B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Comparative Survival Study (CSS) of Hatchery PIT-tagged Spring/Summer Chinook

Migration Years 1997-2002 Mark/Recapture Activities and Bootstrap Analysis

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COMPARATIVE SURVIVAL STUDY (CSS) of PIT-tagged Spring/Summer Chinook

Migration Years 1997 – 2002
Mark/Recapture Activities and Bootstrap Analysis

2003-2004 Annual Reports

BPA Project No. 1996-020-00
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ACKNOWLEDGEMENTS

The Comparative Survival Study (CSS) relies on the cooperation of multiple agencies and individuals to ensure that the major tasks of marking, handling, releasing, and recovery of fish in three States and at hatcheries and dams are completed successfully.

The PIT tag systems that are maintained by PSMFC personnel enable PIT tag data to be collected on a real-time basis. We commend Carter Stein and his staff for their diligence in repair of PIT tag equipment, both in the juvenile and adult fish passage systems; providing the support, computers, software, and databases used for "by-code" diversion at Lower Granite, Little Goose, and Lower Monumental dams; and providing the smooth transfer of PIT tag data to the PIT Tag Operations Center in Portland, OR. We thank Dave Marvin of PSMFC, who provided the support in using the multimon program with CSS study fish to perform the routine "by-code" operations at the dams.

This report covers yearling hatchery Chinook supplied for the CSS by Idaho Department of Fish and Game (IDFG), U.S. Fish and Wildlife Service (USFWS), and Oregon Department of Fish and Wildlife (ODFW) at the following hatcheries. IDFG hatcheries include McCall (1997-2002) and Rapid River (1997-2002). USFWS hatcheries include Dworshak (1997-2002) and Carson (1997-2002). The CSS currently uses ODFW's outplants from Lookingglass Hatchery into Imnaha (1997-2000) and Catherine Creek acclimation ponds (2001-2002). These acclimation ponds are operated as a cooperative venture with Nez Perce and Umatilla tribes, respectively. We appreciate and extend thanks to the Fish and Wildlife agencies and all hatchery managers and staff for their assistance in the planning, raising of, and recovery of study fish at the hatcheries.

From 1997 through 2002, just over one million hatchery spring/summer Chinook have been PIT tagged by State and Federal personnel for the CSS Program. This required a lot of time and effort from individual marking crews to complete tagging of these fish. The USFWS Dworshak Fisheries Resource Office (FRO) personnel PIT tagged fish at Dworshak Hatcheries while the Vancouver, Washington, FRO personnel marked fish at Carson Hatcheries. PIT tagging at IDFG hatcheries was completed with supervision provided by the IDFG office in Lewiston, Idaho. Chinook at the Lookingglass complex were PIT tagged by ODFW personnel from the Northeast District fisheries office in LaGrande, Oregon. We thank the field supervisors and crews for an excellent job in completing the PIT tagging operations at these hatcheries.

We appreciate the diligence and efforts of the Fish Passage Center in its role in the implementation of this program by coordinating PIT tagging and field logistics, performing database development, data compilation and preliminary analyses, and overseeing the budgetary aspects of this study. In addition to the coauthors, FPC staff members Michele DeHart, Jerry McCann, Sergie Rassk, and Dona Watson also provided a valuable contribution to the success of this program. A special thanks goes to coauthers Henry Franzoni, who programmed the "bootstrap" and "simulator" routines, and Paul Wilson, who contributed to algorithms behind the "simulator" program. In addition, Mr. Wilson along with Nick Bouwes of EcoLogical Research, Logan UT, contributed to the early development of the bootstrap program.

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EXECUTIVE SUMMARY

The Comparative Survival Study (CSS) was initiated in 1996 as a multi-year program of the fishery agencies and tribes to estimate survival rates over different life stages for spring and summer Chinook (hereafter, Chinook) produced in major hatcheries in the Snake River basin and from selected hatcheries in the lower Columbia River. Much of the information evaluated in the CSS is derived from fish tagged with Passive Integrated Transponder (PIT) tags. A comparison of survival rates of Chinook marked in two different regions (which differ in the number of dams Chinook have to migrate through) provides insight into the effects of the Snake/Columbia hydroelectric system (hydrosystem). The CSS also compares the smolt-to-adult survival rates (SARs) for Snake River Chinook that were transported versus those that migrated in-river to below Bonneville Dam. Additional comparisons can be made within in-river experiences as well as comparison between the different collector projects from which smolts are transported. CSS also compares survival rates for wild Snake River spring and summer Chinook. These comparisons generate information regarding the relative effects of the current management actions used to recover this listed species.

Scientists and managers have recently emphasized the importance of delayed hydrosystem mortality to long-term management decisions. Delayed hydrosystem mortality may be related to the smolts experience in the Federal Columbia River Power System, and could occur for both smolts that migrate in-river and smolts that are transported. The CSS PIT tag information on in-river survival rates and smolt-to-adult survival rates (SARs) of transported and in-river fish are relevant to estimation of ”D”, which partially describes delayed hydrosystem mortality. The parameter D is the differential survival rate of transported fish relative to fish that migrate in-river, as measured from below Bonneville Dam to adults returning to Lower Granite Dam. When $D = 1$, there is no difference in survival rate after hydrosystem passage. When $D < 1$, then transported smolts die at a greater rate after release below Bonneville Dam than smolts that have migrated in-river to below Bonneville Dam

Major objectives of the CSS include: (1) development of a long-term index of transport SAR to in-river SAR for Snake River hatchery and wild spring and summer Chinook smolts measured at Lower Granite Dam; (2) develop a long-term index of survival rates from release of smolts at Snake River hatcheries to return of adults to the hatcheries; (3) compute and compare the overall SARs for selected upriver and downriver spring and summer Chinook hatchery and wild stocks; and (4) begin a time series of SARs for use in hypothesis testing and in the regional long-term monitoring and evaluation program. Primary CSS focus in this report is for wild and hatchery spring/summer Chinook that outmigrated in 1997 to 2002 and their respective adult returns through 2004.

The CSS PIT tagged and released annually more than 200,000 smolts from Snake River hatcheries (primarily Dworshak, McCall, Rapid River, and Imnaha) and 5,000-15,000 smolts from a downriver hatchery (Carson) in 1997-2002. ODFW ceased production of Lookingglass Hatchery stock in 2000 and information on this stock is found in the 2002 CSS Annual Report. PIT-tagged smolts from the Snake River are detected in collection systems at Snake and Columbia River dams and diverted into transportation or bypassed to the river according to the annual study design. Detection histories are used to estimate numbers of smolts in in-river and transport categories, and to estimate survival between release and the first dam encountered (Lower Granite Dam), and from Lower Granite Dam to subsequent dams (Chapter 2).

In-river groups of Snake River hatchery Chinook in 1997-2002 were those smolts that were never collected or bypassed at Snake River collector dams (C_0) and smolts that were collected and bypassed at one or more Snake River collector dams (C_1). Hatchery Chinook smolts transported from all projects (T_0) were the primary transport group evaluated in 1997-2002. Returning PIT tagged adults are detected at Lower Granite Dam and assigned to appropriate in-river and transport groups. SARs (measured from smolts at Lower Granite to adult returns to Lower Granite) were calculated for transport and in-river groups, and ratios of transport SAR to in-river SAR (T/C ratios) were analyzed for each hatchery and year. In addition, we estimated the ratio of SAR from below Bonneville Dam back to Lower Granite Dam for transported groups relative to in-river groups (parameter *D*) for information about delayed impacts of transportation on survival rates that occur in the estuary and ocean. Bootstrap confidence intervals are computed for all parameter estimates.

The CSS objectives address both hatchery and wild spring/summer Chinook stocks, but most of the CSS PIT tagging to date has been on the hatchery spring/summer Chinook because of the extremely low abundance of wild Snake River stocks. Evaluating smolt mitigation and recovery strategies by tracking the performance of wild spring and summer Chinook has been a CSS study objective (supported in project reviews by the Independent Scientific Review Panel) since the beginning of the program. Since 2002, the CSS has increased the releases of PIT tagged wild Chinook in the Snake River basin through the coordination and provision of additional PIT tags for use at tributary traps operated by other programs. This report incorporates available wild Chinook PIT tag data from smolt migration years 1994-2002 to estimate wild Chinook SARs, to compare wild Chinook SARs between transportation and in-river migration, and to compare wild and hatchery Chinook responses (T/I ratios, ”D” values) to management actions (Chapter 2). It also looks at the extent to which the responses of hatchery Chinook to management actions can be used as a surrogate for wild Chinook.

Another focus of this annual report (Chapter 4) is the partitioning of survival from hatchery smolt release to Lower Granite Dam, adult return to Lower Granite Dam and to the hatchery. Accounting for adult survival between Lower Granite Dam and the natal hatchery requires accounting for any harvest in the terminal fisheries. Based on PIT detections at the hatchery racks, the conversion rate of adults from Lower Granite Dam to the rack is approximately 50% after adjusting for harvest. However, the SARs estimated from total production and PIT tag SARs differed and the reasons are unresolved.

Estimates of SARs of selected downriver wild and hatchery spring Chinook will allow for comparisons to Snake River stocks (Chapter 5). The CSS utilizes the ODFW PIT tagged wild Chinook from the John Day River (downriver stock above three dams) for regional SAR comparisons with the PIT tagged wild Chinook from the Snake River basin. SAR data is available for outmigrants from 2000 to 2002. The CSS has PIT tagged hatchery spring Chinook at the Carson Hatchery for migration years 1997-2002. Hatchery SARs were estimated from smolt release to smolts at Bonneville Dam, adults returning to Bonneville Dam, and finally adults to the hatchery for smolts that out-migrated in 1998 to 2002.

New this year is a look at losses of PIT tagged returning adults between monitored fish ladders at dams between Bonneville Dam and Lower Granite Dam. Beginning with the 2003 return year, PIT tag detections at ladders in Ice Harbor, McNary, and Bonneville dams have provided the ability to investigate changes in interdam "drop off" rates (caused by mortality, straying, harvest, etc.) in the hydrosystem. These early findings are presented in Chapter 3.

<u>The following summarize key findings to date</u>

<u>Chapter 2 Findings:</u>

- Hatchery Chinook may not generally function as good surrogates for wild Chinook with respect to survival rates in transportation or in-river through the hydrosystem. SARs and T/C ratios for PIT tagged wild and hatchery Chinook from migration years 1997 to 2002 show evidence of transportation benefits for hatchery spring/summer Chinook and transportation disadvantages for wild spring/summer Chinook. This finding adds another level of difficulty to future management of salmon in the Snake River basin, and could lead to erroneous conclusions regarding the use of transportation to recover wild Chinook if hatchery Chinook are used in general as a surrogate.

- However, the similarity of the jack return proportion and similarity of the pattern of overall SAR (computed by weighting the study specific SARs by the estimated proportion of fish in the run-at-large in each study category) between PIT tagged wild Chinook and PIT tagged Rapid River Hatchery Chinook make the Rapid River Hatchery Chinook stock the best of the CSS hatcheries as a surrogate for the wild Chinook.

- Little or no transport benefit was evident in non-drought years for Snake River wild Chinook based on PIT tag data. Although PIT tagged hatchery Chinook in general tended to have higher survival to adulthood by being transported, the opposite was true for PIT tagged wild Chinook, except in the drought year of 2001. The 8-yr geometric mean T/C ratio (1994-2000, 2002) for PIT tagged wild Chinook was 0.98; however, when averaged over 5 more recent years starting 1997, it was only 0.78. In the drought year of 2001, the T/C ratio exceeded 9. Overall, the PIT tagged wild Chinook aggregate performed poorly in transportation, and so transportation does not appear to be working as a management tool for recovery of listed wild spring/summer Chinook.

- SARs of transported and in-river wild Chinook migrants were much less than the 2-4% SARs needed to recover Snake River spring/summer Chinook (Marmorek *et al*. 1998). Except for the PIT tagged wild Chinook aggregate that were transported in 1999 or migrated in-river (C_0 category fish) in 1997, 1999, and 2000, all annual SARs for the PIT tagged wild Chinook were less than 2%.

- Transportation benefits were more evident for hatchery summer Chinook stocks than hatchery spring Chinook stocks in 1997-2002. The 5-year geometric mean T/C ratio was highest for hatchery summer Chinook (T/C=1.57), intermediate for hatchery spring Chinook (T/C=1.30) and lowest for the aggregate wild Chinook (T/C=0.78) in the years 1997 to 2002, excluding 2001. In the drought year of 2001, Chinook from all five CSS hatcheries had T/C ratios well in excess of 5, reflecting the extremely poor in-river conditions that year.

- Delayed hydrosystem mortality was evident for transported Snake River wild and hatchery Chinook smolts, which died at a greater rate after release than wild and hatchery smolts that migrated through the hydrosystem in non-drought years. For available years excluding 2001, the 8-year geometric mean D was 0.47 for the PIT tagged wild Chinook aggregate, and the 5-year geometric mean D was 0.73 for the PIT tagged hatchery spring Chinook stocks and 0.84 for the PIT tagged hatchery summer Chinook stocks. In 2001, the *D* for wild and hatchery Chinook groups were in excess of 2. But in the non-drought years, the wild Chinook *D* values have been considerably lower than the *D* of 0.7 used in NMFS' 2000 Biological Opinion.

- Through 2000, the CSS found evidence of delayed hydrosystem mortality of in-river migrants associated with collection and bypass at Snake River dams. In those years, there existed a pattern of lower SARs for wild and hatchery Chinook that were detected in the bypass at Lower Granite, Little Goose, or Lower Monumental Dam and returned-to-river (Category C_1) compared to the Chinook that passed those three dams undetected through the combined routes of spill and turbines (Category C_0). The incomplete return data for migration year 2002 does not follow that pattern, with SARs being similar for both types of in-river migrants.

<u>Chapter 3 Findings:</u>

- Losses of adult Chinook, both hatchery and wild stocks, were greatest between Bonneville Dam and McNary Dam for the 2003 and 2004 migration seasons with 11.5% to 20.3% of the fish dropping out or non-detected between the two projects.

- Losses of adult Chinook between McNary Dam and Ice Harbor Dam were minimal for both years of record. Less than 1% of the wild and hatchery PIT tagged groups were lost between the Columbia River (McNary Dam) and the Snake River (Ice Harbor Dam).

- Losses of adult Chinook between Ice Harbor Dam and Lower Granite Dam ranged from 4.0 to 4.6% for the hatchery spring Chinook; less than 1% for the wild spring Chinook; 3.1 to less than 1% for hatchery summer Chinook, and 3.7 to 3.3% for wild summer Chinook for the respective 2003 and 2004 adult PIT tag returns.

Chapter 4 Findings:

- Survival of PIT tagged juvenile spring/summer Chinook was estimated from CSS hatcheries to the tailrace of Lower Granite Dam for migration years 1997 to 2002. These estimates ranged from 39 % to 85 %.

- Weighted SARs from Lower Granite Dam as smolts to Lower Granite Dam as adults (weighted to represent the run-at-large in each CSS study category) were higher for the summer Chinook stocks than spring Chinook stocks. From 1997 to 2001, the weighted SARs varied widely among hatcheries with the highest SARs at McCall Hatchery (range 1.2–3.3%) and lowest SARs at Dworshak Hatchery (range 0.4–1.1%). Weighted SARs were highest in 1999 (range 1.1–3.3%) and lowest in 2001 (range 0.2–1.2%).

- For PIT tagged adults detected at Lower Granite Dam, there was no significant difference in proportion detected at the hatchery racks based on their juvenile outmigration experience (in-river versus transported) as smolts in 1997 to 2000.

- The overall hatchery-to-hatchery SARs were highest for spring stocks that out-migrated in 1999 (around 1.2%) and for summer stocks that out-migrated in 2000 (around 1.8–2.0%). Smolts that outmigrated in the drought conditions of 2001 had extremely low hatchery-to-hatchery SARs, which are expected to remain below 0.5% in four of five hatcheries even after the harvest adjusted 3-salt return to the hatchery is later added.

- The procedures to estimate survival rates for adult migrating from Lower Granite Dam back to the hatchery (with adjustments for harvest rates) based on PIT tag data are providing lower than expected estimates for that partition of the overall hatchery-to-hatchery SAR.

- Although magnitudes differ, there is a similar trend across the migration years between PIT tag based and run-at-large based estimates of hatchery-to-hatchery SARs.

Chapter 5 Findings:

- Juvenile to adult survival rates from Bonneville Dam tailrace to Bonneville Dam ($SAR_{BON\text{-}to\text{-}BON}$) for Carson Hatchery spring Chinook salmon was 3.44% and 1.78% for fish out-migrating in 2000 and 2001, respectively. For migration year 2000, this is close to the estimate for Rapid River Hatchery spring Chinook, higher than that of Dworshak Hatchery spring Chinook, and lower than that of the two summer stocks. For migration year 2001, the $SAR_{BON\text{-}to\text{-}BON}$ for Carson Hatchery Chinook was higher than that of the CSS upriver hatcheries, but relatively close to that of Rapid River and McCall hatcheries.

- Adult fish returns from Carson NFH show a similar trend with respect to higher SARs in migration years 1999 and 2000 as did the CSS upriver spring/summer Chinook hatchery groups. Improving ocean conditions appear to have contributed to the higher SARs at both the downriver and upriver hatcheries participating in the CSS program.

- Harvest of adult fish from the sport and tribal fisheries from Bonneville Dam to Carson NFH ranged from 26 to 86% (across years and age of returning adults) prior to these fish reaching the hatchery. Adult return rates to the hatchery based on harvest adjusted (harvest ranging from 26 to 86% across years and age of returning adults) from PIT tagged adults detected at the hatchery may be biased low in most years compared to the run-at-large estimated total escapement.

- Juvenile to adult survival rates from John Day Dam tailrace to Bonneville Dam ($SAR_{JDA\text{-}to\text{-}BON}$) for PIT tagged wild Chinook migrating from John Day River in 2000 to 2002 (latter year is incomplete with only 2-salt returns available) was 11.40, 3.86, and 3.37%, respectively. These magnitudes were generally twice or better than the corresponding SARs for the upriver PIT tagged wild Chinook.

- The timing of entry into the estuary based on PIT tag detections at the lower Columbia River trawl for the wild and hatchery stocks of "downstream" origin is closer to that of the transported wild and hatchery stocks of "upstream" origin than their in-river counterparts.

INTRODUCTION

Fisheries agencies and tribes have developed a multi-year program, the Comparative Survival Study (CSS), for the purpose of monitoring and evaluating the impacts of the mitigation measures and actions (e.g., flow augmentation, spill, and transportation) under the National Marine Fisheries Service (NMFS) Biological Opinion to recover listed stocks. This annual status report presents adult return information collected from PIT tagged wild spring/summer Chinook that outmigrated during 1994 to 2002 and PIT tagged hatchery spring/summer Chinook that outmigrated during 1997 to 2002. All study fish used in this report were uniquely identifiable based on a passive integrated transponder (PIT) tag implanted in the body cavity during the smolts life stage and retained through their return as adults. These tagged fish can then be detected as juvenile and adults at several locations of the Snake and Columbia Rivers. Reductions in the number of individuals detected as the tagged fish age provide estimates of survival. This allows comparisons of survival over different life stages between fish with different experiences in the hydrosystem (e.g. different routes of dam passage, transportation vs. in-river migrants, and migration through various numbers of dams). Figure 1 illustrates these different spring/summer Chinook life stages.

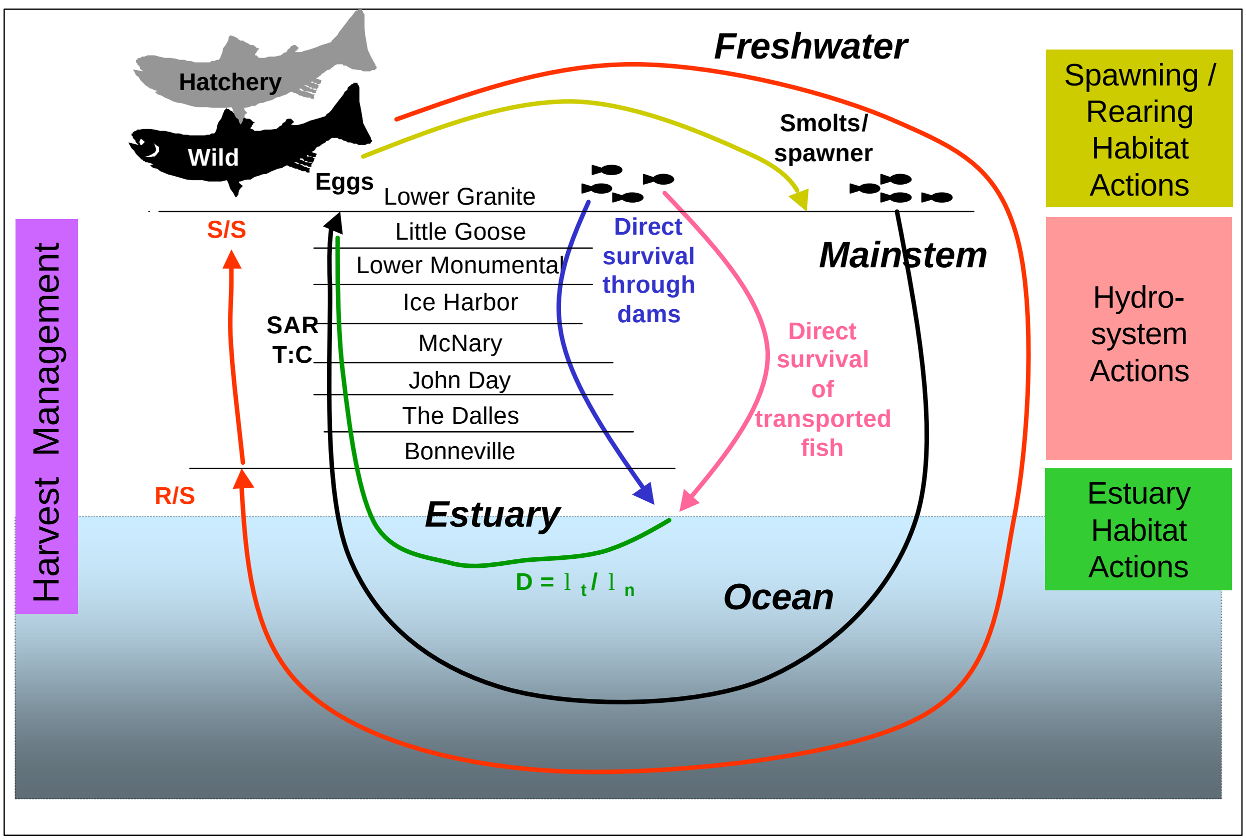


Figure 1. Spring/summer Chinook salmon life cycle in the Snake River and lower Columbia River basins (source: Marmorek et al 2004).

The CSS has PIT tagged large numbers of hatchery Chinook to obtain adequate sample sizes for these different comparisons. In addition, PIT tagged wild Chinook from other regional studies have also been used for survival estimation. This includes the following: (i) survival of migrating smolts over different reaches of the hydro system; (ii) survival of smolts-to-adults (SARs) from either Lower Granite Dam (LGR) back to LGR (*i.e.*, $SAR_{LGR\text{-}to\text{-}LGR}$) or Bonneville Dam (BON) back to LGR (*i.e.*, $SAR_{BON\text{-}to\text{-}LGR}$); (iii) the ratio of $SAR_{LGR\text{-}to\text{-}LGR}$ of fish transported around the dams to $SAR_{LGR\text{-}to\text{-}LGR}$ of fish that migrated in-river (T/Cs); and, (iv) the ratio of $SAR_{BON\text{-}to\text{-}LGR}$ of transported fish to $SAR_{BON\text{-}to\text{-}LGR}$ of in-river fish (Ds). By comparing the estimates of these parameters for hatchery and wild Chinook, it is possible to determine if hatchery fish are a reasonable surrogate for wild fish in aspects of hydro system passage survival. If so, hatchery fish could be used to track wild stocks in years where there are too few wild smolts to mark. The objectives of this study are as follows:

1. Develop a long-term index of transport to in-river survival rate (smolt-to-adult) for Snake River hatchery yearling Chinook and wild yearling Chinook smolts. This includes computing annual ratios of transport to in-river survival rate (measured at LGR-to-LGR) with associated confidence interval.

2. For Snake River and Mid-Columbia River basin hatcheries, develop a long-term index of survival rates from release of yearling Chinook smolts at hatcheries to return of adults to hatcheries. This objective includes partitioning survival rates (*i*) from hatchery (smolts) to LGR (smolts), (*ii*) from LGR (smolts) to back to LGR (adults), and (*iii*) from LGR (adults) to the hatchery (adults).

3. Compute and compare overall smolt-to-adult survival rates for selected upriver and down-river yearling spring/summer Chinook hatchery and wild stocks.

4. Begin a time series of smolt-to-adult survival rates for use in the regional long-term monitoring and evaluation program.

A key aspect of Objective 4 is to develop a time series of SARs for wild Snake River spring/summer Chinook for use in the regional monitoring and evaluation program. One use of the SAR index will be for assessment of temporal changes in patterns of life cycle survival (e.g., recruit/spawner or R/S residuals; Schaller et al. 1999; Deriso et al. 2001). For Snake River wild spring/summer Chinook, changes in SAR explained most of the changes observed in life cycle survival following FCRPS development and operation (Petrosky et al. 2001). A second application, in combination with SARs from downriver stocks, would be for assessing temporal and spatial changes in life cycle survival. Temporal and spatial R/S patterns indicated survival and productivity of Snake River stocks declined more than downriver stocks following FCRPS development and operation (Schaller et al. 1999; Deriso et al. 2001; Marmorek et al. 2004). The upriver/downriver SAR comparison (Objective 3) will shed additional light on life stage survival patterns that drives life-cycle survival for Snake River populations. Continuing these assessments will be valuable in diagnosing the population response to the package of FCRPS management actions in the face of changing climatic and oceanic conditions.

The 2003 CSS Annual Report is organized into six chapters. The first chapter provides general information of groups of PIT tagged spring/summer Chinook used in the CSS including hatchery Chinook PIT tagged specifically for the CSS and wild Chinook PIT tagged for other studies but available to create a wild Chinook aggregate for each migration year. Information on timing of migrating smolts and returning adults are found in this chapter.

The second chapter presents the methods and estimated in-river survivals, SARs, T/Is, and Ds for both hatchery and wild PIT-tagged Snake River spring/summer Chinook. Estimating the associated variance of these parameters is important in evaluating whether the study needs to be modified to provide adequate precision. Because the estimation of these parameters is complex, theoretical estimates of variance are extremely difficult. An alternative approach is to bootstrap the estimation procedure to produce the appropriate variance estimates and to directly produce non-parametric 95% confidence intervals for each parameter estimated in this study. The CSS continues to make progress in building the long-term time series of smolt-to-adult survival rates with associated bootstrap confidence intervals and in assessing the representativeness of the estimates based on groups of PIT tagged smolts to the unmarked population. This time series of SAR estimates will be useful to fishery managers in the regional long-term monitoring and evaluation program. The estimates of smolt-to-adult survival rates may also be useful for investigating the relationship between survival rates and hydro system experiences for yearling Chinook.

The third chapter presents PIT tag adult conversion rates from Bonneville Dam to Lower Granite Dam that have only been available since return year 2002 when PIT tag detectors in all fish ladders at Bonneville Dam were operational.

The fourth chapter presents estimated adult survival rates from Lower Granite Dam fish ladder back to the hatcheries. These estimates require adjustments for the sport and tribal fisheries on these fish prior to arriving at the hatcheries. The estimated survival rate incorporates straying and unaccountable losses within the mortality factor.

The fifth chapter presents results for the planned upstream-downstream comparisons for hatchery and wild stocks. The yearly trends in SARs for Carson Hatchery Chinook are compared to the upstream hatcheries (Rapid River, McCall, Dworshak, and Imnaha). Likewise, the yearly trends in SARs of PIT tagged wild Chinook from John Day River are compared with those of PIT tagged wild spring/summer Chinook from the Snake River.

The sixth chapter presents the background on a simulation program developed cooperatively between FPC and USFWS staff as a result of review comments by the ISRP. The simulator program is designed to evaluate the robustness of the Cormack-Jolly- Seber (CJS) methodology utilized in the CSS, by creating simulated datasets with user controlled input parameters of reach survival, collection efficiency, travel time and other passage parameters.

CHAPTER 1

Background of PIT tagged smolts used in CSS and timing at Lower Granite Dam of smolts and adults

PIT Tagging of Smolts

Yearling Chinook were PIT tagged for the CSS at specific hatcheries within the four tributary drainages above Lower Granite Dam including the Clearwater, Salmon, Imnaha, and Grande Ronde rivers. Both spring and summer stocks were included. Hatchery programs were selected which accounted for a major portion of the Chinook production in their respective drainage in order to have sufficient numbers of smolts and returning adults for computing statistically rigorous smolt-to-adult survival rates. Since study inception, hatchery fish consistently used in the CSS include Chinook tagged at McCall, Rapid River, Dworshak, and Lookingglass hatcheries (Table 1). Chinook tagged at Lookingglass Hatchery included the Imnaha River stock that continues to be released at the Imnaha River weir and the Catherine Creek stock that was developed from broodstock taken from that tributary and became available to the CSS in 2001 to replace the onsite releases made at Lookingglass Hatchery through 1999.

Table 1. Hatchery release statistics and numbers of PIT tagged Chinook released for CSS in 1997 to 2002.

Hatchery	Migration Year	Hatchery Release	Fish # / lb	Median Fork Length at Tagging (mm)	PIT Tags Released	PIT Tag Proportion
Rapid River H (RAPH)	1997	85,838	20.5	100[A]	40,452	0.4713
	1998	896,170	20.3	117	48,336	0.0539
	1999	2,847,283	17.9	120	47,812	0.0168
	2000	2,462,354	19.2	119	47,747	0.0194
	2001	736,601	18.8	118	55,085	0.0748
	2002	2,669,476	19.8	122	54,908	0.0206
Dworshak H (DWOR)	1997	53,078	12.7	118	14,080	0.2653
	1998	973,400	20.9	121	47,703	0.0490
	1999	1,044,511	21.0	116	47,845	0.0458
	2000	1,017,873	24.0	112	47,743	0.0469
	2001	333,120	19.7	121	55,139	0.1655
	2002	1,000,561	20.1	119	54,725	0.0547
Catherine Ck AP (CATH)	2001	136,833	19.7	117[A]	20,915	0.1529
	2002	180,343	18.6	115[A]	20,796	0.1153
McCall H (MCCA)	1997	238,647	17.1	128	52,652	0.2206
	1998	393,872	17.5	126	47,340	0.1202
	1999	1,143,083	23.9	117	47,985	0.0420
	2000	1,039,930	23.3	117	47,705	0.0459
	2001	1,076,846	19.4	129	55,124	0.0512
	2002	1,022,550	23.0	122	54,734	0.0535
Imnaha AP (IMNA)	1997	50,911	17.0	122	13,378	0.2628
	1998	93,108	21.1	122	19,825	0.2129
	1999	184,725	18.5	117[A]	19,939	0.1079
	2000	179,797	19.1	113[A]	20,819	0.1158
	2001	123,014	16.0	121[A]	20,922	0.1701
	2002	303,737	14.1	121[A]	20,920	0.0689

[A] Tagged in fall ~5 months before release; otherwise tagged in spring 1-2 months before release.

The PIT tagged wild Chinook utilized in the CSS were obtained from all available marking efforts in the Snake River basin above Lower Granite Dam (Appendix A). The wild stocks included Chinook PIT tagged as parr (summer/fall tagging season) and smolts (spring tagging season) in each of the four tributaries above Lower Granite Dam. The number of PIT tagged wild Chinook available from each tributary plus the Snake River trap at Lewiston over the migration years 1994 to 2002 is present in Table 2.

Table 2. Number of PIT tagged wild Chinook smolts from the four tributaries above Lower Granite Dam and Snake River trap used in the CSS for migration years 1994 to 2002.

Migr. Year	Number of PIT tagged wild Chinook parr/smolts utilized in CSS by drainage					
	Total PIT Tags	Clearwater River	Grande Ronde River	Salmon River	Imnaha River	Snake River trap[1]
1994	49,659	8,292	8,828	27,725	3,391	1,423
1995	74,640	17,605	12,330	40,609	2,148	1,948
1996	21,523	2,246	7,079	7,016	4,269	913
1997	9,781	671	3,870	3,543	1,697	None
1998	33,836	4,681	8,644	11,179	8,411	921
1999	81,493	13,695	11,240	43,323	10,184	3,051
2000	67,841	9,921	7,706	39,609	9,079	1,526
2001	47,775	3,745	6,354	23,107	14,540	29
2002	67,331	14,060	9,715	36,051	6,428	1,077

[1] Snake River trap collects fish originating in Salmon, Imnaha, and Grande Ronde rivers.

Each PIT tag has a unique code. The tags are glass encapsulated and 12 mm in length. Individual PIT tags were implanted into the fish's underbelly using a hand-held syringe. To the extent possible, these PIT tagged fish should be representative of their untagged cohorts. At trapping sites, sampling and tagging occur over the entire migration season. At hatcheries, fish were obtained across as wide a set of ponds and raceways as possible to allow effective representation of production. Tag loss and mortality of PIT tagged fish were monitored, and the tagging files were transferred to the regional PTAGIS database in Portland, OR.

For detection of smolts, PIT tag detectors are installed at six Snake and Columbia River dams, including Lower Granite (LGR), Little Goose (LGS), Lower Monumental (LMN), McNary (MCN), John Day (JDA), and Bonneville (BON). In addition, PIT tag detections were obtained from the NOAA Fisheries trawling operation (TWX) in the lower Columbia River near Jones Beach (located about half-way between BON and the mouth of the Columbia River). These site abbreviations will be used throughout the remainder of this document.

PIT tagged returning adults were detected at LGR in each year. Beginning in return year 2002, detectors were installed at BON and MCN, allowing detection of returning PIT tagged adults at these additional locations. In 2003, Ice Harbor Dam (IHR) was fitted with a PIT tag detection system in its fish ladder. Lower Granite Dam now has two sets of PIT tag detection coils – one set installed at the adult trapping facility and the new installation of coils located in the exit section of the adult fish ladder.

Juvenile Migration Timing at Lower Granite Dam

For McCall, Imnaha, Dworshak, Catherine Creek, and Rapid River hatchery Chinook smolts, LGR is the first dam encountered during their seaward outmigration. LGR incorporates PIT tag detection systems in the fish bypass channels that transfers data to the PTAGIS computer system in Portland, OR. Figure 2 shows cumulative plots of PIT tagged smolt's passage timing at LGR for hatcheries participating in the CSS. For the 1997 to 2000 migration years, there have been fairly specific timing trends among the hatcheries used in the CSS. In 1998 and 1999, Dworshak Hatchery Chinook smolts were passing LGR earlier than the other CSS hatcheries, but in the other years the passage timing of Dworshak Hatchery smolts was closer to that of the other CSS hatcheries. The McCall Hatchery summer Chinook smolts generally had the latest migration timing of all the CSS hatchery groups. Chinook smolts from Rapid River Hatchery and Imnaha Acclimation Pond (AP) had very similar passage timing at LGR, with timing between that of the other hatcheries.

Recovery Activities at McCall, Catherine Creek, Imnaha, Rapid River, and Dworshak Hatcheries

The adult sampling facilities and methods of handling the PIT tagged fish that return to hatcheries used consistently in the CSS program during migration years 1997 to 2000 were described in last year's CSS annual report (Berggren *et al*. 2002). Additional information as it pertains to return year 2003 (covering fish that out-migrated in 2000 and 2001) is presented below for each hatchery. All PIT tags detected/retrieved from the adult Chinook were recorded as "recaptures" (RF- returning fish) and the information sent to the PTAGIS database for storage.

McCall Hatchery: South Fork Salmon Weir

Summer Chinook from McCall Hatchery returned to a weir installed in the South Fork Salmon River. A small fish ladder is located on the south bank of the river and the ladder leads the adult Chinook to a holding area that allows IDFG the opportunity to sample or take adult Chinook for spawning or else return them to the river above the weir. All adult fish handled were interrogated for PIT tags at this site prior to release or holding in ponds. The weir was in place by June 25, 2003. The weir remained in place until mid-September.

Catherine Creek Acclimation Pond

The Catherine Creek Acclimation Facility is located at RM 29.5 of Catherine Creek. Juvenile salmon released at this site are reared to smolt-size at Lookingglass Hatchery and trucked to the site from late February to mid-April to achieve length of acclimation desired for the facility. Adult fish returning from these juvenile releases from the acclimation pond are captured downstream at RM 20.5 of Catherine Creek. The facility consists of a hydraulic weir that is attached at the bottom sill of a full channel width poool and chute-type ladder. Trapping of adult fish is accomplished by directing adult fish into an off-channel trap (fyke opening) and hold area that is 25 feet long and 6 feet wide with a depth normally kept at about 6 feet. Photographs and more in-depth details of the juvenile ponds and adult trapping facility can be found in a 2002 BPA Report by McLean *et al*.(March 2003).

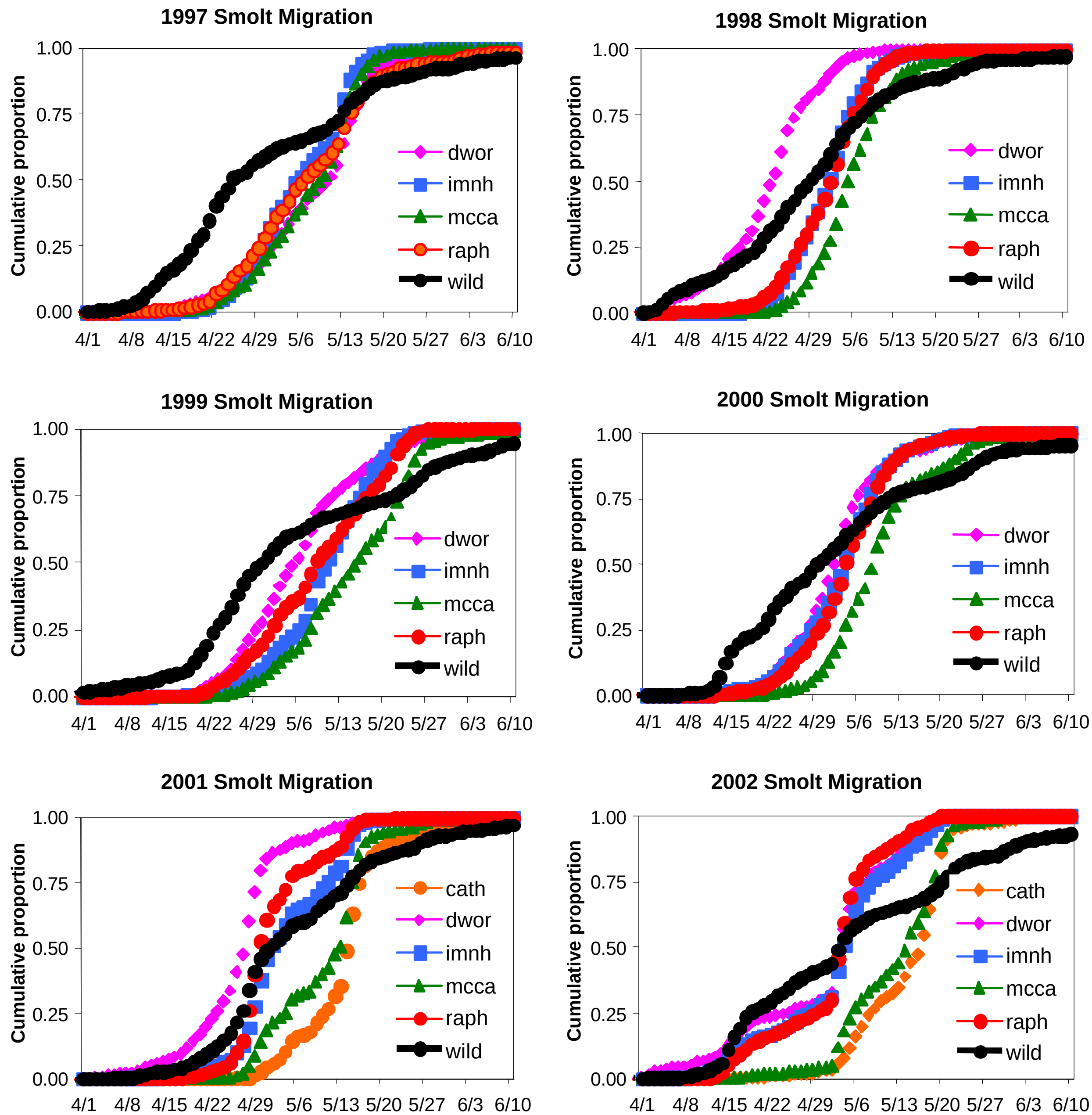


Figure 2. Cumulative passage timing of PIT tagged hatchery Chinook smolts at Lower Granite Dam in migration years 1997 to 2002 for tagged hatchery fish released for the CSS (cath = Catherine Ck AP, dwor = Dworshak H, imnh = Imnaha AP, mcca = McCall H, raph = Rapid River H, and wild = aggregate wild Chinook PIT tag releases).

Imnaha River Acclimation Pond: Imnaha River Weir

ODFW hatchery personnel installed the Imnaha River weir on July 7, 2003, after an estimated 62.7% of returning adults had already passed upstream of the weir site. Once the weir had been set in the river, all fish must pass through a small fish ladder to the holding area. Each adult (including jacks) Chinook is interrogated for the presence of PIT tags well in advance of spawning at the hatchery. Some PIT tagged fish may spawn above or below the weir on an annual basis. Adult fish that spawn above the weir were interrogated for PIT tags by ODFW unless the fish passed the weir prior to it being set in place. Those adults spawning below the weir could not be checked for PIT tags.

Rapid River Hatchery

An impassable velocity barrier located one mile below the hatchery is the site where returning adult Chinook are diverted from Rapid River into a holding area. At this point fish are normally shunted through an Alaska Steeppass (Denil-type fishway) into a trapping site where they can be sampled prior to being used for broodstock or recycled back to the Salmon River for potential harvest. All sampled fish were interrogated for PIT tags, and other pertinent data on length and sex was taken. Sampled fish are trucked to the hatchery for spawning or recycled as necessary through the season.

Dworshak National Fish Hatchery

Spring Chinook bound for Dworshak Hatchery volitionally swim to the fish ladder located in the North Fork Clearwater River that leads into the hatchery. The fish ladder was opened and closed several times over the adult collection period in an attempt to manage the large number of returns in 2003. In some instances the ladder was opened and closed more than once before the fish in the receiving pond were examined. Therefore the number of fish trapped during a given time period is an estimated total. Table 3 shows the ladder opening/closing dates and estimated number of fish collected each period. Fish that were unable to enter the hatchery due to arrival during times of non-operation of the fish ladder increase the opportunities of tribal and sport harvest. Collected adult spring Chinook were checked for PIT tags before going to the hatchery holding ponds where they wait until spawning.

Table 3. Dworshak Hatchery ladder operations[1] for adult spring Chinook returning in 2003.

Date Opened 2003	Date Closed 2003	Approx. Number Trapped
May 28	June 14	709
June 17	June 18	492
June 23	June 28	493
July 2	July 10	550
July 16	July 25	522
July 31	Aug 7	231
Aug 26	Sept 22	425
TOTAL		**3,422**

[1] Source: DNFH-Production Narrative June-September 2003 (IFRO – SCSent03.wk4).

Adult Chinook Migration Timing at Lower Granite Dam for returns from migration years 1997 to 2002

Returning adults from Dworshak, and Rapid River hatcheries are typical spring Chinook stocks that arrive at LGR primarily between mid-April and mid-May each year (Figure 3). Returning adults from Imnaha AP and McCall Hatchery are the next groups to pass LGR primarily between late May and the end of June. The return timing of the Imnaha AP adults is a key reason for considering these fish a summer stock.

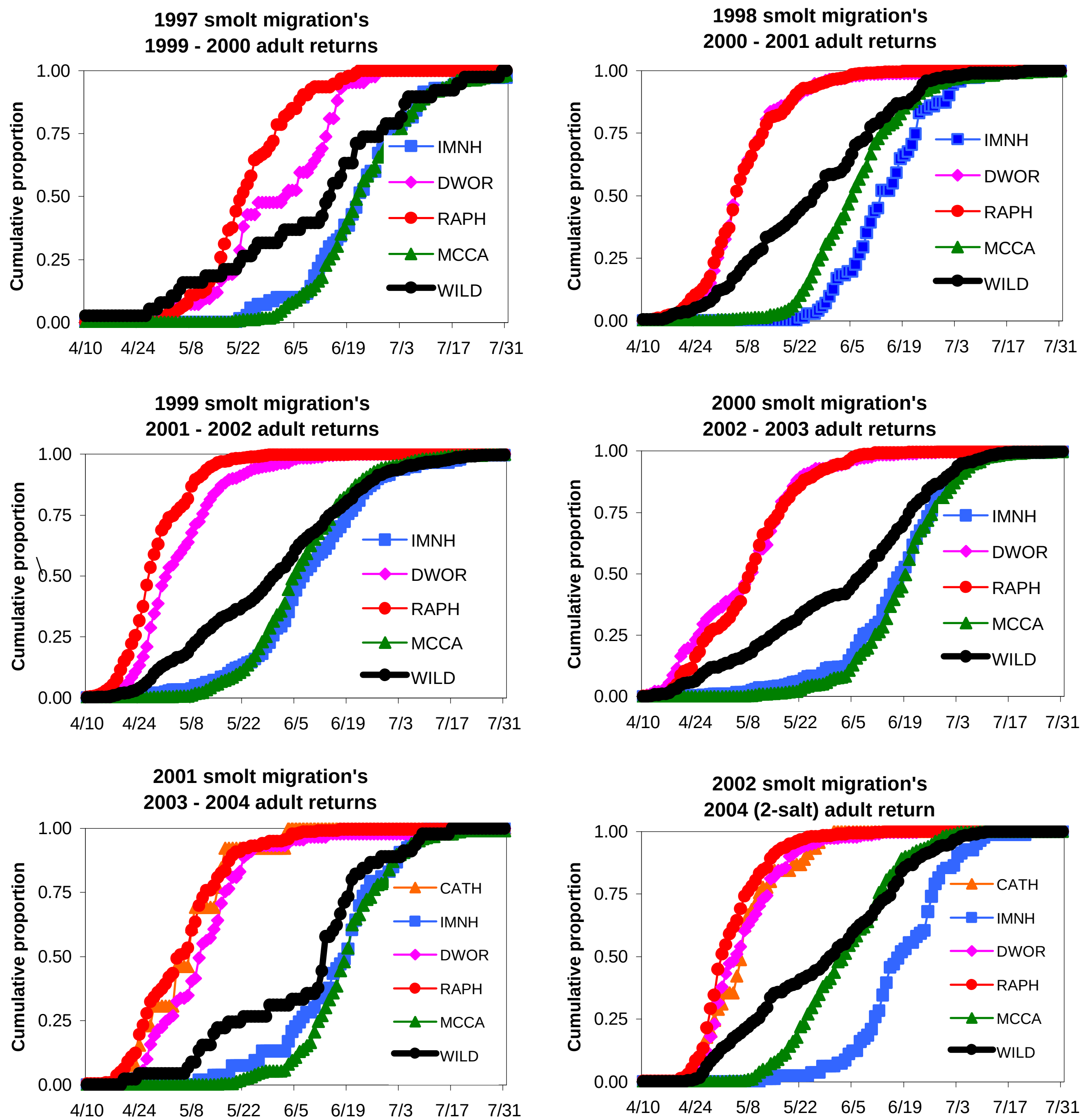


Figure 3. Passage timing at Lower Granite Dam of PIT tagged hatchery Chinook adults (composite of the two return years for the 2- and 3-salt fish from the same brood year) for PIT tagged hatchery fish released as smolts in 1997 to 2002 for the CSS (cath = Catherine Ck AP, dwor = Dworshak H, imnh = Imnaha AP, mcca = McCall H, raph = Rapid River H, and wild = aggregate wild Chinook PIT tag releases).

CHAPTER 2

Smolt-to-adult survival rate from Lower Granite Dam (smolts) to Lower Granite Dam (adults)

METHODS

Program for Parameter Estimation and Confidence Intervals

The schematic of the computer program written to compute the in-river survivals, SARs, ratios of selected SARs, and D indices along with associated bootstrapped confidence intervals is presented in Figure 4. During a bootstrapped iteration, the

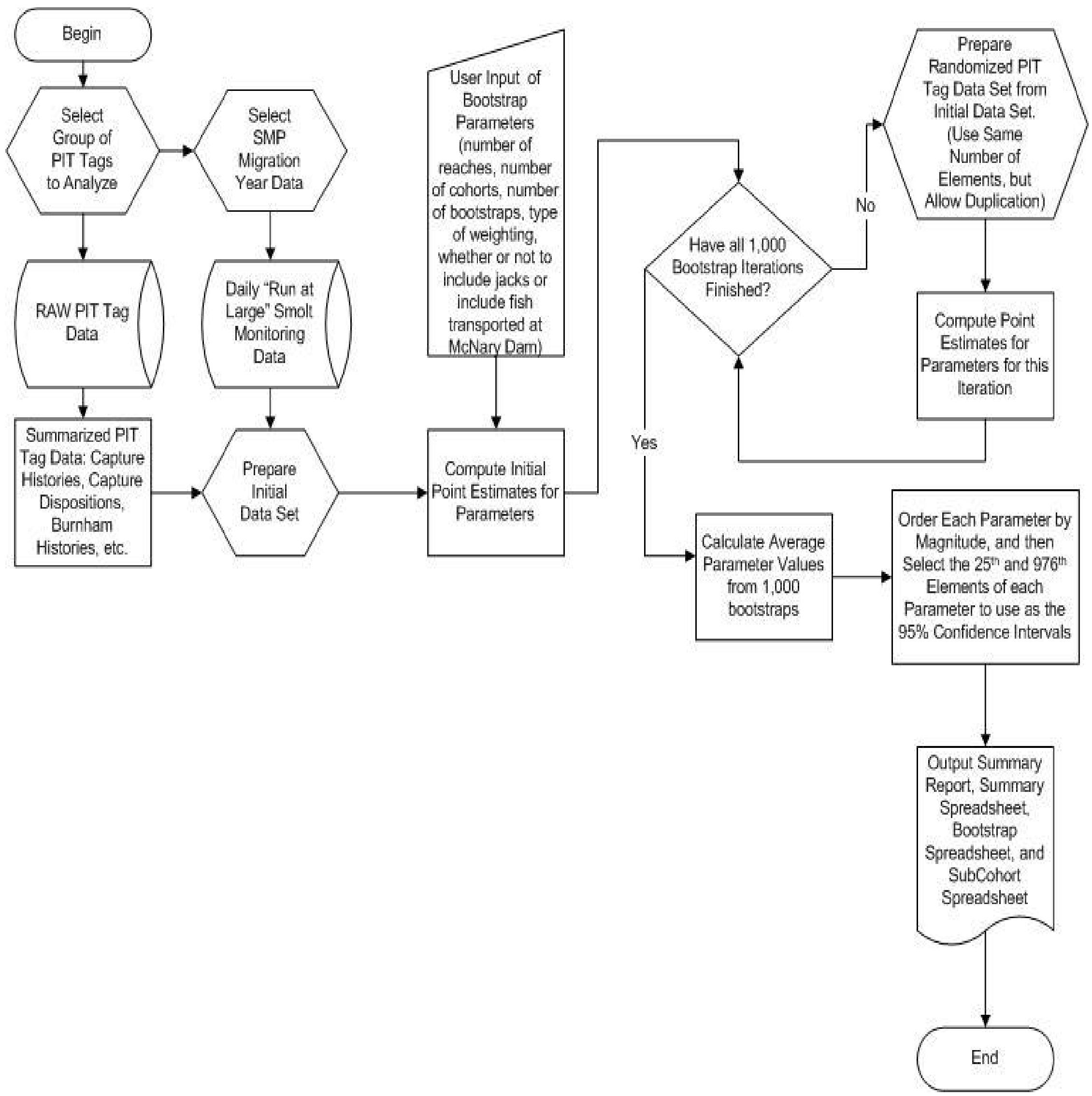


Figure 4. Schematic of bootstrap program for estimating study parameters and associated 95% confidence intervals.

computer program obtains a random sample of PIT tags with replacement from the full set of PIT tags in the particular group of interest. During each iteration, all relevant study parameters are computed, while retaining the raw data used in the computations. From the set of bootstrap iterations (typically 1,000 runs), non-parametric 95% confidence intervals were computed for each parameter of interest using methods of Efron and Tibshirani 1993).

In-river Survival Estimation

PIT-tagged smolts can be detected in the bypass/collection facilities at LGR, LGS, LMN, MCN, JDA and BON, and in trawls equipped with PIT tag detectors deployed near Jones Beach (TWX). This array of detection sites is analogous to multiple recaptures of tagged individuals allowing for standard multiple mark-recapture survival estimates over several reaches of the hydro system. The Cormack-Jolly-Seber (CJS) (Cormack 1964; Jolly 1965; and Seber 1965) methodology was used to obtain point estimates of survival with corresponding standard errors from release to Lower Granite Dam tailrace and up to five reaches between Lower Granite Dam tailrace and Bonneville Dam tailrace. The likelihood equations underlying the CJS methodology used in the CSS are shown in the following text box. Description of the "full sample" and "subcohorts" CJS approaches will be presented in the next several paragraphs.

SUBCOHORTS CJS:

The likelihood used to estimate in-river survival probabilities for each temporal stratum created at LGR can be written in short form as follows,

$$L\left(S_{ij}, p_{lj} \middle| R_i, m_{ij}\right)$$

where S_{ij} **= survival probability to the *i*^th^ location for the *j*^th^ stratum,**

p_{ij} **= detection probability at the *i*^th^ location for the *j*^th^ stratum,**

R_j **= number released for the *j*^th^ stratum (equal to number of tagged fish detected at LGR and returned to the river in the *j*^th^ stratum),**

m_{ij} **= number of tags observed at the *i*^th^ location for the *j*^th^ stratum.**

FULL SAMPLE CJS:

The notation for the full sample likelihood can be expressed as follows,

$$L\left(S_i, p_i \middle| R_i, m_i\right),$$

where S_i **= survival probability to the *i*^th^ location, common across all *j* strata,**

p_i **= detection probability at the *i*^th^ location, common across all *j* strata and,**

$$m_i = \sum_{j=1}^{n} m_{ij} \ .$$

In the estimation of in-river survival rates, the CJS method assumes all PIT tagged smolts out-migrate together in a single migration year. PIT tagged fish that completely migrate as smolts in a year later than the expected are excluded from the release group because these "hold-over" fish would experience a different set of riverine and dam operational conditions. PIT tagged fish that are detected at upper dams during their reported migration year, but then holdover and continue their migration passed lower dams the following year are still included in the release group. However, these fish must only be considered as return-to-river fish for survival estimation purposes through the last dam where they are detected in their reported migration year. Effectively, these hold-over fish are handled as removals for estimation purpose at that last dam.

The computer program computed the in-river survival and associated bootstrapped confidence intervals with two methodologies. The first methodology used the CJS directly on the total PIT tagged release group of interest, producing survival estimates for up to six reaches between release site and tailrace of BON (survival estimates S_1 through S_6); see Appendix B. This method is called the "full sample" CJS in this annual report. The total number of reaches to estimate was a function of the number of smolts in the initial release and recovery effort available in that year. Prior to 1998, there was only limited PIT tag detection capability at JDA and the NMFS trawl. Therefore, reliable survival estimates in those years were only possible to the tailrace of LMN or MCN. In years subsequent to 1998, reliable survival estimates to the tailrace of JDA or BON have been possible. An estimate of survival was considered unreliable when its coefficient of variation exceeded 25%. Estimates of individual reach survival (e.g. LGR-LGS) can exceed 100%; however, this is often associated with an underestimate of survival in preceding or subsequent reaches. Therefore, when computing an overall multi-reach survival estimate (the product of individual reach estimates), we allow individual reach survival estimates to exceed 100%.

The second method applies the CJS method to a subset of the PIT tagged data based on dates of detection at LGR. The PIT tagged passage distribution was stratified into a series of similarly-sized smolt "subcohorts", and reach survival estimates S_2 to S_6 were obtained for each separate subcohort using the CJS from LGR tailrace to the tailrace of the lowest dam determined when applying the first method above. In prior CSS annual reports, a weighted average of the survival estimates S_j across the set of subcohorts was computed, where the weight was the product of inverse relative "theoretical" variance and proportion of the total wild Chinook passage index that occurred during the same timeframe as the subcohort's passage dates at LGR. Weighting by the inverse relative variance gives cohorts with more precise survival estimates greater representation (Sandford and Smith 2002). Weighting by the passage index gives greater representation to cohorts migrating during periods when the largest proportion of the non-tagged smolts are migrating (Bouwes et al. 2002). With specific hatchery releases, the weight used with subcohorts was simply the inverse relative "theoretical" variance. These weighted estimates of S_2 to S_6 were then multiplied together to create the overall reach survival estimate for a given year and group of smolts. But during preliminary investigations of the weighting schemes utilized, it was determined that using the relative "theoretical" variance was creating biases. This is because the total variance consists of both a population component (the between variance component) and theoretical model variance (the within variance component). With no measure of the population variance component available from the single release-recapture methods utilized in this study, the "theoretical" variance alone was used in the weighing. In computing theoretical variance f_i in the i^{th} reach, there are factors of $(1-p_{(i+1)})^2$ that relate the probability of not collecting fish at the downstream site of this reach. See page 115 in Burnham et al. (1987) for "theoretical" variance formula and pages 260-266 for discussion of the estimation of "between" and "within" variance components. Because we were creating subcohorts of equal size at LGR over the season, there was cause for little difference between estimated "theoretical" variance except as one moved out later in the season with higher spill proportions and lower collection efficiencies caused these later and often higher survival estimates to receive a lower weight. The net effect was a bias towards a lower weighted average survival based on the subcohorts approach. Running the same subcohorts with equal weighting (ie, unweighted estimates), we found that the resulting average survival estimate for a reach was much closer to that of their "full sample" CJS survival estimate. Based on these findings, and until more detailed investigation may be performed with simulated data sets (see later discussion of the simulation program developed for the CSS during this contract period), it was decided that results in this year's annual report will concentrate on parameters estimated with the "full sample" CJS method alone.

In the computation of the total LGR tailrace to BON tailrace reach survival, termed V_C, an expansion was necessary whenever less than the full set of survivals S_2 to S_6 was available. The method of expanding survival over the reaches without a direct survival estimate required taking the survival estimated over the upstream portion of the overall reach, converting this to a "per mile" survival rate, and then applying this "per mile" survival rate to the remaining miles of the overall reach to BON. To the nearest mile, the distance from LGR to LMN is 66 miles with 77% of the total reach to BON remaining to be estimated, LGR to MCN is 140 miles with 51% remaining, and LGR to JDA is 216 miles with 24½ % remaining. By using the "full sample" CJS, we were also able to estimate survival all the way to BON in each year from 1999 to 2002 for both wild and hatchery Chinook. This is an improvement over last year's analyses where the V_c for 1999 and 2000 were directly estimated only to JDA. An in-river survival estimate was directly estimated to JDA in 1998 and to MCN in 1995, whereas in the remaining years of 1994, 1996 and 1997, the in-river survival estimate was only available to LMN. Although the "per mile" expansion provides a mechanism to fill in a survival rate in reaches for which no estimate exists, it has a major drawback in that the "per mile" survival rates generated in the Snake River are generally lower, but not always, than the "per mile" survival rates observed in the lower Columbia River based on data from migration years when survival components in the lower Columbia River are directly computable.

In addition, the oscillating nature of reach survival estimates between adjacent reaches compounds the difficulty of accurately expanding survival rates over downstream reaches. Since the population estimated at the end of a reach is the starting population of the next downstream reach, an inaccuracy of that population estimate causes the resulting survival estimates upstream and downstream to be biased, however, the product of those two reaches will be less biased. But starting with a biased high (or low) survival and expanding downstream does not benefit from this biased reducing aspect of the adjacent reaches. Therefore, direct estimates of in-river survival over the longest reach possible are preferable.

Study Categories

The population of PIT tagged study fish arriving at LGR is partitioned into three categories of smolts related to the manner of subsequent passage through the hydro system. Fish are "destined" to either (1) pass in-river through the Snake River collector dams in a non-bypass channel route (spillways or turbines), (2) pass in-river through the dam's bypass channel, or (3) pass in a truck or barge to below BON. These three ways of hydro system passage define the study categories C_0, C_1 and T_0, respectively, of the CSS.

One major objective of the CSS was to compute and compare overall smolt-to-adult survival rates for smolts transported through the hydro system versus smolts migrating in-river. Since 1995, the standard hydro system operation was to transport all smolts collected at LGR, LGS, and LMN throughout the spring and summer seasons, and at MCN only when the subyearling Chinook migration predominates the collections in the summer. An exception to this rule occurred in 1997 when large portions of the collections at LGS and LMN were returned to the river in a fishery agencies/tribal effort to equalize the numbers of smolts being transported and remaining in-river that year. The last year of springtime transportation at MCN occurred in 1994. Although all collected smolts were transported in 1994, there were only 42 PIT tagged wild Chinook with first detection at MCN that were transported. With so few PIT tagged smolts and no adult PIT tag detections, it was not possible to estimate a SAR for yearling Chinook transported from MCN in 1994. Therefore, this status report only addresses the effects of the transportation of yearling wild and hatchery spring/summer Chinook from the Snake River dams.

The PIT tagged study groups should be representative of their non-tagged counterparts, hence PIT tagged fish passing through the hydro system must mimic the experience of non-tagged fish. For example, only first-time detected smolts at a dam may be considered for transportation since non-tagged smolts are nearly always transported when they enter a bypass/collector facility (where PIT tag detectors are in operation) at the Snake River dam. For convenience, we make comparisons between different groups of smolts with different hydrosystem experiences from a common starting and end points. Thus, LGR-LGR SARs must be estimated for all groups even if a smolt was not detected at LGR. Smolts destined for transport at the lower projects include a larger group than actually transported at the lower projects, due to mortality from migrating in-river from LGR to the lower projects. Therefore, an estimated survival rate is needed to convert actual transport numbers at LGS and LMN into their LGR starting number (in LGR equivalents). We define transportation at LGR, LGS, and LMN in terms of LGR equivalents, because we are in effect making our allocation into transportation at each dam from the starting number of fish at LGR. The PIT tagged fish destined for transportation at LGR, LGS, and LMN together form Category T_0. Using the symbols and definitions presented in the following text box, the formula for estimating the number of fish in Category T_0 is

$$T_0 = X_{12} + X_{102}/S_2 + X_{1002}/S_2S_3.$$

Symbol Definitions:

X_{12} = number transported at LGR
X_{102} = number first-detected and transported at LGS
X_{1002} = number first-detected and transported at LMN
S_1 = estimated survival from hatchery release site to LGR tailrace
S_2 = estimated survival from Lower Granite tailrace to LGS tailrace
S_3 = estimated survival from Little Goose tailrace to LMN tailrace
p_2 = estimated collection efficiency at LGR
m_{12} = number of fish first detected at LGR (Lower Granite Dam)
m_{13} = number of fish first detected at LGS (Little Goose Dam)
m_{14} = number of fish first detected at LMN (Lower Monumental Dam)
m_{15} = number of fish first detected at MCN (McNary Dam)
m_{16} = number of fish first detected at JDA (John Day Dam)
m_{17} = number of fish first detected at BON (Bonneville Dam)
m_{18} = number of fish first detected at TWX (lower Columbia River trawl)
d_0 = site-specific removals at dams below LMN of fish not detected previously at a Snake River Dam (includes incidental MCN transport, CSS fish collected for UICFWRU study, and fish accidentally taken for other studies)
d_1 = site-specific removals at dams below Lower Monumental Dam of fish previously detected at a Snake River Dam (includes incidental MCN transport, CSS fish collected for UICFWRU study, and fish accidentally taken for other studies)
d_2 = number of fish removed at LGR regardless of prior capture history (includes transported fish, site-specific mortalities, and unknown disposition fish)
d_3 = number of fish removed at LGS regardless of prior capture history (includes transported fish, site-specific mortalities, and unknown disposition fish)
d_4 = number of fish removed at LMN regardless of prior capture history (includes transported fish, site-specific mortalities, unknown disposition fish, and fish accidentally removed at LMN for studies at another dam)
Note: both d_0 and d_1 are inflated by a constant factor of 2 to offset the approximate 50% survival rate to the lower Columbia River of fish starting at LGR

The PIT tagged smolts that migrate past the Snake River dams undetected and remain in-river below LMN, the last transportation site in the spring season, defines the group most representative of the non-tagged smolts that migrate in-river. These PIT tagged fish form Category C_0. This group's starting number is also computed in LGR equivalents, and therefore requires estimates of survival. To estimate the number of smolts that were not detected at any of the collector projects, the number of smolts first detected (transported and non-transported) at LGR, LGS, and LMN (in LGR equivalents) is subtracted from the total number of smolts estimated to arrive at LGR. The number of Chinook smolts arriving at LGR dam was estimated by dividing the number of smolts detected at LGR by the "full sample" CJS estimate of LGR collection efficiency specific for the Chinook group of interest. Based on simulations, this approach, which previously had only been applied to hatchery groups, was found to be less biased over the method of estimating daily LGR collection efficiencies described in Sandford and Smith (2002) for wild Chinook groups. Smolts detected at MCN, JDA, and BON are included in this group as fish entering the bypass facilities at these projects, both tagged and untagged, are generally returned to the river. Using symbols defined in the text box, the formula for estimating the number of fish in Category C_0 is

$$C_0 = m_{12}/p_2 - (m_{12} + m_{13}/S_2 + m_{14}/S_2S_3) – 2d_0$$

where:

$p_2 = m_{12} /(m_{12} + Z_2(R_2/r_2))$
$Z_2 = m_{13} + m_{14} + m_{15} + m_{16} + m_{17} + m_{18}$,
$R_2 = (m_{12} – d_2)$, and
$r_2 = m_{23} + m_{24} + m_{25} + m_{26} + m_{27} + m_{28}$

The last group of interest is fish that are detected at one or more Snake River dams and remain in-river below LMN. These PIT tagged fish form Category C_1. These fish are important because of the need to estimate reach survival components. Although these fish do not mimic the general untagged population, they are of interest with regards to possible effects of passing through Snake River dam bypass/collection systems on subsequent survival. Using symbols defined in the text box, the formula for estimating the number of fish in Category C_1 is

$$C_1 = (m_{12} – d_2) + (m_{13} – d_3)/S_2 + (m_{14} – d_4)/S_2S_3 – 2d_1.$$

<u>Estimation of SARs and Ratios of SARs for Study Categories</u>

To date, LGR has been the primary upriver evaluation site for many objectives of the CSS. The adult fish passage facilities at LGR incorporate an adult fish trap located just off the main fish ladder. When trapping occurs, adult fish are diverted from the main fish ladder into a pool area where two false weirs, a metal flume, coded wire detectors, and PIT detectors are in line leading to the adult holding trap. Unmarked fish or fish not required to be diverted will drop back into the fish ladder, and continue up to the main fish ladder where they can exit to the forebay of the dam. In return years through 2001, the tag identification files for CSS PIT tagged Chinook were installed in the separation-by-code program that allows the PIT tag detector to selectively trip a gate and shunt these fish to the holding trap. This was done in order to obtain data on fish length, sex, condition (injury), and age (scale sample). Beginning in return year 2002, these data were no longer collected at LGR. Fish length, sex, and condition data will be obtained from the hatcheries. Therefore, returning adults reaching LGR will continue upstream without any handling at that site. Adults detected at LGR are assigned to a particular study category based on the study category they belonged to as a smolt (fish with no previous detections at any dam are automatically assigned to Category C_0).

As stated earlier, we only used first-time detections for transported smolts in order to represent the non-tagged smolts. Smolts have been transported at LGR, LGS, and LMN throughout the migration season and starting 1995 only during the summer season at MCN. To accurately portray the overall springtime transportation operations, all Snake River collection projects where smolts were collected and transported must be included. However, because most PIT-tagged wild Chinook were returned to river at the collector dams and the CSS hatchery Chinook were mostly transported at LGR in the early years of this study, the number of PIT-tagged smolts transported at some projects did not adequately reflect the run-at-large. However, because a portion of the PIT tagged fish are returned to the river to allow for a mark-recapture estimate of in-river survival, the proportion of tagged smolts transported at a collection facility may not represent the proportion of non-tagged fish that were transported at these sites. Therefore, when site-specific SARs exist, estimates of the overall SARs of the aggregate dams must account for the proportion of the PIT-tagged smolts transported to the proportion of the run-at-large that actually was transported at each project to avoid bias. Using a stratified sampling approach, each dam was considered a stratum containing an estimated number of tagged and untagged smolts that are to be transported. Details of the theory are presented in Berggren *et al*. (2002). The resulting formula for estimating $SAR(T_0)$ uses the site-specific SAR (adults at LGR / smolts at specific dam) along with estimates of the total number of PIT tagged fish that would have been transported at each dam (estimates t_j for the j^{th} dam) if all PIT tagged fish had been routed to transport at the same rate as the untagged fish.

$$SAR_1(T_0) = [t_2 \bullet SAR(T_{LGR}) + t_3 \bullet SAR(T_{LGS}) + t_4 \bullet SAR(T_{LMN})] / [t_2+(t_3/S_2)+(t_4/S_2S_3)]$$

When site-specific SARs do not exist or are unrealistic due to very low numbers of PIT tagged smolts available, a more simplified estimate of the transportation SAR is used. When the same proportion of collected PIT tagged smolts are routed to transportation at each collector dam, the simplified estimate is self-weighting and is equivalent to the estimate $SAR(T_0)$ shown above. The same transportation proportion was at each Snake River collector dam beginning in 2000 for hatchery Chinook and 2002 for wild Chinook. The formula for the simplified estimate is:

$$SAR_2(T_0) = adults(T_0)/T_0$$

The SARs for Category C_0 and C_1 smolts do not require the same type of adjustment as was needed for Category T_0 smolts. The SAR formula is like the simplified transportation estimate in that the number of adults is simply divided by number of smolts (in LGR equivalents) for each respective study category:

$$SAR(C_0) = adults(C_0)/C_0$$
$$SAR(C_1) = adults(C_1)/C_1$$

In this report, the adult count is the sum of all 2-salt and 3-salt returning Chinook for the category of interest. All jacks (1-salt) and mini-jacks (0-salt) are excluded from the adult count. Adult returns for this report include adults detected at BON and LGR through August 2, 2004. The reported SARs for migration year 2002 Chinook must be viewed as preliminary until the 3-salt adults return in 2005.

In addition, ratios of selected pairs of these SARs are computed to characterize differences in survival rate. The primary ratio is $SAR(T_0)/SAR(C_0)$ which has been termed the transport-benefit ratio in earlier NOAA Fisheries studies. Another ratio is $SAR(C_1)/SAR(C_0)$ was is used to characterize the impacts of passing through Snake River dams' bypass systems back to the river. Smolts in Category C_1 may pass through 1 to 3 Snake River collector dams plus the bypasses at 0 to 3 lower Columbia River dams, whereas the smolts in Category C_0 may only pass through 0 to 3 bypasses at lower Columbia River dams.

New for migration year 2001 is the use of SAR(T_0)/SAR(C_1) to characterize the effects of transportation in that drought year. Because of the low flow conditions of 2001, the management approach was to not spill at Snake River collector dams and transport all collected fish. High collection efficiencies (CJS estimates shown in parenthesis after dams) were measured in 2001 for CSS hatchery Chinook at LGR (71-79%), LGS (70-78%), and LMN (58-66%). The collection efficiency estimates jump to 83% for the aggregate wild Chinook at LGR and LGS. The probability of passing undetected in-river passed these three collector dams was less than 3%, so the population of PIT tagged fish in the Category C_0 was negligible. In order to have an in-river group of PIT tagged smolts to compare with the transported smolts, it was necessary to change the in-river reference group from Category C_0 to Category C_1. There were several adults that returned with no detection at a Snake River collector dam, but only two hatchery adults (one Rapid River Hatchery fish and one Imnaha Hatchery fish) could be confirmed with a lower Columbia River dam detection as a Category C_0 migrant. The remaining 4 adults – three McCall Hatchery fish and one Rapid River Hatchery fish – had no detections at any dam, and therefore were more likely to have been collected at Lower Granite Dam and passed to the raceways undetected along with the untagged fish. This was due to the large volume of fish collected at Lower Granite Dam in 2001 potentially causing a greater probability of non-detection of PIT tagged smolts that year. Any undetected smolt would have a greater probability of following the untagged fish into the raceways than following another PIT tagged fish back to the river. In addition, there was a series of outages on May 21 that exceeded the duration of time that the back-up computers could record PIT tag detections, and resulted in an 18 minute loss of PIT tag detections around 3 PM that day. PIT tagged smolts passing during that interval would have ended up in the raceways undetected, and of the CSS hatchery stocks, more McCall Hatchery Chinook are present in late May than the other hatchery groups. So it appears more than just coincidental that most returning adults with no detection at any dam are from McCall Hatchery.

Weighting of SARs for Study Category to Create Annual Indices

In order to create annual time series of SARs reflective of the run-at-large wild spring/summer Chinook originating above LGR and for the individual hatcheries used in the CSS, a weighted average of the SARs of PIT tagged fish in each study category was obtained. This was accomplished by combining SARs for the C_0 and T_0 groups (plus C_1 group in 1997). The weight for each study category is equal to the estimated proportion of the run-at-large utilizing the route of passage represented by that particular study category. An underlying assumption is that the aggregate PIT tagged wild Chinook represents the wild run-at-large migrating through the FCRPS dams. This assumption is not necessary for the hatchery Chinook since they were collected and PIT tagged directly from hatchery production.

The weights are necessary since some PIT tagged fish migrate through the system differently than the run-at-large due to the study requirement of obtaining in-river survival estimates between key dams in the hydro system. Except for migration year

1997, virtually all smolts from the run-at-large collected at LGR, LGS, and LMN were transported, whereas there was a fairly large portion of PIT tagged fish returned to the river each year for survival estimation purposes. In those years, the PIT tagged fish in study categories T_0 and C_0 best represented the run-at-large rather than any fish in study category C_1, except in 2001 (see below). In migration year 1997, a large portion of run-at-large smolts were purposely returned to the river at LGS and LMN, thus making PIT tagged fish in study category C_1 an additional group that represented a portion of the run-at-large in that year. If we had routed PIT tagged smolts to transportation in the same proportion as the run-at-large in migration years 1995 to 2001, the total number of PIT tagged smolts that would have been transported from each of the three Snake River collector dams would be estimated as t_j, where t_2 is at LGR, t_3 is at LGS, and t_4 is at LMN. The total transported across the three Snake River collector dams is then given by $T^* = t_2+t_3/S_2+t_4/(S_2S_3)$. The reach survival estimates, S_j's, are presented in Appendix A Tables A-2 to A-6. In 1994 all PIT tagged wild Chinook collected at MCN were transported because the ability to return PIT tagged fish to the river at that dam did not exist until 1995. In years after 1994 virtually all PIT tagged wild Chinook were returned to the river at MCN. Therefore for migration year 1994, a transport component $t_5/(S_2S_3S_4)$ for MCN is added to the sum of T*.

The study category C_0 PIT tagged fish, which by definition all pass the three Snake River collector dams undetected (by going through either the spillways or turbines), directly mimics run-at-large without the need for any further adjustments. The estimated LGR population of PIT tagged fish in study categories C_0, C_1 and T_0 for a particular hatchery minus the C_0 and estimated T* PIT tagged fish gives an estimate of the number of C_1 category fish that mimic the run at large in 1997, whereas in 1998 to 2001 the number of C_1 category fish that mimic the run-at-large was zero. Except for 2001, the proportion of the run-at-large that is represented by each category of PIT tagged fish is then multiplied by the SAR obtained with PIT tagged fish for that particular study category to obtain the overall weighted $SAR_{LGR\text{-}to\text{-}LGR}$. For migration year 2001, the SAR of Category C_1 fish will be applied to the proportion of fish in Category C_0, because as will be described later in this chapter, the few adult that returned with no detections as smolts at any dam were determined to have been most likely collected at LGR that passed to the raceways undetected along with the untagged fish.

The trend in annual indices is only done through migration year 2001, since the 3-salt returns from migration year 2002 will not available until next year. The annual SAR indices of wild Snake River spring/summer Chinook cover migration years 1994-2001 and each hatchery Chinook group covers migration years 1997-2001.

Estimation of *D*

The transport SAR(T_0) and in-river SAR(C_0) estimates provide a measurement of survival from smolts-to-adults includes survival rates through the hydropower system for transported (V_T) and for in-river (V_C) smolts as well as survival after smolts pass BON and return to LGR. Like parameter T/I, the parameter *D* is the ratio of the SAR survival rate of transported smolts relative to smolts migrating in-river, but this time the SAR survival rate is measured from BON (smolts) to LGR (adults). If the *D* ratio is around 1, there is no differential mortality occurring between transported and in-river migrating smolts once they are both below BON. However, with *D* ratios averaging around 0.6 for hatchery and wild Chinook in recent years (see Bouwes 2002), there is evidence that the post-BON survival rate of in-river fish is higher than that of transported fish.

D is computed as the ratio of post-BON survival rate of Category T_0 transported fish to post-BON survival rate of Category C_0 in-river fish as:

$$D = \text{BON-LGR } SAR_T / \text{BON-LGR } SAR_C$$

However, the number of smolts passing BON is not observed. Therefore, to estimate $SAR_{BON\text{-}to\text{-}LGR}$ for transported and in-river migrating fish, the hydrosystem survival rates V_T and V_C are removed from their respective LGR-LGR SAR values. The resulting estimate of *D* is

$$D = [SAR(T_0) / V_T] / [SAR(C_0) / V_C]$$

where V_C is the estimated in-river survival from LGR tailrace to BON tailrace and V_T is the assumed direct transportation survival rate of 98% adjusted for survival to the respective transportation site.

In the denominator of *D* (in-river portion), the ratio is $SAR(C_0)/V_C$, where V_C is estimated with the CJS estimate expanded to the entire hydro system (LGR to BON). Errors in estimates of V_C influence the accuracy of *D* estimates. Since estimating V_C through 1998 required a "per/mile" expansion ranging from 25 to 77% of the total LGR-to-BON reach, the *D* reported for 1994, 1995, 1996, and 1997 may be less accurate than those of later migration years.

In the numerator of *D* (transportation portion), the ratio is $SAR(T_0)/V_T$, where V_T must be estimated following the same logic that was applied to $SAR(T_0)$. The parameter V_T takes into account an estimate of survival to each transportation site, effectively putting V_T into LGR equivalents as is $SAR(T_0)$, and a fixed 98% survival rate for the fish once they are placed into the transportation vehicle (truck or barge). The resulting formula for estimating V_T uses estimates of the total number of PIT tagged fish that would have been transported at each dam (estimates t_j for the j^{th} dam) if all PIT tagged fish had been routed to transport at the same rate as the untagged fish. The V_T estimate is $V_T = 0.98 * [t_2 + t_3 + t_4] / [t_2 + (t_3/S_2) + (t_4/S_2S_3)]$.

Dividing V_T into $SAR_1(T_0)$ and simplifying terms produces the numerator of *D* as

$$\begin{aligned} SAR_1(T_0)/V_T &= [t_2 \bullet SAR(T_{LGR}) + t_3 \bullet SAR(T_{LGS}) + t_4 \bullet SAR(T_{LMN})] / [0.98(t_2 + t_3 + t_4)] \\ &= [Pt_2 \bullet SAR(T_{LGR}) + Pt_3 \bullet SAR(T_{LGS}) + Pt_4 \bullet SAR(T_{LMN})]/0.98 \end{aligned}$$

where $Pt_j = t_j / (t_2 + t_3 + t_4)$ for j =2 to 4.

Since $SAR_2(T_0)$ is self-weighting across the collector dams when the expected proportion transported of collected fish is the same at each dam, the numerator of *D* is simply $SAR_2(T_0)/(0.98)$.

RESULTS AND DISCUSSION: WILD CHINOOK

The PIT tagged wild Chinook used in the CSS were initially PIT tagged to satisfy the goals of several different research studies. Therefore, we had to ensure that smolts used in our annual aggregate groups were actually migrating out in the respective year of interest. Tagging activities at upper basin traps may have periods of time when more than one age class of smolts are being PIT tagged and recorded in the same tagging file. This occurs primarily in late spring and early summer during the transition from the tagging of the current year's outmigrants and to the tagging of the next year's outmigrants. Review of tagging files in PTAGIS and dates of detections at dams, we found a window after May 20 and before July 25 as having the greatest overlap in tagging of multiple age classes of wild Chinook. Therefore, for a particular migration year designated by the researchers, the CSS also looks at the release date of the PIT tagged wild Chinook and retains those fish released from July 25 of the preceding year through May 20 of the migration year of interest. In addition, wild Chinook within the ten month period from July 25 to May 20 that were still detected at the dams or trawl in a year outside the migration year were also excluded (this was less than 0.1% in all years except 1994 when it was 0.18%) because estimates of collection efficiency and survival must reflect a single year. The resulting numbers of wild Chinook per year used in the annual aggregates are presented in Table 4.

Table 4. Numbers of wild spring/summer Chinook in the annual aggregate groups of PIT tagged smolts originating above Lower Granite Dam from 1994 to 2002 based on 10-month tagging period from July 25 to May 20.

Migration Year	Wild Chinook PIT tagged between 7/25 and 5/20	Number migrating outside of expected migration year	Final number of wild Chinook in each annual aggregate group
1994	49,719	60	49,659
1995	74,692	52	74,640
1996	21,532	9	21,523
1997	9,791	10	9,781
1998	33,850	14	33,836
1999	81,495	N/A	81,495
2000	67,882	41	67,841
2001	47,788	13	47,775
2002	67,334	3	67,331

The number of returning wild Chinook adults and jacks from migration years 1994 to 2002 is shown in Table 5. For the completed migration years 1994 to 2001, the average percent of the total return was 3.6% jacks, 64.6% 2-salt, and 31.8% 3-salt. In addition there was one 4-salt adult returning from the 2000 out-migration. All further analyses involving adult returns include only 2-salt and 3-salt fish, thereby excluding all jacks from the adult count.

Table 5. Number of returning PIT tagged wild Chinook adults and jacks detected at Lower Granite Dam that were PIT tagged during the 10-month period from July 25 to May 20 for each migration year between 1994 and 2002.

Migration Year	Jacks 1-salt	Adults 2-salt	Adults 3-salt	Percent 1-salt	Percent 2-salt	Percent 3-salt
1994	1	11	11	4.3	47.8	47.8
1995	1	38	20	1.7	64.4	33.9
1996	0	11	5	0.0	68.8	31.3
1997	2	33	5	5.0	82.5	12.5
1998	17	148	47	8.0	69.8	22.2
1999	25	517	144	3.6	75.4	21.0
2000	9	259	312 (1[B])	1.5	44.6	53.7 (0.2 [B])
2001	2	30	15	4.3	63.8	31.9
2002[A]	26	196	N/A	N/A	N/A	N/A
Average				**3.6**	**64.6**	**31.8**

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

[B] Migration year 2000 has one 4-salt adult shown in the parenthesis under 3-salt column.

The numbers of PIT tagged wild Chinook actually transported in migration years 1994 to 2001 has been relatively small due to the fact that the standard protocol in those years was to return all PIT tagged smolts back to the river (Table 6). Until 2002, the most common way for PIT tagged wild Chinook to be transported was to first be detected in the sample room. At each dam there exists a sampling program that obtains a daily timed collection (typically 2-6 subsamples per hour of varying duration for 24-hrs) of fish for hands-on counts by species and condition indexing. This process requires anesthetizing the fish collected. Both PIT tagged and untagged fish are collected for processing during the timed subsamples. Most of the PIT tagged wild Chinook utilized in the CSS evaluation to date were transported following this collection process. Beginning with the 2002 out-migration, the CSS coordinated with state and tribal research programs to purposely route 50% of the first-time detected PIT tagged wild Chinook smolts at the

Table 6. Number of PIT tagged wild Chinook actually transported from each dam and estimate (t_i) of total PIT tagged wild Chinook that would have been transported if all PIT tagged fish had been transported at same rate as the untagged run-at-large.

Migr. Year	Lower Granite Dam		Little Goose Dam		Lower Monumental Dam	
	Actual	t_2	Actual	t_3	Actual	t_4
1994	1,051	6,851	387	2,094	330	1,308
1995	1,702	9,657	356	3,626	156	1,490
1996	268	2,269	85	1,749	32	927
1997	185	1,064	30	335	11	171
1998	820	7,669	359	4,002	79	1,632
1999	1,107	8,183	319	14,213	287	4,594
2000	327	7,095	244	6,603	187	2,095
2001	451	18,062	72	2,904	13	278
2002	1,638	4,813	1,854	6,505	167	3,705
9-yr mean percent[1]		**7,296 53 %**		**4,670 34 %**		**1,800 13 %**

[1] Estimated percentage of total transported population transported at each Snake River dam.

Snake River transportation facilities to the raceways for transportation. This action provided more PIT tagged wild Chinook smolts in the transportation category in 2002.

Although dam-specific transportation SARs [*e.g.*, SAR(T_{LGR}), SAR(T_{LGS}), and SAR(T_{LMN})] were computed for the Snake River dams for migration years 1994 to 2002, most of these SAR estimates had wide confidence intervals (Table 7) due to extremely small numbers of PIT tagged wild Chinook transported at each dam (Table 6). For example, the 95% CI lower limit for SAR(T_{LGS}) and SAR(T_{LMN}) was zero in 1994 to 1998, while the 95% CI lower limit for SAR(T_{LGR}) was zero in 1996 and 1997. The non-parametric 95% confidence intervals were right skewed, with widths over twice the magnitude of their respective point estimates (Table 7). The extremely small numbers of transported PIT tagged wild Chinook from LMN resulted in no adult returns and SAR(T_{LMN}) of zero in 5 years at LMN. However, 13% of the total wild yearling Chinook transported in the Snake River occurred at LMN on average (Table 6). The inclusion of LMN in the computations would negatively bias the estimate of SAR(T_0) because of the PIT tagged smolts routed to transportation in these early years made it difficult to obtain reliable total Snake River transportation SARs for wild Chinook. On the other hand, one PIT tagged adult returning out of 30 PIT tagged smolts transported at LGS in 1997 produced an extremely high SAR of 6.67 which would contribute positive bias to the computed SAR(T_0) for that year. To assess the impact of low probability that an adult would return from the small number of PIT tagged smolts released, two estimates of transportation SAR will be presented, $SAR_1(T_0)$ and $SAR_2(T_0)$, which were each described in the methods section of this report.

Table 7. Estimated dam-specific transportation SAR percentages of PIT tagged wild spring/summer Chinook in the annual aggregate groups for 1994 to 2002 (95% confidence intervals in parenthesis).

Migration Year	SAR(T_{LGR}) %	Adults #	SAR(T_{LGS}) %	Adults #	SAR(T_{LMN}) %	Adults #
1994	0.67 (0.19 – 1.15)	7	0.52 (0.0 – 1.34)	2	0	None
1995	0.41 (0.17 – 0.72)	7	0.28 (0.0 – 0.96)	1	0	None
1996	0.37 (0.0 – 1.19)	1	1.18 (0.0 – 3.95)	1	0	None
1997	1.08 (0.0 – 2.8)	2	6.67 (0.0 – 17.2)	2	0	None
1998	1.34 (0.61 – 2.18)	11	0.84 (0.0 – 1.96)	3	1.27 (0.0 – 4.40)	1
1999	2.53 (1.63 – 3.47)	28	2.82 (1.29 – 4.69)	9	2.09 (0.70 – 3.86)	6
2000	1.22 (0.29 – 2.60)	4	2.46 (0.85 – 4.70)	6	1.07 (0.0 – 2.86)	2
2001	1.33 (0.43 – 2.55)	6	1.39 (0.0 – 4.65)	1	0	None
2002[A]	0.49 (0.18 – 0.87)	8	0.81 (0.43 – 1.22)	15	0.60 (0.0 – 1.94)	1

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

The estimated population numbers of PIT tagged wild spring/summer Chinook smolts arriving at LGR each CSS study category, T_0, C_0, and C_1, are presented in Table 8, along with the bootstrapped 95% confidence intervals. The survival rates used to convert PIT tag numbers to LGR-equivalents were based on the "full sample" CJS method. From 1995 to 2000, over two-thirds of the PIT tagged wild Chinook population arriving LGR were destined for Category C_1. In 2001 this percentage increased to 91% in Category C1, while in 2002, it dropped to 54%. This drop in 2002 was due to more of the collected PIT tagged wild Chinook being routed to transportation as a result of the CSS coordination effort to get more PIT tagged wild Chinook routed into transportation. The number of smolts in Category T_0 in 2002 was the highest of any prior year. Unfortunately, there was only 546 PIT tagged wild Chinook in Category T_0 in 2001, since in that year when less than 2% of wild Chinook run-at-large was "destined" to pass in-river through turbines at all three Snake River collector dams. Generally, fish in categories T_0 and C_0 mimic the untagged population, but in 1997 a portion of the in-river migrants were of Category C_1 due to bypass protocols implemented during April and May at LGS and LMN.

Table 8. Estimated number of PIT tagged wild spring/summer Chinook (aggregate of fish tagged in 10-month period between July 25 and May 20) arriving Lower Granite Dam in each of the three study categories from 1994 to 2002 (95% confidence intervals in parenthesis).

Migr. Year	Estimate LGR population	Study category	Estimated smolt numbers per category (using "full sample" CJS survivals)	
1994	15,260	T_0	2,002	(1,912 – 2,104)
	(14,960 – 15,560)	C_0	1,801	(1,672 – 1,931)
		C_1	4,372	(4,164 – 4,586)
1995	20,203	T_0	2,283	(2,184 – 2,379)
	(19,915 – 20,494)	C_0	2,709	(2,595 – 2,831)
		C_1	14,204	(13,981 – 14,449)
1996	7,868	T_0	400	(361 – 443)
	(7,643 – 8,112)	C_0	1,917	(1,791 – 2,051)
		C_1	5,209	(5,037 – 5,396)
1997	2,898	T_0	230	(201 – 260)
	(2,756 – 3,046)	C_0	680	(603 – 755)
		C_1	1,936	(1,826 – 2,054)
1998	17,362	T_0	1,271	(1,205 – 1,345)
	(17,123 – 17,613)	C_0	3,081	(2,954 – 3,206)
		C_1	12,279	(12,072 – 12,483)
1999	33,662	T_0	1,764	(1,679 – 1,846)
	(33,273 – 34,057)	C_0	4,469	(4,320 – 4,608)
		C_1	26,138	(25,818 – 26,476)
2000	25,049	T_0	839	(783 – 904)
	(24,632– 25,453)	C_0	6,491	(6,277 – 6,702)
		C_1	16,827	(16,530 – 17,142)
2001	22,415	T_0	546	(503 – 595)
	(22,196 – 22,636)	C_0	231	(204 – 261)
		C_1	20,298	(20,089 – 20,514)
2002	23,416	T_0	3,880	(3,742 – 4,016)
	(22,994 – 23,863)	C_0	6,289	(6,090 – 6,506)
		C_1	12,676	(12,385 – 12,953)

Higher estimates of $SAR_1(T_0)$, $SAR(C_0)$, and $SAR(C_1)$ for PIT tagged wild spring/summer Chinook occurred in migration years 1997 to 2000 than occurred in migration years 1994 to 1996 and 2001 to 2002 (Table 9). The most significant finding is that the improvement in SARs for both transported and in-river migrating wild Chinook smolts that began in 1997 and remained until 2000 may be over. It would take nearly as many 3-salt returns next year from the 2002 out-migrants as 2-salt return occurred this year to bring the final SARs for 2002 up to the average of the 1997-2000 years. This is not a good sign for recovery of wild Chinook, since the SARs already are seldom getting above the minimum 2% SAR level required for holding the stocks stable and well under the 4% SAR needed for recovery based on PATH evaluations (Marmorek *et al*. 1998). During 1995 to 2000, both over-generation spill and BIOP spill were provided at each Snake River dam during the spring migration, but this has not been the case since 2000. In 2001 and 2002, over-generation spill did not occur due to lower runoff volume in those years.

Table 9. Estimated $SAR_{LGR\text{-}to\text{-}LGR}$ in percentages of PIT tagged wild spring/summer Chinook in the annual aggregate groups for each study category for 1994 to 2002 (95% confidence intervals in parenthesis).

Migration Year	Transport SAR %		In-river SAR %	
1994	$SAR_1(T_0)$	0.50 (0.19 – 0.84)	$SAR(C_0)$	0.28 (0.06 – 0.56)
	$SAR_2(T_0)$	0.45 (0.19 – 0.76)	$SAR(C_1)$	0.09 (0.02 – 0.19)
1995	$SAR_1(T_0)$	0.32 (0.11 – 0.57)	$SAR(C_0)$	0.37 (0.15 – 0.61)
	$SAR_2(T_0)$	0.35 (0.13 – 0.61)	$SAR(C_1)$	0.25 (0.17 – 0.34)
1996	$SAR_1(T_0)$	0.55 (0.00 – 1.53)	$SAR(C_0)$	0.26 (0.05 – 0.52)
	$SAR_2(T_0)$	0.50 (0.00 – 1.29)	$SAR(C_1)$	0.17 (0.08 – 0.30)
1997	$SAR_1(T_0)$	2.08 (0.33 – 4.41)	$SAR(C_0)$	2.35 (1.30 – 3.64)
	$SAR_2(T_0)$	1.74 (0.40 – 3.68)	$SAR(C_1)$	0.93 (0.50 – 1.39)
1998	$SAR_1(T_0)$	1.16 (0.57 – 1.84)	$SAR(C_0)$	1.36 (0.97 – 1.77)
	$SAR_2(T_0)$	1.18 (0.61 – 1.84)	$SAR(C_1)$	1.08 (0.89 – 1.26)
1999	$SAR_1(T_0)$	2.50 (1.57 – 3.58)	$SAR(C_0)$	2.13 (1.67 – 2.56)
	$SAR_2(T_0)$	2.44 (1.72 – 3.20)	$SAR(C_1)$	1.90 (1.74 – 2.07)
2000	$SAR_1(T_0)$	1.58 (0.76 – 2.67)	$SAR(C_0)$	2.39 (2.03 – 2.78)
	$SAR_2(T_0)$	1.43 (0.73 – 2.33)	$SAR(C_1)$	2.34 (2.11 – 2.57)
2002[A]	$SAR_1(T_0)$	0.61 (0.32 – 0.99)	$SAR(C_0)$	1.07 (0.82 – 1.34)
	$SAR_2(T_0)$	0.62 (0.38 – 0.88)	$SAR(C_1)$	0.81 (0.67 – 0.97)
8-yr avg.	**$SAR_1(T_0)$**	**1.16**	**$SAR(C_0)$**	**1.28**
(w/o 2001)	**$SAR_2(T_0)$**	**1.09**	**$SAR(C_1)$**	**0.95**
2001	$SAR_1(T_0)$	1.30 (0.50 – 2.42)	$SAR(C_0)$	N/A
	$SAR_2(T_0)$	1.28 (0.52 – 2.39)	$SAR(C_1)$	0.14 (0.09 – 0.20)

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

The new parameter $SAR_2(T_0)$ shown in Table 9, which takes the total adults in Category T_0 and divides by the total smolts estimated in Category T_0, was created to investigate the biases in the estimates of $SAR_1(T_0)$ caused by few PIT tagged smolts transported from LMN and a "zero" estimated SAR in 5 out of 9 years of study. Although the similarity in magnitude of the $SAR_1(T_0)$ and $SAR_2(T_0)$ estimates implies that the bias due to site specific SAR of LMN being "zero" in over half of the years was relatively small, $SAR_2(T_0)$ is the better estimate to use in pre-1998 years. The greatest difference between these two estimates occurred in 1997 when the site-specific SAR for LGS was too high at 6.7%. Using $SAR_2(T_0)$ to characterize the transportation SAR for 1997 removes this site-specific bias impact. In all years but 2002, the proportion of the total transportation occurring at LMN was much lower than the other two sites, thus reducing the impacts of the "zero" site-specific SARs. In 2002, a larger proportion of the total transportation than usual occurred at LMN, but the CSS program did not route PIT tagged smolts to transportation at that site, so only a small proportion of PIT tags will be transported there. Fortunately, the one returning adult from the low number of PIT tagged smolts transported from LMN provided a site-specific SAR that was comparable to the other dams, and so $SAR_1(T_0)$ and $SAR_2(T_0)$ were virtually identical. This will not always be the case, as will be seen later with the CSS hatchery fish, and so $SAR_2(T_0)$ is the proper transport SAR to use for 2002.

Although $SAR(C_1)$ was not significantly different from other study categories (Table 9), it did follow a trend of lower point estimates than the T_0 and C_0 categories in all years except migration years 2000 and 2002. This may reflect a reduction in overall survival due to passage through bypass systems at Snake River dams, or to the fact that fish in Category C_1 have greater opportunity to pass through more multiple bypasses (1 to 6 bypasses) than do fish in Category C_0 (0 to 3 bypasses) as they migrate in-river through the Snake and lower Columbia rivers.

The annual estimated $SAR_{LGR\text{-}to\text{-}LGR}$ reflective of the run-at-large for wild spring/summer Chinook that outmigrated in 1994 to 2001 (Table 10) is computed by weighting the proportion of the run-at-large transported and remaining in-river by the associated SARs computed with PIT tagged fish for each respective study category. In migration years 1995 to 2001, the estimated numbers of PIT tagged wild Chinook smolts t_j that would have been transported at each of the three Snake River collector dams (j=2 for LGR, j=3 for LGS, and j=4 for LMN) if we had routed PIT tagged smolts to transportation in the same proportion as the run-at-large are presented in Table 6. The total estimated number transported across the three Snake River collector dams in LGR equivalents equals $T^* = t_2+t_3/S_2+t_4/(S_2S_3)$. But in 1994 since all PIT tagged wild Chinook collected at MCN were transported (PIT tagged fish could not be returned to river at that dam until 1995), the MCN transport component, $t_5/(S_2S_3S_4)$, is added with t_5=1,206 and S_4= 0.6567 (the latter resulting from the per-mile expansion of the LGR tailrace to LMN tailrace survival estimate of S_2S_3=0.6872 to cover the entire LGR tailrace to MCN tailrace reach). The proportion of the run-at-large that is represented by each category of PIT tagged fish is then multiplied by the SAR obtained with PIT tagged fish for that study category (from Table 9) to obtain a weighted $SAR_{LGR\text{-}to\text{-}LGR}$ in for each migration year except 2001 when the SAR of Category C_1 fish was applied to the proportion of fish in Category C_0 for the reasons previously described in the methods section.

The trend in the annual $SAR_{LGR\text{-}to\text{-}LGR}$ for Snake River wild spring/summer Chinook ranged from a low of 0.35% in 1995 to a high of 2.45% in 1999, with the lowest SARs occurring in the three pre-1997 years (Table 10 and Figure 5). The annual SAR of 1.29% for the drought year of 2001 was higher than expected given the poor river conditions that year. Nearly 99% of the wild Chinook smolts were transported in 2001. As will be shown later in Table 11, approximately 70% of the PIT tagged wild Chinook

Table 10. Proportion of Lower Granite Dam estimated combined tagged and untagged population of wild Chinook in each study category with associated LGR-to-LGR SAR (returning adults age 4 and 5 in all years).

Migr. Year	Population proportion in study category[1]			SAR for study category			Weighted $SAR_{LGR\text{-}to\text{-}LGR}$
	T_0	C_0	C_1	$SAR(T_0)$[2]	$SAR(C_0)$	$SAR(C_1)$	
1994	0.886	0.114		0.0045	0.0028		0.0043
1995	0.851	0.149		0.0035	0.0037		0.0035
1996	0.735	0.265		0.0050	0.0026		0.0044
1997	0.561	0.235	0.204	0.0174	0.0235	0.0093	0.0172
1998	0.815	0.185		0.0116	0.0136		0.0120
1999	0.863	0.137		0.0250	0.0213		0.0245
2000	0.725	0.275		0.0158	0.0239		0.0180
2001	0.989	0.011		0.0130		0.0014	0.0129

[1] Estimated proportion of total smolt population (tagged and untagged) at LGR in each study category.
[2] Estimated SAR for PIT tagged Chinook for each hatchery group and migration year; $SAR_1(T_0)$ used for 1998-2001 and $SAR_2(T_0)$ used for 1994-1997.
[3] Migration year 2001 uses $SAR(C_1)$ with the C_0 population proportion in the weighted SAR computation.

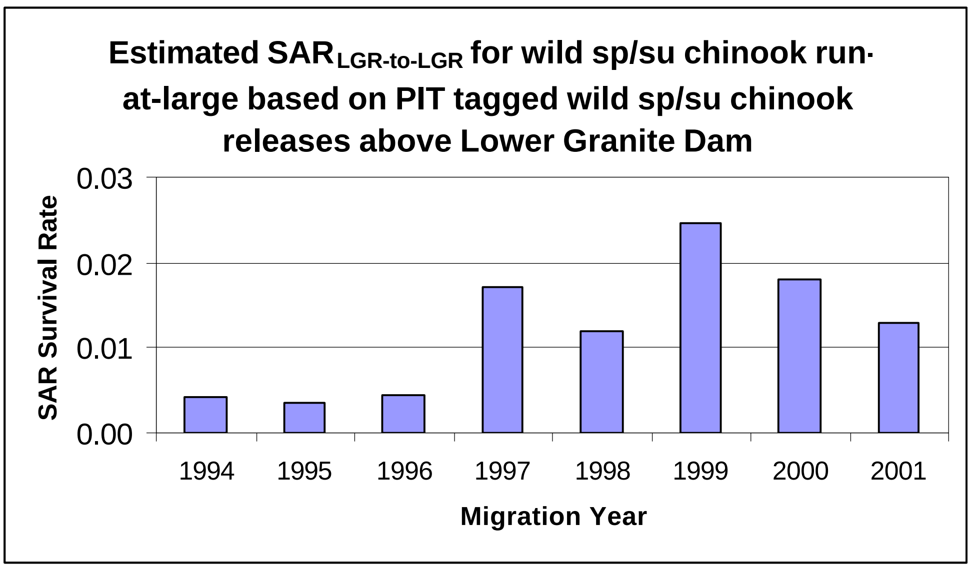


Figure 5. Trend in estimated annual SAR for wild sp/su Chinook based on PIT tagged sp/su Chinook SARs in transport and in-river study categories weighted by estimated proportion of run-at-large in each study category for migration years 1994 to 2001.

adults returning from migration year 2001 outmigrated as smolts from the Imnaha River drainage, and smolts from that drainage tend to have higher SARs, on average, over the study years. Therefore, the magnitudes of annual SARs may not totally reflect the corresponding magnitude of the total run-at-large of untagged wild Chinook. However, the general trend over the years does reflect a period of low SAR survival rates in pre-1997 years when ocean conditions were considered poor and higher SAR survival rates in later years when ocean conditions were considered improved. But only for wild Chinook that outmigrated in 1999 did the overall SAR exceed 2.0, the minimum level required to stabilized the decline of wild spring/summer Chinook stocks in the Snake River basin. According to Marmorek *et al*. (1998), SARs in the 2-6% range will be needed to recover Snake River wild spring/summer Chinook. A contrast of the time series of aggregate wild spring/summer Chinook SARs with the time series for hatchery spring/summer Chinook SARs for migration years 1997 to 2001 will be presented later.

The estimated in-river survival from LGR tailrace to BON tailrace (V_C), transport SAR to inriver SAR (T/C) ratio, and delayed mortality D for the PIT tagged wild spring/summer Chinook aggregate group is presented in Table 11 for migration years 1994 to 2002. Although the V_C in pre-1998 years is less reliable due to the expansion of a "per/mile" survival rate to over 50% of the full reach distance, the trend in the V_C estimates agreed with hydroproject operations in that the V_C estimates were lowest in 1994 and 2001, the two years with limited to no spill provided at the Snake River collector dams. The individual reach survival estimates used to obtain Vc are presented in Appendix Table A-1 for each migration year. The geometric mean (geomean in table) of the T/C ratio was approximately 1.0 for the 8 years 1994 to 2002, excluding 2001. In the drought year of 2001 the T/C ratio was 9.1, while in the other more recent years (1997-2000 and 2002), the 5-yr geometric mean dropped to 0.78. The resulting D estimates are comparable during both the pre-1998 years and year afterwards except for the drought year of 2001. The 5-yr and 8-yr geometric means of D were similar at 0.46 and 0.47, respectively, while in 2001 the D rose to 2.2. In 2001, the T/C ratio had SAR(C_1) in the ratio denominator because there were too few smolts (<2% of LGR population) in Category C_0 that year. Because C_0 fish would have passed through the turbines at all three Snake River collector dams in 2001, it is unlikely that the "true" survival of those fish was any better than that of Category C_1 fish.

Obtaining T/C < 2 in all study years except 2001 is further evidence of the presence of delayed mortality in transported PIT tagged wild Chinook smolts after release below BON. The drought year of 2001 stands out as uniquely different from the other years of study and corresponding SARs show that most non-transported wild Chinook smolts died that year. The pattern of the data suggests that transporting wild Chinook smolts may be no better than in-river migration in years of adequate flows, and therefore is not working as a mitigation tool to guarantee recovery of the listed wild spring/summer Chinook originating in the Snake River basin above LGR.

The PIT tagged wild Chinook used in the CSS analyses is an aggregate of available marked fish released in migration years 1994 to 2002 from the four tributaries above LGR and PIT tagged wild Chinook released at the Snake River trap at Lewiston (plus some PIT tagged wild Chinook released in LGR reservoir in 1994). These wild spring/summer Chinook were PIT tagged by various organizations over a 10-month period at numerous locations with varied sampling gear including incline-plane (scoop) traps, screw traps, electrofishing, hook and line, and beach seining. The numbers of fish PIT tagged in each tributary is not expected to be proportional to the population of wild Chinook present, however, if enough fish are PIT tagged over as wide a range of the population as possible, it is hoped that the PIT tagged aggregate population will adequately represent the total wild Chinook as it relates to SARs computed from LGR as smolts and back to LGR as adults. If the proportion of returning PIT tagged adults from each tributary drainage is similar to the proportion of PIT tagged smolts estimated arriving LGR forebay, then the aggregate of these tributary drainages will provide a representative SAR even if the level of PIT tagging in each drainage is not proportional to the wild population sizes present.

Table 11. Estimated in-river survival LGR to BON (V_C), T/C ratio, and *D* of PIT tagged wild spring/summer Chinook for migration years 1994 to 2002 (95% confidence intervals in parenthesis).

Migration Year	Parameter	Estimate
1994	V_C	0.20 (77% expansion)[A]
	$SAR_2(T_0)/SAR(C_0)$	1.62 (0.49 – 6.05)
	D	0.32 (0.10 – 1.19)
1995	V_C	0.41 (51% expansion)
	$SAR_2(T_0)/SAR(C_0)$	0.95 (0.30 – 2.40)
	D	0.40 (0.12 – 1.11)
1996	V_C	0.44 (77% expansion)
	$SAR_2(T_0)/SAR(C_0)$	1.92 (0.00 – 8.75)
	D	0.86 (0.00 – 3.75)
1997	V_C	0.51 (77% expansion)
	$SAR_2(T_0)/SAR(C_0)$	0.74 (0.13 – 1.87)
	D	0.39 (0.06 – 1.19)
1998	V_C	0.61 (25% expansion)
	$SAR_1(T_0)/SAR(C_0)$	0.85 (0.39 – 1.49)
	D	0.54 (0.24 – 0.95)
1999	V_C	0.59 (0.51 – 0.69)
	$SAR_1(T_0)/SAR(C_0)$	1.17 (0.73 – 1.79)
	D	0.74 (0.45 – 1.14)
2000	V_C	0.48 (0.41 – 0.61)
	$SAR_1(T_0)/SAR(C_0)$	0.66 (0.32 – 1.14)
	D	0.36 (0.17 – 0.64)
2002[B]	V_C	0.61 (0.50 – 0.77)
	$SAR_2(T_0)/SAR(C_0)$	0.58 (0.35 – 0.91)
	D	0.36 (0.20 – 0.61)
1994-2000, 2002	**8-yr geomean T/C ratio**	**0.98**
1994-2000, 2002	**8-yr geomean D**	**0.47**
1997-2000, 2002	**5-yr geomean T/C ratio**	**0.78**
1997-2000, 2002	**5-yr geomean D**	**0.46**
2001	V_C	0.23 (0.20 – 0.28)
	$SAR_1(T_0)/SAR(C_1)$	9.11 (3.02 – 18.6)
	D	2.20 (0.75 – 4.51)

[A] Full reach 95% confidence interval is not available – a constant "per/mile" survival expansion rate is used over the percentage of reach shown in parenthesis.
[B] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

Table 12 shows the proportion of PIT tagged smolts in the combined three study categories, T_0, C_0, and C_1, and the corresponding number of adults (2-salt and 3-salt in each year except 2002, which is incomplete until next year). Although there existed sizeable variability across the four tributaries throughout the 9 years of available data, there was emerging a trend between the proportions of PIT tagged smolts and returning adults. The proportion of PIT tagged adult returns from the Grande Ronde and Salmon River basins was similar, on average, to the proportion of PIT tagged smolts estimated at LGR, whereas the proportion of PIT tagged adult returns relative to proportion of PIT tagged smolts was on average lower for Clearwater River basin fish and higher for Imnaha River basin fish. In terms of the overall average SARs, this indicates that SARs tend to be lower for Clearwater River basin wild Chinook, similar for wild Chinook from the Grande Ronde River and Salmon River basins, and higher for the Imnaha River basin fish. In terms of the PIT tagged wild Chinook aggregate reported in the CSS, this could indicate that our reported SAR estimates are higher than exists for the population as a whole if the Imnaha River basin wild Chinook population makes up much less than 20% of the run arriving LGR forebay and the Clearwater River basin wild Chinook population makes up much more than 15% of the run arriving LGR forebay. In this event, the reported CSS PIT tagged wild Chinook aggregate SARs, which were already lower than the recommended recovery SARs of 2-6% discussed earlier, may be considered an upper threashold for management purposes.

Table 12. Estimated number of PIT tagged wild Chinook smolts in the combined three study categories (T_0, C_0, and C_1) and associated total number of returning adults. Comparison across the four tributaries above Lower Granite Dam of the percentages of study smolts and study returning adults from migration years 1994 to 2002.

Migr. Year	Sum of T_0, C_0, C_1 at LGR	Clearwater River No.	Clearwater River %	Grande Ronde River No.	Grande Ronde River %	Salmon River No.	Salmon River %	Imnaha River No.	Imnaha River %
1994	Smolts	1,645	21.7	1,186	15.7	4,181	55.2	568	7.5
	Adults	5	29.4	1	5.9	6	35.3	5	29.4
	SAR	0.30%		0.08%		0.14%		0.88%	
1995	Smolts	4,740	27.2	2,914	16.7	9,161	52.6	603	3.5
	Adults	16	32.0	9	18.0	24	48.0	1	2.0
	SAR	0.34%		0.31%		0.26%		0.17%	
1996	Smolts	663	9.9	1,773	26.5	2,476	37.0	1,780	26.6
	Adults	1	7.7	3	23.1	4	30.8	5	38.5
	SAR	0.15		0.17%		0.16%		0.28%	
1997	Smolts	201	7.0	1,247	43.5	803	28.0	615	21.5
	Adults	1	2.6	21	55.3	5	13.2	11	29.0
	SAR	0.50%		1.68%		0.62%		1.79%	
1998	Smolts	2,158	13.7	3,332	21.1	5,026	31.8	5,297	33.5
	Adults	18	9.8	30	16.4	45	24.6	90	49.2
	SAR	0.83%		0.90%		0.90%		1.70%	
1999	Smolts	3,959	13.4	4,101	13.9	15,644	52.9	5,866	19.8
	Adults	56	9.7	78	13.5	310	53.8	132	22.9
	SAR	1.41%		1.90%		1.98%		2.25%	
2000	Smolts	2,713	11.9	2,937	12.9	12,250	53.8	4,871	21.4
	Adults	41	7.6	76	14.1	277	51.5	144	26.8
	SAR	1.51%		2.59%		2.26%		2.96%	
2001	Smolts	1,441	6.9	2,190	10.4	8,116	38.6	9,279	44.1
	Adults	2	5.4	2	5.4	7	18.9	26	70.3
	SAR	0.14%		0.09%		0.09%		0.28%	
2002[A]	Smolts	4,190	19.3	3,280	15.1	11,378	52.3	2,909	13.4
	Adults	22	11.8	38	20.3	95	50.8	32	17.1
	SAR	0.53%		1.16%		0.83%		1.10%	
Avg.	**Smolts**	**2,412**	**14.9**	**2,551**	**15.8**	**7,671**	**47.5**	**3,532**	**21.9**
	Adults	**18**	**9.8**	**29**	**15.9**	**86**	**47.0**	**50**	**27.3**
	SAR	**0.75%**		**1.14%**		**1.12%**		**1.42%**	

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

Because the Imnaha River drainage contains summer Chinook stock and Chinook from that drainage tended to have a higher total PIT tag SAR compared to the other three drainages, it was a logical extension to see if PIT tagged wild summer Chinook in general had a higher SAR than PIT tagged wild spring Chinook. In addition to the Imnaha River drainage, summer Chinook exists in the Salmon River drainage in both the South Fork Salmon River and Pahsimeroi River. For PIT tagged wild Chinook that out-migrated in 1998 to 2002, the point estimates of $SAR_1(T_0)$, $SAR(C_0)$, and $SAR(C_1)$ were higher for the PIT tagged summer Chinook aggregate than for the PIT tagged spring Chinook aggregate (Table 13), except for the 2002 transport $SAR_2(T_0)$. Although only two comparisons were statistically significant with non-overlapping 95% confidence intervals (*i.e*, $SAR(C_1)$ in 1998 and 2000), the consistency of the pattern suggests that the summer Chinook stocks tend to have a higher $SAR_{LGR\text{-}to\text{-}LGR}$ regardless of whether the fish migrated in-river or were transported through the hydrosystem.

Table 13. Estimated $SAR_{LGR\text{-}to\text{-}LGR}$ (%) of PIT tagged wild spring Chinook aggregate group versus PIT tagged wild summer Chinook aggregate group for each study category for 1998 to 2002 with 95% confidence intervals.

Migration Year	Study Category	Spring Chinook Race		Summer Chinook Race		Ratio of Summer SARs / Spring SARs
		SAR %	95% CI %	SAR %	95% CI %	
1998	$SAR_1(T_0)$	1.25	0.30 – 2.63	1.35	0.46 – 2.31	1.1
	$SAR(C_0)$	1.17	0.64 – 1.81	1.83	1.17 – 2.56	1.6
	$SAR(C_1)$	0.78	0.54 – 1.01	1.48	1.20 – 1.81	1.9
1999	$SAR_1(T_0)$	1.25	0.33 – 2.41	4.34	2.31 – 6.53	3.5
	$SAR(C_0)$	2.01	1.38 – 2.69	2.16	1.54 – 2.87	1.1
	$SAR(C_1)$	1.66	1.42 – 1.92	2.15	1.89 – 2.42	1.3
2000	$SAR_1(T_0)$	1.15	0.00 – 2.62	2.10	0.73 – 3.81	1.8
	$SAR(C_0)$	2.00	1.47 – 2.58	2.87	2.27 – 3.49	1.4
	$SAR(C_1)$	1.83	1.51 – 2.18	2.79	2.43 – 3.16	1.5
2001	$SAR_1(T_0)$	0.98	0.00 – 3.16	1.47	0.26 – 2.79	1.5
	$SAR(C_0)$	N/A	N/A	N/A	N/A	N/A
	$SAR(C_1)$	0.06	0.00 – 1.49	0.17	0.11 – 0.24	2.8
2002[A]	$SAR_2(T_0)$	0.56	0.23 – 0.91	0.24	0.00 – 0.76	0.4
	$SAR(C_0)$	1.02	0.62 – 1.41	1.32	0.84 – 1.86	1.3
	$SAR(C_1)$	0.72	0.50 – 0.96	0.96	0.68 – 1.26	1.3
	$SAR_1(T_0)$				**5-year average**	**1.7**
	$SAR(C_0)$				**4-year average**	**1.4**
	$SAR(C_1)$				**5-year average**	**1.8**

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

RESULTS AND DISCUSSION: HATCHERY CHINOOK

The PIT tagged hatchery Chinook used in the CSS were PIT tagged specifically to satisfy the goals of this study. Therefore, large enough releases of PIT tagged smolts were made at each hatchery participating in the CSS to provide estimation of parameters to the level of each individual hatchery for migration years 1997 to 2002. A check that all hatchery Chinook released actually outmigrated in their expected migration year was made to guarantee that estimates of collection efficiency and survival would reflect a single out-migration year. The number of PIT tagged hatchery Chinook released per year for the CSS is presented in Table 14. This table contains the four hatcheries (Dworshak, Rapid River, Imnaha, and McCall) used continuously since 1997 and Catherine Creek acclimation pond, which is one of three acclimation ponds in the Grande Ronde River basin that receives smolts reared at Lookingglass Hatchery specifically for that stream. The Catherine Creek stock has been available to the CSS beginning in 2001. The 2002 CSS Annual Report completely covers the analyses of the PIT tagged Rapid River stock released on-site releases from Lookingglass Hatchery until 1999 when they were discontinued by ODFW in favor of stocks indigenous to streams within the Grande Ronde River basin, and so no further treatment of that data was necessary for this report.

Table 14. Numbers of PIT tagged hatchery spring/summer Chinook released from hatcheries participating in the CSS from 1997 to 2002.

Hatchery (abbreviation)	Migration Year					
	1997	1998	1999	2000	2001	2002
Rapid River H (RAPH)	40,451	48,336	47,812	47,747	55,085	54,908
McCall H (MCCA)	52,652	47,340	47,985	47,705	55,124	54,734
Dworshak H (DWOR)	14,080	47,703	47,845	47,743	55,139	54,725
Imnaha R AP (IMNA)	13,378	19,825	19,939	20,819	20,922	20,920
Catherine Ck AP (CATH)	Not tagged	Not Tagged	Not tagged	Not tagged	20,915	20,796

The CSS hatcheries accounted for approximately 80% of the hatchery spring/summer production above LGR in the early years of the study, but this level has dropped over the years as additional hatchery production from other non-CSS hatcheries has increased. Approximately 60% of the total hatchery production of 4 million spring/summer Chinook above Lower Granite Dam occurred at CSS hatcheries in 2001, and this percentage has dropped to approximately 46% of the total spring/summer Chinook hatchery production of 11 million in 2002.

The number of returning hatchery Chinook adults and jacks from migration years 1994 to 2002 is shown in Table 15 for spring Chinook from Dworshak and Rapid River hatcheries and Catherine Ck acclimation pond (AP), and for summer Chinook from McCall Hatchery and Imnaha River AP. The average percentage of the total return that return as jacks was higher for the summer Chinook stocks than for the spring Chinook stocks. The highest jack return percentage was for Imnaha River AP fish. This high jack return percentage, and the fact that the returning adults to the Imnaha migrate upstream through the adult ladders at the same time as the McCall Hatchery stock, makes us report the Imnaha River AP fish as a summer stock, even though ODFW, who operates the hatchery and PIT tags the fish reports it as a spring stock. This highly variable jack return rate among the hatcheries and the extremely low jack return rate observed with the wild Chinook is the reason that SARs computed in the CSS report include 2-salt and 3-salt returning adults and no jacks. But of particular interest is the high percentage of 3-salt returning adults from the 2000 out-migration -- about 5-fold higher than usual for spring Chinook from Rapid River and Dworshak hatcheries and at least 2-fold higher for summer Chinook from Imnaha and McCall hatcheries (Table 15).

Table 15. Number of returning PIT tagged hatchery Chinook adults and jacks detected at Lower Granite Dam that migrated as smolts in 1997 to 2002 and percent of total return.

Hatchery (run)	Migration Year	Jacks 1-salt	Adults 2-salt	Adults 3-salt	Percent 1-salt	Percent 2-salt	Percent 3-salt
RAPH	1997	2	86	7	2.1	90.5	7.4
(spring)	1998	32	390	23	7.2	87.6	5.2
	1999	43	787	31	5.0	91.4	3.6
	2000	8	371	256	1.3	58.4	40.3
	2001	21	206	13	8.8	85.8	5.4
	2002 [A]	60	298	N/A	N/A	N/A	N/A
Average					4.9	82.7	12.4
MCCA	1997	21	263	11	7.1	89.2	3.7
(summer)	1998	108	394	37	20.0	73.1	6.9
	1999	119	722	113	12.5	75.7	11.8
	2000	144	635	239 (1[B])	14.1	62.3	23.5 (0.1[B])
	2001	62	200	23	21.8	70.2	8.1
	2002 [A]	116	347	N/A	N/A	N/A	N/A
Average					15.2	74.1	10.8
DWOR	1997	1	36	6	2.3	83.7	14.0
(spring)	1998	51	372	23	11.4	83.4	5.2
	1999	14	393	44	3.1	87.1	9.8
	2000	3	180	197	0.8	47.4	51.8
	2001	14	79	10	13.6	76.7	9.7
	2002 [A]	52	222	N/A	N/A	N/A	N/A
Average					6.2	75.7	18.1
IMNA	1997	24	63	7	25.5	67.0	7.4
(summer)	1998	54	69	2	43.2	55.2	1.6
	1999	81	226	12	25.4	70.8	3.8
	2000	149	289	79	28.8	55.9	15.3
	2001	30	49	4	36.1	59.0	4.8
	2002 [A]	46	81	N/A	N/A	N/A	N/A
Average					31.8	61.6	6.6
CATH	2001	2	13	0	13.3	86.7	0.0
(spring)	2002 [A]	11	45	N/A	N/A	N/A	N/A

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.
[B] Migration year 2000 has one 4-salt adult shown in the parenthesis under 3-salt column.

The estimated population numbers (with bootstrapped 95% confidence intervals) of PIT tagged Chinook smolts arriving at LGR for each CSS hatchery group are presented in Table 16 for spring stocks and Table 17 for summer stocks. These tables also provide the estimated number of smolts (with bootstrapped 95% confidence intervals) occurring in each CSS study category, T_0, C_0, and C_1. Unlike their wild Chinook counterparts, the PIT tagged hatchery Chinook populations arriving at LGR were fairly well split across the three study categories in all years except 2001. Few PIT tagged smolts were in Category C_0 in 2001 due to the lack of spill at collector dams and subsequent high collection efficiency allowing for few fish to pass the three Snake River collector dams undetected

Table 16. Estimated number of PIT tagged hatchery spring Chinook arriving Lower Granite Dam in each of the three study categories from 1997 to 2002 (95% confidence intervals in parenthesis).

Migr. Year	Hat.	Estimate LGR population	Study category	Est. smolt numbers per category (using "full sample" CJS survivals)	
1997	RAPH	15,765 (15,246 – 16,439)	T_0 C_0 C_1	4,321 4,176 6,843	(4,204 – 4,451) (3,889 – 4,506) (6,477 – 7,254)
1997	DWOR	8,175 (7,735 – 8,683)	T_0 C_0 C_1	1,931 2,529 3,613	(1,856 – 2,015) (2,283 – 2,798) (3,344 – 3,938)
1998	RAPH	32,148 (31,801 – 32,473)	T_0 C_0 C_1	12,862 4,402 13,597	(12,659 – 13,057) (4,232 – 4,563) (13,344 – 13,841)
1998	DWOR	40,218 (39,660 – 40,742)	T_0 C_0 C_1	14,708 11,151 13,128	(14,486 – 14,927) (10,770 – 11,483) (12,831 – 13,412)
1999	RAPH	35,895 (35,272 – 36,542)	T_0 C_0 C_1	12,833 7,040 14,456	(12,602 – 13,078) (6,799 – 7,323) (14,123 – 14,810)
1999	DWOR	40,804 (39,771 – 41,948)	T_0 C_0 C_1	9,783 10,484 19,081	(9,549 – 10,022) (10,109 – 10,930) (18,473 – 19,705)
2000	RAPH	35,192 (34,526 – 35,910)	T_0 C_0 C_1	16,584 11,046 5,244	(16,249 – 16,925) (10,582 – 11,568) (5,097 – 5,408)
2000	DWOR	39,410 (38,652 – 40,203)	T_0 C_0 C_1	18,314 13,075 5,416	(17,915 – 18,726) (12,516 – 13,644) (5,249 – 5,583)
2001	RAPH	38,020 (37,793 – 38,251)	T_0 C_0 C_1	19,066 966 15,965	(18,844 – 19,286) (905 – 1,025) (15,735 – 16,152)
2001	DWOR	41,248 (41,018 – 41,489)	T_0 C_0 C_1	21,726 886 16,864	(21,496 – 21,951) (830 – 942) (16,628 – 17,080)
2001	CATH	10,885 (10,728 – 11,042)	T_0 C_0 C_1	4,788 379 4,636	(4,664 – 4,918) (342 – 420) (4,513 – 4,755)
2002	RAPH	41,471 (40,777 – 42,294)	T_0 C_0 C_1	11,562 13,625 14,852	(11,326 – 11,811) (13,221 – 14,023) (14,496 – 15,264)
2002	DWOR	45,233 (43,995 – 46,535)	T_0 C_0 C_1	9,647 19,008 14,912	(9,404 – 9,926) (18,329 – 19,708) (14,420 – 15,444)
2002	CATH	8,435 (8,118 – 8,752)	T_0 C_0 C_1	2,688 2,445 3,120	(2,570 – 2,816) (2,287 – 2,613) (2,968 – 3,283)

that year. In the other years there were relatively large numbers in categories T_0 and C_0. Fish in categories T_0 and C_0 mimic the untagged population in each year except 1997, when approximately 40% of the in-river migrating hatchery Chinook smolts were of Category C_0 and the remaining 60% were of Category C_1 due to the bypass protocols implemented during portions of April and May at LGS and LMN that year.

Table 17. Estimated number of PIT tagged hatchery summer Chinook arriving Lower Granite Dam in each of the three study categories from 1997 to 2002 (95% confidence intervals in parenthesis).

Migr. Year	Hat.	Estimate LGR population	Study category	Estimated smolt numbers per category (using "full sample" CJS survivals)	
1997	MCCA	22,381	T_0	6,001	(5,859 – 6,138)
		(21,588 – 23,224)	C_0	6,761	(6,339 – 7,214)
			C_1	9,272	(8,779 – 9,795)
1997	IMNA	8,254	T_0	2,135	(2.050 – 2,223)
		(7,814 – 8,740)	C_0	2,219	(1,993 – 2,478)
			C_1	3,785	(3,475 – 4,091)
1998	MCCA	27,812	T_0	10,080	(9,916 – 10,258)
		(27,474 – 28,141)	C_0	3,849	(3,685 – 4,006)
			C_1	12,816	(12,537 – 13,075)
1998	IMNA	13,577	T_0	4,773	(4,648 – 4,895)
		(13,327 – 13,833)	C_0	1,995	(4,884 – 2,104)
			C_1	6,335	(6,156 – 6,523)
1999	MCCA	31,571	T_0	10,457	(10,200 – 10,710)
		(30,816 – 32,358)	C_0	8,407	(8,081 – 8,734)
			C_1	11,391	(11,037 – 11,782)
1999	IMNA	13,244	T_0	4,779	(4,616 – 4,955)
		(12,829 – 13,687)	C_0	2,869	(2,690 – 3,050)
			C_1	5,084	(4,871 – 5,327)
2000	MCCA	31,825	T_0	12,725	(12,398 – 13,043)
		(31,017 – 32,692)	C_0	13,064	(12,440 – 13,748)
			C_1	4,481	(4,319 – 4,651)
2000	IMNA	14,267	T_0	6,706	(6,469 – 6,960)
		(13,864 – 14,779)	C_0	4,396	(4,113 – 4,746)
			C_1	2,254	(2,148 – 2,356)
2001	MCCA	36,781	T_0	16,641	(16,421 – 16,856)
		(36,555 – 37,021)	C_0	1,000	(932 – 1,060)
			C_1	15,474	(15,253 – 15,704)
2001	IMNA	15,650	T_0	7,695	(7,547 – 7,834)
		(15,518 – 15,790)	C_0	366	(328 – 403)
			C_1	6,939	(6,802 – 7,084)
2002	MCCA	32,599	T_0	8,790	(8,586 – 9,012)
		(31,938 – 33,282)	C_0	10,280	(9,934 – 10,650)
			C_1	12,313	(11,976 – 12,659)
2002	IMNA	13,962	T_0	3,884	(3,723 – 4,037)
		(13,484 – 14,451)	C_0	4,639	(4,418 – 4,893)
			C_1	5,139	(4,911 – 5,384)

A portion of the CSS PIT tagged hatchery Chinook was purposely diverted into transportation at LGR in each of the years 1997 to 2002, but this was not the case at the other two Snake River transportation facilities until 2000 (Table 18). At LGS the CSS

PIT tagged hatchery Chinook were routed to transport for part of the seasons of 1998 and 1999 (routing PIT tagged fish to transportation ended on May 9 in 1998 and commenced on May 10 in 1999). CSS PIT tagged hatchery Chinook were not intentionally routed to transportation at LMN until 2000. It was decided not to route CSS PIT tagged hatchery Chinook to transportation at LMN in 2002 because of the non-standard operations implemented there to reduce the numbers of fish collected and transported in the absence of spill at that site. This non-standard operation included primary bypass without PIT tag detections during most of April and alternating 2-day transport and 1-day primary bypass without PIT tag detections during May and part of June at LMN. Even with the 2002 operation, LMN still transported a higher number of fish than either LGR or LGS. Springtime transportation at MCN did not occur in migration years 1997 to 2002.

Table 18. Number of PIT tagged hatchery Chinook actually transported from each dam and estimate (t_i) of total PIT tagged hatchery Chinook that would have been transported if all PIT tagged fish had been transported at same rate as the untagged run-at-large.

Migr. Year	Hatchery	Lower Granite Dam		Little Goose Dam		Lower Monumental Dam	
		Actual	**t_2**	**Actual**	**t_3**	**Actual**	**t_4**
1997	RAPH	4,135	5,365	132	1,618	38	949
	MCCA	5,851	7,428	105	2,241	31	1,153
	DWOR	1,864	2,351	52	970	15	517
	IMNA	2,074	2,603	45	954	12	487
1998	RAPH	11,279	15,274	1,359	7,578	197	3,100
	MCCA	8,988	12,178	896	6,970	157	3,073
	DWOR	11,096	14,350	3,574	9,326	225	3,887
	IMNA	4,036	5,621	606	3,749	97	1,354
1999	RAPH	7,385	9,488	4,724	12,750	290	3,818
	MCCA	4,730	6,374	4,986	10,584	203	3,515
	DWOR	4,930	6,346	3,798	14,602	484	5,304
	IMNA	2,160	2,785	2,293	5,129	114	1,428
2000	RAPH	10,367	14,386	4,181	6,123	1,213	1,625
	MCCA	8,496	11,734	2,821	4,086	776	1,279
	DWOR	9,805	13,399	4,911	7,206	2,030	2,539
	IMNA	3,862	5,447	1,812	2,705	530	713
2001	RAPH	15,385	28,122	2,846	5,874	582	1,076
	MCCA	13,093	27,575	2,643	5,119	500	892
	DWOR	16,567	28,345	4,091	8,490	639	1,177
	IMNA	5,734	10,629	1,604	3,380	246	483
	CATH	3,375	7,356	1,096	2,143	195	373
2002	RAPH	5,339	8,475	5,312	8,852	572	8,534
	MCCA	4,284	6,729	4,140	6,951	200	7,305
	DWOR	4,088	6,417	4,348	7,274	734	9,673
	IMNA	1,616	2,531	1,953	3,271	194	2,814
	CATH	1,464	2,286	1,112	1,826	50	1,586
	6-yr avg		**10,138**		**5,760**		**2,641**
	percent		**55 %**		**31 %**		**14 %**

Although dam-specific transportation SARs [*e.g.*, SAR(T_{LGR}), SAR(T_{LGS}), and SAR(T_{LMN})] were computed for each Snake River facility for migration years 1997 to 2002, there was the problem of low precision in the estimates of SAR(T_{LGS}) and SAR(T_{LMN}) in several of these years (Table 19). There were extremely low numbers of first-time detected PIT tagged smolts routed to transportation from LGS in 1997 and from LMN in 1997, 1998, 2001, and 2002. As was the case with the wild Chinook, there will be bias and imprecision in estimated $SAR_1(T_0)$ for migration years 1997 and 1998 in particular due to very low numbers of first-time detected PIT tagged hatchery Chinook being routed to transportation at LGS and LMN in those years. The small numbers of PIT tagged smolts routed to transportation in these early years has made it difficult to obtain unbiased total Snake River transportation SAR for hatchery Chinook prior to 2000 when we began to route the same proportion of first-time PIT tagged hatchery to transportation at each Snake River transportation dam. Under this approach there will be self-weighting across the three Snake River collector dams.

Table 19. Estimated dam-specific transportation SAR percentages of PIT tagged hatchery spring/summer Chinook that migrated as smolts in 1997 to 2002 (95% confidence intervals in parenthesis).

Migr. Year & Hatchery	$SAR(T_{LGR})$ %	Adults #	$SAR(T_{LGS})$ %	Adults #	$SAR(T_{LMN})$ %	Adults #
1997 RAPH	0.80 (0.54 – 1.09)	33	0	None	2.63 (0.0 – 9.76)	1
1997 MCCA	1.49 (1.17 – 1.81)	87	2.86 (0.0 – 6.48)	3	3.23 (0.0 – 10.7)	1
1997 DWOR	0.86 (0.48 – 1.29)	16	0	None	0	None
1997 IMNA	1.21 (0.75 – 1.73)	25	0	None	0	None
1998 RAPH	2.12 (1.85 – 2.37)	239	1.18 (0.66 – 1.80)	16	1.02 (0.0 – 2.54)	2
1998 MCCA	2.93 (2.60 – 3.29)	263	1.00 (0.44 – 1.70)	9	0.64 (0.0 – 2.34)	1
1998 DWOR	0.99 (0.81 – 1.17)	110	0.62 (0.39 – 0.89)	22	0	None
1998 IMNA	0.92 (0.62 – 1.23)	37	0.66 (0.16 – 1.45)	4	0	None
1999 RAPH	3.20 (2.80 – 3.58)	236	3.22 (2.75 – 3.75)	152	1.03 (0.0 – 2.42)	3
1999 MCCA	4.36 (3.80 – 4.94)	206	3.23 (2.78 – 3.73)	161	4.93 (2.15 – 8.37)	10
1999 DWOR	1.26 (0.96 – 1.55)	62	1.29 (0.94 – 1.65)	49	0.83 (0.20 – 1.72)	4
1999 IMNA	3.43 (2.67 – 4.26)	74	2.31 (1.71 – 2.94)	53	2.63 (0.0 – 5.77)	3
2000 RAPH	2.34 (2.06 – 2.65)	243	1.89 (1.52 – 2.30)	79	2.23 (1.43 – 3.06)	27
2000 MCCA	4.54 (4.12 – 5.01)	386	3.26 (2.56 – 3.90)	92	2.45 (1.42 – 3.58)	19
2000 DWOR	1.18 (0.96 – 1.41)	116	1.08 (0.80 – 1.37)	53	0.69 (0.34 – 1.08)	14
2000 IMNA	3.99 (3.34 – 4.63)	154	2.48 (1.77 – 3.24)	45	2.26 (1.09 – 3.57)	12
2001 RAPH	1.18 (1.01 – 1.37)	182	0.74 (0.43 – 1.05)	21	0.69 (0.16 – 1.42)	4

Migr. Year & Hatchery	$SAR(T_{LGR})$ %	Adults #	$SAR(T_{LGS})$ %	Adults #	$SAR(T_{LMN})$ %	Adults #
2001 MCCA	1.41 (1.21 – 1.61)	184	0.76 (0.45 – 1.10)	20	0.40 (0.00 – 0.99)	2
2001 DWOR	0.36 0.28 – 0.46)	60	0.44 (0.25 – 0.65)	18	0.16 (0.00 – 0.49)	1
2001 IMNA	0.73 (0.52 – 0.96)	42	0.37 (0.12 – 0.68)	6	0	None
2001 CATH	0.33 (0.15 – 0.53)	11	0	None	0	None
2002 [A] RAPH	1.11 (0.83 – 1.39)	59	0.92 (0.70 – 1.21)	49	1.05 (0.18 – 2.00)	6
2002 [A] MCCA	1.54 (1.16 – 1.91)	66	1.40 (1.03 – 1.75)	58	0.50 (0.00 – 1.60)	1
2002 [A] DWOR	0.56 (0.34 – 0.82)	23	0.71 (0.48 – 0.99)	31	0.27 (0.00 – 0.70)	2
2002 [A] IMNA	0.74 (0.37 – 1.16)	12	0.77 (0.41 – 1.18)	15	1.55 (0.00 – 3.64)	3
2002 [A] CATH	1.09 (0.60 – 1.73)	16	0.72 (0.26 – 1.21)	8	0	None

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

Estimated SARs for hatchery Chinook in study categories T_0, C_0, and C_1 are presented in Table 20 for spring Chinook stocks and Table 21 for summer Chinook stocks. The two estimates of total transport SAR in 2000 and 2001 are virtually identical, which illustrates the benefits of routing the same proportion of collected PIT tagged smolts to transportation at each of the three collector dams to create self-weighting across these three facilities. In 1997, 1998, and 2002, the limited numbers of PIT tagged smolts transported at LMN (plus LGS in 1997) make greater differences in the two estimates of total transport SAR. In these years the "true" transport SAR is expected to be located closer to the $SAR_2(T_0)$ than $SAR_1(T_0)$ since the latter is highly influenced by the very imprecise site-specific SAR estimates at LMN in each year and at LGS in 1997. For this reason, subsequent ratios of SARs and *D* computation will utilize $SAR_2(T_0)$ in these three years for each hatchery.

There was an increasing trend in the magnitude of $SAR_{LGR\text{-}to\text{-}LGR}$ in recent years for hatchery Chinook, but in the year since the drought year of 2001, the trend began to head downward again. For migration years 1997 to 2000, the highest estimates of $SAR_{LGR\text{-}to\text{-}LGR}$ for PIT tagged hatchery Chinook occurred for the spring stocks that migrated in 1999 (Table 20) and for summer stocks that migrated in 1999 and 2000 (Table 21). But although the SAR for migration year 2002 is incomplete until the 3-salt returns next year, the early indications based on 2-salt returns is that the SARs for both transported and in-river migrating smolts in 2002 will be much lower than observed in 1999 and 2000.

From 1998 to 2002, the $SAR_{LGR\text{-}to\text{-}LGR}$ of spring Chinook have generally been higher at Rapid River Hatchery than Dworshak Hatchery (Table 20). Rapid River Hatchery spring Chinook had SARs that were higher in Category T_0 than in Category C_0 in each year, with significant differences shown in 2000 and 2002 (latter year with 2-salt returns only available). Migration year 2001 Category T_0 fish were compared to Category C_1 fish with over 21-fold higher transport SARs for Rapid River Hatchery

Chinook and 8-fold higher transport SARs for Dworshak Hatchery Chinook. In the other years, Dworshak Hatchery spring Chinook had SARs that were mostly similar in magnitude (around 1%) between the transport T_0 and in-river C_0 categories. PIT tagged spring Chinook from Dworshak Hatchery migrated past Lower Granite Dam earlier than their Rapid River Hatchery counterparts in most years. The later migration period of Rapid River Hatchery spring Chinook may partly contribute to their higher transport SARs, as this same pattern was observed with the two summer Chinook stocks.

Table 20. Estimated $SAR_{LGR\text{-}to\text{-}LGR}$ (%) of PIT tagged hatchery spring Chinook for each study category for 1997 to 2002 (95% confidence intervals in parenthesis).

Mig. Year Hatchery	Transport SARs %		In-river SARs %	
1997 RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	0.82 (0.39 – 1.63) 0.79 (0.54 – 1.07)	$SAR(C_0)$ $SAR(C_1)$	0.46 (0.26 – 0.68) 0.53 (0.35 – 0.72)
1997 DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	0.52 (0.30 – 0.79) 0.83 (0.47 – 1.25)	$SAR(C_0)$ $SAR(C_1)$	0.47 (0.22 – 0.78) 0.36 (0.18 – 0.56)
1998 RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	1.68 (1.43 – 1.98) 2.00 (1.76 – 2.25)	$SAR(C_0)$ $SAR(C_1)$	1.20 (0.88 – 1.56) 0.67 (0.52 – 0.80)
1998 DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	0.72 (0.60 – 0.85) 0.90 (0.75 – 1.05)	$SAR(C_0)$ $SAR(C_1)$	1.25 (1.05 – 1.45) 0.91 (0.75 – 1.08)
1999 RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	2.72 (2.42 – 3.04) 3.05 (2.76 – 3.35)	$SAR(C_0)$ $SAR(C_1)$	2.37 (2.03 – 2.76) 1.63 (1.43 – 1.82)
1999 DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	1.07 (0.83 – 1.33) 1.18 (0.96 – 1.39)	$SAR(C_0)$ $SAR(C_1)$	1.19 (1.00 – 1.40) 0.95 (0.81 – 1.10)
2000 RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	2.10 (1.85 – 2.30) 2.10 (1.86 – 2.31)	$SAR(C_0)$ $SAR(C_1)$	1.59 (1.34 – 1.84) 1.35 (1.00 – 1.68)
2000 DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	1.00 (0.85 – 1.17) 1.00 (0.85 – 1.17)	$SAR(C_0)$ $SAR(C_1)$	1.01 (0.85 – 1.19) 0.85 (0.61 – 1.11)
2001 RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	1.08 (0.93 – 1.24) 1.09 (0.94 – 1.25)	$SAR(C_0)$ $SAR(C_1)$	N/A 0.05 (0.02 – 0.09)
2001 DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	0.37 (0.29 – 0.45) 0.36 (0.28 – 0.45)	$SAR(C_0)$ $SAR(C_1)$	N/A 0.04 (0.02 – 0.07)
2001 CATH	$SAR_1(T_0)$ $SAR_2(T_0)$	0.24 (0.11 – 0.39) 0.23 (0.11 – 0.37)	$SAR(C_0)$ $SAR(C_1)$	N/A 0.04 (0.00 – 0.13)
2002 [A] RAPH	$SAR_1(T_0)$ $SAR_2(T_0)$	0.98 (0.71 – 1.33) 0.99 (0.81 – 1.18)	$SAR(C_0)$ $SAR(C_1)$	0.65 (0.52 – 0.78) 0.63 (0.51 – 0.76)
2002 [A] DWOR	$SAR_1(T_0)$ $SAR_2(T_0)$	0.45 (0.31 – 0.65) 0.58 (0.44 – 0.75)	$SAR(C_0)$ $SAR(C_1)$	0.48 (0.38 – 0.58) 0.50 (0.39 – 0.61)
2002 [A] CATH	$SAR_1(T_0)$ $SAR_2(T_0)$	0.65 (0.41 – 0.94) 0.89 (0.56 – 1.30)	$SAR(C_0)$ $SAR(C_1)$	0.45 (0.20 – 0.73) 0.32 (0.13 – 0.53)

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

Table 21. Estimated $SAR_{LGR\text{-}to\text{-}LGR}$ (%) of PIT tagged hatchery summer Chinook for each study category for 1997 to 2002 (95% confidence intervals in parenthesis).

Mig. Year Hatchery	Transport SARs %		In-river SARs %	
1997 MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	1.89 (1.16 – 2.93) 1.52 (1.21 – 1.82)	$SAR(C_0)$ $SAR(C_1)$	1.09 (0.83 – 1.36) 1.10 (0.88 – 1.33)
1997 IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	0.75 (0.48 – 1.09) 1.17 (0.76 – 1.71)	$SAR(C_0)$ $SAR(C_1)$	0.86 (0.52 – 1.26) 0.69 (0.42 – 0.99)
1998 MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	1.95 (1.66 – 2.27) 2.71 (2.41 – 3.03)	$SAR(C_0)$ $SAR(C_1)$	1.38 (1.03 – 1.77) 0.73 (0.58 – 0.89)
1998 IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	0.69 (0.46 – 0.97) 0.86 (0.62 – 1.14)	$SAR(C_0)$ $SAR(C_1)$	0.55 (0.25 – 0.90) 0.30 (0.17 – 0.44)
1999 MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	3.58 (3.04 – 4.15) 3.61 (3.26 – 3.97)	$SAR(C_0)$ $SAR(C_1)$	2.40 (2.08 – 2.76) 2.05 (1.78 – 2.30)
1999 IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	2.52 (2.00 – 3.16) 2.72 (2.26 – 3.19)	$SAR(C_0)$ $SAR(C_1)$	1.43 (1.00 – 1.87) 1.22 (0.91 – 1.54)
2000 MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	3.86 (3.53 – 4.21) 3.91 (3.57 – 4.25)	$SAR(C_0)$ $SAR(C_1)$	2.06 (1.79 – 2.33) 2.08 (1.65 – 2.50)
2000 IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	3.13 (2.73 – 3.56) 3.15 (2.74 – 3.58)	$SAR(C_0)$ $SAR(C_1)$	2.41 (1.96 – 2.92) 1.64 (1.13 – 2.19)
2001 MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	1.25 (1.08 – 1.43) 1.24 (1.07 – 1.41)	$SAR(C_0)$ $SAR(C_1)$	N/A 0.04 (0.01 – 0.07)
2001 IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	0.61 (0.45 – 0.80) 0.62 (0.45 – 0.81)	$SAR(C_0)$ $SAR(C_1)$	N/A 0.06 (0.01 – 0.12)
2002 [A] MCCA	$SAR_1(T_0)$ $SAR_2(T_0)$	1.10 (080 – 1.49) 1.42 (1.18 – 1.67)	$SAR(C_0)$ $SAR(C_1)$	0.98 (0.80 – 1.17) 0.97 (0.80 – 1.15)
2002 [A] IMNA	$SAR_1(T_0)$ $SAR_2(T_0)$	0.96 (0.45 – 1.59) 0.77 (0.50 – 1.08)	$SAR(C_0)$ $SAR(C_1)$	0.45 (0.27 – 0.67) 0.53 (0.33 – 0.73)

[A] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

From 1998 to 2002, the $SAR_{LGR\text{-}to\text{-}LGR}$ of summer Chinook have generally been higher at McCall Hatchery than Imnaha AP (Table 21). Summer Chinook from both McCall Hatchery and Imnaha AP had SARs that were higher in Category T_0 than in Category C_0 in each year, with significant differences shown in 1999 for both hatchery stocks and in 2000 and 2002 (latter year with 2-salt returns only available) for McCall Hatchery Chinook. Migration year 2001 Category T_0 fish were compared to Category C_1 fish with over 32-fold higher transport SARs for McCall Hatchery Chinook and 10-fold higher transport SARs for Imnaha AP Chinook. PIT tagged summer Chinook from Imnaha AP migrated past LGR earlier than their McCall Hatchery counterparts in every year. Imnaha AP summer Chinook migrated past LGR as smolts at a time similar to that of the Rapid River Hatchery spring Chinook smolts. The later migration period of McCall Hatchery summer Chinook may partly contribute to their higher transport SARs.

The annual estimated $SAR_{LGR\text{-}to\text{-}LGR}$ reflective of the run-at-large for each hatchery that out-migrated in 1997 to 2001 (Table 22) is computed by weighting the proportion of the run-at-large transported and remaining in-river by the associated SARs computed with PIT tagged fish for each respective study category. For each hatchery release, the estimated numbers of PIT tagged Chinook smolts t_j that would have been transported at each of the three Snake River collector dams (j=2 for LGR, j=3 for LGS, and j=4 for LMN) if we had routed PIT tagged smolts to transportation in the same proportion as the run-at-large are presented in Table 18. The total estimated number transported across the three Snake River collector dams in LGR equivalents equals $T^* = t_2+t_3/S_2+t_4/(S_2S_3)$. The proportion of the run-at-large that is represented by each category of PIT tagged fish is then multiplied by the SAR obtained with PIT tagged fish for that study category (from Tables 20 and 21) to obtain a weighted $SAR_{LGR\text{-to-}LGR}$ in for each migration year except 2001 when the SAR of Category C_1 fish was applied to the proportion of fish in Category C_0 for reasons previously described in the methods section.

Table 22. Proportion of Lower Granite Dam estimated combined tagged and untagged population of each hatchery group in each study category with associated LGR-to-LGR SAR (returning adults age 4 and 5 in all years).

Migr. Year	Hatchery[1]	Population proportion in study category[2]			SAR for study category[3]			Weighted $SAR_{LGR\text{-to-}LGR}$[4]
		T_0	C_0	C_1	SAR(T_0)	SAR(C_0)	SAR(C_1)	
1997	DWOR	0.481	0.313	0.205	0.0083	0.0047	0.0036	0.0062
1997	IMNA	0.516	0.273	0.211	0.0117	0.0086	0.0069	0.0098
1997	MCCA	0.509	0.307	0.184	0.0189	0.0109	0.0110	0.0150
1997	RAPH	0.539	0.272	0.189	0.0079	0.0046	0.0053	0.0065
1998	DWOR	0.714	0.286		0.0090	0.0125		0.0100
1998	IMNA	0.848	0.152		0.0086	0.0055		0.0081
1998	MCCA	0.856	0.144		0.0271	0.0138		0.0252
1998	RAPH	0.857	0.143		0.0200	0.0120		0.0189
1999	DWOR	0.735	0.265		0.0107	0.0120		0.0110
1999	IMNA	0.777	0.223		0.0252	0.0143		0.0228
1999	MCCA	0.725	0.275		0.0358	0.0240		0.0326
1999	RAPH	0.797	0.203		0.0272	0.0237		0.0265
2000	DWOR	0.660	0.340		0.0100	0.0101		0.0100
2000	IMNA	0.686	0.314		0.0313	0.0241		0.0290
2000	MCCA	0.580	0.420		0.0386	0.0206		0.0310
2000	RAPH	0.679	0.321		0.0210	0.0159		0.0194
2001	DWOR	0.978	0.022		0.0037		0.0004	0.0036
2001	IMNA	0.976	0.024		0.0061		0.0006	0.0060
2001	MCCA	0.972	0.028		0.0125		0.0004	0.0122
2001	RAPH	0.974	0.026		0.0108		0.0005	0.0105
2001	CATH	0.964	0.036		0.0024		0.0004	0.0023

[1] Hatchery coding: DWOR=Dworshak H; IMNA=Imnaha AP; MCCA=McCall H; RAPH=Rapid River H; CATH=Catherine Creek AP.
[2] Estimated proportion of total smolt population (tagged and untagged) at LGR in each study category.
[3] Estimated SAR for PIT tagged Chinook for each hatchery group and migration year; $SAR_1(T_0)$ used for 1999-2001 and $SAR_2(T_0)$ used for 1997-1998.
[4] Estimated overall weighted $SAR_{LGR\text{-to-}LGR}$ (rounded to 4 digits past decimal) is obtained by taking proportion of total population of smolts (tagged and untagged) at Lower Granite Dam in each study category and multiplying by the respective study category's $SAR_{LGR\text{-to-}LGR}$ (see text for exception in 2001).

The trend in annual $SAR_{LGR\text{-to-}LGR}$ for each hatchery and wild chinnook is presented in Figure 6. A general trend of increasing SARs from 1997 to 1999 and decreasing trend from 1999 to 2001 is shown for hatchery Chinook from McCall, Rapid River, and Dworshak hatcheries. Unlike the other three hatcheries, the SARs of Imnaha Hatchery Chinook dipped in 1998 and peaked in 2000. The annual trends observed for the PIT tagged wild sp/su Chinook aggregate was similar to that of Imnaha Hatchey

Chinook from 1997 to 1999 and similar to that of Rapid River Hatchery Chinook from 1999 to 2001. From the patterns of annual SARs, the Rapid River Hatchery Chinook had the most similar trend as the PIT tagged wild Chinook aggregate across the five years of completed adult returns for the four hatcheries continuosly used in the CSS since 1997. In addition, the rate of returning jacks from migration years 1997 to 2001 was the closest for PIT tagged Rapid River Hatchery Chinook (5-yr average of 4.9%) and PIT tagged wild Chinook (5-yr average of 4.5%) stock compared to any other CSS hatchery stock. This finding and the similarity of the SAR pattern over most of the past 5 years make the Rapid River Hatchery Chinook the best surrogate for the wild Chinook to date.

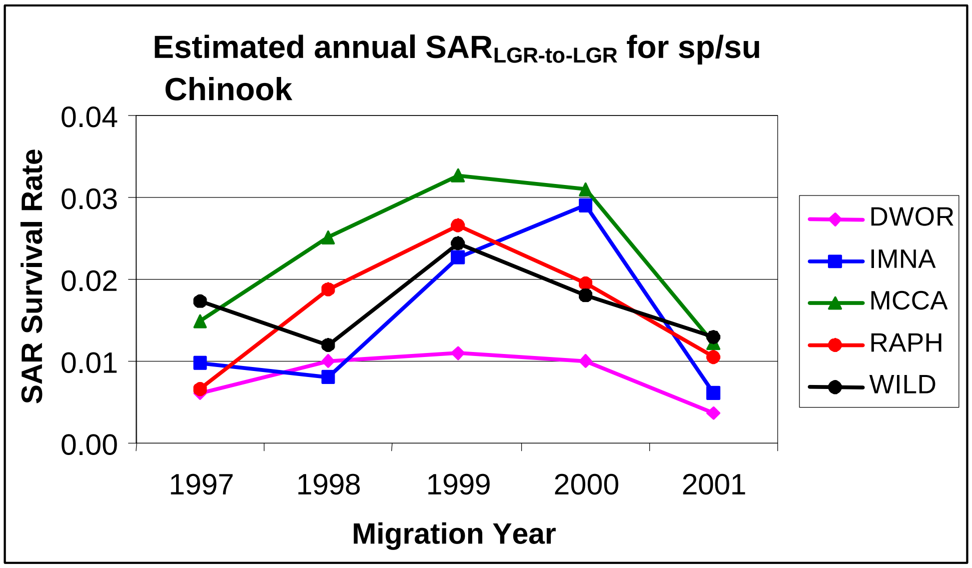


Figure 6. Trend in estimated annual SAR for hatchery and wild sp/su Chinook based on PIT tagged sp/su Chinook SARs in transport and in-river study categories weighted by estimated proportion of run-at-large in each study category for migration years 1997 to 2001.

The trend in annual $SAR_{LGR\text{-}to\text{-}LGR}$ for transported and in-river migrating PIT tagged sp/su Chinook from each hatchery and the wild Chinook aggregate is presented in Figure 7. Since over a majority of the run-at-large was transported in each year, the general trend in the transport plot was similar to the weighted overall $SAR_{LGR\text{-}to\text{-}LGR}$ previously presented, except for a shift in the peak McCall Hatchery SAR to migration year 2000. In the case of the in-river migrating PIT tagged Chinook, the SAR trend for both McCall and Rapid River hatcheries was the closest to that of the PIT tagged wild Chinook. Both transported and in-river migrating spring Chinook from Dworshak Hatchery had the least similar pattern of SARs to those of the wild Chinook. Overall, the SAR trend for PIT tagged Rapid River Hatchery Chinook and PIT tagged wild Chinook still remains the most similar of any pairing between wild and CSS hatchery groups.

The number of smolts PIT tagged at each hatchery was set to fixed numbers regardless of size of the hatchery production starting in1998 to ensure similar numbers of PIT tagged smolts at each hatchery across future years. The factor $?_h$ is the proportion of PIT tags in population released from the h^{th} hatchery. Dividing the number of PIT tags

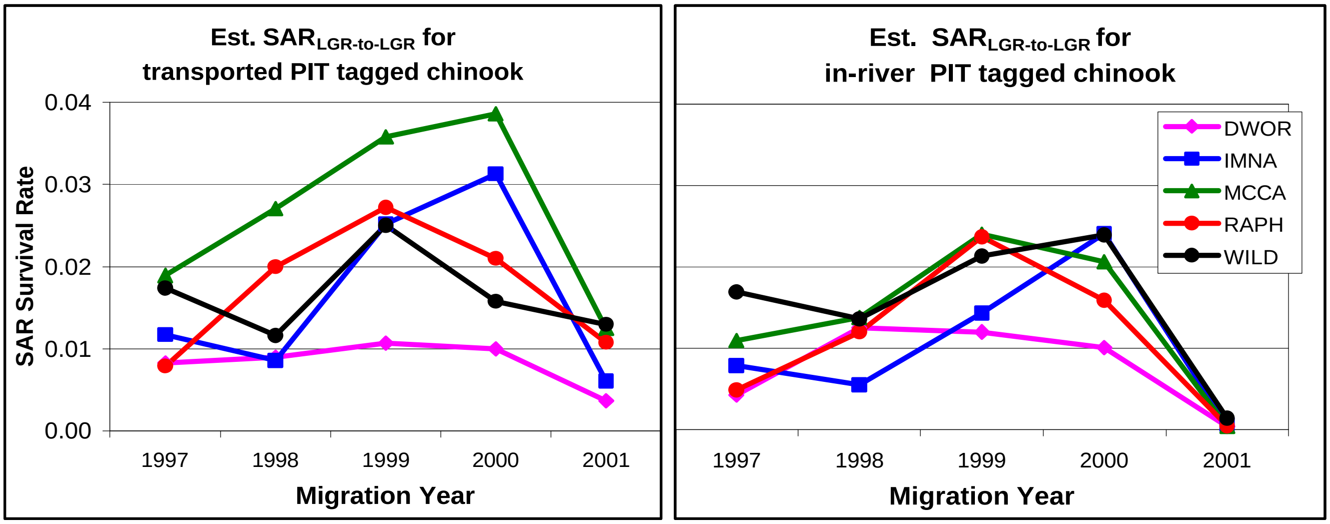


Figure 7. Trend in estimated annual SAR for PIT tagged hatchery and wild sp/su Chinook that were transported versus migrated in-river from 1997 to 2001.

detected at the various dams by $?_h$ provides an estimate of the total population of that particular hatchery collected at the various dams. Likewise, dividing the number of PIT tagged smolts in categories T_{0h}, C_{0h}, and C_{1h} in Tables 16 and 17 by $?_h$ for the h^{th} hatchery provides an estimate of the total number of tagged and untagged smolts from that hatchery in those categories. Considering each hatchery as a stratum, the seasonal average SAR across a set of hatcheries utilizes the populations (T_{0h} / $?_h$), (C_{0h} / $?_h$), and (C_{1h} / $?_h$) as the proper stratum weights for the h^{th} hatchery. The values of $?_h$ for each hatchery across migration years 1997 to 2002 are presented in Table 23.

Computed with the stratum weights from Table 23, annual SARs based on four CSS hatcheries used continuously since 1997 are presented in Table 24. From the SAR data in Tables 20 and 21, the transport SARs computed by $SAR_1(T_0)$ was used in 1999, 2000, and 2001, whereas the $SAR_2(T_0)$ was used in 1997, 1998, and 2002 to reduce estimate biases as described earlier in this report. Migration years 1999 and 2000 had the highest seasonal SARs across migration years 1997 to 2002 (latter year with 2-salt returns only available). The strata weighted seasonal means were most influenced by the large production hatcheries such as Rapid River and least influenced by the relatively small hatchery production at Imnaha River AP. Therefore, an unweighted mean is also presented in Table 24. Although year-to-year differences between the weighted and unweighted mean SAR for each study category occurred, the overall 6-year mean for each study category showed similar results for weighted and unweighted SAR data. The average SAR across 5 years for the combined Rapid River, Dworshak, McCall, and Imnaha River hatcheries was 42-49% higher for transported fish (Category T_0) than for fish undetected at a transportation site and remaining in-river below LMN (Category C_0). The average SAR across these same years and combined stocks was 16-20% lower for those fish having one or more detections at a transportation site before remaining in-river below LMN (Category C_1) than those in-river migrants not detected at a transportation site in the Snake River (Category C_0). Although the SAR for transported hatchery Chinook in 2001 was much lower than the recent 5-year average, it was 16-25 times higher than the SAR estimated for fish in Category C_1.

Table 23. Proportion of PIT tags in hatchery release number ($?_h$) for CSS hatchery groups migrating in 1997 to 2002.

Hatchery	Migration Year	Hatchery Release	Number of PIT Tags Released	Proportion of PIT tags in hatchery release ($?_h$)
Rapid River H (RAPH)	1997	85,838	40,452	0.4713
	1998	896,170	48,336	0.0539
	1999	2,847,283	47,812	0.0168
	2000	2,462,354	47,747	0.0194
	2001	736,601	55,085	0.0748
	2002	2,669,476	54,908	0.0206
Dworshak H (DWOR)	1997	53,078	14,080	0.2653
	1998	973,400	47,703	0.0490
	1999	1,044,511	47,845	0.0458
	2000	1,017,873	47,743	0.0469
	2001	333,120	55,139	0.1655
	2002	1,000,561	54,725	0.0547
Catherine Ck AP (CATH)	2001	136,833	20,915	0.1529
	2002	180,343	20,796	0.1153
McCall H (MCCA)	1997	238,647	52,652	0.2206
	1998	393,872	47,340	0.1202
	1999	1,143,083	47,985	0.0420
	2000	1,039,930	47,705	0.0459
	2001	1,076,846	55,124	0.0512
	2002	1,022,550	54,734	0.0535
Imnaha AP (IMNA)	1997	50,911	13,378	0.2628
	1998	93,108	19,825	0.2129
	1999	184,725	19,939	0.1079
	2000	179,797	20,819	0.1158
	2001	123,014	20,922	0.1701
	2002	303,737	20,920	0.0689

Table 24. Stratified (by hatchery population) weighted mean SAR and arithmetic (unweighted) mean SAR of the four CSS hatcheries used in migration years 1997 to 2002.

Migration Year	Strata Weighted Mean SAR			Unweighted Mean SAR		
	T_0	C_0	C_1	T_0	C_0	C_1
1997	1.24	0.86	0.81	1.08	0.72	0.67
1998	1.54	1.23	0.76	1.62	1.10	0.65
1999	2.60	1.43	1.22	2.47	1.85	1.46
2000	2.17	1.59	1.39	2.52	1.77	1.48
2002 (2-salts only)	0.98	0.64	0.66	0.94	0.64	0.66
5-yr average	**1.71**	**1.15**	**0.97**	**1.73**	**1.22**	**0.98**
2001	1.00	N/A	0.04	0.83	N/A	0.05

[1] Catherine Ck acclimation pond is not included since it covers only 2001 and 2002.
[2] Category T_0 uses $SAR_1(T_0)$ in 1999, 2000 and 2001, and $SAR_2(T_0)$ in 1997, 1998 and 2002.

The estimated in-river survival from LGR tailrace to BON tailrace (V_C), transport SAR to inriver SAR (T/C) ratio, and delayed mortality D for the PIT tagged hatchery spring Chinook and summer Chinook is presented in Tables 25 and 26, respectively, for migration years 1997 to 2002. For spring and summer Chinook stocks in 1997 to 2002, the V_C estimates ranged from 0.31 to 0.71, except in 2001 when in-river survival dropped

Table 25. Estimated in-river survival LGR to BON (V_C), T/C ratio, and *D* of PIT tagged hatchery spring Chinook from 1997 to 2002 (95% confidence intervals in parenthesis).

Migration Year	Hatchery	Parameter	Estimate
1997	RAPH	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.32 (77% expansion)[A] 1.73 (0.98 – 3.18) 0.58 (0.30 – 1.18)
1997	DWOR	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.49 (77% expansion) 1.75 (0.82 – 4.88) 0.87 (0.34 – 2.44)
1998	RAPH	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.59 (25% expansion) 1.66 (1.26 – 2.28) 0.99 (0.72 – 1.38)
1998	DWOR	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.51 (25% expansion) 0.72 (0.57 – 0.89) 0.37 (0.28 – 0.49)
1999	RAPH	V_C $SAR_1(T_0)/SAR(C_0)$ D	0.57 (0.48 – 0.70) 1.15 (0.96 – 1.38) 0.70 (0.55 – 0.92)
1999	DWOR	V_C $SAR_1(T_0)/SAR(C_0)$ D	0.54 (0.46 – 0.66) 0.90 (0.67 – 1.18) 0.55 (0.39 – 0.77)
2000	RAPH	V_C $SAR_1(T_0)/SAR(C_0)$ D	0.58 (0.46 – 0.89) 1.32 (1.09 – 1.59) 0.82 (0.60 – 1.32)
2000	DWOR	V_C $SAR_1(T_0)/SAR(C_1)$ D	0.48 (0.39 – 0.67) 0.99 (0.80 – 1.23) 0.53 (0.40 – 0.80)
2002[B]	RAPH	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.71 (0.59 – 0.89) 1.51 (1.13 – 2.05) 1.09 (0.77 – 1.62)
2002[B]	DWOR	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.62 (0.53 – 0.73) 1.21 (0.87 – 1.73) 0.76 (0.54 – 1.11)
2002[B]	CATH	V_C $SAR_2(T_0)/SAR(C_0)$ D	0.65 (0.41 – 1.22) 1.98 (0.98 – 4.87) 1.31 (0.58 – 4.20)
1997-2000, 2002		**Geomean T/C ratio** **Geomean D**	**1.30** **0.73**
2001	RAPH	V_C $SAR_1(T_0)/SAR(C_1)$ D	0.33 (0.27 – 0.42) 21.5 (12.0 – 57.2) 7.17 (3.88 – 19.0)
2001	DWOR	V_C $SAR_1(T_0)/SAR(C_1)$ D	0.24 (0.20 – 0.31) 8.79 (4.64 – 23.9) 2.17 (1.08 – 6.67)
2001	CATH	V_C $SAR_1(T_0)/SAR(C_1)$ D	0.25 (0.17 – 0.42) 5.50 (0.00 – 14.9) 1.39 (0.00 – 4.26)
2001		**Geomean T/C ratio** **Geomean D**	**10.1** **2.8**

[A] Full reach 95% confidence interval is not available – a constant "per/mile" survival expansion rate is used over the percentage of reach shown in parenthesis.

[B] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

Table 26. Estimated in-river survival LGR to BON (V_C), T/C ratio, and *D* of PIT tagged hatchery summer Chinook from 1997 to 2002 (95% confidence intervals in parenthesis).

Migration Year	Hatchery	Parameter	Estimate	
1997	MCCA	V_C	0.43	(77% expansion) [A]
		$SAR_2(T_0)/SAR(C_0)$	1.39	(1.05 – 1.95)
		D	0.61	(0.39 – 0.98)
1997	IMNA	V_C	0.31	(77% expansion)
		$SAR_2(T_0)/SAR(C_0)$	1.37	(0.76 – 2.69)
		D	0.43	(0.20 – 0.97)
1998	MCCA	V_C	0.56	(25% expansion)
		$SAR_2(T_0)/SAR(C_0)$	1.97	(1.48 – 2.70)
		D	1.13	(0.85 – 1.59)
1998	IMNA	V_C	0.53	(25% expansion)
		$SAR_2(T_0)/SAR(C_0)$	1.56	(0.88 – 3.41)
		D	0.84	(0.47 – 1.87)
1999	MCCA	V_C	0.52	(0.45 – 0.63)
		$SAR_1(T_0)/SAR(C_0)$	1.49	(1.19 – 1.82)
		D	0.86	(0.65– 1.13)
1999	IMNA	V_C	0.54	(0.41 – 0.78)
		$SAR_1(T_0)/SAR(C_0)$	1.76	(1.19 – 2.64)
		D	1.03	(0.66 – 1.71)
2000	MCCA	V_C	0.61	(0.49 – 1.42)
		$SAR_1(T_0)/SAR(C_0)$	1.88	(1.61 – 2.20)
		D	1.24	(0.94 – 2.99)
2000	IMNA	V_C	0.57	(0.41 – 0.91)
		$SAR_1(T_0)/SAR(C_0)$	1.30	(1.02 – 1.64)
		D	0.82	(0.55 – 1.37)
2002[B]	MCCA	V_C	0.58	(0.49 – 0.69)
		$SAR_2(T_0)/SAR(C_0)$	1.45	(1.12 – 1.85)
		D	0.85	(0.64 – 1.17)
2002[B]	IMNA	V_C	0.49	(0.39 – 0.69)
		$SAR_2(T_0)/SAR(C_0)$	1.71	(1.01 – 3.13)
		D	0.88	(0.49 – 1.77)
1997-2000, 2002		**Geomean T/C ratio**	**1.57**	
		Geomean D	**0.84**	
2001	MCCA	V_C	0.26	(0.22 – 0.36)
		$SAR_1(T_0)/SAR(C_1)$	32.3	(16.9 – 99.0)
		D	8.85	(4.53 – 28.5)
2001	IMNA	V_C	0.37	(0.26 – 0.66)
		$SAR_1(T_0)/SAR(C_1)$	10.7	(4.45 – 44.0)
		D	4.05	(1.53 – 19.4)
2001		**Geomean T/C ratio**	**18.6**	
		Geomean D	**6.0**	

[A] Full reach 95% confidence interval is not available – a constant "per/mile" survival expansion rate is used over the percentage of reach shown in parenthesis.
[B] Migration year 2002 has incomplete adult returns with only 2-salt returns as of 2004.

to only 0.24 to 0.37. The individual reach survival estimates used to obtain *V*c and expand smolt counts per category to LGR equivalents are presented in Appendix Table A-1 for each migration year and hatchery. Except for 2001, the T/C ratios ranged from 0.72 to 1.98 between 1997 and 2002, with a 5-year geometric mean of 1.30 for spring Chinook stocks and 1.57 for summer Chinook stocks. In 2001, the T/C ratio ranged from

5.5 to 32.3 across the five hatcheries using SAR(C_1) in the denominator of the ratio due to few smolts (<3.5% of LGR population) in Category C_0 that year. Because C_0 fish would have to have passed through the turbines at all three Snake River collector dams, it is unlikely that the "true" survival of those fish was any better than that of Category C_1 fish. Except for 2001 when *D* across hatcheries ranged from 1.39 to 8.85, *D* normally ranged from 0.37 to 1.31 between 1997 and 2002, with a 5-year geometric mean of 0.73 for spring Chinook stocks and 0.84 for summer Chinook stocks. Obtaining T/C ratios less than 2 in all study years except 2001 is further evidence of the presence of delayed mortality in transported PIT tagged hatchery Chinook smolts after release below BON. The drought year of 2001 stands out as uniquely different from the other years of study and corresponding survival measures show that non-transported hatchery Chinook smolts faired poorly that year as did their wild Chinook counterparts.

Although the T/C ratio was nearly identical in 1997 at Rapid River and Dworshak hatcheries, the T/C ratio of Rapid River Hatchery spring Chinook was always higher than that of Dworshak Hatchery spring Chinook in the subsequent 5 years including 2001 (Table 25). With only two years of Catherine Ck AP spring Chinook, it is not clear how this stock will rank with the other two spring Chinook stocks since it had the lowest T/C ratio in 2001 and highest T/C ratio in 2002 of the three stocks. However, 2002 is still an incomplete return year with only 2-salt returns available. The 1997 T/C ratios were also nearly identical at McCall and Imnaha hatcheries, and in the subsequent 5 years including 2001, the hatchery with the higher of the two T/C ratios fluctuated over time with McCall Hatchery summer Chinook having the higher T/C ratio in 3 years and Imnaha Hatchery summer Chinook having the higher T/C ratio in 2 years (Table 26).

Table 27 presents a comparison of the annual T/C ratios for the PIT tagged wild Chinook aggregate from Table 11 to the annual T/C ratios for the PIT tagged hatchery Chinook aggregate created by dividing the strata weighted and unweighted transport SARs by their in-river counterparts from Table 24. The two methods of computing an aggregate hatchery SAR provides some year-to-year differences in magnitude, but the overall 5-year geometric means excluding 2001 were very similar at 1.47 for the strata weighted T/C ratio and 1.44 for the unweighted T/C ratio. These 5-year geometric means were much higher than the corresponding 5-year geometric mean T/C ratio of 0.78 for the PIT tagged wild Chinook aggregate. When the additional 3 years prior to 1997 were included for PIT tagged wild Chinook, an 8-year geometric mean T/C ratio of 0.98 was obtained. Likewise, in 2001, the T/C ratio of PIT tagged wild Chinook aggregate was lower than that of the PIT tagged hatchery Chinook aggregate. Although hatchery Chinook tend to have higher survival to adulthood by being transported, wild Chinook do not follow that trend, except in drought years such as 2001. Overall, PIT tagged wild Chinook continue to show little benefit by transportation. Therefore, transportation does not appear to be working as a management tool for recovery of listed wild spring/summer Chinook. But complicating this finding is the trend for PIT tagged hatchery Chinook from McCall, Imnaha, Catherine Ck, Rapid River, and in some years Dworshak hatcheries toward a higher SARs for transported smolts. Having transportation benefits for hatchery spring/summer Chinook and transportation disadvantages for wild spring/summer Chinook adds another level of difficulty to future management of salmon in the Snake River basin.

Table 27. Annual T/C ratios of wild Chinook in 1994 to 2002 compared to annual T/C ratios of the combination of four CSS hatcheries (Rapid River, Dworshak, Imnaha, and McCall) computed by two methods in 1997 to 2002.

Migration Year	Wild Chinook[1]	Hatchery Chinook[2]	
	Aggregate Population	Strata Weighted	Unweighted
	T0/C0 SAR Ratio		
1994	1.62		
1995	0.95		
1996	1.92		
1997	0.74	1.44	1.50
1998	0.85	1.25	1.47
1999	1.17	1.82	1.34
2000	0.66	1.36	1.42
2002 (2-salts only)	0.58	1.53	1.47
Geometric mean:			
1994-2000, 2002	0.98	N/A	N/A
1997-2000, 2002	0.78	1.47	1.44
	T0/C1 SAR Ratio		
2001	9.11	25.0	16.6

[1] Yearly T/C ratios from Table 11.

[2] Yearly T/C ratios created using strata weighted and unweighted mean SAR data from Table 24.

CONCLUSIONS

- SARs and T/C ratios for PIT tagged wild and hatchery Chinook from migration years 1997 to 2002 suggest that hatchery Chinook in general should not be used as a surrogate for wild Chinook with regard to SARs based on route of passage through the hydro system. However, the similarity of the jack return proportion and pattern of overall SAR (study category specific SARs weighted by the estimated proportion of fish in the run-at-large in each study category) between PIT tagged wild Chinook and PIT tagged Rapid River Hatchery Chinook make the Rapid River Hatchery Chinook stock the best of the CSS hatchery groups for a surrogate for the wild Chinook.

- Hatchery-specific differences in LGR-LGR smolt-to-adult survival rates (SARs) have occurred with the CSS hatcheries used in each year from 1997 to 2002 with Dworshak Hatchery spring Chinook typically having the lowest SARs and McCall Hatchery summer Chinook typically having the highest SARs.

- Drainage-specific differences in overall SARs for PIT tagged wild Chinook may exist with higher SARs of wild Chinook from the Imnaha River drainage, intermediate SARs from the Salmon River and Grande Ronde River drainages, and lower SARs from the Clearwater River drainage.

- Yearling Chinook from Rapid River, Imnaha, and McCall hatcheries typically had higher LGR-LGR SARs for transported fish than for those fish that migrated in-river through the hydro system, whereas yearling Chinook from Dworshak

Hatchery typically had similar LGR-LGR SARs for both transported and in-river migrating fish.

- Estimated SARs of hatchery smolts transported from LGS and LMN may be similar or lower than smolts transported from LGR, but the data is inconclusive since total season transportation of CSS PIT tagged fish from the dams did not start until 2000.

- Estimated SARs of PIT tagged wild and hatchery summer Chinook stocks tend to be higher than their PIT tagged spring Chinook stock counterparts.

- The 5-year geometric mean T/C ratio was highest for hatchery summer Chinook (T/C=1.57), intermediate for hatchery spring Chinook (T/C=1.30) and lowest for the aggregate wild Chinook (T/C=0.78) in the years 1997 to 2002, excluding 2001. In the drought year of 2001, Chinook from the five CSS hatcheries and the wild aggregate all had T/C ratios well in excess of 5, reflecting the extremely poor in-river conditions that year.

- Evidence of delayed mortality of transported wild and hatchery Chinook smolts exists since T/C ratios did not exceed 2.0 in any year except in the drought year of 2001. For available years excluding 2001, the 8-year geometric mean D was 0.47 for the PIT tagged wild Chinook aggregate, and the 5-year geometric mean D was 0.73 for the PIT tagged hatchery spring Chinook stocks and 0.84 for the PIT tagged hatchery summer Chinook stocks.

- In years through 2000, there exists a pattern of lower SARs for wild and hatchery Chinook that are detected in the bypass at LGR, LGS, or LMN and returned-to-river (Category C_1) compared to the Chinook that pass those three dams undetected through the combined routes of spill and turbines (Category C_0). The incomplete return data for migration year 2002 does not follow that pattern, with SARs being similar for both types of in-river migrants.

- The precision of estimated SARs of transported and in-river migrating wild Chinook was low due to low numbers of PIT tagged smolts in the two key study groups of interest, namely Category T_0 and Category C_0. Most PIT tagged wild Chinook occurred in Category C_1 in 1994 to 2001 due to the standard protocol of routing all detected PIT tagged wild (and most hatchery) smolts back to the river in those years. By 2002, several fishery agencies and tribes allowed the CSS to purposely route a portion of their PIT tagged wild Chinook to transportation, which will improve our ability make statistical comparisons between the SARs of transported and in-river migrating wild Chinook in the future.

CHAPTER 3

Conversion Rates from Bonneville Dam to Lower Granite Dam in 2003-2004 for Spring/Summer Chinook originating in Snake R Basin

RESULTS AND DISCUSSION

For return years 2003 and 2004, PIT tagged hatchery and wild spring/summer Chinook salmon destined for the Snake River basin above LGR were monitored at upstream dams after they were detected and passed BON. PIT tag detection capabilities at BON, MCN, IHR, and LGR allowed the tracking of tagged hatchery and wild Chinook as they pass from lower Columbia River projects to upstream Snake River projects. The adult fish traverse about 286 river miles and encounter eight dams from BON to LGR inclusive. Once fish pass BON, they pass through a tribal fishery (between BON and MCN) and a sport fishery in both the Columbia and Snake Rivers.

PIT tagged hatchery and wild Chinook of Snake River origin that were detected at BON and then again at MCN, IHR, and finally LGR are tabulated in Table 28. Whether these fish dropout from fisheries, natural mortality, or injuries is not known, only that these fish arrive at the lower projects and a lesser portion of them are detected again at the upstream projects.

Table 28. PIT tagged adult Chinook detected at Bonneville and upstream dams in 2003 and 2004 with known source tags from the Snake River basin.

	Number of unique PIT tags detected in adult ladders[1]							
	Bonneville Dam		McNary Dam		Ice Harbor Dam		Lower Granite Dm	
	PIT tag number		PIT tag number		PIT tag number		PIT tag number	
Hatchery spring Chinook	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Jack	347	117	325	113	325	113	305	112
2-salt	448	1551	370	1359	367	1354	348	1299
3-salt	749	31	596	23	595	23	570	23
Wild spring Chinook								
Jack	13	1	13	0	13	0	12	0
2-salt	5	98	5	84	5	84	5	84
3-salt	135	0	116	0	116	0	115	0
Hatchery summer Chinook								
Jack	143	239	140	226	139	225	136	223
2-salt	247	570	209	456	208	452	204	450
3-salt	331	37	278	28	275	28	264	27
Wild summer Chinook								
Jack	7	2	7	2	7	2	7	2
2-salt	28	88	24	78	24	78	24	76
3-salt	203	16	166	14	165	14	158	13

[1]Data through 2004 from IDFG showing unique adult return detections based on last observation date at Bonneville, McNary, Ice Harbor, and Lower Granite dams.

The differences in PIT tagged adult detections from BON to MCN, MCN to IHR, and IHR to LGR are presented, respectively, in the loss columns under the headings of McNary, Ice Harbor, and Lower Granite dams in Table 29. For both return years 2003 and 2004, the largest amount of loss occurred on the PIT tagged adults from BON to MCN, ranging between 11.5 and 20.3% with no apparent pattern between hatchery and wild stocks over the two return years. With an active tribal harvest occurring during the spring and summer Chinook migration in Zone 6, one would expect a loss of these PIT tagged fish in this area and a near equal percentage loss between fish of hatchery or wild origin. The sport fishery regulations require that Chinook with an adipose fin be returned back to the river unharmed while fish with a clipped adipose fin may be retained as part of their catch. In some stretches of river, such as from MCN or IHR to LGR, one would anticipate that fewer wild fish would be taken or missing than hatchery Chinook that can be kept as part of the bag limit. The loss numbers in Table 29 are higher for hatchery stocks, which supports this claim. Other factors that can reduce numbers of fish passing to upstream tributaries and hatcheries include injuries that are debilitating, straying to other watersheds than where released, and passage mortality through the hydrosystem.

Table 29. PIT tagged adult Chinook detected[1] at Bonneville in 2003 - 2004 and percentage of adult fish dropping out or lost prior to upstream detection sites in Columbia River and Snake River projects.

	Bonneville Dam		**McNary Dam**		**Ice Harbor Dam**		**Lower Granite Dam**	
Hatchery spring Chinook	**# of PIT tags**		**# Loss (% loss)**		**# Loss (% loss)**		**# Loss (% loss)**	
	2003	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Jack	347	117	22 (6.3)	4(3.4)	0 (0.0)	0	20 (6.2)	1(0.9)
2-salt	448	1551	78 (17.4)	192(12.4)	3 (0.8)	5(0.4)	19 (5.2)	55(4.1)
3-salt	749	31	153 (20.4)	8(25.8)	1 (0.2)	0	25 (4.2)	0
Total 2/3-salt	1197	1582	231 (19.3)	200(12.6)	4 (0.4)	5(0.4)	44 (4.6)	55(4.0)
Wild spring Chinook								
Jack	13	1	0	0	0	0	1 (7.7)	0
2-salt	5	98	0	14(14.3)	0	0	0	0
3-salt	135	0	19 (14.1)	0	0	0	1 (0.9)	0
Total 2/3-salt	140	98	19 (13.6)	14(14.3)	0	0	1 (0.8)	0
Hatchery summer Chinook.								
Jack	143	239	3 (2.1)	13(5.4)	1 (0.7)	1(0.4)	3 (2.2)	2(0.9)
2-salt	247	570	38 (15.4)	114(20.0)	1 (0.5)	4(0.9)	4 (1.9)	2(0.4)
3-salt	331	37	53 (16.0)	9(24.3)	3 (1.1)	0	11 (4.0)	1(3.6)
Total 2/3-salt	578	607	91 (15.7)	123(20.3)	4 (0.8)	4(0.8)	15 (3.1)	3(0.6)
Wild summer Chinook								
Jack	7	2	0	0	0	0	0	0
2-salt	28	88	4 (14.3)	10(11.4)	0	0	0	2(2.6)
3-salt	203	16	37 (18.2)	2(12.5)	1 (0.6)	0	7 (4.2)	1(7.1)
Total 2/3-salt	231	104	41 (17.8)	12(11.5)	1 (0.5)	0	7 (3.7)	3(3.3)

[1]Data through 2004 from IDFG showing unique adult return detections based on last observation date at Bonneville, McNary, Ice Harbor, and Lower Granite dams.

The larger 2- and 3-salt adult Chinook are a greater targeted size fish for the Tribal gillnets and related fishery as well as the sport fishery, than would be the smaller 1-salt jack Chinook. The percentage of jack hatchery spring/summer Chinook that are lost or not detected between BON and MCN were lower by greater than 3-fold than their returning adult counterparts.

CONCLUSIONS

- Losses of adult Chinook, both hatchery and wild stocks, were greatest between BON and MCN for the 2003 and 2004 migration seasons with 11.5% to 20.3% of the fish dropping out or non-detected between the two projects.

- Losses of adult Chinook between MCN and IHR were minimal for both years of record. Less than 1% of the wild and hatchery PIT tagged groups were lost between the Columbia River (MCN) and the Snake River (IHR).

- Losses of adult Chinook between IHR and LGR ranged from 4.0 to 4.6% for the hatchery spring Chinook; less than 1% for the wild spring Chinook; 3.1 to less than 1% for hatchery summer Chinook, and 3.7 to 3.3% for wild summer Chinook for the respective 2003 and 2004 adult PIT tag returns.

CHAPTER 4

Hatchery-to-hatchery smolt-to-adult survival rates for key upstream Chinook hatcheries adjusted for harvest

RESULTS AND DISCUSSION

Juvenile Migration Survival Rates

Survival estimates for the five CSS hatcheries from hatchery release site to LGR tailrace are presented in Table 30 for migration years 1997 to 2002.

Table 30. Estimated Chinook survival from key upstream CSS hatcheries to Lower Granite Dam tailrace for migration years 1997 to 2002.

Hatchery	Parameter	Migration year					
		1997	1998	1999	2000	2001	2002
McCall H	PIT tag release	52,652	47,340	47,985	47,705	55,124	54,734
	Survival S_1	0.425	0.588	0.658	0.667	0.667	0.596
	Standard Error	0.00768	0.00363	0.00817	0.00899	0.00218	0.00639
	LL 95% CI	0.410	0.580	0.642	0.651	0.663	0.584
	UL 95% CI	0.441	0.594	0.674	0.686	0.672	0.608
Imnaha AP	PIT tag release	13,378	19,825	19,939	20,819	20,922	20,920
	Survival S_1	0.617	0.685	0.664	0.685	0.748	0.667
	Standard Error	0.01736	0.00621	0.01102	0.01077	0.00330	0.01185
	LL 95% CI	0.584	0.673	0.643	0.665	0.742	0.645
	UL 95% CI	0.653	0.697	0.686	0.709	0.755	0.691
Dworshak H	PIT tag release	14,080	47,703	47,845	47,743	55,139	54,725
	Survival S_1	0.581	0.843	0.853	0.825	0.748	0.827
	Standard Error	0.01690	0.00586	0.01147	0.00869	0.00210	0.01163
	LL 95% CI	0.549	0.831	0.831	0.809	0.744	0.804
	UL 95% CI	0.617	0.854	0.877	0.843	0.752	0.850
Rapid River H	PIT tag release	40,452	48,336	47,812	47,747	55,085	54,908
	Survival S_1	0.390	0.665	0.751	0.737	0.690	0.755
	Standard Error	0.00756	0.00341	0.00644	0.00677	0.00210	0.00704
	LL 95% CI	0.377	0.658	0.738	0.724	0.686	0.743
	UL 95% CI	0.406	0.672	0.764	0.750	0.694	0.770
Catherine Creek AP[1]	PIT tag release	N/A	N/A	N/A	N/A	20,915	20,796
	Survival S_1					0.520	0.406
	Standard Error					0.00384	0.00763
	LL 95% CI					0.513	0.390
	UL 95% CI					0.528	0.421

[1] Catherine Creek acclimation pond spring Chinook became available for migration year 2001 following discontinuance of the on-site releases of hatchery Chinook from Lookingglass Hatchery in 1999.

PIT Tag Detections at Lower Granite Dam Adult Trap and the Hatcheries

The total numbers of PIT tagged adult Chinook detected at LGR and also at the hatcheries are presented in Table 31 for each CSS hatchery from migration years 1997 to 2001. Because harvest for return year 2004 is not available until next year, PIT tagged fish returns to the hatchery from migration year 2001 will only include 2-salt returns and PIT tagged from migration year 2002 will not be included in this chapter. This table includes all returning CSS fish including the primary study categories C_0, C_1, and T_0, and the extra categories containing fish that had an unknown passage route at a transportation dam (designate as Category U) and fish that were transported after having had prior detections at upstream dams (designated as Category T_1). PIT tagged fish in study categories C_0, C_1, and T_0 were analyzed in Chapter 1 relative to survival rates from LGR as smolts to LGR as adults. These three categories plus the PIT tagged fish in categories U and T_1 were utilized in this chapter to determine adult survival rates from LGR back to the hatchery of origin.

Table 31. Number of returning PIT tagged hatchery Chinook adults and jacks detected at Lower Granite Dam (LGR) and the hatchery racks (HAT) from smolts migrating in 1997 to 2002. Includes all returning jacks and adults from Chinook PIT tagged for the CSS regardless of final category assignment.

Hat. (run)	Age	Migration Year									
		1997		1998		1999		2000		2001	
		LGR	HAT	LGR	HAT	LGR	HAT	LGR	HAT	LGR	HAT
RAPH (sp)	Jacks	2	0	32	13	43	7	8	1	21	5
	2-salt	86	40	390	44	787	85	371	63	206	25
	3-salt	7	1	23	1	31	2	256	24	13	N/A[1]
MCCA (su)	Jacks	21	7	108	63	119	84	144	46	62	33
	2-salt	263	141	394	269	722	217	635	181	200	58
	3-salt	11	6	37	5	113	20	240[2]	65	23	N/A
DWOR (sp)	Jacks	1	0	51	40	14	4	3	0	14	8
	2-salt	36	15	372	81	393	82	180	31	79	18
	3-salt	6	1	23	9	44	4	197	44	10	N/A
IMNA (su)	Jacks	24	15	54	25	81	41	149	37	30	5
	2-salt	63	31	69	33	226	73	289	28	49	16
	3-salt	7	1	2	0	12	1	79	5	4	N/A
CATH (sp)	Jacks									2	1
	2-salt									13	9
	3-salt									0	N/A

[1] PIT tagged adult returns to Lower Granite Dam and the hatchery racks are not available at time of report.
[2] Total in 3-salt return to LGR for MCCA includes one 4-salt fish.

What is readily apparent from Table 31 is that a relatively small number of the PIT tagged adults detected at LGR were subsequently detected at the hatchery. This was due to extensive terminal sport and tribal fisheries in recent years, as the number of returning adults has risen. At all hatchery sites, a sport fishery was not allowed in return year 1999 due to the reduced number of adult fish that returned to the Snake River basin. Although a limited tribal fishery was allowed in some regions in 1999, more extensive tribal fisheries were allowed in later return years. In return years 2000 through 2003, a sport fishery was allowed to reduce surplus fish that were destined for the CSS hatcheries. In estimating the survival rate of adult fish from LGR to the hatchery of origin, fishery harvest return numbers were reviewed from tribal and sport sources. Note that Imnaha River did not have a sport fishery in these years with exception of a limited one in 2002; however, they do have adults that spawn below the weir based on carcass counts. Likewise, in the South Fork Salmon River, IDFG accounts for about 10% of the total annual McCall hatchery returns on the spawning grounds below the hatchery weir, and a smaller fraction that have strayed into the Secesh River and Johnson Creek.

Returning adult salmon that spawn below a hatchery weir or stray into different streams and do not return to the hatchery of origin will lower the perceived survival rate to the hatchery. The level of this impact cannot be determined from the PIT tag data.

In last year's CSS annual report, we investigated whether transported versus in-river migrating smolts produced returning adults that had differences in their proportion returned to the hatchery from what was detected at LGR. We determined that the combined PIT tagged adults and jacks detected at LGR for each separate hatchery did not have subsequent detections at the hatchery that differed greater than could occur by random chance for fish that as smolts had migrated through the hydro system in-river versus those transported in 1997 to 2000. With only 2 to 8 adults from in-river migrants (Category C_1 fish) detected at LGR in 2001, there was too few fish to consider updating this analysis with an additional year of data. Overall, we concluded that computing separate survival rates from LGR back to the hatchery based on prior hydro system passage history of the smolts was not necessary. Therefore, for each hatchery and migration year of interest, only a single survival parameter (adjusted for harvest) was needed for the LGR-to-hatchery reach.

Hatchery-to-Hatchery Smolt-to-Adult Survival Rates, Migration Years 1997 to 2001

Partition of hatchery-to-hatchery SARs into components

Task 2(a) of Objective 2 (presented in Introduction) aims to estimate hatchery-to-hatchery survival rates and partition these rates into their three survival components, hatchery-to-LGR survival as smolts, LGR (smolts)-to-LGR (adults) SAR, and LGR-to-hatchery survival as adults. This partitioning requires estimates of survival to LGR tailrace (Table 30), an overall run-at-large estimate of $SAR_{LGR\text{-}to\text{-}LGR}$, and harvest adjusted LGR-to-hatchery survival rates. In estimating the latter two components, it is important to know the efficiency of the PIT tag detection equipment at LGR. In return years 1999, 2001 and 2002, a total of only 18 PIT tagged CSS hatchery Chinook were detected at the hatchery that previously were not detected at LGR adult trap (where 984 jacks and adults were detected), giving an overall 98% detection efficiency rate at the dam. In return year 2000, all PIT tagged CSS hatchery Chinook detected at the hatchery were also detected at LGR adult trap. Because of the very high PIT tag detection efficiency rate at the dam, we concluded that no adjustments to the number of detected PIT tagged fish at LGR were necessary.

The overall run-at-large estimate of $SAR_{LGR\text{-}to\text{-}LGR}$ for each hatchery and migration year was computed in Chapter 2 by taking the study group specific SARs (see Chapter 2 Tables 20 and 21) and weighting them by an estimate of the proportion of the run-at-large reflected by each study group in each year. This weighting was necessary since some PIT tagged fish migrate through the system differently than the run-at-large due to the study requirement of obtaining in-river survival estimates between key dams in the hydro system. The resulting weighted $SAR_{LGR\text{-}to\text{-}LGR}$ for each hatchery and migration year is presented in Table 32 along with the survival rate from hatchery to LGR as a smolt. Multiplying these two survival rates with the hatchery production release number provides an estimate of the number of returning adults (age 2- and 3-salt adults) passing LGR. This completes the first two components of the hatchery-to-hatchery SAR partition.

Table 32. Estimated number of smolts and returning adults (age 2- and 3-salt) at Lower Granite Dam for each hatchery group used in the CSS for migration years 1997 to 2001.

Migr. Year	Hatchery[1]	Hatchery Release	Hat-to-LGR Survival (S_1)[2]	Est. Smolts at LGR	Weighted $SAR_{LGR\text{-}to\text{-}LGR}$[3]	Est. adults at LGR
1997	DWOR	53,078	0.581	30,800	0.0062	191
1997	IMNA	50,911	0.617	31,400	0.0098	308
1997	MCCA	239,647	0.425	101,800	0.0150	1,527
1997	RAPH	85,838	0.390	33,500	0.0065	218
1998	DWOR	973,400	0.843	820,600	0.0100	8,206
1998	IMNA	93,108	0.685	63,800	0.0081	517
1998	MCCA	393,872	0.588	231,600	0.0252	5,836
1998	RAPH	896,170	0.665	596,000	0.0189	11,264
1999	DWOR	1,044,511	0.853	891,000	0.0110	9,801
1999	IMNA	184,725	0.664	122,700	0.0228	2,798
1999	MCCA	1,143,083	0.658	752,100	0.0326	24,518
1999	RAPH	2,847,283	0.751	2,138,300	0.0265	56,665
2000	DWOR	1,017,873	0.825	839,700	0.0100	8,397
2000	IMNA	179,797	0.685	123,200	0.0290	3,573
2000	MCCA	1,039,930	0.667	693,600	0.0310	21,502
2000	RAPH	2,462,354	0.737	1,814,800	0.0194	35,207
2001	DWOR	333,120	0.748	249,200	0.0036	897
2001	IMNA	123,014	0.748	92,000	0.0060	552
2001	MCCA	1,076,846	0.667	718,300	0.0122	8,763
2001	RAPH	736,601	0.690	508,300	0.0105	5,337
2001	CATH	136,833	0.520	71,200	0.0023	164

[1] Hatchery coding: DWOR=Dworshak H; IMNA=Imnaha AP; MCCA=McCall H; RAPH=Rapid River H; CATH=Catherine Creek AP.
[2] Survival from hatchery to LGR is from Table 30
[3] Weighted estimated $SAR_{LGR\text{-}to\text{-}LGR}$ is from Table 22 in Chapter 2.

In the hatchery-to-hatchery survival rate partitioning, the final reach of interest for the returning adult Chinook is from LGR to the hatchery. This includes the hatchery rack counts and adjustments for harvest (and potential adjustments for periods when weirs and adult fish traps are non-operational when adults are returning to the hatchery). The returning jacks and adults counted at the hatchery from each brood year consist of three age classes (1-salt [jacks], 2-salt and 3-salt) that show up over three successive return years (a single migration year 2000 McCall Hatchery 4-salt returning adult was also detected at LGR and is included in the adult count). In the estimating of survival of adult Chinook from LGR back to the hatchery, jacks are excluded because SAR estimates used to compare upstream and downstream hatcheries are based only on adult returns. Although only returning adult Chinook are used in SAR estimation, we still show the jack count provided by the fishery agencies (and tribes for harvest) in Tables 33 to 37 for CSS hatcheries in migration years 1997 to 2001. The smolts that migrated in 1997 to 2001 were from the 1995 to 1999 brood years, and had returns of jacks and adults in 1998 to 2003. Hatchery rack returns adjusted for harvest will not be available until next year, so the total adults estimated at LGR for each hatchery in Table 32 for migration year 2001 will be reduced by the proportion of 3-salts in the adult count from Table 31. Virtually all of the jacks and adults that arrived at a CSS hatchery were checked for the presence of a PIT tag. However, there was no program for detecting PIT tags in the sport/tribal harvest (IDFG has reported a few PIT tags detections from sport fishermen, but this PIT tag detection information is very spotty). The sum of the harvest and rack counts is the total return for a given year.

Table 33. Dworshak Hatchery production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration years 1997 to 2001 with respective hatchery-to-hatchery SARs of returning age 2- and 3-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack	Total Adult Return[1]	Hat-to-hat SAR[1] (%)
1997	53,078	1998	(3 jacks)		(11 jacks)	---	
		1999	None		78	78	0.80 %
		2000	240		104	344	
1998	973,400	1999	None		(670 jacks)	---	
		2000	4,606		2,827	7,443	1.02 %
		2001	1,705		747	2,452	
1999	1,044,511	2000	(275 jacks)	N/A	(221 jacks)	---	
		2001	7,731	502	3,235	11,468	1.23 %
		2002	655	155	615	1,425	
2000	1,017,873	2001	(59 jacks)	N/A	(36 jacks)	---	
		2002	2,679	639	1,480	4,798	0.99 %
		2003	1,915	1,031	2,364	5,310	
2001[2]	333,120	2002	(208 jacks)	N/A	(62 jacks)	---	
		2003	247	414	478	1,139	0.34 %
		2004	N/A	N/A	N/A	N/A	Incomplete

[1] Total adult return and respective SAR estimate exclude returning jacks.
[2] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete.
Data source: Hatchery rack from Burge *et al.* (2002) and total return minus hatchery rack count produced combined sport & tribal harvest for migration years 1997 and 1998; for migration years 1999 to 2001, sport harvest from Larry Barrett (IDFG) and tribal harvest from Snake River Fisheries Biological Assessment, Shoshone-Bannock Tribes, provided by Keith Kutchins (Fort Hall Indian Reservation, ID).

Table 34. Catherine Creek acclimation pond production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration year 2001 associated hatchery-to-hatchery SARs of returning age 2-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack	Total Adult Return[1]	Hat-to-hat SAR[1] (%)
2001	136,833	2002	None	None	(N/A jacks)	---	
		2003	None	None	181	181	0.13 %
		2004[2]	N/A		N/A	N/A	Incomplete

[1] Tribal harvest, total adult return and respective SAR estimate exclude returning jacks.
[2] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete

Table 35. Rapid River H production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration years 1997 to 2001 with associated hatchery-to-hatchery SARs of returning age 2- and 3-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack	Total Adult Return[1]	Hat-to-hat SAR[1] (%)
1997	85,838	1998	None	N/A	(7 jacks)	---	
		1999	None	87	152	239	0.31 %
		2000	9	10	12	31	
1998	896,170	1999	None	N/A	(639 jacks)	---	
		2000	2,179	2,547	3,086	7,812	0.95 %
		2001	518	105	96	719	
1999	2,847,283	2000	(695 jacks)	N/A	(1,701 jacks)	---	
		2001	14,851	7,362	12,546	34,759	1.23 %
		2002	137	51	157	345	
2000	2,462,354	2001	(117 jacks)	N/A	(128 jacks)	---	
		2002	5,972	2,374	2,872	11,218	0.79 %
		2003	4,003	2,342	2,010	8,355	
2001[2]	736,601	2002	(56 jacks)	N/A	(119 jacks)		
		2003	1,090	1,884	506	3,480	0.47 %
		2004	N/A	N/A	N/A	N/A	(Incomplete)

[1] Tribal harvest, total adult return and respective SAR estimate exclude returning jacks.
[2] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete.
Data source: Sport harvest from Barrett (2002, 2003) and Paul Janssen (IDFG, McCall, ID); Nez Perce and Shoshone-Bannock tribal harvest from Table 3 in Snake River Fisheries Biological Assessment, Shoshone-Bannock Tribes, April 24, 2003, provided by Keith Kutchins (Fort Hall Indian Reservation, ID).

Table 36. Imnaha AP production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration years 1997 to 2001 with associated hatchery-to-hatchery SARs of returning age 2- and 3-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack	Total Adult Return[1]	Hat-to-hat SAR[2] (%)
1997	50,911	1998	None	None	(73 jacks)	---	
		1999	None	None	148	585	1.21 %
		2000	None	None	15	32	
1998	93,108	1999	None	None	(174 jacks)	---	
		2000	None	None	254	542	0.76 %
		2001	14	None	84	162	
1999	184,725	2000	None	None	(511 jacks)	---	
		2001	218	None	1,298	2,489	1.53 %
		2002	30	None	81	342	
2000	179,797	2001	(103 jacks)	None	(621 jacks)	---	
		2002	280	None	746	3,151	2.25 %
		2003	77	135	256	898	
2001[2]	123,014	2002	N/A	N/A	(N/A jacks)	---	
		2003	48	55	264	811	0.66 %
		2004	N/A	N/A	N/A	N/A	Incomplete

[1] To arrive at total return, ODFW adjusts hatchery rack count for periods when weir is not operating.
[2] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete.
Data source: Harvest, rack count, and total adult return provided by Pat Keniry (ODFW, La Grande, OR).

Table 37. McCall Hatchery production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration years 1997 to 2001 with associated hatchery-to-hatchery SARs of returning age 2-salt and 3-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack	Total Adult Return[1]	Hat-to-hat SAR[1] (%)
1997	239,647	1998	None	N/A	N/A	---	
		1999	None	59	1,086	1,145	0.50 %
		2000	6	4	45	54	
1998	393,872	1999	None	N/A	(87 jacks)	---	
		2000	648	443	4,780	5,871	1.59 %
		2001	140	41	226	407	
1999	1,143,083	2000	(213 jacks)	N/A	(1,566 jacks)	---	
		2001	5,863	1,754	9,476	17,093	1.64 %
		2002	729	152	807	1,688	
2000	1,039,930	2001	(79 jacks)	N/A	(128 jacks)	---	
		2002	5,699	1,208	6,423	13,330	1.78 %
		2003	1,782	757	2,640	5,179	
2001[2]	1,076,746	2002	(217 jacks)	N/A	(1,134 jacks)	---	
		2003	3,275	634	3,664	7,573	0.70 %
		2004	N/A	N/A	N/A	N/A	(Incomplete)

[1] Tribal harvest, total adult return and respective SAR estimate exclude returning jacks.
[2] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete for 2001.
Data source: Sport harvest provided by Kim Apperson (IDFG, McCall, ID) and Larry Barrett (IDFG, Lewiston, ID); Nez Perce and Shoshone-Bannock tribal harvest and South Fork weir counts from Snake River Fisheries Biological Assessment, Shoshone-Bannock Tribes, provided by Keith Kutchins (Fort Hall Indian Reservation, ID), and the 2003 South Fork weir counts from McCall Hatchery manager.

Tables 33 to 37 also show the estimated hatchery-to-hatchery SAR (designated as $SAR_{hatchery\text{-}to\text{-}hatchery}$) for the total hatchery production released in 1997 to 2001 (harvest adjusted total return divided by hatchery release) for each CSS hatchery. For 1997 to 2000 the estimated hatchery-to-hatchery SAR ranged from 0.76% to 2.25% across four CSS hatcheries. Although the SARs reported for the 2001 season is preliminary since it only includes 2-salt adults in order to match the available harvest data, the expected increase with 3-salt adults will be only about 6-11% given the number of 3-salt adults detected at LGR (see Table 31). So none of the 2001 hatchery-to-hatchery SARs are likely to exceed 0.8% even with the PIT tagged 3-salt adult returns.

The estimated survival rates of PIT tagged adult spring/summer Chinook from LGR to the hatchery rack, adjusted for harvest removals, are presented in Table 38 for CSS hatchery groups that out-migrated in 1997 to 2001. Estimated survival rates ranged from 29% to over 100% survival rate with the middle half of the estimates between 50 and 69%. With over half of the estimates below 60%, the overall trend is toward lower survival rates given the adjustments made for harvest. Additionally, the expansions made by ODFW to arrive at the total run-at-large return in the Imnaha River for periods when the weir was not in place were applied to the PIT tag returns, but this approach produced wide variability in resulting survival estimates ranging from 36% to over 100%. There are multiple factors that could result in fewer PIT tagged adults detected at the hatchery rack than expected ranging from unaccounted adults spawning below weirs and trapping sites, adults overshooting the trapping sites during periods when weirs are not installed, straying into other streams, missed detections of PIT tagged adults or shed tags at the hatchery, under-reporting of harvest, delayed mortality from hooking and handling these fish in fisheries, and higher than expected natural mortality of adults after passing upstream through the hydrosystem.

Table 38. Estimated harvest-adjusted survival of PIT tagged adults from Lower Granite Dam to hatchery rack (LGR to HAT) for hatchery spring/summer Chinook that out-migrated in 1997 to 2001.

Hatchery	Mig. Year	Return Year	PIT tag count at LGR	PIT tag count at hat. rack[1]	% sport-tribal harvest rate.[2]	Harvest-adjusted PIT tags at hat. rack	Estimated survival LGR to HAT
Spring Chinook Stocks							
Dworshak	1997	’99-’00	42	16	56.9	37	0.884
	1998	’00-’01	395	90	63.9	249	0.631
	1999	’01-’02	437	86	70.1	288	0.658
	2000	’02-’03	377	75	62.0	197	0.524
	2001[3]	2003	79	18	58.0	43	0.543
Rapid River	1997	’99-’00	93	41	39.3	68	0.726
	1998	’00-’01	413	45	62.7	121	0.292
	1999	’01-’02	818	87	63.8	240	0.294
	2000	’02-’03	627	87	75.1	349	0.557
	2001[3]	2003	206	25	85.5	172	0.837
Catherine Ck	2001[3]	2003	13	9	None	9	0.692
Summer Chinook Stocks							
McCall	1997	’99-’00	274	147	5.7	156	0.569
	1998	’00-’01	431	274	20.3	344	0.798
	1999	’01-’02	835	237	45.3	433	0.519
	2000	’02-’03	875	246	51.0	502	0.574
	2001[3]	2003	200	58	51.6	120	0.599
Imnaha	1997	’99-’00	70	32	None	121[4]	>1
	1998	’00-’01	71	33	2.0	69[4]	0.972
	1999	’01-’02	238	74	8.8	152[4]	0.638
	2000	’02-’03	368	33	12.2	133[4]	0.362
	2001[3]	2003	49	16	12.7	49[4]	1.000

[1] PIT tag detection count at Lower Granite Dam and at hatchery rack from Table 29.
[2] Sport/tribal harvest proportion from data in Tables 33 to 37.
[3] Return year 2004 harvest information is not available until next year; PIT tagged adults at LGR and hatchery rack include 2-salt fish from Table 31.
[4] PIT tagged rack return adjusted by ODFW estimate of adult returns missed prior to installation of weir each year and fish spawning downstream of weir in addition to harvest removals.

The full partition of the $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate into its three survival components, hatchery-to-LGR survival rate S_1 as smolts, a weighted $SAR_{LGR\text{-}to\text{-}LGR}$ estimate, and LGR-to-hatchery survival rate as adults is presented in Table 39. This partition utilizes the PIT tagged spring/summer Chinook released with production in migration years 1997 to 2001. The product of the three survival components provides an estimate of the hatchery-to-hatchery SAR based on the PIT tagged fish. This PIT tag based $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate was lower than the estimate directly computed with the run-at-large fish in all cases except for Rapid River Hatchery fish in migration years 2000 and 2001. For the other hatcheries and migration years the PIT tagged based estimates were less by half or more than the run-at-large based estimates. However, as shown in Figure 8 a similar trend occurs across the migration years between the two methods of estimating $SAR_{hatchery\text{-}to\text{-}hatchery}$. As previously stated, there was an overall tend toward lower than expected survival rates based on PIT tag data given the adjustments made for harvest based on run-at-large data.

Table 39. Full partition of hatchery-to-hatchery SAR rate into three components from hatchery release to LGR (smolts), LGR (smolts) to LGR (adults), and LGR to hatchery (adults) based on PIT tagged hatchery sp/su Chinook that out-migrated in 1997 to 2001.

Hatchery	Mig. Year	Return Year	Survival HAT-to-LGR[1] (S_1)	Weighted $SAR_{LGR\text{-}to\text{-}LGR}$[1]	Survival LGR to HAT[2]	HAT-to-HAT SAR from PIT tags[3]	HAT-to-HAT SAR from run-at-large[4]
Spring Chinook Stocks							
Dworshak	1997	'99-'00	0.581	0.0062	0.884	0.0032	0.0080
	1998	'00-'01	0.843	0.0100	0.631	0.0053	0.0102
	1999	'01-'02	0.853	0.0110	0.658	0.0062	0.0123
	2000	'02-'03	0.825	0.0100	0.524	0.0043	0.0099
	2001[3]	2003	0.748	0.0036	0.543	0.0013	0.0034
Rapid River	1997	'99-'00	0.390	0.0065	0.726	0.0018	0.0031
	1998	'00-'01	0.665	0.0189	0.292	0.0037	0.0095
	1999	'01-'02	0.751	0.0265	0.294	0.0058	0.0123
	2000	'02-'03	0.737	0.0194	0.557	0.0080	0.0079
	2001[3]	2003	0.690	0.0105	0.837	0.0057	0.0047
Catherine Ck	2001[3]	2003	0.520	0.0023	0.692	0.0008	0.0013
Summer Chinook Stocks							
McCall	1997	'99-'00	0.425	0.0150	0.569	0.0036	0.0050
	1998	'00-'01	0.588	0.0252	0.798	0.0118	0.0159
	1999	'01-'02	0.658	0.0326	0.519	0.0111	0.0164
	2000	'02-'03	0.667	0.0310	0.574	0.0119	0.0178
	2001[3]	2003	0.667	0.0122	0.599	0.0044	0.0070
Imnaha	1997	'99-'00	0.617	0.0098	Set to 1	0.0061	0.0121
	1998	'00-'01	0.685	0.0081	0.972	0.0054	0.0076
	1999	'01-'02	0.664	0.0228	0.638	0.0097	0.0153
	2000	'02-'03	0.685	0.0290	0.362	0.0072	0.0225
	2001[3]	2003	0.748	0.0060	1.000	0.0041	0.0066

[1] Survival rate from hatchery to LGR and $SAR_{LGR\text{-}to\text{-}LGR}$ are from Table 32.
[2] Survival rate from LGR to hatchery as adults is from Table 38.
[3] Product of survival rates S_1 and $SAR_{LGR\text{-}to\text{-}LGR}$, and LGR-to-HAT.
[4] Run-at-large Hat-to-Hat survival rates are from Tables 33 to 37.

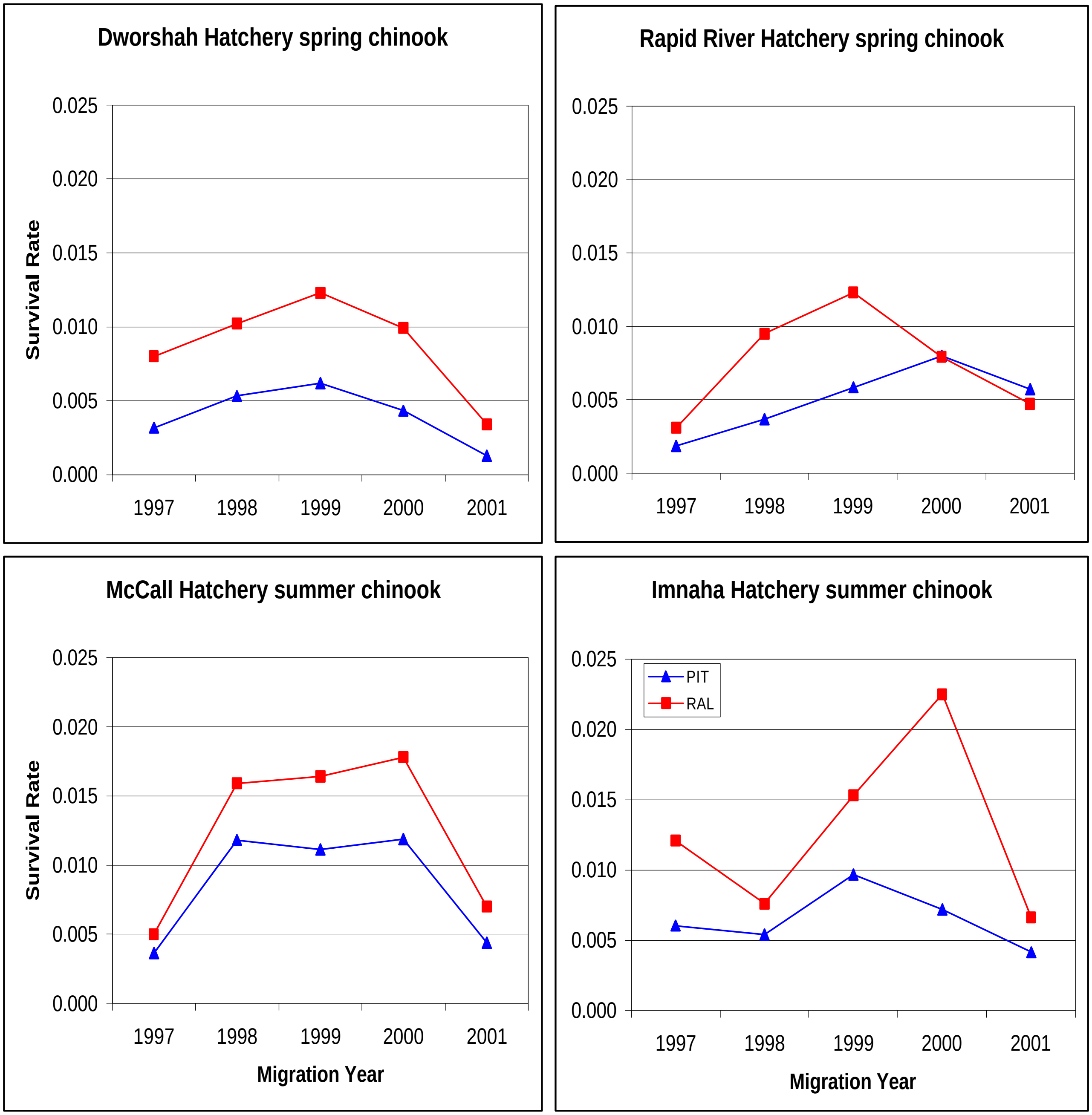


Figure 8. Comparison of hatchery-to-hatchery SAR survival rate for the total escapement to hatchery (adjusted for harvest) based on the run-at-large production fish (RAL red line) and based the product of the three components of survival of PIT tagged fish within the production (PIT blue line). The three survival rate components include: (i) Hatchery to LGR (smolts); (ii) LGR (smolts) to LGR (adults); and (iii) LGR to Hatchery (adults).

Likewise, there appears to be a lower than expected estimate of adults at LGR based on PIT tags for fish released from Dworshak, Catherine Ck, and Imnaha hatcheries and in some years from Rapid River and McCall hatcheries as shown in Table 39. In these cases, the total escapement to the hatchery (harvest adjusted) was greater than the estimated number of adults arriving at LGR based on applying the product of two survival components, the hatchery-to-LGR survival rate and the weighted $SAR_{LGR\text{-}to\text{-}LGR}$ survival rate, to the total production release number (Table 40).

Table 40. Comparison of PIT-tag based estimate of adult population at Lower Granite Dam and the total run-at-large escapement (including harvest) to the hatchery for spring/summer Chinook that out-migrated in 1997 to 2001.

Hatchery	Mig. Year	Hatchery Production Release	Estimated total adults at LGR (based on PIT tag data)[1]	Total escapement to Hatchery (based on run-at-large data)[2]	Difference from LGR to Hatchery
Spring Chinook Stocks					
Dworshak	1997	53,078	191	422	>1
	1998	973,400	8,206	9,895	>1
	1999	1,044,511	9,801	12,893	>1
	2000	1,017,873	8,397	10,108	>1
	2001[3]	333,120	796	1,139	>1
Rapid River	1997	85,838	218	270	>1
	1998	896,170	11,264	8,531	0.76
	1999	2,847,283	56,665	35,104	0.62
	2000	2,462,354	35,207	19,573	0.56
	2001[3]	736,601	5,020	3,480	0.69
Catherine Ck	2001[3]	136,833	164	181	>1
Summer Chinook Stocks					
McCall	1997	239,647	1,527	1,199	0.79
	1998	393,872	5,836	6,278	>1
	1999	1,143,083	24,518	18,781	0.77
	2000	1,039,930	21,502	18,509	0.86
	2001[3]	1,076,846	7,859	7,573	0.96
Imnaha	1997	50,911	308	617	>1
	1998	93,108	517	704	>1
	1999	184,725	2,798	2,831	>1
	2000	179,797	3,573	4,049	>1
	2001[3]	123,014	510	811	>1

[1] Estimated adults at LGR computed by multiplying hatchery production release by survival rate S_1 and $SAR_{LGR\text{-}to\text{-}LGR}$ from Table 32 for each hatchery and migration year.
[2] Total escapement (including harvest) of run-at-large to hatchery from Tables 33 to 37.
[3] Return year 2004 harvest information is not available until next year; so estimated adults at LGR split by proportion of PIT tagged 2-and 3-salt fish in return at LGR from Table 31, and only 2-salt proportion is used here.

The methods for estimating $SAR_{hatchery\text{-}to\text{-}hatchery}$ have a number of problems as identified above and elaborate further here. The harvest adjustment was based on run-at-large data and the same removal proportion applied to the PIT tagged and run-at-large data to arrive at total escapement to the hatchery, so any errors in harvest adjustment would applied equally to both data sets. Since the survival rates generated from the run-at-large method are nearly always higher than those estimated from PIT tagged fish

(Figure 7), one possible explanation of this pattern in estimated survival is that not all of the PIT tagged fish were being detected at the hatchery and/or PIT tags were being shed before passing LGR or arriving at the hatchery. Tag loss could occur with gravid females that shed PIT tags, which could be tested by comparing sex ratios for tagged and untagged returns. In any event, these results continue to show that partitioning the $SAR_{hatchery\text{-}to\text{-}hatchery}$ into three survival components is not straightforward. In addition, the tendency for $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates based on PIT tagged fish to be lower than estimates obtained with the run-at-large may indicate a potential for underestimation of the "true" SAR magnitude, although relative comparisons between SARs for the various study categories would be unaffected.

CONCLUSIONS

- Survival of PIT tagged juvenile spring/summer Chinook was estimated from CSS hatcheries to the tailrace of LGR for migration years 1997 to 2001. These estimates ranged from 39 % to 85 %.

- The weighted LGR (smolts)-to LGR (adults) SARs ($SAR_{LGR\text{-}to\text{-}LGR}$), weighted to represent the run-at-large in each CSS study category, were higher for summer Chinook stocks than spring Chinook stocks. Weighted $SAR_{LGR\text{-}to\text{-}LGR}$ varied widely among the hatcheries with the highest SARs going to McCall Hatchery and lowest SARs going to Dworshak Hatchery. Overall, weighted SARs were highest in 1999 and lowest in 2001.

- For PIT tagged adults detected at LGR, there was no significant difference in proportion detected at the hatchery racks based on their juvenile outmigration experience (in-river versus transported) as smolts in 1997 to 2000.

- The $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates were highest for the 1999 outmigration of spring Chinook stocks and the 2000 outmigration of summer Chinook stocks. Most of the lowest $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates to date were for smolts from the 2001 outmigration. Drought conditions in 2001 resulted in record low flows and limited spill throughout the Snake and lower Columbia rivers.

- The procedures to estimate survival rates for adult migrating from LGR back to the hatchery (with adjustments for harvest rates) based on PIT tag data are providing lower than expected estimates within the $SAR_{hatchery\text{-}to\text{-}hatchery}$ partition.

- Although magnitudes differ, there is a similar trend across the migration years between PIT tag based and run-at-large based estimates of $SAR_{hatchery\text{-}to\text{-}hatchery}$.

CHAPTER 5

Smolt-to-adult survival rates for lower Columbia River stocks including Carson NFH spring Chinook and John Day River wild Chinook with comparisons to upriver stocks

BACKGROUND

The upstream/downstream stock comparison was initiated primarily to provide information relevant to the patterns observed in recruit/spawner patterns between upriver and downriver stream-type Chinook (e.g., Schaller et al. 1999, Deriso et al. 2001). The PATH comparison of R/S patterns indicated Snake River stocks productivity and survival rates declined coincident with development and operation of the FCRPS. The R/S comparisons also provided evidence of delayed mortality of inriver migrants from the Snake River, after accounting for direct mortality, differential delayed mortality of transported smolts (D), and the common year effect (CSS Delayed Mortality Workshop proceedings, Marmorek et al. 2004). Downriver stocks in the PATH comparisons included: John Day River (North Fork, Middle Fork and upper mainstem), Deschutes River (Warm Springs River), Klickitat River, and Wind River. The CSS study objective is to calculate the ratio of SARs for (downriver stocks/Snake River stocks), and determine whether the ratio is greater than 2.0. Additional contrasts would be to compare dowriver SARs to SARS of Snake River inriver and transport groups.

At the beginning of CSS in 1996, we had limited number of wild Snake River spring/summer Chinook being PIT tagged, and no ability to detect returning PIT tagged wild adults from any candidate downriver spring Chinook stock. Our focus at the startup of CSS was therefore on hatchery stocks, with an intended inference (if justified) to the patterns in wild stocks. CSS and cooperators increased PIT tagging for wild spring/summer Chinook, and research protocols at the dams were changed to improve the estimate of Snake River wild SARs starting in about 2000. Installation of the adult detector at BON in 2002 eventually gave us the ability to monitor adult returns for downriver stocks, and CSS collaborated with ODFW to begin PIT tagging John Day River smolts in migration year 2000.

In addition to John Day River spring Chinook, other downriver Interior Columbia Basin stocks are candidates for PIT tagging for the upstream/downstream comparison. The Warm Springs tribal fishery staff operate a screw trap near the mouth of the Warm Springs River, but do not currently PIT tag outmigrants. CSS attempted to coordinate PIT tagging in the Warm Springs River, and is in the process of getting approval for the tagging from the WS Tribal Council. Other candidate downriver stocks considered for this upstream/downstream SAR comparison include Klickitat and Wind, however, may be logistical issues with these. The Yakima River may also be a good candidate for PIT tagging (coordinated with YIN and WDFW).

As described above, the upriver/downriver stock comparison for hatchery Chinook was intended to shed light on the PATH wild stock comparisons, which were based on spawner-recruit data. With hatchery stocks, CSS could compare hatchery returns (expanded by harvest), and we were less dependent on BON detections of returning adults. These comparisons depend on hatchery stocks providing reasonable surrogates for wild stock performance. CSS results to date suggest this may not be the case for metrics such as T/C and D values, however we have not ruled out using temporal patterns of SARs for hatchery fish as a surrogate for wild stocks.

CSS began with two downriver hatchery stocks in 1996, Round Butte and Cowlitz. CSS dropped these hatcheries after a short period and moved PIT tagging to Carson NFH for the 1998 release. CSS dropped Round Butte because the hatchery developed severe BKD problems, which would clearly bias the SAR ratio we were interested in. NMFS Science Center questioned the choice of Cowlitz, pointing out some major stock differences between Cowlitz and Snake River hatcheries. Issues included: Cowlitz was more divergent genetically from Snake stocks than were the downriver Interior Columbia Basin Chinook (coastal origin vs. interior), larger proportions of Cowlitz fish were captured in BC/Alaska fisheries compared to Snake stocks, and Cowlitz had larger proportions of mini-jacks than the Snake stocks. CSS agreed with this assessment and therefore selected a more appropriate downriver stock, Carson NFH. Carson NFH stock is genetically very similar to Snake River stocks, since it was developed from the upriver spring Chinook run crossing BON.

RESULTS AND DISCUSSION: HATCHERY CHINOOK

Carson NFH Spring Chinook

Carson NFH was selected as the site to release PIT tagged spring Chinook for the CSS's upstream-downstream comparison because, of all the spring Chinook stocks available in the lower Columbia River, the Carson stock is the most closely related to the hatchery stocks of the Snake River basin. Since 1997 the CSS has PIT tagged a given number of Carson Hatchery production with the goal of assessing SAR survival rates for comparison with those of the upstream PIT tagged stocks over a series of years. However, an adult PIT tag system was not fully installed at BON until the 2002 return season, so only limited PIT tag detections were available prior to that year. A goal of the study will be to fully partition the hatchery-to-hatchery SARs into components of hatchery-to-BON survival rate, BON-to-BON SARs, and BON-to-hatchery survival rates (adjusted for harvest).

PIT Tagging

The USFWS operated a marking trailer that incorporated the PIT tag equipment, generally two marking stations with six personnel completing the work. The PIT tag marking at Carson NFH was normally accomplished during one week in January of the migration year and tagged fish were placed back into the production raceways after the marking was completed. The release date for yearling Chinook was normally set for mid-late April and this gave USFWS sufficient time to finalize the tagging and release files.

Table 40 lists the number of yearling spring Chinook from Carson NFH marked with PIT tags for the CSS program from 1997 to 2002. During the initial two seasons of marking, the number of fish PIT tagged were minimal (5,000 and 7,500), rising to 13,000 in 1999, and finally increasing to the full complement of 15,000 fish from 2000 through 2002. The marking goal was set to allow detection of adequate numbers of PIT tagged fish for estimating survival for both the juvenile and adult fish through the river system and ocean and return through the life of the Carson Chinook. Pertinent data for the marked release groups are included in Table 41, including hatchery production numbers and the proportion of PIT tags in that production. Lengths of individual PIT tagged fish were taken at Carson NFH at the time of marking through most years and generally did not vary substantially through the study years. Hatchery staff assessed numbers of fish per pound at time of release. Release dates ranged from April 16 to April 20 for the migration years 1997 to 2002. Hatchery managers indicated that the yearling spring Chinook met the required health standards at time of release for all years in the study. PIT tagged Chinook were marked from and held in raceways that represented most of the production fish. Mortality from time of marking to release was minimal (less than 0.5% of the marked release).

Table 41. Carson NFH release statistics and numbers of PIT tagged Chinook released for CSS in 1997 to 2002.

Migration Year	Dates of Release	# Release from Hatchery	# Fish per Pound	Median Fork Length[1] at Tagging (mm)	# of PIT Tags Released	% PIT Tags in Hatchery Release
1997	4/17/97	907,708	15.5	119	4,983	0.55
1998	4/20/98	1,734,188	16.6	115	7,491	0.43
1999	4/20/99	1,415,744	12.6	120	12,977	0.92
2000	4/20/00	1,430,022	15.6	116	14,992	1.05
2001	4/19-21/01	1,608,684	14.9	108	14,978	0.93
2002	4/16-17/02	1,449,361	15.6	116	14,983	1.03

[1] Fork length taken at time of tagging in early January approx. 3 months before release.

<u>Juvenile Migration Timing to Bonneville Dam</u>

The juvenile migration of Carson Hatchery spring Chinook begins with the release of the fish directly from the hatchery raceways and into the small stream (approximately 50 yards in length) that leads to the Wind River. Although the first Carson Hatchery yearling salmon may reach BON in less than 24 hours, the overall passage timing of the middle 80% of the run takes around 2 to 3 weeks (median middle 80% passage between April 23 and May 14)(Table 42). The earlier 10% passage dates in 1997 and 2002 coincided with the earlier hatchery release in those two years. The passage timing is based on the PIT tagged fish that pass through the juvenile bypass systems at the old and new powerhouses. A juvenile PIT tag detection system has been fully operational at BON throughout the time frame that Carson Hatchery spring Chinook have been PIT tagged for the CSS. The fish PIT tag detectors at BON were upgraded in 2000 to the newer and more powerful 134 kHz PIT tag that improved the readability and detection efficiency at all the mainstem dams.

River flow and spill at BON are shown when the Carson spring Chinook juveniles would be passing through the project and the lower Columbia River. As shown in Table 42, average river flow in 1997 ranked first with year 2001 ranked last in magnitude for the April 15 – May 31 timeframe.

Table 42. Yearling spring Chinook timing from Carson NFH to Bonneville Dam for migration years 1997 to 2002.

Migration Year	Passage Timing at BON			Ave. River Flow/Spill Data at BON		
	10%	50%	90%	Flow (kcfs)	Spill (kcfs)	Flow Range (kcfs)
1997	4/22	5/4	5/13	430	216	251 – 515
1998	4/25	5/1	5/8	285	103	138 – 420
1999	4/23	4/29	5/11	294	98	186 – 384
2000	4/23	5/2	5/16	286	92	211 – 387
2001	4/26	5/8	5/15	136	16	94 – 180
2002	4/21	5/3	5/14	254	117	198 – 348
6-yr median	4/23	5/3	5/14			

Juvenile Migration Survival Rates

For Carson Hatchery spring Chinook, BON is the primary evaluation site. BON is the only project these fish pass on their way to the ocean, and juvenile survival estimates must rely on a recapture site(s) below the project to estimate survival from the hatchery to BON tailrace. As in previous years, NMFS employed a trawl located near the estuary, equipped with PIT tag detection equipment on the cod-end of the net that guided fish must pass through. Only a specific amount of sets can be made during the season, and catch rate will vary based on river flow, velocity of the flow, and debris and other factors that might reduce sampling time during a given year. The NMFS normally operates the trawl near Jones Beach Site, located close to Clatskanie, OR (Rkm 74). Since these recapture numbers can be minimal, we explored the use of PIT tags that were decoded from the tern and cormorant nesting sites at Rice Island (Rkm 34) and East Sand Island (Rkm 8) in the lower Columbia River estuary in our previous CSS report. Based on those data, reach survival estimates for migration years 1998 to 2002 using the CJS estimates of survival from Carson NFH to BON from PIT tags sampled at the trawl as last recovery site, and then using estimates from the trawl plus the PIT recoveries made at Rice and East Sands Island from the piscivorous bird colonies are presented in Table 43. The release of 4.983 PIT tags in 1997 produced too few PIT tag recaptures to produce a reasonable survival estimate (estimate of only 0.524) from the hatchery to BON tailrace. Since 1998, the use of the trawl detections plus PIT tag detections from the tern and cormorant bird colonies reduced the error bounds around this reach survival estimates.

Table 43. Estimated Chinook survival from Carson NFH to Bonneville Dam tailrace based on either (1) solely trawl detections or (2) trawl detections plus additional detections from PIT tags deposited by birds on the colonies of East Sand and Rice islands for migration years 1998 to 2002.

PIT tag recovery data source	Migration year	1998	1999	2000	2001	2002
	PIT tag release no.	7,491	12,977	14,992	14,978	14,983
Trawl as last recovery site	Survival	0.793	0.975	0.531	0.726	0.871
	Lower limit 95% CI	0.204	0.387	0.308	0.583	0.438
	Upper limit 95% CI	1.381	1.564	0.755	0.870	1.305
Trawl plus bird colonies detections as last recovery site	Survival	0.863	0.931	0.862	0.830	0.810
	Lower limit 95% CI	0.605	0.736	0.693	0.720	0.604
	Upper limit 95% CI	1.122	1.125	1.031	0.941	1.017

Hatchery-to-Hatchery SARs for Carson NFH

Adult Chinook returning to Carson Hatchery pass BON from mid-March through mid-May during the same time frame as the upriver spring Chinook stocks from the Snake River basin, based on PIT tag detections in the fish ladders at BON. After passing the project, the adult Carson spring Chinook do not enter the Wind River and swim directly upstream to the hatchery, but rather hold up in the vicinity of mouth of the Wind River where a sizeable sport and tribal fisheries occurs. From mid-May through June, these adult Chinook begin moving up into the Wind River and to the hatchery. Once these fish near the hatchery, they have the option of entering the small stream to the hatchery ponds or continuing upstream. The hatchery does not employ a weir across the Wind River.

Estimating $SAR_{hatchery\text{-}to\text{-}hatchery}$ for Carson Hatchery spring Chinook requires a valid measure of harvest of adult fish returning to the hatchery. Harvest information is available through return year 2003 at this time. The computed SARs used to compare between upstream and downstream hatcheries are based on 2- and 3-salt adult returns only (PIT tagged jacks are excluded) detected at the hatchery for each migration year. Table 4 lists the estimated numbers of adult Chinook taken in the tribal and sport fisheries (designated area downstream from the Wind River mouth as well as in the main Wind River), plus adult Chinook arriving at the hatchery (rack count), which includes those fish distributed from the hatchery directly to the tribe. The total adult return (escapement), which is the sum of the hatchery rack count and harvest, is divided by the hatchery release to arrive at the $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate for the run-at-large (Table 44). The SARs reported for the 2001 outmigration are preliminary since only 2-salt returning adults are available to date.

Table 44. Carson Hatchery production release number and total adult return (including jacks) split into sport/tribal harvests and hatchery escapement for migration years 1997 to 2001 with associated hatchery-to-hatchery SARs of returning 2- and 3-salt adults.

Migr. Year	Hatchery Release	Return Year	Sport Harvest	Tribal Harvest[1]	Hatchery Rack[2]	Total Adult Return[1]	Hat-to-hat SAR[1] (%)
1997	907,708	1999 2000	1,091 156	195 40	3,524 376	4,810 572	0.59 %
1998	1,734,188	2000 2001	9,298 615	1,095 98	10,341 972	20,734 1,685	1.29 %
1999	1,415,744	2001 2002	10,874 529	1,742 45	10,897 93	23,513 667	1.71 %
2000	1,430,022	2002 2003	17,507 3,150	680 148	7,403 2,204	25,590 5,502	2.17%
2001[3]	1,608,684	2003 2004	9,300 N/A	437 N/A	5,471 N/A	15,208 N/A	0.95%

[1] Tribal harvest, total adult return and respective SAR estimate exclude returning jacks.
[2] Hatchery rack includes tribal distribution counts
[3] Only 2-salt returning adults were used in 2001 to match the hatchery rack PIT tag data available at the time of this report; so hatchery-to-hatchery SAR is incomplete for 2001.
Data source: Richard Pettit (WDFW) Columbia River Progress Report 2003-05

For migration years 1997 through 2000, the $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates are: 0.59%, 1.29%, 1.71%, and 2.17%, respectively (Table 44). For migration year 2001 which will not have a completed adult return set until late 2004, the $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate for 2-salt returns is 0.95%. The overall trend for migration year 1997 to 2000 SARs has been increasing in value, and we expect that the 2001 migration year will give a greater SAR than in 1997, a slightly lower SAR than in 1998, but a far reduced SAR from that of the 1999 and 2000 migration seasons when SARs were estimated at 1.7 and 2.2%, respectively. This pattern of high SARs in migration years 1999 and 2000 and low SARs in migration years 1997 and 2001 were also observed for the upstream CSS hatcheries from the Snake River basin.

Almost all adult fish that arrived at Carson NFH were interrogated for presence of PIT tags, whether distributed to the tribes or saved for spawning, whereas there was no program for detecting PIT tags in the sport/tribal harvest. Since approximately 28 to 70 percent of the total run was removed in the sport/tribal harvest (Table 44), expansion of the PIT tag detections at the hatchery to account for these removals prior to arriving at the hatchery was required. The number of PIT tagged fish detected at the hatchery was multiplied by the factor $1/(1- p_R)$, where p_R is the proportion of total run harvested, to estimate the number of PIT tags that would have been detected if no harvest had taken place. The resulting $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate for the PIT tagged Chinook following the harvest adjustment (Table 45) for migration year 1999 was very close to what was computed for the full production (tagged and untagged fish) shown in Table 44. However, the other four migration years had $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates based on the PIT tagged data that were 28 to 51% lower than the full production estimates. Lower $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimates based on PIT tagged data compared to the run-at-large data were also reported with the upstream hatchery stocks in Chapter 4.

Table 45. Carson NFH PIT tag release, number of returning adults (jacks not included) detected at the hatchery with a PIT tag, and estimated number of total PIT tags that would have been detected if no removals of adults prior to PIT tag detection had occurred for migration years 1997 to 2001.

Mig. Year	PIT tagged smolts release at hatchery	Return Year	PIT tagged adults detected at hatchery	% sport-tribal harvest removal rate prior to PIT tag detection	Estimated total escapement of PIT tagged adults to hatchery	Hatchery-to-hatchery SAR (%)
1997	4,983	1999	11	26.7 %	15	0.42 %
		2000	4	34.3 %	6	
1998	7,491	2000	22	50.1 %	44	0.63 %
		2001	2	42.3 %	3	
1999	12,977	2001	83	53.7 %	179	1.66 %
		2002	5	86.1 %	36	
2000	14,992	2002	50	71.1 %	173	1.57%
		2003	25	59.9%	62	
2001[A]	14,978	2003	30	64.0%	83	0.55%
		2004		N/A	N/A	

[A] Return year 2004 harvest information is not available until next year.

To partition the $SAR_{hatchery\text{-}to\text{-}hatchery}$ estimate into three components as was attempted for the upstream stocks, we need to estimate the number of Carson Hatchery adult Chinook at the final dam passed before entry into the hatchery, which in the case of Carson Hatchery is BON. Beginning with return year 2002 there was the capability to detect nearly all PIT tagged adult fish passing the three ladders at BON. However, since a portion of the fish swim over the weir crests and don't pass through the orifices where the detection equipment is installed, the detection of the adult fish past the project will be somewhat less than 100%. Through 2001, the only sampling for PIT tags at BON was at the adult trapping facility located on the Washington shore fish ladder. In this case, PIT tagged fish were diverted from the main fish ladder and into the sampling facility (B2A) where PIT tag detection equipment was installed on the chutes prior to the sampling tanks. The adult sampling facility was operated only a portion of the passage day during the spring migration season, so only a small percentage of the adult Chinook run were actually sampled for PIT tags there.

With the PIT tagged adult Chinook detected at Carson NFH, it was possible to determine whether these fish were seen at BON or not seen there. This allowed the estimation of returning adult collection efficiency at BON and an estimation of population number of PIT tagged Carson Hatchery Chinook passing the dam as adults. The equation for estimating the population of PIT tagged Carson Hatchery adult Chinook is $N = m_2 / p_2$ where $p_2 = X_{11} / (X_{01} + X_{11})$, $m_2 = X_{10} + X_{11}$ and Xij denotes the number of PIT tagged fish detected where the i^{th} subscript represents presence (1) or absence (0) at BON and the j^{th} subscript represents presence (1) or absences (0) at the hatchery. The proportion of the population PIT tagged as smolts in the h^{th} year, ?$_h$, may be divided into the estimated population of PIT tags N_h to obtain the total population of adult returns (tagged and untagged). The resulting estimated number of Carson NFH adults passing the BON fish ladders is presented in Table 46 for returns from out-migration years 1997 to 2001.

Table 46. Estimated number of PIT tagged and total population of adults (no jacks) from Carson NFH (CARS) passing Bonneville Dam (BON) from migration years 1998 – 2001.

Juvenile Migration Year	# PIT tags detected at sites			2-yr est. BON collection efficiency (p_2)[A]	Est. Carson Tags at BON (N)	Proportion PIT tags in production ?	Est. total Carson adults @ BON (N / ?)
	BON (m_2)	BON+CARS (X_{11})	CARS only (X_{01})				
1997	4	2	13	0.1333	30	0.0055	5,455
1998	10	2	22	0.0833	120	0.0043	27,907
1999	60	15	73	0.1705	352	0.0092	38,261
2000	427	72	3	0.9600	445	0.0105	42,381
2001[B]	205	30	0	1.0000	205	0.0093	22,043

[A] Since 2-salt and 3-salt adults are passing Bonneville Dam ladders over two years, the collection efficiency is effectively an average of the effect of those two years.
[B] Excludes 3-salt return (17 adults) at Bonneville Dam since return year 2004 harvest information is not available until next year.

Comparisons of the total Carson NFH adult escapement (including harvest) based on PIT tags and run-at-large data and associated estimates of adult survival from BON (tagged and untagged fish) back to the hatchery are shown in Table 47. After adjusting for harvest, the estimated adult Chinook survival from BON to the hatchery for migration year 1999 was similar between the PIT tag and run-at-large data, whereas in all other years the PIT tag data produced a substantially lower estimated survival. For 1997 out-migrants, the nearly identical estimate of Carson NFH Chinook at BON based on PIT tag data and at the hatchery based on run-at-large data points to the possibility of an underestimate of the Carson NFH adult population at the dam also. Underestimation of returning adult populations at the final dam prior to the hatchery has been reported in the previous chapter with the upstream hatchery stocks as well. These comparisons illustrate that estimated adult survival from BON to the hatchery based on harvest adjusted PIT tagged adults detected at the hatchery may be biased low in most years. This points to the difficulty of partitioning $SAR_{\text{hatchery-to-hatchery}}$ estimates into their three survival components, the hatchery-to-BON survival rate as smolts, the $SAR_{\text{BON-to-BON}}$ estimate, and BON-to-hatchery survival rate as adults.

Table 47. Comparison of estimated adult survival from Bonneville Dam to the hatchery using Carson NFH total escapement (including harvest) based on PIT tag versus run-at-large data for smolts out-migrating in 1997 to 2001.

Juvenile Migration Year	Carson NFH Chinook adult run estimated at Bonneville Dam[1]	Carson NFH estimated escapement (including harvest)		Estimated survival BON to HAT	
		PIT tagged total hatchery returns[2]	Run-at-large hatchery returns[3]	Based on PIT tags	Based on run-at-large
1997	5,455	3,818	5,382	0.70	0.99
1998	27,907	10,930	22,419	0.39	0.80
1999	38,261	23,370	24,180	0.61	0.63
2000	42,381	22,381	31,092	0.53	0.73
2001[4]	22,043	8,925	15,208	0.40	0.69

[1] Estimate based on adult return population estimate at Bonneville Dam from Table 45.
[2] Estimate of total escapement of PIT tagged adults to hatchery from Table 45 divided by proportion of PIT tags released in production (?) from Table 46.
[3] Estimate of total escapement of run-at-large (tagged and untagged fish) to the hatchery from Table 44.
[4] Does not include 3-salt returning adults since return year 2004 harvest information is not available.

Comparing $SAR_{\text{BON-to-BON}}$ for Upstream and Downstream Hatchery Stocks

The PIT tag estimates of the population of smolts at BON and population of returning adults at BON are used to partition out the $SAR_{\text{BON-to-BON}}$ component for comparisons between upstream and downstream stocks. The $SAR_{\text{BON-to-BON}}$ estimates for Carson NFH Chinook that out-migrated in 2000 and 2001 are compared with the CSS upriver stocks in Table 48. With completion of the PIT tag detectors on each ladder at BON prior to the start of the 2002 return year, a high PIT tag detection rate for adult fish at BON was possible beginning with migration year 2000 released fish (see Table 46). The PIT tag data presented in Table 48 has not been expanded to the total hatchery population (tagged and untagged) since estimated survival rates from hatchery to BON and the estimated $SAR_{\text{BON-to-BON}}$ are unaffected by that expansion when dealing with the individual hatcheries. In estimating $SAR_{\text{BON-to-BON}}$, we made no attempt to assess numbers of fish that might be taken in the fisheries or preyed upon by marine mammals below BON since both the Carson adult returns and the other returning spring Chinook adults from CSS hatcheries should be subjected to similar fishing effort and predation level below BON.

Both the upstream stocks and Carson Hatchery Chinook have a $SAR_{\text{BON-to-BON}}$ estimate that was about half the magnitude in 2001 as it was in 2000. Across both years, Carson and Rapid River hatcheries had the most similar estimate of $SAR_{\text{BON-to-BON}}$. For migration year 2000, the summer Chinook stocks had a higher level of $SAR_{\text{BON-to-BON}}$ than the spring Chinook stocks. In 2001 this pattern switched, but there were very low

SARs across all upstream hatcheries in that year. Since these patterns are based on only the two years of complete adult returns with PIT tag detect detections available at the BON ladders, the patterns may change in future years. These comparisons mark the beginning of future efforts to obtain $SAR_{BON\text{-}to\text{-}BON}$ estimates for upstream and downstream hatchery groups for use in evaluating the effects of the hydrosystem on adult returns.

Table 48. Estimates of $SAR_{BON\text{-}to\text{-}BON}$ for upriver hatchery stocks (Dworshak, Rapid River, McCall, and Imnaha) and the downriver Carson NFH stock that out-migrated in 2000 and 2001, grouped by study category.

Mig. Year	Hatchery[1] plus study category	Estimated # smolts at first dam encountered[2]	LGR-to-BON survival rate[3]	Estimated PIT tagged smolt number at BON	Estimated PIT tagged adults at BON[4]	Estimate of $SAR_{BON\text{-}to\text{-}BON}$ %
2000	CARS	12,923	---	12,923	445	3.44
	DWOR – T_0	18,314	0.894	16,373	299	1.83
	DWOR – C_0	13,075	0.481	6,289	175	2.78
	RAPH – T_0	16,584	0.930	15,423	502	3.25
	RAPH – C_0	11,046	0.580	6,407	204	3.18
	IMNA – T_0	6,706	0.905	6,069	263	4.33
	IMNA – C_0	4,396	0.572	2,515	115	4.57
	MCCA – T_0	12,725	0.928	11,809	591	5.00
	MCCA – C_0	13,064	0.612	7,995	303	3.79
2001[6]	CARS	12,432	---	12,432	222[5]	1.78
	DWOR – T_0	21,726	0.959	20,835	95	0.46
	DWOR – C_1	16,864	0.241	4,064	10	0.25
	RAPH – T_0	19,066	0.966	18,418	267	1.45
	RAPH – C_1	15,965	0.327	5,221	12	0.23
	IMNA – T_0	7,695	0.965	7,456	61	0.82
	IMNA – C_1	6,939	0.372	2,581	4	0.15
	MCCA – T_0	16,641	0.959	15,959	254	1.59
	MCCA – C_1	15,474	0.269	4,163	7	0.17

[1] Hatchery codes: Carson Hatchery =CARS, Dworshak Hatchery =DWOR, Rapid River Hatchery =RAPH, Imnaha Acclimation Pond =IMNA, and McCall Hatchery =MCCA
[2] First dam encounted is LGR for smolts from upstream hatcheries and BON for Carson NFH smolts; CARS release number times survival is 14,992*0.862 in 2000 and 14,978*0.830 in 2001; estimated number of upstream smolts in study categories T_0, C_0, and C_1 from Chapter 2 Tables 16 and 17.
[3] LGR to BON survival rates are V_C and V_T for in-river and transported fish.
[4] Estimated PIT tag adults at BON include LGR detected adults that were not detected at BON since BON detection efficiency was 94% and 95% for adults that out-migrated in 2000 and 2001, respectively.
[5] Includes the 17 returning 3-salt adults that were omitted in Table 46.
[6] Migration year 2001 is complete – it includes both 2- and 3-salt returning adults.

Comparing Timing of Upstream and Downstream Hatchery Stocks at the Lower Columbia River Trawl

The timing in Figure 9 of PIT tagged Carson Hatchery spring Chinook passage at the lower Columbia River trawl was closest to that of the transported fish from Rapid River and Imnaha River hatcheries in each of the years 1998 to 2002 except 1999 when the Carson Hatchery fish were about a week earlier than any upstream stock). Dworshak Hatchery Chinook transported in 2000 and 2002 also had similar passage timing at the trawl to Carson Hatchery Chinook, whereas in 1998 and 2001, the transported Dworshak Hatchery Chinook were the earliest of the CSS hatchery groups detected at the trawl. McCall Hatchery summer Chinook transported in each year had a later passage timing than the Carson Hatchery spring Chinook. The in-river migrating Dworshak Hatchery Chinook were slightly earlier than the transported McCall Hatchery Chinook in 1998 and 1999, but in the subsequent three years the upstream in-river migrating Chinook were later than any of their transported counterparts. Generally, the in-river migrating smolts were about 7 to 10 days later than the transported smolts from the same hatchery, but in the drought conditions of 2001, the in-river migrating smolts were detected at the trawl between 3 to 4 weeks later than their transported cohorts. In each year except 2001, the in-river migrating smolts had completed over 99% of their detections by the end of the first week of June. But in 2001, there still remained about 20% of the detections for in-river migrating upstream stocks after the end of the first week in June. Late entry of in-river migrating upstream Chinook smolts into the estuary may have contributed to the low survival estimates occurring in 2001.

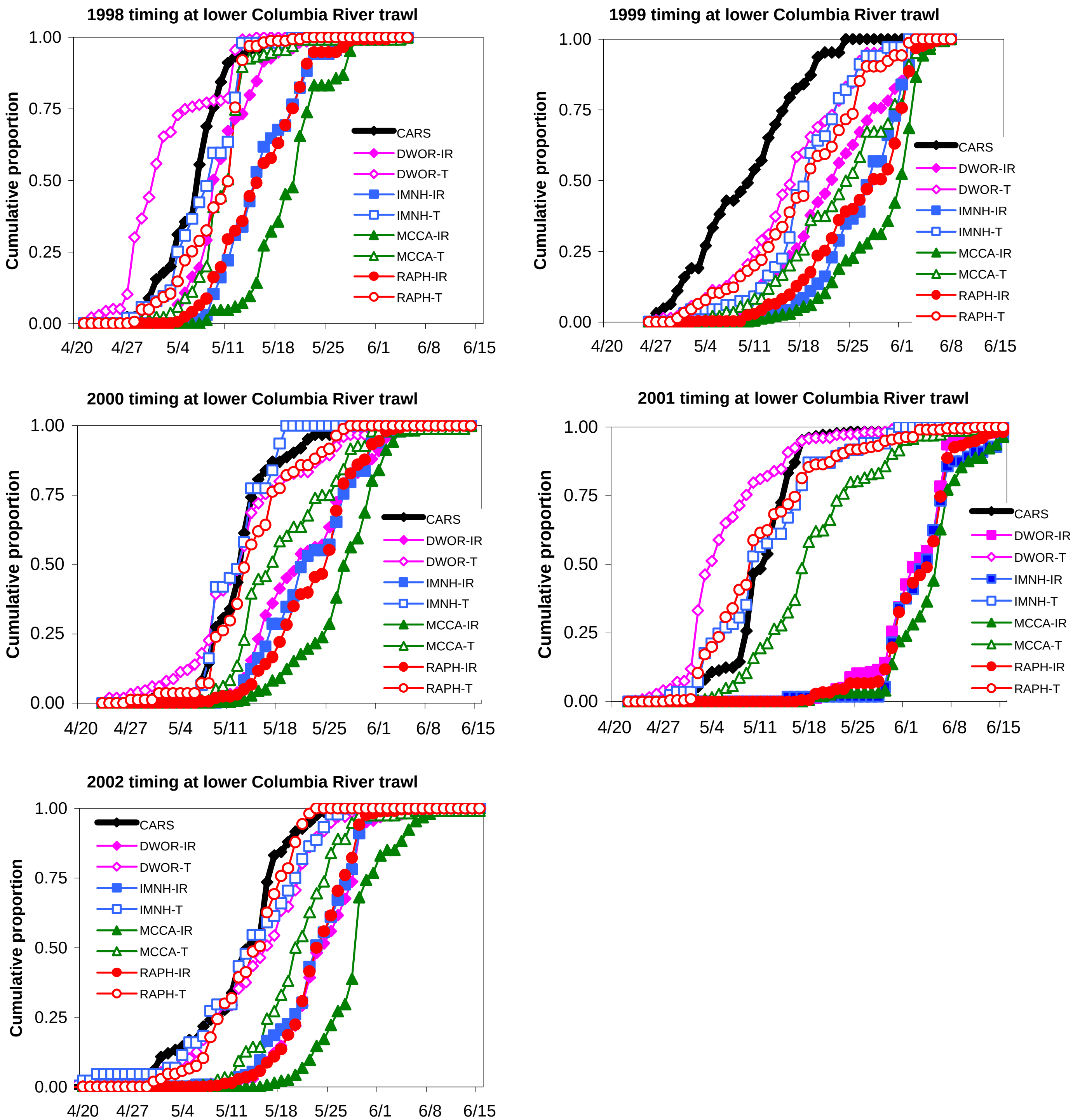


Figure 9. Timing at the lower Columbia River trawl of PIT tagged Carson Hatchery Chinook (downstream stock) and the five upstream hatchery stocks used in each of the years 1998 to 2002, split between transported and in-river migrating fish.

RESULTS AND DISCUSSION: WILD CHINOOK

PIT Tagging John Day River Wild Chinook

In the lower Columbia River basin, the CSS utilizes the wild spring Chinook from John Day River, PIT tagged under a separate contract between ODFW and BPA, in the planned upstream/downstream comparison. From various locations within the mainstem John Day River and North and Middle forks of the John Day River, ODFW crews have PIT tagged 1,853 smolts in 2000, 3,891 smolts in 2001, and 3,999 smolts in 2002. The methods and locations of this PIT tagging are found in Carmichael *et al.* (2002).

Juvenile Migration Survival Rates

The in-river survivals from release to JDA tailrace and JDA tailrace to BON tailrace are presented in Table 49. The survival rate estimates from release to JDA tailrace was relatively stable across the three migration years, ranging between 0.63 and 0.71 regardless of whether the trawl alone or trawl plus detections on the bird colonies was used as the final recovery site in the survival estimation process. However, estimating the survival rate from JDA tailrace to BON tailrace was more problematic with imprecise estimates occurring with either set of last recovery data used. When these estimates were compared to those of the upstream wild Chinook aggregate, the inconsistencies in the direction of change in estimated survival from year to year was further evidence that a reliable estimate of survival from JDA tailrace to BON tailrace was not available for the PIT tagged wild spring Chinook released in John Day River. Therefore, further partitioning of the survival components for the John Day River wild Chinook will be made from release to JDA tailrace and from JDA tailrace as smolts to BON as adults.

Table 49. Estimated Chinook survival from the aggregate of release sites in John Day River to John Day Dam (JDA) and Bonneville Dam (BON) tailraces based on either (1) solely trawl detections or (2) trawl detections plus additional detections from PIT tags deposited by birds on the colonies of East Sand and Rice islands for migration years 2000 to 2002.

PIT tag recovery data source	Migration year	2000	2001	2002
	PIT tag release no.	1,853	3,891	3,999
John Day River wild Chinook survival estimates based on trawl as last recovery	Survival Release to JDA	0.677	0.699	0.639
	Lower limit 95% CI	0.601	0.665	0.548
	Upper limit 95% CI	0.754	0.734	0.730
	Survival JDA to BON	1.106	0.826	0.693
	Lower limit 95% CI	< 0	0.359	0.072
	Upper limit 95% CI	> 2	1.292	1.315
John Day River wild Chinook survival estimates based on trawl plus bird colonies detections as last recovery	Survival Release to JDA	0.679	0.707	0.632
	Lower limit 95% CI	0.603	0.672	0.545
	Upper limit 95% CI	0.754	0.742	0.720
	Survival JDA to BON	0.940	0.877	0.644
	Lower limit 95% CI	0.291	0.542	0.210
	Upper limit 95% CI	1.588	1.213	1.078
Upstream aggregate wild Chinook survival estimates based on trawl as last recovery	Survival JDA to BON	0.866	0.663	0.967
	Lower limit 95% CI	0.713	0.546	0.787
	Upper limit 95% CI	1.101	0.817	1.237

$SAR_{REL\text{-}to\text{-}BON}$ for PIT Tagged John Day River Wild Chinook

The number of returning adults from the yearly aggregate group of PIT tagged smolts are presented in Table 50 along with the estimated SAR from release to BON as an adult ($SAR_{REL\text{-}BON}$). The estimated $SAR_{REL\text{-}BON}$ for PIT tagged wild John Day River Chinook was nearly 3 fold-higher in 2000 than during the drought year of 2001. When the 3-salt adults return next year from the 2002 out-migrants, that year's estimated $SAR_{REL\text{-}BON}$ will likely be between the magnitude of the other two years.

Table 50. PIT tagged wild John Day River Chinook release number and total adult return (including jacks) for migration years 2000 to 2002 with associated release-to-BON (adults) SARs of returning age 2- and 3-salt adults.

Migration Year	# Smolt Released	Jack Return	2-salt Return	3-salt Return	Total Adults	Release-BON SAR %
2000	1,853	3	112	31	143	7.72
2001	3,891	7	90	15	105	2.70
2002[A]	3,999	5	86	N/A	86	2.15 (incomplete)

[A] Migration year 2002 is incomplete as only 2-salt returning adults are available as of the 2004 return year.

Comparing $SAR_{JDA\text{-}to\text{-}BON}$ for Upstream and Downstream Wild Stocks

Comparisons of SARs with the upstream PIT tagged wild Chinook aggregate will be made for the in-river migrating smolts between JDA tailrace as smolts and BON as adults ($SAR_{JDA\text{-}to\text{-}BON}$). The resulting SAR for the PIT tagged John Day River wild Chinook will also be compared with the transported upstream PIT tagged wild Chinook aggregate. The John Day River fish pass three dams enroute to the estuary while the upstream transported may pass from 0 to 2 dams before being collected at the next dam for transportation. Since both upstream and downstream fish encounter up to three dams, there will be no need to divide the $SAR(T_0)$ by V_t to adjust for post-BON losses in the transportation group.

The partition of the PIT tagged wild John Day River spring Chinook $SAR_{REL\text{-}BON}$ into its components of estimated smolt survival from release-to-JDA tailrace and estimated $SAR_{JDA\text{-}to\text{-}BON}$ for fish that out-migrated in 2000, 2001, and 2002 requires an estimated of the population of PIT tagged fish passing JDA. Survival rates to JDA tailrace (with the trawl as the last recovery site from Table 49) were used to determine the number of PIT tagged wild John Day River Chinook smolts at JDA. Table 51 provides the estimated $SAR_{JDA\text{-}to\text{-}BON}$ for PIT tagged John Day River spring Chinook that out-migrated in 2000 to 2002. These yearly downstream wild stock estimates are also compared with the estimated $SAR_{JDA\text{-}to\text{-}BON}$ of the aggregate of upstream PIT tagged wild spring/summer Chinook that has been split by route of passage through the hydro-system each year (*i.e.*, CSS study categories). The $SAR_{JDA\text{-}to\text{-}BON}$ for PIT tagged wild spring Chinook from John Day River was 11.40, 3.86, and 3.37% for smolts that out-migrated in 2000 to 2002, respectively, a magnitude that is generally twice or better than observed for any category of the upriver PIT tagged Snake River basin wild Chinook aggregate.

Table 51. Estimates of $SAR_{JDA\text{-}to\text{-}BON}$ for upriver wild Chinook aggregate and the downriver John Day River wild Chinook aggregate that out-migrated in 2000 and 2001, grouped by study category.

Mig. Year	Study category	Estimated # smolts at first dam encountered[1]	In-river survival rate to JDA[2]	Estimated PIT tagged smolt numbers	Estimated PIT tagged adults at BON[3]	Estimate of $SAR_{JDA\text{-}to\text{-}BON}$ %
2000	Downriver	1,254	--	1,254	143	11.40
	Upriver – T_0	839	--	839	21	2.50
	Upriver – C_0	6,491	0.55	3,570	186	5.21
	Upriver – C_1	16,827	0.55	9,255	465	5.02
2001	Downriver	2,720	--	2,720	105	3.86
	Upriver – T_0	546	--	546	10	1.83
	Upriver – C_1	20,298	0.35	7,104	33	0.46
2002[4]	Downriver	2,555	--	2,555	86	3.37
	Upriver – T_0	3,880	--	3,880	32	0.82
	Upriver – C_0	6,289	0.63	3,962	76	1.92
	Upriver – C_1	12,676	0.63	7,986	118	1.48

[1] First dam encounted is LGR for wild Chinook smolts in upriver group and JDA for wild Chinook smolts from John Day River in downriver group; estimated number of upstream smolts in study categories T_0, C_0, and C_1 from Chapter 2 Table 8; estimated number of downstream smolts for John Day River fish use the release to John Day Dam tailrace survival estimate with trawl as last recovery location from Table 49.
[2] LGR to JDA survival rates are (V_C/S_6) for upstream in-river fish.
[3] Estimated PIT tag adults at BON include LGR detected adults that were not detected at BON since BON detection efficiency was 94% and 95% for adults that out-migrated in 2000 and 2001, respectively.
[4] Migration year 2002 is incomplete as only 2-salt returning adults are available as of the 2004 return year.

The $SAR_{JDA\text{-}to\text{-}BON}$ for PIT tagged Snake River basin wild Chinook aggregate for migration years 2000 to 2002 (the latter being incomplete with only 2-salt returns to date) was highest for wild Chinook smolts that migrated in 2000 (Table 51). Even when the 3-salt returns take place next year for the 2002 out-migrants, the magnitude of the final $SAR_{JDA\text{-}to\text{-}BON}$ for migration year 2002 is expected to remain lower than that of 2000. The $SAR_{JDA\text{-}to\text{-}BON}$ for transported upriver smolts was about half of their in-river counterparts for migration years 2000 and 2003, but during the drought year of 2001 the $SAR_{JDA\text{-}to\text{-}BON}$ was 4-fold higher for the transported wild Chinook than the in-river migrating wild Chinook. Since the number of PIT tagged smolts in the wild Chinook transport category is relatively small compared to the other study categories, the effects of survival differences between smolts from the four tribuataries above LGR may have some compounding influence here. In Chapter 2 Table 12, we showed that there was a pattern of higher overall survival for PIT tagged fish from the Imnaha River drainage compared the other three drainages. Migration years 2000 to 2002 had 29%, 70%, and zero %, respectively, returning PIT tagged adults from the Imnaha River drainage in Category T_0. This could cause the estimated $SAR_{JDA\text{-}to\text{-}BON}$ (as well as the previously reported $SAR_{LGR\text{-}to\text{-}LGR}$) magnitude for Category T_0 to be higher in 2001 and lower in 2002 than occurs for the total run-at-large (tagged and untagged) population of wild Chinook originating above LGR and out-migrating in those years.

Comparing Timing of Upstream and Downstream Wild Stocks at the Lower Columbia River Trawl

The timing of PIT tagged John Day River wild spring Chinook passage at the lower Columbia River trawl was earlier than that of the in-river migrating wild Chinook originating above LGR in each of the three years (2000-2002) of available PIT tag data (Figure 10). With low numbers of PIT tagged wild Chinook from the upstream tributaries transported prior to 2002, there were only two tributaries in 2001 and again in 2002 with 7 or more PIT tag detections at the lower Columbia River trawl for comparison with the John Day River Chinook timing. For these pairs of transported PIT tagged upstream groups, fish from Imnaha River passed the trawl closest to the time of the John Day River fish in 2001 and fish from the Salmon River passed at the same time as the John Day River fish in 2002. Overall the pattern of earlier passage of transported wild Chinook groups would place them in the lower Columbia River closer to the time when the John Day River wild Chinook are present there than occurs for the in-river migrating wild Chinook originating above LGR. The effect of the drought conditions of 2001 delaying the timing of arrival at the estuary was apparent in Figure 9. In 2001 only about 25% of the PIT tag detections occurred by June 1 for each tributary group compared to the more typical 75% or more PIT tag detections by June 1 as seen for migration years 2000 and 2002.

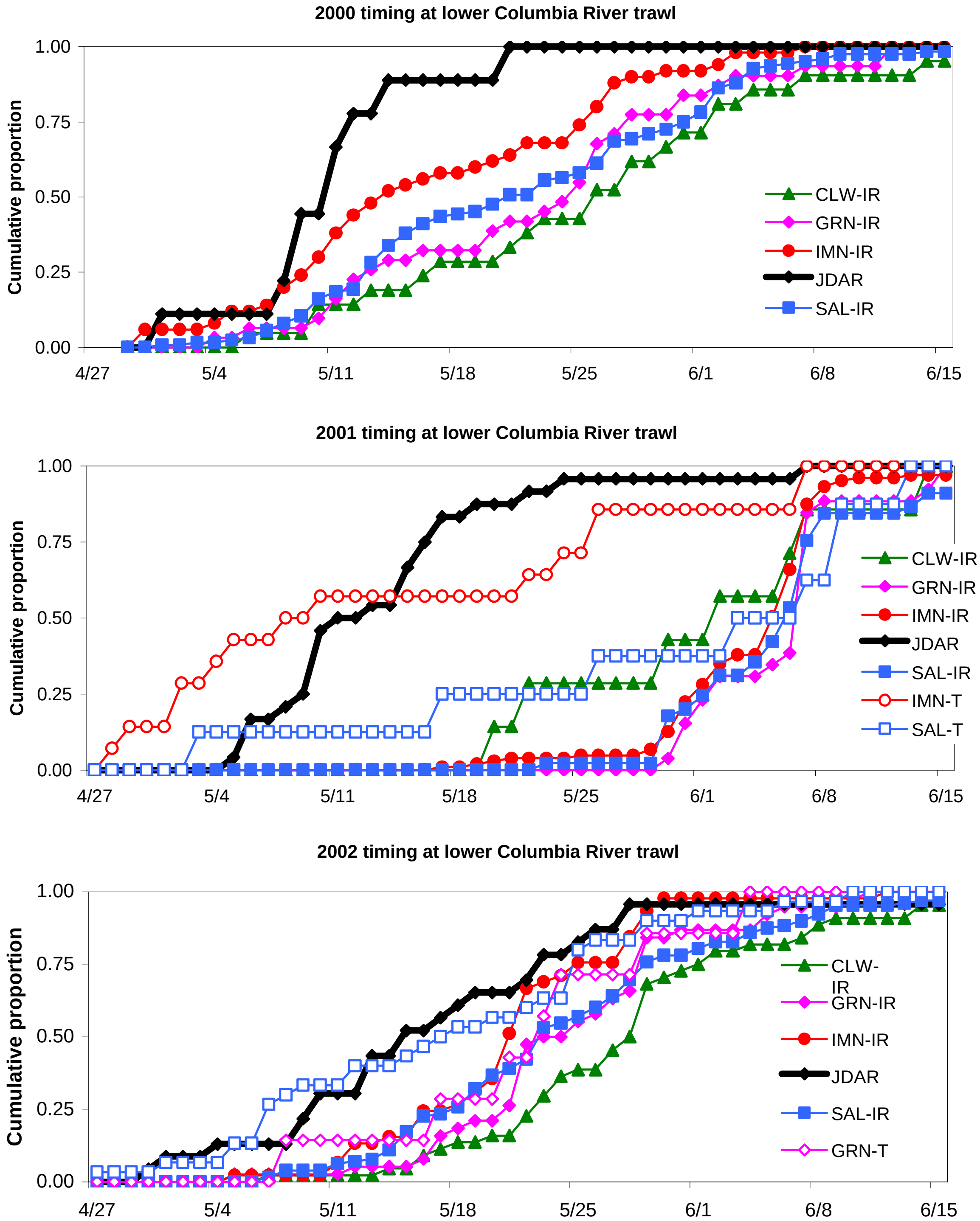


Figure 10. Timing at the lower Columbia River trawl of PIT tagged John Day River wild Chinook (downstream stock) and the upstream wild stocks split by tribuatary drainage for migration years 2000 to 2002, with timing of in-river (IR) and transported (T) fish shown for groups with 7 or more PIT tag detections available at the trawl.

CONCLUSIONS

- Juvenile to adult survival rates from BON tailrace to BON ($SAR_{BON\text{-}to\text{-}BON}$) for Carson Hatchery spring Chinook salmon was 3.44% and 1.78% for fish out-migrating in 2000 and 2001, respectively. For migration year 2000, this is close to the estimate for Rapid River Hatchery spring Chinook, higher than that of Dworshak Hatchery spring Chinook, and lower than that of the two summer stocks. For migration year 2001, the $SAR_{BON\text{-}to\text{-}BON}$ for Carson Hatchery Chinook was higher than that of the CSS upriver hatcheries, but relatively close to that of Rapid River and McCall hatcheries.

- Adult fish returns from Carson NFH show a similar trend with respect to higher SARs in migration years 1999 and 2000 as did the CSS upriver spring/summer Chinook hatchery groups. Improving ocean conditions appear to have contributed to the higher SARs at both the downriver and upriver hatcheries participating in the CSS program.

- Harvest of adult fish from the sport and tribal fisheries from BON to Carson NFH ranged from 26 to 86% (across years and age of returning adults) prior to these fish reaching the hatchery. Adult return rates to the hatchery based on harvest adjusted (harvest ranging from 26 to 86% across years and age of returning adults) from PIT tagged adults detected at the hatchery may be biased low in most years compared to the run-at-large estimated total escapement.

- The $SAR_{JDA\text{-}to\text{-}BON}$ for PIT tagged wild Chinook migrating from John Day River in 2000 to 2002 (latter year is incomplete with only 2-salt returns available now) was 11.40, 3.86, and 3.37%, respectively. These magnitudes were generally twice or better than the corresponding SARs for the upriver PIT tagged wild Chinook aggregate.

- The timing of entry into the estuary based on PIT tag detections at the lower Columbia River trawl for the wild and hatchery stocks of “downstream” origin is closer to that of the transported wild and hatchery stocks of “upstream” origin than their in-river counterparts.

Chapter 6

Computer program to created simulated PIT tag input files for testing robustness of CJS survival estimates

Background on the Need to Create Simulated PIT Tag Input Files

In the 2002 CSS Annual Report, the estimation of in-river survival between monitored dams is made with two approaches. The first approach utilizes the entire release group of PIT tags with the CJS capture-recapture method of survival estimation (termed the "full sample" approach in the CSS report). The second approach utilized only those PIT tags detected at LGR from a particular release group and splits the detected fish into temporal strata (termed the "subcohort" approach in the CSS report). For each stratum, a CJS survival estimate is obtained between monitor dams. From LGR tailrace (j=2) to BON tailrace (j=7) there are 6 reaches between monitored dams, i.e., S_2, S_3, …, S_7. A weighted average survival across the subcohort strata for the j^{th} individual reach, S_{jW}, was computed in the second approach. The expansion of smolts to LGR equivalents then uses the S_{2W} and $S_{2W}*S_{3W}$ instead of S_2 and S_3 from the "full sample" CJS approach. Likewise the in-river survival through the hydrosystem V_C is estimated with the "subcohort" method as the product $S_{2W}*S_{3W}*S_{4W}*S_{5W}*S_{6W}*S_{7W}$ and with the "full sample" method as the product $S_2*S_3*S_4*S_5*S_6*S_7$. The subcohort weighting method uses the product of inverse relative variance (based on model variance) and proportion of annual passage index for wild Chinook run-at-large in each stratum for PIT tagged wild Chinook and simply the inverse relative model variance for each hatchery Chinook group.

In the 2002 CSS Annual Report, the use of the "subcohort" approach often allowed in-river survival estimation to MCN or JDA tailrace, requiring the "per mile" expansion of survival to BON tailrace. In those cases both the "subcohort" approach and "full sample" approach were applied to the shorter reach and the expansion applied. However, by using only the "full sample" CJS, we were more often able to directly estimate in-river survival to BON tailrace. Through the simulations, we plan to investigate under a range of conditions of changing survival and detection probabilities, whether the full sample method provides precise and unbiased estimates of parameters, relative to the subcohort approach.

In Chapter 1 of the methods section of the current annual report, we discuss the potential for bias in weighted average reach survival estimates in the subcohort approach due to the use of the theoretical model variance instead of total variance, which includes an unknown population variance component in addition to the theoretical model variance. Through the simulations, we plan to investigate the accuracy of the subcohort method relative to the "full sample" CJS estimates when assumptions of the CJS are being violated.

The estimation of number of smolts in Category C_0 relies on both an accurate estimate of population of PIT tagged smolts arriving at LGR and the associated downstream survival components required to convert first-time detections at the transportation collector dams into numbers in "LGR equivalents". Determining the number of smolts in Categories C_1 and T_0 only requires the associated downstream survival components required to convert first-time detections at the transportation collector dams into counts in LGR equivalents. Through simulations, we plan to investigate the how well the "full sample" CJS has estimated the population at LGR, and ultimately the number of smolts in Category C_0. Likewise, the accuracy of the expansions to numbers in LGR equivalents for the other two study categories will also be investigated.

Confidence intervals created by the bootstrapping program for the various survival rate parameters and combinations of these parameters presented in the CSS should have the expected coverage around the point estimate of interest. The program to create a set of simulated data allows the user to adjust the "noise" level around the expectation of key parameters. Through simulations, we plan to investigate the effect of various levels of "noise" in the input data set on the confidence intervals obtained around key parameters produced with the CSS bootstrapping program.

To address the needs for performing simulation studies, FPC staff with assistance from USWFS staff, prepared a computer program that creates simulated sets of data with controlled parameter expectations. We plan to conduct numerous runs of simulated data to investigate the issues discussed above in the next contract year of the CSS program.

Verification of Computer Program to Create Desired Simulated PIT Tag Input Files

The simulator computer program has been developed over the past year, and during development, many tests have been performed to provide assurance that it is doing what it is designed to do. This section of the CSS annual report describes the procedures conducted to verify that the computer program was operating properly to generate a simulated data file that reflects the user's intended choices. At the end of this chapter is Figure 11, a flow diagram that illustrates the design of the simulator computer program.

The first version of the simulator could only accept constants as user inputs for expected reach survivals, project collection efficiencies, and travel time distributions. The CSS Oversight Committee commented that survival, collection efficiency, and travel time distributions might vary over the migration season. The simulator was modified to address this comment. This version allowed for expected reach survivals, collection efficiencies, and travel time distributions to vary day by day over the migration season, either linearly or parabolically. Constants could still be input for these parameters if desired.

The simulator was made with two toggle switches for testing purposes to provide some assurance that the stochastic drawing functions were working properly. The first switch turned off the stochastic random drawing binomial and beta distribution functions throughout the program, and used constant probabilities to calculate the capture histories instead. This enabled the designers to test the simulator's output against the theoretical numbers of detected, undetected, and removed tags at each project and tailrace as calculated by hand. A simple example of a hand calculation follows: if the collection efficiency at LGR is 50%, and the survival from release to LGR forebay is 65%, and 50,000 tags are released; then theoretically, 32,500 of the 50,000 tags will reach the LGR forebay and 16,250 of these tags will be detected. When turning the random binomial drawing function "OFF" and toggling the simulator to use only constant probabilities, a rounding bias was demonstrated. Since this exercise used only 50,000 tags in the initial simulated PIT tag set, and these tags were spread over a 100-day migration season, the tails of the migration distribution contained many days were there was only one tag arriving at a particular observation site. When constant probabilities were used for detection probability, many of these single arrival days became zero arrival days, which created a bias. When the random binomial draw of detection probabilities was used instead of constant detection probabilities, far fewer single arrival days were converted to zero arrival days. However, the design of the simulator relied extensively on random draws from different distributions, and it turned out that turning the binomial drawing functions “ON” yielded results much closer to the hand calculations.

The second toggle switch allowed changing the way survival, collection, and travel time distributions were calculated. The toggle would make these distributions calculated once per project, or calculated once per capture history per project. The distribution of the arrival times at each site was examined as well as the overall number of tags for each capture history, and compared to the hand calculation. Both compared favorably to the hand calculation, but choosing to calculate once per capture history per project yielded results slightly closer to the hand calculation.

Histograms of the detection distributions at each site were drawn and examined to make sure that they reflected the initial parameters chosen by the user, and to make sure the stochastic distribution formed a Gaussian distribution curve at LGR, and similar bell shaped curve at each of the downstream sites, with the peak of the curve shifting to later dates as fish move downstream, reflecting travel time between dams.

The simulator produces a companion output report for each simulated data set that it outputs. This report contains many parameters that could be directly compared to the parameters output by the bootstrapper in order to see if the simulated data set was producing what it was supposed to. The number of tagged fish transported at each transportation site, (x12, x102, x1002, x10002) and the number of adults from those groups that returned are parameters that were output from both the bootstrapper and the simulator that were not estimates, but simple counts of observations. These numbers were the exact same in the bootstrapper output and in the simulator output.

A preliminary comparison was made by creating 15 simulated tag files with reach survivals having constant expectation (*i.e.*, simulated baseline) and then comparing them to the estimated reach survivals obtained with the bootstrapper. The bootstrapper program uses two different methods, the “subcohort” CJS method and the “full sample” CJS method, to compute individual reach survival estimates. Table 52 illustrates the results of this comparison with one of the 15 simulated data sets.

In this example, the “full sample” reach survival estimates tended to be closer to the simulated baseline survival rates (“known truth”) than were the “subcohort” reach survival estimates when using three subcohorts. Compared to the simulated baseline results, the full sample CJS survival estimates when rounded to two significant digits were the same for S_2 and S_4, 1.1% lower for S_3 and S_6, and 2.3% lower for S_5. The three-subcohort survival estimates were 2.8% higher for S_2, 2.2% lower for S_3, 1.1% lower for S_4, 5.6% lower for S_5, and 2.3% lower for S_6. The other 14 simulated tag files produced comparable results when run through the bootstrapper. The “3 subcohorts” estimates varied up to ±5 percentage points about the “known truth” and the “full sample” estimates varied up to ±2 percentage points about the “known truth.”

Table 52. Comparison of simulated reach survivals with two methods of estimating reach survivals.

Data Type for Survival Estimate	Reach Survival Estimates and Change from Baseline (%)				
	S2	**S3**	**S4**	**S5**	**S6**
Simulated baseline (“known truth”)	0.91	0.93	0.89	0.89	0.88
Full Sample	0.91 (0)	0.92 (-1.1)	0.89 (0)	0.87 (-2.3)	0.87 (-1.1)
3 SubCohort	0.935 (+2.8)	0.91 (-2.2)	0.90 (-1.1)	0.84 (-5.6)	0.85 (-2.3)

Simulating random numbers from various kinds of distributions can be done on a computer using tools such as Microsoft Excel with the add-on statistical package “Poptools”, written by Gary Hood, which provided “wrapper” functions for algorithms from a statistical function library principally written by Alan Miller. This package did not meet the demanding output and performance required by the simulator, so the Fortran and Pascal source code for Poptools was obtained from Gary Hood (website link is http://www.cse.csiro.au/poptools/), and the algorithms were ported from the Fortran and Pascal source code to FoxPro. Thus a new statistical function library was created that met the performance requirements of the simulator. Other required statistical functions were not found in Poptools, and in these cases, new functions were written from scratch using algorithms found in Press *et al*. (1986), Knuth (1998), and Gentle (2003).

Various simple tests were performed on the statistical functions to make sure they were working properly. For example, the Beta function was tested using the following equivalence:

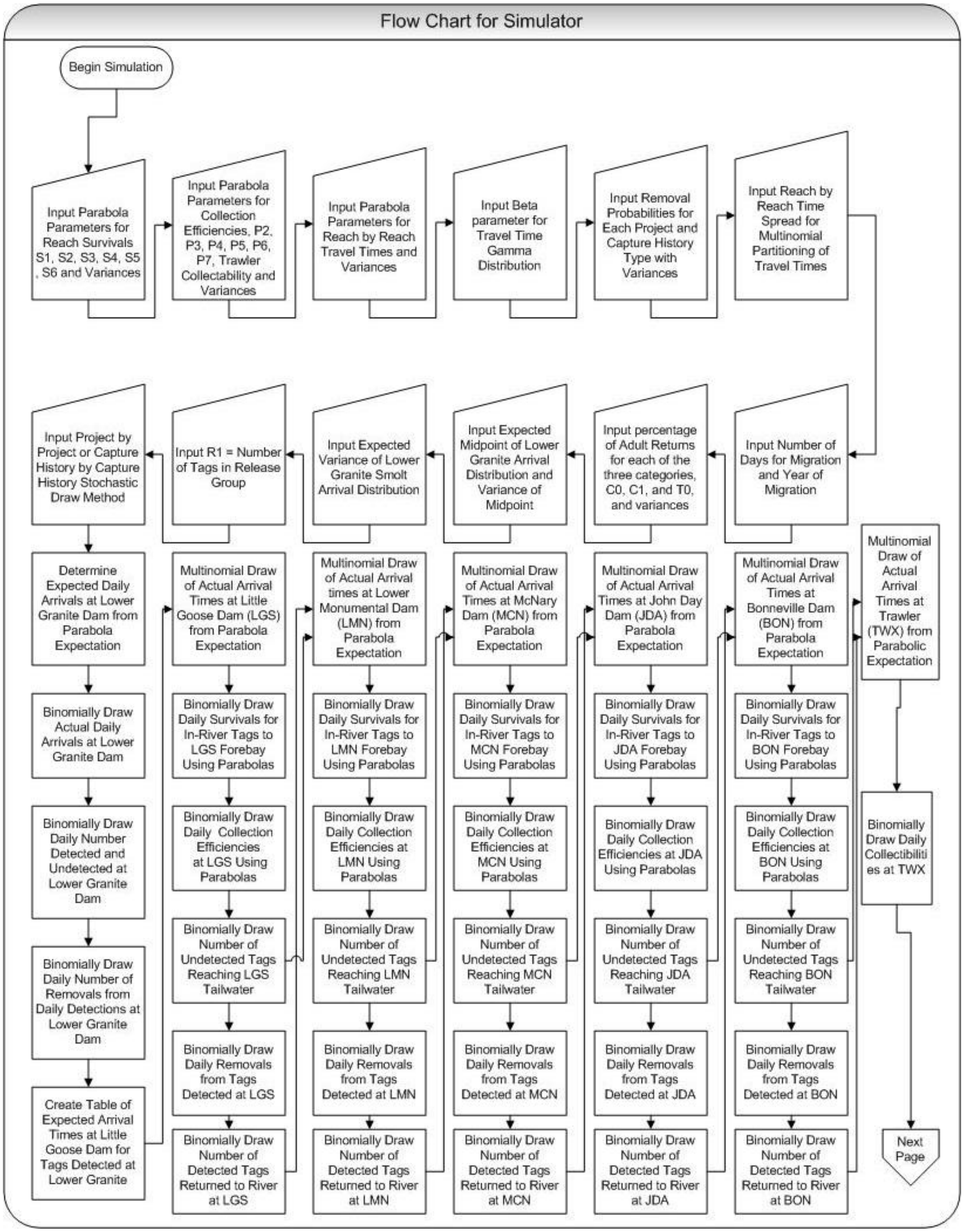
$$\text{Beta}(z,w) = \text{Beta}(w,z) = \text{Exp}(\text{gammln}(z)+\text{gammln}(w)-\text{gammln}(z+w))$$

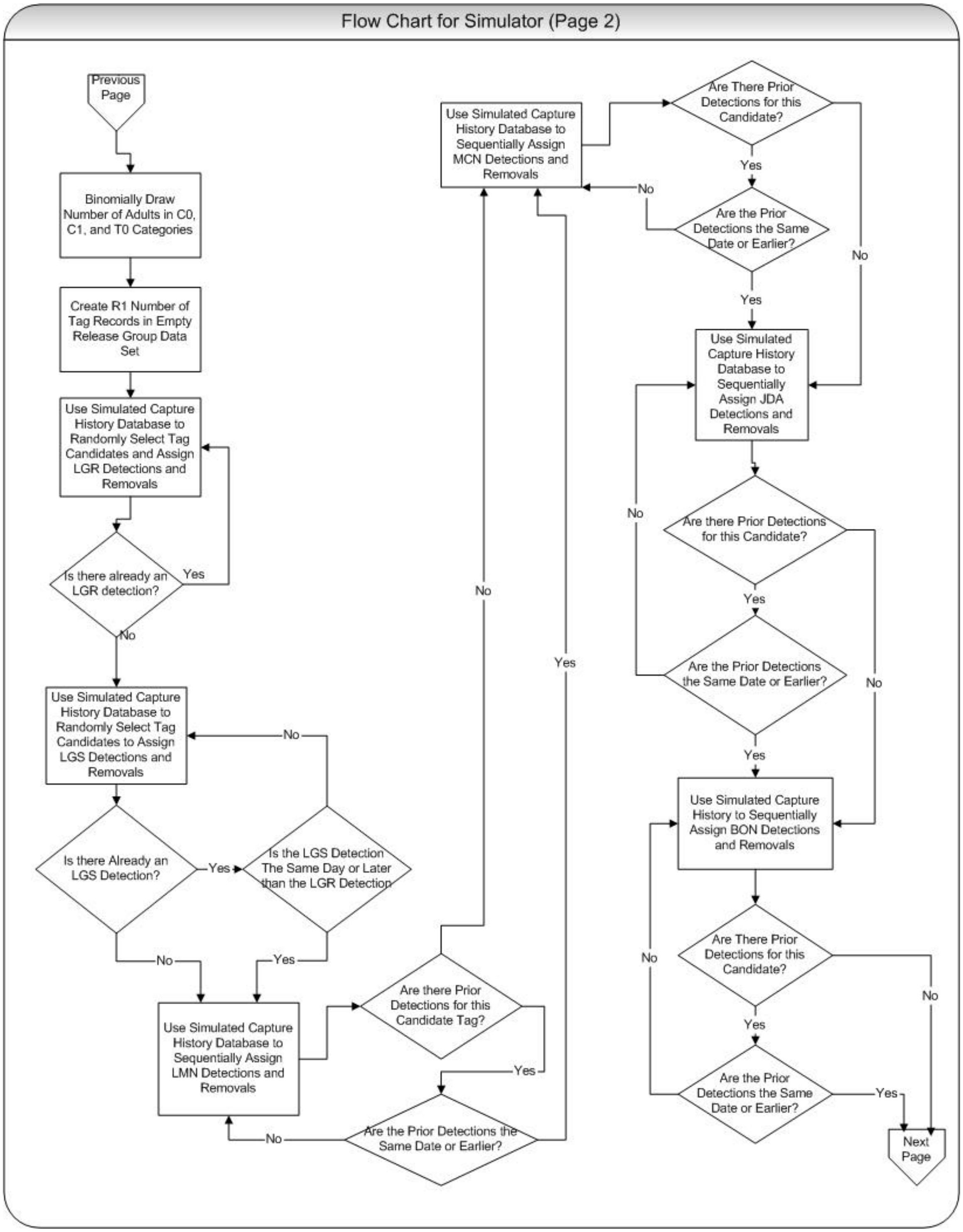
By writing the Beta function in terms of the Gammln function (which is the logarithm of the Gamma function) and the Exponential function, we can simultaneously test the Gammaln, Beta, and Exponential functions. Since Beta(z,w) = Beta (w,z), all three of these functions were first tested by substituting a range of values for z and w, and checking that the results were identical when z and w were switched.

A second test was performed using the property that when z = w = 0.5, the Beta(z,w) should be equal to 3.14; in other words, Beta(0.5,0.5) = p. The function passed this test as well.

Statistical functions that returned random variables from distributions such as normal distributions, beta distributions, and gamma distributions were tested by calling each of the functions five hundred times with a given mean and standard deviation, and graphing the resulting output data to make the output random variables matched the desired distribution with the desired standard deviation.

The algorithms for three random uniform number generators were obtained from Knuth (1998); the associated functions were developed in FoxPro. These functions were then compared to the built-in pseudorandom uniform number generator in FoxPro by using the functions to output 1,000 points. After comparing the results, it was determined that the FoxPro pseudorandom uniform number generator performed the best of the four functions when it was seeded with minus the number of seconds after midnight.


Flow Chart for Simulator
Begin Simulation
Input Parabola Parameters for Reach Survivals S1, S2, S3, S4, S5 , S6 and Variances
Input Parabola Parameters for Collection Efficiencies, P2, P3, P4, P5, P6, P7, Trawler Collectability and Variances
Input Parabola Parameters for Reach by Reach Travel Times and Variances
Input Beta parameter for Travel Time Gamma Distribution
Input Removal Probabilities for Each Project and Capture History Type with Variances
Input Reach by Reach Time Spread for Multinomial Partitioning of Travel Times
Input Number of Days for Migration and Year of Migration
Input percentage of Adult Returns for each of the three categories, C0, C1, and T0, and variances
Input Expected Midpoint of Lower Granite Arrival Distribution and Variance of Midpoint
Input Expected Variance of Lower Granite Smolt Arrival Distribution
Input R1 = Number of Tags in Release Group
Input Project by Project or Capture History by Capture History Stochastic Draw Method
Determine Expected Daily Arrivals at Lower Granite Dam from Parabola Expectation
Binomially Draw Actual Daily Arrivals at Lower Granite Dam
Binomially Draw Daily Number Detected and Undetected at Lower Granite Dam
Binomially Draw Daily Number of Removals from Daily Detections at Lower Granite Dam
Create Table of Expected Arrival Times at Little Goose Dam for Tags Detected at Lower Granite
Multinomial Draw of Actual Arrival Times at Little Goose Dam (LGS) from Parabola Expectation
Binomially Draw Daily Survivals for In-River Tags to LGS Forebay Using Parabolas
Binomially Draw Daily Collection Efficiencies at LGS Using Parabolas
Binomially Draw Number of Undetected Tags Reaching LGS Tailwater
Binomially Draw Daily Removals from Tags Detected at LGS
Binomially Draw Number of Detected Tags Returned to River at LGS
Multinomial Draw of Actual Arrival times at Lower Monumental Dam (LMN) from Parabola Expectation
Binomially Draw Daily Survivals for In-River Tags to LMN Forebay Using Parabolas
Binomially Draw Daily Collection Efficiencies at LMN Using Parabolas
Binomially Draw Number of Undetected Tags Reaching LMN Tailwater
Binomially Draw Daily Removals from Tags Detected at LMN
Binomially Draw Number of Detected Tags Returned to River at LMN
Multinomial Draw of Actual Arrival Times at McNary Dam (MCN) from Parabola Expectation
Binomially Draw Daily Survivals for In-River Tags to MCN Forebay Using Parabolas
Binomially Draw Daily Collection Efficiencies at MCN Using Parabolas
Binomially Draw Number of Undetected Tags Reaching MCN Tailwater
Binomially Draw Daily Removals from Tags Detected at MCN
Binomially Draw Number of Detected Tags Returned to River at MCN
Multinomial Draw of Actual Arrival Times at John Day Dam (JDA) from Parabola Expectation
Binomially Draw Daily Survivals for In-River Tags to JDA Forebay Using Parabolas
Binomially Draw Daily Collection Efficiencies at JDA Using Parabolas
Binomially Draw Number of Undetected Tags Reaching JDA Tailwater
Binomially Draw Daily Removals from Tags Detected at JDA
Binomially Draw Number of Detected Tags Returned to River at JDA
Multinomial Draw of Actual Arrival Times at Bonneville Dam (BON) from Parabola Expectation
Binomially Draw Daily Survivals for In-River Tags to BON Forebay Using Parabolas
Binomially Draw Daily Collection Efficiencies at BON Using Parabolas
Binomially Draw Number of Undetected Tags Reaching BON Tailwater
Binomially Draw Daily Removals from Tags Detected at BON
Binomially Draw Number of Detected Tags Returned to River at BON
Multinomial Draw of Actual Arrival Times at Trawler (TWX) from Parabolic Expectation
Binomially Draw Daily Collectibilities at TWX
Next Page


Flow Chart for Simulator (Page 2)
Previous Page
Binomially Draw Number of Adults in C0, C1, and T0 Categories
Create R1 Number of Tag Records in Empty Release Group Data Set
Use Simulated Capture History Database to Randomly Select Tag Candidates and Assign LGR Detections and Removals
Is there already an LGR detection?
Yes
No
Use Simulated Capture History Database to Randomly Select Tag Candidates to Assign LGS Detections and Removals
Is there Already an LGS Detection?
Yes
Is the LGS Detection The Same Day or Later than the LGR Detection
No
No
Yes
Use Simulated Capture History Database to Sequentially Assign LMN Detections and Removals
Are there Prior Detections for this Candidate Tag?
No
Yes
Are the Prior Detections the Same Date or Earlier?
No
Yes
Use Simulated Capture History Database to Sequentially Assign MCN Detections and Removals
Are There Prior Detections for this Candidate?
Yes
Are the Prior Detections the Same Date or Earlier?
No
No
Yes
Use Simulated Capture History Database to Sequentially Assign JDA Detections and Removals
Are there Prior Detections for this Candidate?
Yes
Are the Prior Detections the Same Date or Earlier?
No
No
Yes
Use Simulated Capture History to Sequentially Assign BON Detections and Removals
Are There Prior Detections for this Candidate?
Yes
Are the Prior Detections the Same Date or Earlier?
No
No
Yes
Next Page

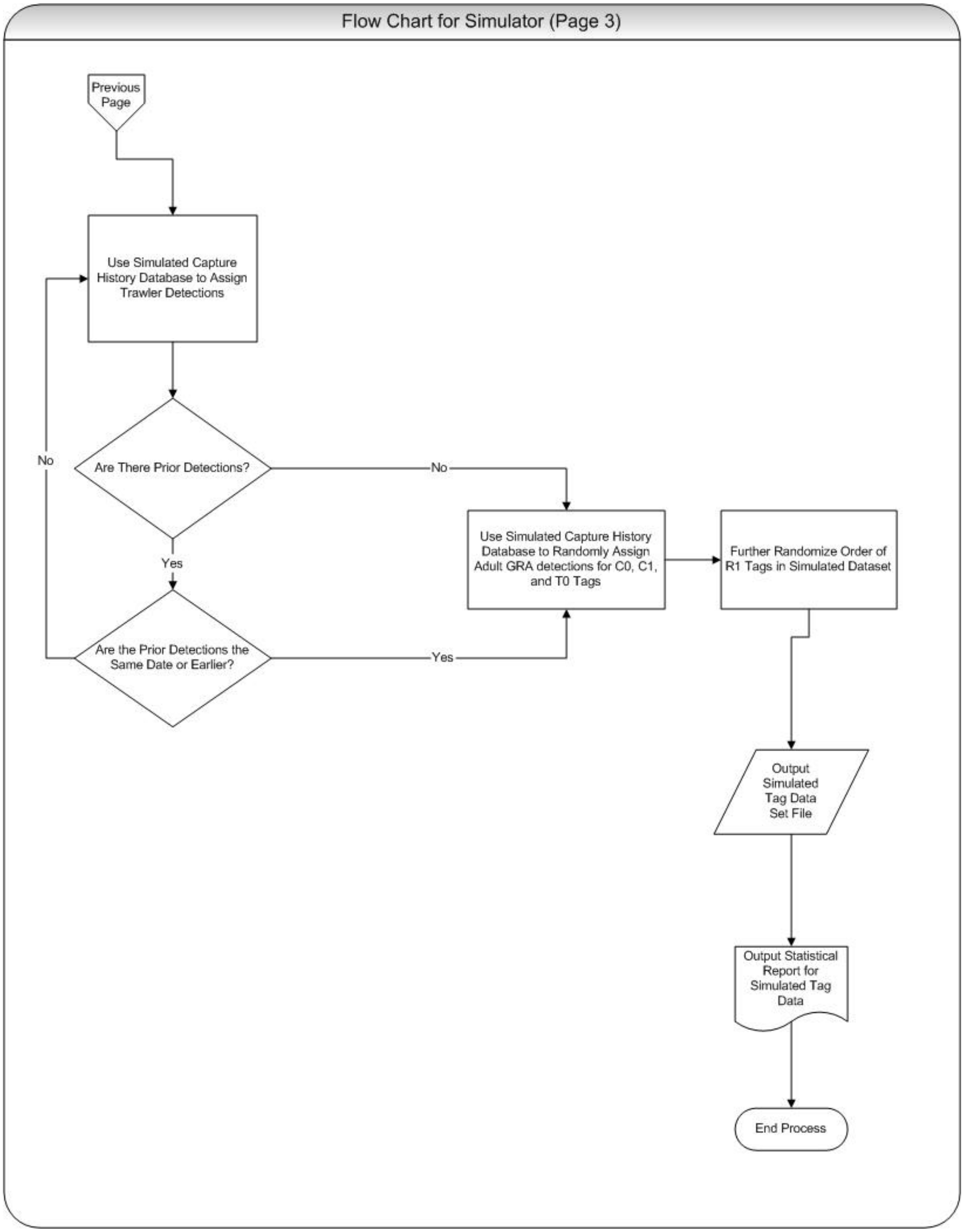


Figure 11. Flow chart of the computer program "simulator" to create a set of simulated PIT tag data with capture-recapture histories following user inputted criteria that allow the examination of the properties of parameters generated with the CSS Bootstrap Program.

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APPENDIX A: Release sites of PIT-tagged wild Chinook used in aggregate (tagged fish are not present at every site in each year) for migration years 1999 to 2002.

Release River KM	Release Site	Rel-site Code
CLEARWATER RIVER SUB-BASIN		
522.224	Clearwater River	CLWR
522.224.010	Clearwater Trap	CLWTRP
522.224.087	Lolo Creek	LOLOC
522.224.120.004	Clear Creek	CLEARC
522.224.120.037	Lochsa River	LOCHSA
522.224.120.037	Selway River	SELWYR
522.224.120.037.003	Pete King Creek	PETEKC
522.224.120.037.029	Gedney Creek	GEDNEC
522.224.120.037.031	Meadow Creek, Selway R.	MEADOC
522.224.120.037.039	Fish Creek	FISHC
522.224.120.037.039.002	Fish Creek Trap	FISTRP
522.224.120.037.096	Squaw Creek	SQUAWC
522.224.120.037.105	Papoose Creek	PAPOOC
522.224.120.037.113	Colt Kill Creek (Replaces WHITSC)	COLTKC
522.224.120.037.113.003	Crooked Fork Creek Trap	CFCTRP
522.224.120.037.113.011	Brushy Fork Creek	RUSHC
522.224.120.037.113.016	Storm Creek	STORMC
522.224.120.037.264	White Cap Creek	WHITCC
522.224.120.084	Newsome Creek	NEWSOC
522.224.120.094	Crooked River	CROOKR
522.224.120.094.001	Crooked River Trap	CROTRP
522.224.120.101	American River	AMERR
522.224.120.101	Red River	REDR
522.224.120.101.006	Red River Trap	REDTRP
SNAKE RIVER TRAP AT LEWISTON		
522.225	Snake Trap	SNKTRP
GRANDE RONDE RIVER SUB-BASIN		
522.271	Grande Ronde R (km 131-325)	GRAND2
522.271	Grande Ronde R (Archaic)	GRANDR
522.271.002	Grande Ronde River Trap	GRNTRP
522.271.073	Wenaha River	WENR
522.271.073.035	North Fork Wenaha River	WENRNF
522.271.073.035	South Fork Wenaha River	WENRSF
522.271.131	Wallowa River	WALLOR
522.271.131.016	Minam River	MINAMR
522.271.131.042	Lostine River	LOSTIR
522.271.137	Lookingglass Creek	LOOKGC
522.271.232	Catherine Creek	CATHEC

SALMON RIVER SUB-BASIN

522.303	Salmon R (Archaic)	SALR
522.303.103	Salmon Trap	SALTRP
522.303.215	SF Salmon River	SALRSF
522.303.215.000	Lower SF Salmon River Trap	LSFTRP
522.303.215.059	Secesh River	SECESR
522.303.215.059.045	Lake Creek	LAKEC
522.303.215.060	EF South Fork Salmon R.	SAEFSF
522.303.215.060.024	Johnson Creek	JOHNSC
522.303.215.060.024.007	Johnson Creek Trap	JOHTRP
522.303.215.115	SF Salmon River Trap	SFSTRP
522.303.215.125	Stolle Pond	STOLP
522.303.282	Chamberlain Creek	CHAMBC
522.303.282.024	WF Chamberlain Ck	CHAMWF
522.303.319.029	Big Creek, MF Salmon R.	BIG2C
522.303.319.029.011	Rush Creek, MF Salmon R.	RUSHC
522.303.319.057	Camas Creek, MF Salmon R.	CAMASC
522.303.319.073	Loon Creek	LOONC
522.303.319.150	Sulphur Creek, MF Salmon R.	SULFUC
522.303.319.170	Bear Valley Creek	BEARVC
522.303.319.170	Marsh Creek	MARSHC
522.303.319.170.010	Capehorn Creek	CAPEHC
522.303.319.170.011	Marsh Creek Trap	MARTRP
522.303.319.170.014	Elk Creek	ELKC
522.303.381	NF Salmon River	SALRNF
522.303.416	Lemhi River	LEMHIR
522.303.416.049	Lemhi River Weir	LEMHIW
522.303.489	Pahsimeroi River	PAHSIR
522.303.489.002	Pahsimeroi River Trap	PAHTRP
522.303.552	EF Salmon River	SALREF
522.303.552.014	Herd Creek	HERDC
522.303.552.030	EF Salmon River Weir	SALEFW
522.303.591.011	WF Yankee Fork	YANKWF
522.303.609	Valley Creek	VALEYC
522.303.615.003	Redfish Lake Ck Trap	RLCTRP
522.303.617	Sawtooth Trap	SAWTRP
522.303.622	Williams Creek	WILLIC
522.303.624	Huckleberry Creek	HUCKLC
522.303.633	Alturas Lake Creek	ALTULC
522.303.633.002	Pettit Lake Creek	PETTLC
522.303.642	Beaver Creek	BEAVEC
522.303.644	Smiley Creek	SMILEC
522.303.647	Frenchman Creek	FRENCC

IMNAHA RIVER SUB-BASIN

522.308	Imnaha River	IMNAHR
522.308.007	Imnaha Trap	IMNTRP
522.308.074	Imnaha River Weir	IMNAHW

APPENDIX B : REACH SURVIVAL ESTIMATES

(Reach survival rates are estimated using full sample CJS; all estimates to lower reaches than shown in last year's CSS report are presented in bold type through 2000)

Appendix Table B-1. Estimates of in-river survival rates of PIT tagged wild Chinook aggregate smolts for migration years 1994 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream dam.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
1994	S2 (lgr-lgs)	0.822	0.80	0.85
	S3 (lgs-lmn)	0.836	0.81	0.87
1995	S2 (lgr-lgs)	0.895	0.88	0.91
	S3 (lgs-lmn)	0.951	0.93	0.98
	S4 (lmn-mcn)	0.764	0.66	0.91
1996	S2 (lgr-lgs)	0.908	0.87	0.95
	S3 (lgs-lmn)	0.911	0.85	0.98
1997	S2 (lgr-lgs)	0.922	0.85	0.99
	S3 (lgs-lmn)	0.931	0.81	1.06
1998	S2 (lgr-lgs)	1.003	0.99	1.02
	S3 (lgs-lmn)	0.850	0.83	0.88
	S4 (lmn-mcn)	0.940	0.89	0.99
	S5 (mcn-jda)	0.854	0.77	0.96
1999	S2 (lgr-lgs)	0.958	0.95	0.97
	S3 (lgs-lmn)	0.924	0.91	0.93
	S4 (lmn-mcn)	0.889	0.87	0.91
	S5 (mcn-jda)	0.889	0.85	0.93
	S6 (jda-bon)	**0.845**	0.72	1.00
2000	S2 (lgr-lgs)	0.898	0.88	0.91
	S3 (lgs-lmn)	0.867	0.84	0.89
	S4 (lmn-mcn)	0.978	0.94	1.02
	S5 (mcn-jda)	0.734	0.68	0.80
	S6 (jda-bon)	**0.866**	0.71	1.10
2001	S2 (lgr-lgs)	0.930	0.92	0.94
	S3 (lgs-lmn)	0.773	0.76	0.78
	S4 (lmn-mcn)	0.684	0.67	0.70
	S5 (mcn-jda)	0.714	0.67	0.77
	S6 (jda-bon)	0.663	0.55	0.82
2002	S2 (lgr-lgs)	0.902	0.88	0.92
	S3 (lgs-lmn)	0.997	0.98	1.02
	S4 (lmn-mcn)	0.813	0.79	0.84
	S5 (mcn-jda)	0.866	0.82	0.92
	S6 (jda-bon)	0.967	0.79	1.24

Appendix Table B-2. Estimates of in-river survival rates of PIT tagged Rapid River Hatchery Chinook smolts for migration years 1997 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream dam.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
1997	S2 (lgr-lgs)	0.964	0.90	1.03
	S3 (lgs-lmn)	0.803	0.75	0.87
1998	S2 (lgr-lgs)	1.005	0.99	1.02
	S3 (lgs-lmn)	0.847	0.83	0.87
	S4 (lmn-mcn)	0.982	0.92	1.04
	S5 (mcn-jda)	**0.798**	0.71	0.90
1999	S2 (lgr-lgs)	0.923	0.90	0.94
	S3 (lgs-lmn)	0.957	0.94	0.98
	S4 (lmn-mcn)	0.906	0.87	0.94
	S5 (mcn-jda)	0.945	0.88	1.02
	S6 (jda-bon)	**0.750**	0.62	0.92
2000	S2 (lgr-lgs)	0.846	0.81	0.88
	S3 (lgs-lmn)	1.127	1.02	1.25
	S4 (lmn-mcn)	0.823	0.72	0.94
	S5 (mcn-jda)	**0.945**	0.76	1.25
	S6 (jda-bon)	**0.782**	0.55	1.17
2001	S2 (lgr-lgs)	0.958	0.95	0.97
	S3 (lgs-lmn)	0.856	0.84	0.87
	S4 (lmn-mcn)	0.698	0.68	0.71
	S5 (mcn-jda)	0.924	0.85	1.01
	S6 (jda-bon)	0.618	0.50	0.80
2002	S2 (lgr-lgs)	0.947	0.92	0.97
	S3 (lgs-lmn)	0.981	0.96	1.00
	S4 (lmn-mcn)	0.841	0.82	0.87
	S5 (mcn-jda)	0.953	0.90	1.02
	S6 (jda-bon)	0.951	0.78	1.20

Appendix Table B-3. Estimates of in-river survival rates of PIT tagged Dworshak Hatchery Chinook smolts for migration years 1997 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream dam.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
1997	S2 (lgr-lgs)	1.047	0.96	1.15
	S3 (lgs-lmn)	0.810	0.72	0.91
1998	S2 (lgr-lgs)	1.071	1.04	1.10
	S3 (lgs-lmn)	0.765	0.74	0.79
	S4 (lmn-mcn)	0.931	0.89	0.98
	S5 (mcn-jda)	**0.782**	0.70	0.89
1999	S2 (lgr-lgs)	0.887	0.86	0.91
	S3 (lgs-lmn)	0.952	0.94	0.97
	S4 (lmn-mcn)	0.875	0.85	0.90
	S5 (mcn-jda)	0.899	0.85	0.96
	S6 (jda-bon)	**0.816**	0.68	1.01
2000	S2 (lgr-lgs)	0.807	0.78	0.84
	S3 (lgs-lmn)	1.036	0.96	1.12
	S4 (lmn-mcn)	0.834	0.75	0.92
	S5 (mcn-jda)	**0.944**	0.80	1.14
	S6 (jda-bon)	**0.730**	0.54	1.01
2001	S2 (lgr-lgs)	0.941	0.93	0.95
	S3 (lgs-lmn)	0.839	0.83	0.85
	S4 (lmn-mcn)	0.694	0.68	0.71
	S5 (mcn-jda)	0.693	0.65	0.74
	S6 (jda-bon)	0.636	0.51	0.84
2002	S2 (lgr-lgs)	0.917	0.88	0.95
	S3 (lgs-lmn)	0.978	0.95	1.01
	S4 (lmn-mcn)	0.810	0.79	0.83
	S5 (mcn-jda)	0.931	0.87	0.99
	S6 (jda-bon)	0.910	0.77	1.09

Appendix Table B-4. Estimates of in-river survival rates of PIT tagged Catherine Creek Acclimation Pond Chinook smolts for migration years 2001 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream dam.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
2001	S2 (lgr-lgs)	0.945	0.93	0.96
	S3 (lgs-lmn)	0.814	0.79	0.84
	S4 (lmn-mcn)	0.659	0.62	0.70
	S5 (mcn-jda)	0.768	0.65	0.90
	S6 (jda-bon)	0.639	0.42	1.10
2002	S2 (lgr-lgs)	0.949	0.90	1.00
	S3 (lgs-lmn)	1.013	0.96	1.07
	S4 (lmn-mcn)	0.808	0.74	0.88
	S5 (mcn-jda)	0.928	0.79	1.12
	S6 (jda-bon)	0.896	0.56	1.72

Appendix Table B-5. Estimates of in-river survival rates of PIT tagged McCall Hatchery Chinook smolts for migration years 1997 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
1997	S2 (lgr-lgs)	0.935	0.89	0.99
	S3 (lgs-lmn)	0.882	0.82	0.95
1998	S2 (lgr-lgs)	0.991	0.97	1.01
	S3 (lgs-lmn)	0.843	0.82	0.87
	S4 (lmn-mcn)	0.942	0.88	1.01
	S5 (mcn-jda)	**0.824**	0.74	0.93
1999	S2 (lgr-lgs)	0.908	0.88	0.94
	S3 (lgs-lmn)	0.936	0.91	0.96
	S4 (lmn-mcn)	0.913	0.87	0.96
	S5 (mcn-jda)	1.086	0.99	1.21
	S6 (jda-bon)	**0.622**	0.51	0.77
2000	S2 (lgr-lgs)	0.867	0.81	0.93
	S3 (lgs-lmn)	0.917	0.81	1.04
	S4 (lmn-mcn)	1.034	0.91	1.18
	S5 (mcn-jda)	**1.307**	0.90	2.26
	S6 (jda-bon)	**0.570**	0.32	0.89
2001	S2 (lgr-lgs)	0.928	0.92	0.94
	S3 (lgs-lmn)	0.771	0.76	0.79
	S4 (lmn-mcn)	0.647	0.63	0.67
	S5 (mcn-jda)	0.862	0.78	0.95
	S6 (jda-bon)	0.674	0.53	0.92
2002	S2 (lgr-lgs)	0.964	0.93	0.99
	S3 (lgs-lmn)	0.990	0.96	1.02
	S4 (lmn-mcn)	0.837	0.81	0.87
	S5 (mcn-jda)	1.051	0.96	1.15
	S6 (jda-bon)	0.688	0.58	0.84

Appendix Table B-6. Estimates of in-river survival rates of PIT tagged Imnaha Hatchery Chinook smolts for migration years 1997 to 2002 in the hydro system between the tailrace of Lower Granite Dam and the tailrace of the furthest downstream dam.

Migr Year	Parameter	Full Sample CJS Estimates		
		Point Estimate	Bootstrap Lower CI	Bootstrap Upper CI
1997	S2 (lgr-lgs)	0.994	0.91	1.08
	S3 (lgs-lmn)	0.768	0.69	0.86
1998	S2 (lgr-lgs)	0.978	0.95	1.01
	S3 (lgs-lmn)	0.843	0.81	0.87
	S4 (lmn-mcn)	0.956	0.89	1.03
	S5 (mcn-jda)	**0.784**	0.69	0.91
1999	S2 (lgr-lgs)	0.921	0.89	0.96
	S3 (lgs-lmn)	0.954	0.92	0.99
	S4 (lmn-mcn)	0.876	0.82	0.93
	S5 (mcn-jda)	**0.944**	0.84	1.08
	S6 (jda-bon)	**0.740**	0.55	1.10
2000	S2 (lgr-lgs)	0.822	0.77	0.88
	S3 (lgs-lmn)	1.008	0.87	1.20
	S4 (lmn-mcn)	0.885	0.72	1.08
	S5 (mcn-jda)	**0.893**	0.68	1.29
	S6 (jda-bon)	**1.013**	0.57	2.47
2001	S2 (lgr-lgs)	0.958	0.95	0.97
	S3 (lgs-lmn)	0.892	0.88	0.91
	S4 (lmn-mcn)	0.751	0.73	0.78
	S5 (mcn-jda)	0.853	0.76	0.96
	S6 (jda-bon)	0.678	0.46	1.23
2002	S2 (lgr-lgs)	0.951	0.91	1.00
	S3 (lgs-lmn)	0.947	0.91	0.99
	S4 (lmn-mcn)	0.858	0.82	0.90
	S5 (mcn-jda)	0.828	0.75	0.92
	S6 (jda-bon)	0.788	0.60	1.09

APPENDIX C – COMMENTS AND RESPONSE

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NORTHWESTERN DIVISION
PO BOX 2870
PORTLAND OR 97208-2870

REPLY TO
ATTENTION OF

February 3, 2005

District Support Team

Mr. Tom Berggren
Fish Passage Center
1827 NE 44[th] Ave., Suite 240
Portland, OR 97213

Dear Mr. Berggren:

Please find enclosed a review of the Comparative Survival Study of PIT-tagged Spring/Summer Chinook, 2003/2004 Annual Report, conducted by the Northwestern Division Office of the U.S. Army Corps of Engineers. As the Fishery Biologist for the Northwestern Division Office, I conducted this review, focusing primarily on the technical and policy issues within the document. This review has been provided in a bulletized form to facilitate potential responses and is summarized in the letter below.

Specific items that would help me better understand both the study and the document include: a discussion of how many additional years this study would continue, which groups of naturally spawned fish were used in the analysis and why, how some groups of juvenile and adult fish groups were used in the analysis, and specific questions regarding year to year comparisons.

In addition, there seemed to be little discussion as to improvements at juvenile fish facilities that may have impacted the results of the study from year to year. In the last 4 years, modifications to fish facilities have included barge loading lines at Lower Monumental, the PIT-tag return line being moved to a more optimal location at Little Goose Dam, improvements in PIT-tag flume hydraulics at Little Goose Dam, a separator insert decreasing holding time and increasing separation at Lower Monumental, et cetera, all having a likely level of impact to fish survival through various routes. However, the report seems to portray the dams as static structures by not mentioning any of these changes in the year-to-year variability. These changes may help to explain differences in year-to-year analyses.

This report indicates transport is not an effective management tool and implies that the transportation process is static. However, recently, we have been seeing a function of seasonality in the transportation data, indicating that transportation is much more effective at some times of the year than other times of the year. In the Updated Proposed Action for

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operation of the Federal Columbia River Power System, the action agencies proposed a modification of the transport season, reducing transport when it was less effective early in the season. In addition, the Corps is looking into various measures to improve the transport process. Addressing the seasonal issue could provide insight into how to make things better under the spread the risk operation.

We appreciate the opportunity to review this document, especially the extra 5-day review period offered to us to complete our review. We hope the comments provided prove useful in finalizing your document.

Sincerely,

Paul A. Ocker
Fishery Biologist
Northwestern Division
U.S. Army Corps of Engineers

Enclosure

cc:
Witt Anderson
Marvin Shutters
Gayle Lear
Administrative record

USACE - Northwestern Division Office - Review of CSS Study – Bulletized List

Technical & Policy

General — If we operate according to the new BiOp, it would be useful to compare new operations with the older ones of fish released from the hatcheries and headwaters. Is 2002 the last year of tagging for the CSS or is it continuing?

General — There was a barge dump in 2001 in front of Ice Harbor Dam due to clogged screens. Were the fish in that barge included or excluded from the transport group?

General — Although comparisons of wild fish detected at the dams are probably good representations of those tagged fish, the use of various groups tagged at different times of the year, with differing techniques, is quite possibly not representative of the population. Recent discussions with NOAA fisheries personnel, who are tagging wild fish in the headwater streams and monitoring them with in stream PIT detectors, have indicated that a notable proportion of parr are moving out during the middle of winter, when tagging efforts at traps are not possible and crews are not out tagging using shockers. This indicates that a portion of the run is not being PIT tagged, and therefore is possibly not representing the population.

I am not sure how to reconcile the situation but would appreciate your thoughts.

In addition, fish tagged in the fall in the headwaters and at traps are different groups than those tagged in the spring at traps. Because I could find no reference to which groups of wild fish were used and why, and what groups of fish were not used and why, it was difficult to determine if the groups of wild fish represented the population or not. Perhaps an appendix table with those groups used would provide clarity.

General — The upstream and downstream comparisons of stocks may not be appropriate from a physiological standpoint. Jim Congleton's work has indicated that Snake River fish have essentially used up their reserves of energy by the time they reach Lower Granite Dam. The distance that those fish have traveled to LGR may be similar to or greater than those fish originating from the lower rivers to reach the ocean, yielding fish with different energy potential based on the distance traveled alone.

General — It would be useful to see an expansion of discussion of undetected fish. Not only are the facilities not 100% efficient at detecting tags, but there are outages to PIT tag systems due to power failures, coil failures, etc as outlined on the PTAGIS web site.

General — Page 37 **-** The text indicates that a large proportion of the wild fish were handled at the JFF. Anesthetized and handled fish, a subsample of the overall population, are not representative of the population of fish being transported in that they may be anesthetized for unknown periods of time, handled differentially during the smolt sampling process, and may be exposed to different disease and temperature regimes within the anesthetic recirculation system, than their counterparts in the raceways for the normal barge process. Were these fish included or removed from the barging group for analysis?

Specifics

Page 17 — Under Bullet 2, the reference to the Mid-Columbia hatchery fish, is unclear. Chinook and Steelhead were tagged beginning in 2002 in large numbers in the mid-Columbia, most likely in sufficient numbers to perform a CSS type analysis. Because of the large tagging component that the Corps performed for an analysis of Transport/Bypass/Undetected study at McNary, the CSS tagging effort was determined to not be necessary. If the intent of that statement is to indicate that an analysis was not *funded*, then that is a more appropriate statement.

Page 17 Last Paragraph, line 3, it is unclear whether temporal refers to a between year temporal change or within year temporal change. Many of the recent analyses show both.

Page 19 Table 1 – How has the variability on the size of fish tagged from year to year affect the SARs? NOAA-NWFSC has indicated that bypass systems are size selective, possibly leading to differences between groups from year to year if sizes are different year to year.

In addition, what was the final size at release of those fish that were tagged months prior to release? Are they comparable to the later tagged fish? BIOMARK wrote a report on the tag shedding rate of fish that were tagged in the fall. How was tag shedding prior to release figured in to the release numbers and SARs? Also, there could be a differential shed rate between fish tagged in the spring and the fall.

Page 20 Last Paragraph – The description of the new PIT tag detection system at LGR is inaccurate. The detection system is actually near the old trap.

Page 21 In light of the fact that female fish are known to shed their tags upon getting close to or during spawning, how are fish that do not enter the weir accounted for at McCall, Imnaha, etc…? It appears as though a portion of returning adults would be missed during spawning surveys if tags have been shed.

Page 24 If Imnaha and McCall are behaving differently than the other stocks, is it more appropriate to analyze them separately rather than as a part of the geo-means?

Page 31 Because of the change in the morphology as fish as they move upstream, hooking of jaws, loss of weight, etc, measuring at LGR and at the Hatcheries may not be comparable as you change techniques of how and when you measure fish. Chris Peery at ICFWRU may have some info on those fish at size of tagging at Bonneville and at spawning at the hatchery that could be useful if this information is being used for a specific reason.

Page 32 The objectives of the study seem to answer the overall question of system wide, yearlong transport versus the undetected and presumably inriver migrating component. The Corps believes that transport is viable on a seasonal basis and needs to know what to do with fish once they have been collected regardless of spill volumes.

While we understand the purpose of this analysis, the Corps believes that analyses using Lower Granite Equivalents does not answer the question of whether we should transport at a given facility or not and that actual numbers should be used in that determination.

Page 40 Paragraph 1 last line – Please state why over generation and spill were not provided in 2000 and beyond. Flow years are a major player in operations of the dams and survival of fish.

Page 40 Table 9 – On a year by year basis, according to the use of the better estimator SAR $_2(T_0)$ for pre 1997 years, and all for later years, the years where the T is higher than the C is exceeded for 1994-97, and using SAR $_2$ for the other years, 7 of the 9 years had a transport benefit, yet the geometric mean does not indicate the same result. Given the year-to-year variation, is a geometric mean an appropriate measure of what operations at the dams yielded?

Page 41 Paragraph 1 indicates that the largest transport proportion occurred at LMN. This is not reflected in Table 6.

Page 43	This paragraph (3) belongs more in the discussion.
Page 47	Paragraph 2 **-** How does the decreasing proportion of tagged fish representing the run at large factor into the analysis? If those groups no longer represent the population, it is difficult to make conclusions.
Page 51	Table 18 **-** How does the estimate of percent of the run transported from Lower Monumental compare to the numbers that were reported by the SMP? Are they comparable?
Page 57	Figure 6 – Dworshak fish typically seem to be low performers with respect to transport and inriver success. It appears as though they are not the most representative. Is this an indication of a need to look into hatchery practices, or has the natural culling, which occurs after hatchery release, just not been expressed by the time they get to LGR?
Page 62	Last paragraph **-** While the geometric mean for wild Chinook appears to not show a benefit of transportation, Table 11 indicates that on an annual basis, there is a great deal of variability. For example, for those years with complete study results in, 4 of the 8 study years show a benefit to transport. Unfortunately the confidence intervals make the comparisons difficult. Examining the within year seasonality of this data, to better leave fish inriver when they are benefited, and in the barges when they are benefited, may give a more complete picture rather than an annual estimate leading to the wholesale rejection of a management tool.
Page 64	Bullet 6 – Numerous changes to the hydrosystem have been put in place. Changing the PIT outfall location at LGO to a better location in 2000, probably had a lot to do with this. In addition, other changes at facilities including barge loading lines, loading techniques, inadvertent shortening of return pipes to the river, et cetera, are not captured in this document.
Page 71	Idaho CFWRU indicated that there was a difference in upstream migratory success between those fish PIT tagged as juveniles and handled at the Adult fish Facility at Bonneville and those that were not handled in the AFF. Were these fish included or excluded in your analysis? Did they equally handle transported and non-transported fish yielding differential success rates?
Page 79	Paragraph 2 – What constitutes expected adult survival rates upstream from Lower Granite Dam?
Page 84	I have never heard of a loss of strength of PIT tags over time. Has the manufacturer documented this or is this speculation? An additional explanation could include that PIT-tagged fish have the ability to shed tags during their ocean history. Salmonids have shown this ability with radio and acoustic tags in long-term studies.
Page 85	Paragraph 1 – Why are we trying to test a difference of 2.0? Is there biological significance to this or is this a management question. Is it set up in the statistical parameters for testing? If so, please indicate.
Page 87	Paragraph 1 – Please define what is meant by “clean bill of health”. Not being a hatchery person, this is vague to me.
Page 88	This assumption requires that fish migrating downstream past the bird islands are equal in that they each have an equal potential for predation. Has this been demonstrated? Can we look at if fish are detected in the BONN JBS are equally predated as those undetected at BONN or from the transport program?

Page 88	Table 43 title – While tags are detected in guano, it is a result of deposition through the regurgitated mass of boney structures that the birds leave on the colony.
Page 96	Please describe the method for collecting John Day River fish. This has not been established in the report.

Grammatical & Consistency

In General	In 2004, AFS published an article in support of capitalizing Chinook as the common name for the species. I believe this is the proper standard now.
In General	When using the phrase "PIT tagged", if it is used as an adjective, it needs to by hyphenated (e.g. PIT-tagged smolt, PIT-tagged group", however when used as a verb, (e.g. we PIT tagged fish) it should not be hyphenated.
Page 16	Line 2 of paragraph 1, the name of the project is not the same as in the executive summary
Page 23	What file does the IFRO footnote for Table 3 refer to? Where is it accessible?
Page 36	The number s in table 4 for 1994 do not add up.
Page 65	Is this Chapter 2 or Appendix A?
Page 86	Paragraph 2 – Criticism could be more appropriately stated as "assessment"

Other

Page 14	It is curious as to why the Carson stocks have similar to lower SARs than the upriver stocks. Is there a hypothesis for this?

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June 7, 2005
Mr. Paul Ocker
District Support Team
Northwestern Division
U.S. Army Corps of Engineers
P.O. Box 2870
Portland, OR 97208-2870

Dear Mr. Ocker:

Thank you and the staff of the Northwestern Diversion Office of the U.S. Army Corps of Engineers for your thorough review of the 2003 Draft Comparative Survival Study (CSS). We realize this is the Corps of Engineers first interaction with the CSS, so to help you better understand the objective of this study we offer the following description. The CSS study is a joint agencies and tribes study, which is conducted under the auspices of the CSS Oversight Committee. The study design and its implementation are determined by deliberations and agreement among the state, federal and tribal fishery managers. Specific determinations of fish groups used in analyses, analytical tools, and implementation questions are all determined through Committee review, deliberations and agreement. The Committee has and continues to respond to review comments and recommendations from ISAB and ISRP. The CSS is designed to monitor and evaluate SARs by passage route under the passage management conditions prevailing in any particular year. In this way it represents a monitoring evaluation with underlying specific analytical design. The program is intended and designed to continue annually to provide a consistent and continuous database for short-term and long-term management decisions. The tagging program is designed and implemented to address multiple uses. The CSS tag data is utilized by various entities throughout the region, including NOAA fisheries, in their consideration of passage management throughout the basin.

Our specific responses to both your general and specific comments in your submittal entitled "Review of CSS Study – Bulletized List are addressed in the attached document." If you need further clarification of our responses or other aspects of the CSS, please do not hesitate to contact us.

Sincerely,

Michele DeHart

Michele DeHart
Fish Passage Center Manager

Response to COE's Bulletized List of Comments:

Questions are in italics and numbered; answers follow.

Technical & Policy

General Questions:

1. *If we operate according to the new BiOp, it would be useful to compare new operations with the older ones of fish released from the hatcheries and headwaters. Is 2002 the last year of tagging for the CSS or is it continuing?*

The CSS continued through migration years 2003 and 2004 and will be operating through migration 2005 and beyond. It is considered as part of the Agencies and Tribes long-term monitoring of the hydrosystem impacts on salmonid survival.

2. *There was a barge dump in 2001 in front of Ice Harbor Dam due to clogged screens. Were the fish in that barge included or excluded from the transport group?*

These fish were not considered as transported fish. Instead they were assigned as C_1 Category since they were detected at a collector dam and migrated mostly in-river through the hydrosystem.

3. *Although comparisons of wild fish detected at the dams are probably good representations of those tagged fish, the use of various groups tagged at different times of the year, with differing techniques, is quite possibly not representative of the population. Recent discussions with NOAA fisheries personnel, who are tagging wild fish in the headwater streams and monitoring them with in stream PIT detectors, have indicated that a notable proportion of parr are moving out during the middle of winter, when tagging efforts at traps are not possible and crews are not out tagging using shockers. This indicates that a portion of the run is not being PIT tagged, and therefore is possibly not representing the population. I am not sure how to reconcile the situation but would appreciate your thoughts.*

In the CSS report, all available wild Chinook PIT-tagged and released over a 10-month period (July 25 to May 20) for a given migration year were utilized. This should give as good a cross-section of the wild Chinook population as is possible to date. We acknowledge that the aggregate is not proportional to the stock composition, but we believe it provides a reliable representation of the response of wild Chinook to conditions of migrating through the hydrosystem either in transportation or in-river.

4. *In addition, fish tagged in the fall in the headwaters and at traps are different groups than those tagged in the spring at traps. Because I could find no reference to which groups of wild fish were used and why, and what groups of fish were not used and why, it was difficult to determine if the groups of wild fish represented the population or not. Perhaps an appendix table with those groups used would provide clarity.*

A table identifying the release locations for PIT-tagged wild Chinook in each sub-basin has been added to the report as Appendix A.

5. *The upstream and downstream comparisons of stocks may not be appropriate from a physiological standpoint. Jim Congleton's work has indicated that Snake River fish have essentially used up their reserves of energy by the time they reach Lower Granite Dam. The distance that those fish have traveled to LGR may be similar to or greater than those fish originating from the lower rivers to reach the ocean, yielding fish with different energy potential based on the distance traveled alone.*

A systematic decline in life cycle survival rates occurred for Snake River stocks coincident with hydrosystem development and operation, which was greater than declines for similar downriver stocks above fewer dams (Schaller et al. 1999; Deriso et al. 2001). Congleton's physiological studies and observations of energy depletion as hatchery stocks move through the hydrosystem may help explain why the decline in survival rates was relatively greater for Snake River wild stocks. The comment implies that distance is the primary factor influencing decreases in energy reserves, whereas we believe the mechanism is more closely related to time. Physiologically the fish show that it is a lot harder to survive the hydrosystem if your travel time is long. Historical water travel times did not differ greatly between Snake River and John Day, and wild smolts migrated passively to the estuary within a biological window. The systematic change in life cycle survival rates between Snake and John Day stocks coincided with a dramatic change in water travel times (and other hydrosystem impacts), not a change in distance.

6. *It would be useful to see an expansion of discussion of undetected fish. Not only are the facilities not 100% efficient at detecting tags, but there are outages to PIT tag systems due to power failures, coil failures, etc as outlined on the PTAGIS web site.*

The goal of at least 98% efficiency of the PIT-tag detectors at COE dams is normally met based on efficiency test conducted throughout each season, so the potential number of undetected fish is very small. However, we make every effort through the CSS to utilize all information regarding facility operations that might influence how fish passed a project. See page 33 of the report for a description of how this was accomplished under instances of power outages and equipment malfunctions at Lower Granite Dam in 2001.

7. *Page 37 - The text indicates that a large proportion of the wild fish were handled at the JFF. Anesthetized and handled fish, a subsample of the overall population, are not representative of the population of fish being transported in that they may be anesthetized for unknown periods of time, handled differentially during the smolt sampling process, and may be exposed to different disease and temperature regimes within the anesthetic recirculation system, than their counterparts in the*

raceways for the normal barge process. Were these fish included or removed from the barging group for analysis?

All PIT-tagged wild Chinook, whether handled or not, were included in the analysis because of the low numbers available in the transport category.

Specifics

8. *Page 17 Under Bullet 2, the reference to the Mid-Columbia hatchery fish, is unclear. Chinook and Steelhead were tagged beginning in 2002 in large numbers in the mid-Columbia, most likely in sufficient numbers to perform a CSS type analysis. Because of the large tagging component that the Corps performed for an analysis of Transport/Bypass/Undetected study at McNary, the CSS tagging effort was determined to not be necessary. If the intent of that statement is to indicate that an analysis was not funded, then that is a more appropriate statement.*

We understand the confusion regarding the statement of CSS PIT-tagging of Mid-Columbia hatchery steelhead "not funded to date" in the text, and have changed the text to address your concern. However, the CSS has been unsuccessful in securing funding to PIT-tagged hatchery steelhead in the Snake River basin as recommended in the Independent Scientific Advisory Board's review of this study (ISAB Report 98-1, January 6, 1998).

9. *Page 17 Last Paragraph, line 3, it is unclear whether temporal refers to a between year temporal change or within year temporal change. Many of the recent analyses show both.*

Temporal refers to between-year spawner and recruit patterns.

10. *Page 19 Table 1 – How has the variability on the size of fish tagged from year to year affect the SARs? NOAA-NWFSC has indicated that bypass systems are size selective, possibly leading to differences between groups from year to year if sizes are different year to year.*

While the impact of size variability is an interesting concept, existing PIT-tag technology does not allow us to estimate the size of migrating fish at Lower Granite Dam for all study categories, including the undetected category of fish. Without this information, a complete analysis could not be conducted.

11. *Page 19 In addition, what was the final size at release of those fish that were tagged months prior to release? Are they comparable to the later tagged fish? BIOMARK wrote a report on the tag shedding rate of fish that were tagged in the fall. How was tag shedding prior to release figured in to the release numbers and SARs? Also, there could be a differential shed rate between fish tagged in the spring and the fall.*

When fish were recovered during the marking session as raceway or pond mortalities, they are interrogated and the associated PIT tags are removed from the tagging files. After the marking crews complete the PIT tagging, hatchery personnel check for PIT-tag mortalities in the ponds or raceways until the fish are released. Additionally, most hatcheries "sweep" the raceways or ponds throughout the holding period with a magnetic brush that attracts PIT tags, thus allowing shed tags to be identified. Tag loss or shedding has been minimal and accounted for in the files.

12. Page 20 Last Paragraph – The description of the new PIT tag detection system at LGR is inaccurate. The detection system is actually near the old trap.

The COE is mistaken where the **new** detection system for decoding of adult fish is installed at Lower Granite Dam. The detection system is installed in the exit section of the adult ladder. See the FPC's 2002 Adult Fishway Inspection Report for photographs showing this location.

13. Page 21 In light of the fact that female fish are known to shed their tags upon getting close to or during spawning, how are fish that do not enter the weir accounted for at McCall, Imnaha, etc…? It appears as though a portion of returning adults would be missed during spawning surveys if tags have been shed.

At present, we are simply taking known adult fish that have passed the Lower Granite project and assessing numbers of PIT-tagged adult fish that arrive at the hatchery facilities minus the percentage of sport and tribal harvest. Fish that are not accounted for are part of the missing portion of returning adult from the Lower Granite Dam to the hatchery.

14. Page 24 If Imnaha and McCall are behaving differently than the other stocks, is it more appropriate to analyze them separately rather than as a part of the geo-means?

The study design of the CSS allows for the analyses of these groups together or separately. We conduct both, and both have their applications. In this annual report we kept the hatchery spring Chinook and hatchery summer Chinook stocks separate when presenting tables of SARs, T/C, and D estimates. In other tables where the goal was comparing a yearly average over time with the PIT-tagged wild Chinook aggregate, the four hatcheries common across all study years (2 spring Chinook stocks and 2 summer Chinook stocks) were used.

15. Page 31 Because of the change in the morphology as fish as they move upstream, hooking of jaws, loss of weight, etc, measuring at LGR and at the Hatcheries may not be comparable as you change techniques of how and when you measure fish. Chris Peery at ICFWRU may have some info on those fish at size of tagging at Bonneville and at spawning at the hatchery that could be useful if this information is being used for a specific reason.

At present, the CSS is not using adult length data for specific analysis.

16. Page 32 The objectives of the study seem to answer the overall question of system wide, yearlong transport versus the undetected and presumably inriver migrating component. The Corps believes that transport is viable on a seasonal basis and needs to know what to do with fish once they have been collected regardless of spill volumes.

We thank the COE for their suggestion; but the study was not designed to make the management determination of whether or not to transport collected fish. There are many factors that would have to be incorporated into that type of determination such as in-river conditions downstream. The CSS data could certainly contribute to the consideration of that question. The question of seasonality in transportation data was discussed at the CSS Workshop held February 11-13, 2004. As shown in Section 3.6.2 of the Workshop Proceedings (Marmorek et al 2004), there were higher SARs obtained for PIT-tagged yearling Chinook transported from Lower Granite Dam after April 26 than before that date. This timing corresponded to a window of estuary entry between April 30 and June 18 that produced higher SARs than periods outside that date range. With most PIT-tagged wild Chinook released above Lower Granite Dam in years prior to 2002 following the default operation of return-to-river, there have been relatively low numbers of transported PIT-tagged wild Chinook available in 8 of 9 migration years analyzed in the CSS Annual Report. This made it difficult to evaluate the seasonality of transportation as desired by the COE with this dataset.

17. Page 32 While we understand the purpose of this analysis, the Corps believes that analyses using Lower Granite Equivalents does not answer the question of whether we should transport at a given facility or not and that actual numbers should be used in that determination.

The CSS does report site-specific transportation SARs (Tables 7 and 19) for the use in computing the $SAR_1(T_0)$. However, since the proportion transported from each successive dam tends to be lower than the dam just upstream, there will always be difficulty in getting a large enough number of PIT-tagged smolts into transportation at Lower Monumental Dam for obtaining a site-specific transport SAR there with much precision.

18. Page 40 Paragraph 1 last line – Please state why over generation and spill were not provided in 2000 and beyond. Flow years are a major player in operations of the dams and survival of fish.

Since 2001, over-generation spill has been more limited due to lower runoff volume in those years. This sentence has been added to the main text.

19. Page 40 Table 9 – On a year by year basis, according to the use of the better estimator SAR $_2(T_0)$ *for pre 1997 years, and all for later years, the years* *where the T is higher than the C is exceeded for 1994-97, and using SAR $_2$ for the other years, 7 of the 9 years had a transport benefit, yet the geometric mean does not indicate the same result. Given the year-to-year variation, is a geometric mean an appropriate measure of what operations at the dams yielded?*

In Table 9 an 8-yr arithmetic mean (not geometric mean) of SARs for migration years 1994 to 2002, omitting 2001, is shown. Comparing the transport SAR [either $SAR_1(T_0)$ or $SAR_2(T_0)$] to the bypass $SAR(C_1)$ shows 7 of the 9 years with a higher SAR for the transported fish and comparing the transport SAR to the undetected $SAR(C_0)$ shows 4 of the 8 years with a higher SARs for the transported fish. Showing an average across the above years does not diminish the importance of looking at the year-to-year variability and trends in the data, which are topics we also address in the report.

20. Page 41 Paragraph 1 indicates that the largest transport proportion occurred at LMN. This is not reflected in Table 6.

The annual report should say the largest transport proportion at Lower Monumental Dam occurred in 2002, being 25% of that year's total transport from Snake River dams instead of an average of 13% as seen since 1994. The report text has been corrected.

21. Page 43 This paragraph (3) belongs more in the discussion.

Throughout the report, discussions have been incorporated throughout the results section since there is no formal discussion section to the report. The section titles have been changed from "Results" to "Results and Discussion."

22. Page 47 Paragraph 2 - How does the decreasing proportion of tagged fish representing the run at large factor into the analysis? If those groups no longer represent the population, it is difficult to make conclusions.

If the goal of the CSS was to create a hatchery Chinook aggregate, as the COE did in their McNary Dam transportation study with Mid-Columbia smolts, then we would have needed to have PIT-tag an equal proportion of production at each hatchery. Early in development of the CSS, it was decided that hatchery-specific SARs would be more useful to both the CSS goals and hatchery management goals.

23. Page 51 Table 18 - How does the estimate of percent of the run transported from Lower Monumental compare to the numbers that were reported by the SMP? Are they comparable?

The data produced by the SMP is used to calculate the percent of collected run-at-large Chinook (hatchery and wild separately) at Lower Monumental Dam transported. This information is used in the expansion of the actual number of PIT-tagged fish transported from Lower Monumental Dam to what would have been transported if the PIT-tagged fish had also been transported at the same rate as the run-at-large fish. This same approach is used at Lower Granite and Little Goose dams.

24. Page 57 Figure 6 – Dworshak fish typically seem to be low performers with respect to transport and inriver success. It appears as though they are not the most representative. Is this an indication of a need to look into hatchery practices, or has the natural culling, which occurs after hatchery release, just not been expressed by the time they get to LGR?

Dworshak Hatchery Chinook in most years have the lowest in-river and transport success of the hatcheries currently used in the CSS program. Whether this might be a cause of natural culling or hatchery practices or genetics of the fish is unknown at this time.

25. *Page 62 Last paragraph - While the geometric mean for wild Chinook appears to not show a benefit of transportation, Table 11 indicates that on an annual basis, there is a great deal of variability. For example, for those years with complete study results in, 4 of the 8 study years show a benefit to transport. Unfortunately the confidence intervals make the comparisons difficult. Examining the within year seasonality of this data, to better leave fish inriver when they are benefited, and in the barges when they are benefited, may give a more complete picture rather than an annual estimate leading to the wholesale rejection of a management tool.*

The COE comments are valid, but so is the CSS statement that transportation is unlikely to recover the listed wild Chinook.

26. *Page 64 Bullet 6 – Numerous changes to the hydrosystem have been put in place. Changing the PIT outfall location at LGO to a better location in 2000, probably had a lot to do with this. In addition, other changes at facilities including barge loading lines, loading techniques, inadvertent shortening of return pipes to the river, et cetera, are not captured in this document.*

The study is not designed to measure the survival improvements resulting from any one specific change in the hydrosystem or at a facility. In addition, the facility improvements to which the COE refers were made over the past four years. The returning CSS fish have spent up to three years in the ocean and would have migrated through the hydrosystem as juveniles, prior to most of the modifications having been made. In time, improvements in survival may be linked to changes in the management strategy and hydrosystem improvements, but it unlikely that increases in survival will be attributable to any specific facility improvements.

27. Page 71 Idaho CFWRU indicated that there was a difference in upstream migratory success between those fish PIT tagged as juveniles and handled at the

Adult fish Facility at Bonneville and those that were not handled in the AFF. Were these fish included or excluded in your analysis? Did they equally handle transported and non-transported fish yielding differential success rates?

The CSS did not exclude any returning PIT-tagged adult Chinook based on detection at the B2A site coils located on the route to the adult trap on the Washington ladder. Overall, the percentage of PIT-tagged wild Chinook adults detected in Lower Granite Dam ladder with a prior detection at the Bonneville Dam adult trap B2A was well under 20% in all years except 1999 when it rose to 25% for transported smolts and 33% for inriver smolts. Fish actually handled at the trap by Idaho CFWRU and other researchers would be less than those detected. Since researchers were not targeting CSS hatchery fish the numbers incidentally handled should be lower than that of the PIT-tagged wild Chinook.

28. Page 79 Paragraph 2 – What constitutes expected adult survival rates upstream from Lower Granite Dam?

In most cases, the estimated survival rates to the hatcheries were certainly far lower than what we anticipated and may be attributable to the following as stated in the report: "...unaccounted adults spawning below weirs and trapping sites, adults overshooting the trapping sites during periods when weirs are not installed, straying into other streams, missed detections of PIT tagged adults or shed tags at the hatchery, under-reporting of harvest, delayed mortality from hooking and handling these fish in fisheries, and higher than expected natural mortality of adults after passing upstream through the hydrosystem." In the annual report, the text "lower than expected" has been changed to simply the word "lower."

29. *Page 84 I have never heard of a loss of strength of PIT tags over time. Has the manufacturer documented this or is this speculation? An additional explanation could include that PIT-tagged fish have the ability to shed tags during their ocean history. Salmonids have shown this ability with radio and acoustic tags in long-term studies.*

This statement appears to be speculation and has been eliminated from the report, as we have no solid evidence that the strength of the tag is reduced over time.

30. Page 85 Paragraph 1 – Why are we trying to test a difference of 2.0? Is there biological significance to this or is this a management question. Is it set up in the statistical parameters for testing? If so, please indicate.

Previous spawner-recruit analyses (Schaller et al. 1999; Deriso et al. 2001) demonstrated that Snake River spring/summer Chinook showed a systematic decrease in life-cycle survival rates, about 3-4 fold greater than similar lower river stocks, following completion of the hydrosystem. CSS wanted to ensure that we could detect at least a two-fold difference in SARs, to determine whether the observed difference in life-cycle survival between these stock groups was occurring in the smolt-to-adult life stage.

31. Page 87 Paragraph 1 – Please define what is meant by "clean bill of health". Not being a hatchery person, this is vague to me.

The terminology has been corrected in the report. The State and Federal hatcheries have developed health requirements or fish health standards that must be met prior to fish being released from a hatchery facility. The spring Chinook at Carson NFH met the health standards through the 1997-2002 time frame.

32. Page 88 This assumption requires that fish migrating downstream past the bird islands are equal in that they each have an equal potential for predation. Has this been demonstrated? Can we look at if fish are detected in the BONN JBS are equally predated as those undetected at BONN or from the transport program?

The validity of this assumption may not be testable. If fish detected at Bonneville and those undetected there have equal susceptibility to avian predation as the assumption requires, then the proportion of the in-river migrants in Bonneville Dam forebay detected at the dam should equal the proportion of in-river migrants detected on the bird colonies with a prior detection at Bonneville Dam. This is what the COE recommends testing, but the problem is how to estimate the number of undetected fish at Bonneville Dam, which requires estimating collection efficiency there, without relying on this assumption as being valid. There are too few recoveries at the trawl for the Carson Hatchery Chinook and John Day River wild Chinook to use it as the final recovery site in an independent estimation of collection efficiency at Bonneville Dam. The COE mentions looking at the transported fish also, but that would not be appropriate for addressing the question of equal predation rates on in-river migrants regardless of prior passage history at Bonneville Dam.

33. Page 88 Table 43 title – While tags are detected in guano, it is a result of deposition through the regurgitated mass of boney structures that the birds leave on the colony.

We will drop the word "guano" in the report caption so that it now states "…plus additional detections from PIT tags deposited by birds on the colonies of East Sand and Rice islands …"

34. Page 96 Please describe the method for collecting John Day River fish. This has not been established in the report.

The methods for collecting and PIT-tagging the John Day River spring Chinook are detailed on pages 25 to 31 of BPA Report DOE/BP-00000498-2 by Carmichael, Richard, Glenda Clair, Jason Seals, Sam Onjukka, James Ruzycki, and Wayne

Wilson, titled “Fish Research Project Oregon,” Project No. 1998-01600, 63 electronic pages. This reference has been added to the annual report.

Grammatical & Consistency

35. In 2004, AFS published an article in support of capitalizing Chinook as the common name for the species. I believe this is the proper standard now.

As recommended by the COE, we capitalized all references to Chinook in the report.

36. When using the phrase “PIT tagged”, if it is used as an adjective, it needs to be hyphenated (e.g. PIT-tagged smolt, PIT-tagged group”, however when used as a verb, (e.g. we PIT tagged fish) it should not be hyphenated.

Although the COE recommended that we hyphenate “PIT-tagged” when used as a compound adjective, we did not make this change in the report. We decided it was more clear not to make this global change at this time because there would be a danger of inappropriately hyphenating even when the work “tagged” is being used as a verb.

37. Line 2 of paragraph 1, the name of the project is not the same as in the executive summary.

We will use “Comparative Survival Study (CSS)” as the proper project name throughout the report and standardize the name in the acknowledgement section to be the same by dropping the word “Rate.”

38. What file does the IFRO footnote for Table 3 refer to? Where is it accessible?

The IFRO reference is a spreadsheet that contains production information including the ladder operation presented in Table 3. It is accessible from the Dworshak Hatchery manager.

39. The numbers in table 4 for 1994 do not add up.

In Table 4 for 1994, the correct number migrating outside of expected migration year should be 60 instead of 90. This correction has been made in the report.

40. Is this Chapter 2 or Appendix A?

The reference was to Appendix A of Chapter 2. In the final report, this appendix becomes Appendix B and is located at the end of the document.

41. Paragraph 2 – Criticism could be more appropriately stated as “assessment”

The word “criticism” was changed to “assessment” as recommended by the COE.

Other

42. Page 14 It is curious as to why the Carson stocks have similar to lower SARs than the upriver stocks. Is there a hypothesis for this?

With regard to post-Bonneville Dam SARs, the upstream stocks have had the opportunity to express a larger post-hatchery release mortality prior to arriving at Bonneville Dam as smolts than has the spring Chinook from Carson Hatchery. Post-hatchery release mortality may still be affecting the Carson Hatchery Chinook after passing Bonneville Dam due to the closeness of this hatchery to that hydro-project.

43. Page 40 Steve Achord's 2002-2003 report for BPA also indicated a lower tributary to LGR survival rate in 2003. This was not believed to be due to any external environmental factors other than high densities of juvenile fish in the headwater streams. It will be interesting to look at the 2003 estimates of returns.

The COE notes that SARs for the 2003 migrants will be interesting when available. The next CSS annual report will have preliminary SARs estimates for that migration year based on completion of the 2-salt returns in 2005.

Citations

Deriso, R.B., D.R. Marmorek and I.J. Parnell. 2001. Retrospective patterns of differential mortality and common year-effects experienced by spring and summer Chinook (*Oncorhynchus tshawytscha*) of the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 58:2419-2430.

Marmorek, D.R., M. Porter, I.J. Parnell and C. Peters, eds. 2004. Comparative Survival Study Workshop, February 11-13, 2004, Bonneville Hot Springs Resort. Report compiled and edited by ESSA Technologies Ltd., Vancouver, B.C. for Fish Passage Center, Portland, OR and the US Fish and Wildlife Service, Vancouver, WA. 137 pp.

Schaller, H.A., C.E. Petrosky and O.P. Langness. 1999. Contrasting patterns of productivity and survival rates for stream-type Chinook salmon (*Oncorhynchus tschawystcha*) of the Snake and Columbia Rivers. Canadian Journal of Fisheries and Aquatic Sciences 56:1031-1045.