

**Evaluation of the 1996 Predictions of the Run-Timing
of Wild Migrant Yearling Chinook at Multiple Locations in the
Snake and Columbia River Basins using CRiSP/RealTime**

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Executive Summary

Since 1988, wild salmon have been PIT-tagged through monitoring and research programs conducted by the Columbia River fisheries agencies and Tribes. Information from these studies is presented in reports by the Fish Passage Center (1994, 1995, 1996-in press), National Marine Fisheries Service (Accord et al. 1992, 1994, 1995a, 1995b), Idaho Department of Fish and Game (Kiefer et al. 1993, 1994), Oregon Department of Fish and Game (Walters et al. 1993, 1994a, Keefe et al. 1994b) and the Nez Perce Tribe (Ashe et al. 1995). Workers at the University of Washington have used detection data at Lower Granite Dam to generate predictions of arrival distributions for various stocks at the dam (Townsend et al. 1995, Yasuda et al. 1996). The predictive tool is known as RealTime. In 1996, RealTime predictions were linked to a downstream migration model, CRiSP.1. The composite model, known as CRiSP/RealTime, predicts the arrival distributions and fraction transported at downriver projects - Little Goose, Lower Monumental, Ice Harbor, and McNary Dams. Predictive runs were made weekly and published on World Wide Web pages.

The downstream model takes as inputs fish releases, generated by RealTime, and flow and spill forecasts. The latter are also used to project temperature profiles in the river. Flow forecasts provided by BPA did not predict the period of high flow and uncontrolled spill in the Snake River in May. This omission likely reduced the accuracy of our predictions of downstream arrival distributions. Inaccurate estimates of spill would also have biased estimates of transport fractions at dams where spill occurred.

In general, predictions of downstream arrival distributions were reasonably accurate. Possible sources of error include inaccuracy in the provided flow and spill forecasts, data misclassification, and seasonal variability in relevant model parameters. Fish tended to arrive slightly before their predicted arrival timing; this is probably due to seriously underestimated flow projections used as inputs. Estimates for the composite stock were better than for any particular individual stock, because sample sizes for individual stocks were comparatively small in most cases.

River managers could use the projections generated by the CRiSP/RealTime system to plan operations to target particular stocks or portions of the run. Suggested applications include targeting particular transport percentages and setting spill programs to affect targeted parts of a run.

In 1997 the same information will be presented, along with real time estimates of water temperature, nitrogen saturation, and point to point fish survival rates.

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This work would not be possible without the dedicated labors of all in the region who collect and collate the PIT-tag data. Special thanks to the National Marine Fisheries Service, the non-federal Smolt Monitoring Program agencies and Tribes, the Fish Passage Center and the Pacific States Marine Fisheries Commission PIT-Tag Information System (PTAGIS) primary database centers, as well as the in-house database support center DART (project 9601900). Year-to-date temperature information was provided by the US Army Corps of Engineers.

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1. Introduction

In the Spring of 1996, Columbia Basin Research launched a prototype run timing forecaster, CRiSP/RealTime, with results updated weekly on the World Wide Web. This project was launched in an effort to provide real-time inseason projections of juvenile salmon migration to managers of the Columbia-Snake River hydrosystem so that salmon management policy could be based on up-to-date information, and so that the impacts of management decisions could be quickly assessed. This forecaster takes the arrival distributions of various stocks at Lower Granite Dam, as predicted by the RealTime PIT Forecaster (Yasuda et al. 1996), and extends those predictions downstream to other sites on the Snake River (Little Goose, Lower Monumental, and Ice Harbor dams) and lower Columbia River (McNary dam). At the same time, CRiSP/RealTime produces estimates of the fraction of the run arriving at Lower Granite dam which was subsequently transported at the three Snake River transport projects (Lower Granite, Little Goose, and Lower Monumental dams).

In 1996, several factors combined to produce unusual conditions in the river during the outmigration of juvenile salmon. First, runoff was exceptionally high early in the year, requiring the river to be run under flood control rule curves. Second, these high runoff conditions continued during the rest of the spring, producing extremely high flows both in the Snake and mid-Columbia rivers. Under normal operating conditions, these flows could have been regulated so that hydroprojects could operate within the usual constraints, but existing flood control requirements coupled with high flows led to high levels of uncontrolled spill at many projects during the outmigration. Third, these high spills were exacerbated at Lower Granite dam due to delays in the installation of an experimental surface collector; this required additional diversions of water over the spillway at that project. These changes in the river operation were expected to produce changes in outmigration timing and survival patterns in a number of stocks in the Snake River basin.

This report is a post-season analysis of the performance of the CRiSP portion of the RealTime complex. Observed 1996 data were compared to predictions made by CRiSP/RealTime during the 1996 outmigration for arrival timing, water temperature, flow, and spill at various dams.

2. Methods

2.1. Data

2.1.1. Travel Time Data

The fish analyzed in this study are spring/summer chinook which originate from six tributaries of the Snake River: Catherine Creek, Imnaha River, Lostine River, Minam River, South Fork Salmon River, and South Fork Wenaha River. The fish were tagged in their natal streams in the fall of 1994 with passive integrated transponder (PIT) tags. This PIT tagging of wild salmon continues monitoring and research programs conducted by the Columbia River fisheries agencies and Tribes since 1988. Information from these studies is presented in reports by the Fish Passage Center (1994, 1995, 1996-in press), National Marine Fisheries Service (Achord et al. 1992, 1994, 1995a, 1995b), Idaho Department of Fish and Game (Kiefer et al. 1993, 1994), Oregon Department of Fish and Game (Walters et al. 1993, 1994a, Keefe et al. 1994b) and the Nez Perce Tribe (Ashe et al. 1995). The PIT tags provide instantaneous passage times for individual fish at interrogation sites (Prentice et al. 1990). The four observation sites addressed in these 1996 studies were Lower Granite, Little Goose and Lower Monumental Dams on the Snake River and McNary Dam on the Columbia River.

In addition to the individual stocks, a “composite” stock was formed by combining all six stocks together, weighting each stock equally, following guidance from NMFS. The composite was known as the Evolutionarily Significant Unit or ESU stock.

For the CRiSP downstream projections, we were limited to using only three years of historical data, 1993-1995, to estimate fish travel time parameters and confidence intervals. Although fish were PIT-tagged previous to these years, there was no provision made to return detected PIT-tagged fish to the river. Consequently, the majority of fish observed at Lower Granite Dam were removed from the river by transport. Too few fish were subsequently observed at downstream interrogation sites to generate passage distributions and travel time estimates. In 1993, slide gates were installed which selectively diverted PIT-tagged fish back into the river, allowing for adequate sample sizes at the downstream interrogation sites.

2.1.2. Flows, Spills, and other System Operations

A forecast of fish movement relies critically on accurate forecasts of flow, spill, transportation, and other key system operations. The Bonneville Power Administration generates flow, spill, and reservoir surface elevation forecasts at a number of projects on the Columbia and Snake Rivers (projects used in CRiSP/RealTime are listed below in Table 1) utilizing water supply forecasts from the National Weather Service’s Northwest River Forecast Center, flood control requirements from the U.S. Army Corps of Engineers, electrical power demand forecasts, and other criteria. The substantial uncertainty associated with springtime conditions resulted 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 resulted in a shifting of spill between projects within the basin and even outside of the basin. Although the forecasts covered as much as 120 days into the future, it must be recognized that their principal use was in deciding operations for the next week. Forecast accuracy beyond even a few days was itself uncertain. These forecasts were made available to CBR staff at regular intervals; fish arrival predictions were made using the most recent available flow/spill/elevation forecasts.

Table 1: Dams for which flow/spill/elevation forecasts were made available by BPA.

Dam	abbreviation
Dworshak	DWR
Lower Granite	LGR
Little Goose	LGS
Lower Monumental	LMN
Ice Harbor	IHR
Chief Joseph	CHJ
Wells	WEL
Rocky Reach	RRH
Rock Island	RIS
Wanapum	WAN
Priest Rapids	PRD
McNary	MCN

Table 1: Dams for which flow/spill/elevation forecasts were made available by BPA.

Dam	abbreviation
John Day	JDA
The Dalles	TDA
Bonneville	BON

2.1.3. Temperature Data

The temperature time series used in the CRiSP analysis were a combination of year to date temperature data and forecasted temperatures. The forecasts were based on historical temperature and flow information and the 1996 flow forecasts. The historical data used includes flow and temperature profiles from LGR, PRD, and TDA reservoirs for the years 1976 through 1996. This data was obtained from the Army Corps of Engineers water quality database. Temperature predictions are made using historical average patterns of temperature change and applying a five-day moving window to fit predicted temperature time series. This method is described in detail in the “Temperature prediction algorithm” section on page 10.

2.2. Models

2.2.1. CRiSP

CRiSP is a complex model which attempts to capture the mechanisms controlling movement and survival of juvenile salmon in the Columbia and Snake Rivers. The theory, calibration, and validation of the model is described in detail in Anderson et al. (1996). We include only a brief summary of the model here, but we note that it has been extremely successful in fitting all of the yearling chinook survival data collected in the Columbia Basin, from 1966 through the present day.

Modeled factors that affect survival of hatchery and wild juvenile stocks include daily flow, river temperature, predator activity and density, nitrogen supersaturation, and river operations such as spill, fish transportation and bypass systems. For CRiSP/RealTime, flow and spill were provided by BPA, and temperature forecasts were developed based on those flow estimates. All other relevant parameters were determined at CBR, based on a variety of different sources.

Dam passage changes with fish guidance efficiency, passage mortalities, and diel passage behavior. These factors are modeled on a species and dam specific basis. Relevant model parameters for in-season modeling of yearling chinook stocks are given in Appendix III. These parameters are generally drawn from the literature or are calibrated from related data (e.g. PIT tag detection rates at various projects). Reservoir mortality depends on fish travel time, predator density and activity, nitrogen supersaturation levels, and water temperature. In this study, predator densities were estimated from indexing studies carried out in 1994 (Parker et al. 1994), and generation of nitrogen is modeled using the US Army Corps of Engineers’ “GASSPILL” model (Roesner and Norton 1971, Boyer 1974). Fish migration rate is critical in determining downstream arrival distributions, and so we treat the model of travel time in more detail below.

2.2.2. Travel Time components

The main factor determining predicted arrival distributions at the downstream sites is the travel time between Lower Granite and the sites. Travel time in CRiSP is determined by a reach model and a migration rate model.

The river is divided into a series of reaches, and fish move through the reaches sequentially. In each reach, the travel time distribution is determined by the migration rate (r_t) and the rate of spreading (V_{VAR}) (Zabel and Anderson 1996a).

Migration rate varies by reach and by time step and is stock specific. The CRiSP migration rate equation takes into account fish behavior related to river velocity, seasonal effects, and fish experience in the river (Zabel and Anderson 1996b). For the yearling chinook analyzed here, we did not detect any seasonal behavior, so a reduced equation is used:

$$r_t = \beta_0 + \beta_1 \left[\frac{1}{1 + \exp(-\alpha(t - T_{RLS}))} \right] + \beta_{FLOW} \cdot \bar{V}_t, \quad (1)$$

where

r_t is the time-dependent migration rate;

T_{RLS} is the Julian Date of passage at Lower Granite;

β_0 and β_1 are flow-independent parameters;

α is a slope parameter for the flow-independent term;

β_{FLOW} determines the proportion of river velocity used for migration, and

\bar{V}_t is the average river velocity during the average migration period, determined for each reach.

The flow-independent part of the equation starts fish at a minimal migration rate (β_{MIN}) with fish increasing their flow-independent migration rate to a maximal migration rate (β_{MAX}). These rates are determined as follows:

$$\beta_{MIN} = \beta_0 + \beta_1/2 \quad (2)$$

$$\beta_{MAX} = \beta_0 + \beta_1. \quad (3)$$

The parameter α determines the rate of change from β_{MIN} to β_{MAX} , and for the wild Snake River chinook salmon this parameter is set to 0.3 so that the maximal flow-independent migration rate is reached within approximately 10 days. For each stock, the rate of spreading parameter (V_{VAR}) is estimated, along with the three migration rate parameters from the above equations: β_{MIN} , β_{MAX} , and β_{FLOW} .

2.2.3. Parameter Estimation

Migration rate parameters and the spread parameter (V_{VAR}) were estimated from the historical data using an optimization routine that compares model predicted passage distributions to observed ones. The first step is to use the passage distribution at Lower Granite as a release distribution in the CRiSP model. Based on an initial set of parameters, arrival distributions are generated at the downstream observation sites. The model predictions are compared to the observations, and then the optimization routine selects a new set of parameters to try. This procedure proceeds iteratively until the optimal set of parameters is selected.

The optimized equation is the following:

$$\sum_{k=1}^Y \sum_{j=1}^S \sum_{i=1}^T (F_{ijk} - \hat{F}_{ijk})^2 \quad (4)$$

where

i is the date, and T is the total number of days in the season;

j is the observation site, and S is the total number of sites;

k is the year, and Y is the total number of years;

F_{ijk} is the *observed* cumulative passage on the i th day at the j th site during the k th year.

\hat{F}_{ijk} is the *predicted* cumulative passage on the i th day at the j th site during the k th year.

2.2.4. Confidence Interval calculation

The 95 percent confidence intervals reflect the accuracy of previous years' predictions. They provide an estimate of the reliability of this year's predictions.

The confidence intervals were constructed using a jackknifing method. That is, for each of the years of historical data, predictions were generated using the remaining years of historical data (with the one year omitted). The performance of these jackknifed historical predictions yield confidence intervals on a daily basis.

First, some definitions, which apply to a particular stock at a particular site:

F_{it} is the cumulative passage distribution to time t for the i th year ($i = 1, 2, \dots, n$).

$\hat{F}_{i,t}$ is the model predicted cumulative passage distribution. This distribution is based on jackknifed data.

t is the number of days since the first fish arrived at the observation site for a particular year.

We want to compute the variance in predicted percent passage for each t . The first step is to compute the sample variance for each t :

$$S_t^2 = \frac{1}{n-1} \sum_{i=1}^n ((F_{it} - \hat{F}_{i,t}) \times 100)^2, \quad (5)$$

with n = the number of years of historical data. The factor of 100 is included to convert the CDF's (with range 0 to 1) to percentages (with ranges 0 to 100).

Finally, the 95 percent confidence interval for a particular t is computed as

$$100 \cdot \hat{F}_{i,t} \pm \sqrt{S_t^2} \cdot t_{0.05(2), n-1}. \quad (6)$$

2.2.5. Assessment of passage predictions

To assess the performance of the passage predictions, we applied the same measure used to assess RealTime predictions (Yasuda et al. 1996). For each stock at each observation site, we computed the Mean Absolute Deviation (*MAD*). This measure is based on the average deviation between predicted and observed cumulative passage on the current date of prediction. *MAD* is computed as

$$MAD = \frac{1}{N} \sum_{t=1}^N |F_t - \hat{F}_t| \times 100 \quad (7)$$

where

t is the date of the prediction,

F_t = observed cumulative passage on day t ,

\hat{F}_t = predicted cumulative passage on day t ,

N = number of dates on which predictions were made during the season.

For each stock/site combination, the season length is determined as follows. The season begins when the first fish for the particular stock is observed at the site. The season ends two weeks after the last fish is observed at the site. This arbitrary “tail” of the distribution accounts for the possibility that fish may subsequently without being detected; the same two-week tail is used to generate *MADs* for RealTime. The summation in Equation (7) is performed over the dates on which model predictions were implemented – approximately every other day during the season.

2.2.6. Temperature prediction algorithm

A temperature forecasting algorithm was developed to predict this year's water temperatures on the Snake and Columbia Rivers based on historical data, year-to-date data, and the BPA flow forecast. River temperatures in the near future are based on the current trend in temperature, but far into the future the algorithm relies on the mean temperature profiles and adjusts this mean according to how much flow there is. Mean temperature and flow profiles were computed for LGR, PRD, and TDA using data from the years listed in the above section. The most current year-to-date temperature and flow data are accessed each time a prediction is made. These three dams'

temperature profiles were then used in CRiSP as representative of the Snake, mid- and lower Columbia, respectively.

The forecast algorithm begins by setting the daily temperature to the mean for that day and then replacing the mean temperatures where year-to-date information is available. The last 5 days of available temperatures are looked at to predict the next day's temperature. Averaging over the last five days is an attempt to smooth out some of the day to day variation and to provide a safeguard against bad data giving the algorithm a faulty starting point. Given the averaged starting point, the next 3 weeks of temperatures are calculated by taking the previous day's temperature and adding to it the average daily temperature increment for that day.

Over time the current trend of temperature becomes less and less useful and eventually uncorrelated with future temperatures. Thus after three weeks this predictor is phased out of the calculation. This is when the flow forecast information enters into the algorithm. The flow forecast together with the mean profiles of flow and temperature predict what temperatures a month or more from reliable data will be. The relationship between flow and temperature is the following:

$$T_i = tempmean_i + B_0 + B_1 \cdot (F_i - flowmean_i) \quad (8)$$

Temperature was measured in Celsius and flow in kcfs. Because there is reliable historical temperature data typically only from April to September, these regressions and the flow adjustments were only done within this time interval. The historical data for each of three locations (LGR, PRD, and TDA) spanned 1976-1995. For the remainder of the year the unadjusted mean temperature profiles are used.

3. Results

Estimates of fish arrival distributions and transport fractions at the Snake River collection dams were presented graphically via pages on the World Wide Web at the address:

<http://www.cqs.washington.edu/>

Example graphics from these pages are attached in Appendix V.

3.1. Temperature prediction algorithm

Temperature predictions were made each time a new flow forecast was made available. Monthly predictions versus the 1996 observed temperatures for each of the three reservoirs are shown in Appendix I. For PRD and TDA the April prediction turned out to be very close to the ensuing year's temperature profile. For LGR April forecast followed the basic distribution, with pulses of cooler temperatures being missed by the forecast. For all three reservoirs the predictions became more accurate as the season went on and more data for 1996 became available.

In general, short-term predictions (i.e. for the next week) were no better than long-term predictions; this is a consequence of lack of quality assurance for year-to-date temperature data. Note that some of the "observed" temperature tracks shown in Appendix I are suspiciously noisy. Since predicted temperatures take as their starting point the most recent "observed" temperatures, any inaccuracy in recent temperature records will be reflected in the short-term predictions of temperature. CRiSP, while sensitive to temperature variation, does not produce strongly different results for differences of only one or two Celsius degrees, however, so these inaccuracies are unlikely to have contributed significantly to any model error.

3.2. Flow and Spill Forecasts

Forecasts of flow and spill were made available approximately every two weeks during the season (on February 26, March 24, April 8, 21, and 29, May 6 and 20, June 7 and 16, July 1, 7, 14, and 29, August 5, 19, and 22, and September 4). Forecasted flows and spills for selected dates at LGR, PRD, and TDA are shown below in Appendix II.

April forecasts of daily-averaged flow over the entire season at LGR were not accurate. This reflects the uncertainty associated with weather conditions, snow melt, and runoff from the Snake River basin. Considerable high-flow conditions occurred at the end of May and well into June, with flows approaching 200 kcfs, but the April 8 forecast estimated only about 120 kcfs over the same period. This had a significant influence on the spill forecast at LGR (see Figure 5, Appendix II), because these high flows necessitated fairly high forced spills. There was also a great deal of variability on short time scales (days or weeks) in actual flows and spills that was not captured in the long term forecast. April forecasts of flow at PRD were much better, and captured most of the overall pattern in seasonal flow. Spill forecasts, however, were considerably underestimated for

most of the summer. Early forecasts at TDA suffered from a combination of the problems at the two upper sites: flows were underestimated somewhat in later April, and considerably underestimated (by over 100 kcfs in late May) later in the season, and spill forecasts were off by as much as 200 kcfs during the same period. By the middle of June, however, forecasts for the remainder of the season were reasonably accurate at all three projects, for both flow and spill. Predictions at LGR were particularly good. Forecasts in September, of course, captured the flow/spill patterns up to that time, and made excellent predictions for the remainder of September.

3.3. Passage distributions

Table 2 presents the number of PIT-tagged fish from each stock observed at each of the observation sites. For all stocks, fewer than half of the number of fish observed at Lower Granite were

Table 2: Number of fish observed at the four observation sites.

Stock	Number of fish observed at:			
	L. Granite	L. Goose	Lo Mo	McNary
Catherine Creek	116	99	94	44
Imnaha River	97	77	67	40
Lostine River	81	64	67	24
Minam River	68	70	69	33
S. Fork Salmon River	16	14	18	7
S. Fork Wenaha River	53	72	61	23
composite	431	396	376	171

observed at McNary. The South Fork Salmon River stock has low observation numbers at all four sites.

Plots of predicted passage distributions compared to the observations of PIT-tagged fish are provided in Appendix IV. The entire passage distribution predictions are presented for four dates:

April 23, May 5, May 19, and May 30. Previous to the date of prediction (dashed vertical line) the model predictions are based on the passage data through that time. Since the entire passage distribution is not known at that time, the data must be scaled by the current date’s predicted passage distribution. Thus previous to the date of prediction the predicted passage distribution will have the right shape but may fall below or above the observed distribution depending on the current date’s prediction.

In the plots in Appendix IV, the predictions at Lower Granite Dam are based on RealTime results, and the predictions at the three downstream sites are CRiSP projections. Any error observed at Lower Granite Dam will be propagated down to three downstream sites.

In the appendix IV figures, there appears to be a consistent “stair step” effect observed at dams below Lower Granite, not observed at Lower Granite itself: the observed cumulative arrival distribution at Lower Granite ascends smoothly, but at other dams appears to be considerably sigmoidal. This implies that some portion of the run was detected at Lower Granite Dam but was not subsequently detected at downstream sites. This is particularly obvious for the composite stock (see Figure A4.1, Appendix IV).

The *MAD* results for RealTime and the downstream predictions are presented in Table 3.

Table 3: Mean absolute deviations at the four observation sites; MAD at Lower Granite is from RealTime, the other three are from CRiSP.

Stock	RealTime <i>MAD</i> at L. Granite	Downstream <i>MAD</i>		
		L. Goose	Lo Mo	McNary
Catherine Creek	5.44	3.36	4.99	5.64
Imnaha River	6.77	5.23	5.91	4.32
Lostine River	9.48	6.17	6.85	7.16
Minam River	2.83	4.61	6.55	8.23
S. Fork Salmon River	6.24	12.26	8.82	12.29
S. Fork Wenaha River	3.44	5.37	4.95	7.15
composite	2.40	3.32	2.37	3.43

MAD values for the downstream sites are consistent with RealTime values. The composite stock performs the best, with *MAD* values ranging from 2.37-3.43 at the downstream sites. In other words, the predictions of the current cumulative passage for the composite are within 2-3 percent on average. For three stocks, (Catherine Creek, Lostine River, and Imnaha River) the downstream values are actually lower for the downstream sites than for Lower Granite. The large values for the South Fork Salmon River stock is largely due to the small sample sizes. In general there is a slight trend for increasing *MAD* as fish move downstream.

4. Discussion

4.1. Accuracy of Predictions

4.1.1. Temperature prediction algorithm

The temperature forecasting algorithm was successful in creating an appropriate temperature profile for each of the three reservoirs. For TDA and PRD these predictions were quite accurate, while for LGR certain pulses of cooler temperatures were missed. This could have been the result of an inaccurate flow forecast. Another explanation may be that the algorithm ignores the cooling effects of upstream releases from the storage reservoir behind Dworshak Dam, which is used to augment flows to aid fish passage. Outflows from this reservoir can range from 45-55° F and have been shown to cool Lower Granite's reservoir by a few degrees. Comparing the timing of the observed dips in temperature to that of Dworshak's outflow and spills one can see that the dips in temperature do in fact coincide with higher spills and outflows from Dworshak. Next season work will be done to study this effect and possibly incorporate it into the temperature forecasting algorithm.

Another source of inaccuracy in the temperature predictions turned out to be a data issue. The temperature algorithm uses the year to date temperatures which at times can be provisional. Water quality data are subjected to quality control, and sometimes altered, as late as 30 days after the date on which it is collected. Our prediction algorithm currently rejects values that are negative but will need to be modified to screen incoming temperature data for other bad data points including abnormally high values, such as the 42.2° C that was reported this year on July 16 in Lower Granite reservoir. This will provide protection against nonsensical data.

Screening data except in the case of out of range values is not done in order to avoid biasing the data. Bias can still enter through erroneous but plausible measurements at or near the end of observations. For example, when the last observed temperature jumped more than 5 degrees late in the season at TDA (Figure 3 in Appendix I), the algorithm's projections also jumped 5 degrees and remained at a higher temperature than was later observed. The 5 day running average had muted this effect somewhat, but the algorithm remains sensitive to the quality of data.

By looking at the difference between the observed and predicted data points before the forecasting line, one can see that some of the outlying temperatures were in fact later corrected by the Corps. Any differences between the predictions and the observed data before the forecasting line reflect the changes in the data after it was collected when quality control was applied to the data. Lower Granite had a number of isolated points throughout the year that were corrected in this manner. In light of the changes in historical data, in the future the algorithm will constantly reload the historical temperatures instead of just accessing the latest values for the current year. This way any of the quality assurance corrections will be incorporated into the prediction data files and there will be no discrepancies between the observed and predicted temperatures for the dates prior to the time of the prediction.

Because yearling chinook migrate in the spring and early summer, they are not particularly vulnerable to temperature extremes. In CRiSP, although predation and gas saturation dynamics are somewhat temperature-dependent, the difference in estimated survival resulting from temperature variations of one or two degrees are minimal. The overwhelming majority of temperature predictions fell well within the two-degree window, and thus we do not believe that inaccuracies in temperature forecasts contributed significantly to errors in projections of fish passage.

4.1.2. Flow/Spill Forecasts

Flow and spill forecasts provided by BPA improved in accuracy as the season progressed, but the accuracy of predictions for May and June flows and spills when estimated in April was not very good (see Figure 4 and Figure 5 in Appendix II). The near-flood conditions experienced in the Snake River basin in May were not forecast in mid-April and the underestimation of flow led to a related underestimation of spill at Snake projects. The CRiSP/RealTime model predicted that a larger fraction of the arriving fish would be available at all projects for detection than was in fact

observed in May, since a large number of fish were swept over spillways during the unexpected high flow and spill. The failure of the flow forecasts to adequately forecast the flow conditions a month later is a matter of some concern, but it is recognized that springtime weather and runoff are very difficult to predict. BPA and other parties are currently working to improve forecasts of feeder drainages which may improve inflow forecasts for major hydroprojects. These projections are further complicated by the dynamic nature of spill agreements: there was also a redistribution of spill within the basin and even shifting of spill to projects outside of the Columbia-Snake basin as part of coordinated efforts to minimize spill at Snake projects in the spring. This was possible because of the regional nature of the generation/transmission system. For example, given a certain electrical load to be met by all generating projects in the region, the Snake projects could be operated at maximum generating capacity (even to 1% above capacity) to minimize local spill and dissolved gas generation while a project outside of the Columbia-Snake basin - e.g. on the Willamette - would spill more rather than generate. In 1996 there was an agreed-to order by which the spill would be shifted (details of this agreement are available via the Worldwide Web at <http://www.bpa.gov:2001/efw/EW/EWI/TMT/1996/COE/spill.caps.960621.html> and <http://www.bpa.gov:2001/efw/EW/EWI/TMT/1996/COE/spill.caps.960626.html>). Again, the *ad hoc* nature of these decisions renders long-term forecasts less useful and requires constant updating of the input information used by CRiSP/RealTime.

Estimates of the fraction of fish transported at Snake River projects will be sensitive to estimated spill fractions: fish that are spilled are not collected for transportation. For accurate long-term projections of transport fractions, more accurate long-term projections of spill fraction will be required. Even when spill fraction is accurately measured, variability in spill efficiency and FGE can produce errors in estimated transport fractions.

So far as we are aware, there is no other source for predictions of the fraction of the Snake River run that is transported, except for CRiSP/RealTime. Our final estimate of 67% for the composite stock seems reasonable. Passage index and transportation data from other sources, however, do not combine in a sensible fashion; the Fish Passage Center estimates the total run of yearling chinook at Lower Granite dam at just over 900,000 fish, but over 1,170,000 yearling chinook were transported from the three Snake River projects. Even if we subtract out the potential downriver hatchery releases that could confound these numbers (from the Tucannon hatchery,

about 130,000 fish), this still represents 115% transport efficiency.

4.1.3. Passage Timing Predictions

Confidence Intervals. While confidence intervals were reported for part of the 1996 season (starting on April 28), they are not discussed here since they are based on only three years of historic data and are extremely broad. Moreover, they are limited by historical observations at Lower Granite Dam: confidence intervals cannot be constructed for any stock on any day earlier than the latest historical first arrival date at Lower Granite. For example, in 1993 the first observed fish from Catherine Creek at Lower Granite was on April 29 (julian day 119), and so no confidence interval based in part on 1993 data can be constructed for Catherine Creek fish any earlier than julian day 119.

Arrival Distributions. In general, the composite stock performs better than the individual stocks. This is to be expected as the composite stock has a substantially larger sample size. The results from the composite stock are encouraging – for all four dates for which plots are provided, the run predictions are reasonably accurate, judging by the low MAD values, for all three downstream locations.

RealTime does not provide absolutely accurate estimates of arrival timing at Lower Granite Dam; to the extent that there are errors in RealTime predictions, those errors will be propagated downstream by CRiSP. Yasuda et al. (1996) note that high levels of spill in 1996 required significant adjustments for PIT-tagged fish passing over spillways. If spill efficiency curves are not perfectly accurate, errors will result. It appears that the CRiSP projections at all projects below LGR are shifted later than (to the right of) the observed distributions, even after taking into account the RealTime errors. This would result from fish moving downstream faster than modeled. This is particularly evident for the predictions made on May 19. This effect can be partially explained by the flow predictions which did not capture the large peaks in flow that occurred shortly after this date. Because of this the model moved fish downstream more slowly than it should have. Note that there is no reason to expect predictions made on any particular date to perfectly fit the arrival distribution preceding that date, because the final arrival distribution is contingent on arrivals through the entire system: if the run is 50% complete but RealTime estimates only 40% completion, for example, that will necessarily produce error both before the prediction

date (underestimating) and after it (overestimating, to catch up).

We note that the MAD values for three stocks (Catherine Creek, Imnaha and Lostine) are lower for CRiSP predictions than they are for RealTime predictions - that is, the downstream predictions, using the RealTime predictions as input, were more accurate than the RealTime predictions themselves. This seems counterintuitive, but there are two reasons for this result. First, for these stocks in particular, RealTime predictions (arrival distributions at Lower Granite) are shifted slightly to the left: the stock is estimated to be arriving more quickly than it actually is. When this is coupled with the underestimated flows used by CRiSP, fish are modeled as moving downriver more slowly than was actually the case. The combination of these two errors accidentally produces a more accurate prediction for passage at downstream projects. In addition, CRiSP contains a mechanism for “spreading out” a release of fish as they move downstream; this is an implicit smoothing function and may ameliorate in cases of biased input.

There are some differences between stocks in how well CRiSP/RealTime performed; we discuss these differences (shown in the graphs in Appendix IV) on a stock-by-stock basis below.

Catherine Creek. This is a good example of the “two wrongs make a right” effect: early in the season (Figures A4.5 and A4.6), RealTime predictions were considerably above the observed cumulative line, while CRiSP was much closer at Little Goose and Lower Monumental dams, although it too was notably early for predictions at McNary Dam. This effect became less pronounced as the season wore on; in fact, there is a peculiar flip-flop in late May (Figure A4.7), as predictions suddenly fall well behind the actual arrival distribution, although this is corrected in the last prediction (Figure A4.8). This effect may be a result of undetected PIT-tagged fish passing over the spillways and thus making it appear to RealTime and CRiSP that those fish had not yet arrived at the dam.

Imnaha River. Early predictions by RealTime were very aggressive, and fish were modeled as arriving much earlier than was in fact the case. For the first two predictions, the slower than usual movement predicted by CRiSP predicated on underestimated flows ameliorated this effect (Figures A4.9 and A4.10), but by May 19, RealTime had narrowed the gap significantly, while CRiSP was, as a consequence, underestimating arrival timing (Figure A4.11). By the last prediction, however, both models had achieved good accuracy, while the run was nearly completed

(Figure A4.12).

Lostine River. The pattern here is nearly identical to that for the Imnaha River: significant early bias in RealTime which is “corrected” by CRiSP (Figures A4.13 and A4.14), a subsequent correction by RealTime which produces a late slide in CRiSP (Figure A4.15), and a final correction near the end of the run, where both models are nearly correct (Figure A4.16).

Minam River. This stock exhibited the significant “stair-step” pattern with a sudden decrease in detections for most of May at dams below Lower Granite. Consequently, this is not a problem for RealTime, but was, at least initially, a problem for CRiSP (Figures A4.17 and A4.18). The correct shape was finally achieved later in May (Figures A4.19 and A4.20), when correct estimates of spill were included in model operations.

South Fork Salmon River. Predictions for this stock suffered from low sample sizes. Detection rates at Lower Granite (on which RealTime predictions are based) are adequate, but at lower projects - especially McNary Dam - detections are very sparse. Since CRiSP relies on detections at these lower dams for calibration purposes, our fit for this stock was not very good at all (this stock had the highest CRiSP-related MAD of any stock). This stock also had the most attenuated outmigration; even in the last prediction shown, on May 30 (Figure A4.24), less than 80% of the run had passed McNary Dam - however, the run timing at McNary was based on a sample of only seven fish, hardly enough to make conclusions about the outmigration of this stock.

South Fork Wenaha River. Early RealTime predictions were nearly perfect, and as a consequence, CRiSP underestimated passage while using inaccurate flow and spill forecasts (Figures A4.25 and A4.26); this was somewhat ameliorated by strong flows in the mid-Columbia, so predictions for McNary Dam are not as late-biased as are predictions at Little Goose and Lower Monumental. Later in May, however, predictions tightened considerably (Figures A4.27 and A4.28).

Several potential sources of error exist for the downstream passage predictions. First of all, the downstream predictions depend on the RealTime predictions at Lower Granite. As noted above, and as can be seen in the figures in Appendix IV, RealTime is not perfectly accurate at predicting arrival distributions at Lower Granite. Because RealTime is a statistical procedure, one

expects some degree of variation from the particular conditions observed in any particular year. In addition, the high spills of 1996 could have produced errors in RealTime predictions (Yasuda et al. 1996). Another source of error is in the CRiSP model predictions. The CRiSP errors can be divided into intrinsic model errors, errors in model inputs, and stochasticity in the data. Each of these will be discussed in more detail below.

The two main functions of CRiSP in this application are to move fish downstream and to keep track of survival and passage routes of fish. The primary model inputs are forecasts of flow and spill fractions. Flow is an important input because it partially determines the downstream migration rate of the fish. Behavior-dependent migration rate parameters - and confidence intervals about estimates of arrival distributions - are based on only three years of data. With more years of data in the future, better estimates of the migration rate parameters will be obtained, and the downstream movement of fish will be more accurately characterized. The downstream passage distributions are based on modeled numbers of fish passing the PIT tag detectors. Diversion of migrating fish into sampling systems that detect PIT-tagged fish depends upon the efficiency of spillways and fish diversion screens. The accuracy of CRiSP also depends upon our correctly estimating the values of these parameters.

Spill has several effects on model output. First, it affects the passage routes of the fish – with higher spills, fewer fish pass through the bypass system where PIT-tagged fish can be detected. Survival of migrating fish is also affected by spill: high levels of spill lead to high dissolved nitrogen levels, causing potentially lethal gas bubble trauma. The marked sigmoidal arrival distributions at dams below Lower Granite Dam may be a result of high levels of spill at those projects: fish that were detected at Lower Granite could have been swept over the spillways of lower dams, and would not have been detected. The sudden flattening of cumulative arrival distributions occurs at about April 20-25, which coincides with a significant spike in both flow and spill at Snake projects (see Figure 5 in Appendix II). Cramer (1996) has found an association between high levels of dissolved gas and increased smolt mortality during the 1996 outmigration. If fish were not detected either because they passed over spillways or because they died in elevated nitrogen levels, either (or both) would produce the observed flattening of the arrival distribution.

Deviations between predictions and observations also arise from the randomness of the pro-

cess. This becomes more of a problem with small sample sizes and is particularly evident for the South Fork Salmon River stock where fewer than ten fish were observed at McNary dam.

4.2. Utility of CRiSP/RealTime Predictions in Management

Management of the hydrosystem for the benefit of salmon requires accurate assessments of the status of salmon outmigration and planned responses to various contingencies. For example, one might elect to transport juvenile chinook at collection facilities, but separate fish when flows fall below some target value until the run has reached 80%. This policy requires an accurate assessment of when that 80% level is reached. Similarly, a policy that seeks to transport a given fraction of the run, say, 50%, can only be done if one has estimates of the state of the run and the fraction transported to date.

As noted above, in 1996, CRiSP/RealTime provided users with stock-by-stock estimates of passage to date along with estimates of the shape of the remainder of the run. We also provided estimates of the fraction of any given run transported to date, and a projected total transport fraction. This information could have been used by the Technical Management Team to make decisions on spill volumes and transport operations. One possible pre-season stated goal for transportation, for example, was 50% (i.e. of the fish arriving at Lower Granite Dam, half would be collected for transport at one of the three Snake River collector projects). The first prediction made by CRiSP/RealTime, on April 14, estimated that 1% of the run to date had been collected for transport, and that by season's end about 70% of the run would have been collected. When the final prediction was made, on July 30, we estimated that 67% of the run would be transported by season's end. This was clearly more than originally planned for by the TMT. Had our information been used, separation could have been put in place at the collector projects in order to reduce the fraction of the run collected.

The cumulative passage forecasts provide managers with estimates of the fraction of a given run that will be exposed to expected spill, flow, dissolved gas levels, and transportation during a given period of interest - generally the next one to two weeks. This allows both quantitative and qualitative assessment of the exposure these fish will experience to the conditions. Within limits, the managers can choose to modify operational conditions. For example, in 1996 uncontrolled spill was a serious problem, but in many water years system operators have the luxury of being

able to regulate the amount of spill desired. If spill is to be targeted for particular stocks, CRiSP/RealTime estimates of arrival distributions would allow managers to direct spill at the projects where the bulk of the run is passing, but to reduce spill at projects where few fish are passing, in order to control dissolved gas levels.

4.3. Planned Additions for 1997

For 1997, we will provide the same information as was provided in 1996, and will also add additional forecasts for examination. The addition of another year of historical data will help us to refine our confidence limits and may allow more precise estimates for some stocks.

In 1996 we provided estimates of arrival distributions and transport fractions. While the latter does contain an implicit estimate of inter-dam survival, survival estimates were not made explicitly available. In 1997 we will provide estimates of survival between various points in the hydro-system, both for inriver fish and for the run as a whole, including transportation.

It was clear in 1996 that there are some weaknesses in the prediction of flow and spill patterns in the river; while fish travel time is moderately sensitive to this, other processes are quite sensitive to variation in these parameters, such as nitrogen supersaturation. In 1997, we will provide real-time estimates of nitrogen supersaturation and water temperature at various points in the hydrosystem.

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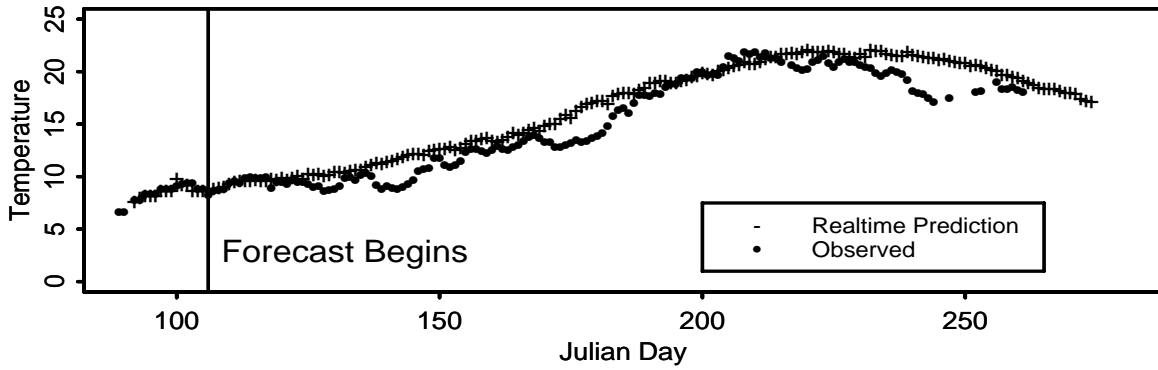
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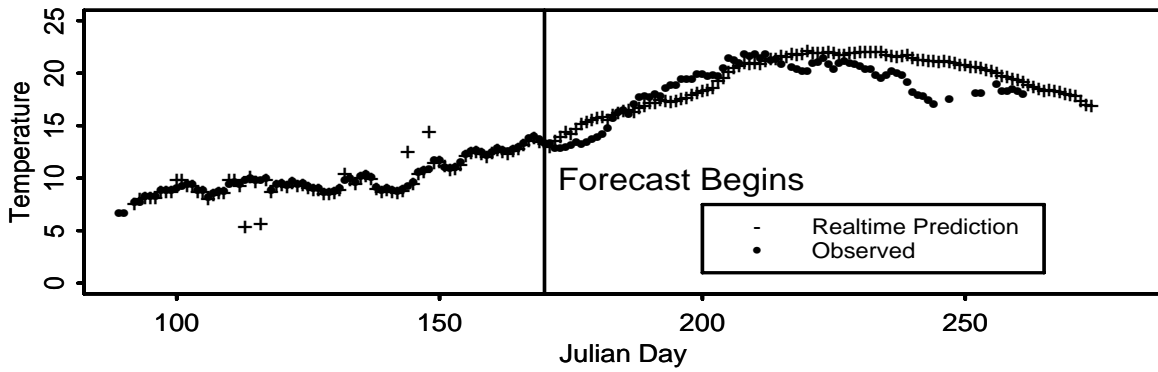
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APPENDIX I: Temperature Forecast Plots

April Prediction vs. 1996 Data



June Prediction vs. 1996 Data



September Prediction vs. 1996 Data

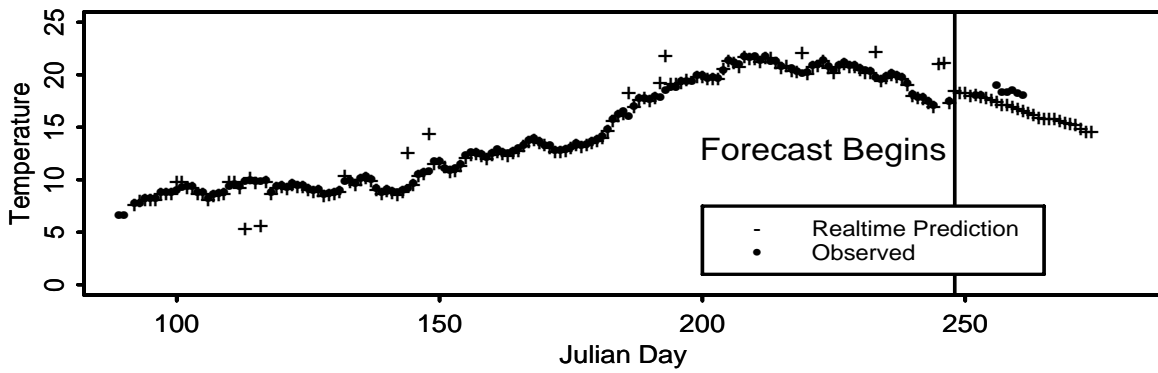
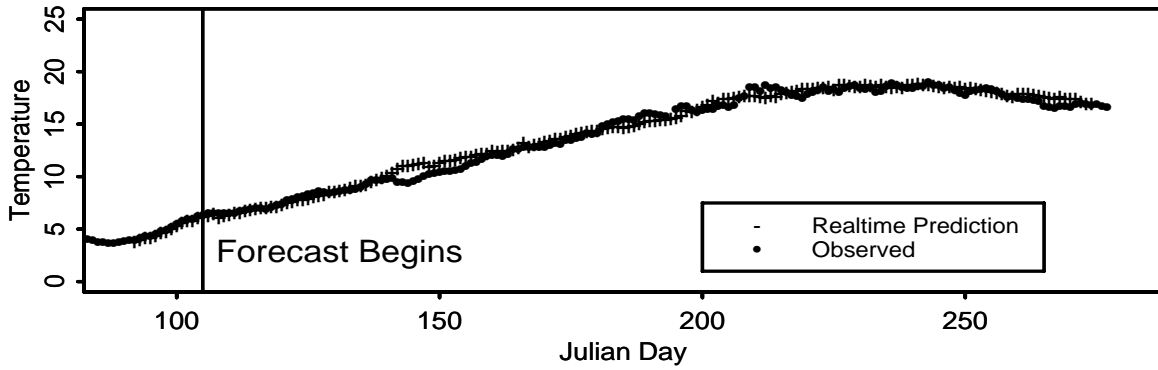
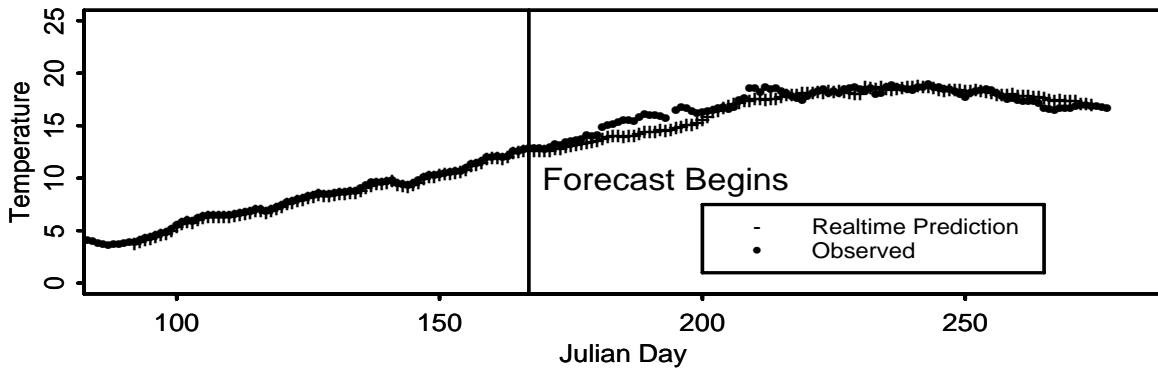


Figure 1: Temperature predictions for Lower Granite Dam.

April Prediction vs. 1996 Data



June Prediction vs. 1996 Data



September Prediction vs. 1996 Data

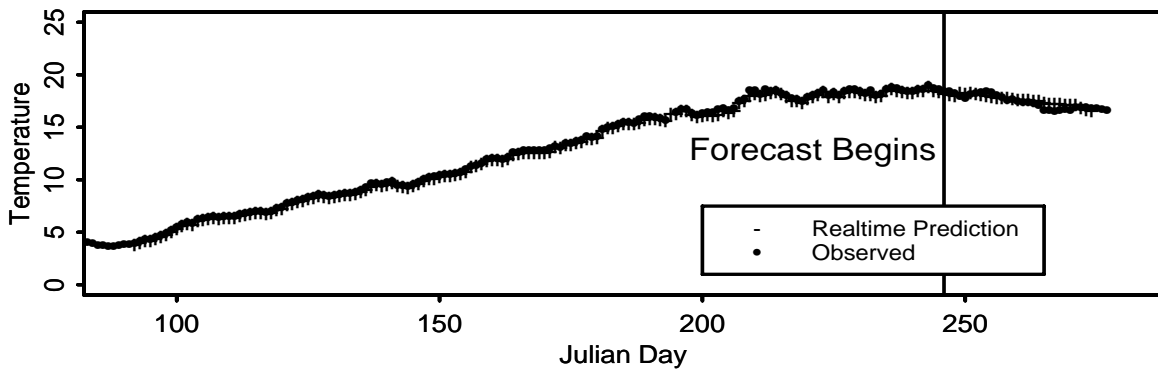
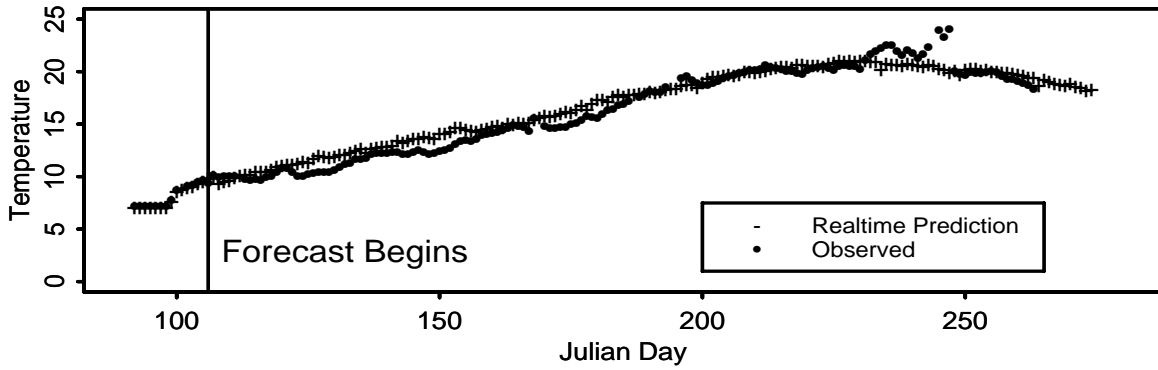
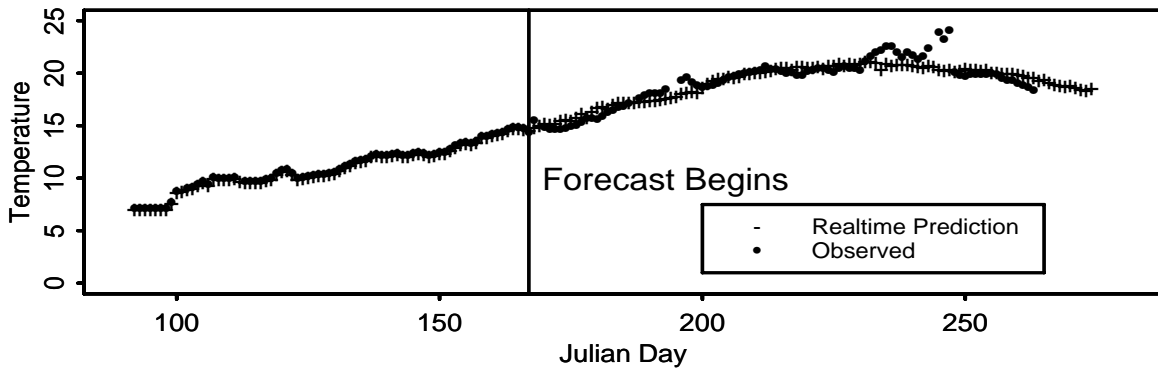


Figure 2: Temperature predictions for Priest Rapids Dam.

April Prediction vs. 1996 Data



June Prediction vs. 1996 Data



September Prediction vs. 1996 Data

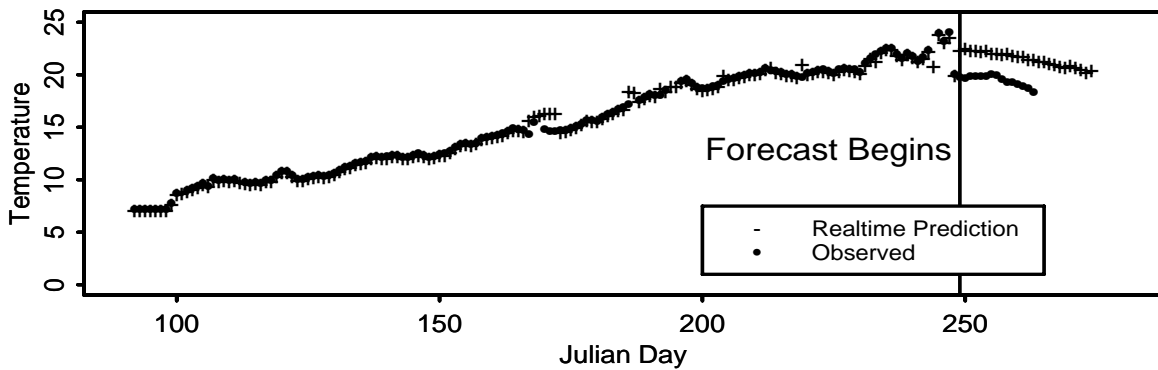


Figure 3: Temperature predictions for The Dalles Dam.

Appendix II: Flow/Spill Forecast Plots

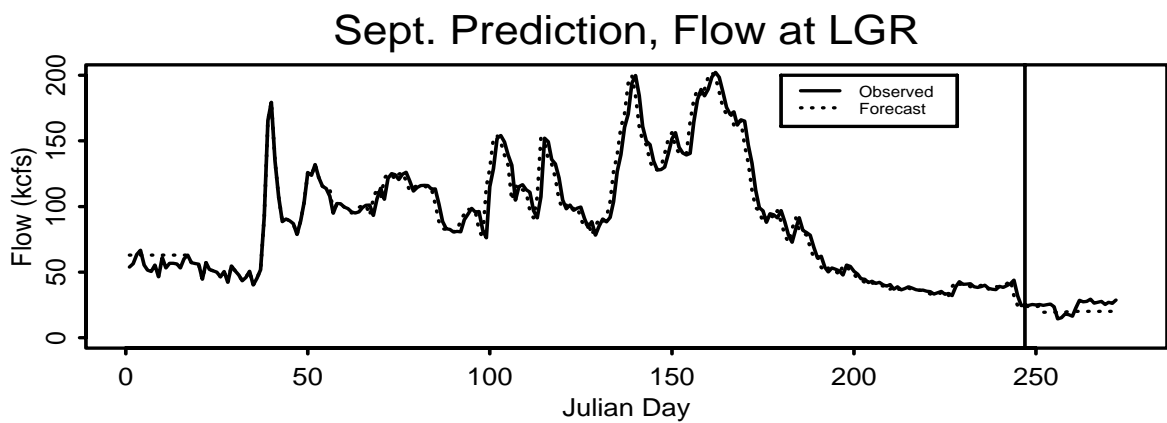
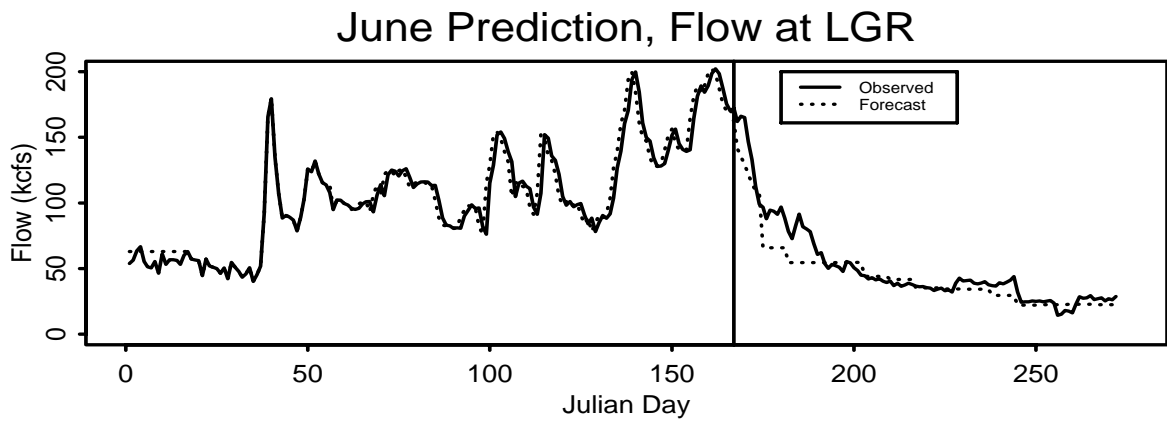
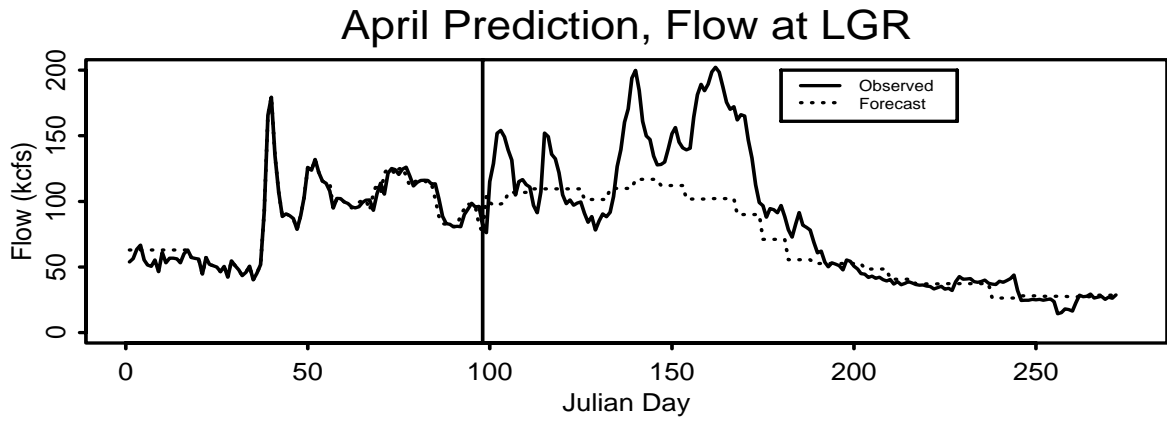
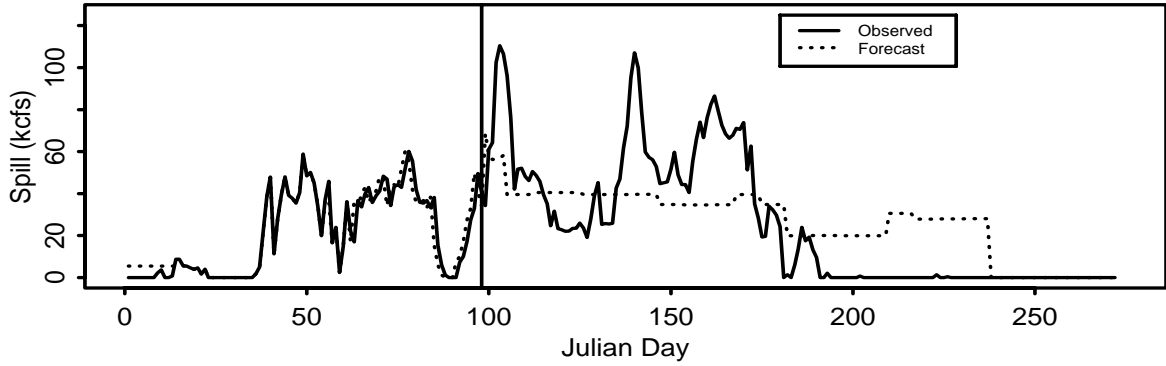
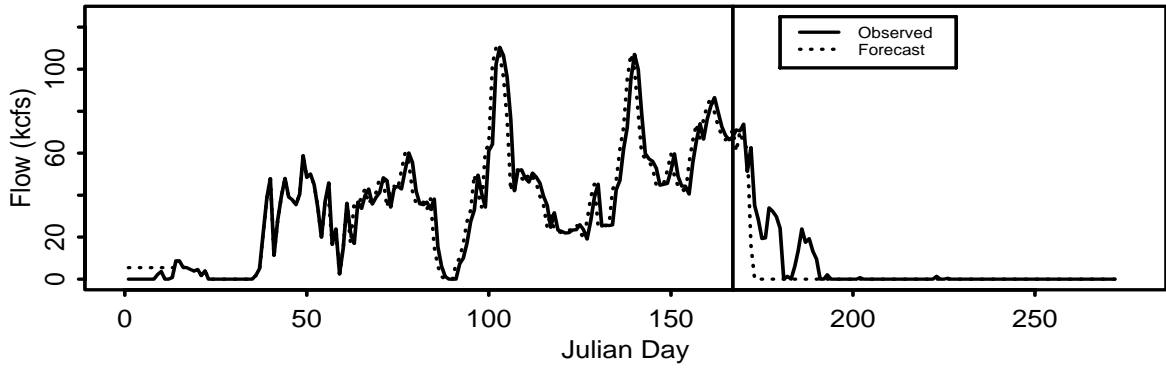


Figure 4: Flow forecasts for Lower Granite Dam.

April Prediction, Spill at LGR



June Prediction, Spill at LGR



Sept. Prediction, Spill at LGR

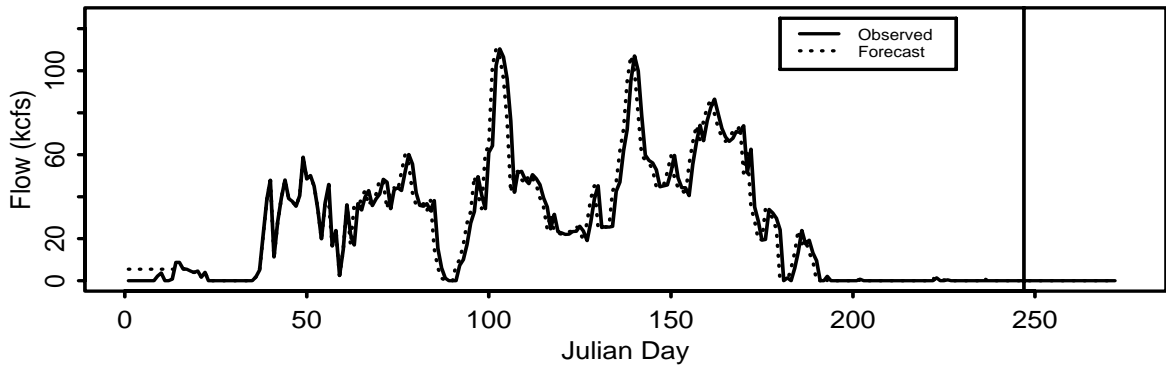


Figure 5: Spill forecasts for Lower Granite Dam.

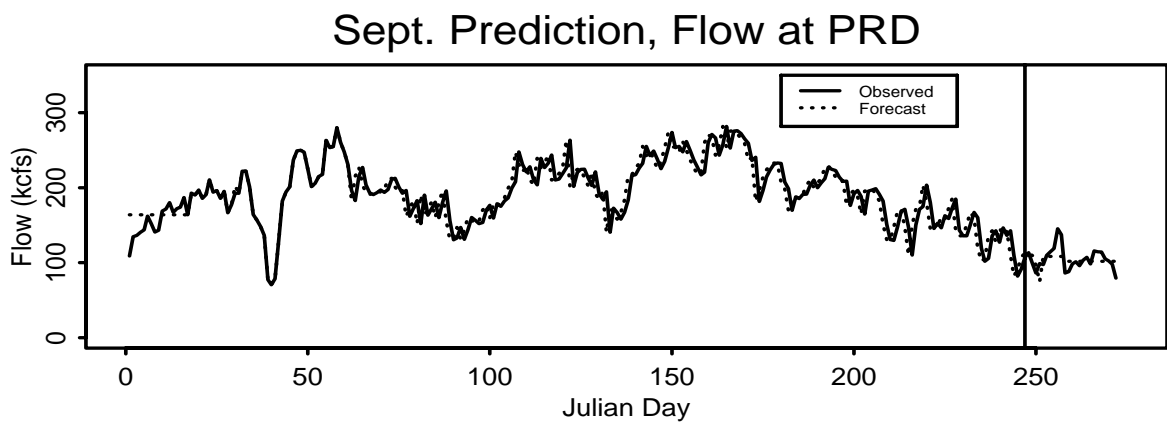
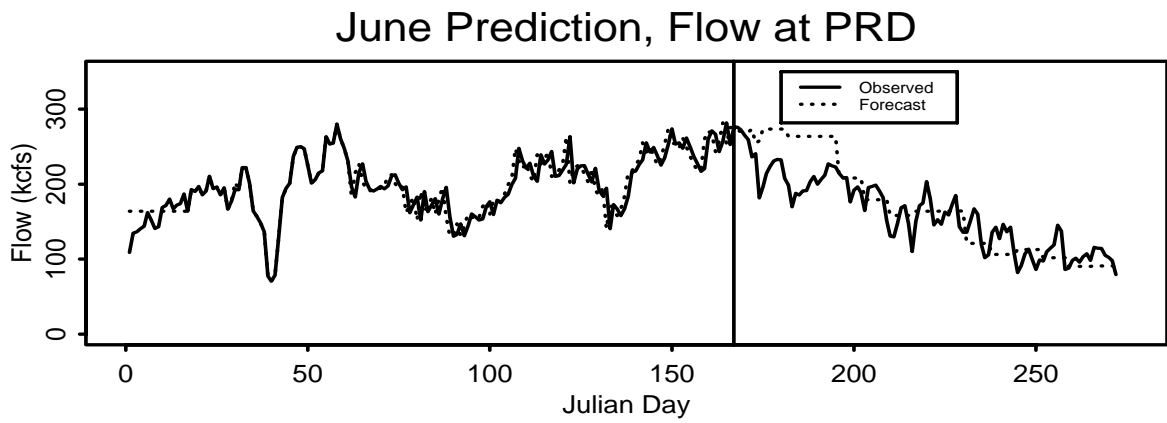
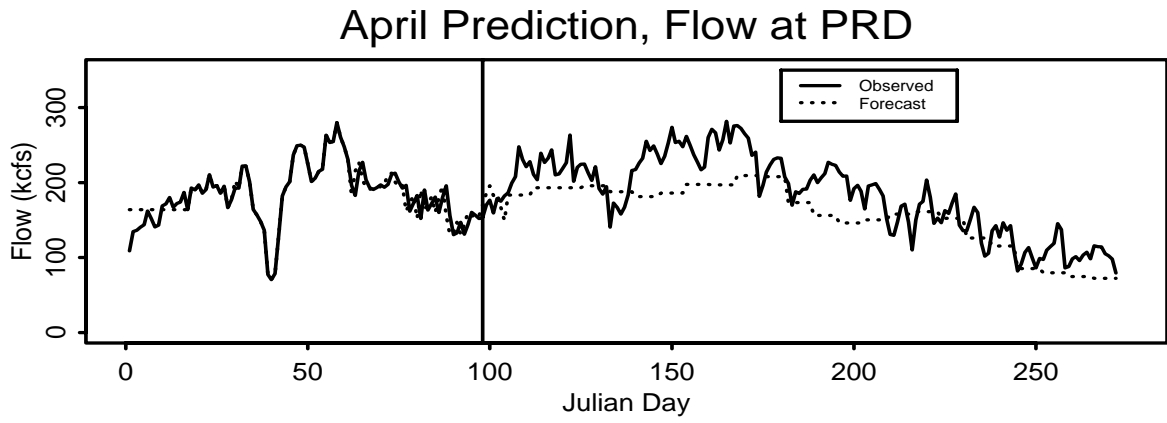


Figure 6: Flow forecasts for Priest Rapids Dam.

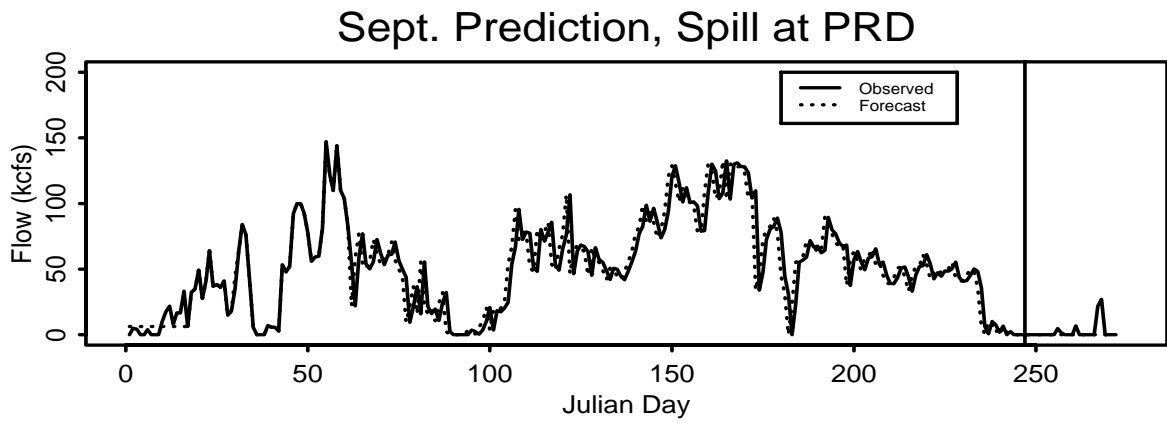
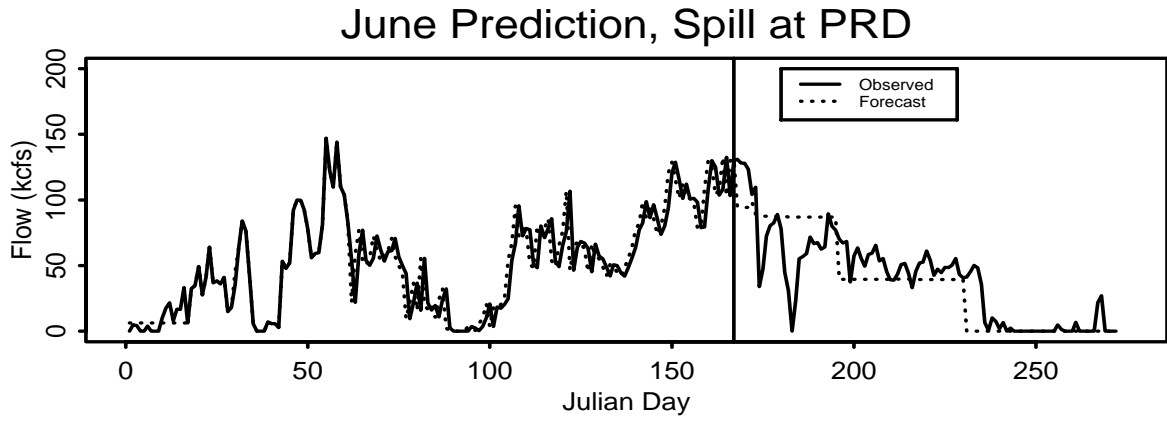
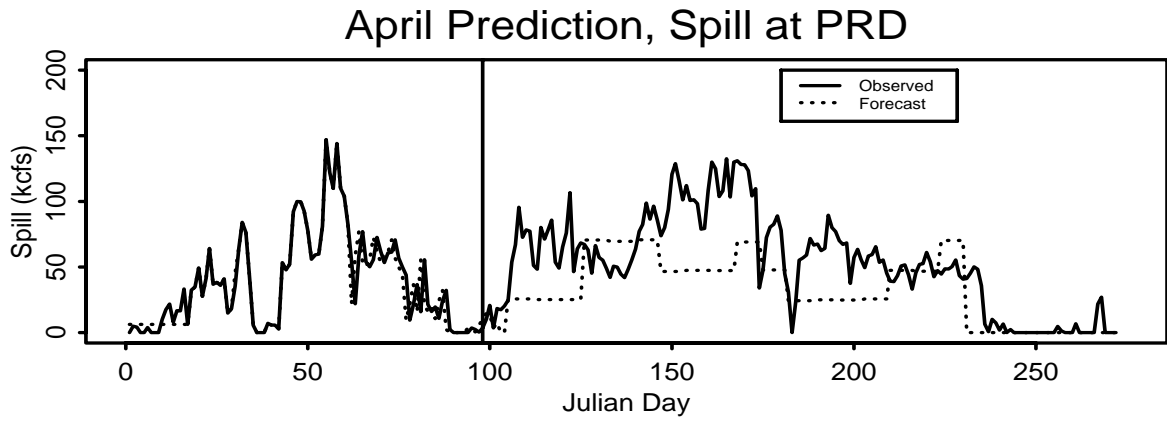


Figure 7: Spill forecasts for Priest Rapids Dam.

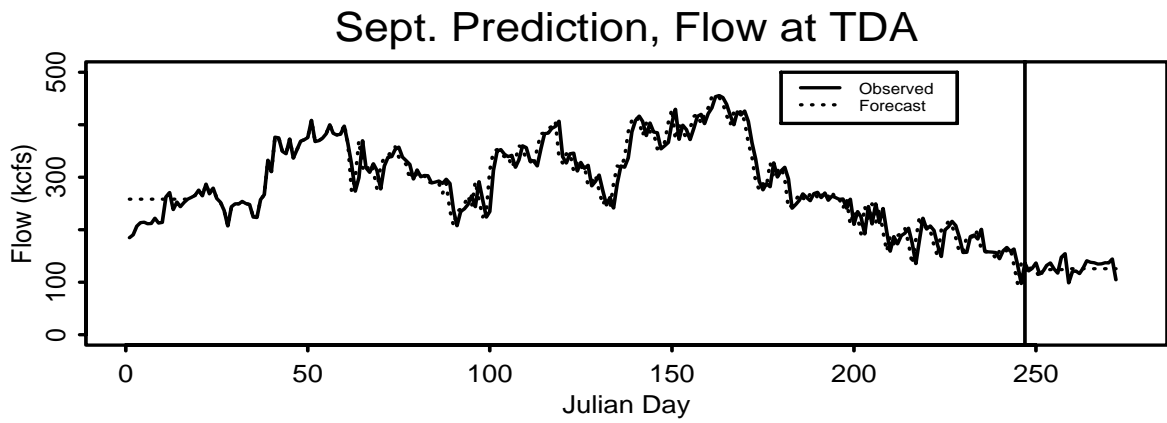
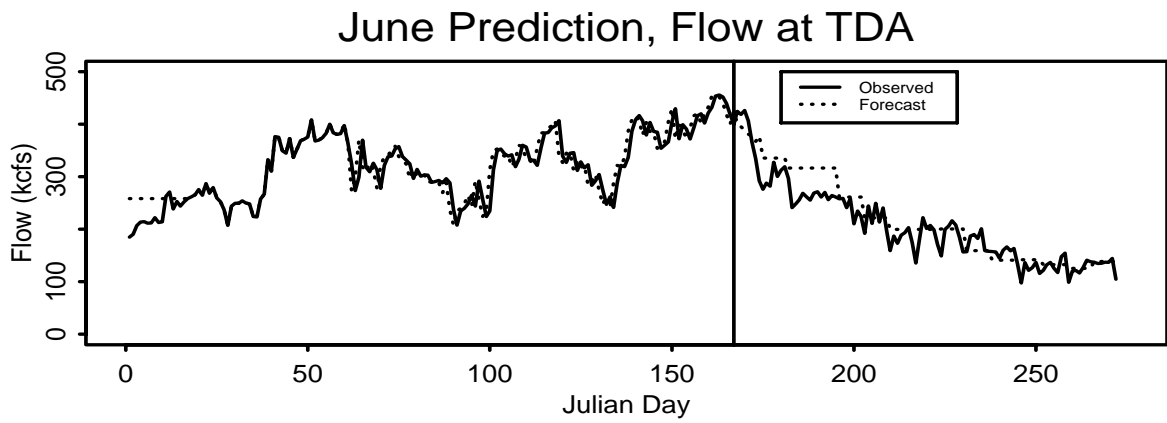
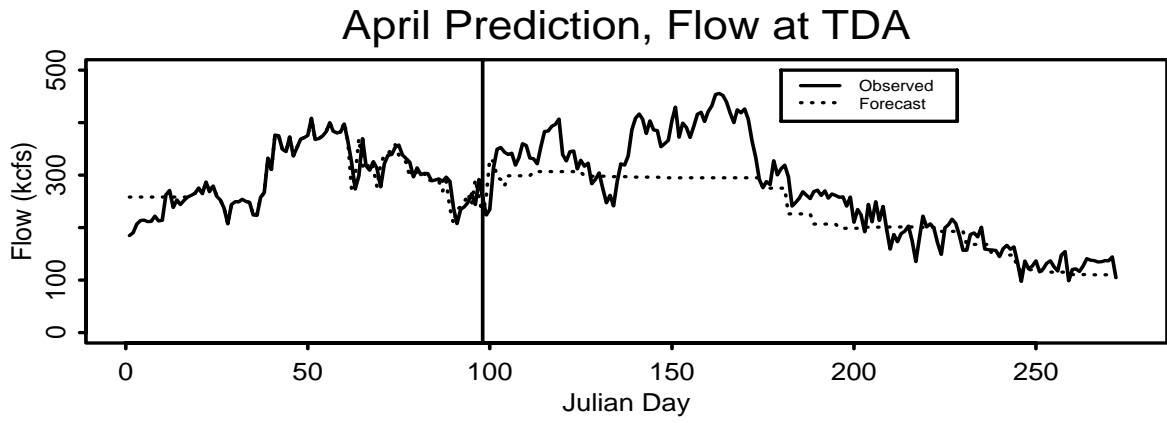
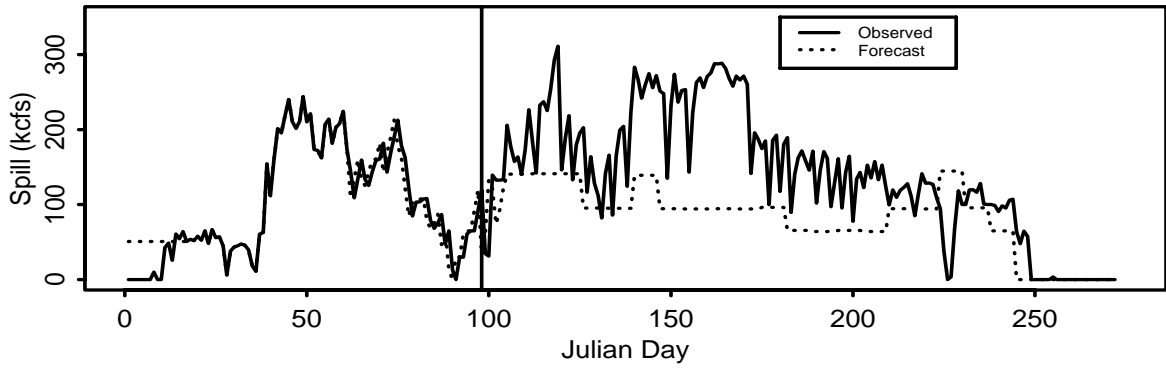
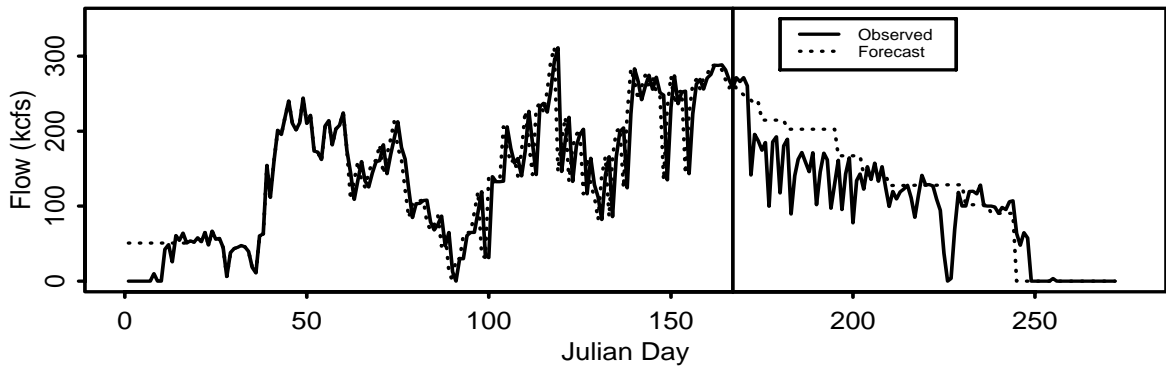


Figure 8: Flow forecasts for The Dalles Dam.

April Prediction, Spill at TDA



June Prediction, Spill at TDA



Sept. Prediction, Spill at TDA

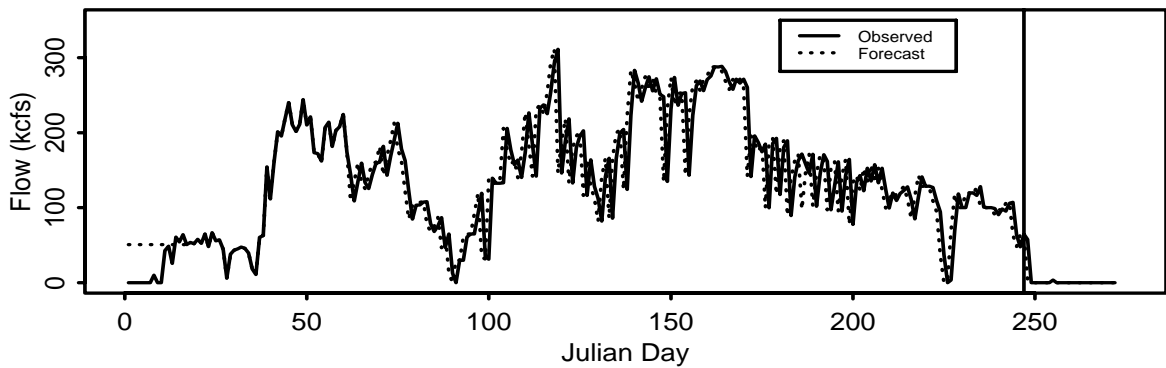


Figure 9: Spill forecasts for The Dalles Dam.

Appendix III – Migration rate parameters

CRiSP-RealTime Migration Rate Parameters

Year	β_{MIN}	β_{MAX}	β_{FLOW}	V_{VAR}	Sum Squares
Catherine Creek					
93	0.9878	34.9995	0.4850	167.96	38308.426
94	-3.7518	33.4497	1.1574	139.71	15304.162
95	0.0574	15.6287	0.6568	177.16	28702.971
96	0.3523	44.3182	0.6840	139.95	51025.641
Imnaha River					
93	-1.7346	1.3438	0.8030	144.96	24086.988
94	-4.9018	22.0732	0.9242	69.22	49570.660
95	-6.4776	16.7086	1.1635	98.80	41657.152
96	-4.6351	19.1234	0.8504	98.01	67075.625
Lostine River					
93	-3.2497	5.6318	0.9245	141.37	16415.223
94	0.3803	22.1464	0.2011	68.56	16696.053
95	3.2081	17.0486	0.0296	100.00	19851.586
96	0.6680	15.0350	0.2473	115.35	31188.645
Minam River					
93	-4.7556	8.0931	0.7758	128.60	23545.438
94	-2.1267	13.3035	0.5398	92.16	19290.254
95	0.1347	8.8995	0.4397	149.82	14146.663
96	-9.6435	18.0506	0.8642	152.52	35990.852
Salmon River South Fork					
93	4.6098	33.84	0.0861	135.87	39646.070
94	2.5000	50.9001	0.0192	127.33	32734.207
95	1.5002	34.60000	0.0447	170.57	44016.504

CRiSP-RealTime Migration Rate Parameters

Year	β_{MIN}	β_{MAX}	β_{FLOW}	V_{VAR}	Sum Squares
96	2.9924	33.3721	0.1291	170.82	
Wenaha River South Fork					
93	-2.2654	13.0791	0.7828	132.48	22781.041
94	-0.7442	24.0282	0.4060	93.12	31653.584
95	2.2998	22.9992	0.3035	116.64	9088.213
96	-1.6150	25.5395	0.3975	117.51	36762.969

Appendix IV: Results plots

The following figures present the CRiSP/RealTime predictions on April 23, May 5, May 19, and May 30. The dashed line represent the model predictions and the solid line is the observed distribution of PIT tag arrivals at Lower Granite, Little Goose, Lower Monumental and McNary Dam. The predicted distribution at Lower Granite Dam is generated by the Realtime program, and the predicted distributions at Little Goose, Lower Monumental and McNary are CRiSP projections of the Lower Granite prediction. The vertical dashed line is the date of the prediction.

Composite Stock– 4/23/96

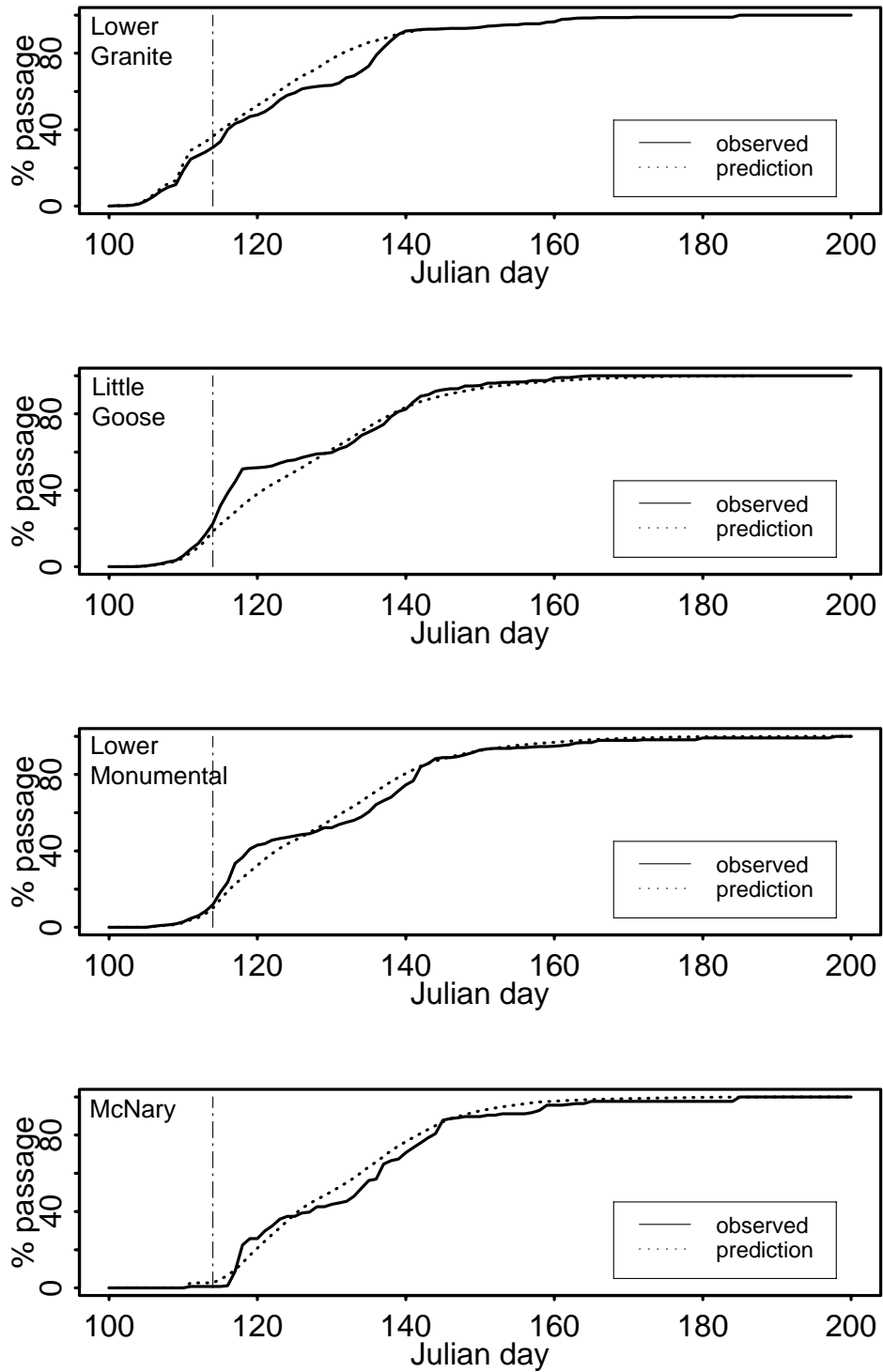


Figure A4.1. CRiSP/RealTime predictions for the composite stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Composite Stock– 5/05/96

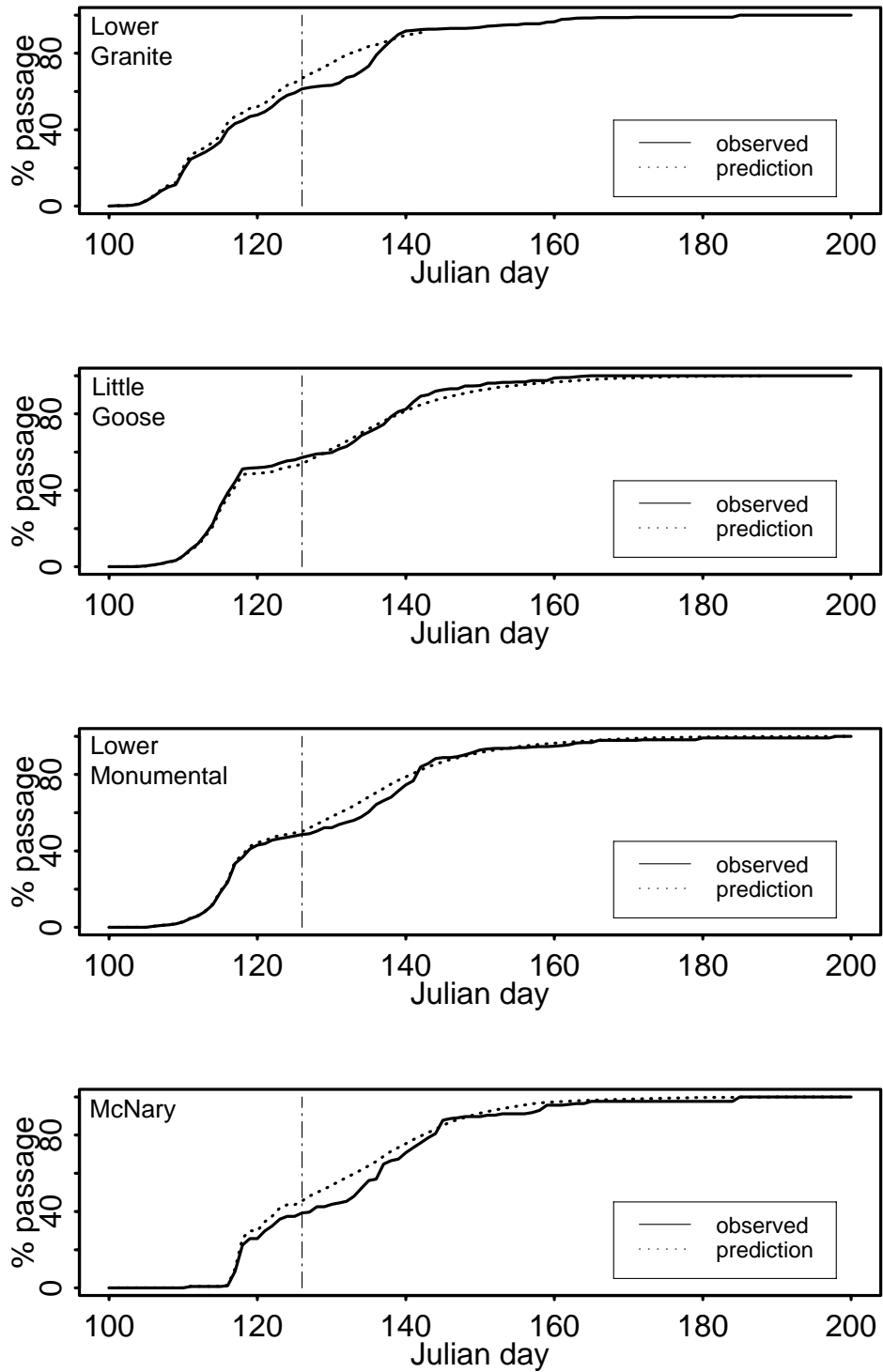


Figure A4.2. CRiSP/RealTime predictions for the composite stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Composite Stock– 5/19/96

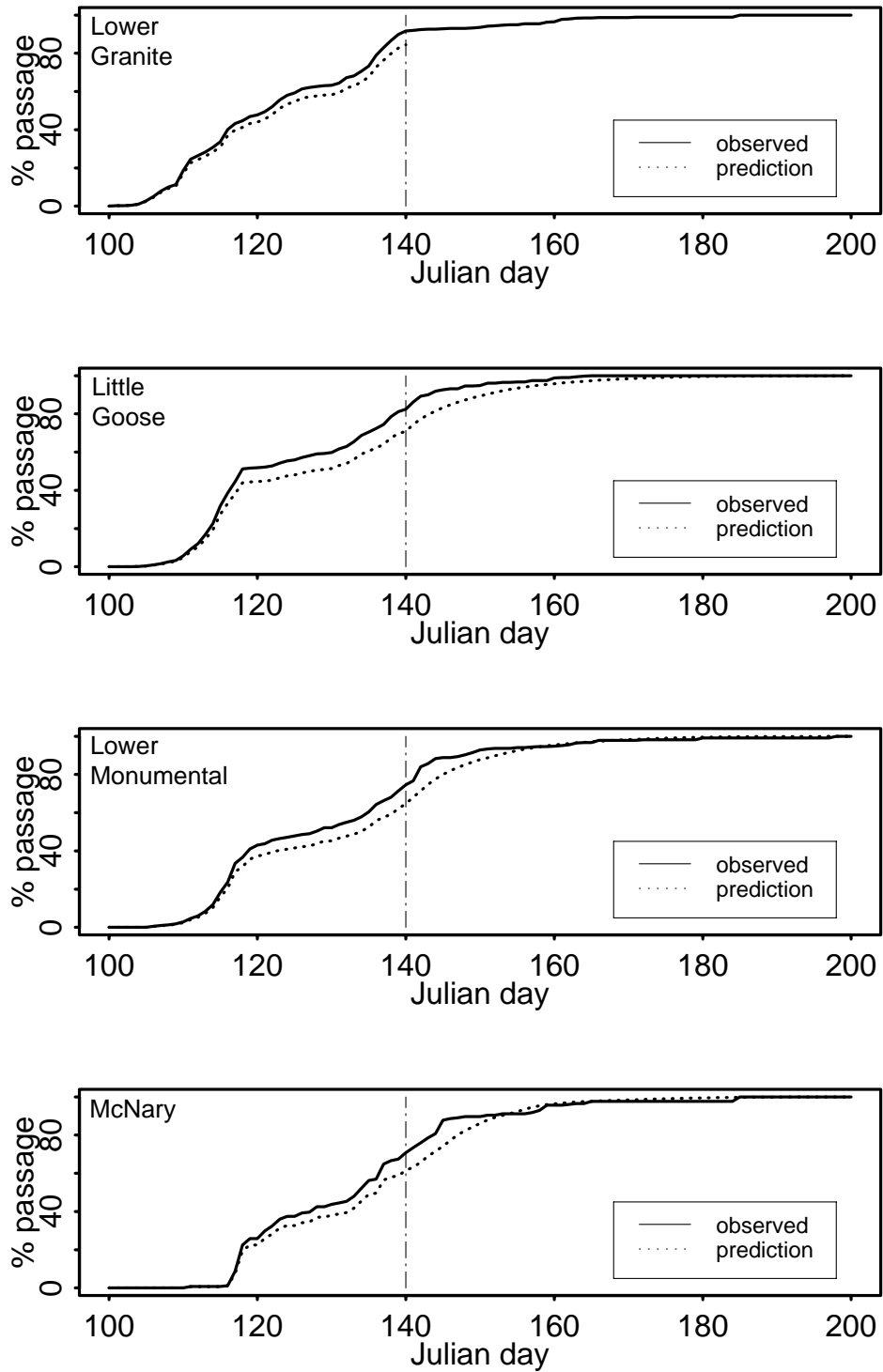


Figure A4.3. CRiSP/RealTime predictions for the composite stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Composite Stock– 5/30/96

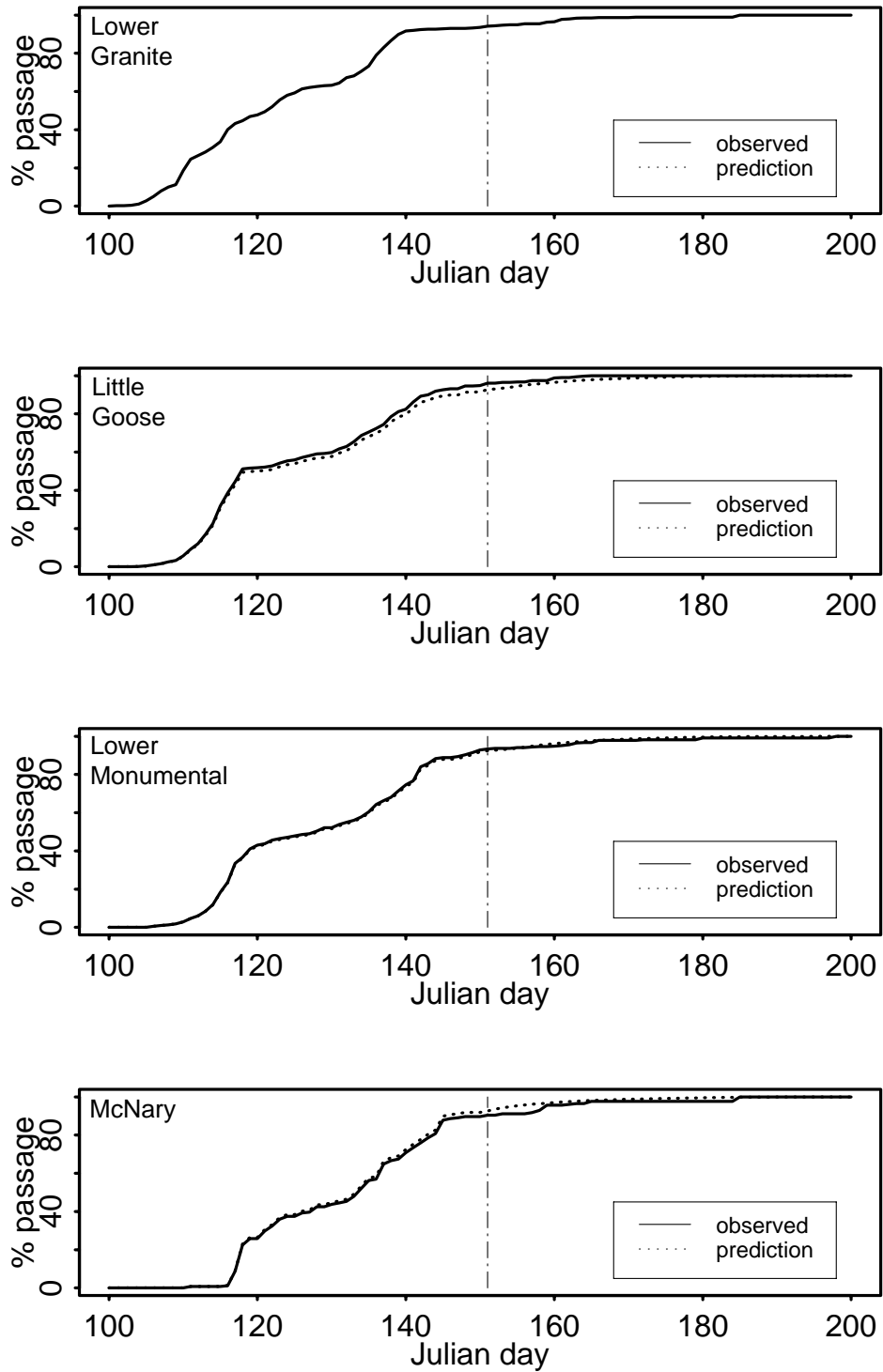


Figure A4.4. CRiSP/RealTime predictions for the composite stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Catherine Creek – 4/23/96

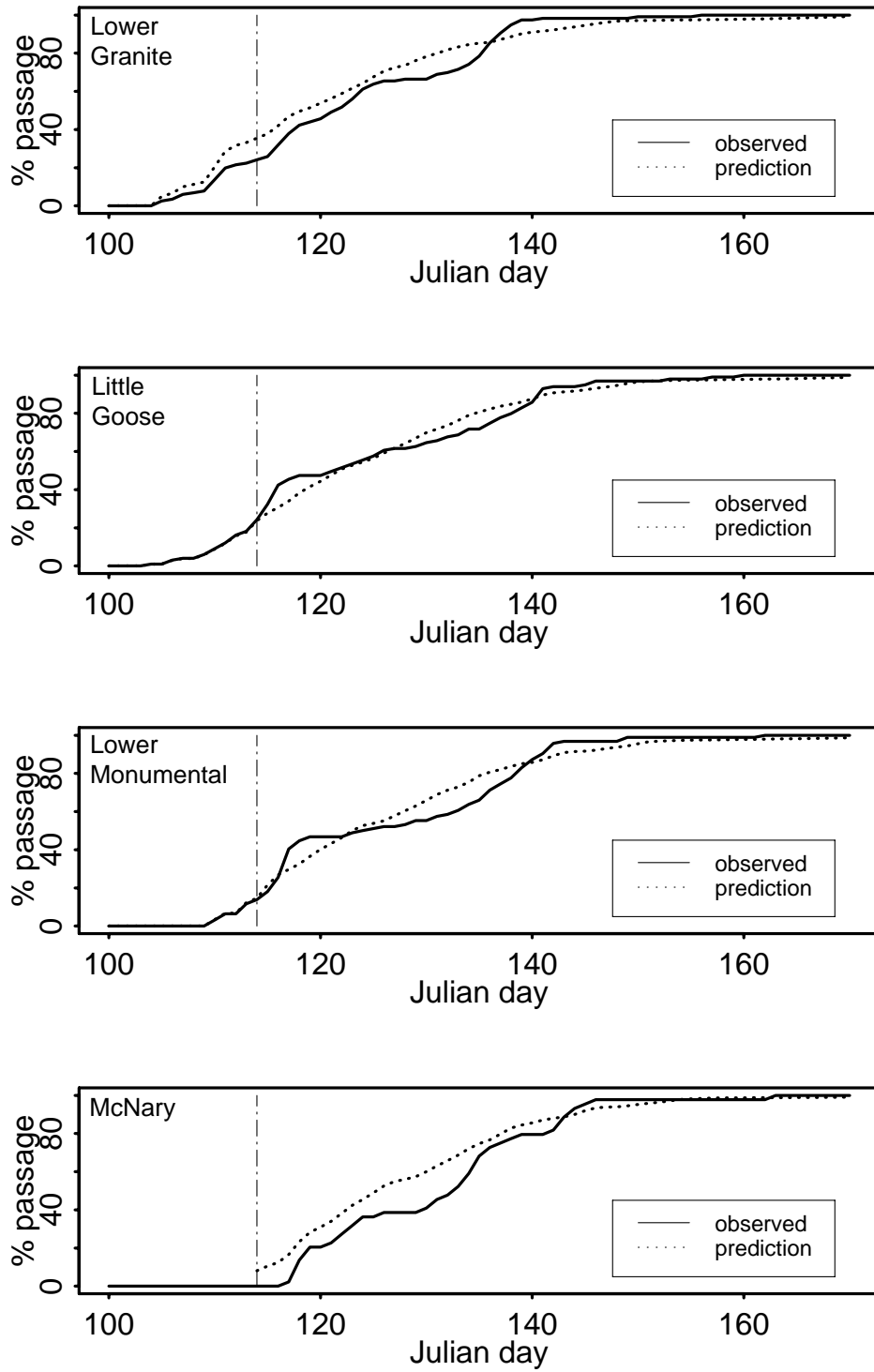


Figure A4.5. CRiSP/RealTime predictions for the Catherine Creek stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Catherine Creek – 5/05/96

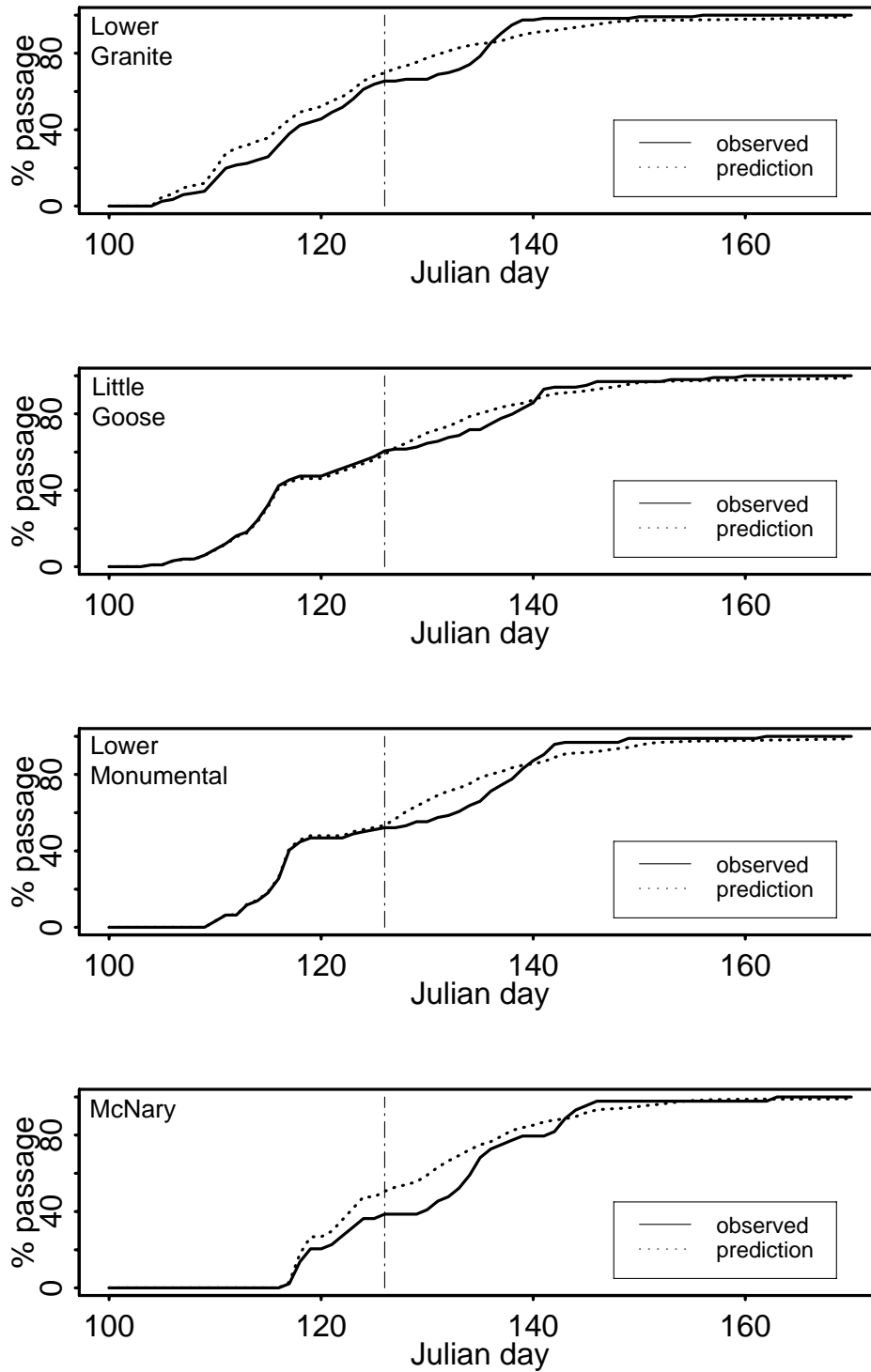


Figure A4.6. CRiSP/RealTime predictions for the Catherine Creek stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Catherine Creek – 5/19/96

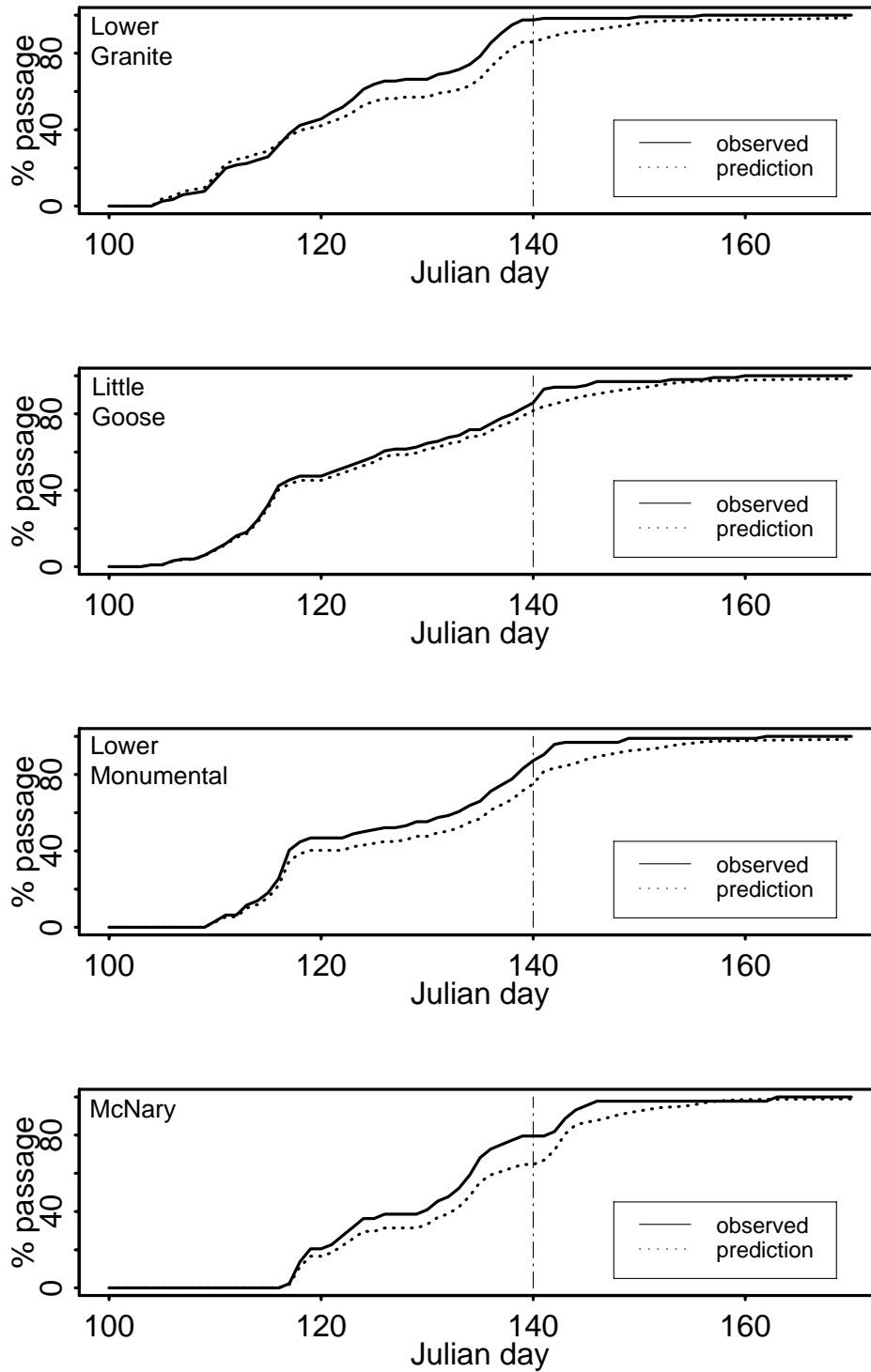


Figure A4.7. CRiSP/RealTime predictions for the Catherine Creek stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Catherine Creek – 5/30/96

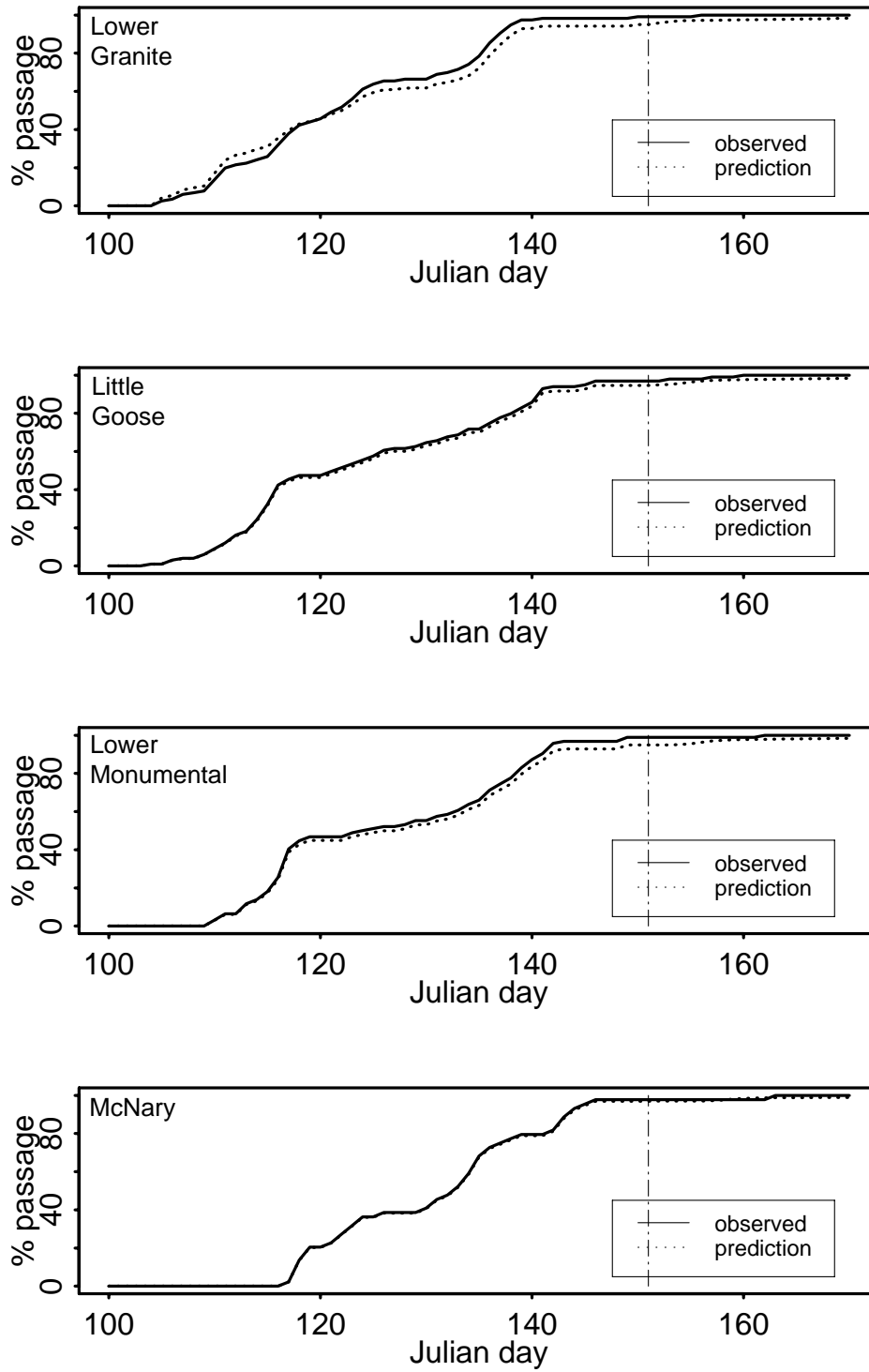


Figure A4.8. CRiSP/RealTime predictions for the Catherine Creek stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Imnaha River – 4/23/96

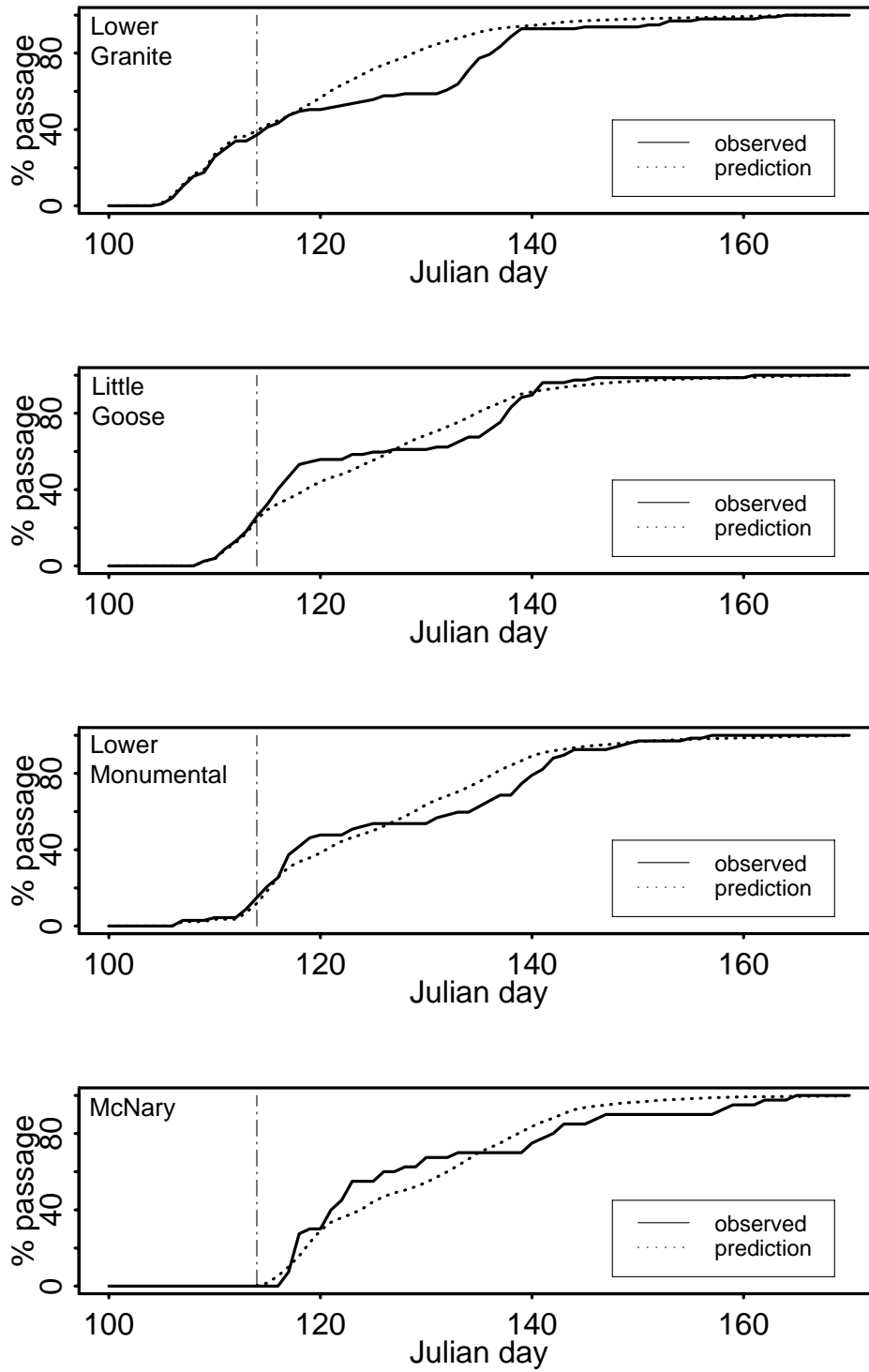


Figure A4.9. CRiSP/RealTime predictions for the Imnaha River stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Imnaha River – 5/05/96

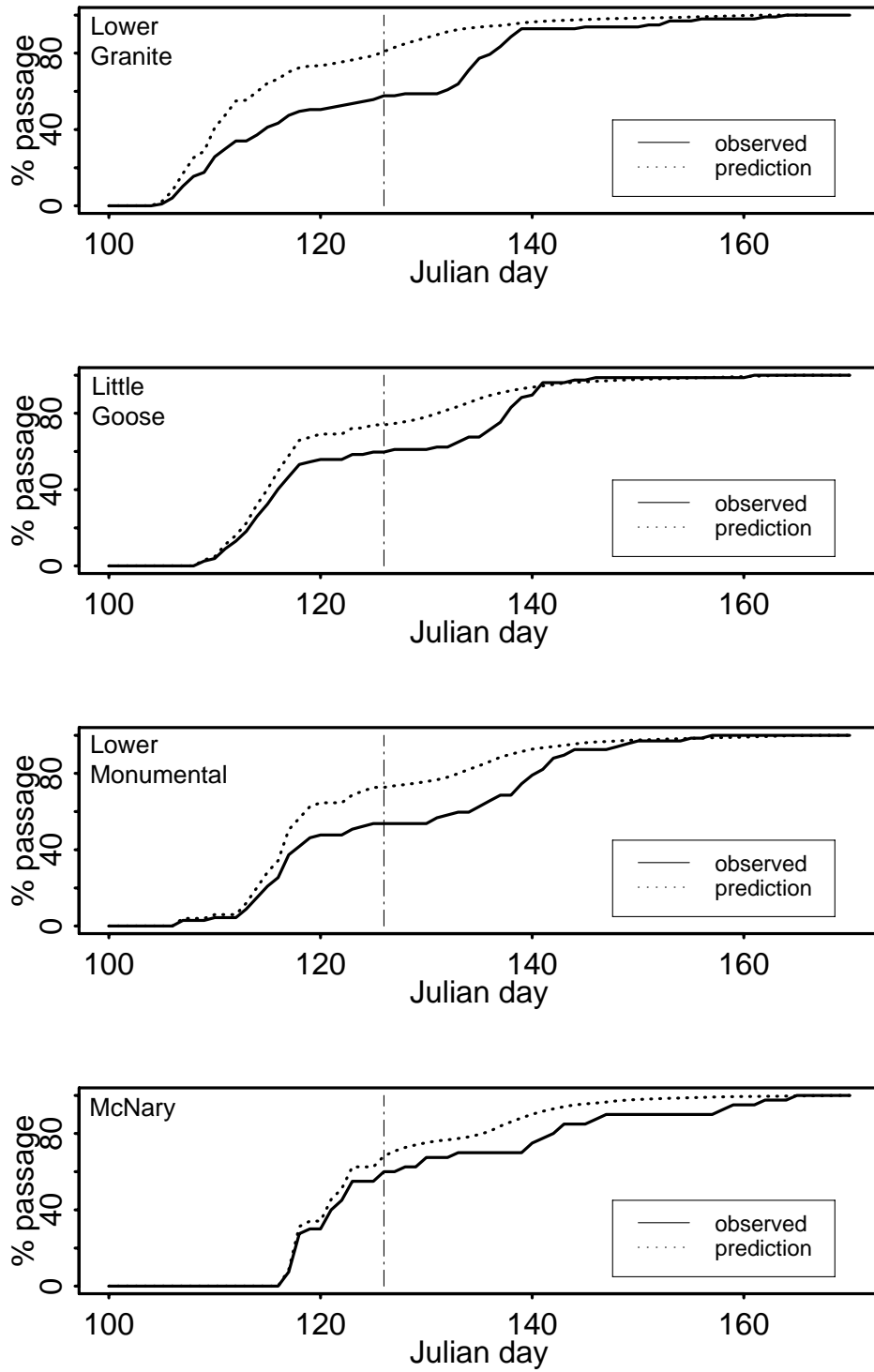


Figure A4.10. CRiSP/RealTime predictions for the Imnaha River stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Imnaha River – 5/19/96

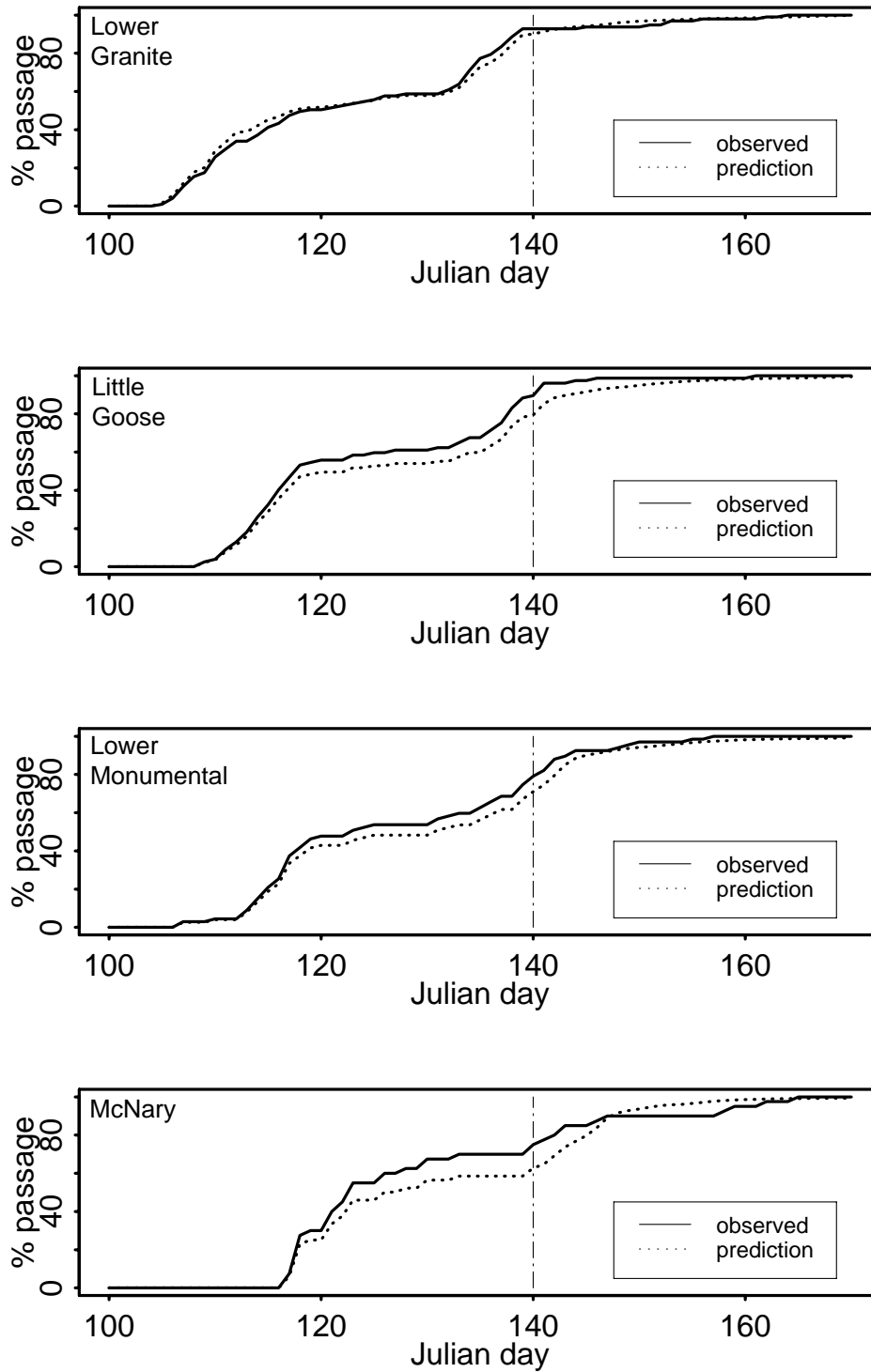


Figure A4.11. CRiSP/RealTime predictions for the Imnaha River stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Imnaha River – 5/30/96

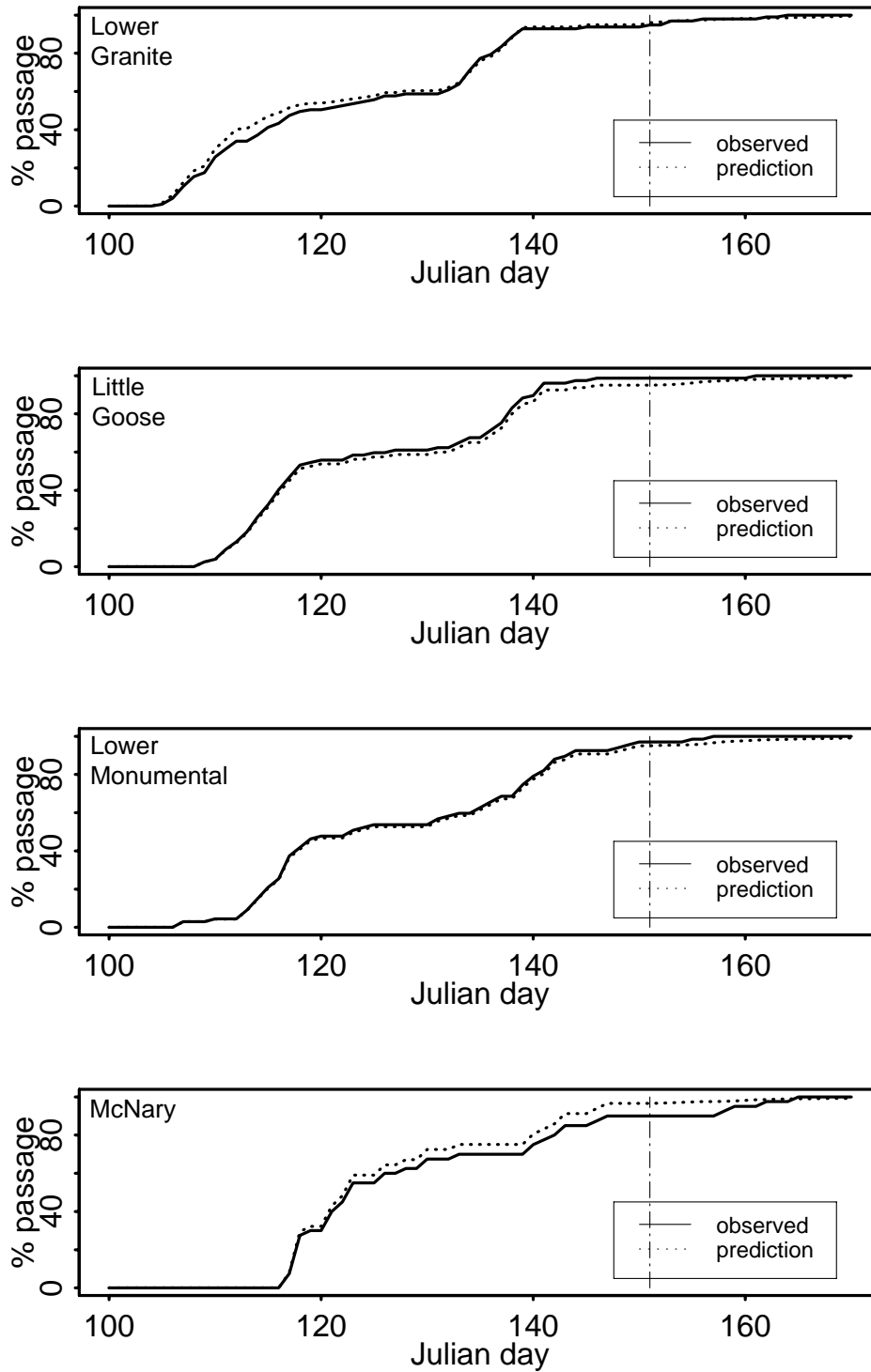


Figure A4.12. CRiSP/RealTime predictions for the Imnaha River stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Lostine River – 4/23/96

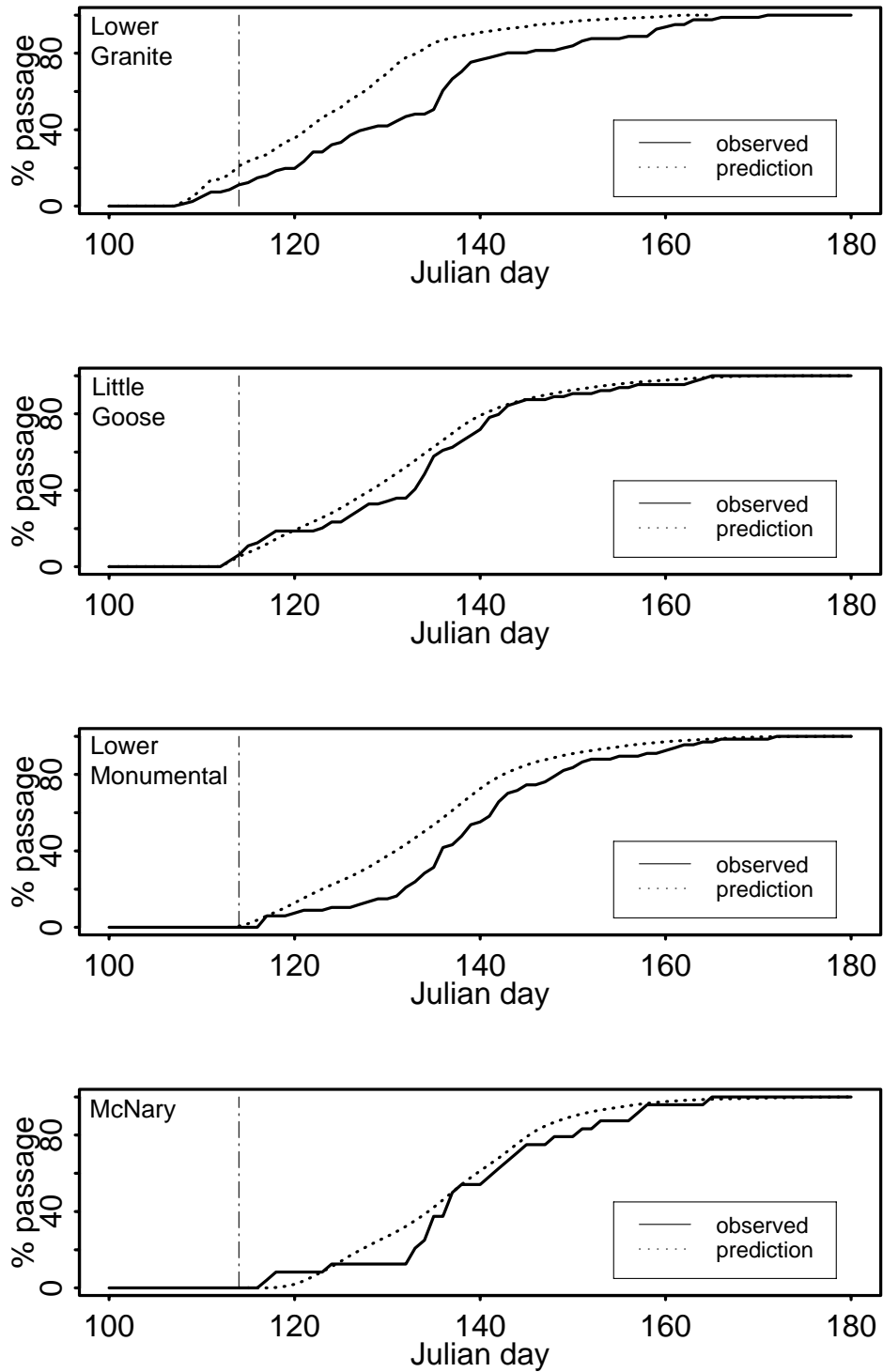


Figure A4.13. CRiSP/RealTime predictions for the Lostine River stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Lostine River – 5/05/96

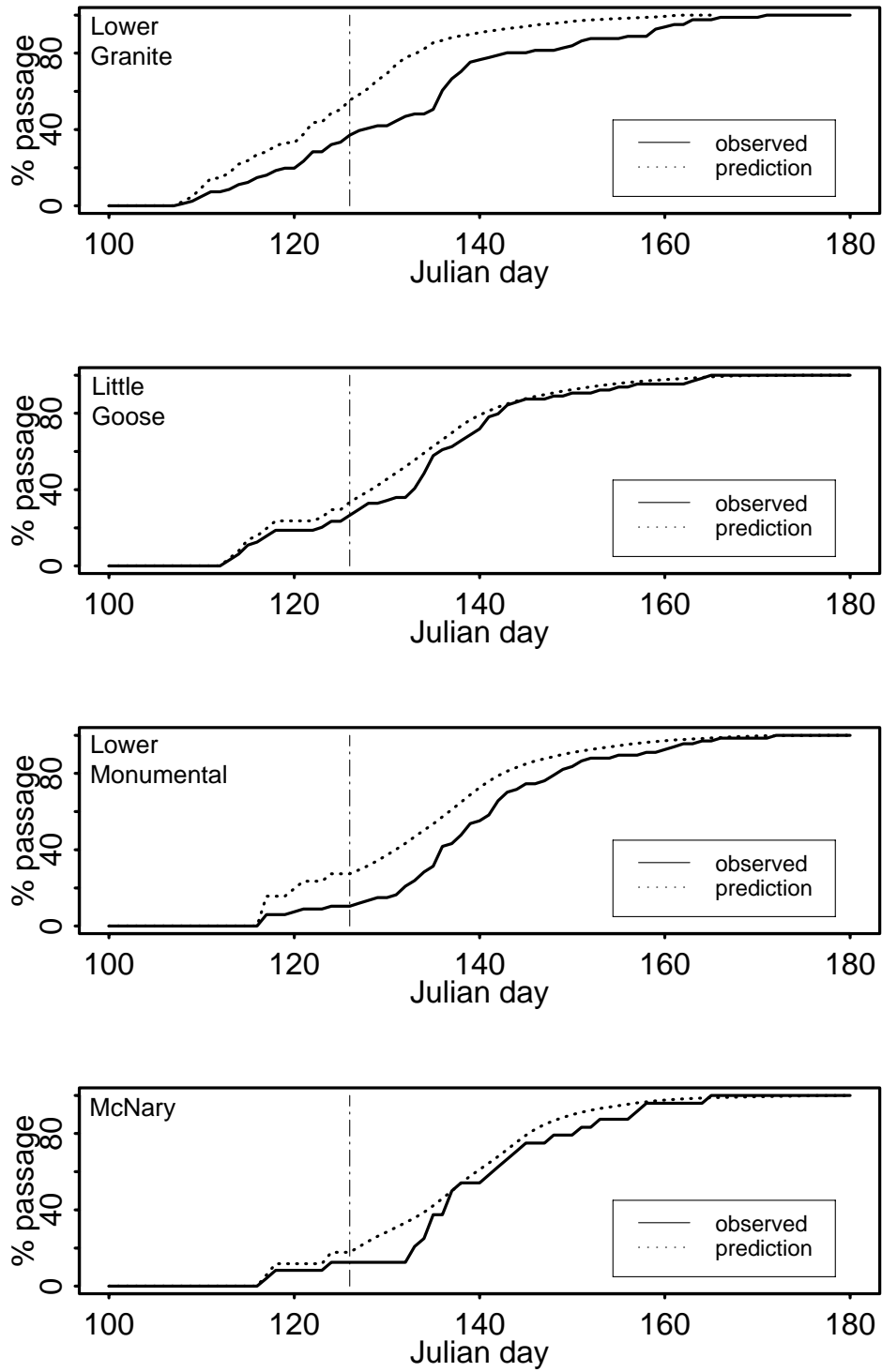


Figure A4.14. CRiSP/RealTime predictions for the Lostine River stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Lostine River – 5/19/96

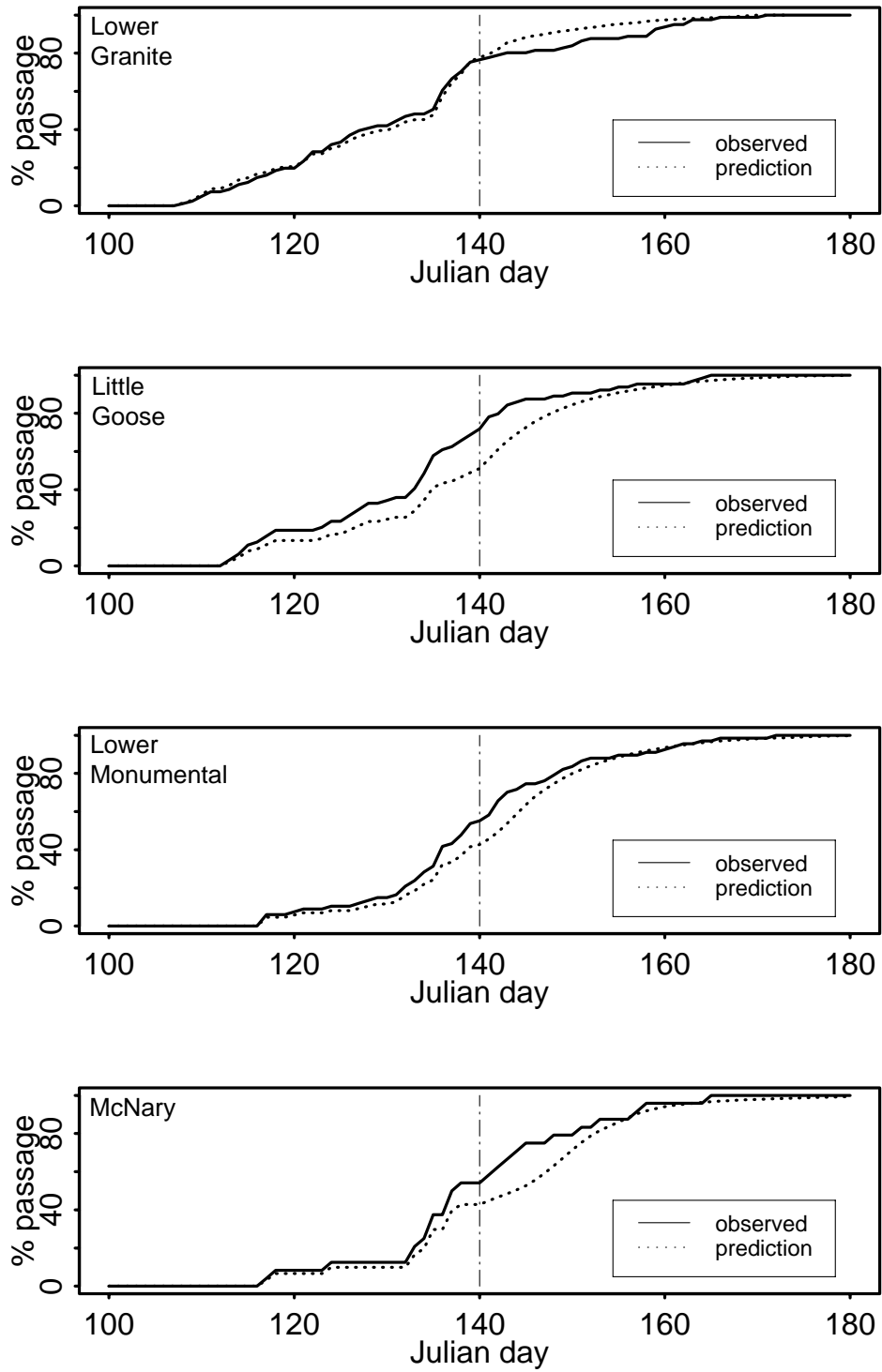


Figure A4.15. CRiSP/RealTime predictions for the Lostine River stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Lostine River – 5/30/96

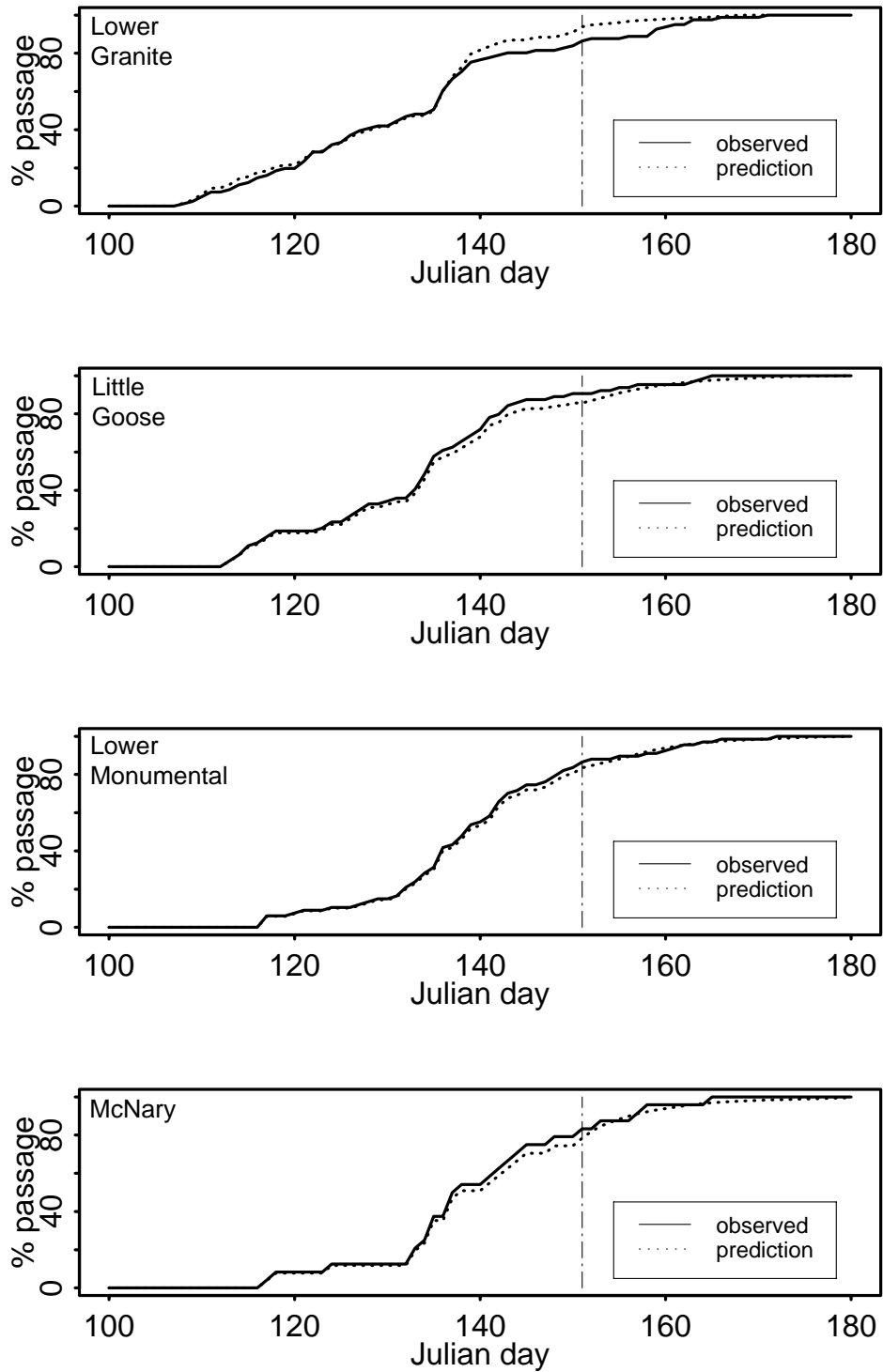


Figure A4.16. CRiSP/RealTime predictions for the Lostine River stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Minam River – 4/23/96

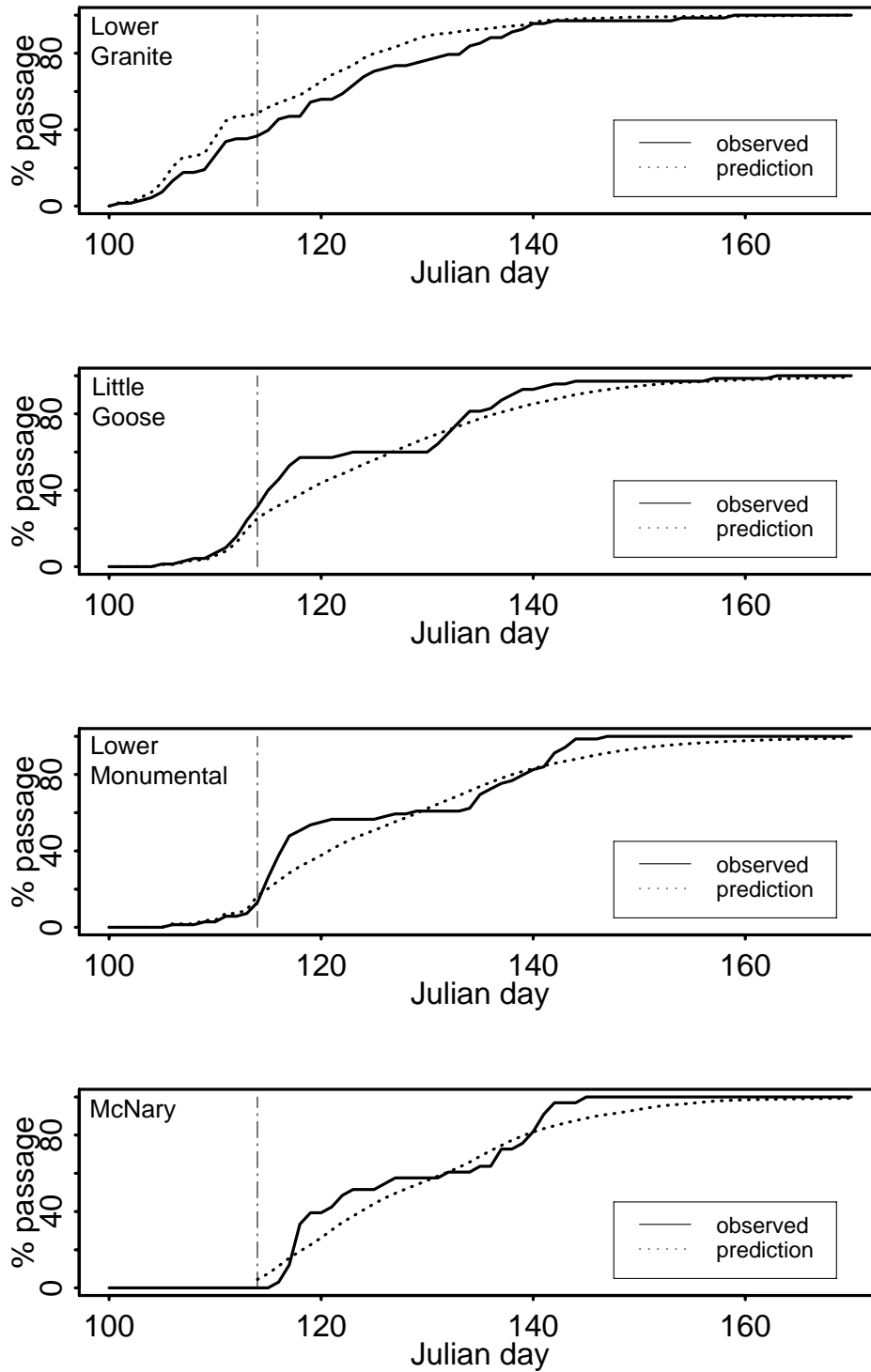


Figure A4.17. CRiSP/RealTime predictions for the Minam River stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Minam River – 5/05/96

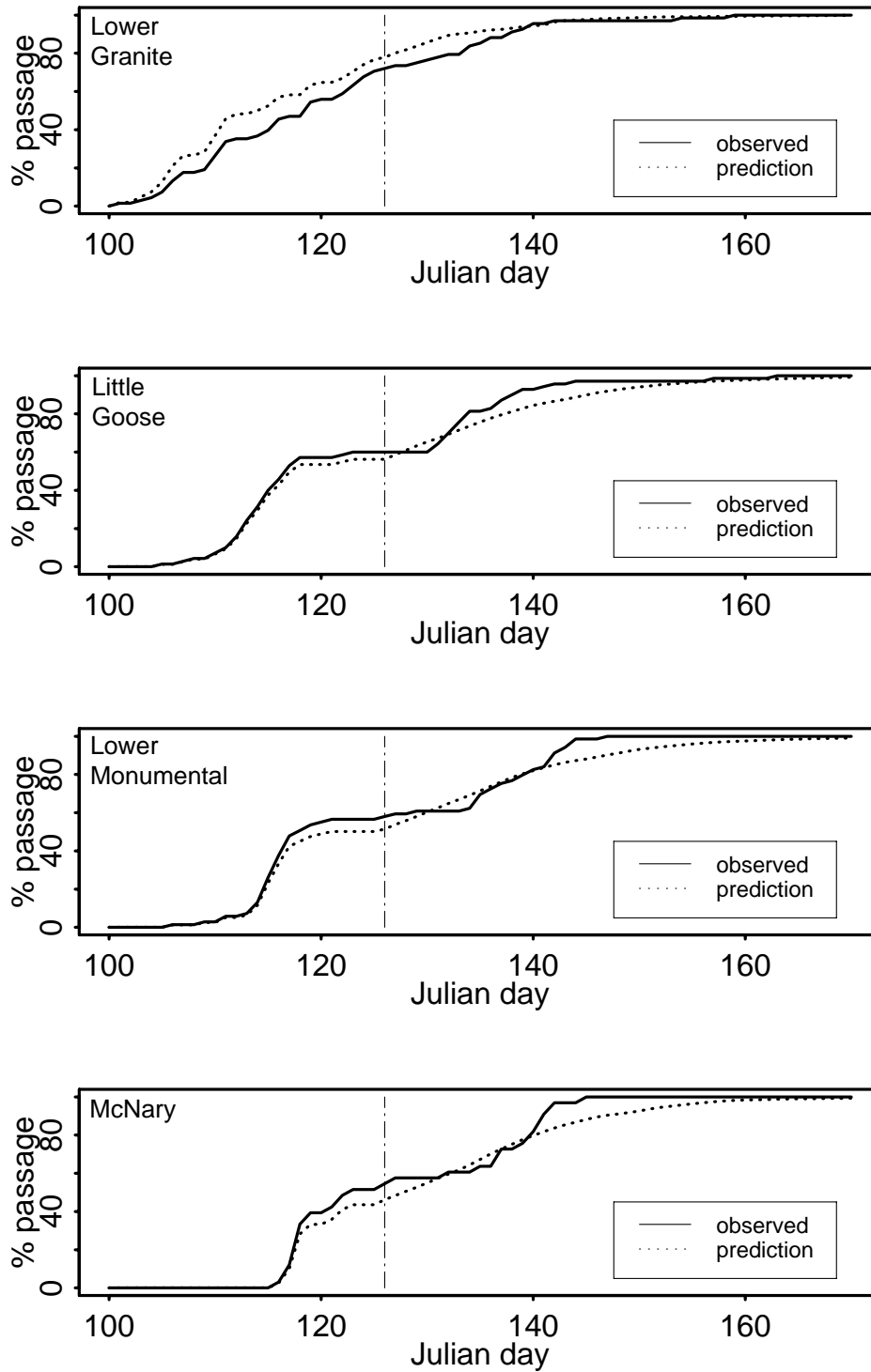


Figure A4.18. CRiSP/RealTime predictions for the Minam River stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Minam River – 5/19/96

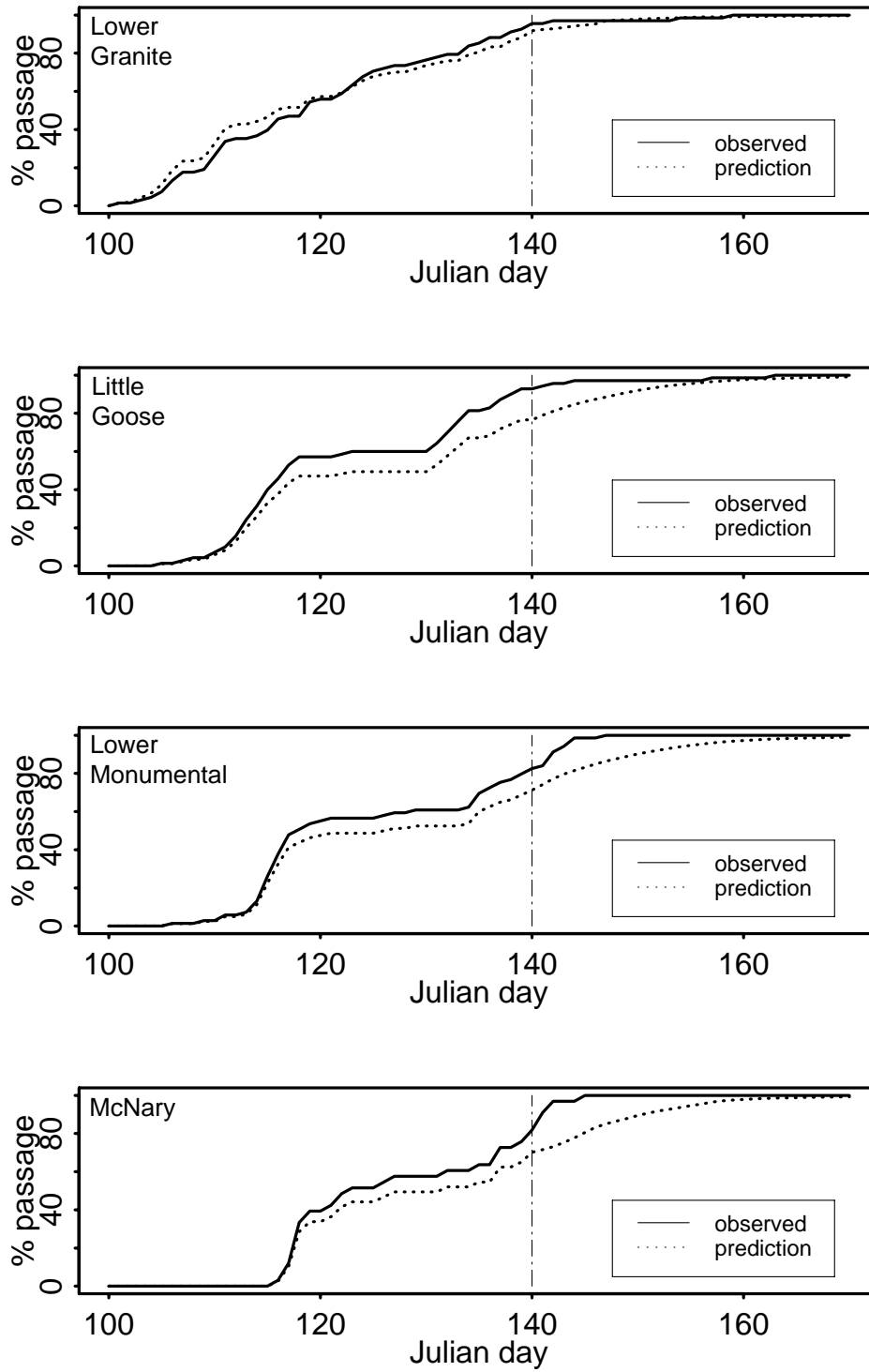


Figure A4.19. CRiSP/RealTime predictions for the Minam River stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

Minam River – 5/30/96

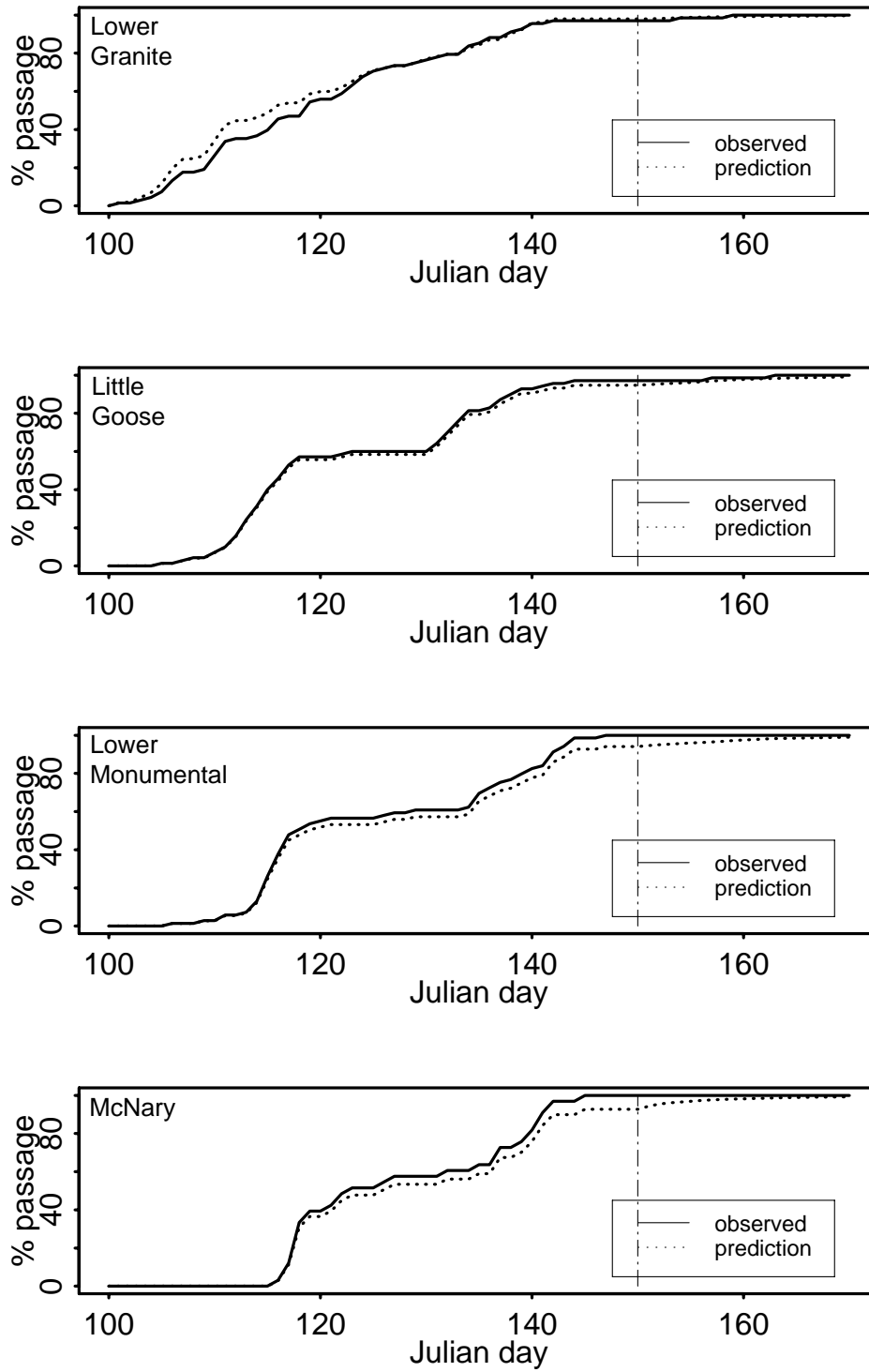


Figure A4.20. CRiSP/RealTime predictions for the Minam River stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

South Fork Salmon River – 4/23/96

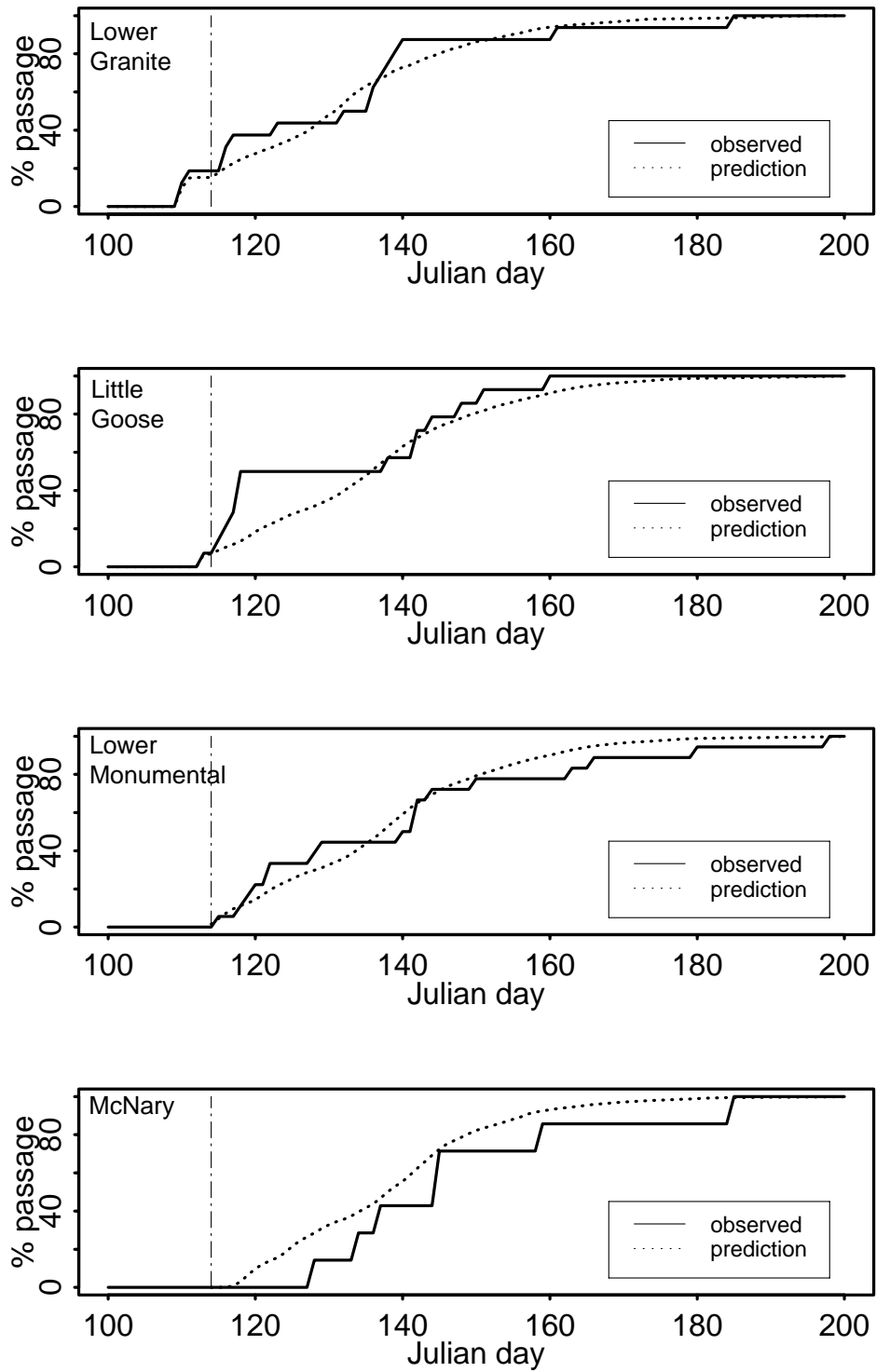


Figure A4.21. CRiSP/RealTime predictions for the S Fk Salmon R stock on April 23, 1996. The top plot is the Realtime prediction; the bottom three plots are the CRiSP projections.

South Fork Salmon River – 5/05/96

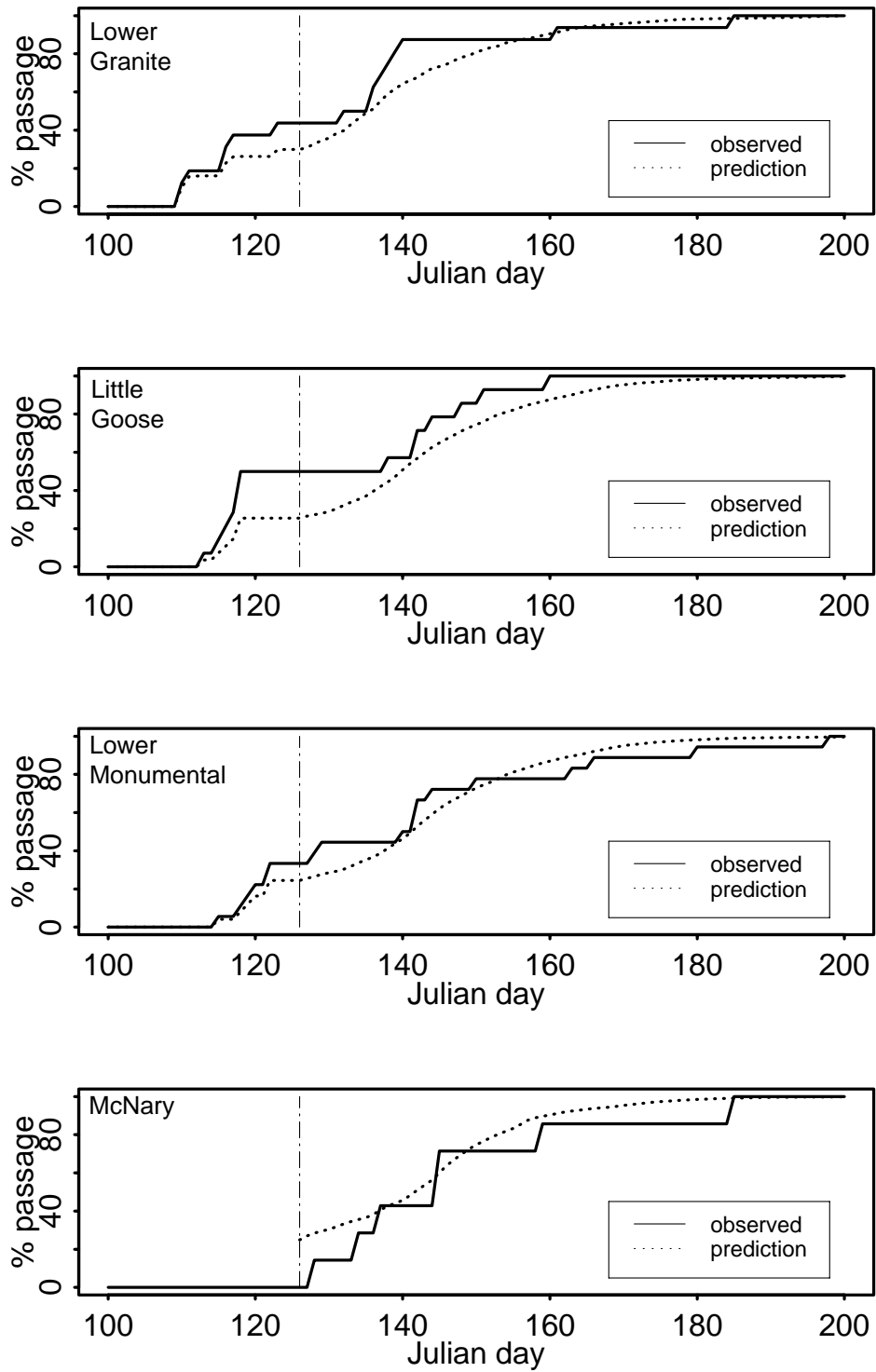


Figure A4.22. CRiSP/RealTime predictions for the S Fk Salmon R stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

South Fork Salmon River – 5/19/96

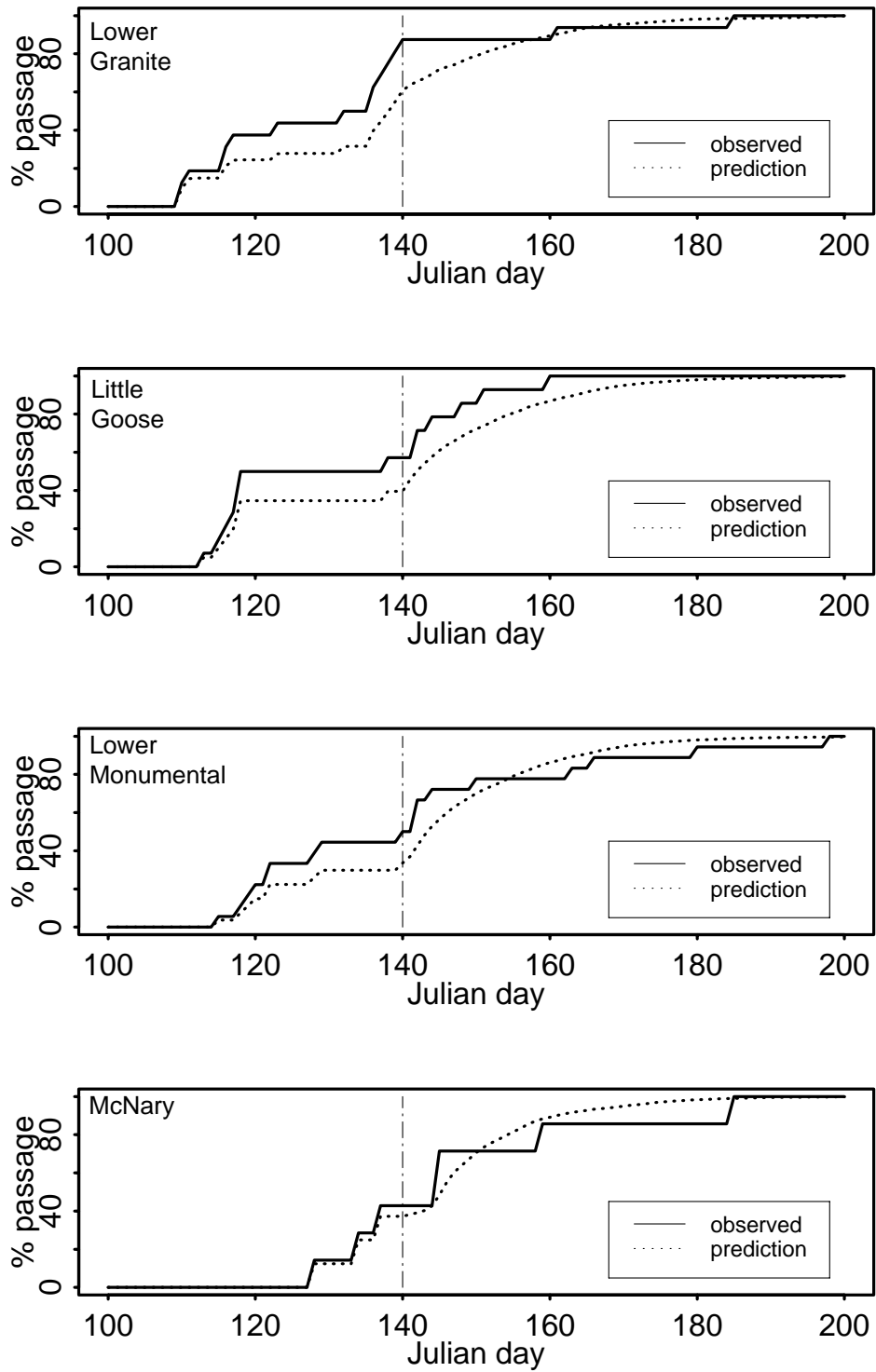


Figure A4.23. CRiSP/RealTime predictions for the S Fk Salmon R stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

South Fork Salmon River – 5/30/96

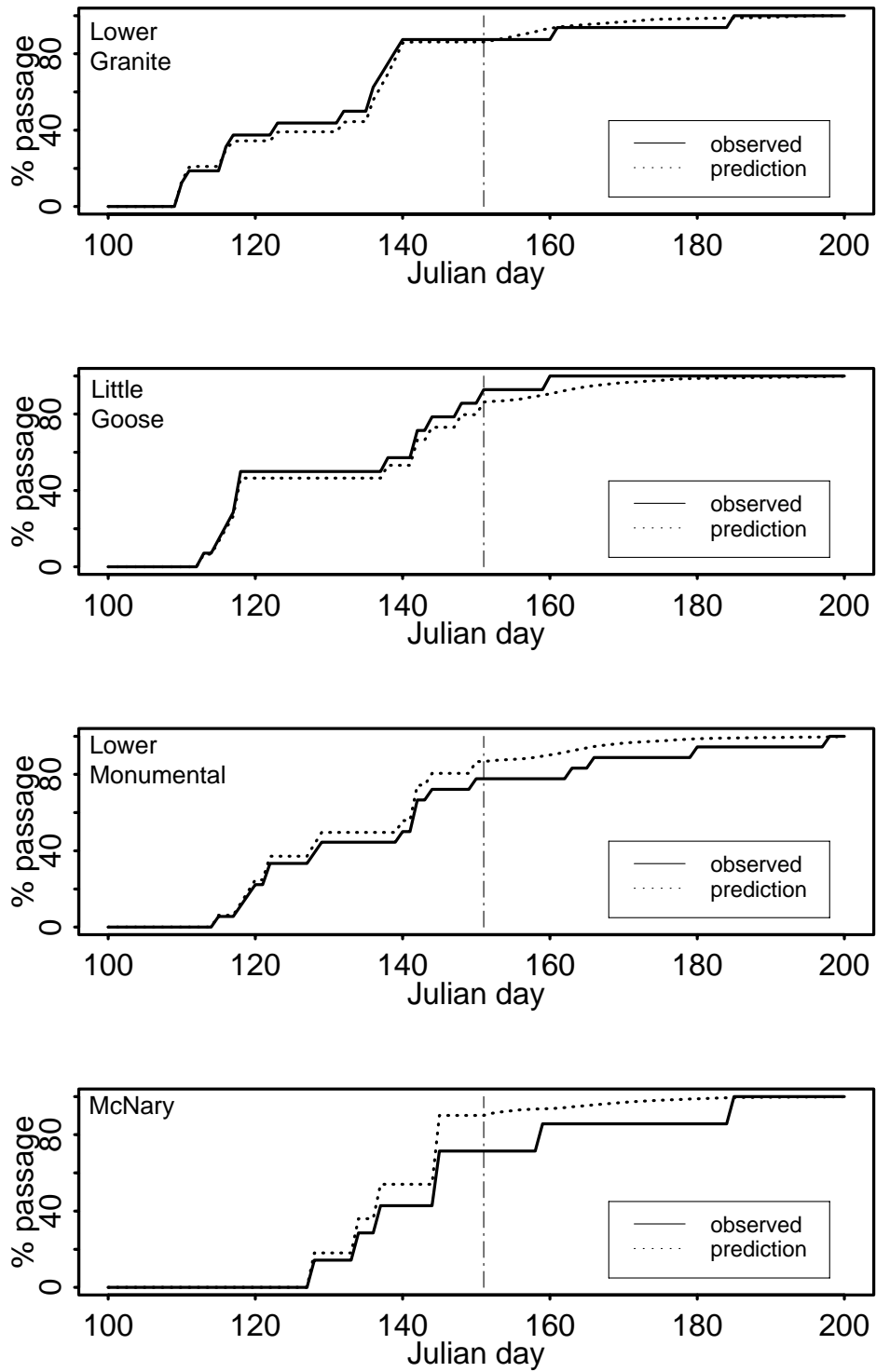


Figure A4.24. CRiSP/RealTime predictions for the S Fk Salmon R stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

South Fork Wenaha River – 4/23/96

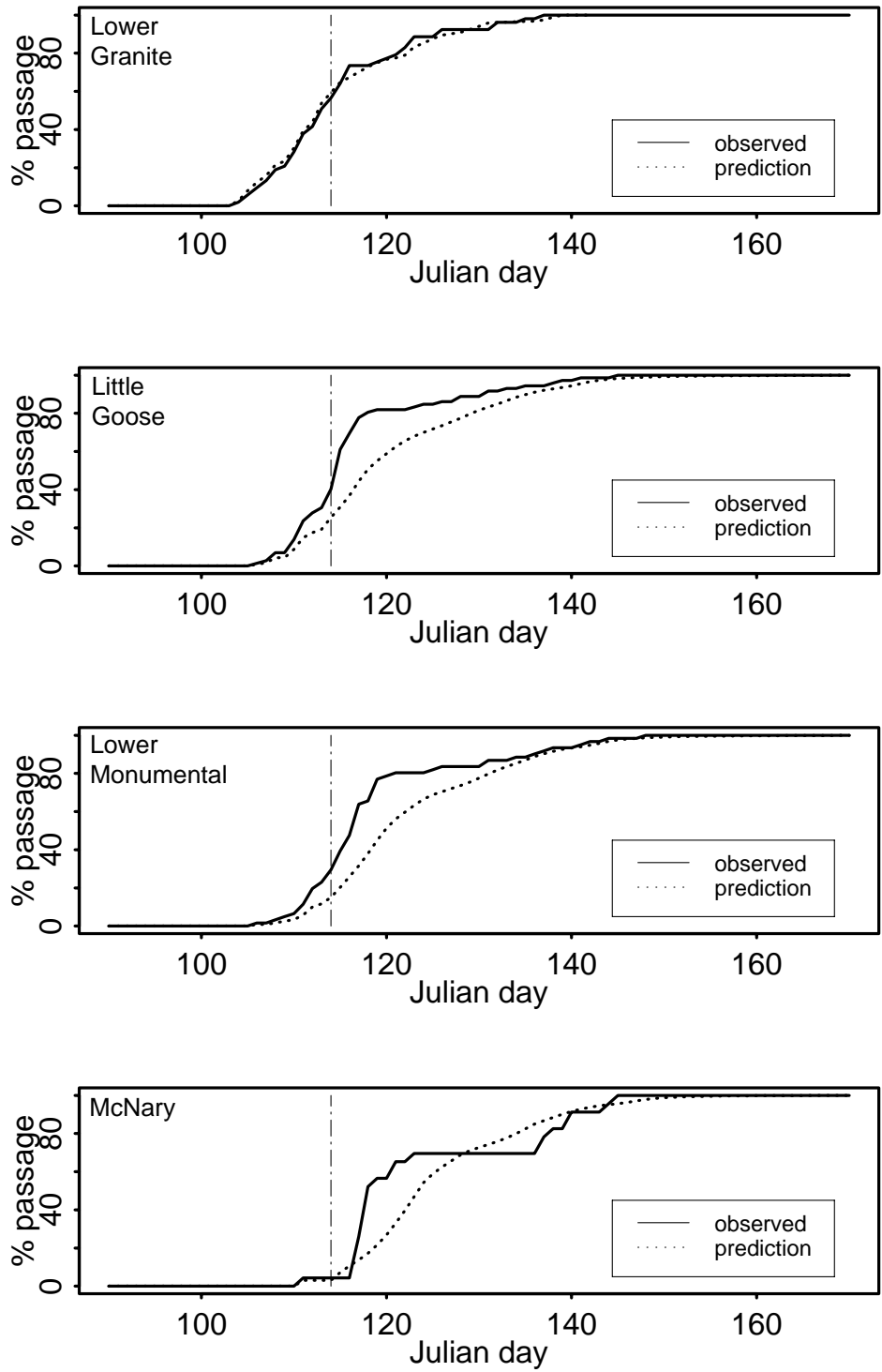


Figure A4.25. CRiSP/RealTime predictions for the S Fk Wenaha R stock on April 23, 1996. The top plot is the Realtime prediction. The bottom three are the CRiSP projections.

South Fork Wenaha River – 5/05/96

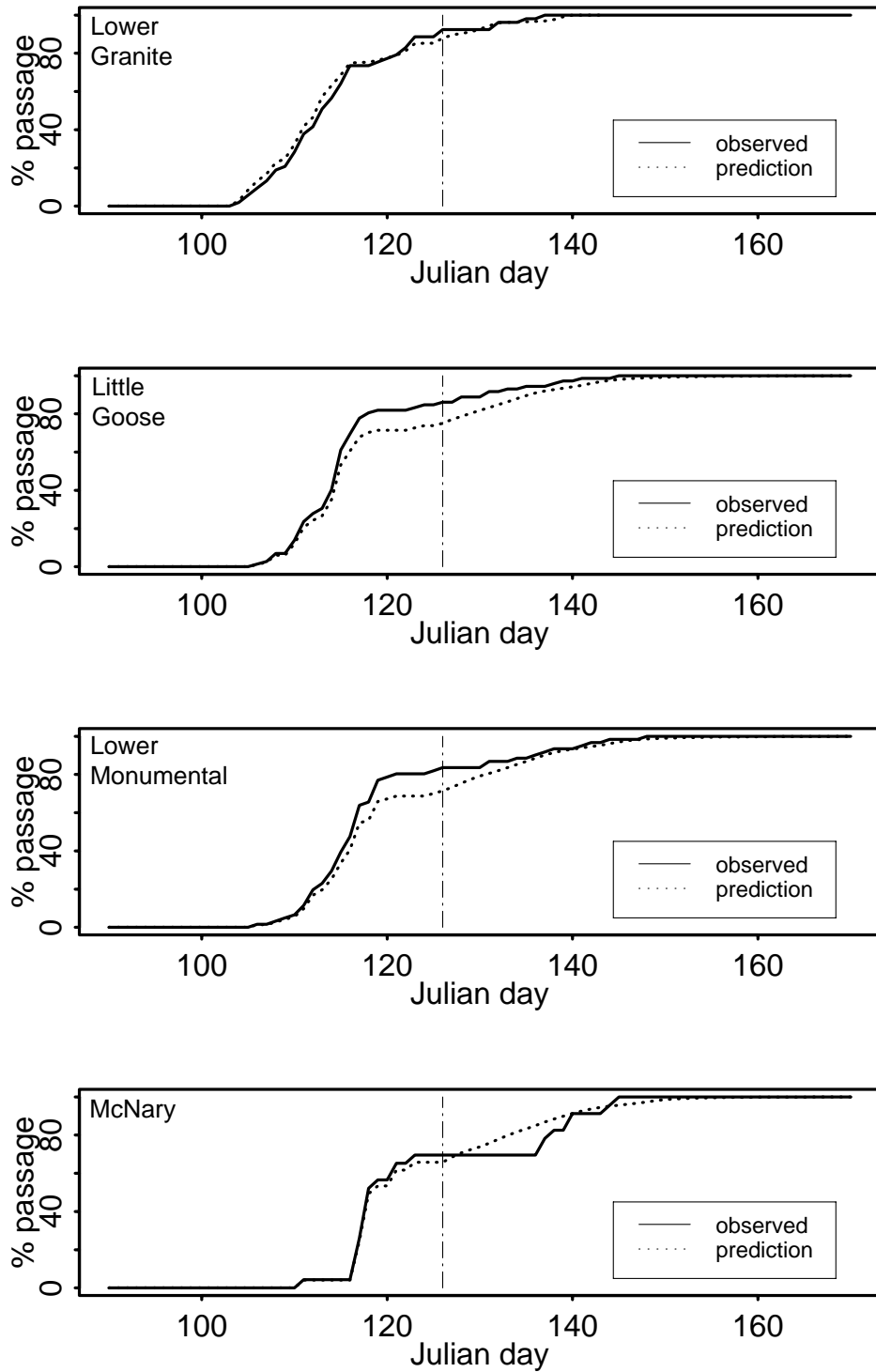


Figure A4.26. CRiSP/RealTime predictions for the S Fk Wenaha R stock on May 5, 1996. The top plot is the Realtime prediction. The bottom three are the CRiSP projections.

South Fork Wenaha River – 5/19/96

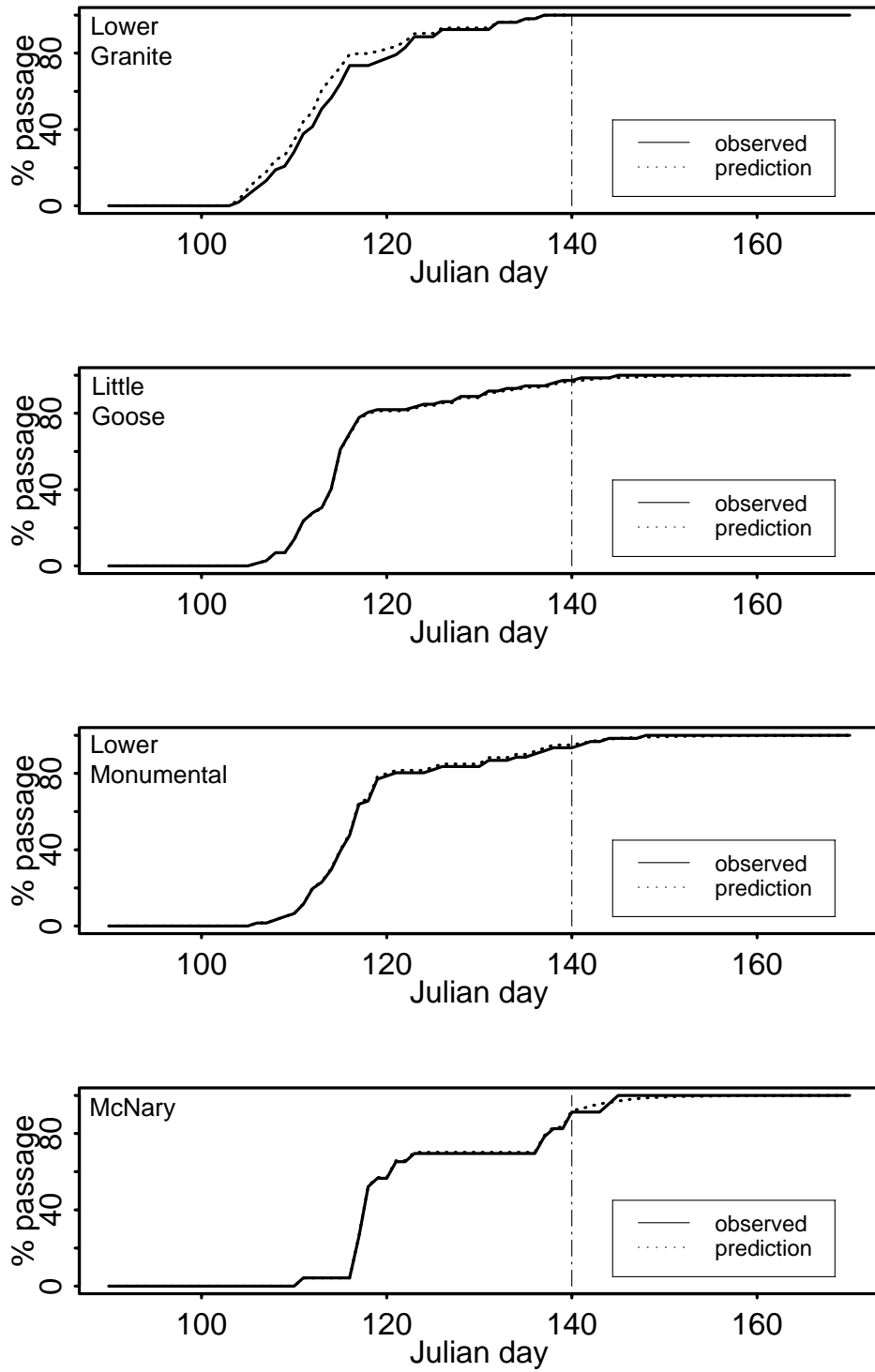


Figure A4.27. CRiSP/RealTime predictions for the S Fk Wenaha R stock on May 19, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

South Fork Wenaha River – 5/30/96

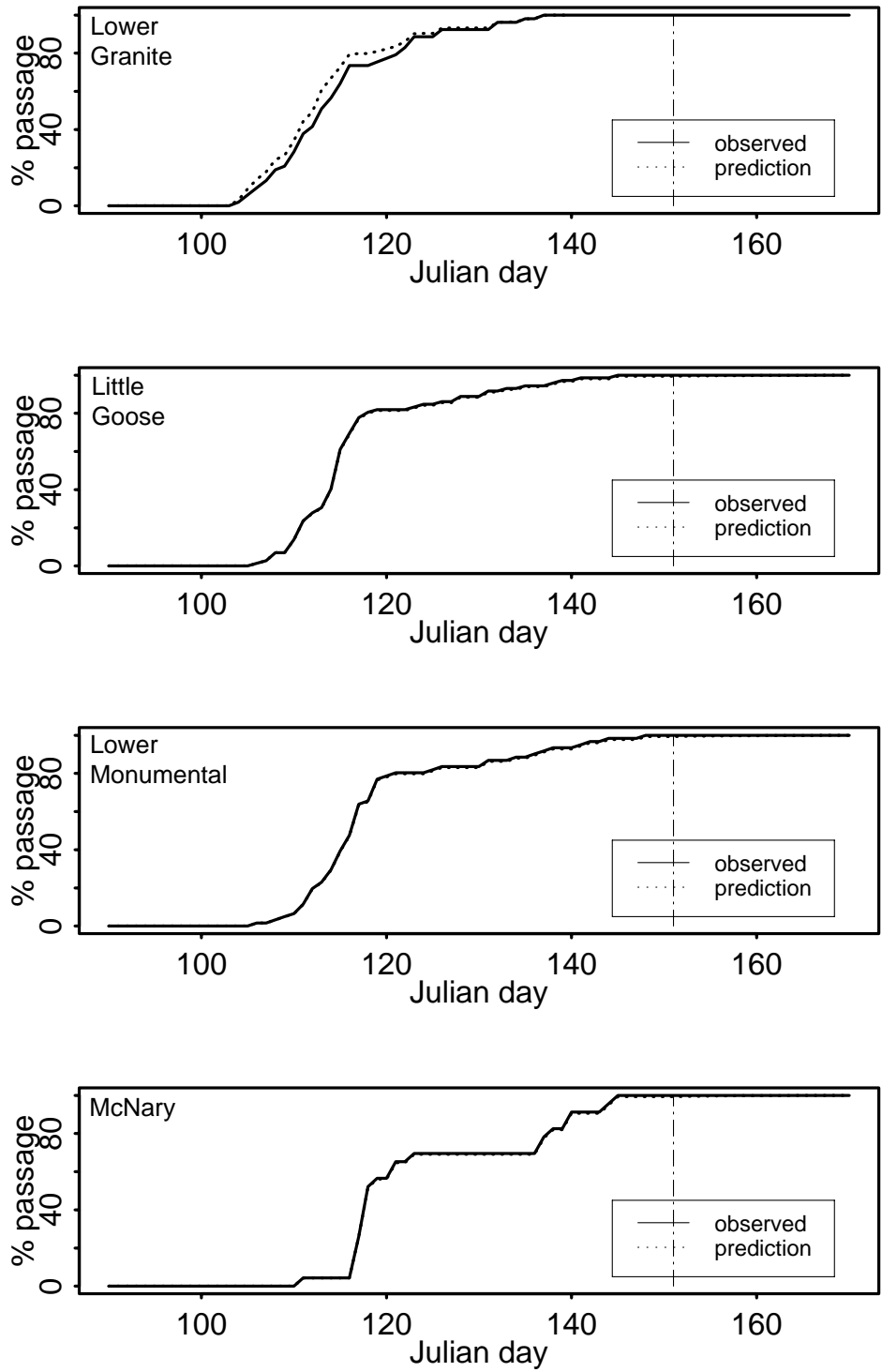


Figure A4.28. CRiSP/RealTime predictions for the S Fk Wenaha R stock on May 30, 1996. The top plot is the Realtime prediction. The bottom three plots are the CRiSP projections.

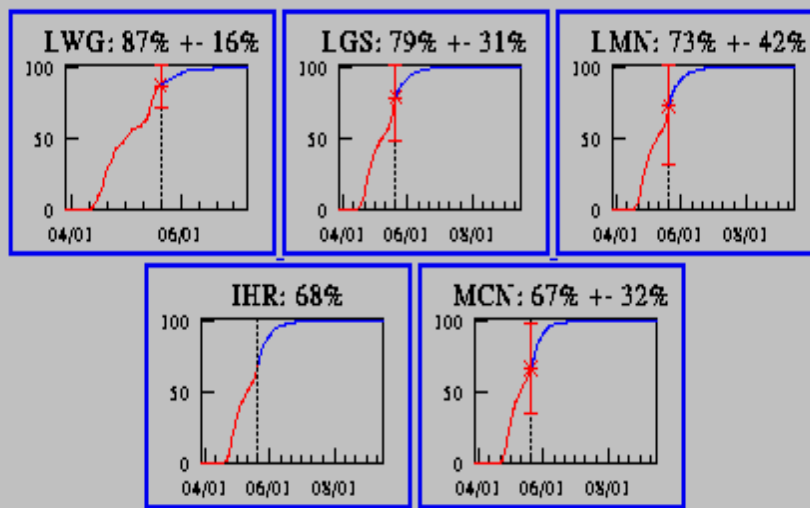
Appendix V: Example Graphics from WWW Pages

Snake River Wild Migrant ESU Yearling Chinook Composite 21 May 1996

Daily predicted passage of PIT tagged ESU Yearling Chinook Index Stocks through the Snake River. Percent of stocks arriving at Lower Granite Dam is predicted with the [RealTime](#) model. Arrivals to the lower dams (Little Goose, Lower Monumental, Ice Harbor and McNary) are predicted with the [CRISP 1.5](#) model. PIT tag data is courtesy of [Pacific States Marine Fisheries Commission](#). Hydrosystem data is courtesy of [Bonneville Power Administration](#) and [Army Corps of Engineers, NPD](#). For further details, see the [information](#) page.

[HOME](#) [COLUMBIA R. WEB SITES](#) [INFO](#) [TRANSPORT SUMMARY](#) [PREVIOUS](#) [NEXT](#)

Click on site to view results in detail. For other dates and stocks select from graphics menu.



[[Lower Granite](#)] [[Little Goose](#)] [[Lower Monumental](#)] [[Ice Harbor](#)] [[McNary](#)]

Figure 10: Screen shot from WWW page, showing the five thumbnail graphs of cumulative percent arrival, with confidence intervals where available, at each of the Snake projects and McNary Dam, for the composite yearling chinook stock. This estimate was made on the 21st of May. Clicking on a thumbnail produces a large version of the graph for that dam alone (Fig. 11); clicking on the “Transport Summary” button produces a cumulative transport estimate graph (Fig. 12).

Snake River Wild Migrant ESU Yearling Chinook Composite at Little Goose Dam 21 May 1996

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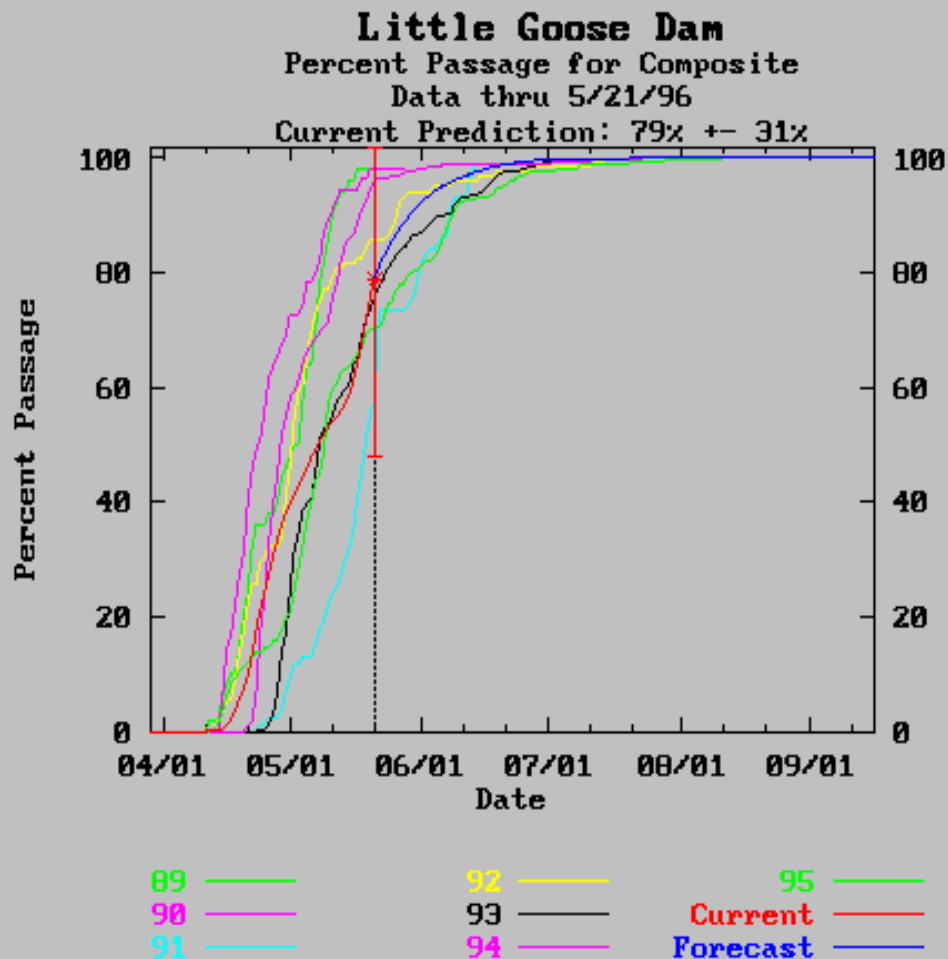


Figure 11: Screen shot from WWW page, showing the graph for a single dam. This graph shows cumulative arrival at Little Goose Dam, estimated on May 21st. The vertical line shows the day of the prediction; the “forecast” is to the right of that line, and “current” to the left of it. Available years of data are overlaid on the plot. The same plot can be generated for a variety of individual stocks, with or without historical data, and can also be smoothed. Note the fairly large confidence interval (79% ± 31%); this is typical during the peak of migration.

Snake River Passage and Transport Summary Wild Migrant ESU Yearling Chinook Composite 21 May 1996

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Snake River Passage and Transport Summary for Composite

Data thru 5/21/96

Current Transport Prediction: 56%

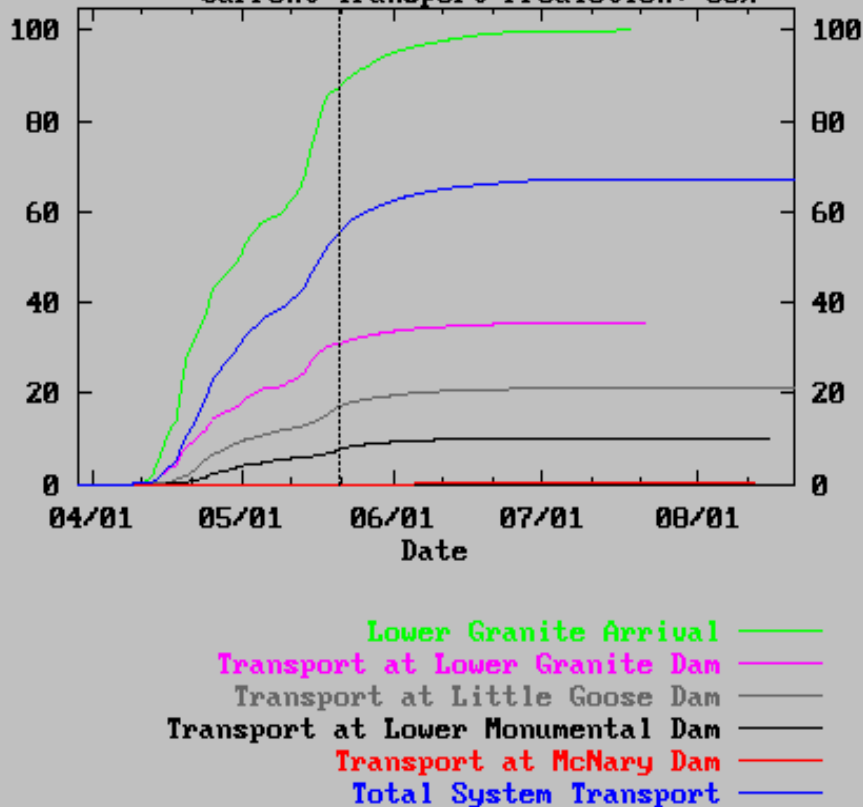


Figure 12: Screen shot from WWW page, showing the dam-by-dam transport projections. The vertical line represents the day of the projection (May 21st); the top line represents the expected arrival distribution at Lower Granite Dam, and the next four lines represent total transport, transport at Lower Granite, Little Goose, and Lower Monumental Dams respectively. We estimated that 56% of the run had already been transported on May 21st, and that about 70% would be transported by the end of the year.