Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 2003:

Final Adult Returns for Wild Yearling Chinook Salmon Migrating in 2000

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EXECUTIVE SUMMARY

Since 1995, the National Marine Fisheries Service has evaluated transportation of Snake River spring/summer chinook salmon smolts. Beginning in 2002, spring chinook salmon transportation was also evaluated from McNary Dam using fish PIT-tagged at upper Columbia River hatcheries.

From March to August 2003, we recovered age-3-ocean spring/summer chinook salmon adults from smolts tagged in 2000, completing adult returns from that study year. In 2000, we tagged only wild fish and released them into the Lower Granite Dam tailrace. For analysis, the transport group included only fish collected and transported from Little Goose Dam and the "inriver" comparison group excluded any fish detected at Little Goose and Lower Monumental Dams. In 2003 we detected 133 wild age-3-ocean transported fish and 222 wild age-3-ocean inriver migrant fish from the 2000 tagging at Lower Granite Dam. Based on all 2000 returns combined (jacks through age-3-ocean fish), the smolt-to-adult return rates (SAR) of transported and inriver fish were 1.47 and 1.44, respectively, resulting in a transport-to-inriver ratio (T/I) of 1.0 (95% confidence interval 0.9, 1.1). As in previous years, SARs were variable over the course of the juvenile migration, but did not follow the pattern seen previously. The overall differential delayed mortality, 'D' value, was 0.48.

Nearly 83% of adults from both transported and inriver groups that were detected at Bonneville Dam migrated successfully to Lower Granite Dam (not adjusted for any take in the Zone 6 fishery). Travel time from Bonneville Dam to Lower Granite Dam was approximately 14 d for both transported and inriver age-2-ocean fish, while age-3-ocean fish were a little slower, averaging approximately 17 d for both transported and inriver fish.

CONTENTS

INTRODUCTION

In 2003, we continued studies to evaluate transportation of juvenile fish to below Snake and Columbia River dams as a means to mitigate for downstream losses that result from the lower Snake and Columbia River hydropower system. The primary objective of our studies is to compare adult returns of chinook salmon and steelhead PIT-tagged as smolts and transported to a release site below Bonneville Dam to those of their cohorts allowed to migrate inriver under optimal conditions for inriver survival. Detections from PIT-tagged smolts released to migrate inriver will also provide data for short-term survival estimates between the point of release and Bonneville Dam tailrace (Iwamoto et al. 1994, Smith et al. 1999).

Here we report adult returns in 2003 and final results from the 2000 spring/summer chinook salmon tagging year at Lower Granite Dam. Information is also provided on the 2003 juvenile transportation study tagging effort (Appendix B) and previous complete returns (1995-99) and incomplete adult returns (2001 to 2003) (Appendix C).

In 1995, 1996, 1998, and 1999, we PIT tagged yearling chinook salmon smolts at Lower Granite Dam to compare adult returns of marked smolts transported to below Bonneville Dam versus those of smolts released to the tailrace of Lower Granite Dam to migrate in the river. Inriver-migrating smolts collected at downstream dams were returned to the river to continue their migration.

Based on adult returns from those years (and from fish PIT tagged in the same years upstream of Lower Granite Dam) we found that smolts bypassed and returned to the river at downstream dams survived to adulthood at lower, rather than higher, rates than those bypassed only at Lower Granite Dam. Further, fish not detected at dams (those fish either spilled, passed through turbines, or not detected through the juvenile fish facilities) returned at higher rates than fish bypassed at downstream collector dams.

Thus, in hindsight, the study designs from 1995 through 1999 did not provide sufficient information to compare the returns of non-detected and non-transported fish to those of fish that were transported. For the 2000 transportation studies we altered the experimental design to provide better comparison between these groups. Here, we report the results of analyses based on complete returns of fish marked in 2000.

METHODS

Sampling and Tagging of Juveniles

As in past years, we collected and PIT tagged wild Snake River spring/summer chinook salmon at Lower Granite Dam. However, in 2000, instead of transporting fish from Lower Granite Dam, all tagged fish were released into the Lower Granite Dam tailrace and allowed to migrate down river. To create the transport study group, we set the separation-by-code PIT-tag diversion system at Little Goose Dam to divert 80% of the fish collected at the juvenile fish facility to transportation. The remaining 20% of bypassed fish were used to help develop survival estimates necessary to estimate differential delayed mortality ('D') of transported fish. The inriver group was composed of fish not detected at either Little Goose or Lower Monumental Dam, consistent with the general unmarked population of fish that migrated through the Snake River without being collected at a Snake River collector dam.

We calculated the number of fish needed for marking to test a null hypothesis that there is no difference between the SARs of transported and inriver migrant fish, versus the alternative hypothesis that the ratio was 1.4 or greater. For a given type I error rate ($t_{\alpha/2}$, rejection of a true null hypothesis) and type II error rate (t_{β}, acceptance of a false null hypothesis), the number of fish needed for tagging was determined as

$$\ln\left(\frac{T}{I}\right)-\left(t_{\frac{\alpha}{2}}+t_{\beta}\right)\times SE\left(\ln\left(\frac{T}{I}\right)\right)\approx 0 \qquad (1)$$

and

$$SE(\ln\frac{T}{I})=\sqrt{\left(\frac{1}{n_T}+\frac{1}{n_I}\right)}=\sqrt{\frac{2}{n}} \qquad (2)$$

where n is the number of adult returns per treatment (for either n_T transport or n_I inriver groups). The previous two statements imply that the sample of adults needed is:

$$n=\frac{2\left(t_{\frac{\alpha}{2}}+t_{\beta}\right)^2}{\left(\ln\left(\frac{T}{I}\right)\right)^2} \qquad (3)$$

Therefore, if $\alpha = 0.05$ and $\beta = 0.20$, and if we wish to discern difference of 40% (T/I = 1.4), and we expect a transport SAR of at least 2.1% for each species, the sample sizes needed at Lower Granite Dam were:

$$n = 142$$
$$N_T = 6{,}800$$
$$N_I = 9{,}520$$
$$\text{Total juveniles} = 16{,}320$$

Where N_T is the number of juveniles needed for the transport cohort and N_I is the number of fish needed for the inriver cohort (6,800 × 1.4).

In 1995, 29.7% of the yearling chinook salmon smolts that we released into the Lower Granite Dam tailrace were never again detected. In 2000, we conservatively estimated that at least 20% of the wild yearling chinook salmon smolts released into the Lower Granite Dam tailrace would not be detected thereafter. Therefore, to provide the 9,520 fish for the non-detected group would require a release of approximately 47,600 fish (9,520/0.2) into the Lower Granite Dam tailrace. This number also provided sufficient smolts for collection at Little Goose Dam to form a transport test group. For example, assuming an approximate 40% collection efficiency at Little Goose Dam, 19,400 (47,600 × 0.4) wild yearling chinook salmon smolts would be collected for transport at that dam.

Throughout the entire juvenile migration season, we PIT tagged a relatively constant proportion of the fish collected at Lower Granite Dam. Marked fish were held an average of 24 h before release into the Lower Granite Dam tailrace, and releases were made in the early morning.

Basic collection and handling followed the methodology described by Marsh et al. (1996, 2001). We continued using the recirculating anesthetic water system described in Marsh et al. (2001).

Inriver Migration

Marsh et al. (1996) provided details on how inriver study fish were tracked as they passed through the collection systems at dams downstream from Lower Granite Dam during this study. Prior to 11 July 2003, McNary Dam was in bypass mode, all tagged and untagged fish collected (except tagged fish from our Columbia River hatchery study) were bypassed to the river after passing through PIT-tag detectors, thus, we included these fish in the study. After this date, all non-tagged fish collected at the dam were transported, so we did not include any bypassed fish in the study. At Little Goose and Lower Monumental Dams, fish detected on coils leading to the raceways were assumed to have been transported, while fish detected on diversion system coils were assumed to have been returned to the river.

Adult Recoveries and Data Analysis

In 2003, we completed the recovery of adults tagged as juveniles in 2000. The procedures for data analysis described by Marsh et al. (1996) were modified as described by Sandford and Smith (2002) to determine the number of juvenile fish in the transport and inriver groups. A synopsis of the method of Sandford and Smith (2002) as applied here is available in Appendix D.

To calculate 95% CIs for various T/Is, release days were pooled until a minimum of two adults returned in both transport and in-river categories. Empirical variance estimates were calculated using these temporal replicates. Daily (or multiple-day pooled) facility collection numbers were used to weight the replicates to provide weighted seasonal T/Is applicable to the untagged population. The weighted mean T/Is and CIs were then constructed on the natural logarithm scale (i.e., such ratio data were assumed to be log-normally distributed) and back-transformed.

RESULTS

Sampling and Tagging of Juveniles

We PIT tagged fish from 30 March through 23 June 2000. During this period, we tagged 59,333 wild yearling spring/summer chinook salmon (Table 1 and Appendix Table A1), or 2.6% of the wild yearling spring/summer chinook salmon collected at Lower Granite Dam in 2000. The number of fish tagged daily ranged from 0 to 3,973. Of the 59,333 wild yearling spring/summer chinook salmon tagged, 58,811 were released into the Lower Granite Dam tailrace.

Based on mortality counts from the recovery holding tank for inriver migrants, post-marking delayed mortality (24-hour) averaged 0.8% for spring/summer chinook salmon over the entire tagging season. We tagged virtually every fish sampled, rejecting only a few fish that were either severely injured or exhibited gross symptoms of bacterial kidney disease. By tracking the unique PIT-tag code of each mortality, we determined the body condition recorded when the live fish was tagged.

As in past years (Marsh et al. 1996, 1997, 2000), descaling appeared to impact post-marking delayed mortality for spring/summer chinook salmon. When tagged, 0.6% of all fish were recorded as descaled; however, of the delayed mortalities, 12.6% had been among those recorded as descaled during tagging.

We recorded fork lengths of all fish during tagging. To avoid tagging spring/summer chinook salmon of hatchery origin that had partial or no fin clips (identifying them as hatchery fish), we set the maximum fork length for a fish to be considered wild at 124 mm. Based on previous analyses of known wild fish collected and measured during their juvenile migration (Marsh et al. 2001), this limited the number of hatchery fish marked while keeping to a minimum the number of wild fish inadvertently excluded. Over the course of the season, only 80 spring/summer chinook salmon smolts greater than 124 mm were tagged (less than 0.02% of the smolts handled).

Table 1. Numbers and mean fork length of wild spring/summer chinook salmon smolts PIT-tagged and released to migrate inriver, Lower Granite Dam, 2000.

	Spring/summer chinook salmon	
	Number	Mean fork length (mm)
Tagged	59,333	110.3
Released	58,811	110.3

Inriver Migration

As inriver study fish continued their seaward migration, some were detected at dams downstream from Lower Granite Dam. Of 58,811 wild yearling spring/summer chinook salmon released, 34,362 (58.4%) were detected at least once at a downstream collector dam. Final dispositions for the 58,811 fish released were as follows: 15,521 were transported from Little Goose Dam (Table 2 and Appendix Tables A2-A5), 24,449 were never detected at a Snake River collector dam downstream from Lower Granite Dam, and 18,841 were detected at one or more Snake River collector dam. This migration history data was analyzed using the methods of Sandford and Smith (2002), which resulted in estimates of 17,367 and 26,329 juvenile fish in the 2000 transport and inriver groups, respectively. All SAR calculations were based on these numbers.

At Little Goose Dam, our initial goal was to transport 80% of the spring/summer chinook salmon and steelhead collected. However, because of technology limitations, only 72.3% of the spring/summer chinook salmon detected were transported from the dam during the smolt migration. In 2000, no spring/summer chinook salmon from the untagged population were returned to the river from the raceways at Little Goose and Lower Monumental Dams.

Based upon PIT-tag detections at John Day and Bonneville Dams and on estuary detections in the pair-trawl system, we made preliminary estimates of survival from the Lower Granite Dam tailrace to the McNary Dam and Bonneville Dam tailraces. For wild spring/summer chinook salmon smolts, we estimated survivals of 76.6 and 47.7% over the two respective reaches.

Table 2. Final disposition of PIT-tagged spring/summer chinook salmon smolts released at Lower Granite Dam in spring 2000 and subsequently detected at Little Goose Dam.

Final disposition*	Number of smolts Little Goose Dam
River	5,590
Bypassed	0
Sample	313
Transported	15,521
Unknown	39
Totals	
Observed	21,463
Transport group	15,521
Removed from study	5,942

* Definitions:

Disposition	Last coil observation	Special circumstances	Ultimate destination	Study status
River	Diversion or river return		River	Removed
Bypassed	Raceway	Raceway emptied to river	River	Removed
Sample	Sample		Unknown	Removed
Transported	Raceway		Barge/Truck	**Retained**
Unknown	Separator		Unknown	Removed

Adult Recoveries and Data Analysis

At Lower Granite Dam, we began recovering jacks in 2001 and finished with age-3-ocean adults in August 2003. Returns by study group and age-class are shown below, with juvenile numbers adjusted as described by Sandford and Smith (2002).

	Juvenile numbers	Returns by Age-class Jack	2-ocean	3-ocean	SAR	T/I	95% C.I.
Transport	17,367	8	114	133	1.47	1	(0.9, 1.1)
Inriver	26,329	8	149	222	1.44		

The percentage of wild age-3-ocean adults in 2003 (from our tagging) was the highest we have observed since we started transport studies in 1995.

Study year	Jack (%)	2-ocean (%)	3-ocean (%)	Total adults
1995	0.0194	0.6323	0.3484	55
1996	0.0625	0.625	0.3125	16
1998	0.069	0.7011	0.2299	87
1999	0.0427	0.811	0.1463	328
2000	0.0383	0.4037	0.558	832

This study year represents the first time we have seen wild age-3-ocean adult returns approach historic levels (Matthews and Waples 1991).

As in previous years, temporal differences were seen in the SARs of both transported and inriver fish, although the differences were much less (Figure 1). The large differences in SARs prior to 14 April were likely more a result of low numbers of juveniles released than an indicator of the effect of the treatments. As in previous years, we observed a decrease in the transport SAR just before its sharpest rise, which began around 6 May. The inriver SAR rose at the same time, although not as high, and the inriver SAR dropped off more quickly than the transport SAR.

The differential delayed mortality (D) also showed seasonal variation (Figure 2), as would be expected given the temporal changes in both transport and inriver SARs. The overall 'D' value for 2000 was 0.48, but varied from 0.37 to 0.92, generally increasing (approaching 1.0) as the juvenile migration progressed. The overall

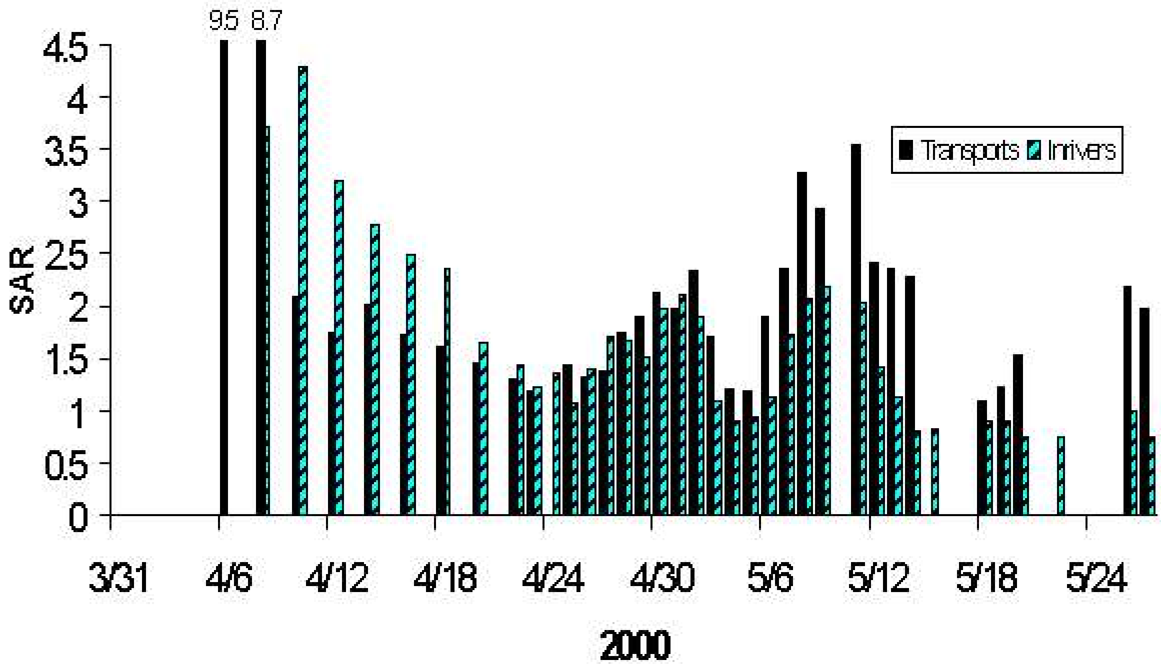

Figure 1. Smolt-to-adult return rates by release date for transported and inriver migrant spring/summer chinook salmon smolts tagged at Lower Granite Dam in 2000. Data presented as 3-day running averages of daily releases and juvenile release numbers adjusted proportionally to daily collection numbers. The percentages shown above the first two "Transport" bars are the SARs for those two bars. Overall transport/inriver ratio was 1.0.

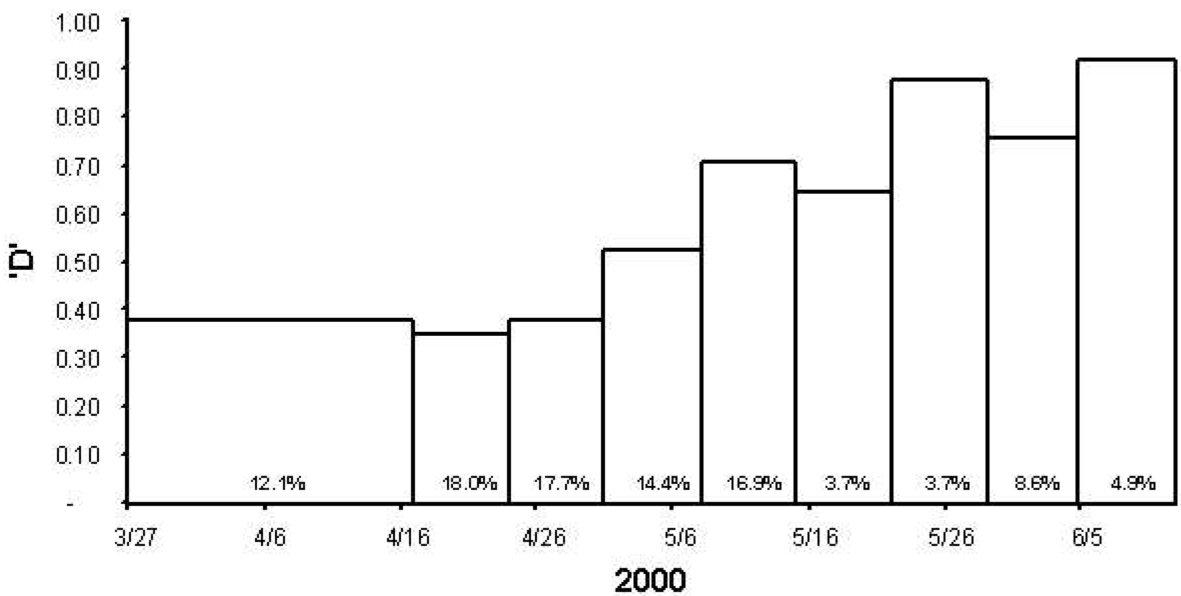

Figure 2. Estimates of differential delayed mortality (D) over time for spring/summer chinook salmon smolts tagged at Lower Granite Dam in 2000. Grouping is based on having adequate numbers of smolts to estimate inriver survival between Lower Granite and McNary Dams and between McNary and Bonneville Dams. Percentages shown are proportions of the juvenile migration represented by each bar. Overall 'D' of the tagged fish for the year was 0.48. The last bar at right includes data through 20 June.

differential delayed mortality (D) for the general population of spring/summer chinook salmon was 0.54. The difference between the study and the general population 'D' was due to more fish in the later groups (Figure 3), which had higher 'D' values.

The number of returning adults observed at Bonneville Dam and subsequently observed at Lower Granite Dam (the conversion rate) was virtually identical for inriver and transport groups (Table 3). During each return year from the 2000 juvenile migration, more dams were being equipped with PIT tag detection systems for adults. When the jacks from 2000 returned in 2001, only Bonneville and Lower Granite Dams were equipped with adult detection systems. McNary Dam was equipped in 2002, when the age-2-ocean adults returned, and by 2003, Ice Harbor, Priest Rapids, Rock Island, and Wells Dams had each been equipped with adult detection systems.

Travel times from Bonneville to Lower Granite Dam ranged from 10.5-17.5 d (Table 4). Travel times increased with each age class, but were similar between treatment groups. In 2003, with the addition of detection capabilities at dams on the Columbia River above the confluence with the Snake River, we could have observed any straying that might have occurred; however, none was observed. For both age-2-ocean and age-3-ocean adults, travel time between Bonneville and McNary Dam was over 1 day longer than the travel time between McNary and Lower Granite Dam.

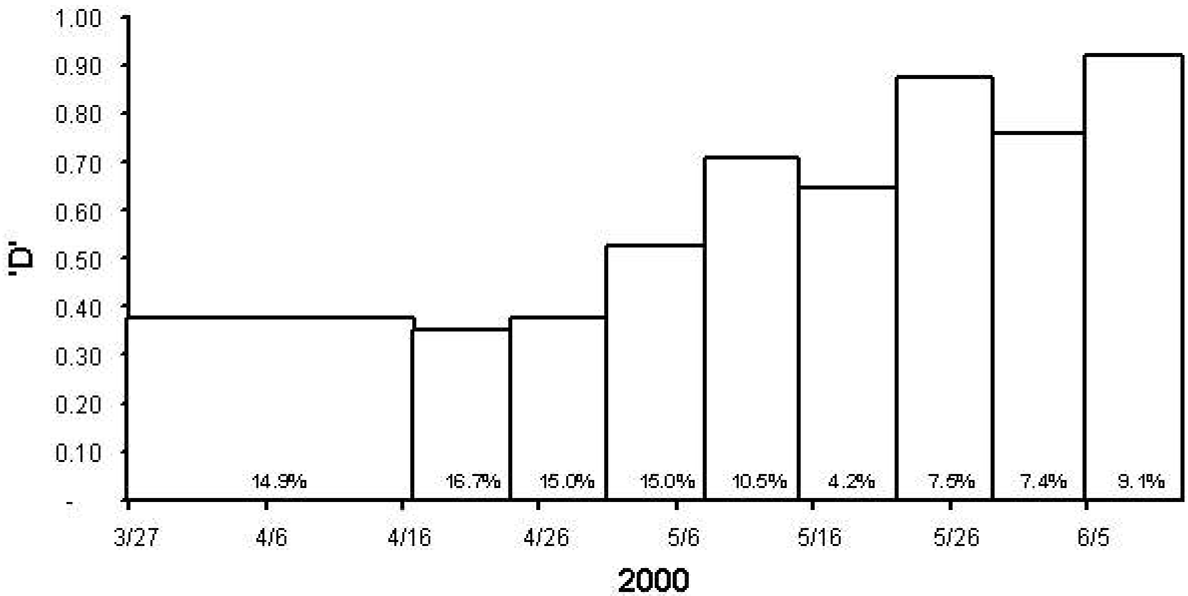

Figure 3. Estimates of differential delayed mortality (D) over time for the general population of spring/summer chinook salmon smolts in 2000, based on the fish tagged at Lower Granite Dam. Grouping is based on having adequate numbers of transport study smolts to estimate inriver survival between Lower Granite and McNary Dams and between McNary and Bonneville Dams. Overall 'D' of the general population for the year was 0.54. The last bar at right includes data through 20 June.

Table 3. Percentage of adult spring/summer chinook salmon PIT tagged in 2000 that were observed at Bonneville Dam and subsequently detected at Lower Granite Dam (the conversion rate).

Age class		Seen at Bonneville Dam	Seen at Lower Granite Dam	Conversion rate
Jacks	Inriver	7	7	100.00
	Transport	4	4	100.00
Age-2-ocean	Inriver	176	151	85.80
	Transport	136	113	83.09
Age-3-ocean	Inriver	272	219	80.51
	Transport	159	131	82.39
Totals	Inriver	455	377	82.86
	Transport	299	248	82.94

Table 4. Travel times from Bonneville Dam to Lower Granite Dam for adult spring/summer chinook salmon PIT tagged as juveniles in 2000.

Age class		Travel time from Bonneville Dam to Lower Granite Dam (days)
Jacks	Inriver	10.5
	Transport	10.5
Age-2-ocean	Inriver	14.4
	Transport	14.4
Age-3-ocean	Inriver	17.5
	Transport	16.8

DISCUSSION

It is of utmost importance that we continue to gather as much data as possible on the relationship between salmon populations and the FCRPS during this period of high post-Bonneville-Dam survival. The inriver and transport SARs for spring/summer chinook salmon began to increase in the late 1990s and for some hatcheries have reached levels reported by Raymond (1988) during the late 1960s, early 1970s, and mid-1980s. These higher return rates have provided us with large numbers of returning adults, which lead to smaller standard errors than originally presumed for our SAR estimates. The large number of returning adults also presents us with opportunities to examine other potentially important trends in the data.

For most transport studies conducted on spring/summer chinook salmon smolts since 1995, annual T/Is, while indicating a transport benefit, were lower than expected when compared to concurrent estimates of inriver survival (Marsh et al. 2000, 2001; Muir et al. 2001). In contrast to all previous studies, contemporary study designs and the use of PIT tags allow for a more refined analysis of SARs and T/Is than a simple calculation of an annual average.

Calculating the statistics for groups of fish by the period when they were marked as smolts revealed an interesting time trend in the data. Recent annual T/Is have been lower than expected, primarily because transport SARs were much lower for smolts tagged earlier than later in the migration season. The timing of the rather abrupt increases in transport SARs has been inconsistent among study years, and until this year, the timing has moved progressively earlier in the season.

In 1995, the increase did not occur until about 5 May (Marsh et al. 2000), while in 1998 and 1999 the increases occurred about 1 and 2 weeks earlier during the respective years. Transport benefits then were equivocal early in the seasons and at roughly expected levels later in the seasons. As a result, when averaged over the entire juvenile migration season, overall T/Is were lower than expected. The timing of the transition during the 2000 juvenile migration was similar to 1995, the first week of May; however, the increase was not as dramatic as seen in previous years.

The within-year dichotomies in the results of these studies were peculiar and unexpected. To the best of our knowledge, the rather abrupt within-year increases in transport SARs were not related to any environmental or biological factor that has been examined during the freshwater phase. For fish tagged through 1999, a rather significant, post-release phenomenon appears to have affected the survival of transported fish during most of April and then dissipated quickly. The SARs of inriver migrants PIT tagged and released in April may not have been similarly affected because the great majority of these fish would have arrived below Bonneville Dam 2-3 weeks later than the transported fish.

We have not observed any temporal differences in migrational behavior, physiology, disease, or transport methodologies that might explain the abrupt and sustained seasonal changes in SARs of transported fish. We believe the pattern relates to arrival timing of smolts in the estuary and near-ocean environments in recent years. Conditions that might vary annually in these areas include predator abundance and dynamics (birds, fish, and marine mammals), alternative prey availability for those predators (anchovies, herring, and sand lance), and abundance of prey for juvenile salmon (enhanced survival of fast-growing, robust smolts). Changes in predator/prey dynamics coincidental with the 1976/1977 oceanic regime shift (Hare et al. 1999) particularly during early ocean residence (Hargreaves 1997) likely play a major role in low annual SARs and high within- and between-year variation in SARs.

The proportions of inriver and transported adults in each age class changed, with a higher percentage of transports returning as age-2-ocean adults (44.7 vs. 39.3% of inriver migrants) and inriver migrants returning as age-3-ocean adults (58.6 vs. 52.2% of transported fish). We have not previously observed similar differences. Based on analyses of the 2000 juvenile migration data, the probability of detection, and therefore transportation, of wild fish at Little Goose Dam was biased toward smaller fish (Rich Zabel, NMFS, personal communication). We are working on analyses to determine if this led toward differential returns by age.

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APPENDIX A

Juvenile Data from the 2000 Spring/Summer Chinook Salmon Tagging Year

Appendix Table A1. Total wild spring/summer chinook salmon tagged at Lower Granite Dam in spring 2000.

Tag date	Tagged	Released	Post-tagging mortality	Lost tags
30-Mar	0	0	0	0
31-Mar	0	0	0	0
1-Apr	2	2	0	0
3-Apr	1	1	0	0
4-Apr	2	2	0	0
5-Apr	5	5	0	0
6-Apr	17	16	1	0
7-Apr	50	48	2	0
8-Apr	30	29	1	0
9-Apr	28	28	0	0
10-Apr	51	49	1	0
11-Apr	127	126	1	0
12-Apr	769	764	1	4
13-Apr	696	690	4	2
14-Apr	2,304	2,291	12	1
15-Apr	3,971	3,957	10	4
16-Apr	3,27	3,251	19	0
17-Apr	1,792	1,782	10	0
18-Apr	1,132	1,128	4	0
19-Apr	556	552	4	0
20-Apr	1,363	1,357	6	0
21-Apr	2,087	2,07	13	4
22-Apr	2,28	2,271	2	7
24-Apr	1,274	1,261	11	2
25-Apr	877	873	4	0
26-Apr	2,317	2,304	12	1
27-Apr	2,178	2,158	18	2
28-Apr	1,662	1,646	13	3
29-Apr	2,418	2,403	12	3
30-Apr	1,261	1,246	13	2
1-May	2,32	2,309	7	4
2-May	1,111	1,101	9	1
3-May	634	630	4	0
4-May	1,227	1,213	14	0

Appendix Table A1. Continued.

Tag date	Tagged	Released	Post-tagging mortality	Lost tags
5-May	739	736	3	0
6-May	623	608	14	1
7-May	692	677	14	1
8-May	869	856	13	0
9-May	1,064	1,057	6	1
10-May	1,579	1,567	10	2
11-May	1,762	1,735	25	2
12-May	1,295	1,264	30	1
13-May	1,41	1,395	15	0
15-May	895	874	21	0
16-May	273	270	3	0
17-May	289	285	4	0
18-May	307	302	5	0
19-May	321	310	11	0
22-May	401	398	3	0
23-May	313	311	2	0
24-May	257	249	8	0
25-May	405	393	12	0
26-May	753	728	24	1
30-May	718	706	12	0
31-May	1,151	1,142	9	0
1-Jun	1,296	1,295	0	1
2-Jun	1,462	1,446	16	0
5-Jun	185	185	0	0
6-Jun	328	328	0	0
7-Jun	1,014	1,011	2	1
8-Jun	148	148	0	0
9-Jun	261	261	0	0
12-Jun	122	122	0	0
13-Jun	56	56	0	0
14-Jun	196	196	0	0
15-Jun	179	179	0	0
16-Jun	65	65	0	0
19-Jun	93	93	0	0

Appendix Table A2. Observations (detections) and transportation numbers at Little Goose Dam of spring/summer chinook salmon released into the Lower Granite Dam tailrace, 2000.

Tag group	Total observed	Number transported	Percent transported
DMM00090.CS1	--	--	--
DMM00091.CS1	--	--	--
DMM00092.CS1	1	0	0
DMM00094.CS1	1	1	100.0
DMM00095.CS1	--	--	--
DMM00096.CS1	3	3	100.0
DMM00097.CS1	10	7	70.0
DMM00098.CS1	34	30	88.2
DMM00099.CH1	21	17	81.0
DMM00099.SH1	--	--	--
DMM00100.CH1	17	14	82.4
DMM00100.SH1	--	--	--
DMM00101.CH1	24	17	70.8
DMM00101.SH1	--	--	--
DMM00101.SH2	--	--	--
DMM00102.CH1	84	64	76.2
DMM00102.SH1	--	--	--
DMM00102.SH2	--	--	--
DMM00103.CH1	355	269	75.8
DMM00103.CH2	74	54	73.0
DMM00103.SH1	--	--	--
DMM00103.SH2	--	--	--
DMM00104.CH1	249	188	75.5
DMM00104.CH2	109	80	73.4
DMM00104.SH1	--	--	--
DMM00104.SH2	--	--	--
DMM00105.CH1	851	629	73.9
DMM00105.CH2	444	331	74.5
DMM00105.SH1	--	--	--
DMM00105.SH2	--	--	--

Appendix Table A2. Continued.

Tag group	Total observed	Number transported	Percent transported
DMM00106.CH1	970	708	73.0
DMM00106.CH2	951	685	72.0
DMM00106.CH1	970	708	73.0
DMM00106.CH2	951	685	72.0
DMM00106.SH1	42	28	66.7
DMM00106.SH2	9	7	77.8
DMM00107.CH1	726	491	67.6
DMM00107.CH2	453	306	67.5
DMM00107.SH1	--	--	--
DMM00107.SH2	--	--	--
DMM00108.CH1	485	327	67.4
DMM00108.CH2	151	91	60.3
DMM00108.SH1	--	--	--
DMM00108.SH2	--	--	--
DMM00109.CH1	367	268	73.0
DMM00109.CH2	63	48	76.2
DMM00109.SH1	--	--	--
DMM00109.SH2	--	--	--
DMM00110.CH1	257	174	67.7
DMM00110.SH1	--	--	--
DMM00110.SH2	--	--	--
DMM00111.CH1	712	485	68.1
DMM00111.CH2	19	12	63.2
DMM00111.SH1	--	--	--
DMM00111.SH2	--	--	--
DMM00111.SH3	--	--	--
DMM00112.CH1	942	657	69.7
DMM00112.CH2	194	151	77.8
DMM00112.SH1	--	--	--
DMM00112.SH2	--	--	--
DMM00113.CH1	1,050	771	73.4
DMM00113.CH2	278	204	73.4
DMM00113.SH1	--	--	--

Appendix Table A2. Continued.

Tag group	Total observed	Number transported	Percent transported
DMM00113.SH2	--	--	--
DMM00115.CH1	396	301	76.0
DMM00115.CH2	246	186	75.6
DMM00115.SH1	--	--	--
DMM00116.CH1	403	300	74.4
DMM00115.CH1	396	301	76.0
DMM00115.CH2	246	186	75.6
DMM00115.SH1	--	--	--
DMM00116.CH1	403	300	74.4
DMM00116.SH1	--	--	--
DMM00117.CH1	766	541	70.6
DMM00117.CH2	266	184	69.2
DMM00117.SH1	--	--	--
DMM00118.CH1	658	449	68.2
DMM00118.CH2	267	186	69.7
DMM00118.SH1	--	--	--
DMM00119.CH1	581	424	73.0
DMM00119.CH2	113	79	69.9
DMM00119.SH1	--	--	--
DMM00120.CH1	589	415	70.5
DMM00120.CH2	306	220	71.9
DMM00120.SH1	--	--	--
DMM00121.CH1	420	286	68.1
DMM00121.CH2	12	10	83.3
DMM00121.SH1	--	--	--
DMM00122.CH1	424	316	74.5
DMM00122.CH2	132	102	77.3
DMM00122.SH1	--	--	--
DMM00123.CH1	244	178	73.0
DMM00123.SH1	--	--	--
DMM00124.CH1	128	94	73.4
DMM00124.SH1	--	--	--
DMM00125.CH1	258	201	77.9

Appendix Table A2. Continued.

Tag group	Total observed	Number transported	Percent transported
DMM00125.SH1	--	--	--
DMM00126.CH1	217	160	73.7
DMM00126.SH1	--	--	--
DMM00127.CH1	193	141	73.1
DMM00127.SH1	--	--	--
DMM00128.CH1	215	156	72.6
DMM00128.SH1	--	--	--
DMM00129.CH1	254	182	71.7
DMM00129.SH1	--	--	--
DMM00130.CH1	215	159	74.0
DMM00130.SH1	--	--	--
DMM00131.CH1	274	187	68.2
DMM00131.SH1	--	--	--
DMM00132.CH1	313	243	77.6
DMM00132.SH1	--	--	--
DMM00133.CH1	189	146	77.2
DMM00133.SH1	--	--	--
DMM00134.CH1	188	148	78.7
DMM00134.CH2	17	15	88.2
DMM00134.SH1	--	--	--
DMM00136.CH1	139	102	73.4
DMM00136.SH1	--	--	--
DMM00137.CH1	46	31	67.4
DMM00137.SH1	--	--	--
DMM00138.CH1	70	56	80.0
DMM00138.SH1	--	--	--
DMM00139.CH1	85	65	76.5
DMM00139.SH1	--	--	--
DMM00140.CH1	96	66	68.8
DMM00140.SH1	--	--	–
DMM00143.CH1	97	75	77.3
DMM00143.SH1	--	--	--
DMM00144.CH1	50	34	68.0

Appendix Table A2. Continued.

Tag group	Total observed	Number transported	Percent transported
DMM00144.SH1	--	--	--
DMM00145.CH1	74	55	74.3
DMM00145.SH1	--	--	--
DMM00146.CH1	102	76	74.5
DMM00146.SH1	--	--	--
DMM00147.CH1	246	183	74.4
DMM00147.SH1	--	--	--
DMM00151.CH1	128	97	75.8
DMM00151.SH1	--	--	--
DMM00152.CH1	263	193	73.4
DMM00152.SH1	30	18	60.0
DMM00153.CH1	407	282	69.3
DMM00153.SH1	70	49	70.0
DMM00154.CH1	352	279	79.3
DMM00154.SH1	174	129	74.1
DMM00157.CH1	75	60	80.0
DMM00157.SH1	--	--	--
DMM00158.CH1	110	85	77.3
DMM00158.SH1	--	--	--
DMM00159.CH1	247	189	76.5
DMM00159.SH1	14	11	78.6
DMM00160.CH1	20	16	80.0
DMM00160.SH1	--	--	--
DMM00161.CH1	45	35	77.8
DMM00161.SH1	--	--	--
DMM00164.CS1	41	27	65.9
DMM00165.CH1	20	11	55.0
DMM00166.CH1	82	57	69.5
DMM00166.SH1	--	--	--
DMM00167.CS1	70	53	75.7
DMM00168.CS1	16	12	75.0
DMM00171.CS1	50	37	74.0
	21,449	15,509	72.3

Appendix Table A3. Locations of observations (detections) of PIT-tagged spring/summer chinook salmon within the Little Goose Dam juvenile fish facility (GOJ), 2000.

Detection date at GOJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
07-Apr-00	-	-	-	-	-	-	1
10-Apr-00	-	-	-	-	-	1	-
11-Apr-00	-	-	-	-	-	1	-
13-Apr-00	-	-	-	-	2	2	-
14-Apr-00	-	-	-	-	2	18	-
15-Apr-00	-	-	-	-	22	93	1
16-Apr-00	-	-	-	-	46	176	6
17-Apr-00	-	-	-	-	91	291	5
18-Apr-00	-	-	-	1	138	426	5
19-Apr-00	1	2	-	2	149	519	3
20-Apr-00	-	-	-	1	187	644	12
21-Apr-00	12	-	-	1	446	803	7
22-Apr-00	2	1	-	4	221	571	8
23-Apr-00	10	-	-	2	280	642	10
24-Apr-00	11	2	-	-	352	787	15
25-Apr-00	5	1	-	4	275	794	13
26-Apr-00	-	1	-	1	154	552	8
27-Apr-00	-	-	-	-	82	264	4
28-Apr-00	2	1	-	1	153	348	-
29-Apr-00	-	1	-	-	121	410	6
30-Apr-00	6	-	-	1	168	395	6
01-May-00	2	1	-	-	334	734	4
02-May-00	-	-	-	-	171	540	3
03-May-00	1	3	-	3	386	945	11
04-May-00	3	1	-	1	164	440	5
05-May-00	-	1	-	1	148	392	5
06-May-00	1	1	-	1	94	233	2
07-May-00	-	-	-	1	45	161	-
08-May-00	-	-	-	-	35	131	1
09-May-00	-	-	-	-	57	200	-
10-May-00	-	-	-	-	53	192	2

Appendix Table A3. Continued.

Detection date at GOJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
11-May-00	2	-	-	-	78	191	3
12-May-00	-	-	-	1	75	150	2
13-May-00	-	1	-	1	54	150	1
14-May-00	2	-	-	-	47	144	-
15-May-00	1	-	-	-	50	163	1
16-May-00	-	-	-	2	40	148	3
17-May-00	-	1	-	-	36	103	3
18-May-00	-	-	-	1	19	83	-
19-May-00	-	-	-	-	28	102	4
20-May-00	-	-	-	-	19	67	3
21-May-00	-	-	-	1	28	100	7
22-May-00	-	-	1	-	24	116	4
23-May-00	-	-	-	1	27	83	6
24-May-00	-	-	-	-	24	74	3
25-May-00	-	-	-	-	15	44	-
26-May-00	-	-	-	-	20	69	3
27-May-00	-	-	-	-	20	54	2
28-May-00	-	-	-	-	21	69	4
29-May-00	-	-	-	1	24	82	1
30-May-00	-	-	-	-	32	114	4
31-May-00	-	-	-	-	13	40	1
01-Jun-00	-	-	-	-	2	5	1
02-Jun-00	-	-	-	-	1	7	1
03-Jun-00	-	-	-	-	8	31	5
04-Jun-00	-	-	-	-	11	48	4
05-Jun-00	-	-	-	-	13	45	3
06-Jun-00	-	-	-	1	18	68	11
07-Jun-00	-	1	-	-	21	82	10
08-Jun-00	-	-	-	-	51	135	9
09-Jun-00	-	-	-	2	95	330	15
10-Jun-00	-	-	-	1	98	351	13
11-Jun-00	-	-	-	1	24	101	1
12-Jun-00	-	-	-	-	6	22	-

Appendix Table A3. Continued.

Detection date at GOJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
13-Jun-00	-	-	-	-	13	53	3
14-Jun-00	-	-	-	-	2	9	-
15-Jun-00	-	-	-	-	1	4	1
16-Jun-00	-	-	-	-	5	13	4
17-Jun-00	-	-	-	-	2	9	1
18-Jun-00	-	-	-	1	1	4	4
19-Jun-00	-	-	-	-	6	18	4
20-Jun-00	-	-	-	-	16	60	5
21-Jun-00	-	-	-	-	3	18	2
22-Jun-00	-	-	-	-	8	28	3
23-Jun-00	-	-	-	-	5	16	1
24-Jun-00	-	-	-	-	3	14	1
25-Jun-00	-	-	-	-	1	6	2
26-Jun-00	-	-	-	-	2	8	-
27-Jun-00	-	-	-	-	2	8	-
28-Jun-00	-	-	-	-	3	11	-
29-Jun-00	-	-	-	-	2	6	-
30-Jun-00	-	-	-	-	3	11	-
01-Jul-00	-	-	-	-	4	24	-
02-Jul-00	-	-	-	-	4	21	1
03-Jul-00	-	-	-	-	3	8	-
04-Jul-00	-	-	-	-	3	14	-
05-Jul-00	-	-	-	-	1	6	-
06-Jul-00	-	-	-	-	1	2	-
07-Jul-00	-	-	-	-	1	4	-
08-Jul-00	-	-	-	-	3	10	-
09-Jul-00	-	-	-	-	1	4	-
10-Jul-00	-	-	-	-	1	5	-
11-Jul-00	-	-	-	-	2	3	-
12-Jul-00	-	-	-	-	1	8	3
13-Jul-00	-	-	-	-	2	2	-
14-Jul-00	-	-	-	-	1	5	-
15-Jul-00	-	-	-	-	-	2	1

Appendix Table A3. Continued.

Detection date at GOJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
16-Jul-00	-	-	-	-	-	3	1
17-Jul-00	-	-	-	-	1	-	-
18-Jul-00	-	-	-	-	1	1	1
19-Jul-00	-	-	-	-	-	2	1
20-Jul-00	-	-	-	-	-	2	-
21-Jul-00	-	-	-	-	1	1	-
22-Jul-00	-	-	-	-	-	2	1
24-Jul-00	-	-	-	-	1	-	-
25-Jul-00	-	-	-	-	-	1	-
03-Aug-00	-	-	-	-	1	-	-
06-Aug-00	-	-	-	-	-	-	1

Appendix Table A4. Locations of observations (detections) of PIT-tagged spring/summer chinook salmon within the Lower Monumental Dam juvenile fish facility (LMJ), 2000.

Detection date at LMJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
13-Apr-00	-	-	-	-	1	-	-
14-Apr-00	-	-	-	-	2	-	-
15-Apr-00	-	-	-	-	3	-	-
16-Apr-00	-	-	-	-	8	-	-
17-Apr-00	-	-	-	-	21	-	-
18-Apr-00	-	-	-	-	41	-	1
19-Apr-00	-	-	-	-	142	5	6
20-Apr-00	-	-	-	-	167	3	6
21-Apr-00	-	-	-	-	188	-	4
22-Apr-00	-	-	-	1	290	99	10
23-Apr-00	-	-	-	-	832	167	17
24-Apr-00	-	1	-	-	832	193	9
25-Apr-00	-	1	-	-	483	7	3
26-Apr-00	-	-	-	-	322	5	1
27-Apr-00	1	-	-	-	195	1	2
28-Apr-00	-	-	-	-	164	4	1
29-Apr-00	-	-	-	-	193	1	-
30-Apr-00	-	-	-	-	128	1	1
01-May-00	-	-	-	-	205	1	1
02-May-00	-	-	-	-	247	7	1
03-May-00	-	-	-	1	351	7	50
04-May-00	-	-	-	7	313	6	51
05-May-00	-	-	-	4	322	3	23
06-May-00	4	-	-	-	283	2	-
07-May-00	5	-	-	1	66	-	8
08-May-00	-	-	-	-	42	8	3
09-May-00	-	-	-	-	62	4	10
10-May-00	-	-	-	1	105	11	17
11-May-00	-	-	-	-	148	6	20
12-May-00	-	-	-	-	135	1	-
13-May-00	-	-	-	-	59	1	-

Appendix Table A4. Continued.

Detection date at LMJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
14-May-00	-	-	-	-	74	-	5
15-May-00	-	-	-	-	34	2	3
16-May-00	-	-	-	-	18	-	2
17-May-00	-	-	-	-	24	-	-
18-May-00	-	-	-	-	29	-	-
19-May-00	1	-	-	-	21	-	-
20-May-00	-	-	-	1	72	3	2
21-May-00	-	-	-	-	108	1	1
22-May-00	-	-	-	-	90	-	3
23-May-00	-	-	1	1	107	3	13
24-May-00	-	-	-	-	54	-	-
25-May-00	-	-	-	-	62	1	3
26-May-00	-	-	-	-	80	2	1
27-May-00	-	-	-	1	78	4	1
28-May-00	-	-	-	-	66	-	3
29-May-00	-	-	-	-	29	-	-
30-May-00	-	-	-	-	21	-	-
31-May-00	-	-	-	-	58	1	-
01-Jun-00	-	-	-	-	15	-	1
02-Jun-00	-	-	-	-	3	-	-
03-Jun-00	-	-	-	-	4	-	-
04-Jun-00	-	-	-	-	8	1	1
05-Jun-00	-	-	-	-	20	-	3
06-Jun-00	-	-	-	-	55	1	3
07-Jun-00	-	-	-	-	53	3	6
08-Jun-00	-	-	-	-	53	2	1
09-Jun-00	-	-	-	-	52	2	3
10-Jun-00	-	-	-	-	51	-	4
11-Jun-00	-	-	-	-	31	-	1
12-Jun-00	-	-	-	-	9	-	1
13-Jun-00	-	-	-	-	13	-	-
14-Jun-00	-	-	-	-	15	-	-

Appendix Table A4. Continued.

Detection date at LMJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
15-Jun-00	-	-	-	-	16	-	-
16-Jun-00	-	-	-	-	4	-	-
20-Jun-00	-	-	-	-	7	-	-
21-Jun-00	-	-	-	-	43	-	1
22-Jun-00	-	-	-	-	39	-	1
23-Jun-00	-	-	-	-	17	-	-
24-Jun-00	-	-	-	-	8	-	-
25-Jun-00	-	-	-	-	17	-	-
26-Jun-00	-	-	-	-	2	-	-
27-Jun-00	-	-	-	-	10	-	-
28-Jun-00	-	-	-	-	3	-	-
29-Jun-00	-	-	-	-	7	-	-
30-Jun-00	-	-	-	-	11	-	1
01-Jul-00	-	-	-	-	7	-	1
02-Jul-00	-	-	-	-	12	1	1
03-Jul-00	-	-	-	-	5	-	-
04-Jul-00	-	-	-	-	3	-	1
05-Jul-00	-	-	-	-	4	-	-
06-Jul-00	-	-	-	-	2	-	-
07-Jul-00	-	-	-	-	3	-	-
08-Jul-00	-	-	-	-	3	-	1
09-Jul-00	-	-	-	-	1	-	-
11-Jul-00	-	-	-	-	1	-	-
12-Jul-00	-	-	-	-	1	-	-
13-Jul-00	-	-	-	-	1	-	2
14-Jul-00	-	-	-	-	4	-	1
15-Jul-00	-	-	-	-	2	-	-
17-Jul-00	-	-	-	-	1	-	-
18-Jul-00	-	-	-	-	1	-	1
20-Jul-00	-	-	-	-	1	-	-
21-Jul-00	-	-	-	-	1	-	-
23-Jul-00	-	-	-	-	3	-	-

Appendix Table A4. Continued.

Detection date at LMJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
25-Jul-00	-	-	-	-	1	-	-
27-Jul-00	-	-	-	-	1	-	-
02-Aug-00	-	-	-	-	1	-	-
03-Aug-00	-	-	-	-	1	-	-
14-Aug-00	-	-	-	-	1	-	-
16-Aug-00	-	-	-	-	1	-	-
18-Aug-00	-	-	-	-	1	-	-
04-Sep-00	-	-	-	-	-	-	1

Appendix Table A5. Locations of observations (detections) of PIT-tagged spring/summer chinook salmon within the McNary Dam juvenile fish facility, 2000.

Detection date at MCJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
17-Apr-00	-	-	1	-	-	-	-
18-Apr-00	-	-	3	-	-	-	-
19-Apr-00	-	-	3	-	-	-	-
20-Apr-00	-	-	4	-	-	-	-
21-Apr-00	-	-	8	-	-	-	2
22-Apr-00	-	-	37	-	-	-	-
23-Apr-00	-	-	77	-	-	-	8
24-Apr-00	-	-	93	-	-	-	3
25-Apr-00	2	-	141	-	-	-	3
26-Apr-00	-	9	193	-	7	-	8
27-Apr-00	-	9	219	-	47	-	8
28-Apr-00	-	-	334	-	-	-	10
29-Apr-00	-	-	309	-	-	-	9
30-Apr-00	-	1	296	-	-	-	10
01-May-00	-	-	266	-	-	1	11
02-May-00	1	3	206	-	-	-	8
03-May-00	-	-	191	-	-	-	5
04-May-00	-	2	197	-	-	-	6
05-May-00	-	1	243	1	1	-	4
06-May-00	-	-	329	-	-	-	6
07-May-00	-	-	303	-	-	-	4
08-May-00	-	-	390	-	-	-	5
09-May-00	-	2	400	-	-	-	8
10-May-00	-	-	407	-	-	-	5
11-May-00	-	-	261	-	-	-	3
12-May-00	-	-	226	-	-	-	2
13-May-00	-	1	127	-	-	-	1
14-May-00	-	-	108	-	-	-	-
15-May-00	-	-	164	-	-	-	6
16-May-00	-	-	80	-	2	-	3

Appendix Table A5. Continued.

Detection date at MCJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
17-May-00	-	-	131	-	-	-	1
18-May-00	-	-	127	-	-	-	2
19-May-00	-	-	169	-	-	-	4
20-May-00	-	-	136	-	-	-	-
21-May-00	-	-	129	-	-	-	3
22-May-00	-	-	137	-	-	-	4
23-May-00	-	-	123	-	-	-	2
24-May-00	-	-	96	-	-	-	4
25-May-00	-	-	105	-	-	-	1
26-May-00	-	-	87	-	-	-	-
27-May-00	-	-	82	-	-	-	1
28-May-00	2	-	67	-	-	-	1
29-May-00	-	-	91	-	-	-	2
30-May-00	-	-	79	-	-	-	1
31-May-00	-	-	85	-	-	1	1
01-Jun-00	-	-	77	-	-	-	-
02-Jun-00	-	1	45	-	5	1	-
03-Jun-00	-	12	19	-	4	-	-
04-Jun-00	-	8	24	-	-	1	-
05-Jun-00	-	4	16	-	-	-	-
06-Jun-00	-	9	2	-	7	1	-
07-Jun-00	-	6	23	-	4	-	-
08-Jun-00	-	-	31	-	-	-	1
09-Jun-00	-	-	48	-	-	-	-
10-Jun-00	-	-	48	-	-	-	-
11-Jun-00	-	-	42	-	-	-	-
12-Jun-00	-	-	51	-	-	-	3
13-Jun-00	-	-	12	-	-	-	1
14-Jun-00	-	-	64	-	-	-	1
15-Jun-00	-	-	83	-	-	-	3

Appendix Table A5. Continued.

Detection date at MCJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
16-Jun-00	-	-	166	-	-	-	1
17-Jun-00	-	-	81	-	-	-	2
18-Jun-00	-	-	53	-	-	-	-
19-Jun-00	-	-	44	-	-	1	9
20-Jun-00	-	-	46	-	-	3	-
21-Jun-00	-	-	32	-	-	1	-
22-Jun-00	-	-	43	-	-	-	-
23-Jun-00	-	-	20	-	-	-	-
24-Jun-00	-	-	13	-	-	-	-
25-Jun-00	-	-	28	-	-	-	-
26-Jun-00	-	-	27	-	-	-	-
27-Jun-00	-	-	18	-	-	-	-
28-Jun-00	-	-	10	-	-	-	-
29-Jun-00	-	-	9	-	-	-	-
30-Jun-00	-	-	5	-	-	-	-
01-Jul-00	-	-	16	-	-	-	-
02-Jul-00	-	-	7	-	-	-	-
03-Jul-00	-	-	12	-	-	-	-
04-Jul-00	-	-	16	-	-	-	-
05-Jul-00	-	-	23	-	-	-	-
06-Jul-00	-	-	14	-	-	-	-
07-Jul-00	-	-	5	-	-	-	-
08-Jul-00	-	-	6	-	-	-	-
09-Jul-00	-	-	5	-	-	-	-
10-Jul-00	-	-	5	-	-	-	-
11-Jul-00	-	-	6	-	-	-	-
12-Jul-00	-	-	5	-	-	-	-
13-Jul-00	-	-	1	-	-	-	-
14-Jul-00	-	-	1	-	-	1	-
15-Jul-00	-	-	1	-	-	-	-

Appendix Table A5. Continued.

Detection date at MCJ	Detected once (coil location)				Detected on separator and one additional coil (coil location)		
	Diversion	Raceway	Sample	Separator	Diversion	Raceway	Sample
16-Jul-00	-	-	4	-	-	-	-
18-Jul-00	-	-	4	-	-	1	-
19-Jul-00	-	-	4	-	-	-	-
20-Jul-00	-	-	2	-	-	-	-
21-Jul-00	-	-	2	-	-	-	-
22-Jul-00	-	-	1	-	-	-	-
23-Jul-00	-	-	1	-	-	-	-
25-Jul-00	-	-	2	-	1	-	-
26-Jul-00	-	-	3	-	-	-	-
27-Jul-00	-	-	2	-	-	-	-
28-Jul-00	-	-	2	-	-	-	-
30-Jul-00	-	-	1	-	-	-	-
21-Aug-00	-	-	1	-	-	-	-
03-Sep-00	-	-	1	-	-	-	-

APPENDIX B

Tagging Results for 2003 Juvenile Transportation Studies

Snake River Spring/Summer Chinook Salmon and Steelhead

From 9 April through 6 June 2003, we PIT tagged a total of 51,261 wild yearling smolts, loaded 7,118 of these into barges at Lower Granite Dam and released 43,108 into the Lower Granite Dam tailrace. From 9 April through 12 June, we PIT tagged 36,291 wild steelhead smolts at Lower Granite Dam, with 3,384 loaded into barges at the dam and 31,544 released into the tailrace.

Based on mortality counts from the inriver-holding tanks, post-marking delayed mortality (24-hour) averaged 0.4% for spring/summer chinook salmon and 0.3% for steelhead over the entire tagging season.

Transport groups were also created at Little Goose and Lower Monumental Dams. The separation-by-code systems were set at 80% and 50% to transport at the respective dam. The remaining fish were diverted back to the river to aid in creating reach survival estimates.

Snake River Fall Chinook Salmon

From 28 May through 5 June 2003, we PIT tagged a total of 53,714 subyearling chinook salmon at Lyons Ferry State Hatchery, releasing 53,583 of these fish into the Snake River above Lower Granite Dam at River Kilometer 254. Also, because few PIT tagged fish are left in the river by the end of August, we tagged an additional 2,034 run-of-the-river subyearling chinook salmon in the fall (September and October) and placed them in trucks to determine the effectiveness of late-season transportation.

Based on mortality counts, post-marking delayed mortality (24-hour) averaged 0.4% over the entire tagging season.

A transport group was created at Lower Granite Dam by setting the separation-by-code system to transport 80% of the fish collected. The remaining fish were diverted back to the river to aid in creating reach survival estimates.

Columbia River Hatchery Spring Chinook Salmon and Steelhead

In 2003, we continued a transportation study from McNary Dam using upper Columbia River hatchery yearling spring chinook salmon and began a transportation study from McNary Dam using upper Columbia River hatchery steelhead. One additional group was added to the study (to be compared against transported fish and fish not collected), fish bypassed through the primary bypass directly to the McNary Dam tailrace.

Beginning in late-August 2002, the U.S. Fish and Wildlife Service and Biomark, Inc. began PIT-tagging hatchery yearling spring chinook salmon and steelhead. A total of 354,928 yearling spring chinook salmon were tagged at Winthrop (19,962 fish), Methow (34,925), Entiat (59,879 fish), and Leavenworth Fish Hatcheries (240,162 fish). A total of 486,368 steelhead tagged at Winthrop (49,947), Wells (246,052), Eastbank (62,036), Chelan (33,172), and Ringold Fish Hatcheries (95,161).

Fish that were guided into the collection channel in McNary Dam were either bypassed directly to the river or sent into the juvenile collection facility on an every-other-day basis. The SAR of fish transported from McNary Dam will be compared to the SAR of fish bypassed directly to the river (without entering the juvenile collection facility) and to the SAR of fish that were never detected at McNary Dam.

APPENDIX C

Adult Returns from Previous and In-progress Studies

Appendix Table C1. Snake River wild spring/summer chinook salmon studies.

Tagging year	Juvenile fish numbers		Returns by Age-class			SAR					Annual report containing final results
	Transport	Inriver	Jack	2-ocean	3-ocean	Transport	Inriver	T/I	95% C.I.	Status	
2003	7,118	43,108	–	–	–	–	–	–	–	In-progress	Fall 2006
2002	4,970	34,059	15	–	–	–	–	–	–	In-progress	Fall 2005
2001	16,733	–	20	113	–	–	–	–	–	In-progress	Fall 2004
2000*	17,367	26,329	16	263	355	1.47	1.44	1	(0.9, 1.1)	Completed	Current
1999	8,384	1,920	11	164	27	2.1	1.35	1.6	(1.0, 2.4)	Completed	2001
1998	5,689	2,932	6	42	14	0.6	0.95	0.6	(0.4, 1.0)	Completed	2001
1996	7,949	3,915	1	8	3	0.11	0.08	1.5	(0.5, 7.5)	Completed	1999
1995	24,066	6,794	1	70	36	0.38	0.22	1.7	(1.1, 2.6)	Completed	1998

* Transport group formed of fish collected and transported from Little Goose Dam, adjusted with Sandford and Smith (2002).

Appendix Table C2. Snake River hatchery spring/summer chinook salmon studies.

Tagging year	Juvenile fish numbers		Returns by age-class			SAR		T/I	95% C.I.	Status	Annual report containing final results
	Transport	Inriver	Jack	2-ocean	3-ocean	Transport	Inriver				
1999	42,273	16,664	99	935	41	1.97	1.45	1.4	(1.2, 1.6)	Completed	2001
1998	39,596	23,552	48	297	34	0.62	0.57	1.1	(0.9, 1.4)	Completed	2001
1996	35,632	20,186	7	43	22	0.13	0.1	1.2	(0.8, 2.0)	Completed	1999
1995	83,064	25,757	34	444	70	0.54	0.32	1.7	(1.4, 2.1)	Completed	1998

Appendix Table C3. Upper Columbia River hatchery spring/summer chinook salmon studies.

	Juvenile fish numbers			Returns by Age-class			SAR					Annual report containing final results
Tagging year	Transport	Bypass[a]	Inriver	Jack	2-ocean	3-ocean	Transport	Inriver	T/I	95% C.I.	Status	
2003	31,323	37,469	–[b]	–	–	–	–	–	–	–	In progress	Fall 2006
2002	50,381	–	–[b]	36	–	–	–	–	–	–	In progress	Fall 2005

a "Bypass" fish were fish guided, then bypassed back to the river through the full-flow outfall pipe; they did not enter the collection facility. This passage route was not used in 2002.

b The"Inriver" number has not been determined at this time.

APPENDIX D:

Overview of Statistical Methodology

For each day of the migration season, we estimated numbers of PIT-tagged fish passing Lower Granite Dam, developing a series of daily passage estimates. These daily estimates were used to estimate SARs according to the method of Sandford and Smith (2002). As an example, a brief synopsis of the method follows.

1) Fish detected on day *k* at Little Goose Dam that had previously been detected at Lower Granite Dam were grouped according to day of detection (passage) at Lower Granite Dam.

2) Fish detected on day *k* at Little Goose Dam that had *not* previously been detected at Lower Granite Dam were assigned a day of passage at Lower Granite Dam based on the distribution at Lower Granite Dam of fish detected at both dams (from step 1). This step assumed that the passage distribution for non-detected fish at Lower Granite Dam was proportionate to that of their cohorts detected at Lower Granite Dam.

3) Steps 1 and 2 were repeated for each day of detection at Little Goose Dam during the juvenile migration season.

4) Using the numbers from steps 1-3 (i.e., fish detected at Little Goose Dam, which constitute a sample of of all PIT-tagged fish passing Little Goose Dam), the probability (p_i) of detection at Lower Granite Dam on day *i* was estimated by dividing the number of fish detected on day *i* by the total number of fish estimated to have passed the dam on day *i*. Numbers were adjusted for fish that had been transported from Lower Granite Dam.

5) The total number of fish arriving at Lower Granite Dam on day *i* (LGR_i) was estimated by dividing the total number detected at Lower Granite Dam on day *i* (including bypassed and transported fish and fish not subsequently detected at Little Goose Dam) by the estimated probability of detection at LGR on day *i*.

We then estimated SARs for various detection-history categories, in particular for fish transported from a dam, for fish bypassed back to the river at one or more dams, and for fish never detected at a Snake River dam. To do this, we developed daily passage estimates at Lower Granite Dam using the following process:

6) For fish detected at Lower Granite Dam on day *i*, we estimated the probability of detection at Little Goose (LGO), Lower Monumental (LMO), and McNary (MCN) Dams using the Cormack-Jolly-Seber single-release model (Cormack 1964; Jolly 1965; Seber 1965).

7) We multiplied the estimated total passing Lower Granite Dam on day *i* (LGR_i) by the detection and transport probabilities derived from step 6 to estimate numbers in each detection history category. For example, the detection-history category "not detected at Little Goose or Lower Monumental Dam and then bypassed at McNary Dam" was estimated as

$$(LGR_i) \times [1 - p\ (LGO_i)] \times [1 - p\ (LMO_i)] \times [p\ (MCN_i)] \times [1 - p\ (\text{transport at } MCN_i)].$$

8) We summed the estimates from step 7 across all days of fish passage at Lower Granite Dam to arrive at the estimated total number of smolts in each detection-history category.

Next we calculated SARs. For a given detection-history category, this was the ratio of the observed number of adults in the category to the estimated total number of smolts in that category.

Finally, we estimated the precision of the estimated SARs. This was done using bootstrap methods wherein the individual fish information (i.e., detection history, detection dates, and adult return record) was resampled 1,000 times with replacement (Efron and Tibshirani 1993). Standard errors and confidence limits about the SARs were generated from the bootstrap sample.