Evaluation of the 2011 Predictions of Run-size and Passage Distributions of Adult Chinook Salmon [*Oncorhynchus tschawytscha*] Returning to the Columbia and Snake Rivers

Technical Report

Postseason Analysis
January 2011 – December 2011

Prepared by:

W. Nicholas Beer
Susannah Iltis
James J. Anderson

Columbia Basin Research
School of Aquatic and Fishery Sciences
University of Washington
Box 358218
Seattle, WA 98195

Prepared for:

United States Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97208

Project No. 1989-108-00
Contract No. 00055905

June 2012

Executive Summary

This report is a postseason analysis of the accuracy of the 2011 predictions from Escapement Forecaster / Adult Upstream Model. The effectiveness of these modeling efforts are compared to observations of passage and river conditions at the end of the season. A pattern matching routine forecasts total run-size and run timing (daily passage) by optimally correlating the shape of the current year's cumulative passage (to date) with truncations of historical cumulative passage data. At the end of the season, for each stock at each observation site, we compute the Mean Absolute Deviation (MAD) for the passage distributions which is a broad measure of the average error in daily passage percentage estimates. For spring and fall Chinook in 2011 it was 1.9% and 3.4% respectively. The maximum daily errors were 7.2% and 14.5% respectively.

Table of Contents

List of Figures

List of Tables

Introduction

Visual counts of returning adult Chinook have been made at Bonneville Dam each year since 1938. The detection of adult Chinook at Bonneville and upstream dams provides a measure of the temporal distribution of the returning adult salmonid populations.

The adult upstream "RealTime" forecaster/passage model was developed to predict the current season's adult salmon run-size at Bonneville Dam and run timing from the Bonneville Dam Tailrace to the upstream dams on the Columbia and Snake Rivers. The forecaster consists of an Escapement Forecaster (EF) that predicts the arrival timing and run-size of adult salmon at Bonneville Dam and an Adult Upstream Model (AUM) that predicts the passage timing of the fish at dams above Bonneville Dam. Each day the predictions are updated on the web.

During the 2001 migration season, Columbia Basin Research launched a prototype run timing system, EF /AUM, to predict run timing with results updated on the World Wide Web. This project was launched in an effort to provide real-time in-season projections of adult salmon migration to managers of the Columbia-Snake River hydrosystem to inform decisions about mitigation efforts such as in-river harvest. The program EF uses an empirical pattern matching routine to predict the arrival distributions for adult Chinook salmon stocks at the first detection point in the migratory route, Bonneville Dam. The AUM model takes the predictions from EF and uses hydrological, fish behavioral and dam geometry information to simulate the movement of the adult salmonid through mainstem Columbia and Snake River dams.

This report is a postseason analysis of the accuracy of the 2011 predictions from EF/AUM. Model results are compared to observations of passage and river conditions at the end of the season. We also compare key results to previous seasons.

Methods

Data

Escapement and travel time data

The fish analyzed in this report are adult spring and fall Chinook salmon returning to spawn in tributaries (or hatcheries) of the Columbia and Snake Rivers above Bonneville Dam. For the escapement forecasts, the daily visual counts of returning adult Chinook data come from Bonneville Dam. To assess our upstream run timing predictions, the daily visual counts come from additional detection sites at McNary and Lower Granite Dams. Data is retrieved from a link to the Columbia River DART database and provided as a courtesy by U.S. Army Corps of Engineers, NWD (http://www.nwd.usace.army.mil).

Flow and other system operations data

Any forecast of fish movement relies critically on accurate forecasts of flow, and other key system operations. The U.S. Army Corps of Engineers generates operational forecasts at all projects on the Columbia and Snake Rivers where there is fish passage. Water supply forecasts are based on a number of factors: the National Weather Service’s Northwest River Forecast Center predictions, flood control requirements from the Army Corps, electrical power demand forecasts, and other criteria. The substantial uncertainty associated with springtime conditions often results in frequent and marked changes in these forecasts during April and May. Moreover, attempts to reduce the biological impacts of dissolved gas generated from high spill levels also results in a shifting of spill between projects within as well as outside the basin. Although the forecasts covered as much as 90 days into the future, it must be recognized that their intended use was in deciding operations for the next week. Forecast accuracy beyond even a few days was itself uncertain. On a monthly basis throughout the season, Bonneville Power Administration provides CBR staff with a long-term system operations forecast.

On a daily basis, forecasts for flow, spill, and elevation are replaced with observations with a query to the

Columbia River DART database (CBR 2011a), which includes water quality data from the Army Corps for the majority of monitoring sites in the Columbia Basin. Subsequent fish arrival predictions are therefore based on the forecasted values for flow and spill and the latest available observed data.

Temperature data

The temperature time series is a combination of year-to-date temperature data and forecasted temperatures. The forecasts are based on observed year-to-date temperature and flow data, historical average temperature and flow profiles for 15 locations in the Snake and Columbia rivers, and the flow forecasts. Historic and observed year-to-date data was obtained from the Columbia River DART database. Temperature predictions are made by applying a three-day moving window to fit predicted temperature time series to historical average patterns of temperature change; this method is described in detail in Beer et al. (2004).

Table 1 U.S. Army Corps of Engineers fixed monitoring sites and USGS gaging stations used for temperature forecasts.

Monitoring Locations	AUM Model Input Locations
Chief Joseph Forebay	Columbia Headwater
Wells Forebay	Methow Headwater
Rock Island Forebay	Wenatchee Headwater
The Dalles Forebay	Deschutes Headwater
Anatone, WA USGS	Snake Headwater
Peck, ID USGS	Clearwater Headwater
Peck, ID USGS	North Fork Clearwater Headwater
Peck, ID USGS	Middle Fork Clearwater Headwater
Anatone, WA USGS	Salmon Headwater
Wells Forebay	Wells Pool
Rocky Reach Forebay	Rocky Reach Pool
Rock Island Forebay	Rock Island Pool
Wanapum Forebay	Wanapum Pool
Priest Rapids Forebay	Priest Rapids Pool
Lower Granite Forebay	Lower Granite Pool
Little Goose Forebay	Little Goose Pool
Lower Monumental Forebay	Lower Monumental Pool
Ice Harbor Forebay	Ice Harbor Pool
McNary Forebay	McNary Pool
John Day Forebay	John Day Pool
The Dalles Forebay	The Dalles Pool
Bonneville Forebay	Bonneville Pool

Archives of model predictions

The results of EF/AUM runs are stored on the Columbia Basin Research web site (CBR 2011b). Graphs based on the results are available through web-based query tools at http://www.cbr.washington.edu/crisprt/index_adult.html. Runs are made daily and include daily passage distribution forecasts and run-size forecasts.

Models

Initial Run size

The year's initial run-size is determined from a linear regression of each year's adult return vs. the previous year's jack return and environmental conditions. The timeframe for the spring run at Bonneville is March 15 to June 15 and the timeframe for the fall run is August 1 to November 15. The spring run was predicted as 209,000 based on:

Adult.count = 37410 + .2479 * *Last.Year.Adult.count* + 0.0510 * *Jack.count*Last.Year.August.Upwelling*, $r^2 = 0.85$.

Escapement Forecaster

The Escapement Forecaster predicts the arrival timing and run-size of adult salmon at Bonneville Dam. It consists of an expected distribution based on the previous year's jack counts in the early season, and switches to a pattern matching algorithm in the later season. There is also a blending routine to switch smoothly between the jack-based and pattern match methods.

The arrival distribution is taken as the historic daily mean scaled to produce the correct total run-size. The pattern matching routine forecasts total run-size and run timing (daily passage) by optimally correlating the shape of the current year's cumulative passage (to date) with truncations of historical cumulative passage data. This returns the fraction of the run complete, *f*. Total run-size is then predicted by $\tilde{r} = P_c / f$ where P_c is the total passage (current year) to date.

To compare the current year's passage to that of historic runs, the cumulative current passage data is partitioned into N time intervals. The pattern matching optimization is performed as least-squares minimization; comparing slopes S_i^c over each subinterval *i* of the current run with slopes $S_i^h(f)$ of subintervals of each historic year run truncated after *f* fraction of the historic run has passed. The optimization to determine *f* is then performed as:

$$\underset{f \in (0,1)}{\text{minimize}} \sum_{h \in H} \sum_{i=1}^{N} \left(S_i^c - S_i^h(f) \right)^2$$

where *H* is the set of historical data years being used.

After the pattern matching method determines the completed fraction *f* of the current run, the passage forecast for each remaining day of the season is produced by appending the historic daily mean passage for each day of the final $1-f$ fraction of the season, scaled to produce the correct total run-size. In this way, the forecast may be a forward or backward shift in time as compared to the historic average, thereby forecasting not just run-size, but also run timing.

Adult Upstream Model

The Adult Upstream Model (AUM) describes in detail fish movement through reaches and dams and the effects of various river operations on their migration. For in-season forecasts, we use the projected escapement at Bonneville as input to AUM and predict the arrival timing at the upstream dams. The model contains a temperature and flow based submodel for reservoir passage and submodels for dam passage, fallback and straying. In addition, it includes a bioenergetic model to predict fish migration energy consumption. River flow and temperature are modeled using portions of the COMPASS smolt passage model. Fish travel time has been calibrated using PIT-tag data of adult Chinook detected at multiple dams following the method of Salinger and Anderson (2006). The temperature and flows encountered by upstream migrating salmon are the main factors determining reach migration speed and a submodel controls this process. The flow encountered should subtract directly from the swimming speed in order to compute net up-river velocity. Because oxygen metabolism of Chinook is optimal at about 17°C, the sustainable swimming speed is also optimal at about 17°C. To represent this, we use a broken linear model for the net up-river velocity V_M in terms of temperature θ and flow *F*:

$$V_M = \begin{cases} \beta_0 + \beta_1\theta + \beta_3 \mathrm{F}, & \text{where } \theta \le \tilde{\theta} \\ \beta_0 + \beta_1\tilde{\theta} + \beta_2(\theta - \tilde{\theta}) + \beta_3 \mathrm{F}, & \text{where } \theta > \tilde{\theta} \end{cases}$$

where β_0, β_1, β_2 and β_3 are the coefficients and $\tilde{\theta}$ is the break point (approximately 17°C). In each reach, the travel time distribution is determined by the migration velocity V_M and by the rate of spreading V_{VAR} (Zabel and Anderson, 1997). Salinger and Anderson (2006) more fully develops the net up-river velocity submodel. The migration velocity parameters and the spread parameter (V_{VAR}) are determined from historical data using an optimization routine that compares model predicted passage distributions to observed ones. The arrival distributions were constructed from PIT-tag data of fish detected at lower and upper dams. These are combined into weekly cohorts with known travel time median and standard deviation. The cohorts create a *release* distribution at Bonneville Dam, and the model results are compared to the observations using least-squares optimization to pick the best parameterization of the model. Fall-back and dam delay are components contributing to the distribution of travel times for the fish.

The travel time parameters used for modeling passage in 2011 are shown in Table 2.

Table 2 Calibration parameters used for AUM runs in 2011.

Stock	Years	b0	bTemp	bFlow	vVar	R^2 (Model vs.Obs.)
Snake Spring	2001-2010	-47.0946	-1.5702	12.5731	92.7221	0.81
Snake Fall	2001-2010	-11.7618	-4.7013	8.8822	221.1399	0.86
UC Spring	2002-2010	41.9984	-1.0080	1.7434	28.6857	0.81
UC Fall	2003-2010	- 9.2297	1.8737	2.7201	2391.0635	0.9
Yakima (All)	2002-2010	-12.8538	-2.4660	9.6807	87.7347	0.43

[a]The parameters for Upper Columbia Fall are also applied to Lower Columbia Fall stocks.
[b]The parameters for Snake Spring are also applied to Lower Columbia Spring stocks.

Schematic of data and modeling

The relationship of the data and models is depicted in Figure 1.

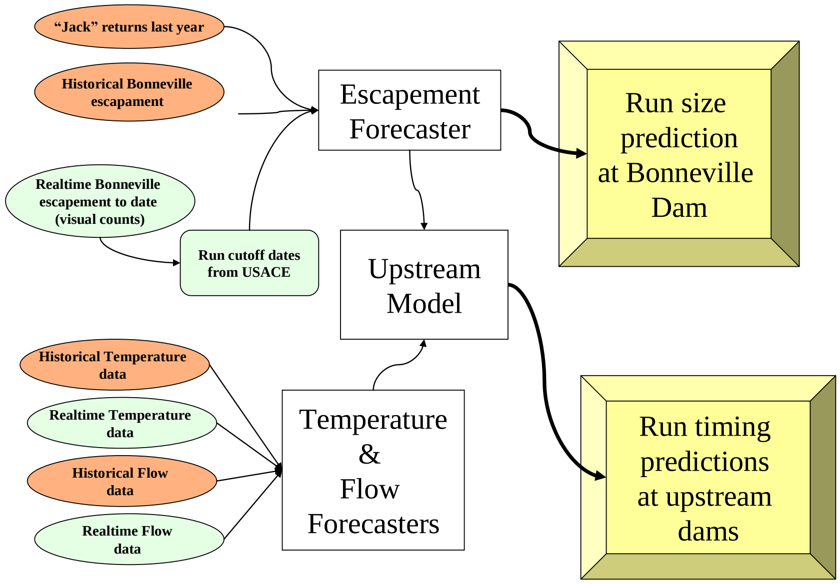


Figure 1 Schematic of data, models and products. Brown is used for historical data, green is real time up-to-date information, white boxes are modeling processes and the yellow frames are final products.

Postseason Assessment of Predictions

Mean Absolute Deviation

To assess the performance of run-size predictions, we compute the first day when the run-size estimate was within 10, 20 and 30% of the true run-size, and we determine what percent of the run had been completed on that day. Run size predictions are important for catch allocations, and compliance with federal and state regulations on fishery management. There is no established standard by which these predictions are evaluated.

To assess the performance of passage timing predictions, we apply the same measure used to assess RealTime/COMPASS predictions (Beer et al. 2008). For each stock at each observation site, we compute the Mean Absolute Deviation (MAD) for the day (*j*) on which the prediction was made. This measure is based on the average deviation between predicted and observed cumulative passage on prediction dates during the season. MAD is computed as:

$$MAD_j = \frac{1}{N}\sum_{t=1}^{N}\left|F_{Day_t} - \hat{F}_{Day_{tj}}\right| \times 100$$

where:

j = forecast day on which MAD_j is calculated;
t = index of prediction day (from 1 to N);
N = number of days on which a prediction and observation were made for the stock at the site during the season;
Day = vector of length N which identifies the days of the year from first observation of the stock at the site until two weeks past last observation (this is fixed for each site and each stock);
F = observed cumulative passage on Day_t; and
$\hat{F}$ = predicted cumulative passage on Day_t.

The MAD summation is performed over each of the dates on which model predictions were implemented – approximately every day during the season. This provides a snapshot of how well the model performs as the season progresses based on the final, "true" data. Ideally, there would be general decrease in MAD as t

goes from 1 to N because the true distribution of the run should be better known and the true state of the flow and spill profiles should be known.

A second measure for run timing is the Maximum Absolute Daily Deviation (MADD)

$$MADD = \max\left\{\left|F_{Day_t} - \hat{F}_{Day_t}\right|\times 100\right.$$

All estimates of the run passage percentage are as good or better than this estimate.

Results

Initial Run-size

The preseason estimates were 32% too low for the fall abundance and within 2% for the spring abundance (see Table 7).

Escapement Forecaster

The escapement forecaster predicted within 20% of the final spring run size on day 87 (March 28), well in advance of the prediction for the previous six years (range: day 109 to 134). The fall prediction was more typical (day 248, Sept. 5, range 234 to 255). The predicted daily passage percentile time series and observed distribution are shown in Figure 3and Figure 4.

Daily predictions for 2011 can be viewed from the Forecast Archive web page, at http://www.cbr.washington.edu/crisprt/archive.html. Alternative targets (10%, 20% and 30%) were each evaluated and are summarized in Table 5.

Run Timing

The EF/AUM model is run daily and upstream passage predictions are archived. Predictions are compared to observations of passage at the end of the migration season. See the figures in the Appendix for passage predictions on several days and the end-of-year observations.

We track the success of these predictions by comparing the estimated percentage passed on each day with the observed passage percentage. For the spring run at Bonneville, the Mean Absolute Deviation (MAD) was 1.9%, the second best in eight years. The worst daily prediction, the maximum absolute daily deviation (MADD) was 7.2% on day 134 (May 14).

These results and others since 2003 are summarized in Table 4

Preseason 2012

For 2012, a single model will be used for the spring Peak run size prediction. The identical form is also to be used for CBR's Escapement Forecaster model. See http://cbr.washington.edu/crisprt/index_adult.html. Abundances are predicted according to the previous year's arrivals of Jacks and Adults and an interaction term with environmental conditions that affects the Jack-to-Adult conversion rate. The expression is:

$$Adult = LYAdult + LYJacks : LYUpwelling$$

The index of Upwelling used is August at 42°N approximately where the sub-arctic current makes landfall on North America. Conditions at this location are highly correlated with conditions along the coast and thus are a single measure of environmental variability with broad impact

Current preseason values are available at http://www.cbr.washington.edu/crisprt/adult_preseason.html.

The fall run is anticipated to be 471,000 and the spring run 591,000. Due to favorable ocean conditions and good returns of both Jacks and Adults in 2011. See Figure 5 and Figure 6. This forecasting method is also applied retrospectively by first calibrating the model with historic data and forecasting the next year. All retrospective predictions since 2001 are shown in Table 3. This time period covers a range of PDO and ENSO conditions. Although the Escapement Forecaster does not predict or track the "summer" run of Chinook to the Columbia River. A retrospective prediction is included here using the same methods. One difficulty in predicting the spring run when using a calendar-based cut-off date is that the run is truncated arbitrarily. Stocks that naturally return near the cut-off date may be included in one group in one year and the other group in a different year. The separation between the summer and fall runs is fairly clear by comparison.

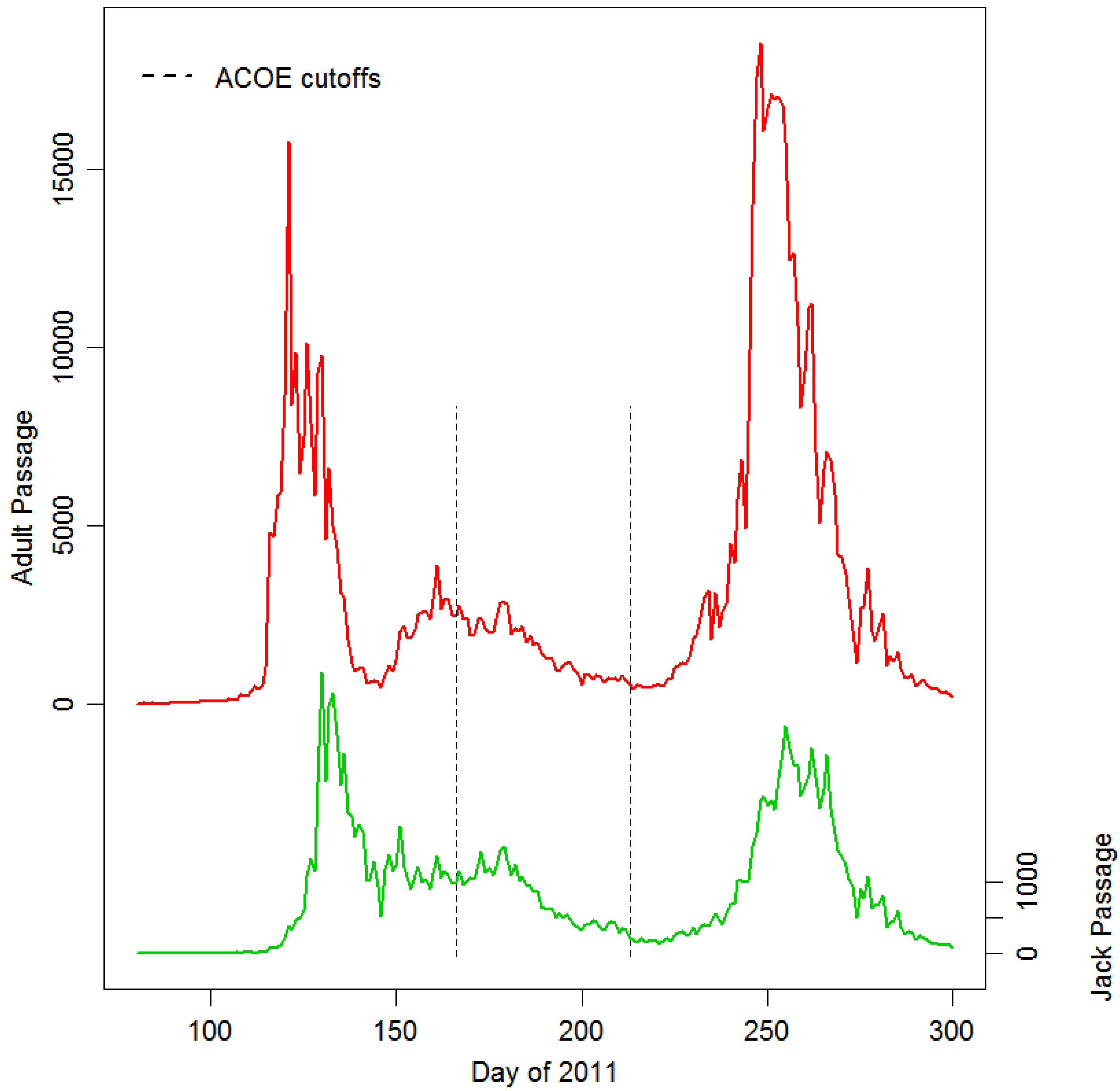


Figure 2 Passage of Chinook at BON in 2011 with calendar cutoff dates shown.

Table 3 Retrospective fitting of adult abundance

Spring Calendar	R^2	N	Prediction year	Prediction	Observed	SE	pre/obs	Avg.
2001	0.848	21	2002	264899	308180	69561	0.9	
2002	0.882	22	2003	253091	225741	20470	1.1	
2003	0.887	23	2004	325885	196290	18920	1.7	
2004	0.828	24	2005	122820	97384	14140	1.3	
2005	0.825	25	2006	113908	126156	8230	0.9	
2006	0.824	26	2007	109076	80807	8066	1.3	
2007	0.822	27	2008	131473	150082	9672	0.9	
2008	0.821	28	2009	166220	147470	8642	1.1	
2009	0.820	29	2010	344990	277350	28745	1.2	
2010	0.827	30	2011	211349	205382	15605	1.0	
2011	0.832	31	2012	591443	NA	51195	NA	1.14
Fall Calendar	R^2	N	Prediction year	Prediction	Observed	SE	pre/obs	
2001	0.764	21	2002	334424	473786	31360	0.7	
2002	0.794	22	2003	431281	610075	38086	0.7	
2003	0.833	23	2004	620186	583754	52346	1.1	
2004	0.876	24	2005	474849	417057	46347	1.1	
2005	0.880	25	2006	354484	299161	19513	1.2	
2006	0.875	26	2007	280878	161415	11115	1.7	
2007	0.849	27	2008	160976	315279	13168	0.5	
2008	0.804	28	2009	262396	283691	16736	0.9	
2009	0.803	29	2010	301363	467524	12477	0.6	
2010	0.770	30	2011	447115	401250	24166	1.1	
2011	0.775	31	2012	471438	NA	27705	NA	0.86
Spring and Summer	R^2	N	Prediction year	Prediction	Observed	SE	pre/obs	
2001	0.859	21	2002	324339	396249	78198	0.8	
2002	0.900	22	2003	343716	306818	25972	1.1	
2003	0.908	23	2004	412142	261846	21368	1.6	
2004	0.855	24	2005	164511	153248	18720	1.1	
2005	0.854	25	2006	150943	193975	8762	0.8	
2006	0.849	26	2007	156001	114506	10473	1.4	
2007	0.844	27	2008	160057	203525	10167	0.8	
2008	0.840	28	2009	193285	196461	9591	1.0	
2009	0.841	29	2010	368797	341988	27120	1.1	
2010	0.857	30	2011	282662	275376	17082	1.0	
2011	0.863	31	2012	769476	NA	64063	NA	1.07

Discussion

Predictions of passage at Bonneville shape the forecasts of passage at other dams, so all the predictions are sensitive to these important first observations. Any errors end up affecting upstream passage predictions, and run-size predictions interact with the passage percentage predictions. One measure of this error, the Maximum Absolute Daily Deviation (MADD), was a low 7.2% for the spring Chinook and a more typical 14.5% for fall Chinook. The spring fish arrived “smoothly” but later than expected.

In early 2011, Pacific Fishery Management Council (PFMC 2011) issued a preseason forecast of ocean escapement for various stocks. Their predictions are a significant forecast that is used by various agencies for fishery management purposes. Although their predictions are different —ocean escapements not dam arrivals— the overall numbers are an index of the escapement that could be expected in the river. We always expect Bonneville passage to be less than the ocean escapement due to turnoffs and harvest. The PFMC Fall Chinook are divided into 5 distinct stocks. Three of them (MCB, URB and SCH) pass Bonneville Dam (and are enumerated as the fall run) and the other two are lower river stocks. Subsequent referrals to the PFMC predictions of fall Chinook will ignore the lower river fish. There is also a Spring Chinook and Summer Chinook prediction. Highlights of their predictions (PFMC 2011) and postseason analysis (PFMC 2012) are shown in Table 6. There are no other estimates of stock run-size for Chinook entering the Columbia.

The fall run is easier to model than the spring run, especially when run size is well predicted, because the timing is much more consistent than the spring run. The jack/adult relationship is shown in Figure 6. For fall Chinook at upstream dams, the final destinations are not certain for any fish arriving on any given day, so a relatively small runs like fall Chinook passing WEL or heading to the Yakima are not a symetrical part of the larger fall run. The stock separation algorithm that routes fish to upstream locations in AUM is dependent on the expected distribution to upstream locations based solely on the previous year's distributions and the timing of the current run relative to the previous year. The best available stock separation fractions are determined daily according to the methods of Beer (2008).

Results and Discussion Figures and Tables

Table 4 Summary of Mean Absolute Deviation (MAD) and Maximum Daily Deviation (MADD) results for the last six years (BON).

Measure	Year	Spring Chinook	Fall Chinook
MAD	2011	1.9%	3.4%
	2010	1.2%	2.5%
	2009	7.0%	2.6%
	2008	5.7%	2.2%
	2007	2.6%	4.7%
	2006	9.5%	5.7%
	2005	3.9%	3.0%
	2004	3.7%	4.8%
	2003	6.7%	3.9%
MADD (day)	2011	7.2% (134)	14.5 (244)
	2010	6.6% (107)	14.1% (266)
	2009	20.0% (118)	13.8% (246)
	2008	30.4% (118)	10.5% (248)
	2007	11.2 % (114)	17.1 % (261)
	2006	43.8% (121)	20.1% (261)
	2005	25.0% (121)	17.7% (244)
	2004	16.4% (114)	14.2% (254)
	2003	18.4% (103)	19.3% (253)

Table 5 Earliest day in 2011, after which the final run-size prediction was within the error specified (10% 20%, or 30%) . In parenthesis, corresponding dates for 2010, 2009, 2008, 2007, 2006 and 2005 respectively.

Stock	Within 10%	Within 20%	Within 30%
Spring	**126** (118, 147, 140, 149, 161, 126)	**87** (109, 129, 126, 128, 134, 126)	**87** (109, 126, 125, 117, 133, 127)
Fall	**263** (268, 264, 243, 267, 269, 249)	**248** (252, 247, 234, 243, 255, 250)	**248** (243, 218, 215, 243, 247, 251)

Table 6 MAD values and MADD values (in parentheses) for other dams in 2011

Site	Spring	Fall
TDA	2.0 (10.5)	4.3 (16.0)
JDA	2.8 (9.9)	3.5 (13.4)
MCN	3.5 (17.9)	4.6 (16.5)
IHR	7.0 (25.4)	5.8 (22.0)
LMN	6.8 (19.6)	5.7 (22.2)
LGS	7.9 (32.8)	5.5 (19.7)
LWG	8.3 (31.4)	6.4 (23.7)
PRD	3.5 (13.9)	4.4 (16.5)
WEL	3.0 (13.9)	8.4 (31.0)

Table 7 Jack-Adult regression and Pacific Fishery Management Council 2011 preseason predictions and postseason results of BON and/or ocean escapement. Numbers in thousands of fish.

Stock	Pre-season	Post-season	Bonneville Passage[d]	Pre/ Postseason	Source
BON Spring	209.0		203.1	1.03	CBR/DART
BON Fall	272.4		400.2	0.68	CBR/DART
Upriver Spring Chinook	198.4	221.2[c]	205.4[c]	0.97	PFMC
Upriver Summer Chinook	91.9	80.6[c]	69.9[c]	1.31	PFMC
Fall Chinook (sum of 3 stocks below)	614.6	493.7	400.0	1.54	PFMC
Spring Creek Hatchery (SCH)	116.4[b]	81[c]	65.9[c]	1.77	PFMC
Upriver Brights (URB)	398.2[b]	335.7[c]	289.6[c]	1.38	PFMC
Mid-Columbia Brights (MCB)	100.0[b]	77[c]	44.5[c]	1.30	PFMC

Note: Data for the PFMC predictions and assessment come from various documents including :
[b] The ocean escapement estimates from a pre-season forecast for 2011 Table I-1 (PFMC March 2011).
[c] A summary of 2011 is in post-season document Table B-13 (PFMC February 2012).

[d] Bonneville passage of a stock is determined by date alone. Springs: Mar 15 – June 15. Summers: June 16 – July 31. Falls: Aug. 1 – Nov. 15. Beginning in 2005, CBR adopted the June 15 end date for our spring Chinook run size forecast to best match the Columbia River Fisheries (CRM) spring management period. It is intended partially at least to include Snake River bound spring Chinook.

Table 8 CBR adult preseason predictions (jack-adult regression) and postseason results for spring Chinook adult run size at Bonneville and fall Chinook run size at Bonneville, 2002-2011. Numbers in thousands of fish.

Stock	Year	Run Dates	Preseason Forecast	Bonneville Passage Observed	Preseason/ Bonneville Passage
Spring Chinook	2011	3/15-6/15	209.0	203.1	1.0
	2010	3/15-6/15	424.4	277.3	1.5
	2009	3/15-6/15	294.3	147.5	2.1
	2008	3/15-6/15	307.0	150.1	2.0
	2007	3/15-6/15	83.1	80.8	1.0
	2006	3/15-6/15	106.7	126.2	0.8
	2005	3/15-6/15	212.4	97.4	2.2
	2004	3/15-5/31	245.4	168.7	1.5
	2003	3/1-5/31	121.4	192.0	0.6
	2002	3/1-5/31	244.0	268.8	0.9
Fall Chinook	2011	8/1-11/15	272.4	400.2	0.7
	2010	8/1-11/15	230.4	467.8	0.49
	2009	8/1-11/15	249.4	283.4	0.88
	2008	8/1-11/15	253.8	315.3	0.8
	2007	8/1-11/15	231.2	157.8	1.5
	2006	8/1-11/15	228.5	299.2	0.8
	2005	8/1-11/15	239.0	415.7	0.6
	2004	8/1-11/15	237.2	583.7	0.4
	2003	8/1-11/15	218.1	610.1	0.4
	2002	8/1-11/15	305.4	473.8	0.6

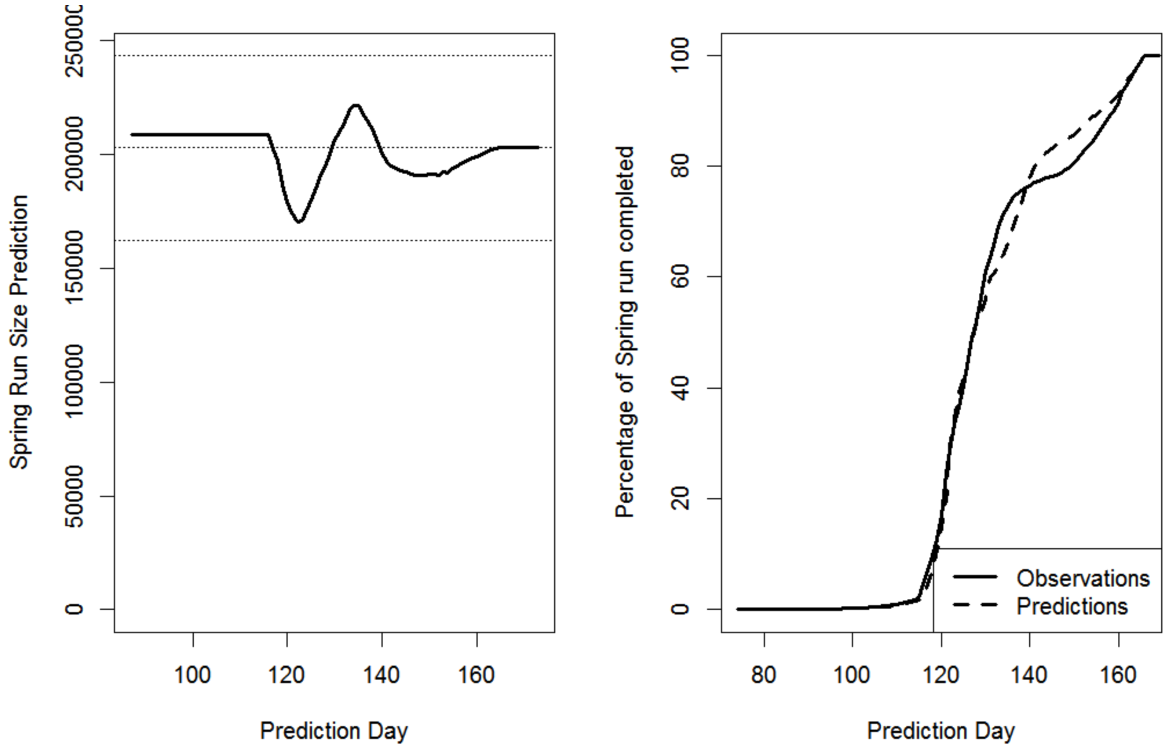


Figure 3 Changes in the daily run size prediction for spring Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of spring Chinook arrivals at Bonneville Dam. Note that the "predictions" are the day-to-day declarations of what percentage of the run has passed on this day. That is one reason it has "notches" in it. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix.

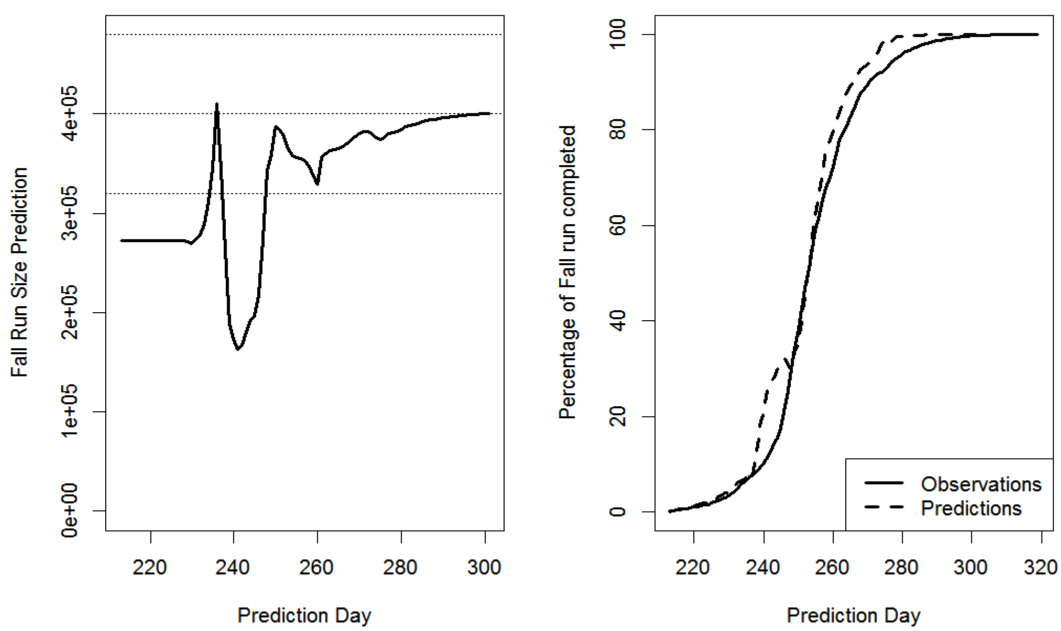


Figure 4 Changes in the daily run size prediction for fall Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of fall Chinook arrivals at Bonneville Dam (right). Note that the "predictions" are the day-to-day declarations of what percentage of the run has passed on this day. That is one reason it has "notches" in it. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix.

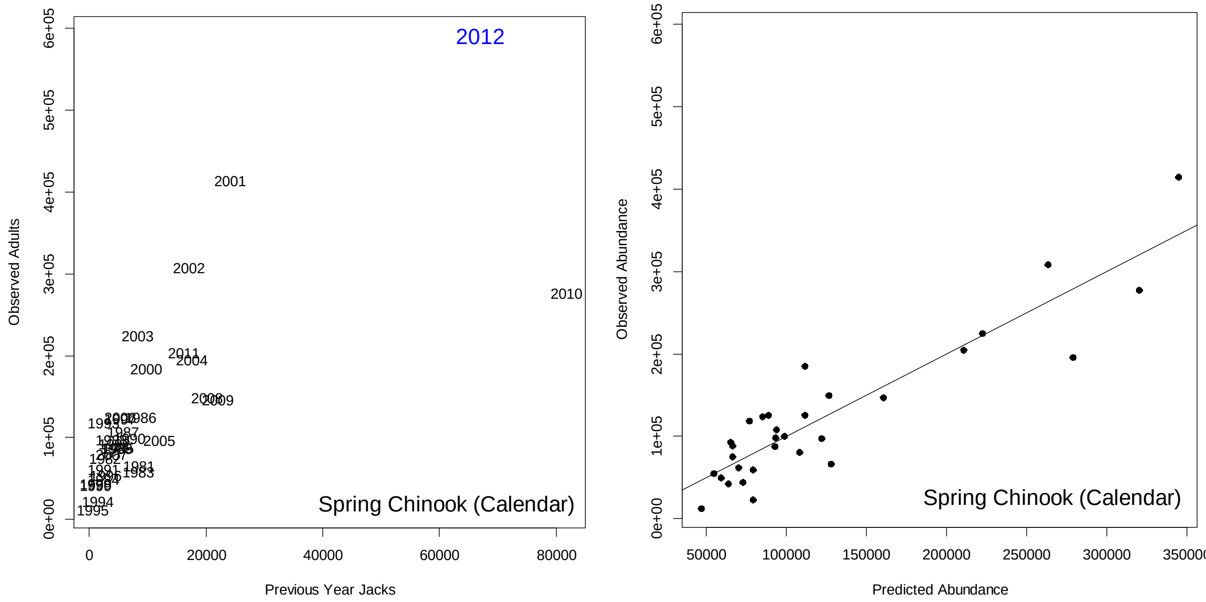


Figure 5 Relationship of previous year Jack counts to year spring Chinook adult returns (left). Point 2012 is observed jacks for 2011 and a prediction of adults 2012 based on an auto-regressive model using the previous year's jack and adult counts and an environmental covariate that interacts with jack abundance (right).

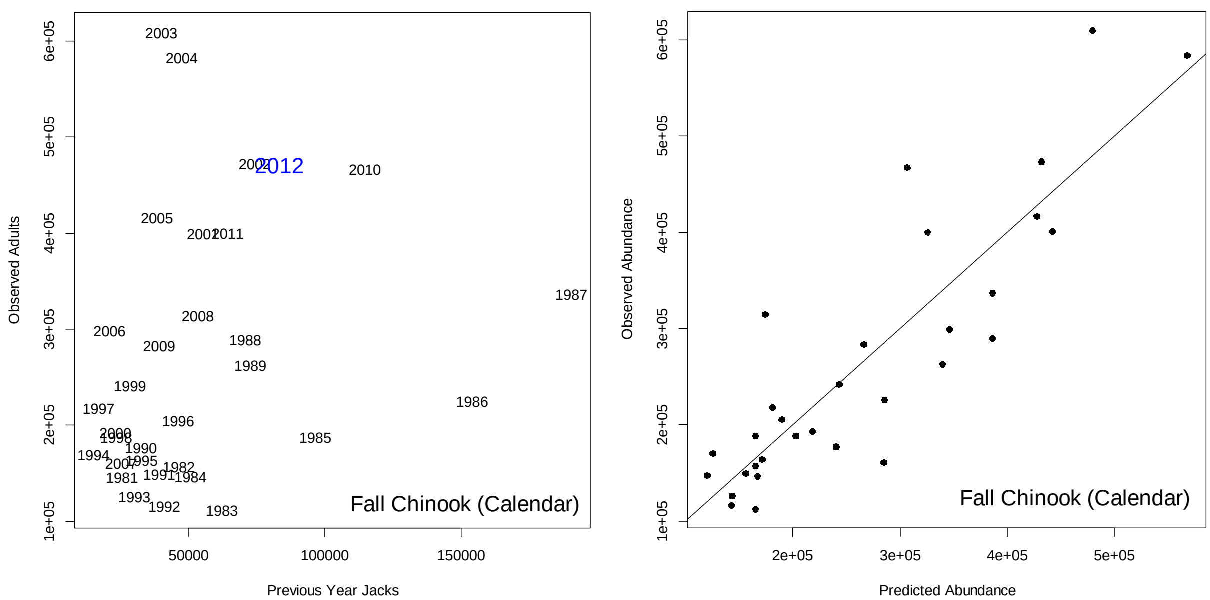


Figure 6 Relationship of previous year Jack counts to year fall Chinook adult returns (left). Point 2012 is observed jacks for 2011 and a prediction of adults 2012 based on an auto-regressive model using the previous year's jack and adult counts and an environmental covariate that interacts with jack abundance (right).

References

Beer, W.N., S. Iltis, C. Van Holmes, and J.J. Anderson. 2004. Evaluation of the 2003 Predictions of the Run-Timing of Wild Migrant Yearling Chinook and Water Quality at Multiple Locations on the Snake and Columbia Rivers using CRiSP/RealTime. Columbia Basin Research, School of Aquatic and Fishery Sciences. University of Washington, Box 358218 Seattle, WA 98195.

Beer, W.N. 2008. Stock Separation of Chinook salmon at Bonneville Dam for Adult Upstream Migration Model (2008). White Paper. Columbia Basin Research, School of Aquatic and Fishery Sciences. University of Washington, Box 358218 Seattle, WA 98195. Avaailable March 31 at: http://www.cbr.washington.edu/papers/StockSeparationforAUM2008.html

Columbia Basin Research (CBR). 2011a. Data Access in Real Time (DART) Available on-line 8 December 2011 at http://www.cbr.washington.edu/dart/.

Columbia Basin Research (CBR). 2011b. Adult Passage Predictions based on Visual Counts for Combined Columbia and Snake River Stocks. Available on-line 8 December 2011 at http://www.cbr.washington.edu/crisprt/index_adult.html

PFMC (Pacific Fishery Management Council) 2011. Preseason Report I. Stock Abundance Analysis for 2011 Ocean Salmon Fisheries: Chapter II - Chinook Salmon Assessment. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220-1384. Available on-line 28 March 2011 at http://www.pcouncil.org/salmon/stock-assessment-and-fishery-evaluation-safe-documents/preseason-reports/2011-preseason-report-i/.

PFMC (Pacific Fishery Management Council) 2012. Review of 2012Ocean Salmon Fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220-1384. Available On-line 10 February 2012 at http://www.pcouncil.org/salmon/stock-assessment-and-fishery-evaluation-safe-documents/review-of-2011-ocean-salmon-fisheries/

Salinger, D.H. and J.J. Anderson. 2006. Effects of water temperature and flow on adult salmon migration swim speed and delay. Transactions of the American Fisheries Society 135:188-199.

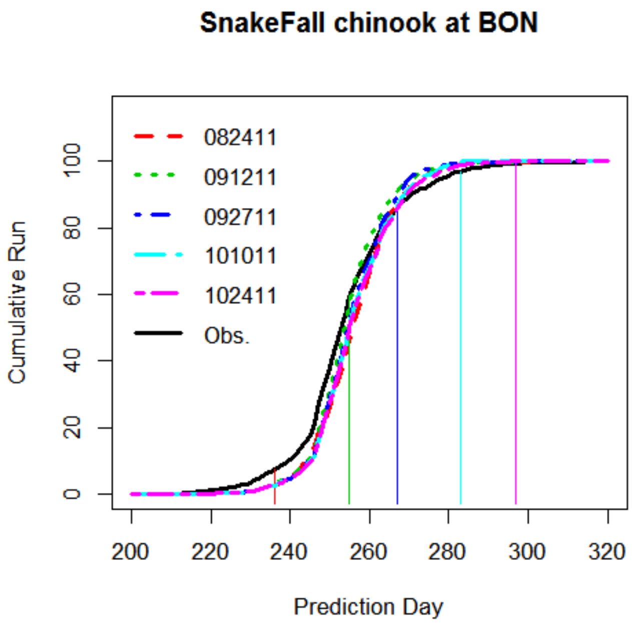
Zabel, R. and J.J. Anderson. 1997. A model of the travel time of migrating juvenile salmon, with an application to Snake River Spring Chinook. N. Amer. J. Fish. Manag. 17:93-100.

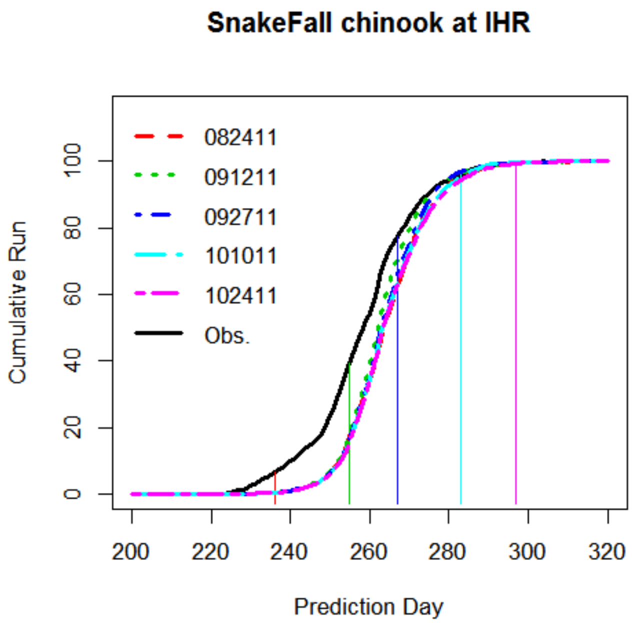
Appendix

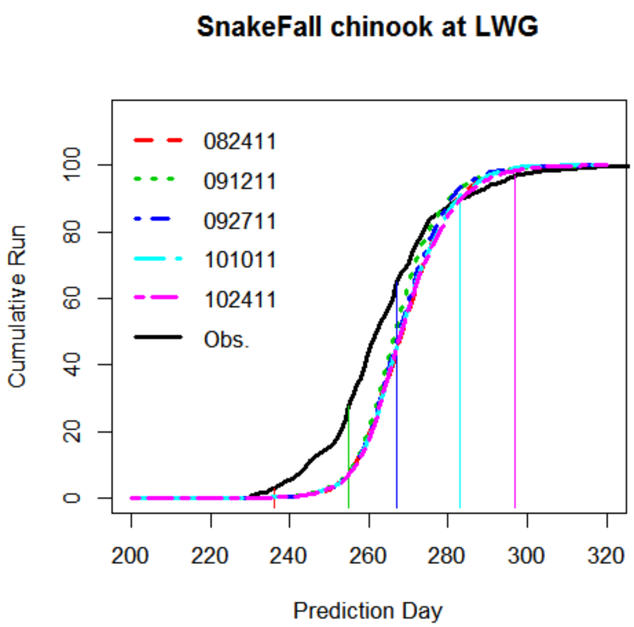
Predictions and observations of cumulative passage at multiple locations. The displays in this appendix depict the distribution of the run and its predictions through the seasons. Interpretation notes: A smooth, "normal-distribution" curve indicates that the stock has a unimodal arrival. When an observation curve is visually between a cluster of predictions, then the stock was represented uniformly across the run at the site.

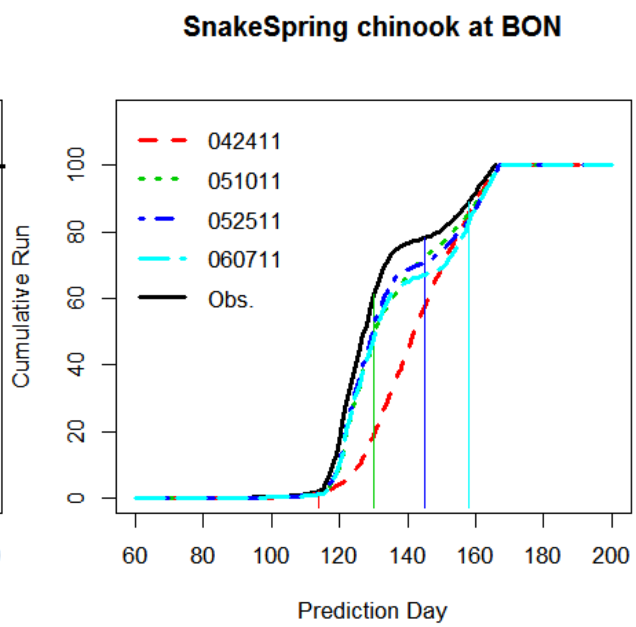
UColFall stocks are very well modeled at BON and PRD but less so at WEL. The group that passes WEL is late compared to the rest of the group. Groups like YakimaSpring at BON and UColSpring fish are bi-modal

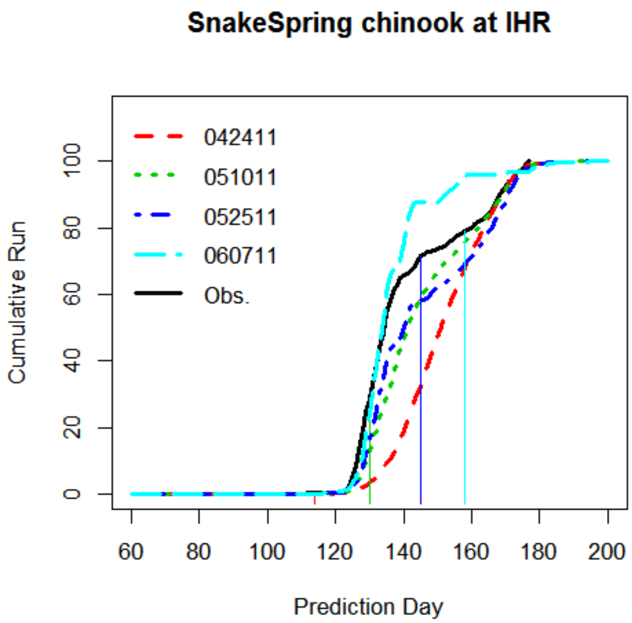
Since the stock separation occurs at BON and is based on a prior year's arrival timing at the dams, differences in abundance between two coincident groups will appear as one modeled early and the other late. For example, Lower and Upper Columbia Spring Chinook are like that. The observations are nearly coincident.

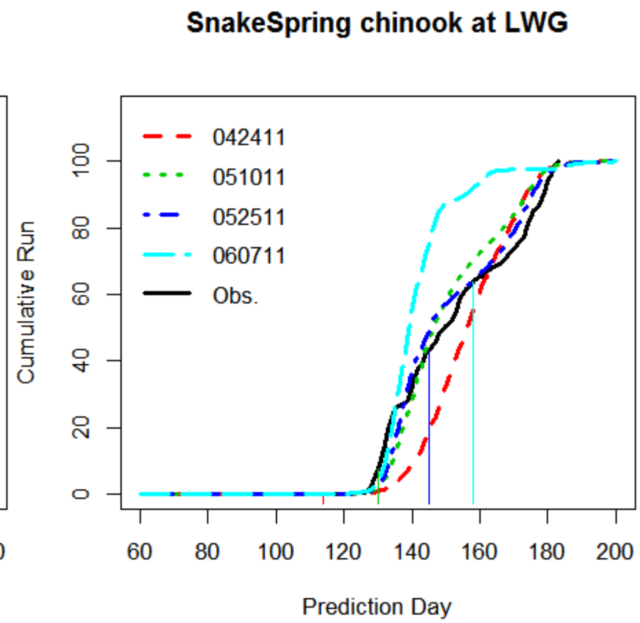

SnakeFall chinook at BON
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day

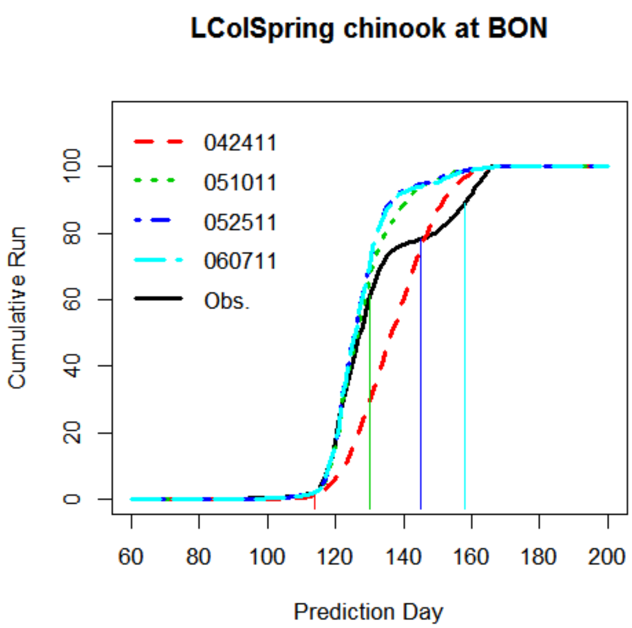

SnakeFall chinook at IHR
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day

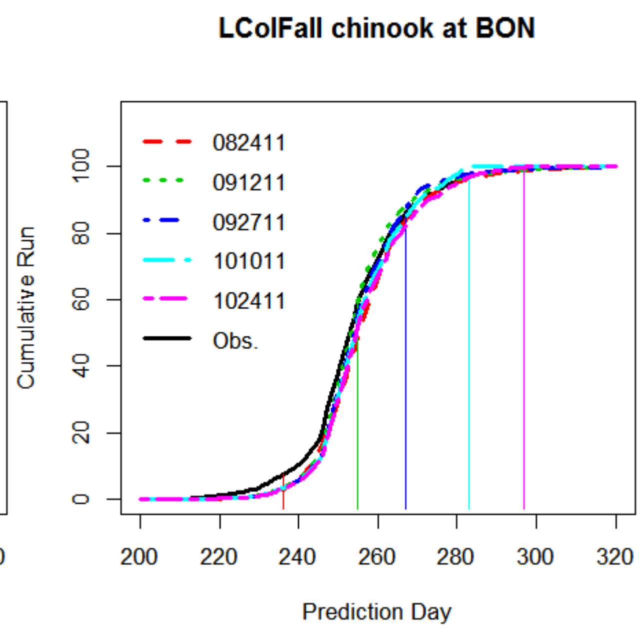

SnakeFall chinook at LWG
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day

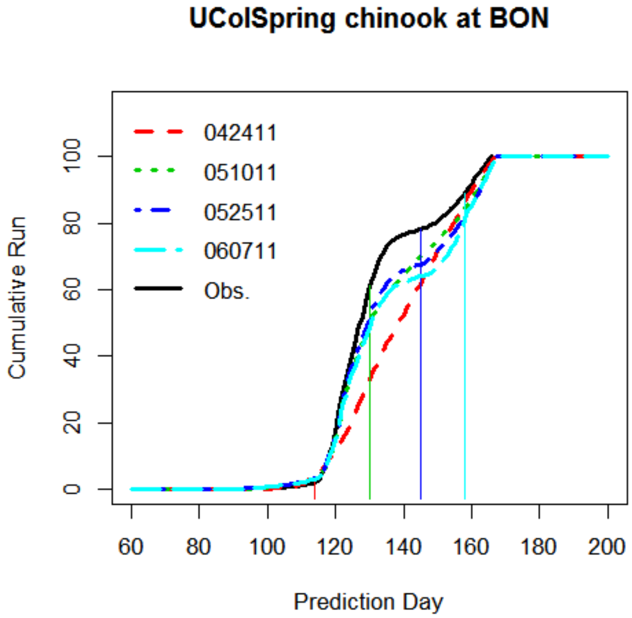

SnakeSpring chinook at BON
042411
051011
052511
060711
Obs.
Cumulative Run
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Prediction Day

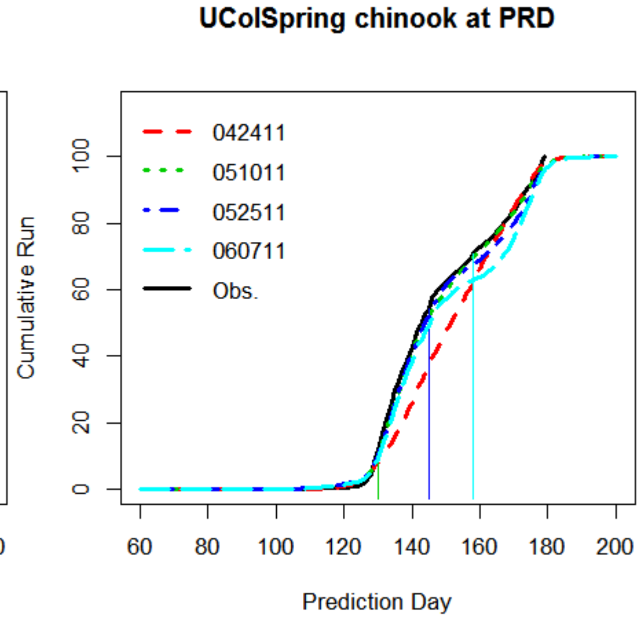

SnakeSpring chinook at IHR
Cumulative Run
Prediction Day
042411
051011
052511
060711
Obs.

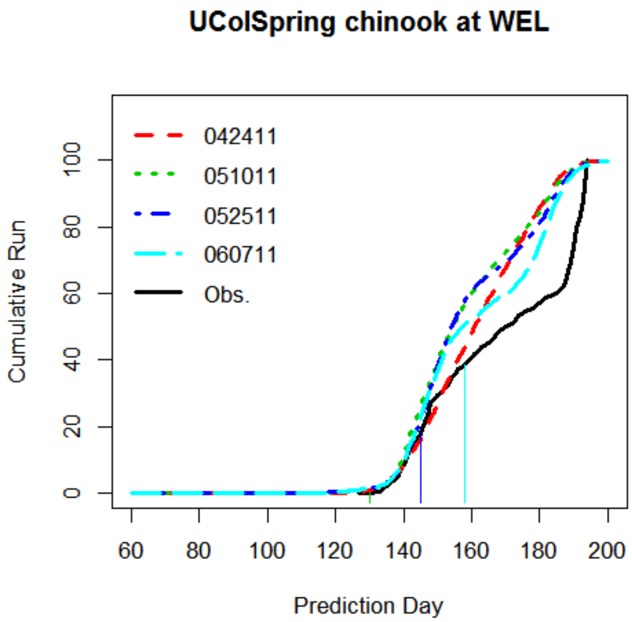

SnakeSpring chinook at LWG
Cumulative Run
Prediction Day
042411
051011
052511
060711
Obs.

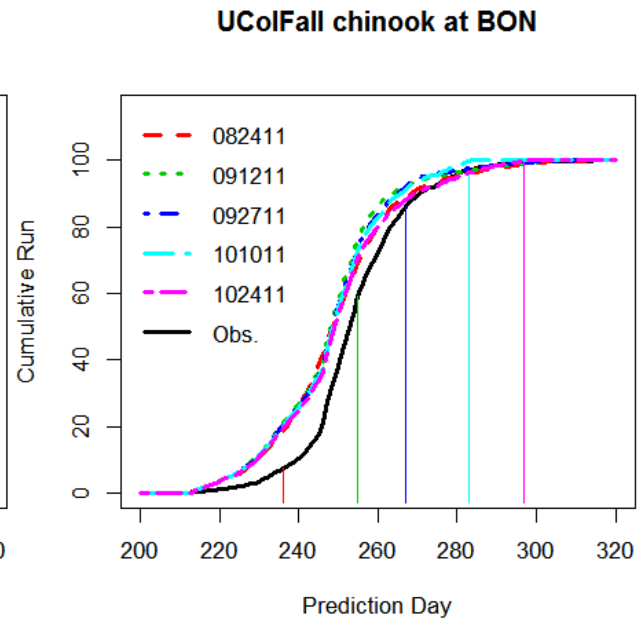

LColSpring chinook at BON
Cumulative Run
Prediction Day
042411
051011
052511
060711
Obs.

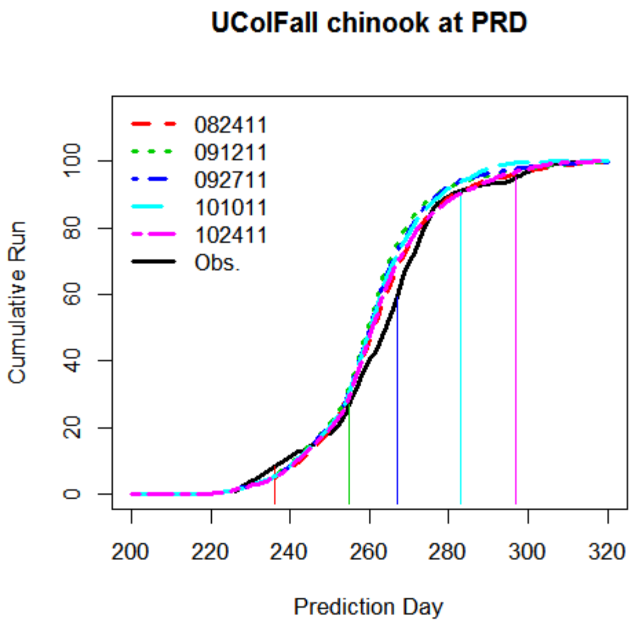

LColFall chinook at BON
Cumulative Run
Prediction Day
082411
091211
092711
101011
102411
Obs.

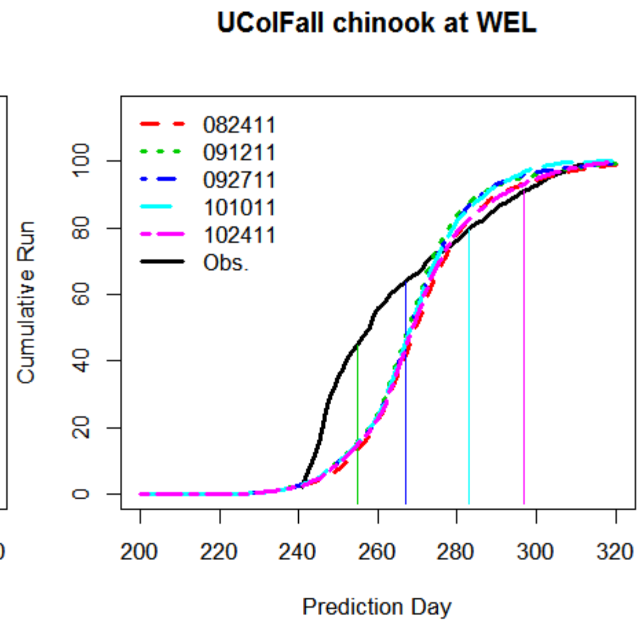

UColSpring chinook at BON
042411
051011
052511
060711
Obs.
Cumulative Run
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Prediction Day

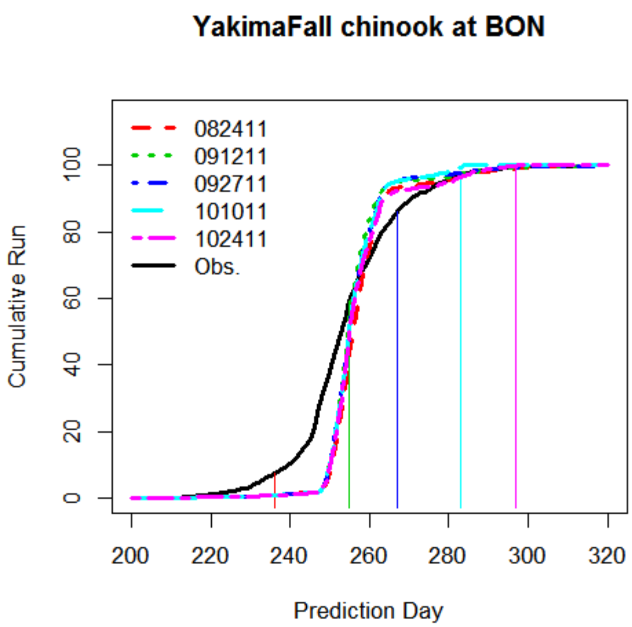

UColSpring chinook at PRD
042411
051011
052511
060711
Obs.
Cumulative Run
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Prediction Day

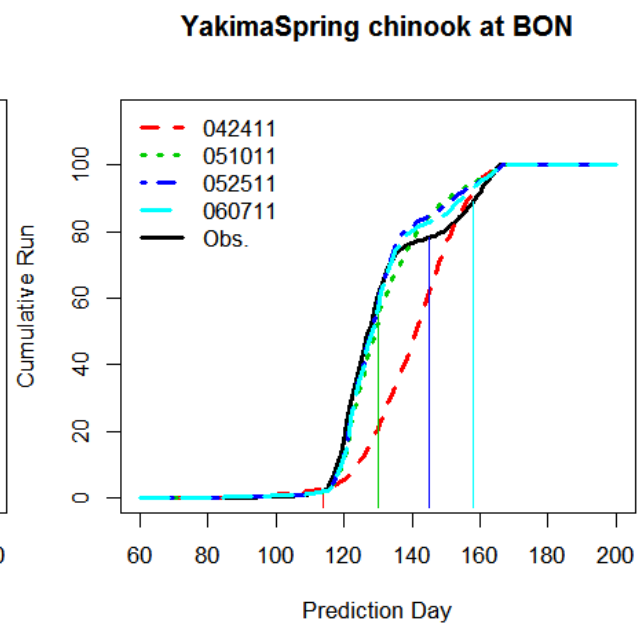

UColSpring chinook at WEL
042411
051011
052511
060711
Obs.
Cumulative Run
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Prediction Day


UColFall chinook at BON
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day


UColFall chinook at PRD
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day


UColFall chinook at WEL
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day


YakimaFall chinook at BON
082411
091211
092711
101011
102411
Obs.
Cumulative Run
0
20
40
60
80
100
200
220
240
260
280
300
320
Prediction Day


YakimaSpring chinook at BON
042411
051011
052511
060711
Obs.
Cumulative Run
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Prediction Day