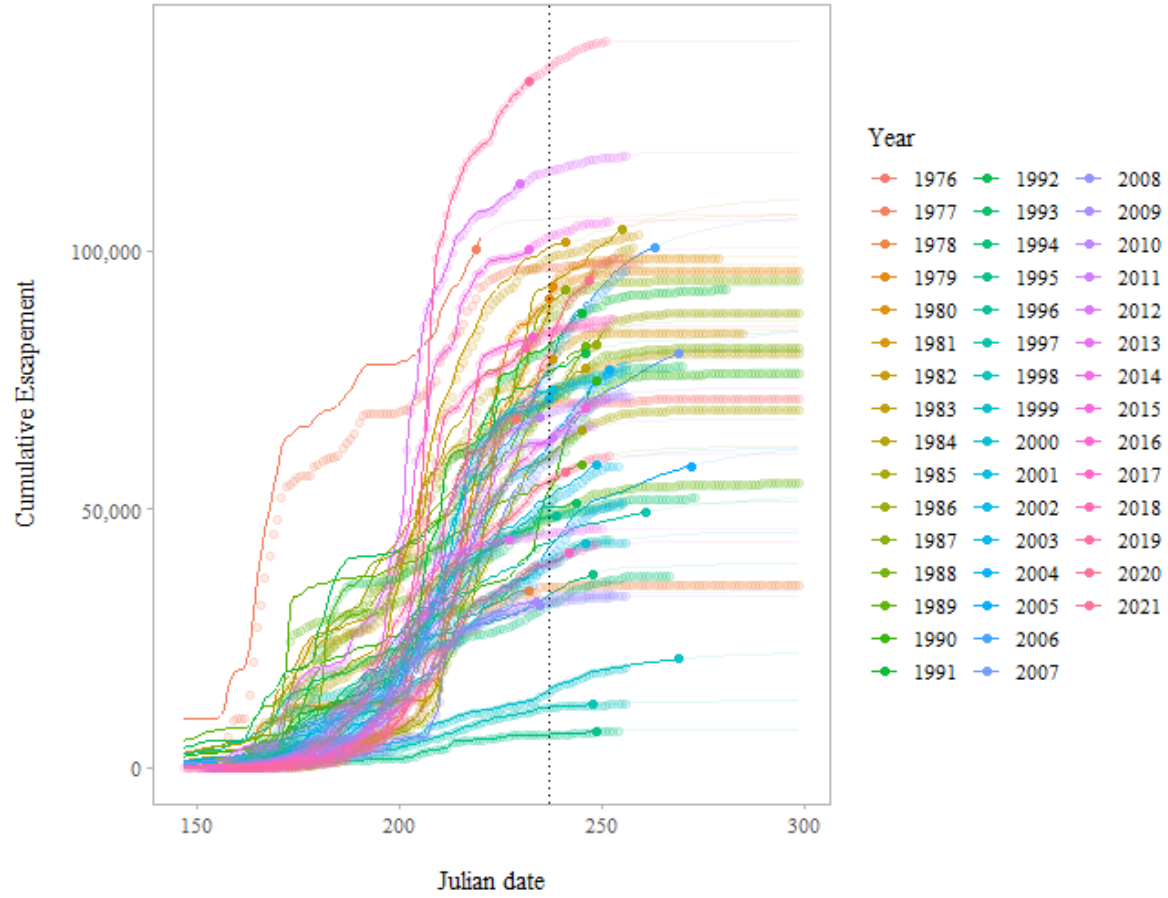


Figure 3: Predicted cumulative escapements by year for the Chilkoot River. Filled circles indicate 95% of the run has passed the weir. The vertical line is the mean date when 95% of the run has passed the weir (based on the most recent 10 years of data). The circles are the cumulative escapement data and the lines are the predicted cumulative escapements.

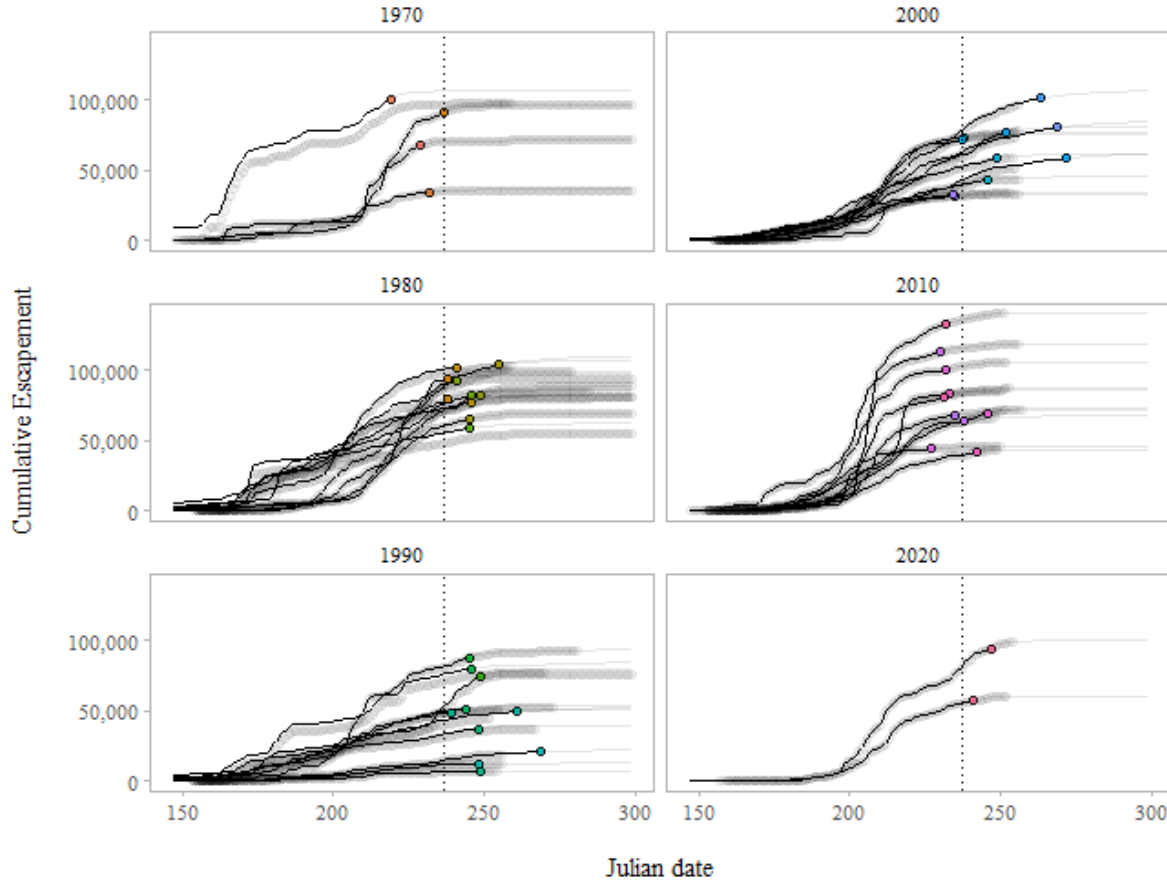


Figure 4: Predicted cumulative escapements by year and decade for the Chilkoot River. Filled circles indicate 95% of the run has passed the weir. The vertical line is the mean date when, on average, 95% of the run has passed the weir (based on the most recent 10 years of data).

3.2 1% Rule

Based upon the median weir removal dates, using the number of days to implement the 1% rule for the Chilkoot River (Table 1), there is a 95% chance of capturing 84-87% of the total run for all weir removal rules (number of days) (Table 2; day one of the 5-day rule starts at the base removal date plus one day (i.e., Julian date 237 plus one day). In addition, there is a 50% chance of capturing 94-98% of the run. This is also reflected in the percent risk as well (Figure 5); Figure 5 reflects the inverse of Table 2. For example, a 99% chance is the same as a 1% risk. About 14% of the run is missed (i.e., 86% caught) at a given risk level (99% chance or 1% risk level) based on implementing a 5-day 1% rule. Using the 5-day 1% rule extends the base removal date (based on using the average 95% mean passage weir removal date of the most recent 10 years; Julian date 237), by a few days to Julian date 245.

Table 1: Median end dates for weir removal based upon number of days to implement the 1% rule for the Chilkoot River.

days	median	l_25	u_75	date
one	243.0	243	244	2021-08-31
two	243.0	243	246	2021-08-31
three	243.0	243	247	2021-08-31
four	243.5	243	249	2021-08-31
five	245.0	243	252	2021-09-02

Table 2: The percent of the run that is caught at a given risk level (% chance) based upon the number of days the 1% rule is implemented for the Chilkoot River.

% Chance	one	two	three	four	five
99	82.5	84.4	84.9	85.3	85.8
95	83.9	84.9	85.7	86.7	87.1
90	86.0	88.0	88.0	89.0	90.4
80	90.7	92.2	92.5	92.8	94.0
70	92.0	93.0	93.5	94.3	96.1
60	93.0	94.0	95.0	96.1	96.8
50	94.4	95.1	95.8	96.7	97.5

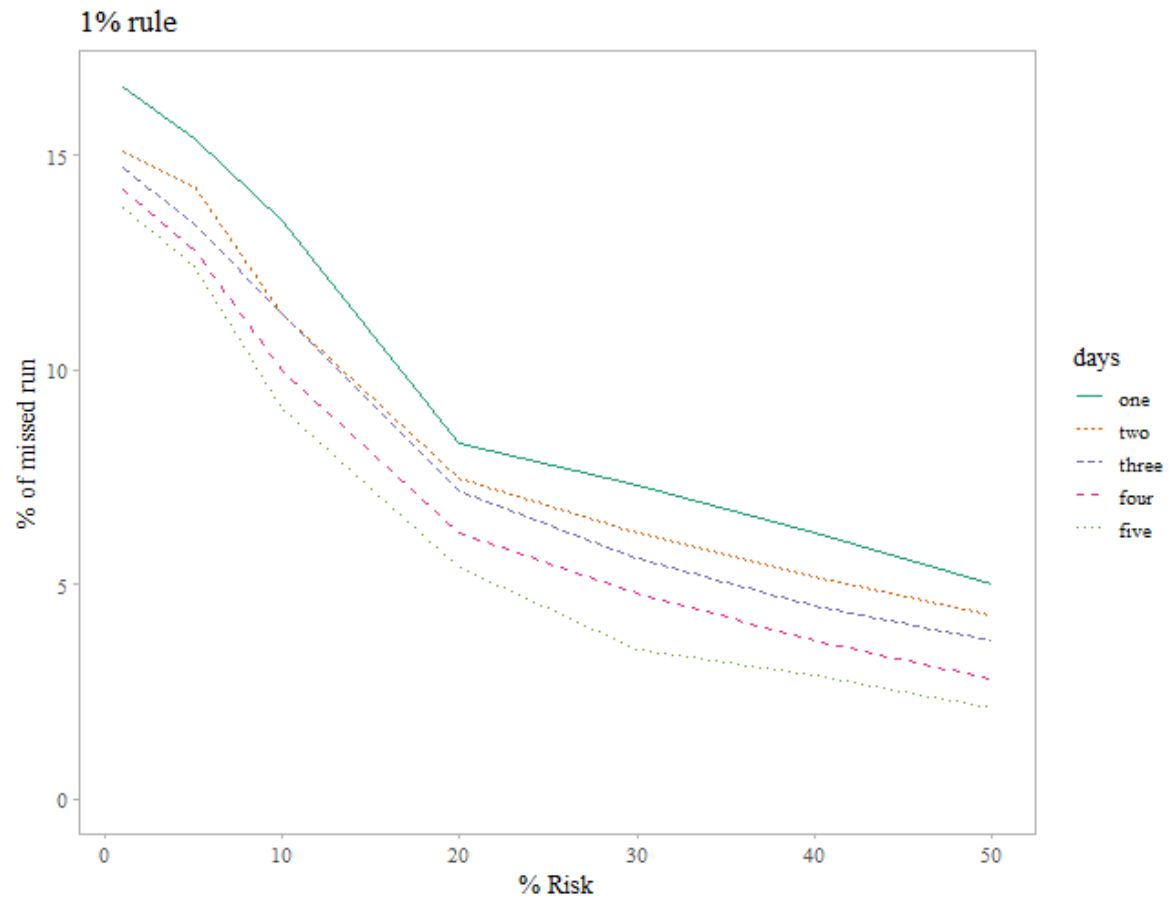


Figure 5: The percent of the run that will be missed at a given risk level, e.g., about 13% of the run will be missed 5% of the time using a 5-day 1% rule for the Chilkoot River.

4 Appendix

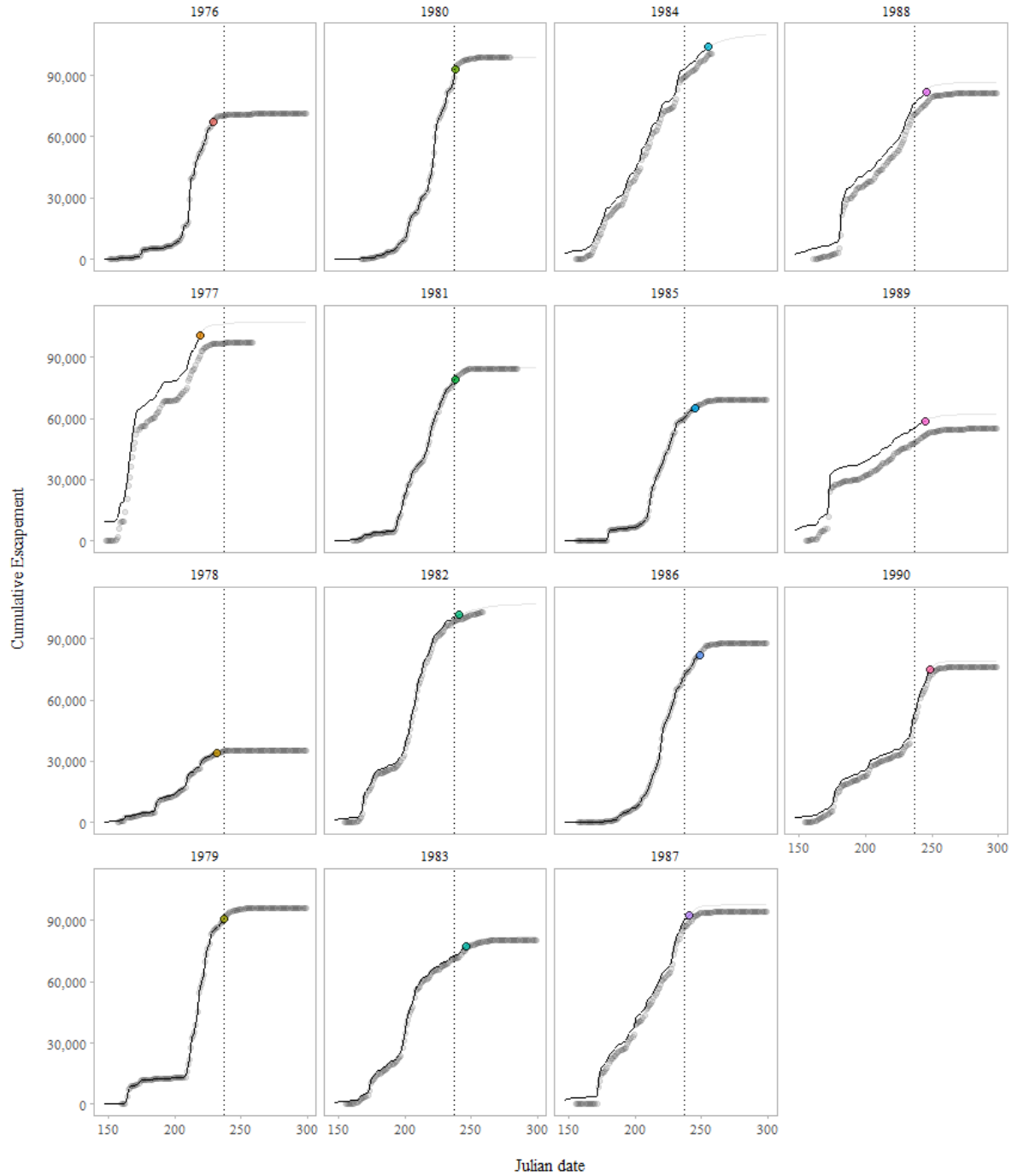


Figure 6: Predicted cumulative escapements by year for the Chilkoot River. Filled circles indicate 95% of the run has passed the weir. The vertical line is the mean date when 95% of the run has passed the weir (based on the most recent 10 years of data). The circles are the cumulative escapement data and the lines are the predicted cumulative escapements.

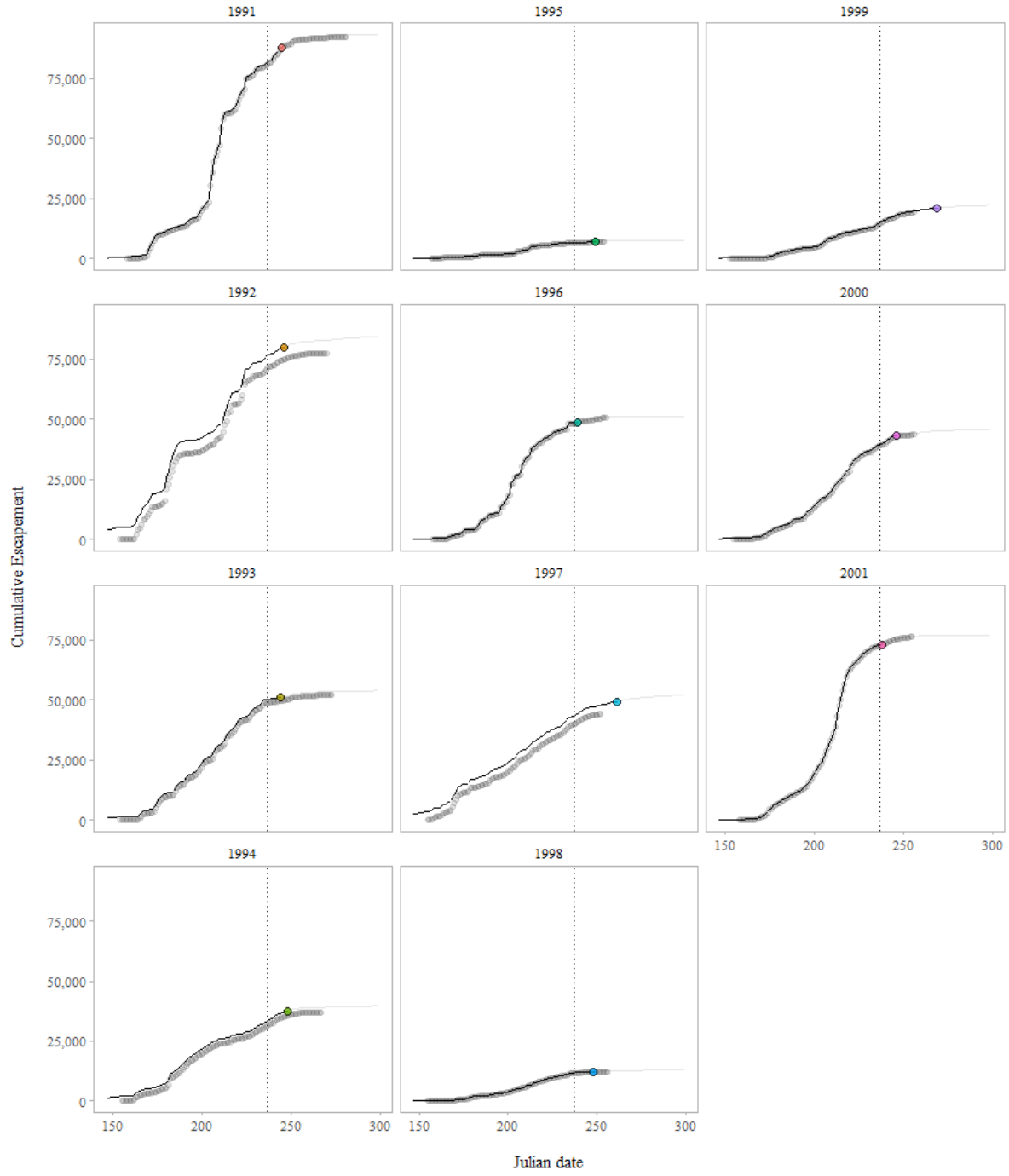


Figure 7: Predicted cumulative escapements by year for the Chilkoot River. Filled circles indicate 95% of the run has passed the weir. The vertical line is the mean date when 95% of the run has passed the weir (based on the most recent 10 years of data). The circles are the cumulative escapement data and the lines are the predicted cumulative escapements.

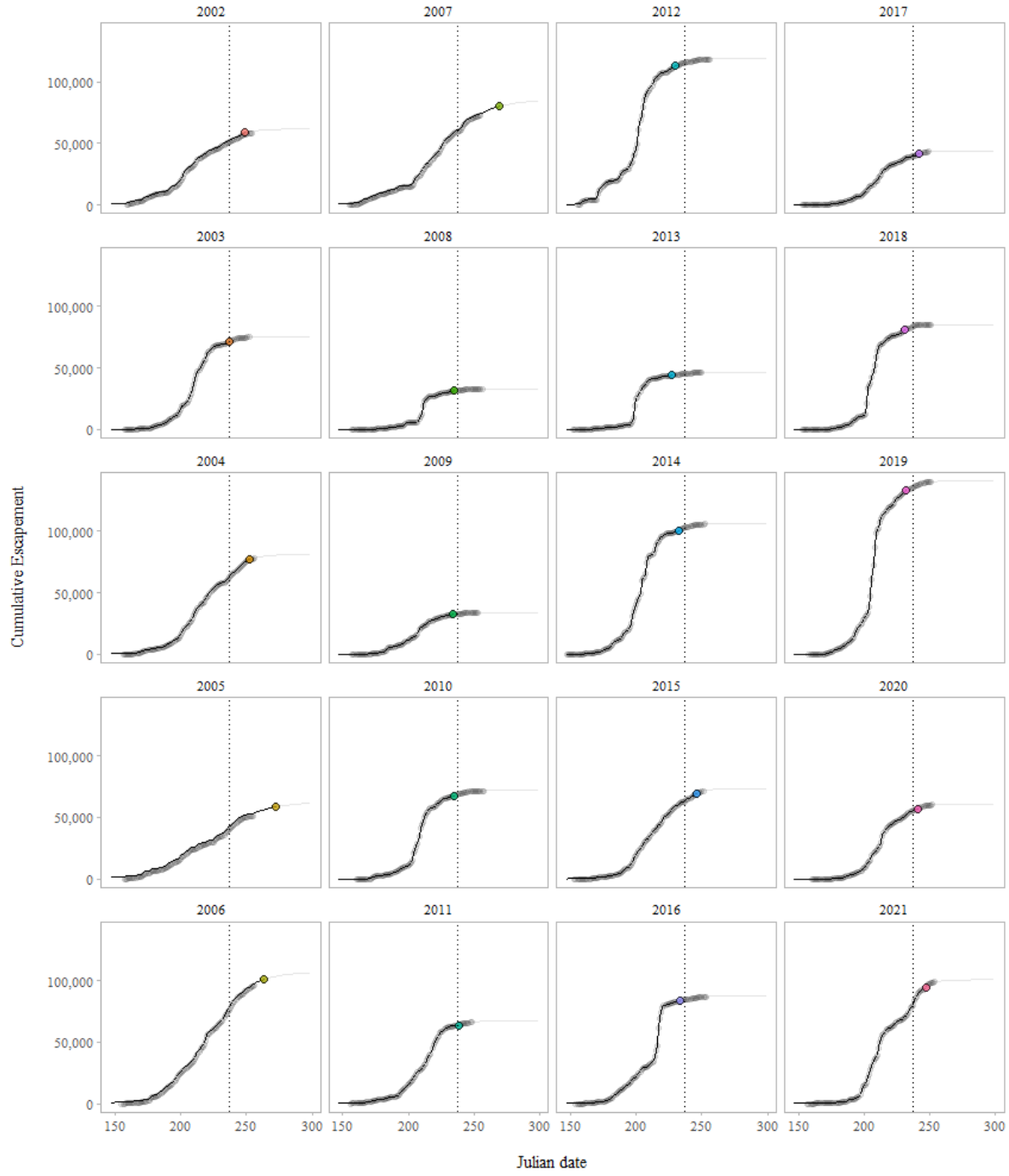


Figure 8: Predicted cumulative escapements by year for the Chilkoot River. Filled circles indicate 95% of the run has passed the weir. The vertical line is the mean date when 95% of the run has passed the weir (based on the most recent 10 years of data). The circles are the cumulative escapement data and the lines are the predicted cumulative escapements.