SURVIVAL ESTIMATES FOR THE PASSAGE OF SPRING-MIGRATING JUVENILE SALMONIDS THROUGH SNAKE AND COLUMBIA RIVER DAMS AND RESERVOIRS, 2002

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EXECUTIVE SUMMARY

In 2002, the National Marine Fisheries Service and the University of Washington completed the tenth year of a study to estimate survival and travel time of juvenile salmonids (*Oncorhynchus* spp.) passing through dams and reservoirs on the Snake and Columbia Rivers. All estimates were derived from detections of fish tagged with passive integrated transponder tags (PIT tags). We PIT tagged and released a total of 19,891 hatchery steelhead at Lower Granite Dam. In addition, we utilized fish PIT tagged by other agencies at traps and hatcheries upstream from the hydropower system and sites within the hydropower system. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams and in the PIT-tag detector trawl operated in the Columbia River estuary. Survival estimates were calculated using a statistical model for tag-recapture data from single release groups (the "Single-Release Model").

Primary research objectives in 2002 were to 1) estimate reach and project survival and travel time in the Snake and Columbia Rivers throughout the migration period of yearling chinook salmon *O. tshawytscha* and steelhead *O. mykiss*; 2) evaluate relationships between survival estimates and migration conditions; and 3) evaluate the survival-estimation models under prevailing conditions.

This report provides reach survival and travel time estimates for 2002 for PIT-tagged yearling chinook salmon (hatchery and wild), hatchery sockeye salmon *O. nerka*, hatchery coho salmon *O. kisutch*, and steelhead (hatchery and wild) in the Snake and Columbia Rivers. Results are reported primarily in the form of tables and figures; details on methodology and statistical models used are provided in previous reports cited here. Results for summer-migrating chinook salmon will be reported separately.

Survival and detection probabilities were estimated precisely for most of the 2002 yearling chinook salmon and steelhead migrations. Hatchery and wild fish were combined in some of the analyses. For yearling chinook salmon tagged above Lower Granite Dam and subsequently recombined into daily "release" groups at the dam, 94% were hatchery-reared and 6% were wild. For steelhead, the percentages were 93% hatchery-reared and 7% wild.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.949 for yearling chinook salmon and 0.882 for steelhead. Respective average survival estimates for yearling chinook salmon and steelhead were 0.980 and 0.882 from Little Goose Dam tailrace to Lower Monumental Dam tailrace; 0.837 and 0.652 from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam); 0.907 and 0.844 from McNary Dam

tailrace to John Day Dam tailrace; and 0.840 and 0.612 from John Day Dam tailrace to Bonneville Dam tailrace (including passage through The Dalles Dam).

Combining average estimates from the Snake River smolt trap to Lower Granite Dam, from Lower Granite Dam to McNary Dam, and from McNary Dam to Bonneville Dam, estimated annual average survival through the entire hydropower system from the head of Lower Granite reservoir to the tailrace of Bonneville Dam (eight projects) was 0.551 (s.e. 0.057) for Snake River yearling chinook salmon and 0.234 (s.e. 0.045) for Snake River steelhead.

For yearling spring chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace was 0.573 (s.e. 0.005) for fish released from Leavenworth Hatchery, 0.533 (s.e. 0.009) for fish released from Entiat Hatchery, and 0.505 (s.e. 0.021) for those from Winthrop Hatchery.

Because of the relatively cool spring, flow volume during the 2002 yearling chinook salmon migration period was only slightly higher than in 2001, which was the lowest recorded during the ten years of this study. The steelhead migration occurs later in the spring; flow volume for steelhead in 2002 was substantially higher than in 2001. For both species, springtime spill levels were much higher than in 2001, more similar to past years. Juvenile survival in 2002 for both species was much greater than in 2001 through most reaches and through the entire hydrosystem, but remained depressed compared to other recent years for steelhead through some reaches and the entire hydropower system. PIT-tag detections on avian bird colonies in those reaches accounted for much of the loss.

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INTRODUCTION

For juvenile chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), and steelhead (*O. mykiss*) that migrate through reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia Rivers, survival estimates are essential to develop effective strategies for recovering depressed stocks. Many present management strategies were based on estimates of system survival (Raymond 1979; Sims and Ossiander 1981) derived in a river system considerably different from today's (Williams and Matthews 1995; Williams et al. 2001). Knowledge of the magnitude, locations, and causes of smolt mortality under present passage conditions, and under conditions projected for the future, are necessary to develop strategies that will optimize smolt survival during migration.

From 1993 through 2001, the National Marine Fisheries Service (NMFS) and the University of Washington (UW) demonstrated the feasibility of using three statistical models to estimate survival of PIT-tagged (Prentice et al. 1990a) juvenile salmonids passing through Snake River dams and reservoirs (Iwamoto et al. 1994; Muir et al. 1995, 1996, 2001a; Smith et al. 1998, 2000a,b; Hockersmith et al. 1999; Zabel et al. 2001, 2002). Evaluation of assumptions for these models indicated that all were generally satisfied, and accurate and precise survival estimates were obtained.

In 2002, NMFS and UW completed the tenth year of the study. Flow levels during the early portion of the 2002 spring migration were only slightly higher than in the drought conditions during 2001. However, spill levels in 2002 were much higher than in 2001 and similar to other recent years. Research objectives were to: 1) estimate reach and project survival and travel time in the Snake and Columbia Rivers throughout the yearling chinook salmon and steelhead migrations; 2) evaluate relationships between survival estimates and migration conditions; and 3) evaluate the performance of the survival-estimation models under prevailing operational and environmental conditions. Additionally, as adult return information becomes available, as part of this study we will evaluate relationships between juvenile survival and subsequent adult returns for fish with different juvenile migration histories.

METHODS

Experimental Design

The Single-Release (SR) Model was used to estimate survival for groups of PIT-tagged yearling chinook salmon, sockeye salmon, and steelhead released from Snake River Basin hatcheries and traps, Upper Columbia River hatcheries, and from Lower Granite Dam in 2002 (Cormack 1964; Jolly 1965; Seber 1965; Skalski 1998; Skalski et al. 1998; Muir et al. 2001a,b). Iwamoto et al. (1994) presented background information and underlying statistical theory.

During the 2002 migration season, automatic PIT-tag detectors (Prentice et al. 1990a,b,c) were operational in the juvenile bypass systems at Lower Granite (RKm 695), Little Goose (RKm 635), Lower Monumental (RKm 589), McNary (RKm 470), John Day (RKm 347), and Bonneville (RKm 234) Dams (Fig. 1). The most downstream site for PIT-tag detections was in the Columbia River estuary between RKm 65 and 84, where a pair trawl towed a PIT-tag detector (Ledgerwood et al. 2000). Lower Monumental Dam was operated in full-bypass mode (wherein all fish guided away from turbines are routed directly to the tailrace of the dam without passing PIT-tag monitors) from the beginning of the migration season until 30 April, so there were no detections during that period.

A large proportion of PIT-tagged yearling chinook salmon released above Lower Granite Dam were released for a multi-agency comparative survival study (CSS) in 2002. Of CSS fish detected at Lower Granite Dam in 2002, about two-thirds were collected and transported, and a little more than half of those detected at Little Goose Dam were transported. Similarly, both wild yearling chinook salmon and wild steelhead were PIT-tagged at Lower Granite Dam for transportation studies and about three-fourths of those detected at Little Goose and Lower Monumental Dams were collected and transported. All other PIT-tagged fish detected at dams were diverted back to the river by slide gates, which allowed for the possibility of detection of a particular fish at more than one downstream site (Marsh et al. 1999).

For fish released in the Snake River Basin, we used the records of downstream PIT-tag detections in the SR Model to estimate survival from the point of release to Lower Granite Dam tailrace, from Lower Granite Dam tailrace to Little Goose Dam tailrace, from Little Goose Dam tailrace to Lower Monumental Dam tailrace, from Lower Monumental Dam tailrace to McNary Dam tailrace, from McNary Dam tailrace to John Day Dam tailrace, and from John Day Dam tailrace to Bonneville Dam tailrace. For fish released in the Upper Columbia River, we estimated survival from the point of release to the tailrace of McNary Dam, from McNary Dam tailrace to John Day Dam tailrace, and from John Day Dam tailrace to Bonneville Dam tailrace.

Lower Granite Dam Tailrace Release Groups

During 2002, hatchery steelhead were collected at the Lower Granite Dam juvenile facility, PIT tagged, and released in approximate proportion to their arrival at Lower Granite Dam throughout the migration season. No yearling chinook salmon or wild steelhead were PIT tagged specifically for this study because the numbers of fish PIT tagged and released from Snake River Basin hatcheries, traps, and at Lower Granite Dam for other studies were sufficient for analysis.

For both yearling chinook salmon and steelhead tagged above Lower Granite Dam and subsequently detected at Lower Granite Dam and released to the tailrace, we created daily "release groups" by combining detections at Lower Granite Dam that occurred on the same day. For steelhead, these groups were then combined with hatchery fish tagged and released each day at Lower Granite Dam. These daily release groups were then pooled into weekly groups, and we estimated survival probabilities in the reaches between Lower Granite Dam tailrace and McNary Dam tailrace for both the daily and weekly groups.

McNary Dam Tailrace Release Groups

For both yearling chinook salmon and steelhead tagged at all locations in the Snake River Basin, and for fish tagged in the Upper Columbia River, we created daily "release groups" of fish according to the day of detection at McNary Dam. Daily groups consisted of fish that were detected and returned to the tailrace, and daily groups were pooled into weekly groups. For weekly groups leaving McNary Dam, we estimated survival from McNary Dam tailrace to John Day Dam tailrace and from John Day Dam tailrace to Bonneville Dam tailrace.

Hatchery and Trap Release Groups

In 2002, most hatcheries in the Snake River Basin released PIT-tagged fish as part of research separate from the NMFS/UW survival study. We analyzed data from hatchery releases of PIT-tagged yearling chinook salmon, sockeye salmon, and steelhead to provide estimates of survival and detection probabilities from release to the tailrace of Lower Granite Dam and to points downstream. We also estimated survival from release to the tailrace of McNary Dam for yearling spring chinook salmon released from Winthrop, Entiat, and Leavenworth Hatcheries in the Upper Columbia River Basin. In the course of characterizing the various hatchery releases, preliminary analyses were performed to determine whether data from multiple release groups could be pooled to increase sample sizes. We neither intended nor attempted to analyze the experiments for which the hatchery groups were released.

We also estimated survival for releases of wild and hatchery PIT-tagged yearling chinook salmon and steelhead from the Salmon (White Bird), Snake, Imnaha, Pahsimeroi, South Fork Salmon, Sawtooth, Crooked Fork Creek, and Clearwater River smolt traps, and for sockeye salmon from the Redfish Lake Creek trap to Lower Granite Dam tailrace and points downstream.

Data Analysis

Tagging and detection data were uploaded to and later retrieved from the PIT Tag Information System (PTAGIS), a regional database maintained by the Pacific States Marine Fisheries Commission (PSMFC 1996). Data were examined for erroneous records, inconsistencies, and data anomalies. Records were eliminated where appropriate, and all eliminated PIT-tag codes were recorded with the reasons for their elimination. For each remaining PIT-tag code, we constructed a record ("detection history") indicating at which sites the tagged fish was detected and at which it was not detected. Methods for data retrieval, database quality assurance/control, and construction of capture histories were the same as those used in past years (Iwamoto et al. 1994; Muir et al. 1995, 1996; Smith et al. 1998, 2000a,b; Hockersmith et al. 1999; Zabel et al. 2001, 2002).

These analyses were conducted with currently available data. It is possible, for a variety of reasons, that the data in the PTAGIS database may be updated. Thus, estimates provided by NMFS or employed in analyses in the future may differ slightly from those presented here.

Tests of Assumptions

As in past years, we evaluated assumptions of the SR Model as applied to the data generated from PIT-tagged juvenile salmonids in the Snake and Columbia Rivers (Burnham et al. 1987).

Survival Estimation

Estimates of survival probabilities under the SR Model are random variables, subject to sampling variability. When true survival probabilities are close to 1.0 and/or when sampling variability is high, it is possible for estimates of survival probabilities to exceed 1.0. For practical purposes, estimates should be considered equal to 1.0 in these cases.

When estimates for a particular river section or passage route were available from more than one release group, the estimates were often combined using a weighted average (Muir et al. 2001a). Weights were inversely proportional to the respective estimated relative variance (coefficient of variation squared). The variance of an estimated survival probability from the SR Model is a function of the estimate itself. Consequently, lower survival estimates tend to have smaller estimated variance. Therefore, we do not use the inverse estimated absolute variance in weighting because lower survival estimates have disproportionate influence, and the resulting weighted mean is biased toward the lower survival estimates.

All survival estimates presented are from point of release (or the tailrace of a dam) to the tailrace of a dam downstream. All survival and detection probability estimates were computed using the statistical computer program SURPH ("Survival with Proportional Hazards") for analyzing release-recapture data, developed at the University of Washington (Skalski et al. 1993; Smith et al. 1994).

Survival Estimates from Point of Release to Bonneville Dam

We estimated survival from point of release to the tailrace of Bonneville Dam (the last dam encountered by seaward-migrating juvenile salmonids) for various stocks from both the Snake and Upper Columbia Rivers. These estimates were obtained by first estimating weighted average estimated survival over shorter reaches for daily or weekly release groups using the same weighting scheme described above. These average survival estimates were then multiplied to compute the estimated survival probability through the entire reach.

We pooled similar fish from different release sites when we re-formed release groups at downstream sites. For example, for Snake River yearling chinook salmon and steelhead, we multiplied the weighted mean survival estimate for daily groups from Lower Granite Dam tailrace to McNary Dam tailrace by the weighted mean estimate for weekly groups from McNary Dam tailrace to Bonneville Dam tailrace to obtain an overall estimated mean survival probability from Lower Granite Dam tailrace to Bonneville Dam tailrace. Finally, we multiplied this result by the survival estimate from fish released from the Snake River trap to Lower Granite Dam to compute estimated survival from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam; essentially the entire eight-project hydropower system negotiated by juvenile salmonids from the Snake River Basin.

Travel Time and Migration Rate

Travel times were calculated for yearling chinook salmon and steelhead from 1) Lower Granite Dam to Little Goose Dam (60 km), 2) Little Goose Dam to Lower Monumental Dam (46 km), 3) Lower Monumental Dam to McNary Dam (199 km),

4) Lower Granite Dam to McNary Dam (225 km), 5) Lower Granite Dam to Bonneville Dam (461 km), 6) McNary Dam to John Day Dam (123 km), 7) John Day Dam to Bonneville Dam (113 km), and 8) McNary Dam to Bonneville Dam (236 km). Travel time between any two dams was calculated for each fish detected at both dams as the number of days between last detection at the upstream dam (generally at a PIT-tag detector close enough to the outfall site that fish arrived in the tailrace within minutes after detection) and first detection at the downstream dam. Travel time included the time required to move through the reservoir to the forebay of the downstream dam and any delay associated with residence in the forebay, gatewells, or collection channel prior to detection in the juvenile bypass system.

Migration rate through a river section was calculated as the length of the section (km) divided by the travel time (days) (which included any delay at dams as noted above). For each group, the 20th percentile, median, and 80th percentile travel times and migration rates were determined.

The true complete set of travel times for a release group includes travel times of both detected and nondetected fish. However, using PIT tags, travel times cannot be determined for a fish that traverses a river section but is not detected at both ends of the section. Travel time statistics are computed only from travel times for detected fish, which represent a sample of the complete set. Nondetected fish pass dams via turbines and spill; thus, their time to pass a dam is typically minutes to hours shorter than detected fish passing to the tailrace via the juvenile bypass system.

Comparison of Annual Survival Estimates

We made two comparisons of 2002 results to those obtained in previous years of the NMFS/UW survival study. First, we related survival estimates from specific hatcheries to Lower Granite Dam to migration distance. Second, we compared season-wide survival estimates for specific reaches across years.

Flow and Spill In Relation to Juvenile Salmonid Survival

Annual travel time and reach survival estimates were compared across years to investigate relationships with general flow and spill conditions during the spring migration.

Low flows and river management decisions in 2001 led to unique migration conditions. In our report for 2001 activities, we included an analysis of survival between McNary and John Day Dams in relation to spill conditions at John Day Dam for a variety of stocks. We noted that the temporal pattern in survival estimates observed in 2001 for

some stocks was not unlike some other years that had differing spill patterns, suggesting that the unique spill conditions in 2001 were not the only cause of the pattern in survival.

To determine whether the temporal pattern in survival estimates occurred again in 2002, we estimated survival probabilities between McNary Dam and John Day Dam for weekly groups of various stocks, comparable to our 2001 survival analysis. For this purpose, the study reach was McNary Dam to John Day Dam. (Detection data were not sufficient to include survival analyses in the John Day Dam to Bonneville Dam reach).

We analyzed each stock of yearling chinook salmon and steelhead that migrated through the study reach with substantial numbers of PIT-tagged individuals. The stocks analyzed were: 1) Snake River spring/summer chinook salmon (hatchery and wild combined); 2) Yakima River spring chinook salmon (hatchery and wild combined); 3) Upper Columbia River spring chinook salmon from the Leavenworth, Entiat, and Winthrop Hatcheries; 4) Upper Columbia River summer/fall chinook salmon raised to yearling stage at Turtle Rock Hatchery; and 5) Snake River steelhead (hatchery and wild combined). For each stock, we created weekly release groups according to the time of passage at McNary Dam. Fish that passed McNary Dam between 17 May and 6 June 2002 subsequently passed John Day Dam under spill conditions. We estimated the survival probability and corresponding standard error for each weekly group.

RESULTS

Lower Granite Dam Tagging and Release Information

During 2002, a total of 32,258 yearling chinook salmon (30,370 hatchery origin, 1,804 wild) that were PIT tagged and released upstream from Lower Granite Dam were detected at the dam and returned to the river. Steelhead we tagged at Lower Granite Dam and released to the tailrace were combined with those that were released upstream, detected at the dam, and returned to the river, for a total of 24,882 (22,770 hatchery origin, 1,680 wild).

For both species, not all detections were included in the analyses because some fish passed Lower Granite Dam early or late in the season, when sample sizes were too small to produce reliable survival or travel time estimates. Survival estimates for wild and hatchery fish combined were predominately based on fish of hatchery origin for yearling chinook salmon (94% hatchery) and steelhead (93% hatchery) during 2002.

Survival Estimation

Tests of Assumptions

Assumption tests for 2002 indicated no major assumption violations (Appendix). However, wild yearling chinook salmon and steelhead tagged at Lower Granite Dam for transportation evaluation were omitted from the final analysis because inconsistent sampling at Lower Monumental Dam resulted in biased estimates of annual average survival. Lower Monumental Dam was operated in full-bypass mode for the first few weeks of the migration season, so there was no PIT- tag detection during that period.

Once PIT-tag detection began at Lower Monumental Dam, the transportation study protocol called for transportation of 80% of fish detected at Lower Monumental Dam. Thus, early groups had very few fish detected at Lower Monumental Dam and relatively large numbers detected at McNary Dam. Just the opposite occurred for later groups, which had relatively high detection rates at Lower Monumental Dam, and because many were transported, few detections at McNary Dam. Resulting differences in the relative precision of reach-by-reach survival estimates caused bias in the annual averages.

Snake River Yearling Chinook Salmon

Survival probabilities were estimated for weekly groups of yearling chinook salmon released to the tailrace of Lower Granite Dam for 11 consecutive weeks from 30 March through 14 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.949 (s.e. 0.006; Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.980 (s.e. 0.008). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.837 (s.e. 0.013). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.757 (s.e. 0.009).

We estimated survival probabilities for weekly groups of yearling chinook salmon released in the tailrace at McNary Dam for six consecutive weeks from 20 April through 31 May. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.907 (s.e. 0.014; Table 2). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 0.840 (s.e. 0.079). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.763 (s.e. 0.079).

The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.578 (s.e. 0.060). Estimated survival probability through Lower Granite Reservoir and Dam (i.e., Snake River wild

and hatchery chinook salmon released from the Snake River trap; Table 25) was 0.953 (0.022). Thus, estimated survival probability through all eight hydrosystem projects encountered by Snake River yearling chinook salmon was 0.551 (0.057).

We also calculated separate survival probability estimates for weekly groups of hatchery and wild yearling chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace (Tables 3-4). Weighted mean survival estimates for wild yearling chinook salmon were higher than for hatchery fish through most reaches in 2002.

Estimated survival probabilities for daily Lower Granite Dam release groups of yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace of Lower Granite Dam did not show any consistent increase or decrease through the migration season during 2002 (Table 5, Fig. 2).

Estimates of detection probability at Snake River dams for the weekly groups varied throughout the season, primarily because of varying levels of spill (Tables 6-9).

Snake River Steelhead

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of Lower Granite Dam for 10 consecutive weeks from 6 April through 14 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.882 (s.e. 0.011; Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.882 (s.e. 0.018). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.652 (s.e. 0.031). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, there was a general downward trend through time in estimated survival, with a seasonal average of 0.536 (s.e. 0.025).

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of McNary Dam for seven consecutive weeks from 20 April through 7 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.844 (s.e. 0.063; Table 11). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 0.612 (s.e. 0.098). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.488 (s.e. 0.090).

The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall average survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.262 (s.e. 0.050). The estimated survival through Lower Granite Reservoir and Dam (i.e., Snake River wild and hatchery steelhead released from the Snake River trap; Table 25) was 0.895 (0.015). Thus, the estimated survival probability through all eight of the hydrosystem projects encountered by Snake River steelhead was 0.234 (0.045).

Survival probabilities were estimated separately for weekly groups of hatchery and wild steelhead from Lower Granite Dam tailrace to McNary Dam tailrace (Tables 12-13). Survival estimates for wild steelhead were higher than for hatchery fish through most reaches.

Estimated survival probabilities from Lower Monumental to McNary Dam (and hence for the overall reach from Lower Granite Dam to McNary Dam) for daily release groups of steelhead (hatchery and wild combined) detected and released, or PIT tagged and released to the tailrace of Lower Granite Dam tended to decrease as the season progressed (Table 14, Fig. 3). Detection probability estimates for the daily and weekly groups varied throughout the season, primarily because of varying levels of spill (Tables 15-18).

Snake River Hatchery Release Groups

Estimated survival probabilities of PIT-tagged hatchery yearling chinook salmon, sockeye salmon, and steelhead from release at Snake River Basin hatcheries to the tailrace of Lower Granite Dam and downstream dams varied among hatcheries (Tables 19-21), as did estimated detection probabilities at the detection sites (Tables 22-24). Estimates of survival for PIT-tagged coho salmon through the Snake River were made for the first time during 2002 (Table 21). Because of small sample sizes of PIT-tagged coho and sockeye salmon released, standard errors for the estimated survival probabilities were quite high, and thus, the results were not very informative.

Snake River Smolt Trap Release Groups

Survival probability estimates for juvenile salmonids PIT tagged and released from Snake River Basin smolt traps were generally inversely related to distance of the traps to Lower Granite Dam (Table 25). Estimated detection probabilities were similar among release groups of the same species from different traps (Table 26).

Upper Columbia River Hatchery Release Groups

Survival probabilities of PIT-tagged hatchery yearling chinook salmon from release at Upper Columbia River hatcheries to the tailrace of McNary Dam varied among hatcheries, with survival decreasing with increasing distance upstream (Table 27). The reverse occurred between McNary and John Day Dam tailraces, with survival highest for the farthest hatchery upstream. Detection probabilities at downstream dams were similar for yearling chinook salmon from all three hatcheries (Table 28).

Travel Time and Migration Rate

Travel time estimates for yearling chinook salmon and juvenile steelhead released in the tailraces of Lower Granite and McNary Dams varied throughout the season (Tables 29-36, Fig. 4). For both species, migration rates were generally highest in the lower river sections. Migration rates generally increased over time as flow and water temperature increased, and, presumably, as fish became more smolted.

Tagging Details for Hatchery Steelhead PIT Tagged at Lower Granite Dam

We tagged 19,948 hatchery steelhead from 9 April through 7 June at Lower Granite Dam for survival estimates (Table 37). There were 57 mortalities, representing less than 1% of the total handled.

Comparison of Annual Survival Estimates

Estimates of survival from Snake River Basin hatcheries to Lower Granite Dam tailrace for 2002 were similar to or higher than those made in past years. Over the years of the study, we have consistently observed an inverse relationship between the migration distance from the release site to Lower Granite Dam and the estimated survival through that reach (Fig. 5). For 1993-2002 estimates, the negative linear correlation between migration distance and estimated survival was significant ($R^2 = 53.1\%$; $P < 0.0001$).

For yearling chinook salmon, estimated survival in 2002 was similar to or slightly higher than that estimated in previous years through all reaches (Figs. 6-7). For steelhead, survival estimates in 2002 were similar to those from previous years through all reaches except that estimates were lower through the John Day Dam to Bonneville Dam reach and, especially, through the Lower Monumental Dam to McNary Dam reach (Figs. 6-7).

For yearling chinook salmon, mean survival for all years combined was similar through each of the Snake River reaches (0.90-0.92) and similar but lower through Columbia River reaches (0.85-0.86; Table 38). For steelhead, mean survival across years showed a slight decline through successive reaches (0.86-0.90), and was lowest through the McNary to John Day reach (0.76), the reach with the longest reservoir (Table 39). Omitting estimates from 2001, average survival estimates for steelhead are similar to those for yearling chinook salmon.

Since 1998, we have combined empirical survival estimates from various reaches for Snake River yearling chinook salmon and steelhead to calculate estimates throughout the entire hydropower system, from the head of Lower Granite Reservoir (Snake River smolt trap) to the tailrace of Bonneville Dam (Table 40).

Flow and Spill In Relation to Juvenile Salmonid Survival

Snake River flow volume during the yearling chinook salmon migration period was expressed as flow exposure at Lower Monumental Dam for each release group. Flow volume was nearly as low during 2002 (average exposure index of 77.6 kcfs) as during 2001 (average index 70.0 kcfs; Fig. 8). However, because the steelhead migration occurred later in the season, flow exposure for steelhead was higher during 2002 (91.7 kcfs) than during 2001 (70.0 kcfs; Fig. 9). Spill was provided during spring 2002 at all dams at levels similar to recent years, excluding 2001 when spill was eliminated at some projects (Lower Granite, Little Goose, and Lower Monumental Dams) and limited in volume and duration at others (Ice Harbor, McNary, John Day, and Bonneville Dams).

Comparing travel times of yearling chinook salmon and steelhead among years, 2002 travel times between Lower Granite and Bonneville Dams were similar to past years during most of the migration, and much shorter than the travel times observed during 2001 (Fig. 4).

Through most reaches, estimated survival of yearling chinook salmon in 2002 was substantially greater than in 2001, and similar to estimated survival in other recent years (Figs. 6-7; Table 38). For steelhead, though survival estimates in 2002 were greater than in 2001 in all but one reach (John Day to Bonneville Dam), survival remained depressed relative to earlier years in the reach from Lower Monumental to McNary Dam and perhaps the reach from John Day to Bonneville Dam, although the survival estimate in this last reach had high variance (Figs. 6-7; Table 39).

During 2002, survival estimates to John Day Dam tailrace for weekly groups of yearling chinook salmon leaving McNary Dam were fairly constant, with no apparent within-season trends (Table 41; Fig. 10). Corresponding estimated detection probabilities are given in Table 42. In past years, the typical pattern was a gradual increase in survival from the earliest groups to a peak in midseason, followed by a gradual decrease (Fig. 11). In 2001, the peak in survival estimates coincided with the period of spill at John Day Dam. In 2002, spill at John Day Dam was fairly constant, coinciding with the constant survival estimates. Survival in this reach was substantially higher in 2002 than in 2001, including during the three-week spill period for 2001 fish.

Survival Estimates from Point of Release to Bonneville Dam

Much more water was spilled at lower Columbia River dams in 2002 than in 2001. Consequently, PIT-tagged fish were detected at lower rates, and survival estimates were less precise for most stocks (Table 43). Many more PIT-tagged spring/summer yearling chinook salmon were released from Upper Columbia hatcheries in 2002, than in previous years, accounting for the improved precision of estimates for this stock.

Estimates to Bonneville Dam were not possible for Upper Columbia summer/fall chinook salmon (ocean-type fish raised in hatcheries to the yearling stage), so we have included estimates for release to John Day Dam as well as to Bonneville Dam (Table 43).

Upper Columbia River summer/fall chinook salmon released from Rock Island Dam migrated past four projects on their way to John Day Dam. Their estimated survival (0.688, s.e. 0.022) was essentially equal to that of Snake River spring/summer yearling chinook salmon from Lower Granite Dam (0.687; s.e. 0.013), a stock that passed five projects on the way to John Day Dam. Summer/fall chinook salmon released at Rocky Reach Dam also migrated past five projects, and their average estimated survival between release and John Day Dam was 0.646 (s.e. 0.021).

Among stocks for which we were able to estimate survival to Bonneville Dam, Snake River yearling spring/summer chinook salmon that migrated past seven projects had the highest average estimated survival at 0.578 (0.060). Estimated survival of yearling spring chinook salmon released at hatcheries in the Upper Columbia River was lower than for their Snake River counterparts in 2002, but greater than observed for them in 2001. In 2002, average survival estimates were 0.427 (0.040) for fish released at Leavenworth Hatchery (seven projects), 0.397 (0.037) for fish released at Entiat Hatchery (eight projects), and 0.376 (0.038) for fish released at Winthrop Hatchery (nine projects). The survival estimate to Bonneville Dam for Snake River steelhead from Lower Granite to Bonneville Dam was 0.262 (0.050), more than six times greater than their estimated survival in 2001, but still the lowest among the stocks in 2002.

DISCUSSION

Flow volume during most of the 2002 spring migration of yearling chinook salmon was only slightly greater than in the drought conditions of 2001. However, spill occurred at levels similar to other recent years. Survival for yearling chinook salmon through the entire hydropower system in 2002 rebounded from the poor survival observed in 2001 to levels similar to other recent years. This is consistent with other findings supporting positive effects of spill on survival on a season-wide basis. Analyses based on early data (1973-1979) suggested that increases in spill had a direct impact on increasing survival (Sims and Ossiander 1981). From our own research, estimated survival through the hydropower system was lower in 1993 and 1994, when spill occurred only in excess of powerhouse capacity, than it was after spill at all dams was prescribed in the 1995 Biological Opinion (NMFS 1995). Demonstrating in-season effects of spill has been more problematic (Smith et al. 2002; Zabel et al. 2002).

For steelhead, although survival and migration rate in 2002 increased substantially over that observed during 2001, survival remained depressed compared to other recent years, particularly in the Lower Monumental to McNary Dam reach and perhaps the John Day to Bonneville Dam reach. Avian predation appears to have decreased survival of steelhead. Steelhead are particularly susceptible to predation by birds: Collis et al. (2001) found that greater than 15% of the tags from PIT-tagged steelhead entering the Columbia River estuary in 1998 were later found on estuarine bird colonies. Only 2% of tags from PIT-tagged yearling chinook salmon were found on the bird colonies. In 1998 the major site of tag recovery was Rice Island, which was then home to the largest Caspian tern *(Sterna caspia)* colony in North America. Ryan et al. (2002, 2003) reported similar results in subsequent years, as the tern colony was relocated from Rice Island to East Sand Island.

Crescent Island in the McNary Dam reservoir harbors the second largest (> 600) Caspian tern colony in North America and large populations (> 39,000) of gulls (*Larus* spp.*)*. Other avian piscivores that reside at other locations within McNary pool include American white pelicans (*Pelecanus erythrorhynchos),* cormorants (*Phalacrocorax auritus*), and herons *(Ardea alba, A. herodias*, and *Nycticorax nycticorax*) (Collis et al. 2002). Over 6,100 PIT tags from steelhead tagged in 2002 were recovered on Crescent Island and other bird colonies in McNary pool (B. Ryan, NMFS, personal communication). Of all PIT-tagged steelhead detected at Lower Monumental Dam, more than 10% of the tags were later detected on McNary Reservoir bird colonies (Table 44), primarily on the Crescent Island Caspian tern colony. Substantial numbers of PIT tags (mostly steelhead) were detected on gull colonies in the John Day and The Dalles Reservoir as well (Ryan et al. 2002).

Tag-detection percentage on avian colonies is a minimum estimate of loss due to bird predation, because not all tags taken by birds are detected (Collis et al. 2001, Ryan et al. 2001). From 1998 to 2002, survival estimates for steelhead in the Lower Monumental to McNary Dam reach (Table 38) correlate strongly ($R^2 = 0.994$, $P < 0.001$) with the percentage of smolts detected on McNary Reservoir bird colonies (Table 42; Fig. 12). There is also significant correlation for yearling chinook salmon ($R^2 = 0.894$; $P = 0.015$; Fig. 12), although the percentage detected on bird colonies is much lower.

In 2002, per-project survival for steelhead was substantially lower in the Lower Monumental to McNary Dam reach (two projects, $0.652^{1/2} = 0.807$) than in the Lower Granite to Little Goose Dam reach (0.882) and the Little Goose to Lower Monumental Dam reach (0.882). Also, estimated per-project survival for steelhead from McNary to John Day Dam (0.844) and from John Day to Bonneville Dam (two projects, $0.612^{1/2} = 0.782$) was lower than estimated per-project survival above Lower Monumental

Dam. In contrast, 1.2% of the yearling chinook salmon detected at Lower Monumental Dam were subsequently detected on Crescent Island or other McNary Reservoir bird colonies, and the per-project survival estimates for the reaches directly above and below McNary Dam were not substantially different than in other reaches.

Lacking a PIT-tag detection system at Ice Harbor Dam, we are currently unable to partition the survival estimate between Lower Monumental and McNary Dams into reach-specific estimates. Survival of yearling chinook salmon passing through the spillway at Ice Harbor Dam was estimated at 0.892 in 2002 and at 0.978 in 2000 (B. Eppard, NMFS, personal communication). In 2001, survival from 5 km upstream from Ice Harbor Dam to McNary Dam tailrace was estimated at 0.724 (B. Eppard, NMFS, personal communication). Steelhead survival has not been estimated at Ice Harbor Dam. Operational changes at Lower Monumental or Ice Harbor Dam, including spill levels and spill patterns, could influence vulnerability of steelhead to avian predators. In addition, tailwater elevation at Ice Harbor Dam could influence spillway survival via the effects of spillbay deflectors installed prior to the 1998 migration.

Proportions of PIT-tagged fish (especially steelhead) taken by avian predators have increased in the last two years, with corresponding decrease in survival. At this point, it is unclear whether this change is due to changes in abundance of predators, susceptibility of smolts to predation, or system operations. The explanation may include a combination of all three causes. Research is ongoing to elucidate the complicated dynamics of this predator-prey system. In particular, we need more fine partitioning of survival estimates in the reach between Lower Monumental and McNary Dams, and we need a better understanding of tern behavior.

Results from the 2002 studies provide estimates of survival only during the downstream portion of the migration. We will analyze these data in conjunction with adult returns that will occur over the next three years to determine whether variations in spill, flow, temperature, and passage route produce patterns in smolt-to-adult survival consistent with those observed during the downstream migration phase.

RECOMMENDATIONS

1) Coordination of future survival studies with other projects should continue to maximize the data-collection effort and minimize study effects on salmonid resources.

2) To date, little mortality has been found in Lower Granite reservoir and most other reservoirs investigated. However, considerable steelhead mortality was observed in 2002 in the river reach between Lower Monumental and McNary Dams. Avian

predators may cause this mortality, and this issue merits further investigation. Estimates of survival from hatcheries to Lower Granite Dam suggest that substantial mortality occurs upstream from the Snake and Clearwater River confluence. Efforts should continue to identify where this mortality occurs.

3) Increasing the number of detection facilities in the Columbia River Basin will improve survival investigations. We recommend installation of detectors and diversion systems at Ice Harbor, The Dalles, and Upper Columbia River dams. The development of flat-plate and full-flow detector technology in bypass systems and other suitable locations at dams and portable streambed flat-plate detectors for use in tributaries would greatly enhance survival estimation capabilities.

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TABLES

Table 1. Estimated survival probabilities for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date of passage or release at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar-05 Apr	126	0.911(0.156)	0.985(0.271)	0.680(0.175)	0.610(0.088)
06 Apr-12 Apr	319	0.905(0.072)	0.817(0.103)	0.967(0.125)	0.715(0.066)
13 Apr-19 Apr	4,310	0.911 (0.017)	0.987 (0.028)	0.823 (0.026)	0.740 (0.018)
20 Apr-26 Apr	2,040	0.960 (0.020)	0.950 (0.029)	0.856 (0.038)	0.781 (0.030)
27 Apr-03 May	2,881	0.962 (0.018)	0.966 (0.027)	0.824 (0.033)	0.765 (0.027)
04 May-10 May	13,687	0.957 (0.012)	0.989 (0.016)	0.803 (0.017)	0.760 (0.014)
11 May-17 May	4,388	0.954 (0.019)	0.985 (0.029)	0.825 (0.039)	0.775 (0.033)
18 May-24 May	4,006	0.963 (0.013)	0.970 (0.024)	0.847 (0.043)	0.791 (0.037)
25 May-31 May	293	0.958 (0.037)	0.917 (0.080)	1.205 (0.388)	1.058 (0.332)
01 Jun-07 Jun	146	0.992 (0.114)	0.976 (0.206)	0.554 (0.173)	0.537 (0.141)
08 Jun-14 Jun	62	1.133 (0.135)	0.653 (0.126)	0.857 (0.290)	0.635 (0.212)
Weighted mean[a]		0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.757 (0.009)

a Weighted means of the independent estimates for daily groups (29 March-31 May), with weights inversely proportional to respective estimated relative variances.

Table 2. Estimated survival probabilities for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
20 Apr-26 Apr	781	0.922 (0.153)	0.235 (0.142)	0.217 (0.126)
27 Apr-03 May	2,871	0.943 (0.063)	1.080 (0.693)	1.018 (0.650)
04 May-10 May	15,173	0.871 (0.032)	0.822 (0.139)	0.716 (0.118)
11 May-17 May	28,713	0.924 (0.023)	1.034 (0.116)	0.956 (0.104)
18 May-24 May	23,041	0.924 (0.030)	0.829 (0.076)	0.766 (0.066)
25 May-31 May	7,403	0.834 (0.043)	0.484 (0.082)	0.403 (0.065)
Weighted mean[a]		**0.907 (0.014)**	**0.840 (0.079)**	**0.763 (0.079)**

a Weighted means of the independent estimates for weekly pooled groups (20 April-31 May), with weights inversely proportional to respective estimated relative variances.

Table 3. Estimated survival probabilities for Snake River hatchery yearling chinook salmon detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar-5 Apr	113	0.851 (0.159)	0.975 (0.294)	0.709 (0.196)	0.589 (0.086)
6-12 Apr	266	0.900 (0.084)	0.824 (0.120)	0.972 (0.147)	0.721 (0.081)
13-19 Apr	3,851	0.902 (0.017)	0.992 (0.029)	0.828 (0.028)	0.741 (0.019)
20-26 Apr	1,754	0.982 (0.023)	0.935 (0.032)	0.833 (0.040)	0.765 (0.032)
27 Apr-3 May	2,721	0.969 (0.020)	0.962 (0.029)	0.832 (0.036)	0.775 (0.029)
4-10 May	13,312	0.957 (0.012)	0.989 (0.016)	0.803 (0.018)	0.760 (0.014)
11-17 May	4,279	0.950 (0.019)	0.993 (0.029)	0.823 (0.040)	0.777 (0.034)
18-24 May	3,718	0.970 (0.014)	0.974 (0.026)	0.832 (0.045)	0.786 (0.039)
25-31 May	219	0.958 (0.047)	0.845 (0.087)	1.304 (0.501)	1.054 (0.397)
1-7 Jun	100	0.934 (0.119)	1.020 (0.239)	0.591 (0.215)	0.563 (0.173)
08-14 Jun	37	1.036 (0.165)	0.683 (0.170)	0.667 (0.244)	0.472 (0.166)
Weighted mean[a]		**0.955 (0.007)**	**0.977 (0.009)**	**0.819 (0.009)**	**0.759 (0.008)**

a Weighted means of the independent estimates for weekly pooled groups (30 March-14 June), with weights inversely proportional to respective estimated relative variances.

Table 4. Estimated survival probabilities for Snake River wild yearling chinook salmon detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
6-12 Apr	53	0.956 (0.135)	0.734 (0.171)	1.056 (0.226)	0.741 (0.119)
13-19 Apr	459	0.997 (0.061)	0.947 (0.094)	0.782 (0.081)	0.738 (0.052)
20-26 Apr	286	0.857 (0.035)	1.044 (0.060)	0.992 (0.110)	0.888 (0.091)
27 Apr-3 May	160	0.900 (0.046)	1.020 (0.081)	0.767 (0.086)	0.704 (0.067)
4-10 May	375	0.936 (0.059)	0.985 (0.085)	0.824 (0.087)	0.760 (0.068)
11-17 May	109	1.074 (0.157)	0.694 (0.142)	0.857 (0.261)	0.639 (0.182)
18-24 May	288	0.891 (0.035)	0.933 (0.064)	1.038 (0.168)	0.864 (0.134)
25-31 May	74	0.940 (0.052)	1.207 (0.197)	0.969 (0.569)	1.100 (0.619)
Weighted mean[a]		**0.911 (0.018)**	**0.990 (0.032)**	**0.870 (0.041)**	**0.768 (0.026)**

a Weighted means of the independent estimates for weekly pooled groups (06 April-31 May), with weights inversely proportional to respective estimated relative variances.

Table 5. Estimated survival probabilities for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled as necessary to calculate estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
29 Mar-02 Apr	59	1.044 (0.311)	0.703 (0.326)	0.867 (0.351)	0.637 (0.146)
03 Apr	40	0.750 (0.205)	1.332 (0.632)	0.675 (0.414)	0.675 (0.309)
04 Apr	13	0.615 (0.135)	1.429 (0.468)	0.800 (0.593)	0.703 (0.448)
05 Apr	15	1.332 (0.878)	0.500 (0.354)	1.050 (0.059)	0.700 (0.134)
06-07 Apr	25	1.040 (0.488)	0.720 (0.602)	0.611 (0.447)	0.458 (0.148)
08 Apr	21	1.000 (0.426)	0.500 (0.250)	1.750 (0.725)	0.875 (0.412)
09 Apr	37	0.973 (0.164)	0.856 (0.237)	1.364 (0.601)	1.135 (0.448)
10 Apr	67	0.796 (0.099)	1.375 (0.473)	0.736 (0.289)	0.806 (0.164)
11 Apr	68	0.799 (0.148)	0.788 (0.229)	1.143 (0.358)	0.719 (0.175)
12 Apr	101	1.056 (0.174)	0.679 (0.157)	0.839 (0.156)	0.602 (0.078)
13 Apr	234	1.034 (0.126)	0.770 (0.139)	1.108 (0.220)	0.883 (0.137)
14 Apr	445	0.960 (0.063)	0.962 (0.105)	0.809 (0.097)	0.748 (0.062)
15 Apr	1,002	0.890 (0.036)	1.100 (0.078)	0.765 (0.059)	0.748 (0.036)
16 Apr	786	0.950 (0.049)	0.913 (0.069)	0.811 (0.059)	0.703 (0.035)
17 Apr	538	0.895 (0.045)	1.002 (0.078)	0.735 (0.060)	0.659 (0.037)
18 Apr	524	0.899 (0.037)	0.968 (0.058)	0.938 (0.075)	0.816 (0.056)
19 Apr	781	0.908 (0.030)	0.987 (0.048)	0.864 (0.063)	0.775 (0.050)
20 Apr	248	1.004 (0.069)	0.864 (0.083)	0.773 (0.084)	0.670 (0.063)
21 Apr	339	0.924 (0.047)	0.980 (0.075)	0.804 (0.085)	0.728 (0.065)
22 Apr	88	1.141 (0.165)	0.841 (0.166)	0.744 (0.150)	0.715 (0.118)
23 Apr	319	0.987 (0.060)	0.878 (0.070)	0.970 (0.109)	0.840 (0.087)
24 Apr	159	0.889 (0.062)	1.026 (0.112)	0.847 (0.133)	0.773 (0.102)
25 Apr	540	0.988 (0.037)	0.976 (0.056)	0.915 (0.094)	0.883 (0.083)
26 Apr	347	0.912 (0.042)	0.983 (0.067)	0.872 (0.087)	0.781 (0.067)
27 Apr	431	0.992 (0.037)	0.869 (0.053)	0.996 (0.104)	0.859 (0.083)
28 Apr	109	0.883 (0.058)	1.098 (0.117)	0.779 (0.132)	0.756 (0.106)
29 Apr	314	0.993 (0.042)	0.962 (0.077)	0.740 (0.096)	0.707 (0.079)

Table 5. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Apr	237	0.947 (0.046)	0.992 (0.088)	0.800 (0.128)	0.751 (0.106)
01 May	180	0.896 (0.063)	0.933 (0.089)	0.786 (0.110)	0.658 (0.083)
02 May	232	1.000 (0.069)	0.925 (0.104)	0.778 (0.123)	0.720 (0.096)
03 May	1378	0.942 (0.035)	1.014 (0.049)	0.812 (0.047)	0.777 (0.038)
04 May	4,379	0.960 (0.021)	1.000 (0.029)	0.847 (0.031)	0.814 (0.026)
05 May	3,506	0.967 (0.023)	1.004 (0.032)	0.795 (0.034)	0.771 (0.028)
06 May	2,387	0.967 (0.029)	0.948 (0.039)	0.751 (0.038)	0.689 (0.029)
07 May	1,468	0.899 (0.030)	1.062 (0.051)	0.775 (0.053)	0.740 (0.043)
08 May	1041	0.913 (0.037)	0.978 (0.056)	0.817 (0.065)	0.730 (0.051)
09 May	646	0.927 (0.053)	0.966 (0.077)	0.762 (0.080)	0.682 (0.061)
10 May	260	1.121 (0.106)	0.853 (0.117)	0.770 (0.126)	0.736 (0.099)
11 May	592	0.980 (0.058)	0.938 (0.077)	0.754 (0.079)	0.693 (0.062)
12 May	258	0.901 (0.057)	1.058 (0.103)	0.998 (0.169)	0.953 (0.144)
13 May	529	0.992 (0.059)	0.895 (0.075)	0.688 (0.086)	0.611 (0.069)
14 May	720	0.966 (0.042)	0.983 (0.068)	0.853 (0.117)	0.810 (0.102)
15 May	1,179	0.993 (0.042)	0.968 (0.061)	0.830 (0.083)	0.798 (0.070)
16 May	357	0.969 (0.077)	0.988 (0.108)	0.996 (0.182)	0.954 (0.158)
17 May	753	0.863 (0.035)	1.064 (0.063)	0.884 (0.106)	0.812 (0.090)
18 May	1,150	0.976 (0.029)	0.926 (0.042)	0.833 (0.074)	0.752 (0.062)
19 May	852	0.977 (0.031)	1.040 (0.063)	0.829 (0.093)	0.843 (0.083)
20 May	1,123	0.934 (0.021)	0.997 (0.045)	0.769 (0.068)	0.716 (0.057)
21 May	393	0.944 (0.041)	0.989 (0.078)	1.084 (0.225)	1.014 (0.199)
22 May	279	0.967 (0.050)	0.849 (0.073)	1.312 (0.321)	1.076 (0.256)
23 May	110	1.060 (0.074)	0.833 (0.130)	0.938 (0.383)	0.828 (0.323)
24 May	99	0.965 (0.064)	1.112 (0.213)	0.525 (0.216)	0.564 (0.207)
25 May	54	0.872 (0.070)	0.937 (0.185)	0.604 (0.322)	0.493 (0.249)
26-28 May	115	0.978 (0.046)	0.939 (0.120)	1.544 (0.778)	1.417 (0.697)
29-31 May	124	1.004 (0.086)	0.849 (0.132)	1.096 (0.646)	0.935 (0.541)
Weighted mean[a]		0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.757 (0.009)

a Weighted means of the independent estimates for daily groups (29 March-31 May), with weights inversely proportional to respective estimated relative variances.

Table 6. Estimated detection probabilities for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little GooseDam	Lower Monumental Dam	McNary Dam
30 Mar-05 Apr	126	0.192 (0.049)	0.161 (0.049)	0.512 (0.086)
06-12 Apr	319	0.287 (0.035)	0.194 (0.032)	0.522 (0.056)
13-19 Apr	4,310	0.272 (0.009)	0.288 (0.010)	0.538 (0.015)
20-26 Apr	2,040	0.313 (0.012)	0.476 (0.016)	0.489 (0.022)
27 Apr-03 May	2,881	0.298 (0.010)	0.444 (0.013)	0.452 (0.018)
04-10 May	13,687	0.197 (0.004)	0.414 (0.006)	0.425 (0.009)
11-17 May	4,388	0.251 (0.008)	0.430 (0.012)	0.322 (0.016)
18-24 May	4,006	0.412 (0.010)	0.486 (0.013)	0.263 (0.015)
25-31 May	293	0.588 (0.037)	0.551 (0.053)	0.114 (0.040)
01-07 Jun	146	0.338 (0.055)	0.306 (0.066)	0.138 (0.053)
08-14 Jun	62	0.441 (0.081)	0.714 (0.099)	0.306 (0.124)

Table 7. Estimated detection probabilities for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
20-26 Apr	781	0.247 (0.044)	0.590 (0.342)
27 Apr-03 May	2,871	0.318 (0.023)	0.137 (0.087)
04-10 May	15,173	0.225 (0.009)	0.189 (0.031)
11-17 May	28,713	0.192 (0.005)	0.183 (0.020)
18-24 May	23,041	0.147 (0.005)	0.235 (0.020)
25-31 May	7,403	0.203 (0.012)	0.398 (0.065)

Table 8. Estimated detection probabilities for Snake River hatchery yearling chinook salmon detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
30 Mar-05 Apr	113	0.187 (0.052)	0.140 (0.049)	0.547 (0.091)
06-12 Apr	266	0.267 (0.038)	0.202 (0.036)	0.495 (0.064)
13-19 Apr	3,851	0.272 (0.009)	0.294 (0.010)	0.536 (0.016)
20-26 Apr	1,754	0.300 (0.013)	0.469 (0.017)	0.490 (0.024)
27 Apr-03 May	2,721	0.289 (0.011)	0.439 (0.014)	0.441 (0.019)
04-10 May	13,312	0.196 (0.004)	0.414 (0.006)	0.424 (0.009)
11-17 May	4,279	0.250 (0.008)	0.428 (0.012)	0.324 (0.016)
18-24 May	3,718	0.400 (0.010)	0.479 (0.013)	0.263 (0.015)
25-31 May	219	0.582 (0.044)	0.561 (0.061)	0.106 (0.045)
01-07 Jun	100	0.343 (0.065)	0.314 (0.078)	0.165 (0.070)
08-14 Jun	37	0.443 (0.108)	0.667 (0.136)	0.412 (0.173)

Table 9. Estimated detection probabilities for Snake River wild yearling chinook salmon detected and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06-12 Apr	53	0.375 (0.086)	0.161 (0.066)	0.611 (0.115)
13-19 Apr	459	0.271 (0.027)	0.244 (0.028)	0.553 (0.045)
20-26 Apr	286	0.396 (0.034)	0.518 (0.040)	0.488 (0.059)
27 Apr-03 May	160	0.438 (0.046)	0.532 (0.055)	0.594 (0.067)
04-10 May	375	0.234 (0.027)	0.427 (0.037)	0.447 (0.048)
11-17 May	109	0.290 (0.060)	0.527 (0.084)	0.262 (0.090)
18-24 May	288	0.561 (0.036)	0.573 (0.046)	0.263 (0.050)
25-31 May	74	0.618 (0.065)	0.522 (0.104)	0.138 (0.089)

Table 10. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
06 Apr-12 Apr	571	0.891 (0.045)	0.976 (0.199)	0.908 (0.207)	0.789 (0.089)
13 Apr-19 Apr	1,432	0.967 (0.037)	1.082 (0.113)	0.616 (0.071)	0.644 (0.040)
20 Apr-26 Apr	2,183	0.898 (0.028)	0.862 (0.039)	0.831 (0.074)	0.644 (0.053)
27 Apr-03 May	4,026	0.862 (0.021)	0.887 (0.035)	0.556 (0.042)	0.426 (0.030)
04 May-10 May	5,081	0.901 (0.037)	0.808 (0.043)	0.536 (0.045)	0.391 (0.030)
11 May-17 May	4,591	0.864 (0.022)	0.860 (0.033)	0.653 (0.058)	0.485 (0.041)
18 May-24 May	3,735	0.903 (0.017)	0.870 (0.032)	0.583 (0.061)	0.458 (0.045)
25 May-31 May	1,987	0.850 (0.020)	1.002 (0.056)	0.770 (0.135)	0.657 (0.110)
01 Jun-07 Jun	1,075	0.940 (0.050)	0.903 (0.093)	0.601 (0.155)	0.511 (0.124)
08 Jun-14 Jun	201	0.771 (0.070)	1.078 (0.294)	0.184 (0.108)	0.153 (0.081)
Weighted mean[a]		**0.882 (0.011)**	**0.882 (0.018)**	**0.652 (0.031)**	**0.536 (0.025)**

a Weighted means of the independent estimates for daily groups (05 April-31 May), with weights inversely proportional to respective estimated relative variances.

Table 11. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released tothe tailrace at McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
20 Apr-26 Apr	445	1.036 (0.183)	1.157 (1.052)	1.199 (1.068)
27 Apr-03 May	912	0.908 (0.110)	0.691 (0.261)	0.628 (0.224)
04 May-10 May	963	0.869 (0.156)	1.209 (0.797)	1.052 (0.667)
11 May-17 May	633	0.640 (0.117)	1.036 (0.912)	0.664 (0.571)
18 May-24 May	1,284	0.968 (0.182)	0.437 (0.141)	0.423 (0.111)
15 May-31 May	1,011	0.600 (0.095)	0.513 (0.161)	0.308 (0.084)
01 Jun-07 Jun	857	1.002 (0.373)	0.388 (0.271)	0.390 (0.230)
Weighted mean[a]		**0.844 (0.063)**	**0.612 (0.098)**	**0.488 (0.090)**

a Weighted means of the independent estimates for weekly pooled groups (20 April-07 June), with weights inversely proportional to respective estimated relative variances.

Table 12. Estimated survival probabilities for juvenile Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
06-12 Apr	567	0.890 (0.045)	0.970 (0.198)	0.913 (0.209)	0.789 (0.091)
13-19 Apr	1,141	0.970 (0.043)	1.112 (0.127)	0.593 (0.076)	0.640 (0.046)
20-26 Apr	1,985	0.891 (0.029)	0.847 (0.039)	0.858 (0.081)	0.647 (0.058)
27 Apr-03 May	3,944	0.862 (0.022)	0.887 (0.035)	0.556 (0.043)	0.425 (0.030)
04-10 May	4,834	0.914 (0.040)	0.799 (0.045)	0.528 (0.046)	0.386 (0.031)
11-17 May	4,325	0.859 (0.022)	0.860 (0.034)	0.662 (0.061)	0.489 (0.043)
18-24 May	3,139	0.902 (0.019)	0.875 (0.036)	0.554 (0.067)	0.437 (0.051)
25-31 May	1,819	0.848 (0.021)	0.986 (0.057)	0.770 (0.134)	0.643 (0.107)
01-07 Jun	1,016	0.915 (0.050)	0.900 (0.096)	0.609 (0.165)	0.502 (0.128)
Weighted mean[a]		**0.883 (0.011)**	**0.880 (0.021)**	**0.638 (0.043)**	**0.533 (0.045)**

a Weighted means of the independent estimates for weekly pooled groups (06 April -07 June), with weights inversely proportional to respective estimated relative variances.

Table 13. Estimated survival probabilities for juvenile Snake River wild steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
13 Apr-19 Apr	291	0.954 (0.077)	0.779 (0.185)	0.893 (0.224)	0.663 (0.080)
20 Apr-26 Apr	198	0.966 (0.100)	1.074 (0.224)	0.605 (0.171)	0.628 (0.134)
27 Apr-03 May	82	0.905 (0.100)	0.871 (0.174)	0.503 (0.186)	0.396 (0.133)
04 May-10 May	247	0.792 (0.093)	0.914 (0.139)	0.654 (0.184)	0.473 (0.125)
11 May-17 May	266	0.945 (0.096)	0.853 (0.126)	0.572 (0.164)	0.461 (0.123)
18 May-24 May	596	0.907 (0.038)	0.847 (0.062)	0.762 (0.150)	0.586 (0.111)
Weighted mean[a]		**0.914 (0.018)**	**0.870 (0.028)**	**0.699 (0.055)**	**0.593 (0.039)**

a Weighted means of the independent estimates for weekly pooled groups (13 April -24 May), with weights inversely proportional to respective estimated relative variances.

Table 14. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled as necessary to calculate estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
05 Apr-10 Apr	196	0.782 (0.056)	1.221 (0.492)	0.967 (0.441)	0.924 (0.201)
11 Apr	186	0.910 (0.094)	0.886 (0.362)	0.890 (0.395)	0.718 (0.141)
12 Apr-13 Apr	394	0.964 (0.056)	1.627 (0.561)	0.421 (0.152)	0.661 (0.075)
14 Apr	68	0.926 (0.131)	0.839 (0.422)	1.217 (0.793)	0.946 (0.420)
15 Apr	106	0.858 (0.101)	0.611 (0.156)	1.018 (0.248)	0.534 (0.080)
16 Apr	300	1.129 (0.117)	0.948 (0.274)	0.623 (0.185)	0.668 (0.084)
17 Apr	276	0.929 (0.078)	0.788 (0.134)	0.995 (0.198)	0.729 (0.100)
18 Apr	244	1.014 (0.109)	1.173 (0.281)	0.440 (0.118)	0.523 (0.081)
19 Apr	234	0.905 (0.097)	1.032 (0.213)	0.793 (0.227)	0.742 (0.167)
20 Apr	234	0.971 (0.099)	0.978 (0.194)	0.944 (0.298)	0.897 (0.237)
21 Apr	62	0.829 (0.150)	1.984 (1.752)	0.433 (0.423)	0.713 (0.307)
22 Apr	90	1.173 (0.245)	0.672 (0.199)	0.929 (0.459)	0.733 (0.335)
23 Apr	467	0.945 (0.070)	0.772 (0.080)	1.171 (0.263)	0.855 (0.185)
24 Apr	413	0.760 (0.046)	0.940 (0.080)	0.868 (0.185)	0.620 (0.127)
25 Apr	410	0.916 (0.063)	0.888 (0.088)	0.759 (0.159)	0.617 (0.122)
26 Apr	507	0.897 (0.055)	0.808 (0.068)	0.635 (0.092)	0.460 (0.063)
27 Apr	527	0.964 (0.064)	0.793 (0.074)	0.740 (0.149)	0.565 (0.109)
28 Apr	175	0.908 (0.099)	0.876 (0.158)	0.530 (0.159)	0.421 (0.112)
29 Apr	83	1.000 (0.220)	0.670 (0.222)	0.479 (0.225)	0.321 (0.133)
30 Apr	855	0.885 (0.044)	0.832 (0.068)	0.543 (0.084)	0.400 (0.057)
01 May	791	0.841 (0.038)	0.956 (0.076)	0.571 (0.099)	0.459 (0.073)
02 May	797	0.834 (0.054)	0.873 (0.087)	0.542 (0.107)	0.395 (0.072)
03 May	798	0.794 (0.053)	1.046 (0.109)	0.452 (0.081)	0.376 (0.060)
04 May	901	0.796 (0.061)	0.861 (0.092)	0.491 (0.103)	0.337 (0.066)
05 May	137	0.722 (0.118)	1.030 (0.226)	0.460 (0.180)	0.342 (0.123)
06 May	170	0.623 (0.115)	0.985 (0.205)	0.730 (0.256)	0.448 (0.151)

Table 14. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
07 May	982	0.945 (0.099)	0.839 (0.111)	0.453 (0.077)	0.360 (0.054)
08 May	954	0.947 (0.106)	0.682 (0.093)	0.616 (0.122)	0.398 (0.074)
09 May	957	1.024 (0.105)	0.710 (0.090)	0.563 (0.104)	0.410 (0.070)
10 May	980	0.934 (0.090)	0.890 (0.115)	0.545 (0.124)	0.453 (0.095)
11 May-13 May	1,080	0.959 (0.078)	0.689 (0.069)	0.690 (0.119)	0.456 (0.075)
14 May	852	0.838 (0.047)	0.969 (0.081)	0.680 (0.136)	0.552 (0.105)
15 May	897	1.000 (0.064)	0.849 (0.089)	0.687 (0.177)	0.584 (0.143)
16 May	873	0.745 (0.034)	1.084 (0.091)	0.466 (0.081)	0.376 (0.060)
17 May	889	0.877 (0.042)	0.759 (0.053)	0.819 (0.177)	0.545 (0.116)
18 May	1,003	0.904 (0.036)	0.792 (0.058)	0.540 (0.097)	0.387 (0.065)
19 May	156	1.056 (0.090)	0.843 (0.150)	0.770 (0.296)	0.686 (0.242)
20 May	134	0.756 (0.070)	1.127 (0.218)	0.486 (0.198)	0.414 (0.151)
21 May	599	0.896 (0.042)	0.925 (0.090)	0.496 (0.141)	0.411 (0.112)
22 May	731	0.937 (0.041)	0.799 (0.062)	0.577 (0.118)	0.432 (0.085)
23 May	578	0.867 (0.038)	0.811 (0.072)	1.590 (1.060)	1.118 (0.741)
24 May	534	0.902 (0.037)	1.012 (0.092)	0.608 (0.174)	0.556 (0.153)
25 May	564	0.869 (0.032)	0.987 (0.093)	0.724 (0.226)	0.621 (0.186)
26 May-28 May	124	0.844 (0.067)	1.264 (0.382)	0.559 (0.521)	0.596 (0.526)
29 May	404	0.897 (0.049)	0.930 (0.124)	0.738 (0.298)	0.616 (0.237)
30-31 May	459	0.902 (0.062)	0.903 (0.114)	0.564 (0.144)	0.460 (0.107)
Weighted mean[a]		**0.882 (0.011)**	**0.882 (0.018)**	**0.652 (0.031)**	**0.536 (0.025)**

a Weighted means of the independent estimates for daily groups (05 April-31 May), with weights inversely proportional to respective estimated relative variances.

Table 15. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr-12 Apr	571	0.468 (0.032)	0.061 (0.016)	0.221 (0.032)
13 Apr-19 Apr	1,432	0.354 (0.019)	0.112 (0.014)	0.289 (0.023)
20 Apr-26 Apr	2,183	0.292 (0.013)	0.496 (0.020)	0.254 (0.024)
27 Apr-03 May	4,026	0.283 (0.010)	0.511 (0.018)	0.256 (0.020)
04 May-10 May	5,081	0.124 (0.007)	0.477 (0.018)	0.223 (0.019)
11 May-17 May	4,591	0.247 (0.009)	0.539 (0.017)	0.180 (0.017)
18 May-24 May	3,735	0.413 (0.011)	0.572 (0.020)	0.206 (0.022)
25 May-31 May	1,987	0.494 (0.016)	0.457 (0.027)	0.118 (0.022)
01 Jun-07 Jun	1,075	0.309 (0.022)	0.396 (0.038)	0.100 (0.027)
08 Jun-14 Jun	201	0.426 (0.053)	0.473 (0.129)	0.167 (0.108)

Table 16. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
20 Apr-26 Apr	445	0.197 (0.040)	0.200 (0.179)
27 Apr-03 May	912	0.208 (0.029)	0.342 (0.123)
04 May-10 May	963	0.122 (0.025)	0.177 (0.113)
11 May-17 May	633	0.183 (0.038)	0.252 (0.218)
18 May-24 May	1,284	0.105 (0.021)	0.353 (0.094)
15 May-31 May	1,011	0.171 (0.031)	0.467 (0.129)
01 Jun-07 Jun	857	0.061 (0.024)	0.288 (0.171)

Table 17. Estimated detection probabilities for juvenile Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr-12 Apr	567	0.469 (0.032)	0.062 (0.017)	0.218 (0.032)
13 Apr-19 Apr	1,141	0.346 (0.021)	0.122 (0.016)	0.274 (0.025)
20 Apr-26 Apr	1,985	0.290 (0.014)	0.525 (0.021)	0.244 (0.025)
27 Apr-03 May	3,944	0.279 (0.010)	0.509 (0.018)	0.252 (0.020)
04 May-10 May	4,834	0.120 (0.007)	0.471 (0.018)	0.218 (0.020)
11 May-17 May	4,325	0.248 (0.009)	0.538 (0.018)	0.175 (0.017)
18 May-24 May	3,139	0.410 (0.012)	0.567 (0.023)	0.200 (0.025)
25 May-31 May	1,819	0.494 (0.017)	0.460 (0.028)	0.124 (0.023)
01 Jun-07 Jun	1,016	0.313 (0.023)	0.403 (0.040)	0.104 (0.030)

Table 18. Estimated detection probabilities for juvenile Snake River wild steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
13 Apr-19 Apr	291	0.389 (0.043)	0.079 (0.025)	0.344 (0.052)
20 Apr-26 Apr	198	0.314 (0.046)	0.249 (0.055)	0.355 (0.085)
27 Apr-03 May	82	0.444 (0.074)	0.557 (0.111)	0.500 (0.177)
04 May-10 May	247	0.184 (0.035)	0.565 (0.067)	0.303 (0.089)
11 May-17 May	266	0.231 (0.035)	0.545 (0.067)	0.242 (0.074)
18 May-24 May	596	0.425 (0.027)	0.595 (0.042)	0.225 (0.048)

Table 19. Estimated survival probabilities for PIT-tagged yearling chinook salmon released from Snake River Basin hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses.Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Num. rel.	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
Crooked River	300	0.466 (0.048)	1.028 (0.127)	1.098 (0.159)	0.790 (0.192)	0.416 (0.092)
Powell Pond	300	0.826 (0.079)	1.014 (0.132)	1.010 (0.134)	0.794 (0.148)	0.673 (0.108)
Red River Pond	301	0.742 (0.055)	1.096 (0.115)	0.901 (0.106)	0.945 (0.184)	0.692 (0.125)
Papoose Creek	750	0.697 (0.052)	0.943 (0.093)	1.247 (0.143)	0.530 (0.073)	0.434 (0.043)
Lolo Creek	1,012	0.588 (0.032)	0.963 (0.066)	1.050 (0.076)	0.892 (0.099)	0.530 (0.052)
Meadow Creek	1,008	0.769 (0.040)	1.040 (0.070)	0.876 (0.057)	0.805 (0.076)	0.564 (0.048)
Dworshak Hatchery						
Dworhsak H.	54,725	0.819 (0.011)	0.926 (0.017)	0.980 (0.014)	0.810 (0.011)	0.602 (0.007)
Kooskia Hatchery						
Kooskia H.	1,500	0.787 (0.036)	1.004 (0.061)	0.924 (0.056)	0.793 (0.065)	0.580 (0.041)
Lookingglass Hatchery						
Catherine Cr. Pond	20,848	0.405 (0.008)	0.948 (0.026)	1.014 (0.030)	0.804 (0.036)	0.313 (0.013)
Grande Ronde R. Pond	1,496	0.408 (0.020)	0.983 (0.053)	0.981 (0.066)	0.835 (0.095)	0.329 (0.034)
Imnaha Weir	20,919	0.667 (0.012)	0.953 (0.023)	0.947 (0.020)	0.856 (0.021)	0.514 (0.011)
Lostine River Pond	15,985	0.653 (0.009)	0.939 (0.019)	0.987 (0.022)	0.821 (0.029)	0.497 (0.016)
McCall Hatchery						
Johnson Creek	9,987	0.242 (0.006)	0.957 (0.025)	0.911 (0.027)	0.875 (0.052)	0.185 (0.011)
Knox Bridge	55,337	0.592 (0.006)	0.972 (0.015)	0.998 (0.014)	0.838 (0.015)	0.476 (0.008)
Pahsimeroi Hatchery						
Pahsimeroi Pond	992	0.687 (0.039)	0.906 (0.067)	0.979 (0.072)	0.927 (0.116)	0.564 (0.066)
Rapid River Hatchery						
Rapid River H.	183,920	0.755 (0.003)	0.943 (0.005)	0.982 (0.005)	0.848 (0.006)	0.592 (0.003)
Sawtooth Hatchery						
Sawtooth Trap	246	0.653 (0.115)	0.756 (0.142)	1.163 (0.149)	0.576 (0.103)	0.331 (0.049)
Salmon R. Trap	250	0.535 (0.078)	0.973 (0.172)	0.760 (0.115)	1.282 (0.272)	0.507 (0.106)
Sawtooth H.	989	0.387 (0.025)	0.990 (0.077)	0.958 (0.089)	0.743 (0.120)	0.273 (0.041)

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Num. rel.	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
S.F. Clearwater R.	302	0.778 (0.078)	0.820 (0.096)	1.018 (0.108)	0.823 (0.279)	0.534 (0.176)
Crooked River Pond	601	0.610 (0.037)	0.937 (0.072)	0.845 (0.083)	0.816 (0.286)	0.394 (0.136)
Red River Pond	298	0.502 (0.044)	1.185 (0.144)	0.740 (0.154)	0.482 (0.287)	0.212 (0.121)
Dworshak Hatchery						
Clear Creek	900	0.766 (0.042)	0.840 (0.063)	1.211 (0.126)	0.574 (0.136)	0.448 (0.098)
South Fork Clearwater R.	900	0.765 (0.038)	0.958 (0.065)	0.978 (0.082)	0.511 (0.092)	0.366 (0.061)
Dworshak Hatchery	4,213	0.786 (0.021)	0.921 (0.032)	0.967 (0.038)	0.528 (0.042)	0.370 (0.027)

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth Hatchery and coho salmon from Kooskia Hatchery in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Num. Rel	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Sawtooth Hatchery sockeye salmon						
Redfish Lake Creek Trap	994	0.345 (0.088)	0.559 (0.177)	0.847 (0.215)	2.577 (2.480)	0.421 (0.400)
Kooskia Hatchery coho salmon						
Kooskia Hatchery	994	1.102 (0.086)	0.687 (0.069)	0.828 (0.088)	0.875 (0.213)	0.549 (0.126)

Table 22. Estimated detection probabilities for PIT-tagged yearling chinook salmon released from Snake River Basin hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses.

Release site	Num. Released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
Clearwater Hatchery					
Crooked River	300	0.200 (0.038)	0.238 (0.042)	0.431 (0.063)	0.282 (0.072)
Powell Pond	300	0.153 (0.027)	0.204 (0.032)	0.375 (0.047)	0.332 (0.062)
Red River Pond	301	0.211 (0.031)	0.252 (0.035)	0.449 (0.049)	0.226 (0.049)
Papoose Creek	750	0.159 (0.020)	0.198 (0.022)	0.277 (0.032)	0.443 (0.049)
Lolo Creek	1,012	0.195 (0.019)	0.244 (0.021)	0.373 (0.029)	0.387 (0.042)
Meadow Creek	1,008	0.155 (0.015)	0.261 (0.020)	0.464 (0.028)	0.393 (0.038)
Dworshak Hatchery					
Dworhsak H.	54,725	0.144 (0.003)	0.204 (0.003)	0.366 (0.004)	0.420 (0.006)
Kooskia Hatchery					
Kooskia H.	1,500	0.158 (0.013)	0.242 (0.016)	0.381 (0.022)	0.357 (0.029)
Lookingglass Hatchery					
Catherine Cr Pond	20,848	0.272 (0.007)	0.316 (0.008)	0.409 (0.011)	0.289 (0.013)
Grande Ronde R. Pond	1,496	0.244 (0.020)	0.373 (0.024)	0.414 (0.031)	0.327 (0.038)
Imnaha Weir	20,919	0.182 (0.005)	0.301 (0.006)	0.412 (0.007)	0.405 (0.010)
Lostine River Pond	15,985	0.228 (0.005)	0.230 (0.005)	0.390 (0.008)	0.294 (0.010)
Johnson Cr	9,987	0.233 (0.010)	0.426 (0.013)	0.527 (0.016)	0.283 (0.019)
Knox Bridge	55,337	0.208 (0.003)	0.280 (0.004)	0.431 (0.005)	0.341 (0.006)
Pahsimeroi Hatchery					
Pahsimeroi Pond	992	0.204 (0.019)	0.233 (0.021)	0.442 (0.031)	0.262 (0.035)
Rapid River Hatchery					
Rapid River H.	183,920	0.203 (0.001)	0.284 (0.002)	0.415 (0.002)	0.432 (0.003)
Sawtooth Hatchery					
Sawtooth Trap	246	0.106 (0.030)	0.346 (0.049)	0.421 (0.064)	0.573 (0.087)
Salmon R. Trap	250	0.157 (0.038)	0.278 (0.050)	0.397 (0.060)	0.324 (0.077)
Sawtooth H.	989	0.251 (0.026)	0.313 (0.030)	0.465 (0.042)	0.278 (0.048)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
Clearwater Hatchery					
South Fork Clearwater R.	302	0.183 (0.031)	0.340 (0.040)	0.619 (0.065)	0.199 (0.072)
Crooked River Pond	601	0.289 (0.028)	0.377 (0.033)	0.645 (0.057)	0.166 (0.062)
Red River Pond	298	0.294 (0.042)	0.366 (0.053)	0.556 (0.106)	0.148 (0.094)
Dworshak Hatchery					
Clear Creek	900	0.263 (0.021)	0.266 (0.023)	0.413 (0.042)	0.179 (0.043)
South Fork Clearwater R.	900	0.237 (0.019)	0.274 (0.022)	0.532 (0.041)	0.270 (0.050)
Dworshak Hatchery	4,213	0.202 (0.009)	0.283 (0.010)	0.509 (0.019)	0.271 (0.022)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth Hatchery and coho salmon from Kooskia Hatchery in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Num. released	LGR	LGO	LMO	MCN
Sawtooth Hatchery sockeye salmon					
Redfish Lake Creek Trap	994	0.096 (0.029)	0.146 (0.037)	0.394 (0.076)	0.038 (0.038)
Kooskia Hatchery coho salmon					
Kooskia Hatchery	994	0.167 (0.017)	0.323 (0.026)	0.352 (0.036)	0.098 (0.026)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Num. Rel.	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
			Hatchery chinook salmon				
Salmon	14 Mar-25 May	5,049	0.792 (0.016)	0.973 (0.026)	0.963 (0.027)	0.825 (0.033)	0.612 (0.022)
Snake	26 Mar-06 Jun	1,901	0.925 (0.027)	0.965 (0.038)	0.933 (0.040)	0.814 (0.055)	0.677 (0.040)
Imnaha	08 Mar-22 May	2,961	0.775 (0.022)	0.922 (0.034)	0.958 (0.035)	0.822 (0.045)	0.562 (0.027)
			Wild chinook salmon				
Salmon	12 Mar-25 May	5,467	0.844 (0.016)	0.930 (0.023)	1.024 (0.027)	0.778 (0.027)	0.626 (0.018)
Snake	26 Mar-06 Jun	1,393	0.985 (0.038)	0.857 (0.042)	1.012 (0.043)	0.852 (0.055)	0.728 (0.041)
Imnaha	04 Mar-12 Jun	2,319	0.872 (0.022)	0.892 (0.029)	0.994 (0.033)	0.817 (0.040)	0.632 (0.027)
Pahsimeroi (spring)	28 Feb-31 May	1,001	0.706 (0.077)	0.648 (0.092)	0.791 (0.089)	0.665 (0.107)	0.241 (0.037)
Pahsimeroi (June)	01 Jun-30 Jun	906	0.494 (0.057)	0.637 (0.135)	0.538 (0.110)	0.615 (0.112)	0.104 (0.019)
S. F. Salmon	21 Mar-20 May	643	0.510 (0.051)	0.811 (0.094)	0.944 (0.102)	0.905 (0.157)	0.354 (0.058)
Sawtooth	14 Mar-30 May	707	0.585 (0.036)	0.949 (0.070)	1.012 (0.083)	0.895 (0.135)	0.503 (0.070)
Crooked Fork Cr.	28 Mar-17 May	139	0.397 (0.055)	1.030 (0.192)	0.771 (0.188)	1.048 (0.281)	0.330 (0.100)
Clearwater	20 Mar-19 May	563	0.888 (0.048)	0.903 (0.067)	1.096 (0.094)	0.755 (0.100)	0.663 (0.073)

Table 25. Continued

Trap	Release dates	Num. Released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
				Hatchery steelhead			
Salmon	01 Apr-19 May	2,060	0.814 (0.041)	0.858 (0.061)	0.815 (0.065)	0.594 (0.089)	0.338 (0.047)
Snake	01 Apr-07 Jun	5,031	0.893 (0.019)	0.894 (0.028)	1.072 (0.049)	0.527 (0.041)	0.451 (0.030)
Imnaha	11 Mar-02 Jun	2,153	0.834 (0.028)	0.961 (0.048)	0.970 (0.064)	0.620 (0.089)	0.482 (0.064)
				Wild steelhead			
Salmon	01 Apr-19 May	390	0.780 (0.050)	0.979 (0.093)	1.010 (0.161)	0.600 (0.155)	0.463 (0.100)
Snake	26 Mar-07 Jun	2,518	0.899 (0.023)	0.989 (0.039)	1.066 (0.066)	0.527 (0.058)	0.500 (0.048)
Imnaha	07 Mar-12 Jun	4,808	0.816 (0.018)	0.886 (0.026)	0.963 (0.035)	0.532 (0.037)	0.370 (0.023)
Pahsimeroi	02 Mar-31 May	734	0.216 (0.035)	0.787 (0.140)	2.017 (0.700)	0.256 (0.130)	0.088 (0.033)
S. F. Salmon	31 Mar-20 May	84	0.071 (0.028)	1.000 (0.000)	2.000 (1.290)	0.500 (0.479)	0.071 (0.050)
Sawtooth	14 Mar-27 May	196	0.384 (0.061)	0.838 (0.166)	1.072 (0.298)	0.366 (0.177)	0.126 (0.054)
Crooked Fork Cr.	06 Apr-15 May	171	0.663 (0.061)	0.859 (0.095)	0.929 (0.126)	0.919 (0.372)	0.486 (0.191)
				Hatchery sockeye			
Redfish Lake Cr.	18Apr-12 Jun	1,813	0.407 (0.036)	0.752 (0.078)	0.881 (0.078)	0.637 (0.088)	0.172 (0.022)
				Wild sockeye			
Redfish Lake Cr.	18 Apr-06 Jun	627	0.387 (0.043)	0.853 (0.114)	1.165 (0.220)	0.499 (0.129)	0.192 (0.038)

Table 26. Estimated detection probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Num rel	LGR	LGO	LMO	MCN
			Hatchery chinook salmon			
Salmon	14 Mar-25 May	5,049	0.213 (0.008)	0.270 (0.009)	0.408 (0.012)	0.392 (0.016)
Snake	26 Mar-06 Jun	1,901	0.222 (0.012)	0.327 (0.015)	0.422 (0.019)	0.373 (0.025)
Imnaha	08 Mar-22 May	2,961	0.200 (0.010)	0.318 (0.013)	0.402 (0.016)	0.396 (0.022)
			Wild chinook salmon			
Salmon	12 Mar-25 May	5,467	0.234 (0.008)	0.406 (0.010)	0.406 (0.012)	0.467 (0.016)
Snake	26 Mar-06 Jun	1,393	0.214 (0.014)	0.481 (0.018)	0.446 (0.023)	0.452 (0.030)
Imnaha	04 Mar-12 Jun	2,319	0.242 (0.011)	0.368 (0.013)	0.411 (0.016)	0.457 (0.022)
Pahsimeroi (spring)	28 Feb-31 May	1,001	0.212 (0.027)	0.383 (0.035)	0.549 (0.049)	0.344 (0.059)
Pahsimeroi (June)	01 Jun-30 Jun	906	0.348 (0.045)	0.267 (0.051)	0.615 (0.067)	0.692 (0.115)
S. F. Salmon	21 Mar-20 May	643	0.201 (0.029)	0.472 (0.041)	0.460 (0.052)	0.265 (0.054)
Sawtooth	14 Mar-30 May	707	0.252 (0.025)	0.458 (0.033)	0.468 (0.043)	0.269 (0.046)
Crooked Fork Cr.	28 Mar-17 May	139	0.399 (0.075)	0.472 (0.103)	0.706 (0.111)	0.337 (0.131)
Clearwater	20 Mar-19 May	563	0.286 (0.025)	0.429 (0.031)	0.393 (0.039)	0.373 (0.049)
			Hatchery steelhead			
Salmon	01 Apr-19 May	2,060	0.197 (0.014)	0.243 (0.017)	0.440 (0.030)	0.200 (0.031)
Snake	01 Apr-07 Jun	5,031	0.267 (0.009)	0.310 (0.010)	0.338 (0.015)	0.212 (0.016)
Imnaha	11 Mar-02 Jun	2,153	0.246 (0.013)	0.252 (0.014)	0.430 (0.026)	0.155 (0.023)

Table 26. Continued

Trap	Release dates	Num. rel	LGR	LGO	LMO	MCN
			Wild steelhead			
Salmon	01 Apr-19 May	390	0.319 (0.033)	0.373 (0.039)	0.315 (0.052)	0.320 (0.076)
Snake	26 Mar-07 Jun	2,518	0.282 (0.012)	0.298 (0.013)	0.357 (0.021)	0.236 (0.025)
Imnaha	07 Mar-12 Jun	4,808	0.251 (0.009)	0.339 (0.010)	0.486 (0.017)	0.284 (0.020)
Pahsimeroi	02 Mar-31 May	734	0.170 (0.039)	0.368 (0.055)	0.206 (0.075)	0.203 (0.089)
S. F. Salmon	31 Mar-20 May	84	0.167 (0.152)	0.333 (0.192)	0.250 (0.217)	0.500 (0.354)
Sawtooth	14 Mar-27 May	196	0.319 (0.068)	0.333 (0.075)	0.429 (0.120)	0.125 (0.083)
Crooked Fork Cr.	06 Apr-15 May	171	0.388 (0.054)	0.456 (0.060)	0.613 (0.085)	0.250 (0.108)
			Hatchery sockeye			
Redfish Lake Cr.	18Apr-12 Jun	1,813	0.158 (0.019)	0.327 (0.027)	0.448 (0.038)	0.383 (0.052)
			Wild sockeye			
Redfish Lake Cr.	18 Apr-06 Jun	627	0.214 (0.034)	0.354 (0.045)	0.272 (0.054)	0.353 (0.078)

Table 27. Estimated survival probabilities for PIT-tagged yearling chinook salmon released from upper-Columbia River hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Hatchery	Number released	Rel to MCN	MCN to JDA	JDA to BON	Rel to BON
Entiat	59,955	0.533 (0.009)	0.889 (0.034)	NA	NA
Leavenworth	268,986	0.573 (0.005)	0.866 (0.014)	0.863 (0.051)	0.428 (0.025)
Winthrop	19,987	0.505 (0.021)	0.925 (0.081)	NA	NA

Table 28. Estimated detection probabilities for PIT-tagged yearling chinook salmon released upper Columbia River hatcheries in 2002. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Release site	Release number	MCN	JDA	BON
Entiat	59,955	0.379 (0.007)	0.273 (0.009)	NA
Leavenworth	268,986	0.355 (0.003)	0.296 (0.004)	0.158 (0.009)
Winthrop	19,987	0.335 (0.015)	0.208 (0.015)	NA

Table 29. Travel time statistics for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2002. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	LGR to LGO (days)				LGO to LMO (days)				LMO to MCN (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	22	12.0	19.6	27.9	5	4.0	4.5	5.5	7	3.8	5.6	6.2
06 Apr-12 Apr	83	5.0	10.5	19.2	12	4.3	5.9	13.2	24	3.6	4.9	6.1
13 Apr-19 Apr	1,067	6.1	10.4	14.4	334	3.3	5.3	9.2	477	3.5	4.4	5.6
20 Apr-26 Apr	614	6.3	8.4	11.4	266	2.5	3.7	6.6	358	3.2	3.9	4.8
27 Apr-03 May	825	3.2	4.2	5.8	355	2.3	3.4	6.8	429	3.0	3.6	4.3
04 May-10 May	2,579	3.8	5.0	6.6	1,080	2.9	4.2	6.2	1,717	2.8	3.2	3.8
11 May-17 May	1,049	3.0	3.7	4.5	439	2.0	2.7	4.3	476	2.4	2.9	3.3
18 May-24 May	1,587	2.2	2.9	3.9	712	1.7	2.9	5.6	392	2.5	3.0	3.6
25 May-31 May	165	2.4	3.2	4.3	74	1.2	1.5	2.1	17	2.4	2.7	3.2
01 Jun-07 Jun	49	2.4	3.0	4.4	12	1.6	2.3	2.7	4	2.6	2.9	3.2
08 Jun-14 Jun	31	3.0	4.4	6.6	14	1.7	2.5	4.4	7	3.1	3.6	5.1

	LGR to MCN (days)				LGR to BON (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	39	21.2	31.6	36.5	12	30.9	33.9	40.5
06 Apr-12 Apr	116	17.0	24.3	29.3	25	25.8	31.2	38.7
13 Apr-19 Apr	1,697	16.2	19.3	23.4	493	22.8	26.3	30.4
20 Apr-26 Apr	759	12.4	15.9	19.9	221	19.1	22.9	27.4
27 Apr-03 May	966	10.0	12.1	15.5	361	16.1	18.1	21.7
04 May-10 May	4,301	10.2	12.0	14.7	1,869	15.2	17.0	19.9
11 May-17 May	1,081	7.8	9.1	11.0	569	11.9	13.4	15.4
18 May-24 May	807	6.9	8.4	10.6	492	11.0	12.5	15.2
25 May-31 May	33	5.8	7.8	8.8	32	9.0	10.3	12.5
01 Jun-07 Jun	10	5.9	6.9	10.4	21	8.4	10.2	12.2
08 Jun-14 Jun	11	7.8	9.7	10.9	7	12.7	14.2	16.1

Table 30. Migration rate statistics for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2002. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; BON-Bonneville Dam; N-Number of fish observed; Med-Median.

	LGR to LGO (km/day)				LGO to LMO (km/day)				LMO to MCN (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	22	2.2	3.1	5.0	5	8.4	10.2	11.5	7	19.1	21.2	31.1
06 Apr-12 Apr	83	3.1	5.7	11.9	12	3.5	7.8	10.6	24	19.4	24.1	33.4
13 Apr-19 Apr	1,067	4.2	5.8	9.9	334	5.0	8.7	14.1	477	21.3	27.2	34.2
20 Apr-26 Apr	614	5.3	7.2	9.5	266	6.9	12.5	18.3	358	24.7	30.8	36.7
27 Apr-03 May	825	10.4	14.2	19.0	355	6.8	13.3	20.0	429	27.7	33.3	39.5
04 May-10 May	2,579	9.0	12.1	15.9	1,080	7.4	11.1	15.8	1,717	30.9	37.2	43.0
11 May-17 May	1,049	13.3	16.1	20.1	439	10.7	17.1	23.0	476	35.6	41.5	49.2
18 May-24 May	1,587	15.4	20.6	27.3	712	8.2	15.8	26.4	392	33.5	40.2	47.8
25 May-31 May	165	13.9	18.6	25.5	74	22.1	30.3	37.1	17	37.7	43.4	48.8
01 Jun-07 Jun	49	13.5	20.3	24.9	12	17.0	20.2	29.7	4	37.2	41.2	45.6
08 Jun-14 Jun	31	9.1	13.7	20.0	14	10.5	18.3	26.6	7	23.2	33.1	38.9

	LGR to MCN (km/day)				LGR to BON (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	39	6.2	7.1	10.6	12	11.4	13.6	14.9
06 Apr-12 Apr	116	7.7	9.3	13.2	25	11.9	14.8	17.9
13 Apr-19 Apr	1,697	9.6	11.6	13.9	493	15.2	17.5	20.2
20 Apr-26 Apr	759	11.3	14.2	18.2	221	16.8	20.2	24.1
27 Apr-03 May	966	14.6	18.6	22.6	361	21.2	25.5	28.6
04 May-10 May	4,301	15.3	18.7	22.1	1,869	23.2	27.1	30.4
11 May-17 May	1,081	20.4	24.7	28.8	569	29.9	34.4	38.8
18 May-24 May	807	21.1	26.9	32.7	492	30.4	37.0	41.8
25 May-31 May	33	25.5	29.0	38.7	32	36.9	44.7	51.2
01 Jun-07 Jun	10	21.5	32.5	37.9	21	37.8	45.2	54.6
08 Jun-14 Jun	11	20.7	23.1	28.8	7	28.6	32.6	36.3

Table 31. Travel time statistics for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2002. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (days)				JDA to BON (days)				MCN to BON (days)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr-26 Apr	178	4.8	6.0	7.4	25	2.4	2.6	3.1	101	7.1	8.1	9.8
27 Apr-03 May	860	3.6	4.4	5.5	129	2.2	2.6	3.1	402	5.4	6.6	8.2
04 May-10 May	2,970	3.2	3.9	4.8	464	2.2	2.4	2.8	2,045	5.3	6.1	6.8
11 May-17 May	5,080	3.1	3.5	4.1	954	1.9	2.2	2.6	5,035	4.4	5.1	5.8
18 May-24 May	3,133	2.2	2.9	3.6	619	1.7	1.9	2.3	4,147	4.0	4.4	5.1
25 May-31 May	1,252	2.4	2.9	3.5	246	1.5	1.7	2.0	1,192	3.7	4.4	4.8

Table 32. Migration rate statistics for Snake River yearling chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2002. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (km/day)				JDA to BON (km/day)				MCN to BON (km/day)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr-26 Apr	178	16.7	20.3	25.7	25	36.1	43.3	47.1	101	24.2	29.1	33.2
27 Apr-03 May	860	22.2	28.3	34.2	129	36.0	43.1	50.9	402	29.0	35.9	43.6
04 May-10 May	2,970	25.5	31.8	38.8	464	39.8	46.3	52.3	2,045	34.7	38.9	44.2
11 May-17 May	5,080	29.8	34.7	39.4	954	44.1	52.3	58.2	5,035	40.3	46.2	53.4
18 May-24 May	3,133	34.0	43.0	54.9	619	48.9	58.5	65.7	4,147	46.5	53.5	58.6
25 May-31 May	1,252	35.5	42.3	51.5	246	57.9	66.1	75.3	1,192	49.0	53.9	63.6

Table 33. Travel time statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	LGR to LGO (days)				LGO to LMO (days)				LMO to MCN (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr-12 Apr	238	2.6	3.3	4.6	8	7.3	15.6	22.2	6	3.0	3.3	5.7
13 Apr-19 Apr	491	2.1	3.0	5.1	45	3.6	8.8	16.6	27	3.5	3.9	4.8
20 Apr-26 Apr	573	2.8	4.4	6.8	233	2.7	4.8	8.9	174	3.0	3.6	4.8
27 Apr-03 May	982	2.8	3.8	6.3	436	2.6	3.8	7.1	215	3.0	3.8	5.2
04 May-10 May	568	3.5	7.3	11.6	221	2.2	3.2	7.7	213	2.4	3.1	4.0
11 May-17 May	981	3.4	4.5	6.4	460	2.0	2.6	5.0	209	2.2	2.8	3.2
18 May-24 May	1,391	2.4	2.9	4.7	673	1.8	2.8	5.0	198	2.1	2.6	3.1
25 May-31 May	835	1.7	2.7	4.8	384	1.7	2.2	3.4	71	2.0	2.2	2.8
01 Jun-07 Jun	312	1.5	1.9	2.8	109	2.2	3.9	9.0	25	2.1	3.0	3.4
08 Jun-14 Jun	66	1.7	2.0	3.0	31	2.6	3.5	8.1	3	2.3	2.6	2.8

	LGR to MCN (days)				LGR to BON (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr-12 Apr	91	8.8	12.4	21.5	90	14.1	19.5	23.6
13 Apr-19 Apr	262	8.7	13.0	18.2	240	15.3	18.5	25.8
20 Apr-26 Apr	348	10.0	12.4	18.6	212	16.3	21.4	28.7
27 Apr-03 May	431	10.5	14.7	20.7	314	17.1	20.7	29.2
04 May-10 May	436	11.5	14.4	19.1	331	17.8	21.5	27.9
11 May-17 May	396	8.4	9.8	14.5	333	12.6	16.4	20.9
18 May-24 May	344	7.1	9.0	11.4	230	11.5	14.4	17.4
25 May-31 May	150	5.8	7.8	9.6	140	10.1	12.3	16.9
01 Jun-07 Jun	54	6.8	9.3	17.4	66	10.0	12.4	17.4
08 Jun-14 Jun	5	9.5	12.7	18.8	8	12.6	15.3	21.3

Table 34. Migration rate statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2002. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	LGR to LGO (km/day)				LGO to LMO (km/day)				LMO to MCN (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr-12 Apr	238	13.0	18.3	23.3	8	2.1	3.0	6.3	6	20.8	35.8	39.7
13 Apr-19 Apr	491	11.7	20.0	28.0	45	2.8	5.2	12.7	27	24.9	30.5	34.2
20 Apr-26 Apr	573	8.9	13.8	21.1	233	5.2	9.5	16.8	174	24.6	32.7	39.8
27 Apr-03 May	982	9.6	15.7	21.7	436	6.5	12.1	17.8	215	22.9	31.1	40.2
04 May-10 May	568	5.2	8.2	16.9	221	5.9	14.6	21.2	213	30.0	38.8	49.2
11 May-17 May	981	9.3	13.4	17.8	460	9.3	18.0	22.8	209	37.1	43.3	53.1
18 May-24 May	1,391	12.7	20.5	25.3	673	9.3	16.2	24.9	198	38.3	45.4	57.5
25 May-31 May	835	12.5	22.4	35.3	384	13.3	20.5	26.6	71	43.1	53.1	59.5
01 Jun-07 Jun	312	21.6	31.7	39.2	109	5.1	11.7	21.2	25	34.6	40.2	56.1
08 Jun-14 Jun	66	20.1	30.2	35.1	31	5.7	13.3	17.4	3	41.9	45.2	50.9

	LGR to MCN (km/day)				LGR to BON (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr-12 Apr	91	10.4	18.2	25.7	90	19.6	23.6	32.6
13 Apr-19 Apr	262	12.4	17.3	25.7	240	17.9	24.9	30.1
20 Apr-26 Apr	348	12.1	18.2	22.4	212	16.1	21.6	28.3
27 Apr-03 May	431	10.9	15.3	21.3	314	15.8	22.3	27.0
04 May-10 May	436	11.8	15.6	19.5	331	16.5	21.5	25.9
11 May-17 May	396	15.5	22.9	26.9	333	22.0	28.1	36.4
18 May-24 May	344	19.8	25.1	31.7	230	26.4	32.0	40.1
25 May-31 May	150	23.5	28.8	39.0	140	27.3	37.4	45.6
01 Jun-07 Jun	54	12.9	24.2	33.2	66	26.4	37.1	46.3
08 Jun-14 Jun	5	12.0	17.7	23.6	8	21.7	30.1	36.6

Table 35. Travel time statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at McNary Dam in 2002. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (days)				JDA to BON (days)				MCN to BON (days)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr-26 Apr	91	3.7	5.0	8.1	22	2.0	2.4	2.9	107	5.4	6.4	9.3
27 Apr-03 May	172	3.6	4.5	6.4	39	1.8	2.2	2.7	195	5.4	6.5	8.0
04 May-10 May	102	3.5	4.0	5.2	21	2.0	2.3	2.5	178	5.1	5.6	7.0
11 May-17 May	74	3.5	4.2	5.9	19	1.7	1.8	2.1	105	5.1	5.7	7.4
18 May-24 May	130	2.9	3.8	5.1	21	1.4	1.7	1.9	191	4.4	5.1	7.0
25 May-31 May	104	2.6	3.3	3.9	27	1.4	1.6	2.1	147	4.4	5.0	6.1
01 Jun-07 Jun	52	2.2	2.6	3.5	6	1.6	1.6	1.8	96	3.4	3.7	4.4

Table 36. Migration rate statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at McNary Dam in 2002. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (km/day)				JDA to BON (km/day)				MCN to BON (km/day)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr-26 Apr	91	15.1	24.7	33.2	22	38.8	46.7	57.9	107	25.4	36.7	43.9
27 Apr-03 May	172	19.2	27.1	34.2	39	41.4	52.3	64.2	195	29.5	36.4	43.7
04 May-10 May	102	23.7	30.8	34.8	21	44.8	50.0	56.2	178	33.7	41.8	46.3
11 May-17 May	74	20.8	29.6	34.9	19	52.8	62.1	67.3	105	32.0	41.6	45.9
18 May-24 May	130	23.9	32.6	42.6	21	58.2	65.7	78.5	191	33.6	46.4	54.0
25 May-31 May	104	31.7	37.3	47.9	27	54.9	68.9	79.0	147	38.8	47.4	53.8
01 Jun-07 Jun	52	35.1	47.1	54.9	6	64.6	71.1	72.4	96	53.3	63.3	69.2

Table 37. Number of PIT-tagged hatchery juvenile steelhead released at Lower Granite by day for survival estimates in 2002. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost Tags
10 Apr	175		2	10 May	908	4	
11 Apr	175		3	11 May	912	2	1
12 Apr	176		6	14 May	805	5	
13 Apr	175		4	15 May	804	9	
16 Apr	141		1	16 May	805	4	3
17 Apr	140			17 May	805	5	
18 Apr	139		1	18 May	805	5	1
19 Apr	141		1	21 May	445	1	
20 Apr	138		5	22 May	465		1
23 Apr	350	2	4	23 May	455		4
24 Apr	350	1	4	24 May	455		
25 Apr	350		3	25 May	455		
26 Apr	350		1	29 May	350	1	
27 Apr	350			30 May	349		
30 Apr	769	5	3	31 May	351	1	
01 May	770	2	1	01 Jun	350		2
02 May	770	1	1	04 Jun	140		
03 May	769			05 Jun	140		
04 May	770	2	1	06 Jun	140		
07 May	910	3	3	07 Jun	140		1
08 May	910	2	3	08 Jun	141		
09 May	910	2	2				

Table 38. Annual weighted means of survival probability estimates for Snake River yearling chinook salmon (hatchery and wild combined), 1993-2002. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two-project estimate to facilitate comparison with other single-project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; IHR-Ice Harbor Dam; MCN-McNary Dam; JDA-John Day Dam; TDA-The Dalles Dam; BON-Bonneville Dam.

Year	LGR-LGO	LGO-LMO	LMO-MCN *	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1993	0.854 (0.012)						
1994	0.830 (0.009)	0.847 (0.010)					
1995	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
Mean	**0.918**	**0.897**	**0.840**	**0.917**	**0.848**	**0.746**	**0.864**
exc. 2001	0.921	0.905	0.859	0.927	0.870	0.779	0.883

Table 39. Annual weighted means of survival probability estimates for Snake River steelhead (hatchery and wild combined), 1994-2002. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two-project estimate to facilitate comparison with other single-project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; IHR-Ice Harbor Dam; MCN-McNary Dam; JDA-John Day Dam; TDA-The Dalles Dam; BON-Bonneville Dam.

Year	LGR-LGO	LGO-LMO	LMO-MCN *	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1994	0.844 (0.011)	0.892 (0.011)					
1995	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
Mean	**0.899**	**0.890**	**0.738**	**0.859**	**0.757**	**0.747**	**0.864**
exc. 2001	0.911	0.912	0.801	0.895	0.862	0.746	0.864

Table 40. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River yearling chinook salmon and steelhead (hatchery and wild combined), 1998-2002. Standard errors in parentheses. Abbreviations: Trap-Snake River Trap; LGR-Lower Granite Dam; BON-Bonneville Dam.

	Yearling Chinook Salmon			Steelhead		
Year	Trap-LGR	LGR-BON	Trap-BON	Trap-LGR	LGR-BON	Trap-BON
1998	NA	NA	NA	0.924 (0.009)	0.500 (0.054)	0.462 (0.050)
1999	0.941 (0.009)	0.557 (0.046)	0.524 (0.043)	0.908 (0.011)	0.440 (0.011)	0.400 (0.016)
2000	0.922 (0.014)	0.486 (0.093)	0.448 (0.086)	0.954 (0.013)	0.393 (0.034)	0.375 (0.032)
2001	0.956 (0.014)	0.279 (0.016)	0.267 (0.015)	0.912 (0.007)	0.042 (0.003)	0.038 (0.003)
2002	0.953 (0.022)	0.578 (0.060)	0.551 (0.057)	0.895 (0.015)	0.262 (0.050)	0.234 (0.045)

Table 41. Estimated survival probabilities between McNary and John Day Dams for various yearling chinook salmon stocks detected and released to the tailrace of McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; SP-spring chinook salmon; S-F-summer/fall chinook salmon.

	Snake River		Upper Columbia R. (SP)		Yakima River		Upper Columbia R. (S-F)	
Date at MCN	Number released	MCN to JDA Survival	Number released	MCN to JDA Survival	Number released	MCN to JDA Survival	Number released	MCN to JDA Survival
19 Apr-Apr 25	619	0.840 (0.147)	630	0.984 (0.193)	476	0.729 (0.113)		
26 Apr-02 May	2,199	0.969 (0.080)	546	0.716 (0.114)	981	0.925 (0.142)	579	0.962 (0.420)
03 May-09 May	13,588	0.893 (0.034)	2,667	0.849 (0.083)	3,112	0.974 (0.073)	1,855	0.905 (0.184)
10 May-16 May	25,553	0.876 (0.021)	5,734	0.848 (0.049)	468	0.959 (0.170)	1,978	0.811 (0.150)
17 May-23 May	26,751	0.958 (0.030)	8,776	0.885 (0.038)	407	0.926 (0.174)	2,391	0.860 (0.101)
24 May-30 May	8,558	0.860 (0.044)	4,807	0.831 (0.039)	181	0.807 (0.174)	2,428	0.876 (0.109)
31 May-06 Jun	2,284	0.850 (0.133)	827	0.810 (0.170)			1,273	0.854 (0.294)
07 Jun-13 Jun	166	0.814 (0.165)						
14 Jun-20 Jun	183	0.747 (0.138)						

Table 42. Estimated detection probabilities at John Day Dam for various yearling chinook salmon stocks detected and released to the tailrace of McNary Dam in 2002. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: JDA-John Day Dam; SP-spring chinook salmon; S-F-summer/fall chinook salmon.

	Snake River		Upper Columbia R. (SP)		Yakima River		Upper Columbia R. (S-F)	
Date at MCN	Number released	JDA Detection	Number released	JDA Detection	Number released	JDA Detection	Number released	JDA Detection
19 Apr-Apr 25	619	0.267 (0.050)	630	0.240 (0.050)	476	0.395 (0.066)		
26 Apr-02 May	2,199	0.284 (0.025)	546	0.378 (0.064)	981	0.280 (0.045)	579	0.199 (0.089)
03 May-09 May	13,588	0.225 (0.009)	2,667	0.268 (0.028)	3,112	0.281 (0.023)	1,855	0.200 (0.042)
10 May-16 May	25,553	0.240 (0.006)	5,734	0.261 (0.016)	468	0.256 (0.050)	1,978	0.178 (0.034)
17 May-23 May	26,751	0.127 (0.005)	8,776	0.281 (0.013)	407	0.244 (0.051)	2,391	0.219 (0.027)
24 May-30 May	8,558	0.183 (0.010)	4,807	0.355 (0.018)	181	0.342 (0.083)	2,428	0.208 (0.027)
31 May-06 Jun	2,284	0.116 (0.020)	827	0.185 (0.041)			1,273	0.076 (0.027)
07 Jun-13 Jun	166	0.348 (0.081)						
14 Jun-20 Jun	183	0.409 (0.085)						

Table 43. Average survival estimates (with standard errors in parentheses) from point of release to Bonneville Dam tailrace for various spring-migrating salmonid stocks in 2002. For each reach, the survival estimate represents a weighted average of daily or weekly estimates (some of which are presented in other Tables in this document). In some cases, fish from separate release sites were pooled at downstream sites so survival estimates were identical. Abbreviations: RLS-release site; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; SP-spring chinook salmon; SP-SU-spring/summer; S-F-summer/fall chinook salmon.

		Survival Estimates (standard errors)				
Stock	Release Location	RLS-MCN	MCN-JDA	RLS-JDA	JDA-Bonneville	RLS-BON
Snake R. Chinook (SP-SU)	Lower Granite Dam	0.757 (0.009)	0.907 (0.014)	0.687 (0.013)	0.840 (0.079)	0.578 (0.060)
U. Columbia Chinook (SP)	Leavenworth H.	0.573 (0.005)	0.856 (0.012)	0.490 (0.008)	0.867 (0.079)	0.427 (0.040)
U. Columbia Chinook (SP)	Winthrop H.	0.505 (0.021)	0.856 (0.012)	0.432 (0.019)	0.867 (0.079)	0.376 (0.038)
U. Columbia Chinook (SP)	Entiat H.	0.533 (0.009)	0.856 (0.012)	0.456 (0.010)	0.867 (0.079)	0.397 (0.037)
U. Columbia Chinook (S-F)	Rock Island Dam	0.795 (0.022)	0.866 (0.013)	0.688 (0.022)	NA	NA
U. Columbia Chinook (S-F)	Rocky Reach Dam	0.746 (0.021)	0.866 (0.013)	0.646 (0.021)	NA	NA
Yakima R. Chinook	Several Locations	NA[1]	0.922 (0.037)	NA[1]	NA	NA[1]
Snake R. Steelhead	Lower Granite Dam	0.536 (0.025)	0.844 (0.063)	0.452 (0.040)	0.612 (0.098)	0.262 (0.050)

[1] Fish were released at numerous locations in the Yakima River basin. Single point of release to McNary survival estimate not possible.

Table 44. Percent of PIT-tagged smolts (wild and hatchery combined) detected at Lower Monumental Dam later detected on McNary pool bird colonies, 1998-2002.

Year	Yearling chinook salmon	Steelhead
1998	0.49	4.20
1999	0.84	4.51
2000	0.98	3.66
2001	5.59	21.06
2002	1.19	10.09

FIGURES

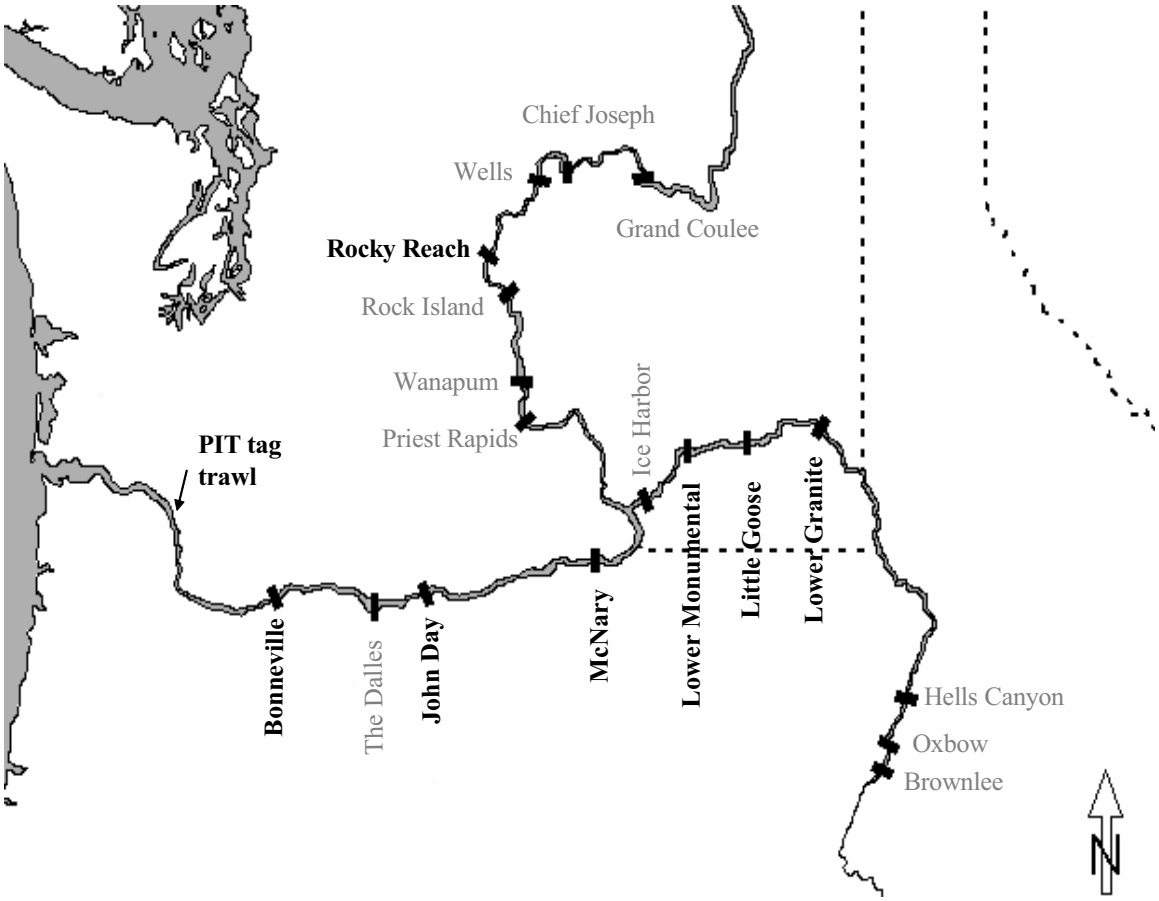

Figure 1. Study area showing sites with PIT-tag detection facilities (names in black), including dams and the PIT-tag trawl in the Columbia River estuary. Dams with names in gray do not have detection facilities.

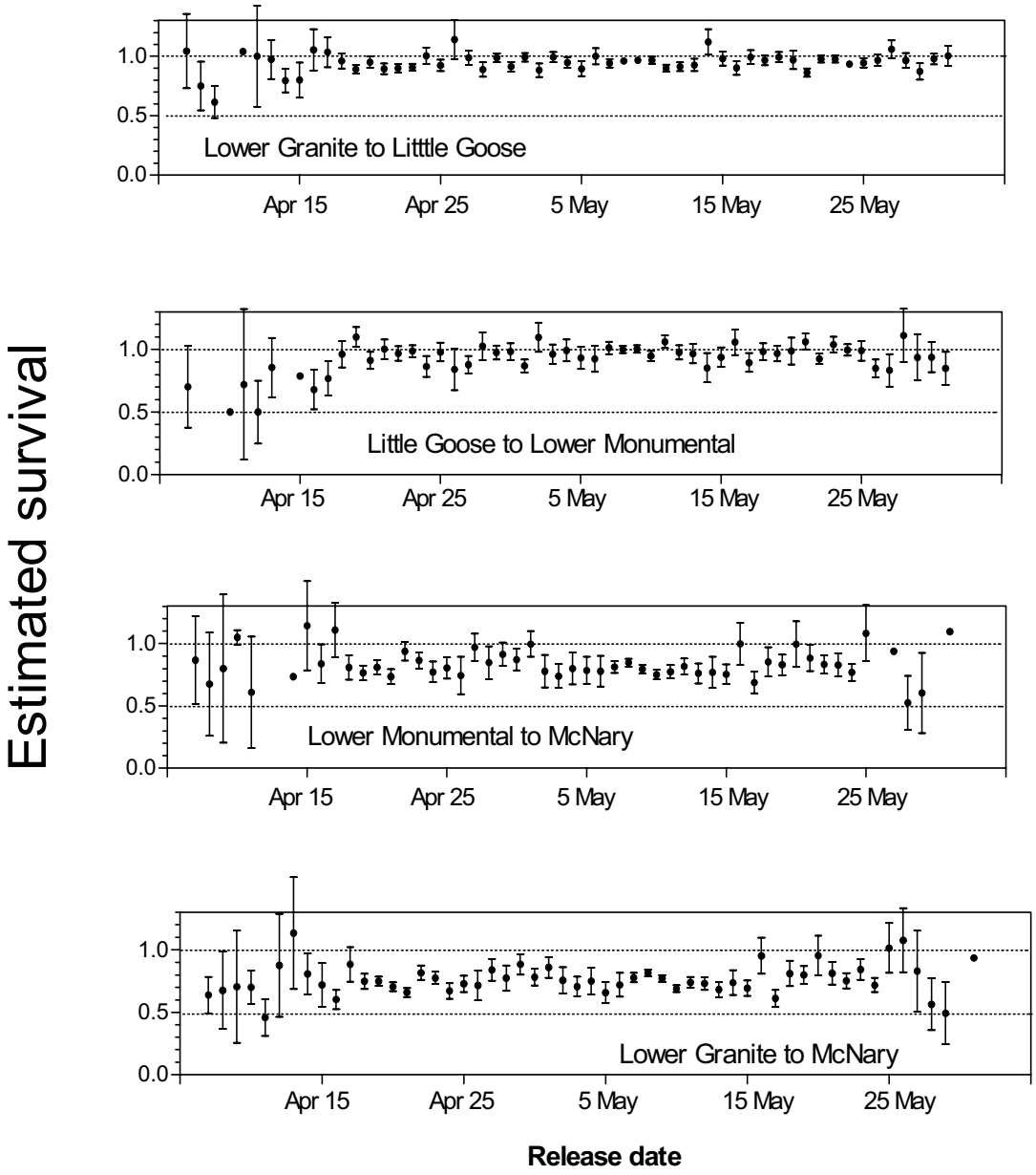

Figure 2. Estimated survival through various reaches vs. release date at Lower Granite Dam for daily release groups of Snake River yearling chinook salmon. Bars extend one standard error above and below point estimates.

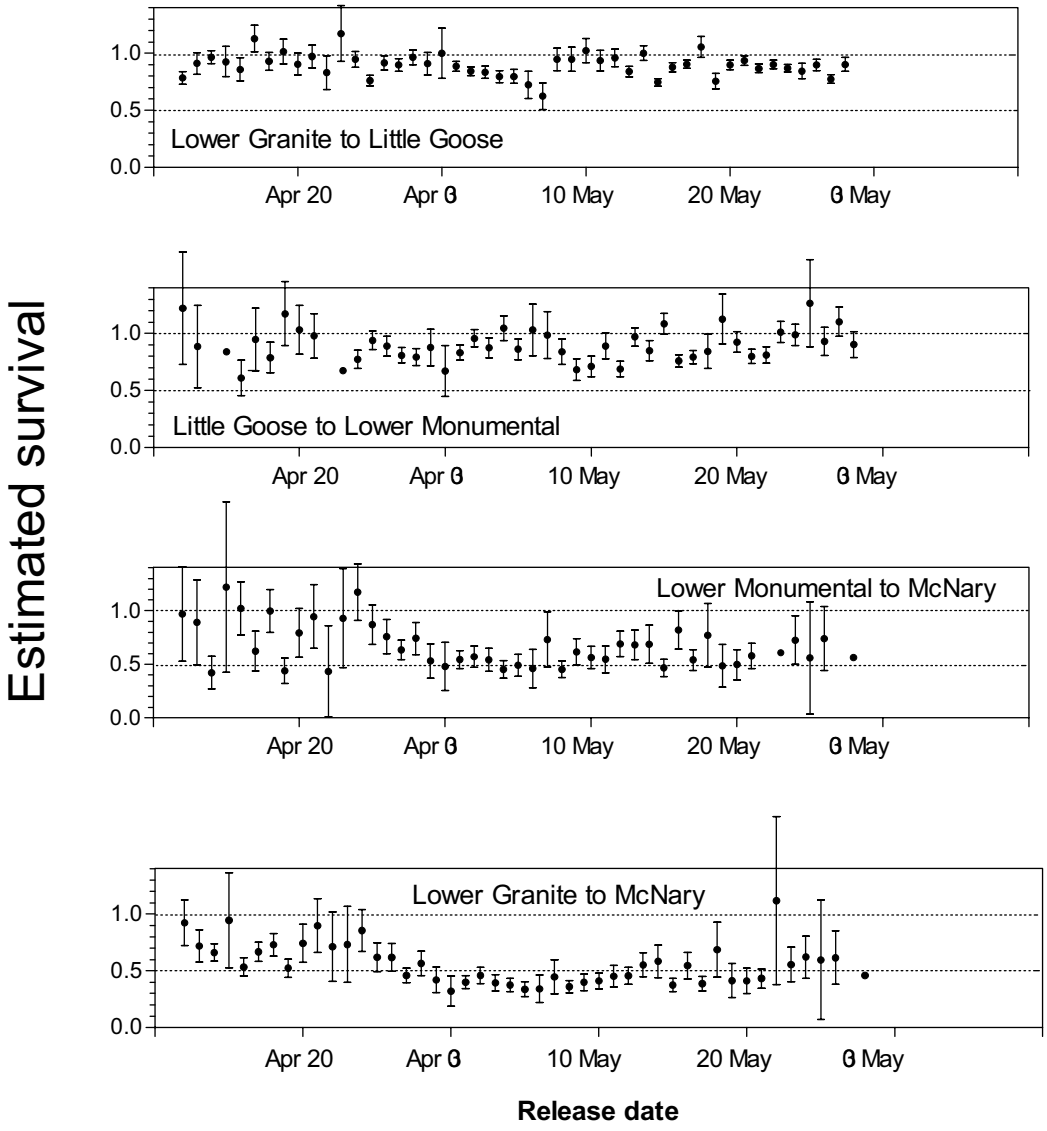

Figure 3. Estimated survival through various reaches versus release date at Lower Granite Dam for daily release groups of Snake River steelhead. Bars extend one standard error above and below point estimates.

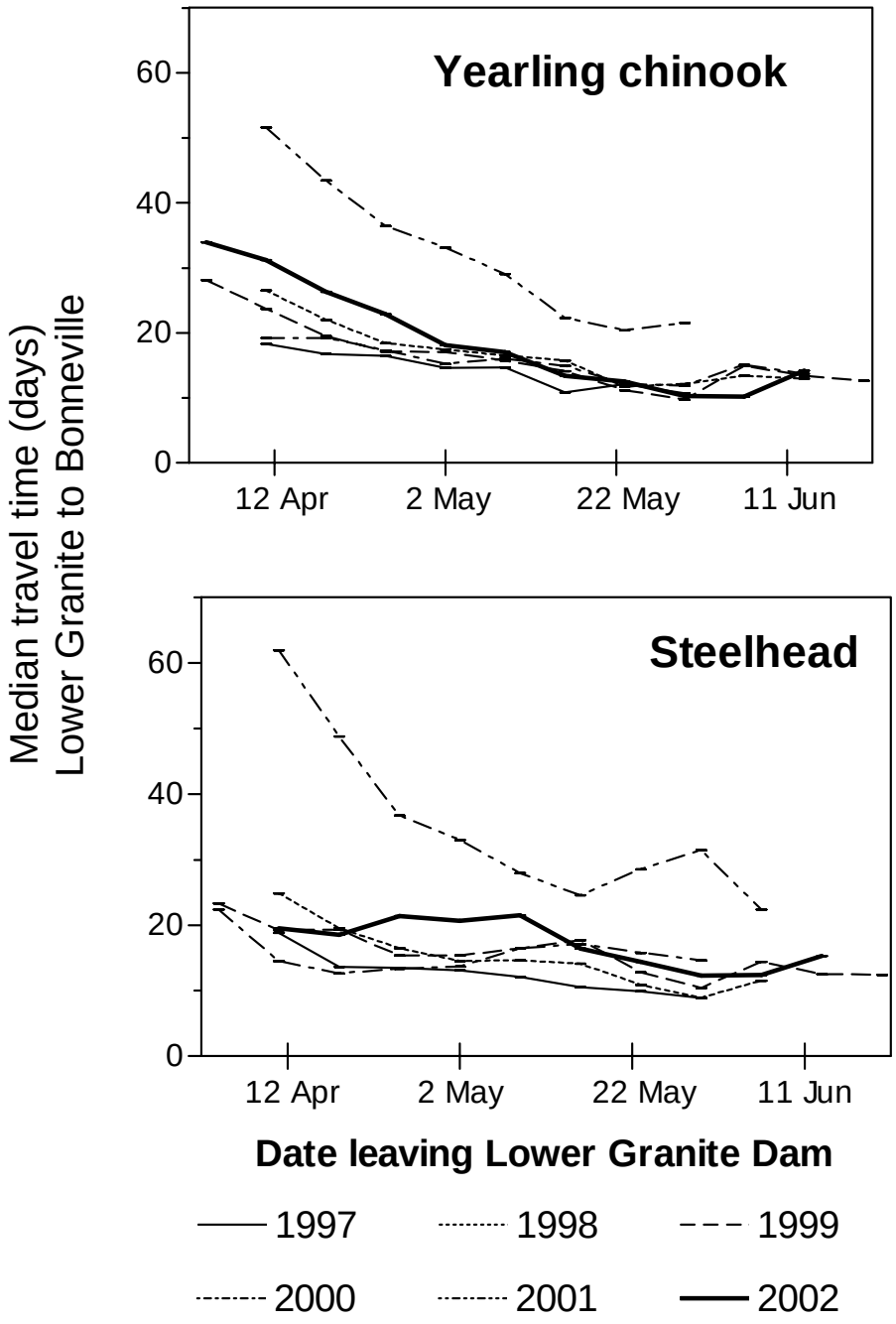

Figure 4. Median travel time (days) from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yealing chinook salmon and steelhead from Lower Granite Dam, 1997-2002.

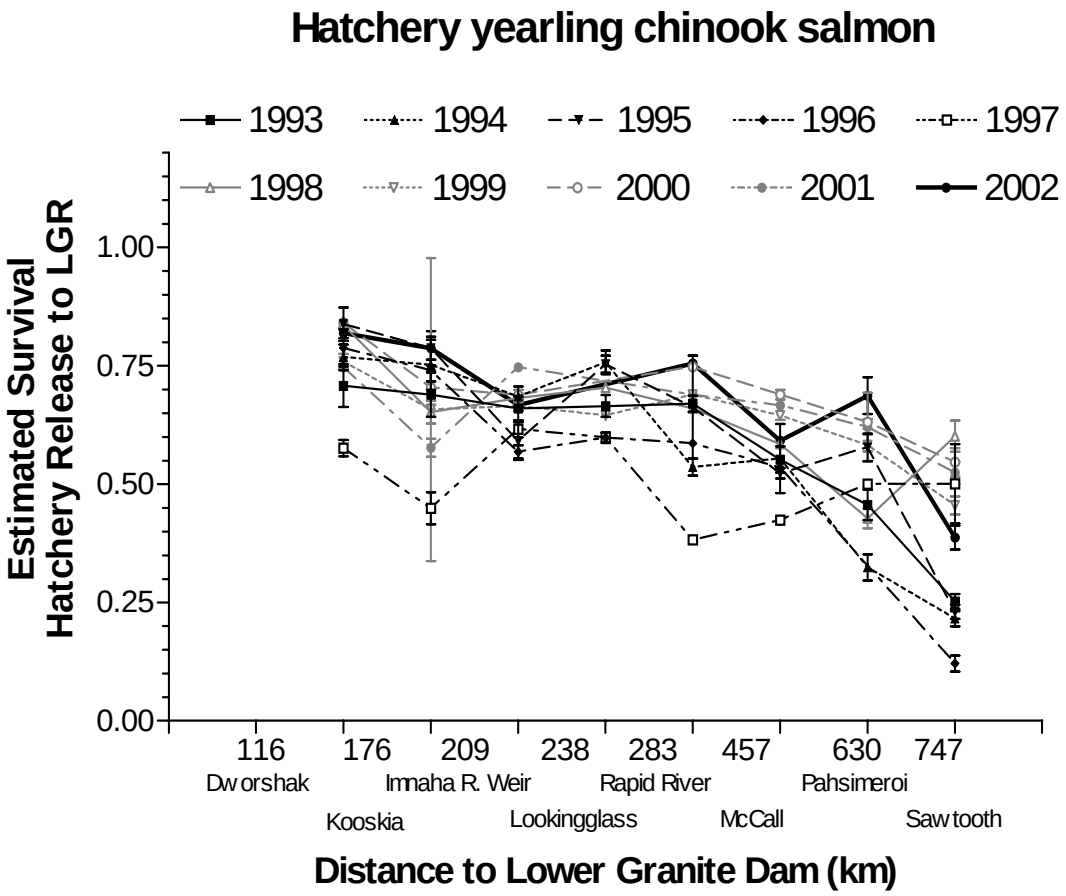

Figure 5. Estimated survival to Lower Granite Dam (LGR) tailrace for PIT-tagged yearling chinook salmon released from Snake River Basin hatcheries, 1993-2002. Distance from release to Lower Granite Dam (km) and standard errors also shown.

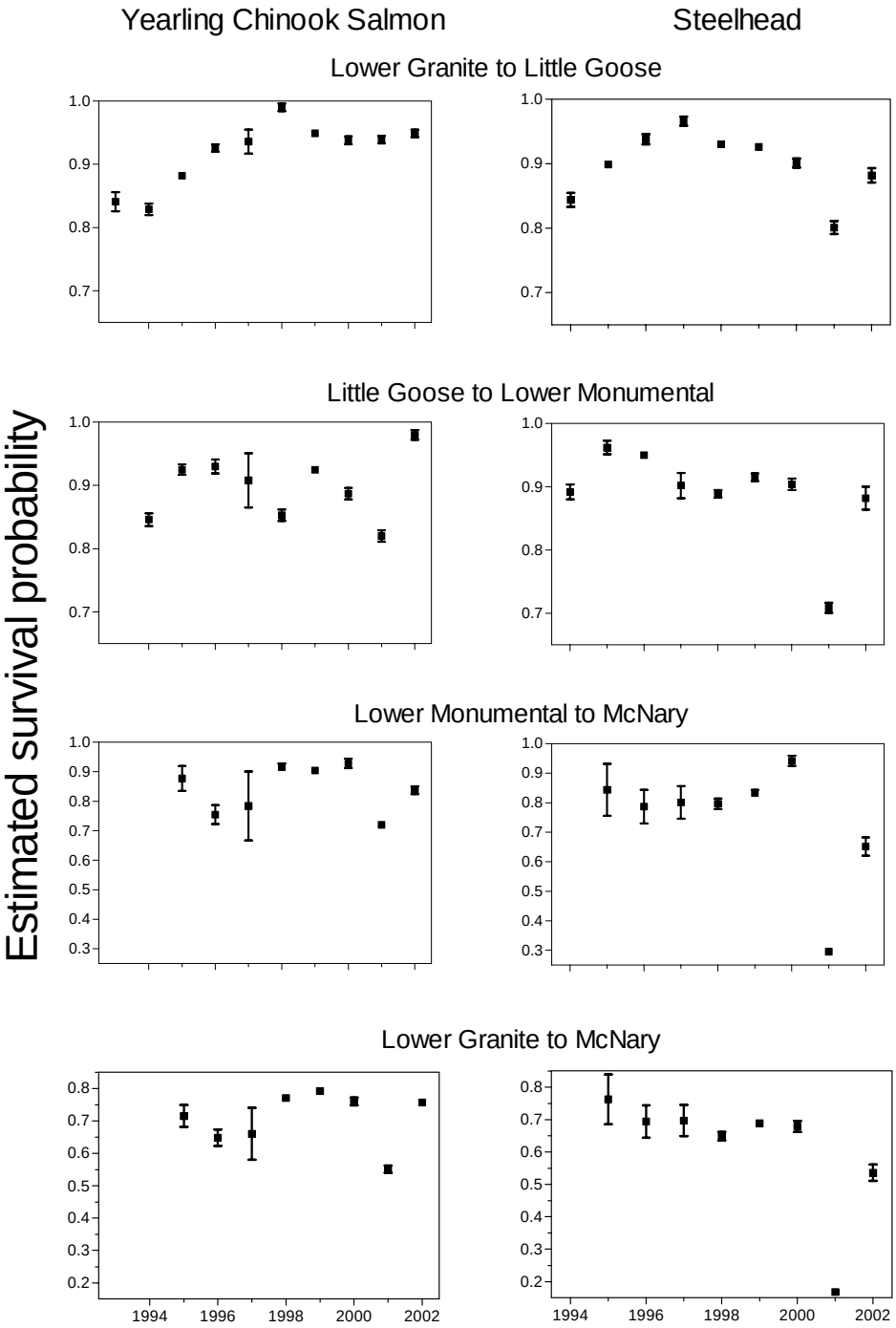

Figure 6. Annual average survival estimates for PIT-tagged yearling chinook salmon and steelhead through Snake River reaches, 2002. Estimates are from tailrace to tailrace with standard errors.

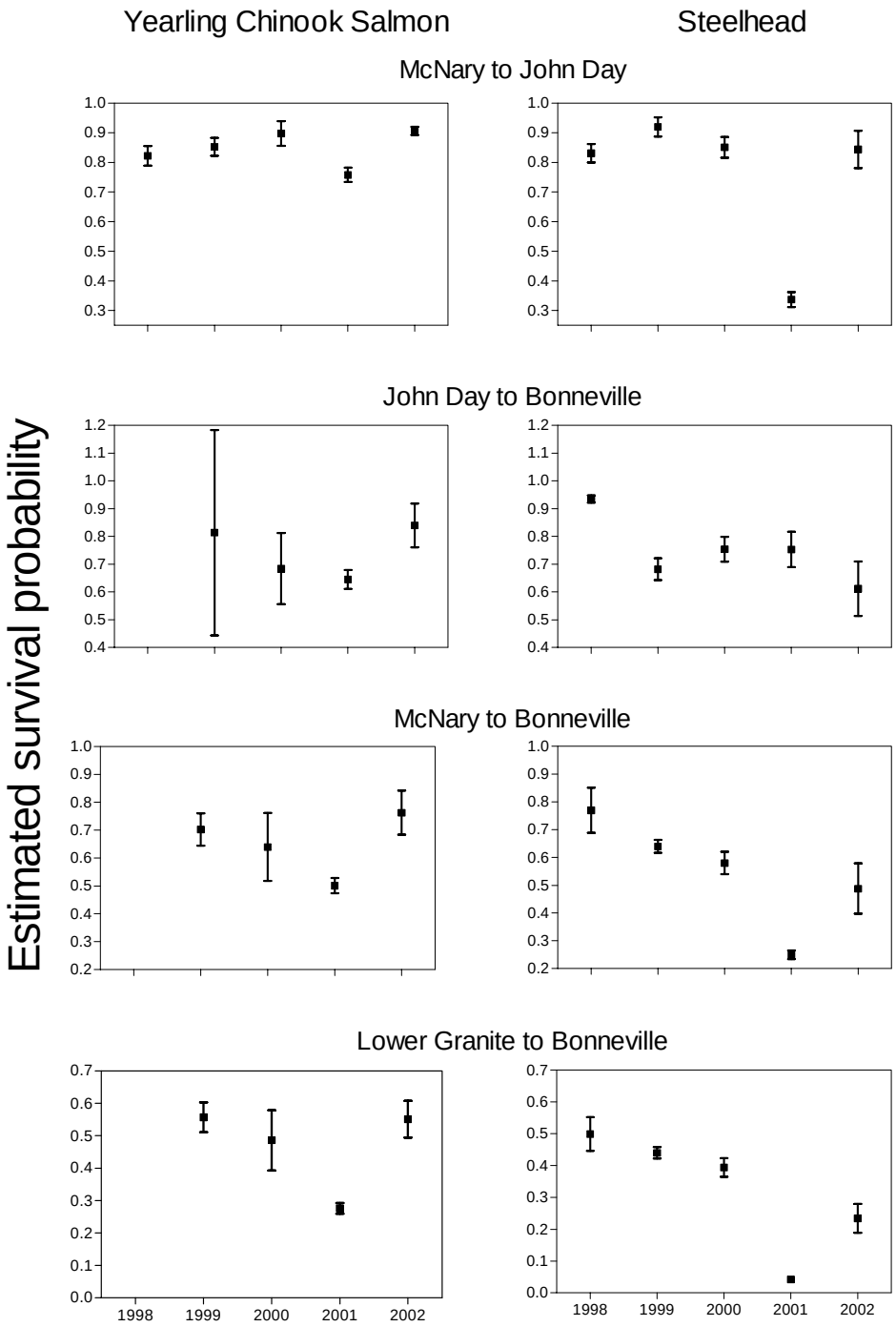

Figure 7. Annual average survival estimates for PIT-tagged Snaker River yearling chinook salmon and steelhead through Columbia River reaches and from Lower Granite Dam to Bonneville Dam, 2002. Estimates are from tailrace to tailrace with standard errors

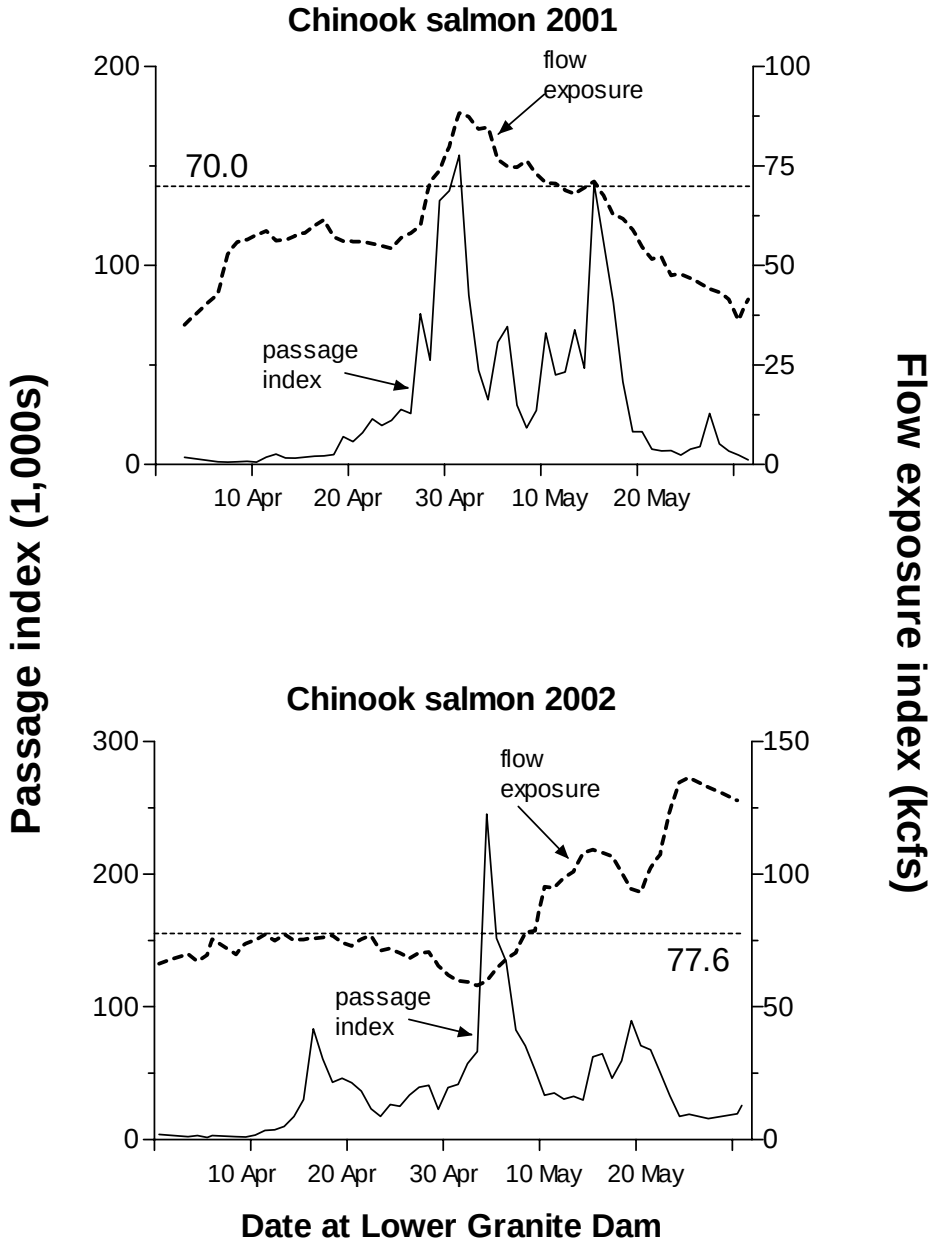

Figure 8. Passage index for yearling chinook salmon at Lower Granite Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged yearling chinook salmon from Lower Granite dam during 2001 and 2002. Horizontal dotted lines represent the average flow exposure index, weighted by number of PIT-tagged fish in each group.

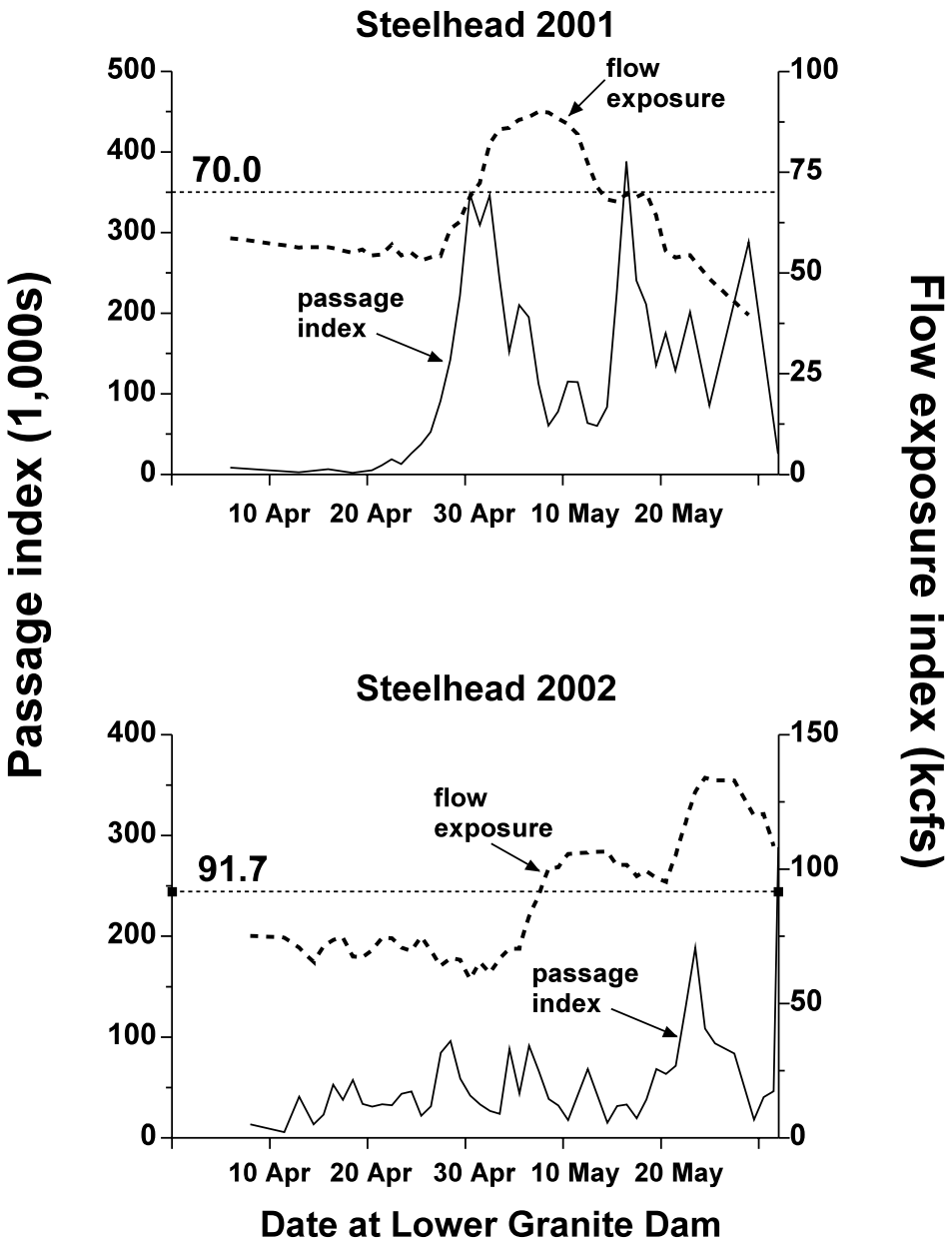

Figure 9. Passage index for steelhead at Lower Granite Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged steelhead from Lower Granite dam during 2001 and 2002. Horizontal dotted lines represent the average flow exposure index, weighted by number of PIT-tagged fish in each group.

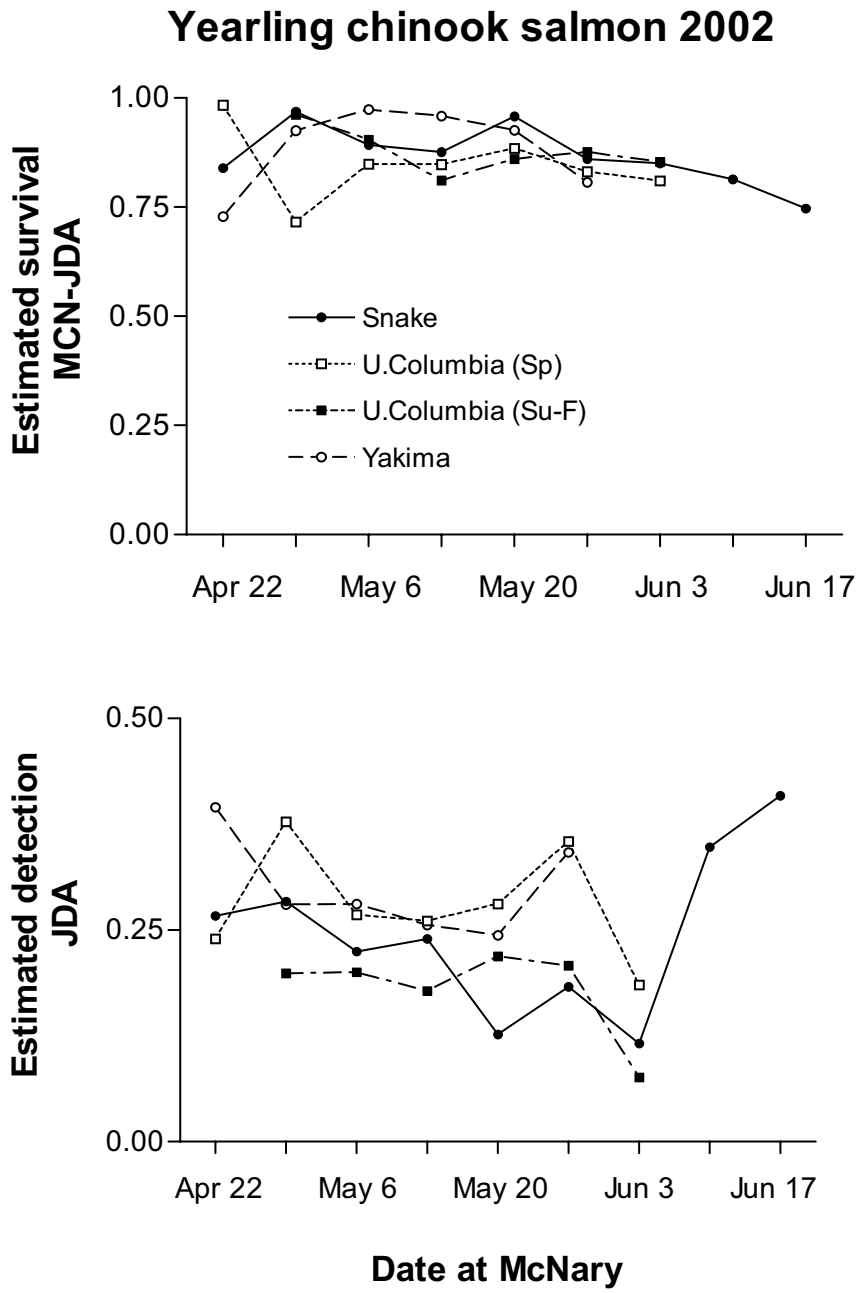

Figure 10. Estimated survival probability between McNary Dam tailrace and John Day Dam tailraice and detection probability at John Day Dam for weekly groups of PIT-tagged yearling chinook salmon detected at McNary Dam, 2002. Dates plotted are midpoints of week. Upper Columbia River fish separated into spring (Sp) and summer/fall (Su-F) stocks.

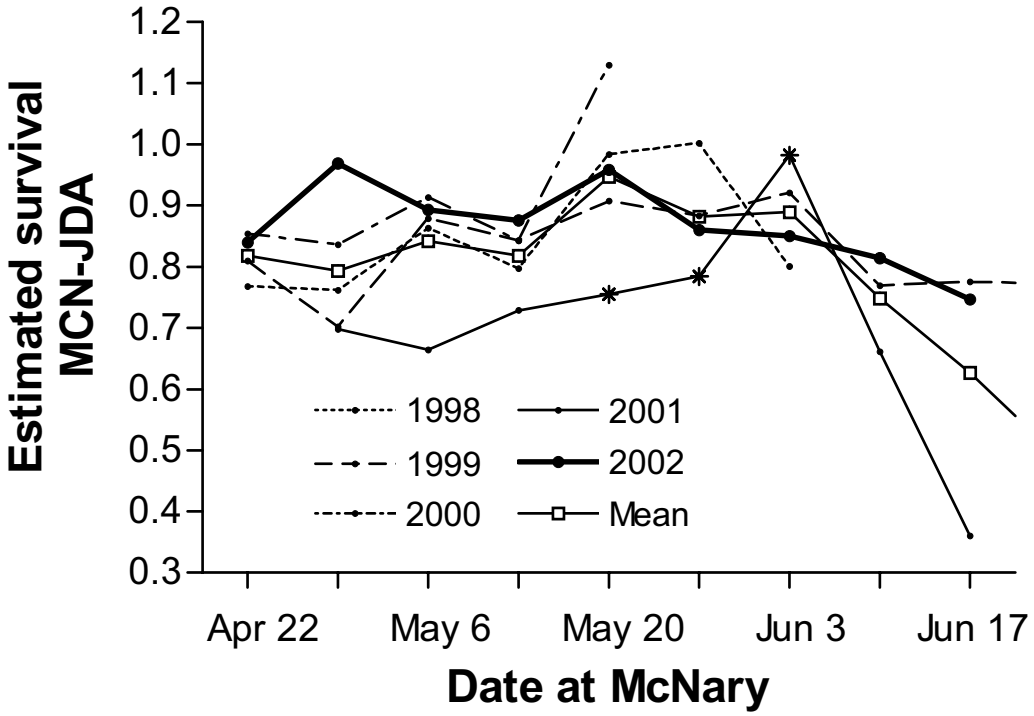

Figure 11. Estimated survival probability between McNary Dam tailrace and John Day Dam tailrace for weekly groups of PIT-tagged Snake River yearling spring/summer chinook salmon, 1998-2002. Dates plotted are midpoints of week. Three weekly groups migrated during the spill period at John Day Dam in 2001: weekly midpoints 20 May, 27 May, and 03 June (points marked with asterisk).

APPENDIX TABLES

Appendix Table 1. Number of tests of goodness of fit to the Single Release Model conducted for weekly release groups of yearling chinook salmon and steelhead (hatchery and wild combined) from Lower Granite Dam, and number of significant ($\alpha = 0.05$) test results, 2002.

	Test 2.C2		Test 2.C3		Test 3.SR3		Test 3.Sm3	
Species	No.	sig.	No.	sig.	No.	sig.	No.	sig.
Chinook	11	1	11	0	11	1	9	0
Steelhead	10	0	10	0	10	2	9	0
Total	21	1	21	0	21	3	18	0

	Test 3.SR4		Test 2 sum		Test 3 sum		Test 2 + 3	
	No.	sig.	No.	sig.	No.	sig.	No.	sig.
Chinook	11	2	11	1	11	1	11	0
Steelhead	9	0	10	0	10	2	10	0
Total	20	2	21	1	21	3	21	0

Appendix Table 2. Results of tests of goodness of fit to the Single Release Model for release groups of yearling chinook salmon (hatchery and wild) from Lower Granite to McNary Dam in 2002.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P*	χ^2	*P*	χ^2	*P*	χ^2	*P*
30 Mar-05 Apr	3.82	0.58	2.15	0.54	1.82	0.40	0.34	0.56
06 Apr-12 Apr	7.31	0.20	1.25	0.74	0.06	0.97	1.19	0.28
13 Apr-19 Apr	11.54	0.07	8.41	0.04	8.13	0.02	0.28	0.60
20 Apr-26 Apr	2.00	0.92	1.03	0.79	0.97	0.62	0.06	0.81
27 Apr-03 May	10.20	0.12	4.43	0.22	2.77	0.25	1.66	0.20
04 May-10 May	11.33	0.08	4.61	0.20	4.59	0.10	0.02	0.90
11 May-17 May	4.46	0.62	3.96	0.27	0.80	0.67	3.16	0.08
18 May-24 May	4.18	0.65	3.06	0.38	2.75	0.25	0.32	0.58
25 May-31 May	8.56	0.20	4.54	0.21	4.27	0.12	0.27	0.61
01 Jun-07 Jun	2.23	0.90	0.61	0.89	0.09	0.96	0.52	0.47
08 Jun-14 Jun	1.55	0.91	0.78	0.68	0.09	0.76	0.69	0.41
Total (d.f.)	67.20 (63)	0.34	34.83 (32)	0.33	26.35 (21)	0.19	8.48 (11)	0.67

Appendix Table 2. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P*	χ^2	*P*	χ^2	*P*	χ^2	*P*
30 Mar-05 Apr	1.67	0.43	0.28	0.60	NA	NA	1.39	0.24
06 Apr-12 Apr	6.07	0.048	5.04	0.03	NA	NA	1.03	0.31
13 Apr-19 Apr	3.13	0.37	0.56	0.45	0.00	0.97	2.57	0.11
20 Apr-26 Apr	0.97	0.81	0.65	0.42	0.27	0.61	0.04	0.83
27 Apr-03 May	5.78	0.12	0.46	0.50	0.23	0.63	5.09	0.02
04 May-10 May	6.72	0.08	0.03	0.87	0.04	0.84	6.65	0.01
11 May-17 May	0.50	0.92	0.01	0.94	0.04	0.85	0.46	0.50
18 May-24 May	1.12	0.77	0.24	0.62	0.74	0.39	0.14	0.71
25 May-31 May	4.03	0.26	2.34	0.13	0.03	0.86	1.66	0.20
01 Jun-07 Jun	1.63	0.65	0.41	0.52	0.68	0.41	0.53	0.47
08 Jun-14 Jun	0.77	0.86	0.56	0.46	0.13	0.71	0.08	0.78
Total (d.f.)	32.36 (31)	0.40	10.57 (11)	0.48	2.16 (9)	0.99	19.64 (11)	0.051

Appendix Table 3. Results of tests of goodness of fit to the Single Release Model for release groups of juvenile steelhead (hatchery and wild) from Lower Granite to McNary Dam in 2002.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P*	χ^2	*P*	χ^2	*P*	χ^2	*P*
06 Apr-12 Apr	3.92	0.69	3.01	0.39	2.49	0.29	0.52	0.47
13 Apr-19 Apr	7.30	0.29	5.42	0.14	5.33	0.07	0.09	0.76
20 Apr-26 Apr	5.16	0.52	0.95	0.81	0.36	0.84	0.59	0.44
27 Apr-03 May	9.10	0.17	1.17	0.76	1.10	0.58	0.07	0.79
04 May-10 May	3.27	0.78	2.07	0.56	0.91	0.64	1.16	0.28
11 May-17 May	10.71	0.10	2.19	0.53	2.04	0.36	0.15	0.70
18 May-24 May	3.97	0.68	2.78	0.43	2.34	0.31	0.44	0.51
25 May-31 May	8.10	0.23	4.04	0.26	3.46	0.18	0.59	0.44
01 Jun-07 Jun	3.45	0.75	2.83	0.42	1.27	0.53	1.56	0.21
08 Jun-14 Jun	5.38	0.15	2.08	0.35	1.54	0.21	0.54	0.46
Total (d.f.)	60.37 (57)	0.35	26.54 (29)	0.60	20.83 (19)	0.35	5.70 (10)	0.84

Table A1.3. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P*	χ^2	*P*	χ^2	*P*	χ^2	*P*
06 Apr-12 Apr	0.92	0.82	0.89	0.35	0.00	1.00	0.03	0.87
13 Apr-19 Apr	1.88	0.60	0.19	0.66	1.61	0.20	0.08	0.78
20 Apr-26 Apr	4.22	0.24	2.53	0.11	1.51	0.22	0.18	0.67
27 Apr-03 May	7.93	0.048	5.11	0.02	2.51	0.11	0.31	0.58
04 May-10 May	1.20	0.75	0.13	0.72	0.12	0.73	0.96	0.33
11 May-17 May	8.52	0.04	6.11	0.01	1.91	0.17	0.50	0.48
18 May-24 May	1.20	0.75	0.44	0.51	0.48	0.49	0.28	0.59
25 May-31 May	4.06	0.26	0.96	0.33	3.08	0.08	0.02	0.89
01 Jun-07 Jun	0.62	0.89	0.49	0.48	0.10	0.75	0.02	0.88
08 Jun-14 Jun	3.30	0.07	3.30	0.07	NA	NA	NA	NA
Total (d.f.)	33.83 (28)	0.21	20.14 (10)	0.03	11.32 (9)	0.25	2.38 (9)	0.98

Appendix Table 4. Number of tests of goodness of fit to the Single Release Model conducted for weekly release groups of yearling chinook salmon and steelhead (hatchery and wild combined) from McNary Dam, and number of significant ($\alpha = 0.05$) test results, 2002.

	Test 2.C3		Test3.SR4		Test 2 + 3	
Spp.	#	sig.	#	sig.	#	sig.
Chinook	5	0	5	0	4	0
Steelhead	4	0	1	0	4	0
Total	9	0	6	0	8	0

Appendix Table 5. Results of tests of goodness of fit to the Single Release Model for release groups of yearling chinook salmon (hatchery and wild) from McNary to Bonneville Dam in 2002.

	Overall		Test 2.C2		Test 3.SR3	
Release	c^2	*P*	c^2	*P*	c^2	*P*
20 Apr-26 Apr	NA	NA	NA	NA	NA	NA
27 Apr-03 May	0.003	0.96	0.003	0.96	NA	NA
04 May-10 May	1.94	0.38	1.92	0.17	0.02	0.89
11 May-17 May	1.86	0.40	1.44	0.23	0.42	0.52
18 May-24 May	1.99	0.37	1.86	0.17	0.12	0.73
25 May-31 May	0.83	0.66	0.40	0.53	0.44	0.51
Total (d.f.)	6.61 (9)	0.68	5.62 (5)	0.34	1.00 (4)	0.91

Appendix Table 6. Results of tests of goodness of fit to the Single Release Model for release groups of steelhead (hatchery and wild) from McNary to Bonneville Dam in 2002.

	Overall		Test 2.C2		Test 3.SR3	
Release	c^2	*P*	c^2	*P*	c^2	*P*
20 Apr-26 Apr	NA	NA	NA	NA	NA	NA
27 Apr-03 May	0.71	0.40	0.71	0.40	NA	NA
04 May-10 May	0.02	0.90	0.02	0.90	NA	NA
11 May-17 May	NA	NA	NA	NA	NA	NA
18 May-24 May	2.08	0.15	2.08	0.15	NA	NA
15 May-31 May	0.13	0.94	0.10	0.76	0.03	0.86
01 Jun-07 Jun	NA	NA	NA	NA	NA	NA
Total (d.f.)	2.93 (5)	0.71	2.90 (4)	0.58	0.03 (1)	0.86