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THE DESIGN AND ANALYSIS OF SALMONID TAGGING STUDIES IN THE COLUMBIA BASIN

VOLUME VI: ASSESSMENT OF SEASON-WIDE SURVIVAL OF SNAKE RIVER YEARLING CHINOOK SALMON

Technical Report

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THE DESIGN AND ANALYSIS OF SALMONID TAGGING STUDIES IN THE COLUMBIA BASIN

VOLUME VI

Assessment of Season-Wide Survival

of Snake River Yearling Chinook Salmon, 1994-1996

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PREFACE

Project 8910700, Epidemiological Survival Methods, was developed to provide statistical guidance on design and analysis of PIT-tag (Passive Integrated Transponder) survival studies to the Northwest fisheries community. Studies under this project have determined the statistical feasibility of conducting PIT-tag smolt survival studies, assessed analytical capabilities for analyzing the tagging experiments, and made recommendations on study design. As PIT-tag capabilities developed and research interests increased, the project has been instrumental in maintaining the statistical capabilities for designing and analyzing tagging studies to meet these expanded objectives. This report describes a new estimator of season-wide survival that is a weighted average of daily survival estimates, and illustrates its use to obtain estimates for the 1994, 1995 and 1996 outmigrations of yearling chinook salmon from the Snake River Basin.

The statistical analysis in this report was motivated by the managerial need for overall season-wide survival estimates. Since 1993, the National Marine Fisheries Service (NMFS), in collaboration with the University of Washington, has been marking juvenile salmonids with PIT-tags to estimate survival and investigate the dynamics of smolt migration. Survival estimates for specific groups of tagged fish at particular times and locations during the outmigration are normally obtained using the statistical computer program SURPH.1 (SURvival with Proportional Hazards). Depending on the sampling effort across the migration period, SURPH.1 provides a series of daily survival estimates and associated standard errors. However, for management purposes, it is often desirable to have an overall season-wide estimate of survival. So far, overall season-wide survival estimates have been obtained as simple or weighted averages of SURPH.1 daily survival estimates. This report presents a novel alternative to those season-wide survival estimates.

ABSTRACT

A new estimator that is a weighted average of daily survival estimates with weights equal to the daily proportion of smolt abundance as represented by the adjusted passage indices was used to estimate season-wide survival estimates for the 1994, 1995 and 1996 outmigrations of yearling chinook salmon from the Snake River Basin. Yearling chinook smolts tagged with PIT-tags (passive integrated transponder) and released at or above Lower Granite (LGR) Dam, and their SURPH.1 (SURvival with Proportional Hazards) daily survival estimates for three reaches: (1) from the tailrace of LGR Dam to that of Little Goose (LGS) Dam, (2) from the tailrace of LGS Dam to the tailrace of Lower Monumental (LMN) Dam, and (3) from the tailrace of LGR Dam to that of LMN Dam were used in the estimation of three season-wide survival probabilities. A second set of PIT-tagged smolts released at LGS Dam was also used to estimate season-wide survival probabilities from the tailrace of LGS Dam to the tailrace of LMN Dam. Season-wide survival estimates for the LGR-LMN reach were highest in 1996 (0.846), lowest in 1994 (0.724), and intermediate in 1995 (0.825). The LGS PIT-tag releases displayed a similar pattern (0.682, 0.910 and 0.967, for 1994, 1995 and 1996, respectively). Weighted averages of daily survival estimates that account for the daily proportion of smolt abundance estimate season-wide survivals reliably, especially over long reaches. These season-wide estimates may lead to the detection of year-to-year changes in survival, and eventually to the discovery of their causes.

EXECUTIVE SUMMARY

Objectives

To obtain season-wide survival estimates for the 1994, 1995 and 1996 outmigrations of yearling chinook salmon from the Snake River Basin using a new estimator that is a weighted average of daily survival estimates, where the weights are the daily proportion of smolt abundance as represented by the adjusted passage indices.

Results

PIT-tagged yearling chinook smolts released at or above Lower Granite Dam and their SURPH.1 daily survival estimates for three reaches: (1) from the tailrace of Lower Granite Dam to that of Little Goose Dam, (2) from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam, and (3) from the tailrace of Lower Granite Dam to that of Lower Monumental Dam were used in the estimation of three season-wide survival probabilities. These were termed $\hat{S}_1$, $\hat{S}_2$ and $\hat{S}_{1.2}$, respectively. A second set of PIT-tagged smolts released at Little Goose Dam was also used to estimate the season-wide survival probability $\hat{S}_S$, from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam.

Estimates $\hat{S}_1$, $\hat{S}_S$ and $\hat{S}_{1.2}$ suggest that the overall survival of Snake River yearling chinook salmon increased from 1994 to 1996. This increasing trend was best accounted for by the $\hat{S}_{1.2}$ estimates (survival from LGR to LMN), and to a lesser extent by the $\hat{S}_S$ estimates. Thus in discerning annual shifts in survival, it may be better to follow the fate of outmigrants over longer reaches than over shorter ones. Similar increasing annual trends were also observed for simple and weighted (weight = 1/variance of daily estimate) averages of the SURPH.1 daily survival estimates.

Management implications

The weighted average of daily survival estimates that accounts for the daily proportion of smolt abundance provides a reliable way to estimate season-wide survivals. These season-wide estimates may lead to the detection of year-to-year changes in survival such as the detected increase from 1994 to 1996. The presence of such changes may be associated to increased flow or spill, or changes in average water temperature or other environmental factors.

Recommendations

The daily releases used in this report consisted mostly of hatchery fish, accompanied by a smaller proportion of wild fish. Thus the inferences made here are more applicable to the fate of hatchery stocks on the Snake River.

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TABLE OF CONTENTS

	Page
Other related publications in the series……..	*ii*
Preface ……..	*iv*
Abstract ……	*v*
Executive summary……	*vi*
Acknowledgments…….	*viii*
Table of contents……..	*ix*
List of figures……	*x*
List of tables……..	*xi*
1. Introduction……	1
2. Materials and methods……	1
2.1 Data…….	1
2.2 Estimators of season-wide survival…….	2
2.3 Comparison of season-wide survival estimates ……	5
3. Results……..	5
3.1 Season-wide estimates for LGR releases ……..	5
3.2 Season-wide estimates for LGS releases ……..	11
3.3 Comparison of seasonal survival estimates and environmental factors……..	18
4. Discussion……..	18
5. Literature cited…….	22
6. Appendix: Daily data on smolt passage and survival…….	24

LIST OF FIGURES

Fig.		Page
1	Schematic of release-recapture study and estimable parameters ……	3
2	Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam……..	8
3	Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam……..	8
4	Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam……..	9
5	Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam..	9
6	Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam..	10
7	Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam..	10
8	Season-wide survival estimates for the middle 95% of the run of yearling chinook salmon……	13
9	Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam….	15
10	Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam….	15
11	Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam….	16
12	Relationship between season-wide survival estimates for S_S and $S_{1.2}$, and the coefficients of variation of daily survival estimates, release sizes and the cumulative adjusted passage index proportion (CAPI), for middle 95% yearling chinook salmon run in 1995……	17
13	Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of flow…….	19
14	Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of spill……	19
15	Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of water temperature…….	20

LIST OF TABLES

Table		Page
1	Season-wide survival estimates for PIT-tagged yearling chinook salmon from Lower Granite Dam to Little Goose Dam (S_1) and Lower Monumental Dam ($S_{1.2}$) for 1994-1996 using daily random samples. Percentiles based on adjusted FPC passage indices……	6
2	Comparison of season-wide survival estimates for PIT-tagged yearling chinook salmon from Lower Granite Dam to Lower Monumental Dam ($S_{1.2}$) for 1994-1996 using daily random samples……	6
3	Season-wide survival estimates for PIT-tagged yearling chinook salmon from Little Goose Dam to Lower Monumental Dam (S_2) for 1994-1996 using daily random samples of yearling chinook salmon released at Lower Granite Dam……	12
4	Season-wide survival estimates for PIT-tag releases from Little Goose Dam to Lower Monumental Dam (S_S) for 1994-1996 using daily random samples of yearling chinook salmon released at Little Goose Dam…….	12
5	Comparison of season-wide survival estimates for PIT-tagged yearling chinook salmon from Little Goose Dam to Lower Monumental Dam (S_S) for 1994-1996 using daily random samples……	16

1. INTRODUCTION

Since 1993, the National Marine Fisheries Service (NMFS), in collaboration with the University of Washington, has marked juvenile salmonids with PITtags, or passive integrated transponders (Prentice et al., 1990a, b, c), to estimate survival and investigate the dynamics of smolt migration (Iwamoto et al., 1994; Muir et al., 1995, 1996). Survival estimates for specific groups of tagged fish released at particular times and locations during the outmigration are normally obtained using the statistical computer program SURPH.1 (SURvival with Proportional Hazards), developed at the University of Washington (Smith et al., 1994). This program extends the standard single-release models (Cormack, 1964; Jolly, 1965; Seber, 1965) to allow simultaneous analysis of release-recapture PIT-tag data from multiple release groups.

Depending on the sampling effort across the migration period, SURPH.1 can provide a series of survival estimates and associated standard errors for groups released daily from a particular dam. However, for management purposes, it may be desirable to have an overall season-wide estimate of survival to assess across seasons or locales. In a recent paper (Skalski 1998) two alternative statistical sampling schemes that allow the estimation of seasonal survival rates were presented. In this report, we apply one of these procedures to obtain season-wide survival estimates for the 1994, 1995 and 1996 outmigrations of yearling chinook salmon from the Snake River Basin. PIT-tag release-recapture results on smolt survival (SURPH.1 daily estimates) are used in the estimation of season-wide survival for three river reaches: from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam, and from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam. Seasonal and daily survival estimates are examined for differences among years and between reaches.

2. MATERIALS AND METHODS

2.1 Data and estimation scheme

The study is based on PIT-tagged yearling chinook salmon that were tagged anywhere in the Snake River Basin at or above Lower Granite Dam (LGR) in 1994, 1995 and 1996. Both hatchery and wild fish were used.

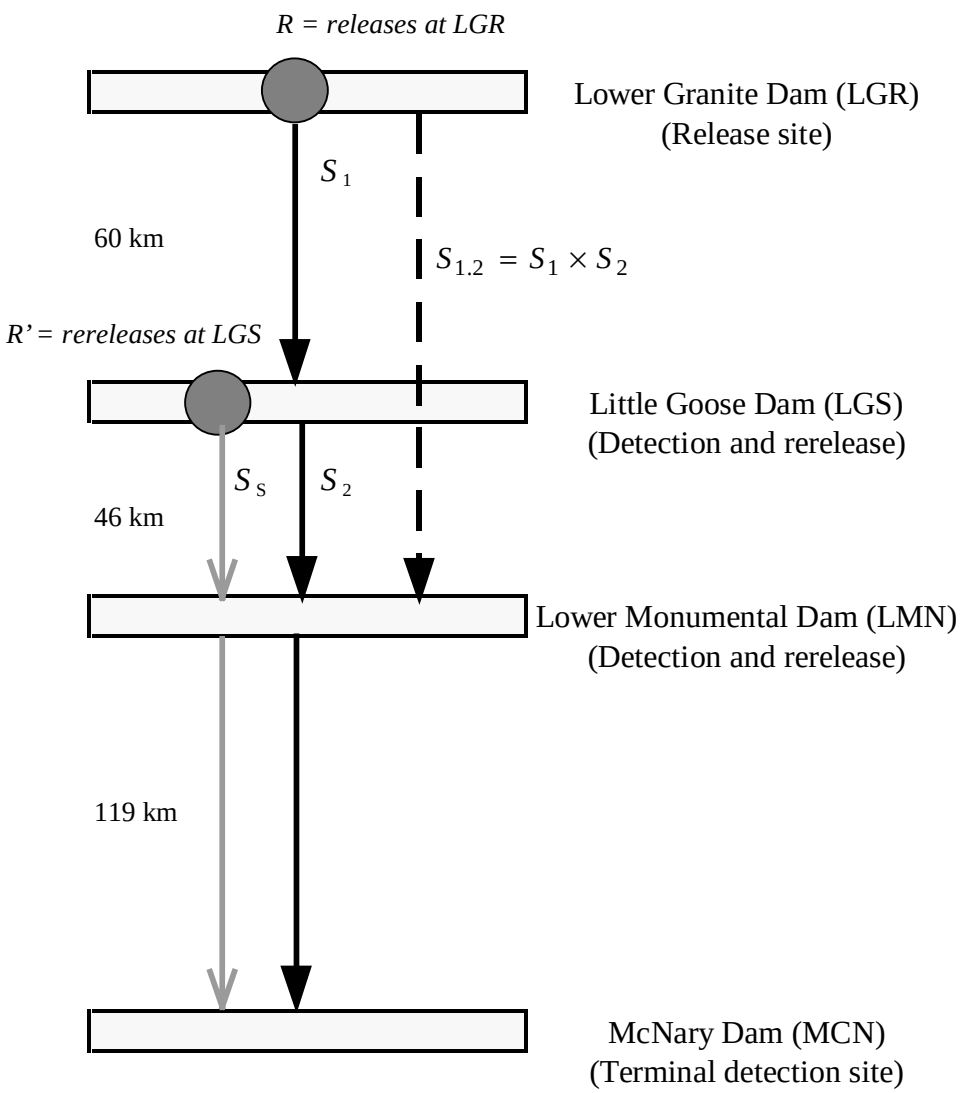
A schematic of the release-recapture study and estimable survival probabilities is displayed in Figure 1. PIT-tagged fish from upriver release sites that were detected and returned to the river at LGR, and fish tagged and released from LGR on the same day formed a daily release group (Fig. 1, *R*). The downstream fate of these release groups (Fig. 1, black arrows) can be followed thanks to detections and re-releases at Little Goose Dam (LGS) and Lower Monumental Dam (LMN). A second set of release groups was formed from all PIT-tagged yearling chinook salmon released or re-released at LGS (Fig. 1, *R'*). The downstream migration of these daily release groups is indicated by gray arrows. SURPH.1 (Smith et al., 1994) was used to obtain survival estimates for daily release groups *R* and *R'* from the tailrace of LGR to the tailrace of LGS (S_1), from the tailrace of LGS to the tailrace of LMN (S_2 and S_S for *R* and *R'* groups, respectively), and from the tailrace of LGR to the tailrace of LMN ($S_{1.2}$).

For daily release groups *R*, sample sizes during the outmigration ranged from 1 to 2,921 fish with an average of 243 fish in 1994, from 1 to 9,355 with an average of 768 fish in 1995, and from 5 to 5,555 fish with an average of 414 in 1996. For the *R'* groups, sample sizes were considerable smaller: between 1 and 460 fish in 1994, between 1 and 1,659 fish in 1995, and between 1 and 2,577 fish in 1996. The corresponding daily averages were 30, 103 and 168 fish in 1994, 1995 and 1996, respectively. The progress of the outmigration at LGR and LGS was followed on a daily basis through the adjusted passage indices reported by the Fish Passage Center (FPC) from smolts collected and counted in the bypass system at the dams. Adjusted daily passage indices (API) at LGR dam, estimates of percent cumulative passage (CPR), tag release numbers (n), SURPH.1 daily survival estimates (S_1, S_2 and $S_{1.2}$) and associated standard errors (SE(S_i)) are reported in Appendices **A 6.1- A6.3**. Daily passage indices at LGS dam and SURPH.1 daily survival estimates for fish released at LGS (S_S) are reported in Appendices **A 6.4 - A6.6**.

2.2 Estimators of season-wide survival

The season-wide estimates of survival were based on the first of the two approaches presented in Skalski (1998). The approach assumes that daily release groups are a random sample of fish passing the dam on that day, and constructs a seasonal average survival estimate weighted by daily smolt abundance.

Figure 1: Schematic of release-recapture study and estimable parameters.



The overall seasonal survival during smolt migration, whether it be S_1, S_2, $S_{1.2}$ or S_S, is defined as:

$$S = \sum_{i=1}^{D} S_i w_i$$

where S_i is the survival rate for smolt passing on day i (i = 1, …, D), with D the total number of migration days. The weights w_i are defined as $w_i = N_i \Big/ \sum_{i=1}^{D} N_i$, with N_i being the smolt abundance on day i.

Then, assuming that the abundances N_i are known without error and that unbiased estimates of the daily survival probabilities S_i are available, an unbiased estimator of seasonal survival is defined as:

$$\hat{S} = \sum_{i=1}^{D} \hat{S}_i w_i \tag{1}$$

The corresponding bias-corrected variance estimator for (1) is defined as (Skalski, 1998):

$$\hat{\mathrm{Var}}(\hat{S}) = \sum_{i=1}^{D} w_i^2 \left[\frac{\hat{S}(1-\hat{S})}{n_i} + \left(1 + \frac{1}{n_i}\right) \mathrm{Var}(\hat{S}_i | S_i) \right], \tag{2}$$

where n_i is the number of tagged fish released on day i. The $\hat{S}_i$ and $\mathrm{Var}(\hat{S}_i | S_i)$ are survival estimates and corresponding estimated variances for the fish released on day i. In all our calculations these estimates where obtained by applying SURPH.1 (Smith et al., 1994). The value of the weights w_i was approximated by using the adjusted passage indices (API) as $w_i = \mathrm{API}_i \Big/ \sum_{i=1}^{D} \mathrm{API}_i$. When we calculated seasonal survival for LGR releases (Fig. 1, R, S_1, S_2 and $S_{1.2}$) we used the passage indices at LGR dam, and when we estimated the seasonal survival rate from the tailrace of LGS to the tailrace of LMN (S_S) for LGS releases (R' groups, Fig. 1) we used the indices at LGS dam. All season-wide survival rates were estimated for the middle 80%, 90% and 95% of the migration, with weights w_i normalized to 100% for each interval.

2.3 Comparison of season-wide survival estimates

Estimates of season-wide survival $S_{1.2}$ calculated with equation (1) were compared with those coming from simple:

$$\bar{S}_{1.2} = \frac{\sum_{i=1}^{D} \hat{S}_{1.2i}}{D} \tag{3}$$

and weighted averages (weights inversely proportional to the estimated variance of the daily estimates):

$$\bar{S}_{\text{wgt}1.2} = \sum_{i=1}^{D} \hat{S}_{1.2i} \left(\frac{\dfrac{1}{\hat{\text{var}}\left(\hat{S}_{1.2}\right)_i}}{\sum_{i=1}^{D} \dfrac{1}{\hat{\text{var}}\left(\hat{S}_{1.2}\right)_i}} \right) \tag{4}$$

where, as before (Fig. 1), $\hat{S}_{1.2_i} = \hat{S}_{1_i} \times \hat{S}_{2_i}$ is the SURPH.1 survival estimate from the tailrace of LGR to the tailrace of LMN on day i (i =1, 2, …, D days), and $\hat{\text{var}}\left(\hat{S}_{1.2}\right)_i$ is the corresponding estimated variance.

3. RESULTS

3.1 Season-wide estimates for LGR releases

Assuming the tagged yearling chinook salmon leaving LGR dam on a particular day represent a random sample of all smolts passing that day, the daily estimates and measurement errors reported in Appendices **A 6.1 - A6.3** were combined in equations (1) and (2) to obtain survival estimates $\hat{S}_1$ and $\hat{S}_{1.2}$ for the spring runs of 1994, 1995 and 1996 (Table 1). Season wide estimates were very similar whether they were calculated from the middle 80%, 90% or 95% of the outmigration. For example, $\hat{S}_1$ was 0.933 for the middle 80% and 0.923 for the middle 95% of the 1996 migration. Similarly, $\hat{S}_{1.2}$ was 0.717 for the middle 80% and 0.724 for the middle 95% of the 1994 migration.

The standard error $\hat{\text{SE}}\left(\hat{S}_1\right)$ of $\hat{S}_1$ ranged between 0.0039 (1995) and 0.0188 (1994), and that of $\hat{S}_{1.2}$ was between 0.0053 (1995) and 0.0148 (1994), (Table 1). Standard errors for 1995

Table 1: Season-wide survival estimates for PIT-tagged yearling chinook salmon from Lower Granite Dam to Little Goose Dam (S_1) and Lower Monumental Dam ($S_{1.2}$) for 1994-1996 using daily random samples. Percentiles based on adjusted FPC passage indices.

Year	Nominal Percentile	Actual Percentile	Days of Year	Dates	$\hat{S}_1$	$S\hat{E}(S_1)$	$\hat{S}_{1.2}$	$S\hat{E}(S_{1.2})$
96	10 - 90	9.75 - 92.02	110 - 141	19 Apr-20 May	0.9326	0.0079	0.8595	0.0131
96	5 - 95	3.93 - 95.22	107 - 147	16 Apr-26 May	0.9342	0.0118	0.8653	0.0147
96	2.5 - 97.5	2.13 - 97.63	105 - 154	14 Apr-2 Jun	0.9233	0.0121	0.8463	0.0142
95	10 - 90	8.65 - 90.16	109 - 139	18 Apr-18 May	0.8882	0.0041	0.8180	0.0053
95	5 - 95	4.32 - 95.42	106 - 148	15 Apr-27 May	0.8849	0.0039	0.8275	0.0072
95	2.5 - 97.5	2.08 - 97.81	103 - 157	12 Apr-5 Jun	0.8844	0.0038	0.8248	0.0069
94	10 - 90	6.49 - 91.21	113 - 134	22 Apr-13 May	0.8881	0.0188	0.7171	0.0141
94	5 - 95	3.99 - 95.17	112 - 138	21 Apr-17 May	0.8870	0.0181	0.7201	0.0147
94	2.5 - 97.5	2.34 - 97.57	111 - 144	20 Apr-23 May	0.8853	0.0176	0.7237	0.0148

Table 2: Comparison of season-wide survival estimates for PIT-tagged yearling chinook salmon from Lower Granite Dam to Lower Monumental Dam ($S_{1.2}$) for 1994-1996 using daily random samples. Estimates are: $\bar{S}_{1.2}$, common average (eq. 3); $\bar{S}_{\mathrm{wgt}_{1.2}}$, weighted average (eq. 4); and $\hat{S}_{1.2}$, Skalski (1998) average (eq. 1). Percentiles based on FPC adjusted passage indices.

Year	Nominal Percentile	Actual Percentile	Days of Year	Dates	$\bar{S}_{1.2}$	$\bar{S}_{\mathrm{wgt}_{1.2}}$	$\hat{S}_{1.2}$
96	10 - 90	9.75 - 92.02	110 - 141	19 Apr-20 May	0.8596	0.8517	0.8595
96	5 - 95	3.93 - 95.22	107 - 147	16 Apr-26 May	0.8643	0.8514	0.8653
96	2.5 - 97.5	2.13 - 97.63	105 - 154	14 Apr-2 Jun	0.8264	0.8447	0.8463
95	10 - 90	8.65 - 90.16	109 - 139	18 Apr-18 May	0.8132	0.8144	0.8180
95	5 - 95	4.32 - 95.42	106 - 148	15 Apr-27 May	0.8443	0.8150	0.8275
95	2.5 - 97.5	2.08 - 97.81	103 - 157	12 Apr-5 Jun	0.8263	0.8122	0.8248
94	10 - 90	6.49 - 91.21	113 - 134	22 Apr-13 May	0.7147	0.6728	0.7171
94	5 - 95	3.99 - 95.17	112 - 138	21 Apr-17 May	0.7192	0.6768	0.7201
94	2.5 - 97.5	2.34 - 97.57	111 - 144	20 Apr-23 May	0.7550	0.6843	0.7237

were generally slightly smaller than those for 1994 and 1996. Despite this interannual difference in precision, we were still able to identify significant differences in annual average survival. Confidence intervals were still quite tight. For example, 95% confidence intervals for S_1, based on the middle 95% the outmigration, were (0.856-0.914), (0.878-0.891) and (0.903-0.943) in 1994, 1995 and 1996, respectively, suggesting a significant difference in average survival, at least between 1995 and 1996. If we consider the 95% confidence intervals for $S_{1.2}$, (0.699-0.748), (0.814-0.836) and (0.823-0.870) in 1994, 1995 and 1996, annual survival seems to have been lower in 1994 than in the later years. The precision achieved in the estimation of the season-wide survival rates S_1 and $S_{1.2}$ (Table 1) depends on the number of daily releases at LGR during the season and on the number of fish per daily release (i.e., n_i). For example, for the middle 95% of the migration, 34 daily releases were included in the calculations of $\hat{S}_1$ and $\hat{S}_{1.2}$ for 1994, while 55 and 48 daily releases were included in the calculations for 1995 and 1996, respectively. The size of the daily releases was quite variable, affecting the precision of SURPH.1 daily estimates, and in turn the overall precision of the season-wide estimates. Release sizes of 500 fish or larger seem to stabilize the overall variance (Skalski, 1998). The fact that in 1994 only 50% of the release groups had 500 or more fish, as opposed to 78% in 1995 and 73% in 1996, may explain the lower precision of the estimates for 1994.

Table 2 compares $S_{1.2}$ season-wide survival estimates obtained with equation (1) with those obtained through the more conventional simple and weighted averages (equations 3 and 4). In general the estimates were fairly close to each other. The weighted average (4) produced the lowest estimates, differences being more pronounced for 1994.

Figures 2-4 plot the daily survival probabilities estimated by SURPH.1 over the course of the 1994, 1995 and 1996 migrations from the tailrace of LGR to the tailrace of LGS dam (i.e., S_{1i} where i is the LGR release day), together with the season-wide estimate $\hat{S}_1$ and the cumulative arrival distribution at LGR dam. Figures 5-7 display similar plots for survival probabilities estimated over the larger reach LGR-LMN (i.e., $S_{1.2,i}$ and $\hat{S}_{1.2}$).

In 1995, daily survival estimates were remarkably stable over the course of the season, without any apparent trend (Fig. 3 and 6). In 1996, daily estimates were also quite stable until

Figure 2: Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, along with the average survival estimate S_1 (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).

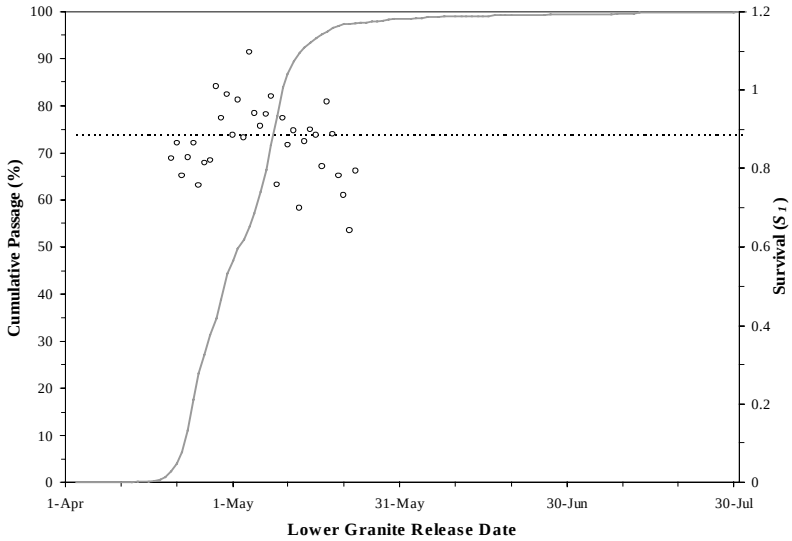


Figure 3: Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, along with the average survival estimate S_1 (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).

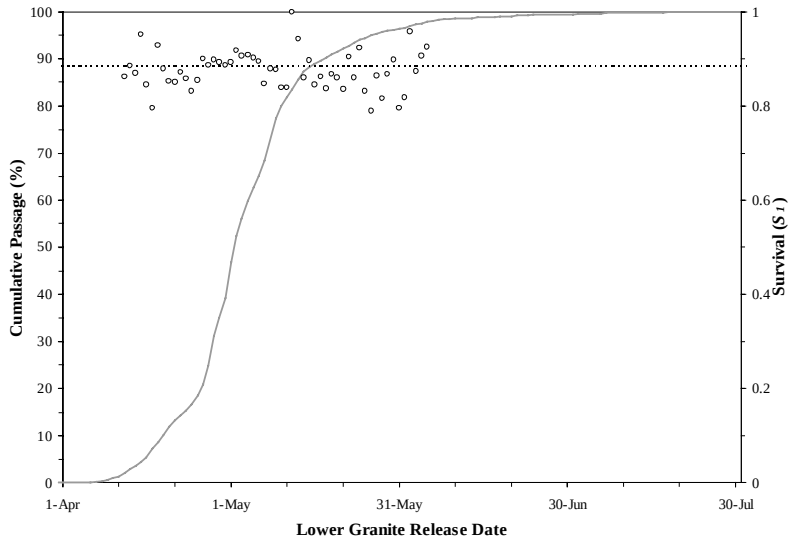


Figure 4: Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, along with the average survival estimate S_1 (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).

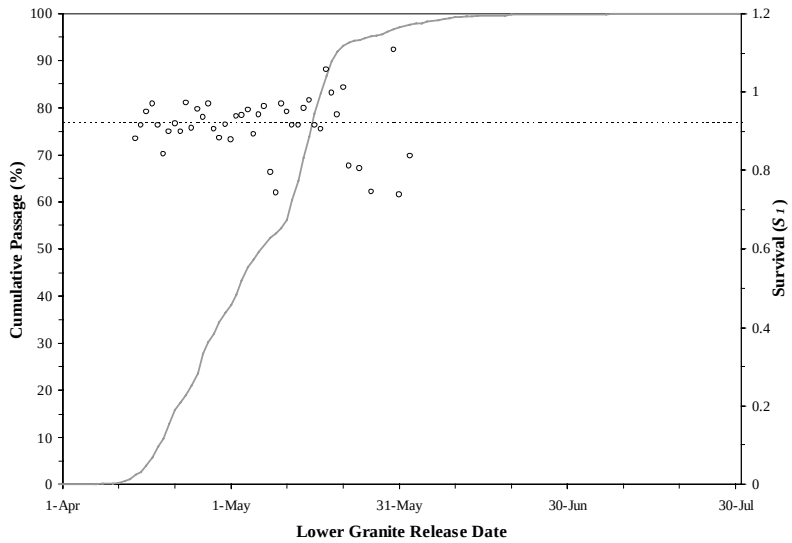


Figure 5: Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate $S_{1.2}$ (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).

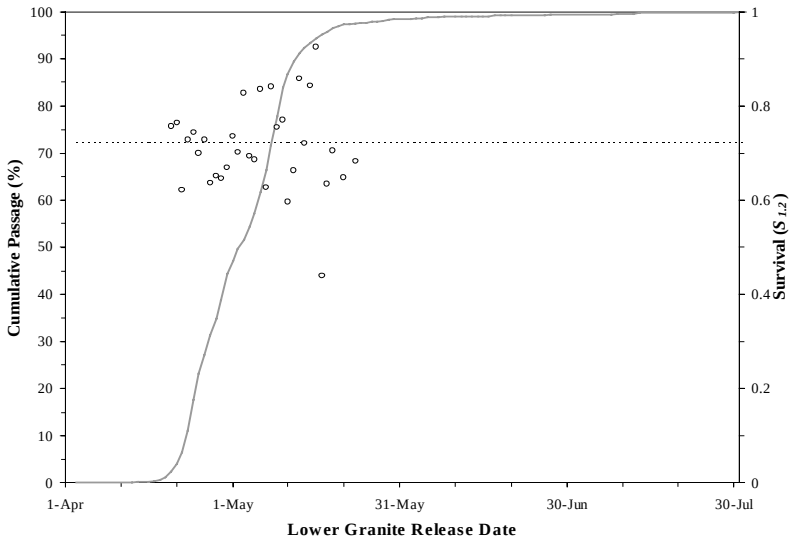


Figure 6: Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate $S_{1.2}$ (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).

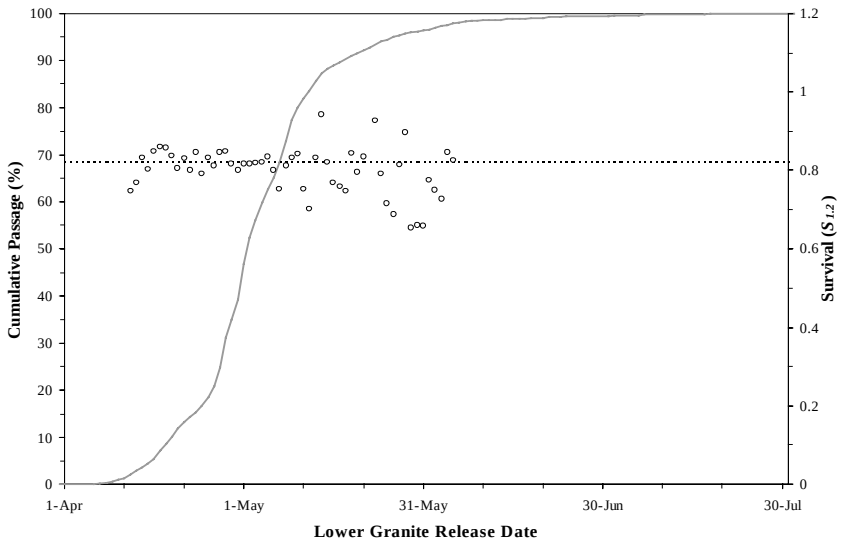
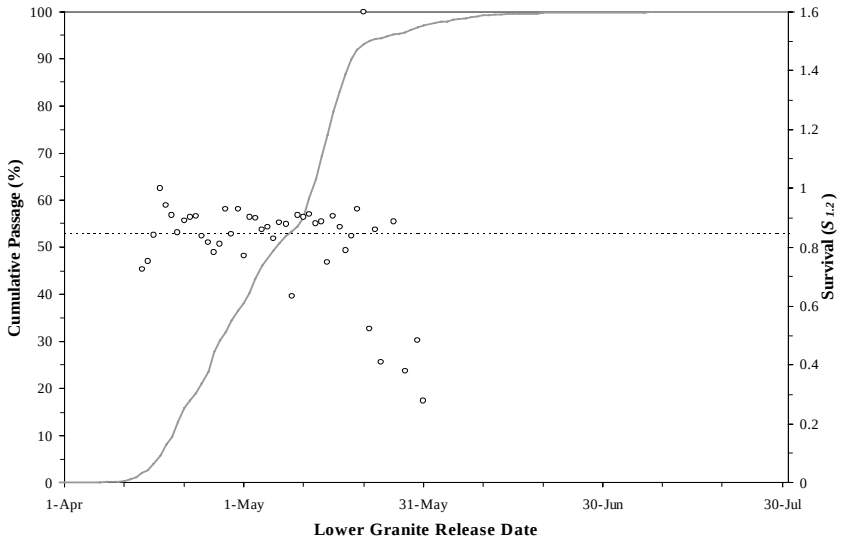


Figure 7: Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Lower Granite Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate $S_{1.2}$ (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Lower Granite Dam (curve).



the final days of the run, when 90% of the run has already passed LGR. Towards the end of the 1996 run, survival estimates decreased, accompanied by a decrease in the precision of the estimates (Fig. 4 and 7). In 1994, daily survival estimates were somewhat less stable, with their variance apparently increasing with the progress of the season and fewer fish tagged (Fig. 5). The reasonably stable survival estimates across the seasons are the likely reason for the similarity among the three estimates of average survival.

Season-wide survival estimates between LGS and LMN dams ($\hat{S}_2$) for fish released at LGR are shown in Table 3. As with previous results, seasonal estimates of $\hat{S}_2$ were very similar whether they corresponded to the middle 80%, 90% or 95% of the outmigration. Standard errors, $\hat{\text{SE}}(\hat{S}_2)$, were somewhat greater than those for $\hat{S}_1$. Standard errors ranged between 0.0071 in 1995 and 0.0224 in 1994. For the middle 95% of the outmigration, 95%confidence intervals for S_2 were still tight: (0.790-0.864), (0.920-0.948) and (0.880-0.934) in 1994, 1995 and 1996, respectively. The survival estimate was significantly lower in 1994 than in the later years, repeating the pattern exhibited by $\hat{S}_{1.2}$. This is not unexpected given that $\hat{S}_{1.2} = \hat{S}_1 \times \hat{S}_2$ (Fig. 8).

3.2 Season-wide estimates for LGS releases

When combined in equations (1) and (2), the daily estimates and measurement errors reported in Appendices **A 6.4 - A6.6** for tagged yearling leaving LGS dam on a daily basis also produced survival estimates ($\hat{S}_S$) for the spring runs of 1994, 1995 and 1996 at LMN (Table 4). Standard errors, $\hat{\text{SE}}(\hat{S}_S)$, were larger than those for the survival estimates based on LGR releases because of generally smaller release groups. They ranged between 0.0113 in 1995 and 0.0281 in 1996.

The 95% confidence intervals (0.644-0.720, 0.887-0.933 and 0.923-1.011 for 1994, 1995 and 1996, respectively) were wider than those for $S_{1.2}$, but they still suggest that survival was lower in 1994 than in 1996 (Fig. 8). This pattern more closely resembled the one displayed by the $S_{1.2}$ estimates than the one exhibited by $\hat{S}_2$. This result may be somewhat surprising, but one must remember that $\hat{S}_S$ and $\hat{S}_2$ were based on different sets of releases. The release groups used to

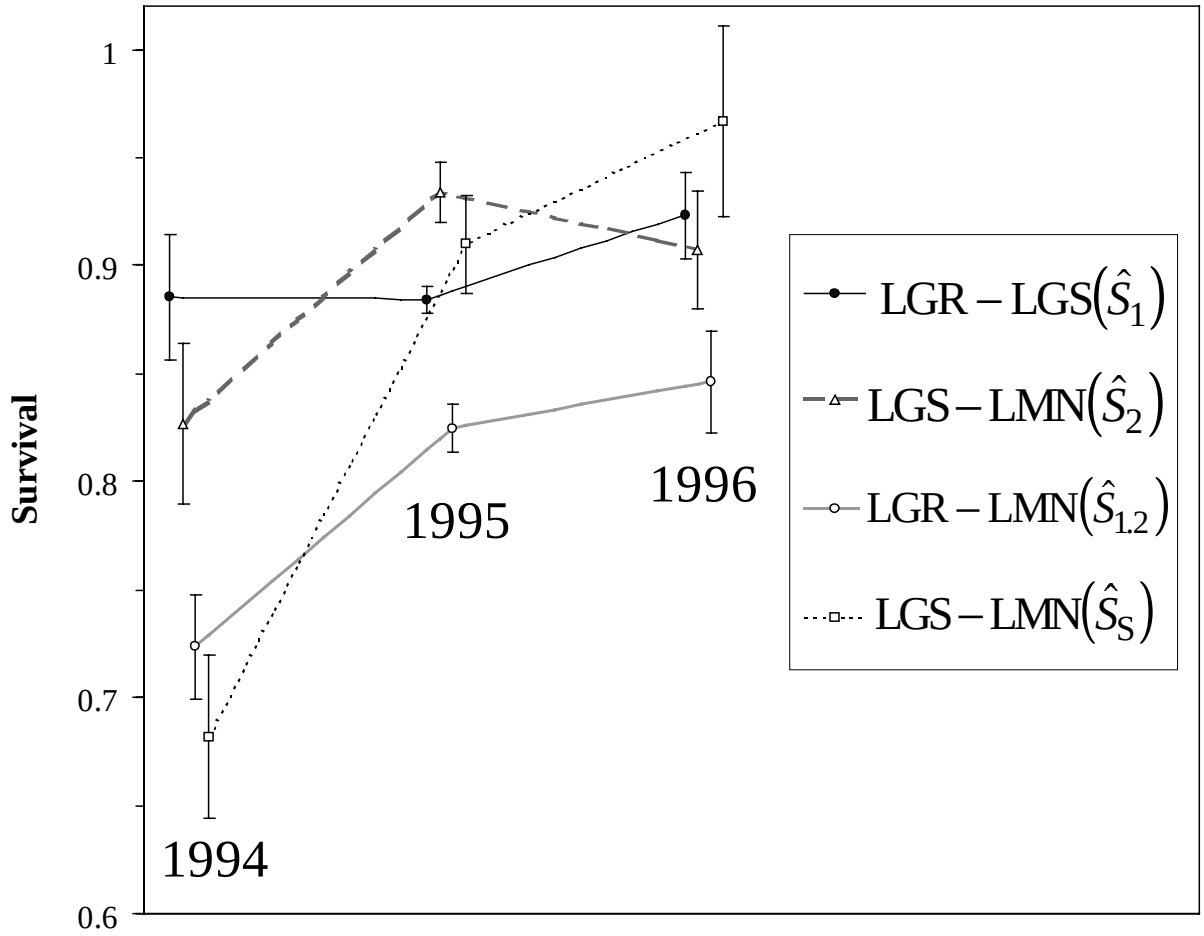
Table 3: Season-wide survival estimates for PIT-tagged yearling chinook salmon from Little Goose Dam to Lower Monumental Dam (S_2) for 1994-1996 using daily random samples of yearling chinook salmon released at Lower Granite Dam. Percentiles based on adjusted FPC passage indices.

Year	Nominal Percentile	Actual Percentile	Days of Year	Dates	$\hat{S}_2$	$S\hat{E}(S_2)$
96	10 - 90	9.75 - 92.02	110 - 141	19 Apr-20 May	0.9245	0.0157
96	5 - 95	3.93 - 95.22	107 - 147	16 Apr-26 May	0.9278	0.0171
96	2.5 - 97.5	2.13 - 97.63	105 - 154	14 Apr-2 Jun	0.9075	0.0166
95	10 - 90	8.65 - 90.16	109 - 139	18 Apr-18 May	0.9222	0.0071
95	5 - 95	4.32 - 95.42	106 - 148	15 Apr-27 May	0.9366	0.0089
95	2.5 - 97.5	2.08 - 97.81	103 - 157	12 Apr-5 Jun	0.9340	0.0085
94	10 - 90	6.49 - 91.21	113 - 134	22 Apr-13 May	0.8163	0.0222
94	5 - 95	3.99 - 95.17	112 - 138	21 Apr-17 May	0.8199	0.0224
94	2.5 - 97.5	2.34 - 97.57	111 - 144	20 Apr-23 May	0.8267	0.0224

Table 4: Season-wide survival estimates for PIT-tag releases from Little Goose Dam to Lower Monumental Dam (S_S) for 1994-1996 using daily random samples of yearling chinook salmon released at Little Goose Dam. Percentiles based on adjusted FPC passage indices.

Year	Nominal Percentile	Actual Percentile	Days of Year	Dates	$\hat{S}_S$	$S\hat{E}(S_S)$
96	10 - 90	8.76 - 90.46	114 - 146	23 Apr-25 May	0.9935	0.0258
96	5 - 95	4.75 - 95.45	112 - 151	21 Apr-30 May	0.9868	0.0280
96	2.5 - 97.5	2.01 - 97.62	109 - 154	18 Apr-2 Jun	0.9668	0.0269
95	10 - 90	8.99 - 91.31	120 - 146	29 Apr-25 May	0.8934	0.0113
95	5 - 95	4.92 - 95.37	117 - 154	26 Apr-2 Jun	0.9030	0.0120
95	2.5 - 97.5	2.43 - 97.67	110 - 161	19 Apr-9 Jun	0.9099	0.0138
94	10 - 90	9.31 - 90.39	117 - 141	26 Apr-20 May	0.7108	0.0250
94	5 - 95	4.65 - 95.25	116 - 145	25 Apr-24 May	0.6853	0.0234
94	2.5 - 97.5	2.23 - 97.76	115 - 150	24 Apr-29 May	0.6819	0.0229

Figure 8: Season-wide survival estimates for the middle 95% of the run of yearling chinook salmon. Error bars indicate 95% confidence limits.



determine $\hat{S}_S$ contained a large number of fish that were also released at LGR and survived to be detected and re-released at LGS, as well as other fish released at LGS for the first time. Thus, $\hat{S}_S$ and $\hat{S}_2$ are not likely to be the same.

Figures 9-11 plot the SURPH.1 daily survival probabilities over the course of the 1994, 1995 and 1996 migration for the releases and re-releases at LGS, together with the season-wide estimate $\hat{S}_S$ and the cumulative arrival distribution at LGS dam. Daily estimates were considerably less stable than those for LGR releases. In all three years, large fluctuations were present over most of the season, mainly because of low sample sizes. Only 13 out of the 52 releases from LGS in 1995, and 24 out of the 50 releases of 1996 consisted of 500 fish or more. None of the 30 releases of 1994 were that large.

Table 5 compares S_S season-wide survival estimates obtained with equation (1) with those obtained through the more conventional simple and weighted averages (equations 3 and 4). The estimates were considerably less close to each other than those for $S_{1.2}$ (Table 2). This was not totally unexpected given the large fluctuations displayed by the daily S_S estimates over most of the season (Fig. 9-11). Once again, it appears that reasonably stable survival estimates across the seasons are the likely cause for the similarity among the three estimates of average survival. Taking the 1995's season-wide estimates for S_S and $S_{1.2}$ as an example (Fig. 12), we can see that the three average estimates, $\bar{S}_{1.2}$, $\bar{S}_{\mathrm{wgt}_{1.2}}$ and $\hat{S}_{1.2}$, were very similar, the 95% confidence intervals for $\bar{S}_{\mathrm{wgt}_{1.2}}$ and $\hat{S}_{1.2}$ overlapping considerably. On the other hand, the averages for the LGS releases were very different with the simple average $\bar{S}_S$ close to one, and the weighted average $\bar{S}_{\mathrm{wgt}_S}$ significantly smaller than $\hat{S}_S$. A closer look at the coefficients of variation of daily estimates for S_S and $S_{1.2}$ and the sizes of their corresponding releases in relation to the cumulative adjusted passage index proportion (CAPI), as an indicator of the progress of the outmigration (Fig. 12, right panels), suggests an explanation. While the LGR releases were larger than 1,000 fish during April and the first week of May, determining considerably stable $S_{1.2}$ survival estimates (i.e., small coefficients of variation and variances) during most of the outmigration (CAPI = 0.8), the LGS releases were consistently small during April, and they barely reached 1,000 fish during

Figure 9: Plots of daily survival estimates of 1994 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate S_S (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Little Goose Dam (curve).

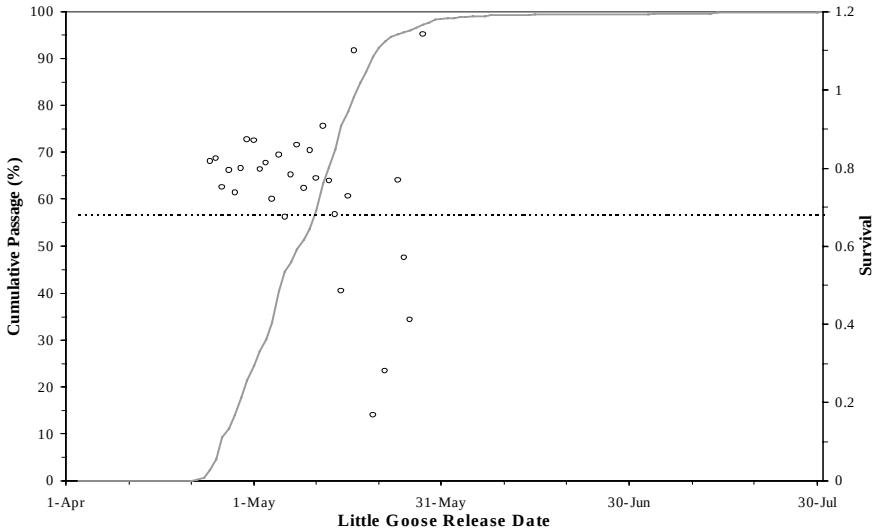


Figure 10: Plots of daily survival estimates of 1995 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate S_S (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Little Goose Dam (curve).

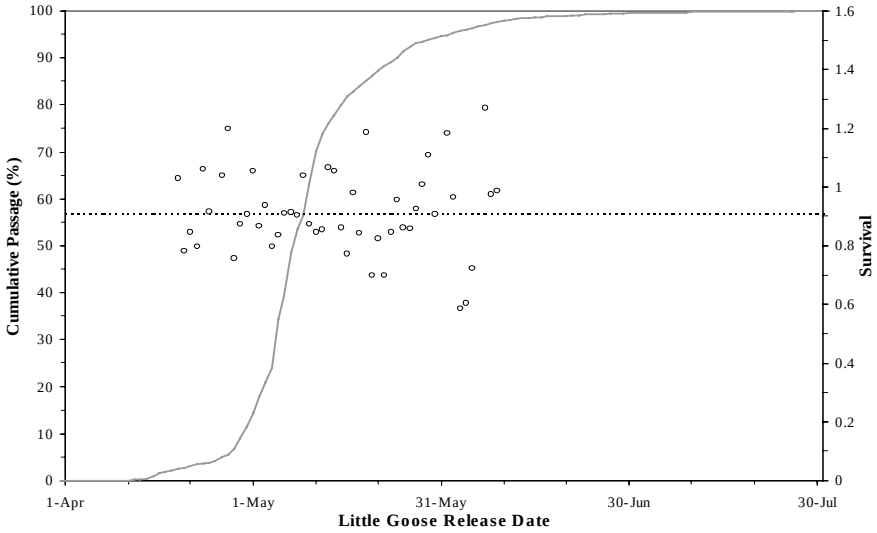


Figure 11: Plots of daily survival estimates of 1996 yearling chinook salmon from the tailrace of Little Goose Dam to the tailrace of Lower Monumental Dam, along with the average survival estimate S_S (horizontal line) for the middle 95% of the run and the cumulative arrival distribution at Little Goose Dam (curve).

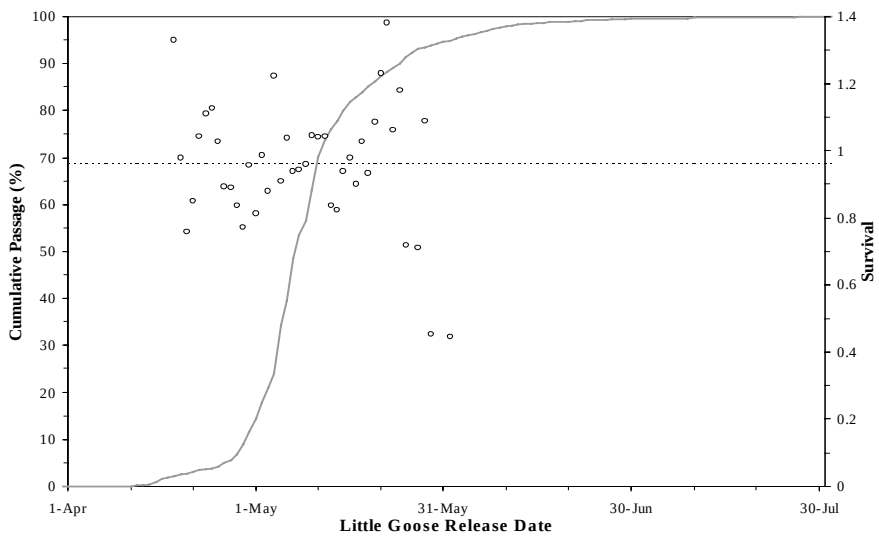
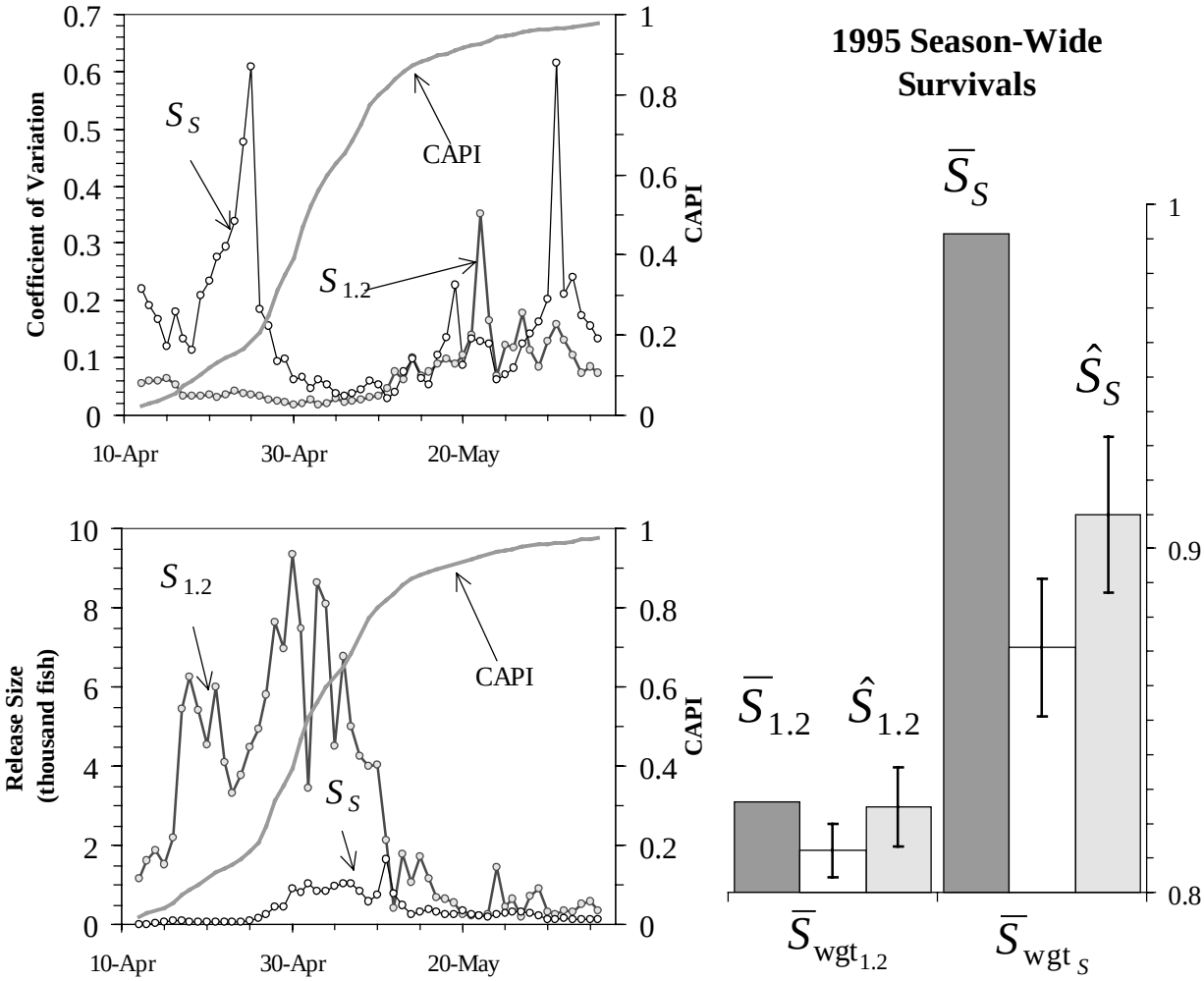


Table 5: Comparison of season-wide survival estimates for PIT-tagged yearling chinook salmon from Little Goose Dam to Lower Monumental Dam (S_S) for 1994-1996 using daily random samples. Estimates are: $\bar{S}_S$, common average (eq. 3); $\bar{S}_{\mathrm{wgt}_S}$, weighted average (eq. 4); and $\hat{S}_S$, Skalski (1998) average (eq. 1). Percentiles based on FPC adjusted passage indices.

Year	Nominal Percentile	Actual Percentile	Days of Year	Dates	$\bar{S}_S$	$\bar{S}_{\mathrm{wgt}_S}$	$\hat{S}_S$
96	10 - 90	8.76 - 90.46	114 - 146	23 Apr-25 May	0.9859	0.9271	0.9935
96	5 - 95	4.75 - 95.45	112 - 151	21 Apr-30 May	0.9886	0.9223	0.9868
96	2.5 - 97.5	2.01 - 97.62	109 - 154	18 Apr-2 Jun	0.9783	0.9169	0.9668
95	10 - 90	8.99 - 91.31	120 - 146	29 Apr-25 May	0.8986	0.8733	0.8934
95	5 - 95	4.92 - 95.37	117 - 154	26 Apr-2 Jun	0.9603	0.8745	0.9030
95	2.5 - 97.5	2.43 - 97.67	110 - 161	19 Apr-9 Jun	0.9914	0.8714	0.9099
94	10 - 90	9.31 - 90.39	117 - 141	26 Apr-20 May	0.7614	0.7575	0.7108
94	5 - 95	4.65 - 95.25	116 - 145	25 Apr-24 May	0.7456	0.7570	0.6853
94	2.5 - 97.5	2.23 - 97.76	115 - 150	24 Apr-29 May	0.7549	0.7695	0.6819

Figure 12: Relationship between season-wide survival estimates for S_S and $S_{1.2}$, and the coefficients of variation of daily survival estimates, release sizes and the cumulative adjusted passage index proportion (CAPI), for middle 95% yearling chinook salmon run in 1995. Estimates are: $\bar{S}_{\bullet}$, common average (eq. 3); $\bar{S}_{\text{wgt}_{\bullet}}$, weighted average (eq. 4); and $\hat{S}_{\bullet}$, Skalski (1998) average (eq. 1). Error bars indicate 95% confidence limits.



the first week of May. This resulted in large coefficients of variation and large variances for S_S during the first 20% of the outmigration. Since the weights for the average $\bar{S}_{\text{wgt}}$ are inversely proportional to the variances of the daily estimates (eq. 4), while those for the season-wide average $\hat{S}$ are directly proportional to the adjusted passage index proportion (eq. 1), the daily S_S estimates of April and early May had almost no impact on $\bar{S}_{\text{wgt}_S}$, but they did affect $\hat{S}_S$. Thus, larger differences between both averages were fostered in this case. On the other hand, the less variable $S_{1.2}$ estimates affected both $\bar{S}_{\text{wgt}_{1.2}}$ and $\hat{S}_{1.2}$ resulting in considerably smaller differences between the averages.

3.3 Comparison of seasonal survival estimates and environmental factors

We have seen that season-wide estimates $\hat{S}_{1.2}, \hat{S}_2$, and $\hat{S}_S$ were lower in 1994 than in 1995 and 1996 (Fig. 8). Reasons for this pattern were probably multifarious, and remain to be clearly identified and stated as alternative hypotheses to be tested in the future as the series of annual survival estimates builds up. Meanwhile, the comparison of the seasonal estimates with the average values of environmental variables at LGR for release days shows that the average flow and spill were lower and the average temperature higher in 1994 than in later years (Fig. 13-15). These patterns may be an indication of directly proportional relationships between survival and flow (Fig. 13), and between survival and spill (Fig. 14), and of an inversely proportional relationship between survival and temperature (Fig. 15).

4. DISCUSSION

In this report we have illustrated the estimation of season-wide survival probabilities from a series of daily survival estimates by assuming that the fish released daily are a random sample of the daily outmigrants arriving either at Lower Granite or Little Goose Dams. The opportunistic nature of the sampling at both release points likely violates this assumption to an unknown degree, in particular if we attempt to make inferences with respect to the survival of hatchery and wild chinook stocks. The daily releases used in this report consisted mostly of hatchery fish, accompanied by a smaller proportion of wild fish. Thus the inferences made here are more applicable to the fate of hatchery stocks on the Snake River.

Figure 13: Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of flow. Error bars indicate 95% confidence limits.

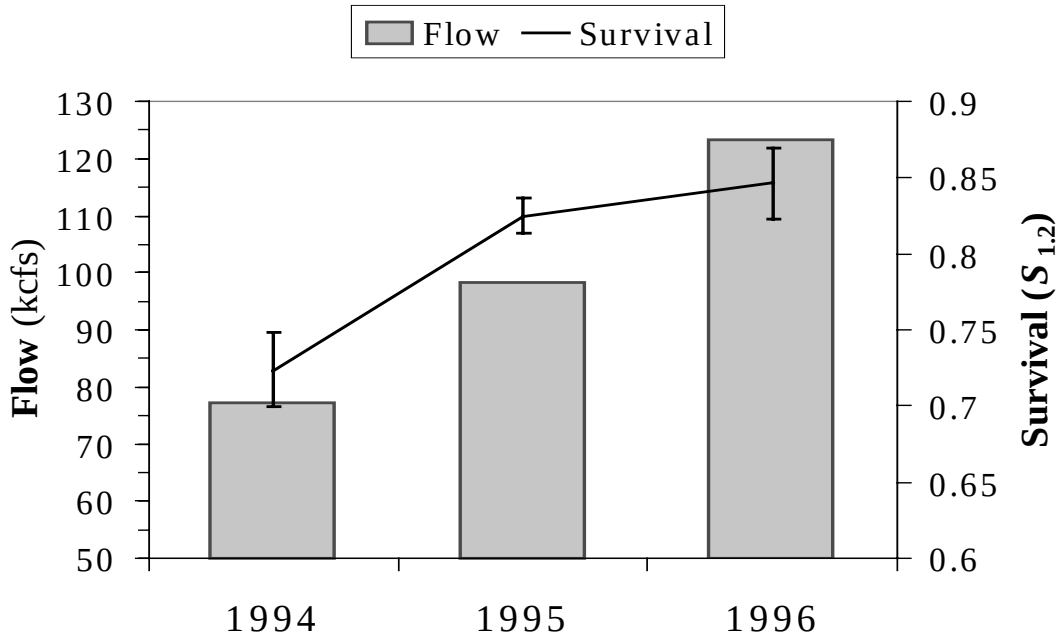


Figure 14: Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of spill. Error bars indicate 95% confidence limits.

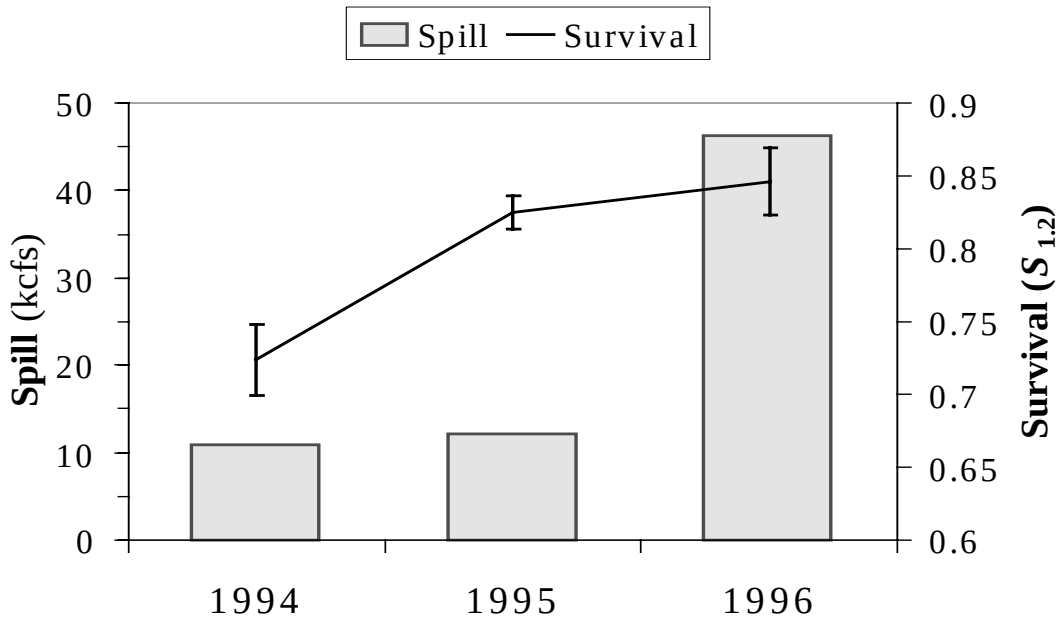
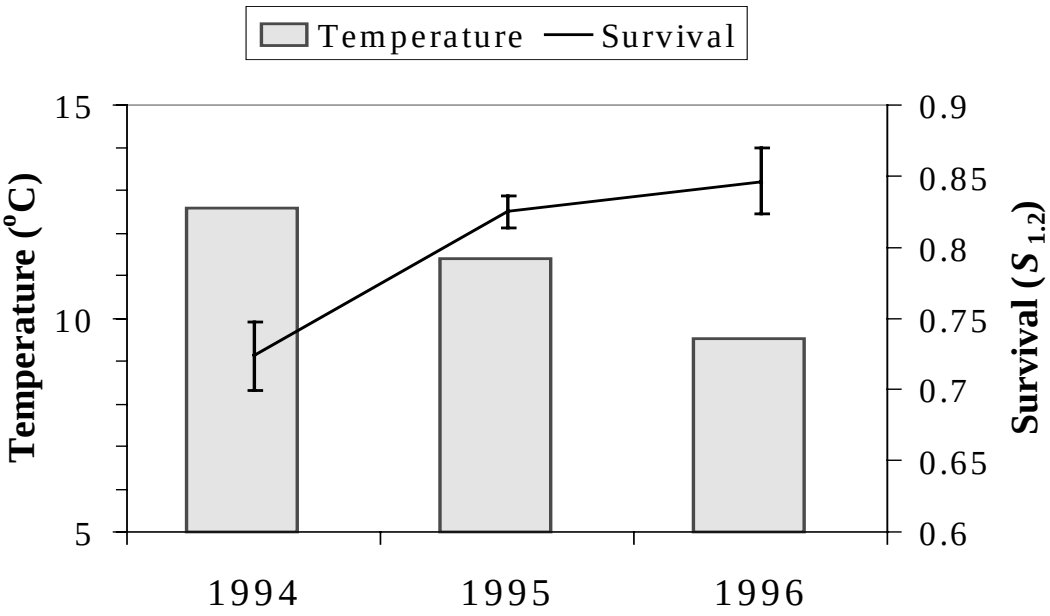


Figure 15: Comparison of seasonal survival estimates ($\hat{S}_{1.2}$) for middle 95% yearling chinook salmon runs and annual averages of water temperature. Error bars indicate 95% confidence limits.



In any case, we have shown that the overall survival of this mixture of Snake River yearling chinook salmon was significantly lower in 1994 than in 1995 and 1996 (Fig. 8). The estimated survival was higher, though not significantly so, in 1996 than in 1995. This pattern was best represented by the $S_{1.2}$ estimates (survival from LGR to LMN), and to a lesser extent by the S_S estimates. Increasing survival from 1994 to 1996 may be associated with patterns in flow (Fig. 13) and spill (Fig. 14), or other factors with a less direct relationship, such as the average water temperature (Fig. 15), or other factors affecting survivability of migrating smolt either in the migration corridor or in early pre-migration life stages.

While reasons for annual differences remain to be investigated, our results suggest that, in discerning annual variation in survival, it may be better to follow the fate of outmigrants over longer reaches than over shorter ones. $\hat{S}_{1.2}$'s, obtained over the 106 km that separate LGR and LMN dams, provided a clearer, better defined trend than any of the complementary $\hat{S}_1$'s or $\hat{S}_2$'s obtained over the shorter reaches LGR-LGS and LGS-LMN.

This analysis has also shown that season-wide estimates of smolt survival can be accurately estimated from daily releases of PIT-tagged fish. These estimates can be valuable indices of the health and success of the outmigration, and should also be monitored to evaluate the success of ongoing mitigation activities. Improvements in the precision of the season-wide estimates can be made by increasing the amount of tagging effort towards the end of the migration. Increased costs of the tagging can be avoided by reducing tagging efforts during the middle of the run when sample sizes are in excess of that needed for precise estimation of smolt survival. In this way, precision can be improved and costs even reduced.

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6. APPENDIX: Daily data on smolt passage and survival

A 6.1: Daily data on smolt passage and survival used in estimating season-wide survivals at Little Goose Dam (S_1), and Lower Monumental Dam (S_2 and $S_{1.2}$) for fish released at Lower Granite Dam 1994. API (Adjusted Passage Index), CPR (Cumulative Percentile of Run, n (number of PIT-tags released), SE (estimated Standard Error).

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
98	30	0.01	1	NA	NA	0.000	NA	NA	NA
99	110	0.01	0	NA	NA	NA	NA	NA	NA
100	110	0.02	0	NA	NA	NA	NA	NA	NA
101	50	0.02	0	NA	NA	NA	NA	NA	NA
102	140	0.02	1	NA	NA	0.000	NA	NA	NA
103	480	0.05	6	NA	NA	0.000	NA	NA	NA
104	700	0.08	5	NA	NA	NA	NA	NA	NA
105	1,060	0.12	3	0.667	0.272	0.500	0.354	0.333	0.272
106	1,170	0.17	7	0.857	0.512	0.333	0.272	0.286	0.171
107	1,390	0.23	11	0.955	0.335	0.714	0.298	0.682	0.166
108	2,570	0.34	27	0.763	0.161	0.982	0.320	0.749	0.213
109	6,810	0.64	89	0.889	0.132	0.687	0.130	0.611	0.074
110	12,480	1.18	175	0.842	0.045	0.950	0.068	0.800	0.050
111	26,920	2.34	1185	0.827	0.021	0.916	0.033	0.757	0.023
112	37,900	3.99	585	0.866	0.031	0.883	0.045	0.765	0.031
113	57,800	6.49	2921	0.782	0.016	0.794	0.023	0.621	0.015
114	107,300	11.14	998	0.829	0.027	0.880	0.040	0.729	0.026
115	148,700	17.58	1037	0.866	0.033	0.860	0.044	0.744	0.028
116	126,900	23.07	1670	0.758	0.027	0.922	0.046	0.699	0.027
117	96,000	27.23	446	0.815	0.061	0.895	0.091	0.729	0.053
118	95,400	31.36	2848	0.822	0.031	0.775	0.038	0.637	0.020
119	78,600	34.77	499	1.009	0.111	0.646	0.083	0.652	0.039
120	95,400	38.90	1439	0.930	0.067	0.695	0.063	0.647	0.033
121	127,700	44.43	535	0.988	0.109	0.678	0.090	0.669	0.048
122	61,900	47.11	2593	0.886	0.042	0.832	0.053	0.737	0.031
123	59,700	49.70	357	0.974	0.157	0.719	0.138	0.701	0.070
124	46,700	51.72	393	0.878	0.111	0.942	0.175	0.827	0.112
125	63,300	54.46	372	1.096	0.187	0.633	0.127	0.694	0.069
126	63,480	57.21	557	0.940	0.111	0.730	0.116	0.687	0.072
127	103,500	61.69	757	0.909	0.095	0.919	0.141	0.836	0.093
128	107,400	66.35	875	0.938	0.090	0.668	0.086	0.627	0.052
129	122,200	71.64	1060	0.984	0.103	0.855	0.128	0.841	0.089
130	142,800	77.82	1290	0.759	0.053	0.996	0.105	0.756	0.061

A 6.1 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
131	142,741	84.01	904	0.930	0.097	0.828	0.126	0.770	0.085
132	66,406	86.88	1610	0.860	0.086	0.693	0.092	0.597	0.052
133	61,520	89.55	385	0.898	0.134	0.740	0.146	0.664	0.086
134	38,391	91.21	314	0.700	0.084	1.227	0.259	0.859	0.154
135	26,101	92.34	275	0.870	0.136	0.829	0.204	0.721	0.138
136	26,179	93.47	281	0.899	0.161	0.938	0.349	0.844	0.273
137	24,665	94.54	203	0.886	0.187	1.046	0.544	0.926	0.441
138	14,600	95.17	171	0.805	0.184	0.546	0.167	0.440	0.086
139	14,496	95.80	195	0.970	0.213	0.653	0.205	0.634	0.141
140	15,988	96.49	196	0.888	0.205	0.795	0.304	0.706	0.215
141	10,664	96.96	120	0.783	0.136	1.567	0.786	1.227	0.580
142	6,385	97.23	92	0.733	0.158	0.885	0.266	0.649	0.140
143	4,105	97.41	57	0.643	0.104	2.481	2.049	1.596	1.310
144	3,724	97.57	41	0.793	0.263	0.862	0.529	0.683	0.361
145	3,028	97.70	29	1.414	0.545	NA	NA	NA	NA
146	2,000	97.79	42	1.298	0.689	0.514	0.376	0.667	0.312
147	1,396	97.85	25	0.627	0.174	1.295	0.863	0.812	0.518
148	1,554	97.92	33	0.727	0.311	1.318	1.174	0.959	0.743
149	3,800	98.08	64	0.682	0.280	NA	NA	NA	NA
150	3,790	98.25	82	0.893	0.313	0.703	0.447	0.628	0.324
151	3,021	98.38	49	NA	NA	NA	NA	NA	NA
152	914	98.42	22	0.750	0.292	1.879	1.608	1.409	1.102
153	1,541	98.48	17	0.235	0.103	1.000	0.000	0.235	0.103
154	1,275	98.54	34	0.206	0.069	NA	NA	NA	NA
155	2,123	98.63	45	0.356	0.071	NA	NA	NA	NA
156	2,544	98.74	42	0.262	NA	2.200	NA	0.576	NA
157	1,528	98.81	31	0.323	NA	1.400	NA	0.452	NA
158	1,534	98.87	21	0.476	0.109	1.600	0.595	0.762	0.333
159	1,512	98.94	29	0.241	NA	1.429	NA	0.345	NA
160	1,061	98.98	13	0.231	0.117	NA	NA	NA	NA
161	356	99.00	2	NA	NA	NA	NA	NA	NA
162	125	99.01	5	NA	NA	NA	NA	NA	NA
163	367	99.02	2	NA	NA	NA	NA	NA	NA
164	174	99.03	3	NA	NA	NA	NA	NA	NA
165	359	99.04	7	NA	NA	0.000	NA	NA	NA
166	402	99.06	12	0.667	0.430	0.500	0.354	0.333	0.136
167	388	99.08	15	0.800	0.343	0.750	0.525	0.600	0.350
168	804	99.11	16	0.562	0.124	1.000	0.000	0.562	0.124

A 6.1 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
169	636	99.14	13	0.385	NA	NA	NA	NA	NA
170	478	99.16	4	NA	NA	NA	NA	NA	NA
171	521	99.18	0	NA	NA	NA	NA	NA	NA
172	287	99.20	0	NA	NA	NA	NA	NA	NA
173	268	99.21	0	NA	NA	NA	NA	NA	NA
174	853	99.24	35	0.743	0.266	NA	NA	NA	NA
175	973	99.29	8	0.500	0.177	NA	NA	NA	NA
176	560	99.31	2	0.000	NA	NA	NA	NA	NA
177	232	99.32	0	NA	NA	NA	NA	NA	NA
178	182	99.33	0	NA	NA	NA	NA	NA	NA
179	292	99.34	1	0.000	NA	NA	NA	NA	NA
180	421	99.36	7	0.000	NA	NA	NA	NA	NA
181	350	99.38	4	0.500	NA	NA	NA	NA	NA
182	120	99.38	8	NA	NA	NA	NA	NA	NA
183	170	99.39	11	0.273	0.134	0.500	0.354	0.136	0.117
184	190	99.40	10	0.300	0.145	NA	NA	NA	NA
185	164	99.40	3	0.000	NA	NA	NA	NA	NA
186	84	99.41	1	1.000	0.000	NA	NA	NA	NA
187	160	99.41	1	1.000	NA	NA	NA	NA	NA
188	256	99.42	14	0.429	0.281	NA	NA	NA	NA
189	710	99.46	32	0.188	0.069	NA	NA	NA	NA
190	940	99.50	50	0.140	0.049	NA	NA	NA	NA
191	1,326	99.55	43	0.413	0.117	NA	NA	NA	NA
192	1,513	99.62	36	0.278	0.191	NA	NA	NA	NA
193	901	99.66	12	0.417	0.219	NA	NA	NA	NA
194	738	99.69	21	NA	NA	NA	NA	NA	NA
195	570	99.72	13	0.692	0.398	NA	NA	NA	NA
196	410	99.73	21	NA	NA	NA	NA	NA	NA
197	610	99.76	6	NA	NA	NA	NA	NA	NA
198	830	99.80	19	NA	NA	NA	NA	NA	NA
199	290	99.81	11	NA	NA	NA	NA	NA	NA
200	210	99.82	0	NA	NA	NA	NA	NA	NA
201	260	99.83	16	NA	NA	NA	NA	NA	NA
202	350	99.84	2	NA	NA	NA	NA	NA	NA
203	230	99.85	3	NA	NA	NA	NA	NA	NA
204	90	99.86	2	NA	NA	NA	NA	NA	NA
205	80	99.86	4	NA	NA	NA	NA	NA	NA

A 6.1 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
206	100	99.86	3	NA	NA	NA	NA	NA	NA
207	120	99.87	3	NA	NA	NA	NA	NA	NA
208	90	99.87	3	NA	NA	NA	NA	NA	NA
209	118	99.88	1	NA	NA	NA	NA	NA	NA
210	212	99.89	5	NA	NA	NA	NA	NA	NA
211	96	99.89	2	NA	NA	NA	NA	NA	NA
212	224	99.90	2	NA	NA	NA	NA	NA	NA
213	68	99.91	1	NA	NA	NA	NA	NA	NA
214	48	99.91	0	NA	NA	NA	NA	NA	NA
215	68	99.91	1	NA	NA	NA	NA	NA	NA
216	48	99.91	1	NA	NA	NA	NA	NA	NA
217	72	99.92	1	NA	NA	NA	NA	NA	NA
218	56	99.92	0	NA	NA	NA	NA	NA	NA
219	108	99.92	0	NA	NA	NA	NA	NA	NA
220	104	99.93	0	NA	NA	NA	NA	NA	NA
221	175	99.93	10	NA	NA	NA	NA	NA	NA
222	252	99.95	5	NA	NA	NA	NA	NA	NA
223	184	99.95	6	NA	NA	NA	NA	NA	NA
224	92	99.96	1	NA	NA	NA	NA	NA	NA
225	92	99.96	4	NA	NA	NA	NA	NA	NA
226	72	99.96	2	NA	NA	NA	NA	NA	NA
227	104	99.97	0	NA	NA	NA	NA	NA	NA
228	52	99.97	0	NA	NA	NA	NA	NA	NA
229	36	99.97	0	NA	NA	NA	NA	NA	NA
230	20	99.97	0	NA	NA	NA	NA	NA	NA
231	24	99.97	1	NA	NA	NA	NA	NA	NA

A 6.2: Daily data on smolt passage and survival used in estimating season-wide survivals at Little Goose Dam (S_1), and Lower Monumental Dam (S_2 and $S_{1.2}$) for fish released at Lower Granite Dam 1995.

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
94	360	0.02	36	NA	NA	NA	NA	NA	NA
95	330	0.03	111	NA	NA	NA	NA	NA	NA
96	660	0.05	0	NA	NA	NA	NA	NA	NA
97	1,330	0.08	0	NA	NA	NA	NA	NA	NA
98	4,900	0.20	0	NA	NA	NA	NA	NA	NA
99	5,100	0.32	267	0.911	0.049	0.791	0.082	0.720	0.061
100	9,478	0.55	327	0.806	0.034	1.324	0.185	1.067	0.146
101	15,855	0.93	564	0.864	0.027	0.960	0.069	0.830	0.055
102	19,422	1.39	978	0.788	0.024	0.951	0.057	0.750	0.040
103	28,422	2.08	1146	0.862	0.034	0.868	0.059	0.748	0.041
104	36,867	2.96	1621	0.886	0.045	0.868	0.071	0.769	0.046
105	27,450	3.62	1863	0.870	0.048	0.958	0.081	0.833	0.051
106	29,150	4.32	1509	0.953	0.069	0.842	0.085	0.802	0.052
107	44,400	5.39	2202	0.846	0.044	1.002	0.076	0.848	0.045
108	80,800	7.33	5449	0.796	0.024	1.081	0.049	0.860	0.029
109	55,000	8.65	6248	0.930	0.032	0.922	0.045	0.858	0.028
110	62,600	10.16	5426	0.880	0.026	0.951	0.043	0.837	0.028
111	67,000	11.77	4562	0.852	0.023	0.946	0.042	0.806	0.028
112	58,500	13.17	5984	0.850	0.019	0.976	0.037	0.830	0.025
113	44,900	14.25	4107	0.871	0.022	0.921	0.039	0.801	0.028
114	43,700	15.30	3309	0.859	0.022	0.987	0.048	0.847	0.035
115	51,600	16.54	3787	0.832	0.020	0.952	0.042	0.792	0.030
116	82,100	18.51	4492	0.855	0.017	0.974	0.040	0.833	0.030
117	93,750	20.77	4951	0.901	0.018	0.902	0.035	0.813	0.027
118	171,450	24.89	5822	0.887	0.015	0.955	0.031	0.846	0.023
119	262,050	31.18	7660	0.898	0.013	0.946	0.026	0.849	0.020
120	160,350	35.04	6970	0.892	0.013	0.916	0.025	0.817	0.019
121	173,400	39.20	9355	0.888	0.011	0.902	0.020	0.801	0.015
122	317,250	46.83	7491	0.892	0.011	0.915	0.020	0.816	0.016
123	228,600	52.32	3439	0.917	0.018	0.890	0.028	0.816	0.021
124	156,282	56.08	8661	0.907	0.011	0.902	0.020	0.818	0.015
125	158,644	59.89	8105	0.908	0.014	0.906	0.024	0.822	0.017
126	118,166	62.73	4527	0.902	0.017	0.925	0.033	0.835	0.025
127	104,312	65.23	6776	0.895	0.013	0.895	0.023	0.801	0.017
128	133,057	68.43	4998	0.847	0.014	0.888	0.026	0.752	0.018
129	180,077	72.76	4269	0.879	0.016	0.924	0.029	0.812	0.021

A 6.2 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
130	193,057	77.40	3985	0.877	0.025	0.951	0.040	0.834	0.026
131	104,815	79.92	4046	0.840	0.023	1.004	0.044	0.843	0.028
132	79,617	81.83	2113	0.840	0.028	0.895	0.051	0.752	0.035
133	75,183	83.64	430	1.000	0.069	0.701	0.073	0.701	0.053
134	86,769	85.72	1762	0.943	0.038	0.884	0.067	0.833	0.052
135	67,055	87.33	1063	0.860	0.043	1.098	0.122	0.944	0.094
136	38,157	88.25	1724	0.896	0.038	0.918	0.075	0.822	0.057
137	31,397	89.00	1155	0.845	0.042	0.910	0.084	0.769	0.059
138	28,483	89.69	669	0.863	0.049	0.879	0.094	0.759	0.068
139	19,788	90.16	631	0.838	0.051	0.894	0.102	0.749	0.073
140	34,629	91.00	541	0.868	0.038	0.974	0.094	0.845	0.075
141	26,957	91.64	244	0.861	0.054	0.925	0.109	0.797	0.083
142	23,594	92.21	232	0.836	0.054	0.999	0.149	0.836	0.117
143	24,780	92.81	215	0.905	0.048	2.399	0.853	2.172	0.766
144	27,220	93.46	246	0.861	0.047	1.076	0.183	0.926	0.153
145	26,998	94.11	1447	0.924	0.033	0.856	0.067	0.791	0.054
146	17,249	94.52	439	0.831	0.052	0.862	0.117	0.716	0.087
147	18,874	94.98	636	0.790	0.045	0.871	0.112	0.688	0.081
148	18,576	95.42	190	0.864	0.073	0.943	0.183	0.814	0.145
149	13,913	95.76	723	0.817	0.036	1.097	0.130	0.896	0.101
150	12,287	96.05	904	0.868	0.044	0.752	0.074	0.653	0.056
151	6,063	96.20	329	0.898	0.067	0.736	0.110	0.661	0.086
152	9,452	96.43	274	0.795	0.069	0.829	0.145	0.659	0.104
153	5,871	96.57	366	0.818	0.046	0.949	0.133	0.776	0.102
154	13,781	96.90	312	0.957	0.067	0.784	0.100	0.750	0.079
155	15,574	97.27	521	0.873	0.035	0.834	0.068	0.728	0.054
156	9,078	97.49	582	0.906	0.029	0.934	0.083	0.846	0.071
157	13,220	97.81	362	0.925	0.029	0.893	0.069	0.826	0.060
158	11,640	98.09	425	0.884	0.023	0.876	0.061	0.774	0.053
159	7,012	98.26	392	0.888	0.027	0.806	0.054	0.715	0.046
160	5,894	98.40	245	0.850	0.033	0.963	0.113	0.819	0.095
161	5,118	98.52	253	0.819	0.040	0.969	0.149	0.794	0.119
162	3,353	98.60	228	0.882	0.047	0.711	0.082	0.627	0.067
163	2,526	98.66	184	0.873	0.043	0.903	0.121	0.788	0.102
164	1,658	98.70	143	0.902	0.057	0.695	0.086	0.627	0.069
165	1,232	98.73	96	0.904	0.081	0.716	0.125	0.647	0.099

A 6.2 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
166	1,129	98.76	77	0.883	0.072	0.721	0.109	0.636	0.088
167	2,338	98.81	72	0.842	0.070	0.803	0.186	0.676	0.153
168	1,710	98.86	116	1.015	0.088	0.751	0.191	0.762	0.180
169	1,614	98.89	105	0.860	0.074	0.696	0.126	0.599	0.100
170	3,096	98.97	108	0.998	0.087	0.665	0.102	0.664	0.083
171	2,889	99.04	166	0.844	0.045	0.838	0.123	0.707	0.101
172	3,956	99.13	161	0.781	0.055	0.749	0.086	0.585	0.062
173	3,425	99.22	197	0.817	0.048	0.780	0.069	0.637	0.051
174	2,622	99.28	164	0.768	0.043	1.052	0.131	0.808	0.102
175	1,356	99.31	142	0.763	0.046	0.772	0.078	0.589	0.061
176	867	99.33	78	0.815	0.063	0.707	0.101	0.576	0.081
177	633	99.35	53	0.646	0.071	0.996	0.155	0.644	0.116
178	800	99.37	48	0.868	0.151	0.926	0.342	0.804	0.266
179	1,311	99.40	64	0.871	0.096	0.950	0.284	0.827	0.234
180	1,400	99.43	97	0.658	0.073	0.735	0.141	0.484	0.089
181	855	99.45	96	0.674	0.066	0.756	0.096	0.509	0.065
182	1,230	99.48	78	0.840	0.103	0.814	0.189	0.684	0.141
183	1,160	99.51	29	0.903	0.110	0.726	0.163	0.655	0.136
184	1,500	99.55	43	0.905	0.105	0.966	0.249	0.874	0.208
185	2,130	99.60	44	0.705	0.082	0.733	0.158	0.517	0.117
186	1,210	99.63	36	0.639	0.088	1.056	0.218	0.674	0.155
187	1,430	99.66	37	0.786	0.098	1.456	0.578	1.144	0.453
188	1,240	99.69	29	0.853	0.092	0.896	0.141	0.765	0.120
189	1,340	99.72	42	0.933	0.133	0.801	0.233	0.748	0.193
190	1,320	99.75	29	0.786	0.101	0.838	0.141	0.659	0.112
191	1,430	99.79	24	0.944	0.115	0.969	0.302	0.915	0.268
192	1,120	99.81	19	0.855	0.116	1.354	0.971	1.158	0.830
193	1,180	99.84	28	0.988	0.134	0.750	0.192	0.741	0.159
194	490	99.85	9	0.593	0.185	NA	NA	NA	NA
195	610	99.87	12	1.083	0.275	0.667	0.333	0.722	0.290
196	350	99.88	6	0.833	0.366	NA	NA	NA	NA
197	310	99.89	7	NA	NA	NA	NA	NA	NA
198	200	99.89	2	0.500	0.354	NA	NA	NA	NA
199	270	99.90	5	NA	NA	0.000	NA	NA	NA
200	550	99.91	3	1.000	0.000	NA	NA	NA	NA
201	520	99.92	6	NA	NA	0.000	NA	NA	NA

A 6.2 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
202	290	99.93	1	NA	NA	NA	NA	NA	NA
203	220	99.93	7	0.714	0.171	NA	NA	NA	NA
204	300	99.94	6	0.667	0.192	1.000	0.000	0.667	0.192
205	230	99.95	5	0.800	0.438	NA	NA	NA	NA
206	150	99.95	4	0.500	0.250	NA	NA	NA	NA
207	160	99.95	1	1.000	NA	NA	NA	NA	NA
208	140	99.96	3	0.667	0.272	NA	NA	NA	NA
209	240	99.96	5	0.800	0.179	NA	NA	NA	NA
210	260	99.97	0	NA	NA	NA	NA	NA	NA
211	110	99.97	0	NA	NA	NA	NA	NA	NA
212	80	99.97	2	0.500	0.354	NA	NA	NA	NA
213	110	99.98	2	NA	NA	NA	NA	NA	NA
214	120	99.98	2	1.000	0.000	1.000	0.000	1.000	0.000
215	120	99.98	3	1.333	0.544	NA	NA	NA	NA
216	40	99.98	0	NA	NA	NA	NA	NA	NA
217	120	99.99	0	NA	NA	NA	NA	NA	NA
218	140	99.99	1	NA	NA	NA	NA	NA	NA
219	60	99.99	2	NA	NA	0.000	NA	NA	NA
220	40	99.99	0	NA	NA	NA	NA	NA	NA
221	20	99.99	0	NA	NA	NA	NA	NA	NA
222	30	99.99	0	NA	NA	NA	NA	NA	NA
223	20	99.99	0	NA	NA	NA	NA	NA	NA
224	30	100.00	1	1.000	0.000	NA	NA	NA	NA
225	0	100.00	1	1.000	NA	NA	NA	NA	NA
226	0	100.00	0	NA	NA	NA	NA	NA	NA
227	0	100.00	2	NA	NA	NA	NA	NA	NA

A 6.3: Daily data on smolt passage and survival used in estimating season-wide survivals at Little Goose Dam (S_1), and Lower Monumental Dam (S_2 and $S_{1.2}$) for fish released at Lower Granite Dam 1996.

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
100	395	0.15	11	1.182	0.423	0.833	0.614	0.985	0.594
101	637	0.22	31	0.968	0.192	1.167	0.659	1.129	0.600
102	1,105	0.34	62	0.855	0.208	0.690	0.259	0.590	0.168
103	3,023	0.67	98	0.979	0.153	0.925	0.339	0.905	0.298
104	4,501	1.17	140	0.798	0.090	0.961	0.270	0.767	0.201
105	8,675	2.13	220	0.881	0.086	0.823	0.177	0.724	0.140
106	5,771	2.76	277	0.916	0.073	0.823	0.125	0.754	0.098
107	10,612	3.93	537	0.949	0.052	0.886	0.110	0.840	0.094
108	16,664	5.77	1091	0.970	0.040	1.031	0.106	1.000	0.094
109	21,128	8.10	1599	0.916	0.027	1.028	0.082	0.943	0.070
110	15,042	9.75	1439	0.843	0.028	1.079	0.099	0.910	0.079
111	27,846	12.82	1831	0.899	0.027	0.945	0.067	0.849	0.055
112	27,400	15.84	2579	0.920	0.026	0.966	0.060	0.889	0.049
113	13,766	17.36	2054	0.899	0.032	1.003	0.073	0.902	0.058
114	14,303	18.93	1476	0.973	0.037	0.933	0.069	0.907	0.057
115	19,725	21.11	2311	0.908	0.028	0.923	0.058	0.838	0.046
116	22,658	23.60	4034	0.957	0.023	0.853	0.037	0.816	0.029
117	38,005	27.79	3069	0.935	0.029	0.839	0.043	0.784	0.033
118	21,987	30.22	2664	0.970	0.029	0.836	0.044	0.811	0.035
119	14,854	31.85	1736	0.907	0.034	1.024	0.074	0.929	0.058
120	24,067	34.50	2501	0.883	0.027	0.955	0.052	0.843	0.038
121	17,912	36.48	3209	0.917	0.026	1.012	0.054	0.929	0.041
122	14,523	38.08	1844	0.878	0.034	0.880	0.057	0.772	0.041
123	21,114	40.41	2167	0.938	0.033	0.963	0.063	0.904	0.050
124	25,905	43.26	3411	0.940	0.027	0.956	0.051	0.899	0.040
125	26,274	46.16	2636	0.955	0.031	0.901	0.058	0.860	0.048
126	15,739	47.89	1813	0.892	0.032	0.974	0.078	0.869	0.063
127	12,772	49.30	2802	0.942	0.029	0.880	0.055	0.829	0.045
128	14,059	50.85	2609	0.964	0.031	0.916	0.064	0.883	0.055
129	14,106	52.40	1688	0.797	0.035	1.102	0.130	0.878	0.097
130	8,252	53.31	429	0.744	0.059	0.852	0.151	0.634	0.104
131	10,110	54.42	1936	0.971	0.038	0.936	0.090	0.909	0.080
132	15,788	56.16	3939	0.951	0.028	0.950	0.069	0.903	0.060
133	38,625	60.42	5222	0.915	0.024	0.997	0.060	0.912	0.050
134	37,137	64.51	5555	0.915	0.027	0.963	0.062	0.881	0.050
135	45,095	69.48	4165	0.960	0.039	0.923	0.074	0.886	0.061

A 6.3 (cont.)

Day of Year	API	CPR	n	S_1	SE(S_1)	S_2	SE(S_2)	$S_{1.2}$	SE($S_{1.2}$)
136	40,073	73.90	3122	0.979	0.048	0.766	0.064	0.750	0.050
137	44,138	78.76	2652	0.916	0.045	0.989	0.104	0.906	0.084
138	39,402	83.10	1740	0.907	0.049	0.957	0.126	0.868	0.104
139	33,092	86.75	1245	1.058	0.081	0.746	0.116	0.790	0.106
140	27,399	89.77	3220	0.998	0.050	0.840	0.087	0.838	0.076
141	20,453	92.02	1629	0.942	0.068	0.985	0.173	0.929	0.149
142	9,787	93.10	505	1.013	0.145	1.580	0.673	1.600	0.640
143	6,690	93.84	210	0.813	0.243	0.644	0.315	0.523	0.203
144	3,219	94.20	168	2.440	2.286	0.353	0.398	0.861	0.531
145	3,107	94.54	165	0.806	0.312	0.508	0.247	0.409	0.118
146	3,211	94.89	139	NA	NA	0.000	NA	NA	NA
147	2,998	95.22	137	0.745	0.228	1.191	0.799	0.887	0.533
148	1,941	95.44	43	NA	NA	NA	NA	NA	NA
149	2,152	95.67	127	1.575	1.454	0.240	0.259	0.378	0.209
150	5,392	96.27	179	1.730	0.883	NA	NA	NA	NA
151	5,064	96.83	319	1.109	0.381	0.435	0.223	0.482	0.181
152	3,317	97.19	262	0.739	0.137	0.377	0.163	0.279	0.108
153	1,844	97.39	175	1.579	0.677	NA	NA	NA	NA
154	2,146	97.63	99	0.838	0.378	NA	NA	NA	NA
155	1,568	97.80	25	0.420	0.175	NA	NA	NA	NA
156	1,712	97.99	86	1.134	0.685	NA	NA	NA	NA
157	2,013	98.21	89	0.433	0.155	NA	NA	NA	NA
158	2,100	98.44	113	1.239	1.117	NA	NA	NA	NA
159	2,694	98.74	103	NA	NA	NA	NA	NA	NA
160	1,787	98.94	120	0.975	0.460	NA	NA	NA	NA
161	1,380	99.09	81	NA	NA	NA	NA	NA	NA
162	1,315	99.24	29	NA	NA	NA	NA	NA	NA
163	660	99.31	51	0.882	0.476	0.556	0.451	0.490	0.299
164	716	99.39	56	0.714	0.601	0.400	0.439	0.286	0.205
165	1,019	99.50	24	0.583	0.395	0.786	0.693	0.458	0.282
166	634	99.57	42	0.500	0.194	0.333	0.157	0.167	0.058
167	302	99.60	20	0.250	0.097	NA	NA	NA	NA
168	293	99.64	5	0.200	NA	NA	NA	NA	NA
169	226	99.66	8	NA	NA	NA	NA	NA	NA

A 6.4: Daily data on smolt passage and survival used in estimating season-wide survivals at Lower Monumental Dam (S_S) for fish released at Little Goose Dam 1994.

Day of Year	API	CPR	n	S_S	SE(S_S)
113	864	0.14	16	0.906	0.130
114	4,991	0.63	194	0.922	0.050
115	16,395	2.23	295	0.818	0.039
116	24,727	4.65	270	0.824	0.043
117	47,673	9.31	460	0.751	0.029
118	18,344	11.10	314	0.794	0.043
119	30,091	14.04	285	0.737	0.045
120	37,222	17.68	270	0.800	0.052
121	37,179	21.32	198	0.874	0.063
122	33,855	24.62	165	0.870	0.070
123	30,216	27.58	241	0.796	0.048
124	26,572	30.18	164	0.814	0.079
125	33,944	33.50	226	0.722	0.054
126	72,543	40.59	223	0.834	0.066
127	40,343	44.53	196	0.675	0.072
128	21,387	46.62	200	0.783	0.085
129	27,910	49.35	131	0.858	0.169
130	21,175	51.42	156	0.748	0.121
131	24,420	53.81	193	0.845	0.161
132	39,118	57.63	282	0.774	0.100
133	57,756	63.28	132	0.907	0.202
134	36,355	66.83	128	0.766	0.107
135	38,616	70.61	209	0.681	0.123
136	51,941	75.69	142	0.487	0.101
137	31,619	78.78	89	0.728	0.136
138	30,289	81.74	106	1.101	0.320
139	31,901	84.86	66	NA	NA
140	23,107	87.12	53	NA	NA
141	33,442	90.39	30	0.167	0.091
142	19,491	92.29	44	NA	NA
143	14,344	93.69	25	0.280	0.111
144	10,406	94.71	18	NA	NA
145	5,543	95.25	13	0.769	0.458
146	3,577	95.60	14	0.571	0.141
147	4,590	96.05	17	0.412	0.139
148	5,951	96.63	14	NA	NA

A 6.4 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
149	6,128	97.23	14	1.143	0.814
150	5,359	97.76	5	NA	NA
151	4,447	98.19	0	NA	NA
152	3,393	98.52	0	NA	NA
153	1,208	98.64	0	NA	NA
154	1,019	98.74	3	NA	NA
155	1,178	98.86	0	NA	NA
156	446	98.90	0	NA	NA
157	531	98.95	0	NA	NA
158	717	99.02	0	NA	NA
159	834	99.10	0	NA	NA
160	439	99.15	0	NA	NA
161	359	99.18	0	NA	NA
162	249	99.20	0	NA	NA
163	292	99.23	0	NA	NA
164	140	99.25	0	NA	NA
165	266	99.27	0	NA	NA
166	264	99.30	1	NA	NA

A 6.5: Daily data on smolt passage and survival used in estimating season-wide survivals at Lower Monumental Dam (S_S) for fish released at Little Goose Dam 1995.

Day of Year	API	CPR	n	S_S	SE(S_S)
101	395	0.04	1	NA	NA
102	1,000	0.08	7	0.857	0.132
103	1,620	0.15	9	0.889	0.197
104	2,344	0.24	11	0.727	0.139
105	5,788	0.47	30	0.700	0.117
106	14,164	1.05	54	0.897	0.107
107	10,547	1.47	81	1.218	0.220
108	9,116	1.84	86	0.928	0.125
109	7,169	2.13	78	0.696	0.079
110	7,510	2.43	67	1.030	0.216
111	6,224	2.68	71	0.783	0.183
112	8,577	3.03	76	0.847	0.235
113	8,907	3.39	76	0.797	0.234
114	7,163	3.68	54	1.060	0.359
115	4,951	3.88	59	0.915	0.437
116	7,046	4.16	86	1.988	1.212
117	18,751	4.92	175	1.038	0.192
118	16,833	5.60	264	1.198	0.186
119	28,633	6.75	438	0.758	0.071
120	55,556	8.99	448	0.874	0.086
121	61,192	11.46	915	0.907	0.056
122	72,630	14.39	812	1.053	0.070
123	86,159	17.87	1023	0.867	0.040
124	74,373	20.87	849	0.939	0.059
125	74,344	23.87	846	0.797	0.043
126	258,572	34.30	961	0.836	0.032
127	130,176	39.55	1032	0.911	0.031
128	221,059	48.47	1035	0.912	0.034
129	124,130	53.48	849	0.905	0.041
130	76,984	56.59	596	1.038	0.062
131	160,699	63.07	734	0.875	0.046
132	175,524	70.15	1659	0.845	0.025
133	89,441	73.76	766	0.855	0.035
134	57,039	76.06	492	1.067	0.080
135	41,035	77.72	260	1.054	0.104
136	51,970	79.82	326	0.861	0.056

A 6.5 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
137	47,302	81.72	383	0.772	0.041
138	27,251	82.82	309	0.982	0.103
139	26,086	83.88	262	0.843	0.115
140	27,336	84.98	264	1.186	0.269
141	29,935	86.19	344	0.700	0.061
142	30,266	87.41	259	0.823	0.111
143	20,796	88.25	218	0.698	0.090
144	20,886	89.09	198	0.845	0.105
145	21,625	89.96	245	0.956	0.060
146	33,337	91.31	279	0.862	0.061
147	24,506	92.30	319	0.857	0.071
148	17,869	93.02	334	0.925	0.115
149	11,820	93.49	286	1.009	0.143
150	9,977	93.90	212	1.110	0.180
151	8,462	94.24	116	0.907	0.184
152	8,034	94.56	115	2.278	1.404
153	8,413	94.90	158	1.184	0.251
154	11,718	95.37	120	0.964	0.232
155	10,401	95.79	139	0.584	0.101
156	6,533	96.06	130	0.605	0.094
157	8,301	96.39	118	0.722	0.097
158	7,324	96.69	90	2.500	2.047
159	6,554	96.95	112	1.268	0.296
160	10,507	97.38	220	0.975	0.076
161	7,249	97.67	202	0.987	0.094
162	5,462	97.89	142	0.787	0.066
163	5,185	98.10	149	0.888	0.072
164	4,425	98.28	96	0.920	0.102
165	3,123	98.40	72	0.889	0.089
166	2,654	98.51	45	0.967	0.123
167	2,475	98.61	31	0.774	0.075
168	2,256	98.70	37	0.749	0.119
169	1,806	98.77	37	0.818	0.093
170	1,306	98.83	20	0.650	0.107
171	1,533	98.89	20	0.733	0.168
172	986	98.93	31	0.452	0.089

A 6.5 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
173	1,122	98.97	27	0.607	0.114
174	2,064	99.06	44	0.949	0.194
175	3,036	99.18	72	0.775	0.106
176	1,859	99.25	60	0.769	0.152
177	848	99.29	13	0.846	0.207
178	620	99.31	7	0.571	0.187
179	1,230	99.36	35	0.838	0.099
180	2,106	99.45	58	1.103	0.116
181	1,406	99.50	39	0.897	0.109
182	760	99.54	28	0.821	0.098
183	700	99.56	35	0.629	0.115
184	450	99.58	17	0.860	0.100
185	280	99.59	13	0.846	0.159
186	510	99.61	21	0.651	0.117
187	350	99.63	16	0.854	0.198
188	280	99.64	17	0.765	0.131
189	330	99.65	16	1.056	0.043
190	370	99.67	16	0.979	0.113
191	670	99.69	31	0.863	0.110
192	490	99.71	26	0.962	0.189
193	310	99.73	26	0.742	0.125
194	590	99.75	11	NA	NA
195	463	99.77	25	0.611	0.122
196	382	99.78	24	0.792	0.152
197	285	99.80	17	1.706	1.188
198	232	99.81	10	0.500	0.158
199	267	99.82	4	0.250	0.217
200	245	99.83	12	0.417	0.238
201	354	99.84	16	NA	NA
202	278	99.85	46	0.848	0.203
203	304	99.86	13	0.808	0.180
204	221	99.87	10	0.700	0.145
205	202	99.88	4	NA	NA
206	216	99.89	5	0.200	0.179
207	192	99.90	12	2.000	0.816
208	145	99.90	11	0.818	0.253

A 6.5 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
209	161	99.91	4	NA	NA
210	148	99.92	4	1.125	0.153
211	198	99.92	3	NA	NA
212	70	99.93	6	NA	NA
213	79	99.93	0	NA	NA
214	55	99.93	5	NA	NA
215	75	99.93	2	NA	NA
216	146	99.94	5	NA	NA
217	123	99.95	7	NA	NA
218	94	99.95	4	NA	NA
219	100	99.95	7	0.714	0.171
220	102	99.96	1	NA	NA
221	63	99.96	5	NA	NA
222	84	99.96	2	NA	NA
223	44	99.97	1	NA	NA
224	55	99.97	1	1.000	0.000
225	61	99.97	4	0.750	0.217
226	57	99.97	0	NA	NA
227	47	99.97	3	NA	NA
228	36	99.98	2	0.500	0.354
229	35	99.98	0	NA	NA
230	53	99.98	2	NA	NA
231	28	99.98	0	NA	NA
232	20	99.98	1	NA	NA
233	29	99.98	0	NA	NA
234	32	99.98	2	NA	NA
235	30	99.98	0	NA	NA
236	15	99.99	0	NA	NA
237	28	99.99	5	NA	NA

A 6.6: Daily data on smolt passage and survival used in estimating season-wide survivals at Lower Monumental Dam (S_S) for fish released at Little Goose Dam 1996.

Day of Year	API	CPR	n	S_S	SE(S_S)
99	85	0.06	2	NA	NA
100	59	0.07	0	NA	NA
101	53	0.08	0	NA	NA
102	264	0.13	0	NA	NA
103	663	0.25	6	NA	NA
104	826	0.39	18	NA	NA
105	775	0.53	27	0.864	0.297
106	1,290	0.77	47	1.170	0.322
107	1,281	1.00	29	0.586	0.141
108	1,249	1.22	59	0.751	0.147
109	4,395	2.01	111	1.330	0.386
110	3,667	2.68	144	0.980	0.207
111	6,164	3.79	202	0.758	0.077
112	5,363	4.75	247	0.851	0.088
113	7,694	6.14	439	1.043	0.132
114	14,562	8.76	655	1.111	0.168
115	22,568	12.83	1294	1.126	0.108
116	14,456	15.43	1301	1.026	0.051
117	14,322	18.02	1242	0.893	0.068
118	23,564	22.26	1908	0.890	0.046
119	24,481	26.67	356	0.838	0.084
120	4,404	27.47	300	0.772	0.060
121	7,021	28.73	291	0.957	0.086
122	4,583	29.56	408	0.812	0.069
123	4,817	30.43	742	0.987	0.087
124	10,331	32.29	1160	0.879	0.061
125	13,969	34.80	596	1.222	0.146
126	10,271	36.66	585	0.909	0.068
127	11,304	38.69	441	1.037	0.100
128	3,689	39.36	555	0.940	0.062
129	8,881	40.96	646	0.944	0.069
130	10,459	42.84	329	0.959	0.122
131	9,847	44.62	692	1.045	0.108
132	9,628	46.35	823	1.041	0.076
133	7,250	47.66	986	1.044	0.096
134	11,910	49.80	1877	0.836	0.050

A 6.6 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
135	24,298	54.18	1746	0.824	0.064
136	20,256	57.83	2060	0.940	0.067
137	19,819	61.40	2512	0.980	0.065
138	28,518	66.54	2577	0.901	0.069
139	31,133	72.15	1835	1.028	0.105
140	20,324	75.82	1213	0.932	0.085
141	19,085	79.25	1286	1.087	0.130
142	24,827	83.73	980	1.232	0.207
143	14,813	86.40	503	1.382	0.467
144	6,050	87.49	347	1.063	0.288
145	7,532	88.85	494	1.180	0.340
146	8,962	90.46	486	0.718	0.155
147	6,446	91.62	422	1.874	0.927
148	7,895	93.04	216	0.710	0.298
149	4,723	93.90	157	1.089	0.808
150	3,602	94.54	179	0.453	0.145
151	5,012	95.45	216	NA	NA
152	6,527	96.62	136	NA	NA
153	2,521	97.08	65	0.446	0.244
154	2,987	97.62	16	NA	NA
155	889	97.78	84	NA	NA
156	1,464	98.04	37	NA	NA
157	1,110	98.24	103	NA	NA
158	1,875	98.58	126	NA	NA
159	2,059	98.95	47	NA	NA
160	820	99.10	27	NA	NA
161	390	99.17	20	NA	NA
162	451	99.25	17	NA	NA
163	914	99.41	23	NA	NA
164	675	99.54	22	0.136	0.073
165	541	99.63	11	NA	NA
166	249	99.68	7	NA	NA
167	268	99.73	13	NA	NA
168	251	99.77	7	NA	NA
169	36	99.78	4	NA	NA
170	43	99.79	2	NA	NA

A 6.6 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
171	61	99.80	3	NA	NA
172	176	99.83	11	0.545	0.343
173	138	99.85	2	NA	NA
174	46	99.86	2	0.500	0.354
175	18	99.86	1	NA	NA
176	39	99.87	2	NA	NA
177	43	99.88	5	NA	NA
178	42	99.89	1	NA	NA
179	13	99.89	0	NA	NA
180	8	99.89	3	1.000	0.000
181	28	99.90	5	NA	NA
182	57	99.91	6	NA	NA
183	44	99.91	6	NA	NA
184	15	99.92	10	NA	NA
185	57	99.93	7	0.429	0.187
186	27	99.93	4	NA	NA
187	35	99.94	1	NA	NA
188	11	99.94	1	NA	NA
189	54	99.95	5	0.600	0.219
190	41	99.96	3	0.667	0.272
191	26	99.96	6	NA	NA
192	18	99.97	5	0.800	0.424
193	2	99.97	2	NA	NA
194	18	99.97	5	NA	NA
195	22	99.97	5	0.400	0.219
196	16	99.98	5	NA	NA
197	14	99.98	1	NA	NA
198	18	99.98	5	NA	NA
199	6	99.98	2	NA	NA
200	6	99.98	2	NA	NA
201	6	99.98	2	NA	NA
202	2	99.99	0	NA	NA
203	12	99.99	1	NA	NA
204	6	99.99	0	NA	NA
205	8	99.99	0	NA	NA
206	10	99.99	1	NA	NA

A 6.6 (cont.)

Day of Year	API	CPR	n	S_S	SE(S_S)
207	6	99.99	0	NA	NA
208	0	99.99	1	NA	NA
209	6	99.99	0	NA	NA
210	4	99.99	0	NA	NA
211	4	100.00	1	NA	NA
212	2	100.00	1	NA	NA
213	1	100.00	0	NA	NA
214	0	100.00	1	NA	NA
215	2	100.00	0	NA	NA
216	0	100.00	0	NA	NA
217	1	100.00	0	NA	NA
218	0	100.00	0	NA	NA
219	1	100.00	0	NA	NA
220	2	100.00	0	NA	NA
221	3	100.00	0	NA	NA
222	0	100.00	0	NA	NA
223	0	100.00	0	NA	NA
224	3	100.00	0	NA	NA
225	1	100.00	0	NA	NA
226	1	100.00	1	NA	NA
227	1	100.00	0	NA	NA
228	0	100.00	0	NA	NA
229	0	100.00	0	NA	NA
230	0	100.00	0	NA	NA
231	1	100.00	0	NA	NA
232	1	100.00	0	NA	NA
233	1	100.00	0	NA	NA
234	0	100.00	0	NA	NA
235	1	100.00	0	NA	NA
236	0	100.00	0	NA	NA
237	0	100.00	0	NA	NA
238	0	100.00	0	NA	NA
239	0	100.00	0	NA	NA
241	0	100.00	1	NA	NA
242	1	100.00	0	NA	NA
243	0	100.00	1	NA	NA