Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2005

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EXECUTIVE SUMMARY

In 2005, the National Marine Fisheries Service and the University of Washington completed the thirteenth 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 18,439 hatchery steelhead, 5,315 wild steelhead, and 6,964 wild yearling Chinook salmon at Lower Granite Dam in the Snake River. In addition, we utilized fish PIT tagged by other agencies at traps and hatcheries upstream from the hydropower system and at sites within the hydropower system in both the Snake and Columbia Rivers. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, 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 Asingle-release model@).

Primary research objectives in 2005 were

1) Estimate reach 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.
3) Evaluate the survival estimation models under prevailing conditions.

This report provides reach survival and travel time estimates for 2005 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. Additional details on the methodology and statistical models used are provided in previous reports cited here.

Survival and detection probabilities were estimated precisely for most of the 2005 yearling Chinook salmon and steelhead migrations. Hatchery and wild fish were combined in some of the analyses. Overall, the percentages for combined release groups used in survival analyses in the Snake River were 81% hatchery-reared yearling Chinook salmon and 19% wild. For steelhead, the overall percentages were 75% hatchery-reared and 25% wild.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.919 for yearling Chinook salmon and 0.940 for steelhead. Respective average survival estimates for yearling Chinook salmon and steelhead through the following reaches were 0.886 and 0.867 from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.903 and 0.722 from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam), and 0.772 and 0.595 from McNary Dam tailrace to John Day Dam tailrace.

The estimate of survival for yearling Chinook salmon from John Day Dam tailrace to Bonneville Dam tailrace (including passage through The Dalles Dam) was not precise: the point estimate exceeded 1.000, with a large standard error. We were unable to estimate survival through this reach at all for steelhead during 2005 because too few fish were detected at Bonneville Dam due to operation of the corner collector at the second powerhouse.

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 average survival through the entire hydropower system from the head of Lower Granite reservoir to the tailrace of Bonneville Dam (eight projects) was 0.530 (s.e. 0.063) for Snake River yearling Chinook salmon during 2005. We could not empirically estimate survival through the entire system for steelhead in 2005 because of the low detection rates for this species at Bonneville Dam.

For yearling spring Chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace was 0.534 (s.e. 0.014) for fish released from Leavenworth Hatchery, 0.635 (s.e. 0.034) for fish released from Entiat Hatchery, 0.324 (s.e. 0.048) for fish released from Wells Hatchery, and 0.469 (s.e. 0.034) for fish released from Winthrop Hatchery. Using pooled data, estimated survival for these groups averaged 0.848 (s.e. 0.090) from McNary Dam tailrace to John Day tailrace and 0.893 (s.e. 0.427) from John Day Dam tailrace to Bonneville Dam tailrace.

For 16 groups of steelhead released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.526 (s.e. 0.016) for fish from Wells Hatchery released in the Chewuch River in April (453 km from McNary Dam) to 0.126 (s.e. 0.018) for fish released at the same location in May. Using pooled data, estimated survival for these groups averaged 0.749 (s.e. 0.045) from McNary Dam tailrace to John Day tailrace, and 0.716 (s.e. 0.120) from John Day Dam tailrace to Bonneville Dam tailrace.

Because forecasted flows were below NMFS BiOp targets, transportation was maximized and voluntary spill curtailed in the Snake River during the 2005 migration, similar to 2001 and 2004 operations. However, flows during the time that fish actually migrated in the Snake River were higher than in recent years. Spill began at Snake River dams on 17 May, when flows exceeded powerhouse capacity, and continued through about 26 May. The migration for spring migrants was more compressed than usual and during much of the peak of the migration, turbidity was high.

Compared to 2004, yearling Chinook salmon survival in 2005 was higher through most reaches, and steelhead survival was higher through all reaches where it could be measured. Hydropower system survival for yearling Chinook salmon was the second highest measured from 1999 through 2005. Steelhead survival remained depressed compared to earlier years through some reaches and through the reaches combined. PIT-tag detections on avian bird colonies continued to account for much of the additional steelhead loss in those reaches compared with earlier years.

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INTRODUCTION

Accurate and precise survival estimates are needed for depressed stocks of 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. 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 recovery strategies that will optimize smolt survival during migration (Williams and Matthews 1995; Williams et al. 2001).

From 1993 through 2005, the National Marine Fisheries Service (NMFS) and the University of Washington (UW) developed survival estimates for these stocks using detections 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, 2003; Smith et al. 1998, 2000a,b, 2003, 2005; Hockersmith et al. 1999; Zabel et al. 2001, 2002). In 2005, NMFS and UW completed the thirteenth year of the study. The forecast for 2005 spring-time flows were below the NMFS Biological Opinion (BiOp) flow targets. As a result, spill was curtailed at Snake River dams for most of the spring migration season, and transportation was maximized, similar to project operations in 2001 and 2004.

Research objectives in 2005 were:

1) Estimate reach 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.
3) Evaluate the performance of the survival-estimation models under prevailing operational and environmental conditions.

Additionally, as adult return information becomes available, we will evaluate relationships between juvenile survival and subsequent adult returns for fish with different juvenile migration histories. This task was recently completed for adult returns to date, and the results were reported by Williams et al. (2005).

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 (Cormack 1964; Jolly 1965; Seber 1965; Skalski 1998; Skalski et al. 1998; Muir et al. 2001a). Iwamoto et al. (1994) presented background information and underlying statistical theory pertaining to the SR model. In 2005, PIT-tagged fish used for survival estimates were released from hatcheries, traps, and Lower Granite Dam in the Snake River Basin, and from hatcheries and dams in the Upper Columbia River.

During the 2005 migration season, automatic PIT-tag detectors (Prentice et al. 1990a,b,c) were operational in the juvenile bypass systems at the following seven dams: Lower Granite (rkm 695), Little Goose (rkm 635), Lower Monumental (rkm 589), Ice Harbor (rkm 538), McNary (rkm 470), John Day (rkm 347), and Bonneville (rkm 234) Dams (Figure 1). The farthest downstream site of 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. 2004). During spring 2005, the corner collector was operated at Bonneville Dam Second Powerhouse; this collector diverted many smolts away from the PIT tag detectors in the second powerhouse bypass system, resulting in a loss of detections for analysis.

A large proportion of PIT-tagged yearling Chinook salmon used in this analysis were released in the Snake River above Lower Granite Dam for a multi-agency comparative survival study (CSS). Of the CSS study fish detected at Lower Granite Dam in 2005, 60% were collected and transported; of those detected at Little Goose Dam, 30% were transported. A large proportion of PIT-tagged steelhead used in this analysis were released in the Upper Columbia River for a study of transportation from McNary Dam. From the transportation study, about 43% of steelhead detected at McNary Dam 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 records of downstream PIT-tag detections with the SR model to estimate survival in the following six reaches:

- Point of release to Lower Granite Dam tailrace
- Lower Granite Dam tailrace to Little Goose Dam tailrace

- Little Goose Dam tailrace to Lower Monumental Dam tailrace
- Lower Monumental Dam tailrace to McNary Dam tailrace
- McNary Dam tailrace to John Day Dam tailrace
- John Day Dam tailrace to Bonneville Dam tailrace

Although the PIT-tag detection system in the Ice Harbor Dam juvenile bypass facility began operating in 2005, because of the high level of spill at this dam, too few smolts were detected there to partition survival between Lower Monumental and McNary Dams.

For fish released in the Upper Columbia River, we estimated survival in the following three reaches:

- Point of release to the tailrace of McNary Dam
- McNary Dam tailrace to John Day Dam tailrace
- John Day Dam tailrace to Bonneville Dam tailrace (for yearling Chinook salmon only).

Lower Granite Dam Tailrace Release Groups

During 2005, hatchery and wild steelhead and wild yearling Chinook salmon were collected at the Lower Granite Dam juvenile facility, PIT tagged, and released to the tailrace for survival estimates. Fish were collected in approximate proportion to the numbers arriving at Lower Granite Dam during the migration season. However, in the early and late periods of the season, we tagged relatively more fish in order to provide sufficient numbers for analysis over these periods. No hatchery yearling Chinook salmon were PIT tagged specifically for this study because the numbers of fish PIT tagged and released from Snake River Basin hatcheries and traps 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. These groups were then combined with 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 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 (yearling Chinook salmon only in 2005).

Hatchery and Trap Release Groups

In 2005, 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, coho salmon, and steelhead to provide survival estimates and detection probabilities from release to the tailrace of Lower Granite Dam and to points downstream. We estimated survival to the tailrace of McNary Dam for yearling spring Chinook salmon released from Winthrop, Entiat, Leavenworth, and Wells hatcheries. Survival to McNary Dam was also estimated for steelhead released from Wells, Chelan, East Bank, Ringold, Lyons Ferry, Turtle Rock, and Winthrop 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 estimated survival to Lower Granite Dam tailrace and points downstream for releases of wild and hatchery PIT-tagged yearling Chinook salmon and steelhead from the Salmon (White Bird), Snake, and Clearwater River traps, and many more smolt traps throughout the Snake River Basin. Survival was also estimated for releases of yearling summer/fall Chinook salmon and steelhead from four Upper and Mid Columbia River dams to the tailrace of McNary Dam and to 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 all locations at which the tagged fish had been detected and all locations at which it had not been detected. Methods for data retrieval, database quality assurance/control, and construction of detection histories were the same as those used in past years (see Iwamoto et al. 1994 for detail).

These analyses were conducted using the data available at the time. 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). These evaluations are detailed in the Appendix.

Survival Estimation

Estimates of survival probability 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 probabilities 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, 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 of yearling Chinook salmon and steelhead were calculated for the following reaches:

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)
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 that of detected fish, which pass to the tailrace via the juvenile bypass system.

Comparison of Annual Survival Estimates

We made two comparisons of 2005 results to those obtained in previous years of the NMFS/UW survival study. First, we related migration distance to survival estimates from specific hatcheries to Lower Granite Dam. Second, we compared season-wide survival estimates for specific reaches across years.

Flow and Spill In Relation to Juvenile Salmonid Survival and Travel Time

Annual travel time and reach survival estimates were compared across years to investigate relationships with general flow and spill conditions during the spring migration. Trends within the 2005 season were also examined.

RESULTS

Lower Granite Dam Tagging and Release Information

During 2005, a total of 102,514 yearling Chinook salmon (83,397 hatchery origin, 19,117 wild) were detected and released or PIT tagged and released to the river in the tailrace of Lower Granite Dam. Steelhead we tagged at Lower Granite Dam and released to the tailrace were combined with those released upstream, detected at the dam, and returned to the river, for a total of 48,819 (36,696 hatchery origin, 11,973 wild, 150 unknown).

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 (82% hatchery) and steelhead (75% hatchery) during 2005.

Survival Estimation

Tests of Assumptions

Assumption tests for 2005 indicated more significant differences between observed and expected detection proportions than would be expected by chance alone. In many cases, sample sizes were such that the contingency table-based tests had power to detect cases where violations had minimal effect on survival estimates. We present a detailed discussion of the assumption tests, the extent of violations, possible reasons for the occurrence of the violations, and their implications in the Appendix.

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 12 consecutive weeks from 30 March through 21 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.919 (s.e. 0.003; Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.886 (s.e. 0.006). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.903 (s.e. 0.010). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.732 (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 27 April through 7 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.772 (s.e. 0.021; Table 2). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 1.028 (s.e. 0.132). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.788 (s.e. 0.092).

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 0.577 (s.e. 0.068). Estimated survival probability through Lower Granite reservoir and Dam for Snake River wild and hatchery Chinook salmon released from the Snake River trap was 0.919 (s.e. 0.015). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River yearling Chinook salmon was 0.530 (0.063).

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 and 4). Weighted mean survival estimates for hatchery yearling Chinook salmon were higher than for wild yearling Chinook salmon for the combined reach from the tailrace of Lower Granite Dam to the tailrace of McNary Dam in 2005.

Estimated survival probabilities for daily release groups of yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam did not show any consistent increase or decrease through Snake River reaches during the 2005 migration season (Table 5; Figure 2).

Estimates of detection probability varied little throughout the season for most weekly groups, as no spill was provided from the beginning of April through 17 May at Snake River Dams (Tables 6-9). The latest (very small) group of yearling Chinook salmon, which left Lower Granite Dam between 15 and 21 June, passed dams under high spill levels in the summertime (Tables 6 and 8). Detection probabilities were more variable at John Day and Bonneville Dams, primarily because of varying levels of spill.

Snake River Steelhead

We estimated survival probabilities for weekly groups of steelhead from 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 0.940 (s.e. 0.004; Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.867 (s.e. 0.009). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.722 (s.e. 0.023). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.593 (s.e. 0.018).

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of McNary Dam for four consecutive weeks from 27 April through 24 May. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.595 (s.e. 0.040; Table 11). Because of poor detection rates for steelhead at Bonneville Dam, we were unable to estimate survival from John Day Dam tailrace to Bonneville Dam tailrace or for the combined reach from McNary to Bonneville Dam.

Lacking an estimate of survival from the tailrace of John Day Dam to the tailrace of Bonneville Dam, we were unable to empirically estimate survival through the entire hydropower system for steelhead in 2005. The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to John Day Dam provided an overall average survival estimate from Lower Granite Dam tailrace to John Day Dam tailrace of 0.353 (s.e. 0.026). Estimated survival through Lower Granite reservoir and Dam for Snake River wild and hatchery steelhead released from the Snake River trap was 0.967 (s.e. 0.004). Thus, the estimated survival probability through six of the eight hydropower projects encountered by Snake River steelhead was 0.341 (s.e. 0.025).

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

Similar to yearling Chinook salmon, estimated survival probabilities for daily release groups of steelhead (hatchery and wild combined) detected and released to the tailrace of Lower Granite Dam did not show any consistent increase or decrease through Snake River reaches during the 2005 migration season (Table 14; Figure 3).

Estimates of detection probability at Snake River dams for the weekly steelhead groups varied little throughout the season as there was no spill provided from the beginning of April through 17 May at Snake River Dams (Tables 15-18). Detection probabilities were more variable at John Day Dam, primarily because of varying levels of spill.

Snake River Hatchery Release Groups

Survival probabilities were estimated for PIT-tagged hatchery yearling Chinook salmon, sockeye salmon, coho salmon, and steelhead from release at Snake River Basin hatcheries to the tailrace of Lower Granite Dam and to downstream dams. These estimates varied among hatcheries and release locations (Tables 19-21), as did estimated detection probabilities among detection sites (Tables 22-24).

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 from 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 and steelhead from release at Upper Columbia River hatcheries to the tailrace of McNary Dam varied among hatcheries and release locations (Table 27). Detection probabilities at downstream dams were similar for most yearling Chinook salmon and steelhead from all 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). 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 (Figure 4). Travel time for yearling Chinook salmon and steelhead from Lower Granite to McNary Dam decreased during early- to mid-April independent of flow (Figure 5) (i.e., travel time decreased considerably without corresponding changes in flow).

Tagging Details for fish PIT Tagged at Lower Granite Dam

We PIT-tagged and released 18,439 hatchery steelhead, 5,315 wild steelhead, and 6,964 wild yearling Chinook salmon from 12 April through 11 June at Lower Granite Dam for survival estimates (Table 37-39). Total mortalities of hatchery steelhead, wild steelhead, and yearling Chinook salmon were 27, 6, and 48, respectively. Each of these numbers represented less than 1% of the total number of fish handled.

Comparison of Annual Survival Estimates

Estimates of yearling Chinook salmon survival from Snake River Basin hatcheries to Lower Granite Dam tailrace for 2005 were similar to those made in past recent years for most hatcheries, but were considerably lower in 2005 for Pahsimeroi and Sawtooth hatcheries (Table 40). 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 (Figure 6). For 1993-2005 estimates, the negative linear correlation between migration distance and average estimated survival was significant ($R^2 = 0.951$, $P = 0.002$).

For yearling Chinook salmon (hatchery and wild combined), estimated survival in 2005 was higher than that estimated in 2004 through most reaches (Table 41; Figures 7-8). For steelhead, survival estimates in 2005 were higher than in 2004 through all reaches where it could be measured. Steelhead survival remained depressed through the reaches from Lower Monumental to McNary Dam and McNary to John Day Dam (Table 42; Figures 7-8).

For yearling Chinook salmon, mean survival for all years combined was similar through each of the Snake River reaches (0.90-0.93) and similar but lower through Columbia River reaches (0.84-0.89; Table 41). For steelhead, mean survival across years showed a slight decline through successive reaches, and was lowest through the McNary to John Day reach (0.715), the reach with the longest reservoir (Table 42).

For several years, we have combined empirical survival estimates for yearling Chinook salmon and steelhead over various reaches to derive estimates of survival throughout the entire Snake River hydropower system, from the head of Lower Granite reservoir (Snake River smolt trap) to the tailrace of Bonneville Dam (Table 43). Data were sufficient for these estimates starting in 1999 for yearling Chinook and 1997 for steelhead, but were not sufficient for steelhead in 2004 and 2005. For yearling Chinook in 2005, estimated hydropower system survival was 0.530 (s.e. 0.063). This was the

second highest survival estimate to date, and was exceeded only by the 2002 estimate of 0.551 (s.e. 0.057).

Flow and Spill In Relation to Juvenile Salmonid Survival and Travel Time

Snake River flow volume during the yearling Chinook salmon migration period was expressed as flow exposure index at Lower Monumental Dam for each release group. The flow exposure index is derived from average flow per day weighted by the numbers of fish detected that day. Thus, values of the exposure index are very similar to those of daily average flow at the dam.

For yearling Chinook, the average flow exposure index in 2005 (95.3 kcfs) was nearly the same as in 2003 (93.5 kcfs), but was higher than in 2004 (76.9 kcfs) and in other recent years (Figure 9). For steelhead, the average flow exposure index during 2005 was 96.7 kcfs; slightly above the flow exposure in 2004 (90.8 kcfs), but lower than in 2003 (117.4 kcfs (Figure10). Flows at Lower Monumental Dam increased in late April and continued to increase through the peak of the migration.

Because of forecasted low flows, transportation of smolts was maximized, and no spill was provided at Lower Granite and Lower Monumental Dams from the beginning of the migration in early April until 17 May. Spill began at those dams on 17 May, when flows exceeded powerhouse capacity, and continued through about 26 May. At Little Goose Dam, only limited spill occurred from 17 through 23 May. Voluntary springtime spill continued at all other Snake and Columbia River Dams.

In comparisons among years, yearling Chinook salmon and steelhead travel times between Lower Granite and Bonneville Dam in 2005 were similar to those in past years during most of the migration, and were much shorter than travel times observed during 2001 (Figure 4). Through most reaches, estimated survival of yearling Chinook salmon was higher in 2005 than in 2004 and 2001 (Figures 7-8; Table 41). For steelhead, survival estimates were also higher in 2005 than in 2004 and 2001 in all reaches where it could be measured. However, survival remained depressed relative to some earlier years in the reaches from Lower Monumental to McNary Dam and from McNary to John Day Dam (Figures 7-8; Table 42).

Survival Estimates from Point of Release to Bonneville Dam

Yearling spring/summer Chinook salmon from Lower Granite Dam on the Snake River migrated past seven projects, while yearling summer/fall Chinook salmon from Rocky Island Dam on the Upper Columbia River migrated past six projects to the tailrace of Bonneville Dam. Estimated survival between these stocks was similar, at 0.577 (0.068) for Snake River stocks and 0.567 (0.115) for Upper Columbia River stocks (Table 44).

In 2005, estimated survival to McNary Dam was lower for yearling spring Chinook salmon released at hatcheries in the Upper Columbia River than for their counterparts released in the Snake River (Tables 19 and 27). For Upper Columbia River fish, average survival to McNary Dam was estimated at 0.534 (0.014) for fish from Leavenworth Hatchery (4 projects; 564 km) and 0.635 (0.034) for fish from Entiat Hatchery (5 projects; 559 km) in the Upper Columbia River. For Snake River fish released at Dworshak Hatchery (5 projects; 575 km), average survival to McNary Dam was estimated at at 0.659 (0.016).

For steelhead from Snake River Basin hatcheries, estimated survival to the tailrace of McNary Dam was generally similar to that of their counterparts from Upper Columbia hatcheries passing a similar number of dams (Tables 20 and 27).

DISCUSSION

Because 2005 Snake River flow forecasts were below the NMFS BiOp target for providing spill, transportation was maximized at collector dams during the spring migration. Spill did not occur at Lower Granite, Little Goose, and Lower Monumental Dams until 17 May, when flows exceeded powerhouse capacities. Spill continued through about 27 May at Lower Granite and Lower Monumental Dams, while at Little Goose Dam, spill ended on 23 May. Flows during spring 2005 were low during early- to mid-April, but increased substantially from late April through the remainder of the migration season.

The yearling Chinook salmon migration in 2005 was more compressed than in other recent years, and the average flow exposure index was the highest observed over the last 5 years. Hydropower system survival for yearling Chinook salmon was the second highest measured since our PIT-tag survival studies began, even with the limited spill provided. The flow exposure index calculated for steelhead was very similar to that for yearling Chinook salmon, and was the second highest measured over the last 5 years. Hydropower system survival for steelhead (to the tailrace of John Day Dam) improved in 2005 (0.341) over 2004 (0.167), but remained depressed compared to most other recent years (excluding 2001).

Analyses based on early data (1973-1979) suggested that increases in spill had the direct effect of 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 BiOp (NMFS 1995). Survival was lowest during the 2001 migration, when spill was eliminated or reduced at all dams.

Demonstrating within-season effects of spill has been more problematic (Smith et al. 2002; Zabel et al. 2002). During 2005, we estimated relatively high survival through the Snake River without spill (and with transportation maximized). During much of the peak migration for yearling Chinook salmon and steelhead, turbidity was greater (water less transparent) than in other recent years, beginning about 10 May and continuing through the rest of the spring migration (Figure 11). Greater turbidity could have reduced predation rates on juvenile salmonids by providing protective cover during migration (Gregory 1993; Gregory and Levings 1998).

For steelhead, survival remained depressed through the reaches from Lower Monumental to McNary Dam and from McNary to John Day Dam compared to earlier

years. Avian predation appears to have decreased survival of steelhead. Steelhead are particularly susceptible to predation by birds: Collis et al. (2001) reported over 15% of the tags from PIT-tagged steelhead detected at Bonneville Dam in 1998 were later found on estuarine bird colonies, while only 2% of the tags from PIT-tagged yearling Chinook salmon were found. 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) and Glabek et al. (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 Caspian tern colony in North America (>600 individuals), as well as large populations of gulls *Larus* spp. (>39,000). Other avian piscivores that reside within the McNary pool include the American white pelican *Pelecanus erythrorhynchos,* cormorant *Phalacrocorax auritus*, and heron *Ardea alba, A. herodias*, and *Nycticorax nycticorax* (Collis et al. 2002).

During 2005, 9.2% of the PIT tags from steelhead detected at Lower Monumental Dam were found on bird colonies upstream from McNary Dam (Table 45). In previous years, additional PIT tags (mostly steelhead) have been detected on gull colonies in the John Day and The Dalles reservoirs as well (Glabek et al. 2003; Ryan et al. 2002). The percentage of detected steelhead PIT tags found on bird colonies upstream from McNary Dam in 2005 was about half of that found in 2001 and 2004, the two other recent low flow years when transportation was maximized and voluntary spill curtailed. However, turbidity was greater and the smolt migration more compressed in 2005, and these factors may have reduced steelhead vulnerability to sight-feeding birds.

Tag-detection percentages on avian colonies are minimum estimates of loss due to bird predation, because not all tags taken by birds are detected (Collis et al. 2001; Glabek et al. 2003; Ryan et al. 2001). From 1998 to 2005, survival estimates for steelhead in the reach from Lower Monumental to McNary Dam (Table 42) have shown a strong negative correlation with the percentage of smolts detected on bird colonies in the McNary pool ($R^2 = 0.867$, $P < 0.001$; Table 45). There has also been a significant negative correlation for yearling Chinook salmon ($R^2 = 0.903$; $P < 0.001$), although the percentages detected on bird colonies have been much lower.

In 2005, per-project survival for steelhead was substantially lower in the reach from Lower Monumental to McNary Dam (two projects, $0.722^{1/2} = 0.850$) than from Lower Granite to Little Goose Dam (0.940) and slightly lower than from Little Goose to Lower Monumental Dam (0.867). Also, estimated per-project survival for steelhead from McNary to John Day Dam (0.595) was lower than estimated per-project survival

upstream of Lower Monumental Dam. In contrast, 1.4% of the yearling Chinook salmon detected at Lower Monumental Dam were subsequently detected on Crescent Island, and per-project survival estimates in reaches directly above and below McNary Dam were lower.

Although a PIT-tag detection system was operational at Ice Harbor Dam in 2005, the high spill rate there resulted in low numbers of fish entering the bypass system and being detected. Thus we were still unable to partition survival between Lower Monumental and McNary Dams into reach-specific estimates. However, there were studies to partition reach survival between Lower Monumental and Ice Harbor using radio telemetry in 2004 and 2005. Telemetry studies in 2004 estimated Ice Harbor pool survival for steelhead at 84.1%. Survival between the tailraces of Ice Harbor Dam and McNary Dam was particularly low from the mouth of the Snake River to Port Kelly on the Columbia River, with many radio tags later found on Crescent Island (Axel et al. 2005). In 2005, steelhead survival through Ice Harbor pool was estimated at 89.1% (E. Hockersmith, NMFS, personal communication).

Proportions of PIT-tagged fish (especially steelhead) taken by avian predators have continued to be high in the last several years, with a corresponding decrease in reach survival. It is unlikely the change is due to increased predator abundance, as the Caspian tern colony has not increased in size during this time period (Glabek et al. 2003). Therefore, a change in susceptibility of smolts to avian predators or system operations are the likely cause. 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 Caspian tern behavior.

One factor that might affect our survival estimates is the maximization of transportation. During years when this occurred (2001, 2004, and 2005), an extremely high proportion of non-PIT-tagged smolts were transported, while PIT-tagged fish were returned to the river by the slide gate. Thus, by the time fish reach Ice Harbor Dam, relatively few non-tagged fish are available for predators. This likely increases the mortality rate on tagged smolts, resulting in reduced estimates of survival.

Results from the 2005 studies provide estimates of survival only during the downstream portion of the migration. We will analyze these data in conjunction with adult returns 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 again observed in 2005 in the river reach between Lower Monumental and John Day Dams. Avian predators are the likely cause of this mortality, and this issue merits further investigation. In addition, estimates of survival from hatcheries to Lower Granite Dam suggest that substantial mortality occurs upstream from the Snake and Clearwater River confluence. Efforts to identify where this mortality occurs should continue.

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 The Dalles and Upper Columbia River dams. Although there is now a PIT-tag detection system in the juvenile bypass facilty at Ice Harbor Dam, because of the high rate of spill, too few fish are detected for survival estimation. Development of flat-plate and full-flow detector technology in bypass systems and other suitable locations at dams (including spillways), 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 or PIT tagged and released to the tailrace at Lower Granite Dam in 2005. 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–05 Apr	68	0.878 (0.065)	0.778 (0.104)	NA	NA
06 Apr-12 Apr	744	0.870 (0.019)	0.863 (0.043)	0.790 (0.072)	0.593 (0.048)
13 Apr-19 Apr	2,097	0.872 (0.011)	0.840 (0.023)	0.880 (0.050)	0.645 (0.035)
20 Apr-26 Apr	5,152	0.890 (0.007)	0.843 (0.019)	0.882 (0.037)	0.662 (0.025)
27 Apr-03 May	17,278	0.917 (0.004)	0.879 (0.014)	0.944 (0.029)	0.761 (0.021)
04 May-10 May	52,978	0.924 (0.002)	0.882 (0.006)	0.910 (0.014)	0.742 (0.010)
11 May-17 May	13,575	0.925 (0.005)	0.931 (0.013)	0.875 (0.027)	0.754 (0.021)
18 May-24 May	4,243	0.920 (0.008)	0.924 (0.021)	0.883 (0.047)	0.751 (0.037)
25 May-31 May	2,515	0.859 (0.010)	0.832 (0.028)	0.896 (0.063)	0.640 (0.041)
01 Jun-07 Jun	2,366	0.820 (0.013)	0.857 (0.035)	0.700 (0.047)	0.492 (0.028)
08 Jun-14 Jun	986	0.795 (0.025)	1.112 (0.116)	0.635 (0.085)	0.562 (0.049)
15 Jun-21 Jun	485	0.981 (0.148)	0.528 (0.083)	NA	NA
Weighted mean*		**0.919 (0.003)**	**0.886 (0.006)**	**0.903 (0.010)**	**0.732 (0.009)**

* Weighted means of the independent estimates for daily groups (26 March -31 May), with weights inversely proportional to respective estimated relative variances (see Table 5).

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 2005. 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
27 Apr–03 May	121	0.495 (0.098)	NA	NA
04 May–10 May	5,305	0.838 (0.056)	0.658 (0.168)	0.551 (0.136)
11 May–17 May	21,431	0.776 (0.041)	1.175 (0.212)	0.913 (0.157)
18 May–24 May	10,344	0.727 (0.058)	1.280 (0.287)	0.931 (0.195)
25 May–31 May	4,450	0.786 (0.115)	0.765 (0.282)	0.602 (0.204)
01 Jun–07 Jun	1,655	0.685 (0.132)	0.579 (0.283)	0.397 (0.178)
Weighted mean*		**0.772 (0.021)**	**1.028 (0.132)**	**0.788 (0.092)**

* Weighted means of the independent estimates for weekly pooled groups (20 April–21 June), 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 2005. 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-05 Apr	28	0.786 (0.129)	0.582 (0.162)	0.820 (0.332)	0.375 (0.158)
06 Apr-12 Apr	212	0.844 (0.034)	0.827 (0.074)	0.872 (0.133)	0.609 (0.084)
13 Apr-19 Apr	692	0.889 (0.023)	0.875 (0.053)	0.804 (0.096)	0.625 (0.068)
20 Apr-26 Apr	2,593	0.907 (0.011)	0.871 (0.033)	0.941 (0.067)	0.744 (0.046)
27 Apr-03 May	13,807	0.929 (0.005)	0.894 (0.016)	0.945 (0.033)	0.784 (0.024)
04 May-10 May	48,060	0.927 (0.003)	0.886 (0.007)	0.911 (0.015)	0.748 (0.011)
11 May-17 May	12,111	0.924 (0.005)	0.932 (0.015)	0.898 (0.031)	0.773 (0.024)
18 May-24 May	3,082	0.919 (0.010)	0.934 (0.027)	0.893 (0.060)	0.766 (0.046)
25 May-31 May	1,392	0.850 (0.015)	0.814 (0.039)	0.987 (0.103)	0.683 (0.066)
01 Jun-07 Jun	1,033	0.774 (0.020)	0.873 (0.059)	0.584 (0.059)	0.395 (0.031)
08 Jun-14 Jun	198	0.752 (0.058)	1.183 (0.380)	0.531 (0.185)	0.473 (0.067)
15 Jun-21 Jun	179	0.946 (0.190)	0.600 (0.126)	1.171 (0.110)	0.665 (0.076)
Weighted mean*		**0.922 (0.006)**	**0.894 (0.008)**	**0.913 (0.018)**	**0.743 (0.019)**

* Weighted means of the independent estimates for weekly pooled groups (30 March-21 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 or PIT tagged and released to the tailrace at Lower Granite Dam in 2005. 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-05 Apr	40	0.938 (0.066)	0.903 (0.130)	NA	NA
06 Apr-12 Apr	532	0.881 (0.022)	0.873 (0.051)	0.765 (0.085)	0.588 (0.059)
13 Apr-19 Apr	1,405	0.867 (0.013)	0.831 (0.025)	0.913 (0.059)	0.658 (0.040)
20 Apr-26 Apr	2,559	0.876 (0.009)	0.833 (0.022)	0.832 (0.042)	0.607 (0.028)
27 Apr-03 May	3,471	0.874 (0.008)	0.834 (0.023)	0.925 (0.058)	0.674 (0.039)
04 May-10 May	4,918	0.925 (0.006)	0.872 (0.014)	0.890 (0.033)	0.717 (0.025)
11 May-17 May	1,464	0.946 (0.010)	0.933 (0.032)	0.756 (0.053)	0.667 (0.042)
18 May-24 May	1,161	0.934 (0.012)	0.906 (0.032)	0.860 (0.074)	0.727 (0.059)
25 May-31 May	1,123	0.872 (0.014)	0.852 (0.039)	0.810 (0.076)	0.602 (0.051)
01 Jun-07 Jun	1,333	0.855 (0.017)	0.847 (0.043)	0.799 (0.074)	0.578 (0.047)
08 Jun-14 Jun	788	0.806 (0.027)	1.098 (0.120)	0.669 (0.101)	0.592 (0.063)
Weighted mean*		**0.903 (0.010)**	**0.865 (0.012)**	**0.856 (0.020)**	**0.661 (0.017)**

* Weighted means of the independent estimates for weekly pooled groups (30 March-14 June), 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 or PIT tagged and released to the tailrace at Lower Granite Dam in 2005. 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
26 Mar-04 Apr	37	0.768 (0.081)	0.838 (0.123)	1.008 (0.473)	0.649 (0.306)
05-06 Apr	76	0.947 (0.057)	0.820 (0.107)	0.879 (0.268)	0.683 (0.200)
07-08 Apr	87	0.887 (0.059)	0.890 (0.133)	0.859 (0.238)	0.678 (0.168)
09 Apr	69	0.741 (0.067)	1.010 (0.197)	0.660 (0.195)	0.494 (0.116)
10 Apr	58	0.904 (0.053)	0.824 (0.142)	0.531 (0.146)	0.396 (0.094)
11 Apr	158	0.917 (0.040)	0.847 (0.091)	0.776 (0.158)	0.602 (0.111)
12 Apr	333	0.854 (0.028)	0.841 (0.061)	0.911 (0.131)	0.654 (0.087)
13 Apr	340	0.863 (0.027)	0.876 (0.056)	1.016 (0.156)	0.768 (0.112)
14 Apr	376	0.856 (0.025)	0.867 (0.052)	0.844 (0.095)	0.627 (0.065)
15 Apr	283	0.893 (0.031)	0.777 (0.057)	0.760 (0.097)	0.527 (0.063)
16 Apr	228	0.853 (0.034)	0.893 (0.064)	0.961 (0.155)	0.732 (0.113)
17 Apr	126	0.882 (0.049)	0.821 (0.106)	0.782 (0.206)	0.566 (0.138)
18 Apr	342	0.897 (0.029)	0.768 (0.055)	1.058 (0.172)	0.729 (0.113)
19 Apr	402	0.864 (0.026)	0.895 (0.070)	0.772 (0.126)	0.597 (0.088)
20 Apr	872	0.888 (0.017)	0.790 (0.034)	0.918 (0.077)	0.644 (0.051)
21 Apr	611	0.915 (0.022)	0.742 (0.044)	0.810 (0.086)	0.551 (0.054)
22 Apr	620	0.898 (0.020)	0.928 (0.063)	0.674 (0.076)	0.561 (0.053)
23 Apr	481	0.852 (0.022)	1.006 (0.081)	0.829 (0.133)	0.710 (0.100)
24 Apr	400	0.921 (0.024)	0.734 (0.053)	1.123 (0.184)	0.759 (0.118)
25 Apr	570	0.935 (0.020)	0.896 (0.060)	0.823 (0.095)	0.689 (0.068)
26 Apr	1,598	0.865 (0.013)	0.876 (0.042)	0.989 (0.091)	0.750 (0.061)
27 Apr	2,775	0.893 (0.010)	0.896 (0.035)	0.915 (0.065)	0.732 (0.045)
28 Apr	2,291	0.878 (0.012)	0.862 (0.038)	1.014 (0.093)	0.768 (0.063)
29 Apr	3,307	0.908 (0.010)	0.857 (0.030)	0.888 (0.057)	0.691 (0.039)
30 Apr	1,788	0.935 (0.013)	0.888 (0.045)	0.781 (0.068)	0.649 (0.048)

Table 5. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
01 May	3,285	0.936 (0.010)	0.879 (0.033)	1.022 (0.079)	0.840 (0.058)
02 May	2,246	0.960 (0.012)	0.863 (0.035)	1.044 (0.091)	0.865 (0.069)
03 May	1,586	0.908 (0.013)	0.929 (0.041)	1.042 (0.115)	0.879 (0.090)
04 May	11,025	0.904 (0.006)	0.849 (0.015)	0.971 (0.038)	0.746 (0.027)
05 May	5,327	0.932 (0.007)	0.857 (0.021)	0.845 (0.040)	0.675 (0.028)
06 May	15,186	0.931 (0.004)	0.890 (0.012)	0.892 (0.024)	0.740 (0.018)
07 May	4,783	0.933 (0.008)	0.906 (0.023)	0.867 (0.040)	0.732 (0.029)
08 May	4,531	0.947 (0.008)	0.879 (0.022)	1.014 (0.051)	0.845 (0.038)
09 May	3,284	0.943 (0.010)	0.886 (0.025)	0.948 (0.054)	0.792 (0.041)
10 May	8,841	0.906 (0.006)	0.910 (0.015)	0.881 (0.030)	0.726 (0.023)
11 May	1,169	0.942 (0.013)	0.882 (0.033)	0.867 (0.063)	0.720 (0.048)
12 May	3,336	0.921 (0.010)	0.993 (0.031)	0.821 (0.051)	0.751 (0.041)
13 May	749	0.914 (0.019)	0.926 (0.058)	0.907 (0.124)	0.768 (0.094)
14 May	3,863	0.909 (0.009)	0.906 (0.025)	0.957 (0.062)	0.788 (0.047)
15 May	253	0.932 (0.034)	0.839 (0.077)	0.922 (0.189)	0.720 (0.136)
16 May	201	0.955 (0.041)	0.842 (0.095)	0.811 (0.202)	0.652 (0.150)
17 May	4,004	0.939 (0.009)	0.947 (0.026)	0.862 (0.052)	0.767 (0.042)
18 May	316	0.938 (0.027)	0.884 (0.067)	0.902 (0.166)	0.748 (0.129)
19 May	2,798	0.917 (0.010)	0.933 (0.027)	0.926 (0.064)	0.792 (0.050)
20 May	321	0.925 (0.023)	0.981 (0.067)	0.622 (0.077)	0.565 (0.059)
21 May	267	0.952 (0.024)	0.844 (0.069)	0.956 (0.205)	0.769 (0.156)
22-23 May	312	0.891 (0.028)	0.876 (0.080)	0.829 (0.170)	0.647 (0.122)
24-25 May	492	0.912 (0.019)	0.929 (0.075)	1.110 (0.271)	0.942 (0.218)
26 May	284	0.861 (0.028)	0.725 (0.060)	0.991 (0.176)	0.619 (0.106)
27 May	302	0.858 (0.028)	0.764 (0.057)	0.850 (0.120)	0.558 (0.074)
28 May	328	0.874 (0.028)	0.895 (0.083)	0.867 (0.157)	0.679 (0.109)
29 May	411	0.861 (0.026)	0.916 (0.094)	0.787 (0.138)	0.621 (0.091)
30 May	470	0.807 (0.023)	0.872 (0.076)	1.040 (0.224)	0.732 (0.146)
31 May	457	0.878 (0.028)	0.798 (0.062)	0.918 (0.149)	0.644 (0.096)
Weighted mean*		**0.919 (0.003)**	**0.886 (0.006)**	**0.903 (0.010)**	**0.732 (0.009)**

* Weighted means of the independent estimates for daily groups (25 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 or PIT tagged and released to the tailrace at Lower Granite Dam in 2005. 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	LGO	LMO	MCN
30 Mar–05 Apr	68	0.720 (0.072)	0.602 (0.093)	NA
06 Apr-12 Apr	744	0.767 (0.021)	0.489 (0.030)	0.456 (0.042)
13 Apr-19 Apr	2,097	0.756 (0.012)	0.530 (0.018)	0.421 (0.025)
20 Apr-26 Apr	5,152	0.789 (0.008)	0.415 (0.012)	0.376 (0.016)
27 Apr-03 May	17,278	0.780 (0.004)	0.322 (0.006)	0.324 (0.010)
04 May-10 May	52,978	0.742 (0.003)	0.379 (0.003)	0.389 (0.006)
11 May-17 May	13,575	0.712 (0.005)	0.391 (0.007)	0.402 (0.012)
18 May-24 May	4,243	0.735 (0.009)	0.458 (0.013)	0.398 (0.021)
25 May-31 May	2,515	0.815 (0.011)	0.385 (0.017)	0.487 (0.033)
01 Jun-07 Jun	2,366	0.720 (0.014)	0.330 (0.017)	0.647 (0.037)
08 Jun-14 Jun	986	0.564 (0.023)	0.130 (0.018)	0.698 (0.061)
15 Jun-21 Jun	485	0.080 (0.017)	0.004 (0.004)	NA

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 2005. 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	JDA	BON
27 Apr-03 May	121	0.534 (0.114)	NA
04 May-10 May	5,305	0.268 (0.019)	0.170 (0.043)
11 May-17 May	21,431	0.148 (0.008)	0.077 (0.013)
18 May-24 May	10,344	0.089 (0.008)	0.127 (0.027)
25 May-31 May	4,450	0.097 (0.015)	0.131 (0.045)
01 Jun–07 Jun	1,655	0.166 (0.034)	0.155 (0.071)

Table 8. Estimated detection probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2005. 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	LGO	LMO	MCN
30 Mar-05 Mar	28	0.727 (0.134)	0.625 (0.171)	0.667 (0.272)
06 Apr-12 Apr	212	0.816 (0.036)	0.459 (0.055)	0.461 (0.073)
13 Apr-19 Apr	692	0.681 (0.024)	0.455 (0.033)	0.380 (0.046)
20 Apr-26 Apr	2,593	0.757 (0.012)	0.335 (0.016)	0.305 (0.021)
27 Apr-03 May	13,807	0.761 (0.005)	0.295 (0.007)	0.318 (0.011)
04 May-10 May	48,060	0.730 (0.003)	0.362 (0.004)	0.383 (0.006)
11 May-17 May	12,111	0.697 (0.006)	0.379 (0.007)	0.386 (0.013)
18 May-24 May	3,082	0.703 (0.011)	0.423 (0.015)	0.382 (0.025)
25 May-31 May	1,392	0.783 (0.016)	0.353 (0.022)	0.442 (0.045)
01 Jun-07 Jun	1,033	0.739 (0.021)	0.330 (0.027)	0.719 (0.055)
08 Jun-14 Jun	198	0.531 (0.054)	0.076 (0.031)	0.833 (0.108)
15 Jun-21 Jun	179	0.094 (0.029)	0.010 (0.010)	0.828 (0.091)

Table 9. Estimated detection probabilities for Snake River wild yearling Chinook Salmon detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2005. 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	LGO	LMO	MCN
30 Mar-05 Mar	40	0.719 (0.084)	0.592 (0.111)	NA
06 Apr-12 Apr	532	0.749 (0.025)	0.502 (0.036)	0.454 (0.051)
13 Apr-19 Apr	1,405	0.790 (0.014)	0.562 (0.021)	0.438 (0.031)
20 Apr-26 Apr	2,559	0.818 (0.010)	0.496 (0.017)	0.450 (0.023)
27 Apr-03 May	3,471	0.851 (0.009)	0.445 (0.015)	0.346 (0.022)
04 May-10 May	4,918	0.846 (0.007)	0.537 (0.011)	0.436 (0.017)
11 May-17 May	1,464	0.824 (0.012)	0.482 (0.021)	0.510 (0.035)
18 May-24 May	1,161	0.813 (0.014)	0.549 (0.024)	0.435 (0.039)
25 May-31 May	1,123	0.850 (0.015)	0.423 (0.025)	0.540 (0.048)
01 Jun-07 Jun	1,333	0.708 (0.018)	0.331 (0.022)	0.597 (0.050)
08 Jun-14 Jun	788	0.572 (0.026)	0.144 (0.020)	0.661 (0.071)

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 2005. 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–05 Apr	107	0.932 (0.031)	1.080 (0.197)	0.655 (0.580)	0.659 (0.569)
06 Apr-12 Apr	435	0.914 (0.018)	0.963 (0.074)	0.644 (0.222)	0.567 (0.190)
13 Apr-19 Apr	1,130	0.913 (0.012)	0.923 (0.042)	0.711 (0.131)	0.599 (0.107)
20 Apr-26 Apr	3,906	0.930 (0.006)	0.911 (0.021)	0.595 (0.047)	0.504 (0.038)
27 Apr–03 May	8,418	0.931 (0.004)	0.844 (0.014)	0.779 (0.047)	0.613 (0.036)
04 May-10 May	15,177	0.953 (0.003)	0.846 (0.010)	0.828 (0.033)	0.668 (0.026)
11 May-17 May	9,140	0.937 (0.004)	0.907 (0.014)	0.672 (0.029)	0.571 (0.023)
18 May-24 May	4,712	0.942 (0.005)	0.929 (0.024)	0.603 (0.049)	0.527 (0.040)
25 May-31 May	2,828	0.783 (0.009)	0.665 (0.029)	0.424 (0.088)	0.220 (0.045)
01 Jun-07 Jun	1,754	0.583 (0.022)	0.577 (0.088)	0.563 (0.296)	0.189 (0.096)
08 Jun-14 Jun	1,089	0.582 (0.052)	NA	NA	NA
Weighted mean*		**0.940 (0.004)**	**0.867 (0.009)**	**0.722 (0.023)**	**0.593 (0.018)**

* Weighted means of the independent estimates for daily groups (01 April–01 June), with weights inversely proportional to respective estimated relative variances (see Table 14).

Table 11. Estimated survival probabilities for juvenile Snake River steelhead (hatcheryand wild combined) detected and released to the tailrace at McNary Dam in 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
27 Apr-03 May	83	0.434 (0.138)	NA	NA
04 May-10 May	898	0.543 (0.123)	NA	NA
11 May-17 May	2,803	0.661 (0.125)	NA	NA
18 May-24 May	3,162	0.617 (0.104)	NA	NA
Weighted mean*		**0.595 (0.040)**	**NA**	**NA**

* Weighted means of the independent estimates for weekly pooled groups (27 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 2005. 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–05 Apr	87	0.974 (0.025)	1.074 (0.191)	0.671 (0.587)	0.701 (0.599)
06 Apr-12 Apr	335	0.931 (0.019)	0.939 (0.074)	0.766 (0.292)	0.670 (0.249)
13 Apr-19 Apr	895	0.926 (0.014)	0.948 (0.050)	0.701 (0.144)	0.615 (0.122)
20 Apr-26 Apr	3,447	0.933 (0.007)	0.924 (0.023)	0.631 (0.055)	0.544 (0.045)
27 Apr-03 May	6,854	0.933 (0.005)	0.850 (0.014)	0.818 (0.056)	0.648 (0.043)
04 May-10 May	10,986	0.947 (0.003)	0.861 (0.011)	0.814 (0.038)	0.663 (0.030)
11 May-17 May	6,657	0.933 (0.004)	0.903 (0.016)	0.660 (0.032)	0.556 (0.025)
18 May-24 May	3,390	0.938 (0.006)	0.940 (0.030)	0.606 (0.061)	0.534 (0.050)
25 May-31 May	1,903	0.771 (0.012)	0.653 (0.038)	0.409 (0.109)	0.206 (0.054)
01 Jun-07 Jun	1,269	0.605 (0.031)	0.723 (0.159)	0.549 (0.367)	0.240 (0.152)
08 Jun-14 Jun	814	0.617 (0.062)	NA	NA	NA
Weighted mean*		**0.936 (0.009)**	**0.877 (0.014)**	**0.727 (0.029)**	**0.598 (0.022)**

* Weighted means of the independent estimates for weekly pooled groups (30 March–14 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 2005. 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–05 Apr	20	0.771 (0.129)	NA	NA	NA
06 Apr-12 Apr	100	0.859 (0.046)	1.213 (0.368)	0.171 (0.127)	0.178 (0.117)
13 Apr-19 Apr	235	0.864 (0.028)	0.833 (0.069)	0.703 (0.286)	0.506 (0.203)
20 Apr-26 Apr	459	0.908 (0.020)	0.822 (0.067)	0.349 (0.070)	0.261 (0.048)
27 Apr-03 May	1,564	0.911 (0.011)	0.844 (0.046)	0.579 (0.076)	0.445 (0.053)
04 May-10 May	4,191	0.968 (0.005)	0.809 (0.019)	0.860 (0.069)	0.674 (0.052)
11 May-17 May	2,402	0.947 (0.006)	0.921 (0.029)	0.711 (0.068)	0.619 (0.056)
18 May-24 May	1,267	0.949 (0.010)	0.908 (0.042)	0.588 (0.078)	0.507 (0.063)
25 May-31 May	918	0.808 (0.014)	0.686 (0.044)	0.423 (0.135)	0.234 (0.074)
01 Jun-07 Jun	479	0.543 (0.027)	0.358 (0.061)	0.498 (0.403)	0.097 (0.078)
08 Jun-14 Jun	275	0.467 (0.090)	NA	NA	NA
Weighted mean*		**0.944 (0014)**	**0.841 (0.028)**	**0.700 (0.054)**	**0.562 (0.046)**

* Weighted means of the independent estimates for weekly pooled groups (30 March -14 June), 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 2005. 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
1-4 Apr	68	0.919 (0.040)	1.056 (0.174)	0.950 (0.827)	0.922 (0.785)
5-7 Apr	142	0.914 (0.028)	0.968 (0.143)	0.647 (0.572)	0.573 (0.498)
8-10 Apr	102	0.913 (0.035)	0.898 (0.108)	1.373 (1.231)	1.124 (1.000)
11-12 Apr	230	0.925 (0.027)	1.032 (0.138)	0.394 (0.160)	0.377 (0.143)
13 Apr	343	0.933 (0.022)	0.832 (0.057)	1.054 (0.337)	0.819 (0.257)
14 Apr	247	0.917 (0.025)	1.122 (0.128)	0.869 (0.451)	0.894 (0.451)
15 Apr	108	0.864 (0.042)	0.734 (0.069)	1.046 (0.598)	0.664 (0.380)
16 Apr	126	0.917 (0.033)	1.117 (0.209)	0.299 (0.141)	0.306 (0.132)
17-19 Apr	306	0.903 (0.025)	0.961 (0.105)	0.438 (0.147)	0.380 (0.120)
20 Apr	645	0.906 (0.018)	0.954 (0.058)	0.431 (0.071)	0.372 (0.057)
21 Apr	571	0.941 (0.018)	0.859 (0.056)	0.564 (0.139)	0.456 (0.108)
22 Apr	636	0.943 (0.016)	0.935 (0.062)	0.572 (0.133)	0.504 (0.112)
23 Apr	603	0.899 (0.017)	0.893 (0.054)	0.653 (0.149)	0.524 (0.115)
24-25 Apr	418	0.948 (0.016)	0.980 (0.063)	0.904 (0.219)	0.840 (0.196)
26 Apr	1,033	0.944 (0.011)	0.879 (0.036)	0.618 (0.087)	0.513 (0.069)
27 Apr	1,343	0.940 (0.011)	0.841 (0.034)	0.736 (0.107)	0.581 (0.082)
28 Apr	1,033	0.921 (0.012)	0.833 (0.035)	0.710 (0.100)	0.544 (0.074)
29 Apr	1,568	0.942 (0.010)	0.855 (0.036)	0.643 (0.085)	0.518 (0.065)
30 Apr	1,905	0.929 (0.010)	0.857 (0.029)	0.963 (0.142)	0.766 (0.111)
01 May	1,058	0.929 (0.013)	0.868 (0.047)	0.840 (0.161)	0.677 (0.125)
02 May	670	0.942 (0.014)	0.862 (0.052)	1.197 (0.357)	0.972 (0.285)
03 May	841	0.909 (0.013)	0.789 (0.034)	0.675 (0.111)	0.484 (0.078)
04 May	1,587	0.953 (0.008)	0.870 (0.030)	0.638 (0.082)	0.529 (0.066)
05 May	1,792	0.953 (0.007)	0.869 (0.028)	0.709 (0.080)	0.587 (0.064)
06 May	2,139	0.950 (0.007)	0.812 (0.021)	0.930 (0.097)	0.718 (0.073)
07 May	2,284	0.953 (0.006)	0.828 (0.021)	0.833 (0.078)	0.657 (0.060)

Table 14. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
08 May	1,469	0.961 (0.008)	0.865 (0.043)	0.804 (0.122)	0.668 (0.096)
09 May	3,030	0.954 (0.006)	0.827 (0.025)	1.040 (0.111)	0.822 (0.084)
10 May	2,876	0.948 (0.006)	0.871 (0.025)	0.744 (0.060)	0.614 (0.047)
11 May	1,879	0.932 (0.007)	0.861 (0.025)	0.806 (0.079)	0.646 (0.062)
12 May	1,695	0.940 (0.007)	0.920 (0.027)	0.637 (0.052)	0.551 (0.042)
13 May	1,881	0.935 (0.007)	0.966 (0.031)	0.647 (0.054)	0.585 (0.045)
14 May	1,514	0.930 (0.009)	0.991 (0.041)	0.639 (0.066)	0.589 (0.055)
15 May	338	0.918 (0.024)	0.797 (0.082)	0.401 (0.107)	0.293 (0.073)
16 May	537	0.973 (0.019)	0.851 (0.070)	0.538 (0.121)	0.446 (0.094)
17 May	1,296	0.949 (0.010)	0.885 (0.056)	0.792 (0.161)	0.665 (0.128)
18 May	1,287	0.950 (0.010)	0.905 (0.047)	0.665 (0.089)	0.572 (0.071)
19 May	1,399	0.945 (0.011)	0.943 (0.050)	0.696 (0.103)	0.620 (0.085)
20 May	943	0.922 (0.014)	0.907 (0.045)	0.739 (0.174)	0.619 (0.142)
21 May	210	0.975 (0.019)	0.819 (0.072)	0.522 (0.166)	0.417 (0.127)
22 May	168	0.942 (0.021)	0.828 (0.077)	0.747 (0.430)	0.583 (0.331)
23 May	97	0.954 (0.027)	0.957 (0.161)	0.473 (0.261)	0.432 (0.227)
24 May	608	0.934 (0.012)	0.819 (0.046)	0.326 (0.071)	0.250 (0.053)
25 May	566	0.896 (0.014)	0.768 (0.046)	0.614 (0.265)	0.423 (0.181)
26 May	572	0.855 (0.016)	0.726 (0.060)	0.343 (0.124)	0.213 (0.075)
27 May	624	0.792 (0.019)	0.602 (0.054)	0.460 (0.188)	0.219 (0.088)
28 May-1 Jun	1,227	0.683 (0.020)	0.604 (0.071)	0.214 (0.069)	0.088 (0.026)
Weighted mean*		**0.940 (0.004)**	**0.867 (0.009)**	**0.722 (0.023)**	**0.593 (0.018)**

* Weighted means of the independent estimates for daily groups (26 March–07 June), 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 2005. 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	LGO	LMO	MCN
30 Mar–05 Apr	107	0.903 (0.035)	0.603 (0.120)	0.156 (0.142)
06 Apr-12 Apr	435	0.860 (0.021)	0.655 (0.055)	0.208 (0.075)
13 Apr-19 Apr	1,130	0.828 (0.014)	0.653 (0.032)	0.195 (0.038)
20 Apr-26 Apr	3,906	0.832 (0.008)	0.657 (0.017)	0.250 (0.021)
27 Apr-03 May	8,418	0.855 (0.005)	0.634 (0.011)	0.211 (0.014)
04 May-10 May	15,177	0.912 (0.003)	0.614 (0.008)	0.209 (0.009)
11 May-17 May	9,140	0.908 (0.004)	0.563 (0.010)	0.356 (0.016)
18 May-24 May	4,712	0.877 (0.006)	0.555 (0.016)	0.306 (0.025)
25 May-31 May	2,828	0.924 (0.008)	0.713 (0.031)	0.291 (0.061)
01 Jun-07 Jun	1,754	0.729 (0.028)	0.358 (0.056)	0.203 (0.104)
08 Jun-14 Jun	1,089	0.496 (0.047)	NA	NA

Table 16. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 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	JDA	BON
27 Apr-03 May	83	0.404 (0.093)	NA
04 May-10 May	898	0.252 (0.048)	NA
11 May-17 May	2,803	0.270 (0.047)	NA
18 May-24 May	3,162	0.105 (0.049)	NA

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 2005. 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	LGO	LMO	MCN
30 Mar–05 Apr	87	0.921 (0.034)	0.626 (0.123)	0.158 (0.143)
06 Apr-12 Apr	335	0.872 (0.023)	0.672 (0.058)	0.185 (0.074)
13 Apr-19 Apr	895	0.820 (0.016)	0.627 (0.036)	0.184 (0.040)
20 Apr-26 Apr	3,447	0.827 (0.008)	0.657 (0.018)	0.233 (0.022)
27 Apr-03 May	6,854	0.847 (0.006)	0.669 (0.012)	0.192 (0.014)
04 May-10 May	10,986	0.907 (0.004)	0.621 (0.009)	0.206 (0.010)
11 May-17 May	6,657	0.900 (0.005)	0.570 (0.012)	0.359 (0.018)
18 May-24 May	3,390	0.880 (0.007)	0.552 (0.019)	0.278 (0.028)
25 May-31 May	1,903	0.909 (0.011)	0.703 (0.041)	0.256 (0.070)
01 Jun-07 Jun	1,269	0.652 (0.035)	0.258 (0.058)	0.170 (0.109)
08 Jun-14 Jun	814	0.482 (0.052)	NA	NA

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 2005. 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	LGO	LMO	MCN
30 Mar–05 Apr	20	0.778 (0.139)	NA	NA
06 Apr-12 Apr	100	0.815 (0.050)	0.521 (0.166)	0.533 (0.350)
13 Apr-19 Apr	235	0.857 (0.030)	0.766 (0.066)	0.257 (0.110)
20 Apr-26 Apr	459	0.869 (0.021)	0.658 (0.057)	0.472 (0.091)
27 Apr-03 May	1,564	0.903 (0.011)	0.467 (0.029)	0.337 (0.043)
04 May-10 May	4,191	0.926 (0.005)	0.593 (0.016)	0.220 (0.019)
11 May-17 May	2,402	0.933 (0.007)	0.545 (0.020)	0.348 (0.033)
18 May-24 May	1,267	0.871 (0.012)	0.565 (0.029)	0.394 (0.052)
25 May-31 May	918	0.952 (0.011)	0.736 (0.048)	0.375 (0.121)
01 Jun-07 Jun	479	0.930 (0.030)	0.705 (0.112)	0.333 (0.272)
08 Jun-14 Jun	275	0.561 (0.111)	NA	NA

Table 19. Estimated survival probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2005. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
Crooked River Pond	150	0.478 (0.050)	0.876 (0.094)	1.002 (0.324)	NA	NA
Crooked River	147	0.676 (0.045)	0.867 (0.062)	1.042 (0.237)	0.861 (0.345)	0.526 (0.178)
Powell Pond	300	0.836 (0.033)	0.844 (0.046)	NA	NA	NA
Red River Pond	300	0.671 (0.034)	0.910 (0.048)	0.902 (0.135)	1.008 (0.323)	0.556 (0.162)
Dworshak Hatchery						
Dworshak H.	51,818	0.832 (0.003)	0.922 (0.005)	0.889 (0.013)	0.967 (0.026)	0.659 (0.016)
Kooskia Hatchery						
Clear Creek	723	0.702 (0.021)	0.889 (0.032)	0.785 (0.061)	0.825 (0.114)	0.405 (0.051)
McCall Hatchery						
Johnson Creek	12,049	0.349 (0.006)	0.897 (0.027)	0.887 (0.067)	0.794 (0.103)	0.221 (0.024)
Knox Bridge	51,821	0.603 (0.003)	0.936 (0.006)	0.914 (0.015)	0.929 (0.030)	0.479 (0.014)

Table 19. Continued.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
			Lookingglass Hatchery			
Catherine Cr. Pond (3/14)	13,928	0.217 (0.004)	0.916 (0.018)	0.906 (0.043)	0.970 (0.095)	0.174 (0.016)
Catherine Cr. Pond (4/04)	6,911	0.264 (0.006)	0.972 (0.023)	0.853 (0.051)	1.056 (0.132)	0.231 (0.027)
Grande Ronde R. Pond	993	0.150 (0.013)	0.829 (0.059)	0.915 (0.123)	0.844 (0.231)	0.096 (0.025)
Imnaha Weir	20,917	0.534 (0.004)	0.921 (0.010)	0.874 (0.022)	1.042 (0.057)	0.447 (0.022)
Lostine R. Pond (3/11)	6,689	0.362 (0.006)	0.934 (0.016)	0.807 (0.037)	1.062 (0.103)	0.290 (0.026)
Lostine R. Pond (3/28)	6,651	0.445 (0.007)	0.937 (0.013)	0.899 (0.037)	0.907 (0.077)	0.340 (0.026)
Lookingglass H.	990	0.517 (0.017)	0.965 (0.030)	0.843 (0.073)	0.873 (0.144)	0.367 (0.055)
			Pahsimeroi Hatchery			
Pahsimeroi River	499	0.218 (0.020)	0.644 (0.059)	NA	NA	NA
			Rapid River Hatchery			
Rapid River H.	51,926	0.735 (0.002)	0.946 (0.005)	0.910 (0.014)	0.907 (0.027)	0.574 (0.015)
			Sawtooth Hatchery			
Sawtooth Hatchery	500	0.220 (0.020)	0.921 (0.064)	0.843 (0.194)	0.717 (0.257)	0.122 (0.037)

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2005. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
S.F. Clearwater R.	300	0.877 (0.026)	0.974 (0.040)	0.835 (0.104)	0.515 (0.148)	0.367 (0.097)
Red River Pond	7,489	0.801 (0.005)	0.957 (0.006)	0.886 (0.019)	0.712 (0.050)	0.484 (0.032)
Crooked River	597	0.850 (0.019)	0.922 (0.024)	0.799 (0.049)	0.775 (0.138)	0.485 (0.084)
Lolo Creek	296	0.841 (0.025)	0.981 (0.028)	0.914 (0.099)	0.700 (0.268)	0.528 (0.195)
Meadow Creek	1,302	0.820 (0.012)	0.961 (0.014)	0.856 (0.041)	0.733 (0.125)	0.495 (0.082)
Mill Creek	1,293	0.711 (0.014)	0.887 (0.016)	0.895 (0.046)	0.842 (0.168)	0.476 (0.093)
Dworshak Hatchery						
Mainstem Clearwater	748	0.725 (0.017)	0.939 (0.014)	0.934 (0.045)	0.758 (0.153)	0.481 (0.095)
N.F. Clearwater	750	0.813 (0.015)	0.962 (0.014)	0.836 (0.038)	0.751 (0.140)	0.491 (0.090)
Hagerman Hatchery						
Little Salmon R.	600	0.781 (0.019)	0.941 (0.020)	0.920 (0.074)	0.955 (0.276)	0.646 (0.181)
East Fork Salmon R.	274	0.677 (0.031)	0.901 (0.033)	0.859 (0.090)	NA	NA
Sawtooth Hatchery	294	0.769 (0.027)	0.977 (0.027)	0.671 (0.065)	0.871 (0.286)	0.439 (0.142)
Yankee Fork	298	0.699 (0.032)	0.883 (0.037)	NA	NA	NA

Table 20. Continued.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Magic Valley Hatchery						
Lemhi R.	597	0.652 (0.022)	0.905 (0.027)	0.895 (0.096)	0.787 (0.352)	0.416 (0.181)
Little Salmon R.	599	0.793 (0.018)	0.927 (0.019)	0.918 (0.075)	0.751 (0.231)	0.507 (0.151)
Squaw Creek Pond	499	0.620 (0.023)	0.958 (0.019)	1.008 (0.102)	0.597 (0.166)	0.358 (0.093)
Valley Creek	298	0.814 (0.024)	0.941 (0.025)	0.924 (0.093)	1.070 (0.417)	0.757 (0.286)
Salmon R. (Rkm 385)	298	0.817 (0.024)	0.991 (0.021)	0.856 (0.069)	0.947 (0.297)	0.656 (0.201)
Salmon R. (Rkm 476)	298	0.772 (0.026)	0.950 (0.026)	1.040 (0.120)	0.668 (0.199)	0.510 (0.141)
Salmon R. (Rkm 506)	300	0.713 (0.028)	0.987 (0.029)	0.748 (0.057)	NA	NA
Salmon R. (Rkm 591)	297	0.762 (0.028)	0.891 (0.029)	0.958 (0.103)	0.509 (0.112)	0.331 (0.065)
Niagara Springs Hatchery						
Hells Canyon Dam	298	0.723 (0.033)	0.907 (0.049)	0.726 (0.097)	NA	NA
Little Salmon R.	597	0.742 (0.021)	0.892 (0.023)	0.852 (0.059)	0.961 (0.257)	0.542 (0.142)
Pahsimeroi Weir	298	0.772 (0.027)	0.950 (0.030)	0.819 (0.096)	0.638 (0.215)	0.383 (0.123)

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth hatchery and coho salmon from Kooskia, Clearwater, and Eagle Creek hatcheries released in fall 2004 and spring 2005. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Release date	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN	Rel to MCN
Sawtooth Hatchery sockeye salmon								
Alturus Lake	05 Oct 04	1,009	0.167 (0.019)	0.680 (0.093)	NA	NA	NA	NA
Pettit Lake	09 Sep 04	1,013	0.198 (0.021)	0.750 (0.082)	NA	NA	NA	NA
Redfish Lake	29 Sep 04	1,020	0.279 (0.047)	0.613 (0.147)	NA	NA	NA	NA
Redfish Lk, Cr. Trap	10 May 05	2,016	0.372 (0.042)	0.705 (0.146)	0.738 (0.457)	0.451 (0.286)	0.234 (0.103)	0.087 (0.037)
Kooskia Hatchery coho salmon								
Kooskia Hatchery	25 Apr 05	1,999	0.863 (0.013)	0.825 (0.019)	0.780 (0.061)	NA	NA	NA
Clearwater Hatchery coho salmon								
Eldorado Creek	29 Sep 04	999	0.036 (0.008)	0.681 (0.158)	NA	NA	NA	NA
Lolo Creek	28-29 Sep 04	1,964	0.100 (0.015)	0.395 (0.070)	NA	NA	NA	NA
Eagle Creek Hatchery coho salmon								
Clearwater River	9 Mar	1,702	0.322 (0.013)	0.849 (0.035)	0.910 (0.141)	0.710 (0.196)	0.549 (0.127)	0.177 (0.041)
Potlatch River	7 Mar	1,799	0.296 (0.012)	0.891 (0.042)	0.703 (0.095)	NA	NA	NA

Table 22. Estimated detection probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2005. 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.

Release site	Number released	LGR	LGO	LMO	MCN
Clearwater Hatchery					
Crooked River Pond	150	0.543 (0.067)	0.742 (0.079)	0.305 (0.112)	0.169 (0.151)
Crooked River	147	0.695 (0.052)	0.794 (0.058)	0.265 (0.076)	0.294 (0.111)
Powell Pond	300	0.602 (0.036)	0.767 (0.040)	0.114 (0.036)	0.353 (0.084)
Red River Pond	300	0.561 (0.039)	0.774 (0.042)	0.286 (0.054)	0.337 (0.103)
Dworshak Hatchery					
Dworshak H.	51,818	0.591 (0.003)	0.720 (0.004)	0.324 (0.006)	0.360 (0.009)
Kooskia Hatchery					
Clear Creek	723	0.672 (0.024)	0.714 (0.029)	0.408 (0.038)	0.454 (0.061)
McCall Hatchery					
Johnson Creek	12,049	0.598 (0.010)	0.755 (0.015)	0.387 (0.032)	0.489 (0.055)
Knox Bridge	51,821	0.676 (0.003)	0.730 (0.005)	0.323 (0.007)	0.374 (0.011)

Table 22. Continued.

Release site	Number released	LGR	LGO	LMO	MCN
		Lookingglass Hatchery			
Catherine Cr. Pond (3/14)	13,928	0.658 (0.010)	0.746 (0.014)	0.369 (0.022)	0.376 (0.036)
Catherine Cr. Pond (4/04)	6,911	0.676 (0.012)	0.723 (0.019)	0.372 (0.027)	0.340 (0.042)
Grande Ronde R. Pond	993	0.576 (0.047)	0.715 (0.051)	0.424 (0.070)	0.407 (0.110)
Imnaha Weir	20,917	0.657 (0.005)	0.746 (0.008)	0.372 (0.012)	0.307 (0.017)
Lostine River Pond (3/11)	6,689	0.692 (0.011)	0.679 (0.014)	0.303 (0.017)	0.293 (0.027)
Lostine River Pond (3/28)	6,651	0.682 (0.010)	0.725 (0.012)	0.310 (0.015)	0.296 (0.024)
Lookingglass H.	990	0.727 (0.022)	0.717 (0.028)	0.349 (0.036)	0.359 (0.057)
		Pahsimeroi Hatchery			
Pahsimeroi River	499	0.846 (0.045)	0.814 (0.059)	0.238 (0.093)	0.289 (0.138)
		Rapid River Hatchery			
Rapid River H.	51,926	0.696 (0.003)	0.769 (0.004)	0.312 (0.006)	0.341 (0.010)
		Sawtooth Hatchery			
Sawtooth H.	500	0.719 (0.048)	0.771 (0.061)	0.281 (0.079)	0.364 (0.117)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2005. 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	Number released	LGR	LGO	LMO	MCN
		Clearwater Hatchery			
S.F. Clearwater R.	300	0.623 (0.032)	0.742 (0.038)	0.522 (0.070)	0.314 (0.091)
Red River Pond	7,489	0.631 (0.023)	0.826 (0.023)	0.632 (0.042)	0.285 (0.055)
Crooked River	597	0.623 (0.032)	0.822 (0.031)	0.588 (0.069)	0.172 (0.070)
Lolo Creek	296	0.644 (0.015)	0.849 (0.014)	0.619 (0.032)	0.209 (0.038)
Meadow Creek	1,302	0.667 (0.017)	0.891 (0.014)	0.616 (0.035)	0.173 (0.037)
Mill Creek	1,293	0.644 (0.006)	0.860 (0.006)	0.573 (0.014)	0.217 (0.016)
		Dworshak Hatchery			
Mainstem Clearwater	748	0.821 (0.017)	0.911 (0.015)	0.709 (0.039)	0.205 (0.045)
N.F. Clearwater	750	0.758 (0.018)	0.883 (0.016)	0.753 (0.036)	0.224 (0.046)
		Hagerman Hatchery			
Little Salmon R.	600	0.721 (0.022)	0.875 (0.020)	0.520 (0.047)	0.200 (0.059)
East Fork Salmon R.	274	0.727 (0.035)	0.904 (0.029)	0.619 (0.073)	0.176 (0.092)
Sawtooth Hatchery	294	0.624 (0.033)	0.896 (0.028)	0.663 (0.067)	0.261 (0.092)
Yankee Fork	298	0.600 (0.037)	0.864 (0.032)	0.480 (0.074)	0.130 (0.070)

Table 23. Continued.

Release site	Number released	LGR	LGO	LMO	MCN
		Magic Valley Hatchery			
Lemhi R.	597	0.624 (0.027)	0.866 (0.024)	0.557 (0.065)	0.160 (0.073)
Little Salmon R.	599	0.741 (0.021)	0.904 (0.018)	0.579 (0.052)	0.167 (0.054)
Squaw Creek Pond	499	0.688 (0.027)	0.931 (0.019)	0.510 (0.059)	0.266 (0.075)
Valley Creek	298	0.767 (0.029)	0.888 (0.026)	0.545 (0.063)	0.160 (0.065)
Salmon R. (Rkm 385)	298	0.649 (0.031)	0.879 (0.026)	0.645 (0.058)	0.219 (0.073)
Salmon R. (Rkm 476)	298	0.713 (0.031)	0.873 (0.028)	0.481 (0.064)	0.235 (0.073)
Salmon R. (Rkm 506)	300	0.655 (0.034)	0.814 (0.034)	0.787 (0.057)	0.147 (0.078)
Salmon R. (Rkm 591)	297	0.676 (0.033)	0.945 (0.020)	0.519 (0.066)	0.419 (0.090)
		Niagara Springs Hatchery			
Hells Canyon Dam	298	0.580 (0.037)	0.772 (0.043)	0.529 (0.076)	0.100 (0.067)
Little Salmon R.	597	0.641 (0.025)	0.894 (0.020)	0.614 (0.048)	0.200 (0.057)
Pahsimeroi Weir	298	0.695 (0.032)	0.875 (0.030)	0.568 (0.073)	0.250 (0.088)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth hatchery and coho salmon from Kooskia, Clearwater, and Eagle Creek hatcheries released in fall 2004 and spring 2005. 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	Release date	Number released	LGR	LGO	LMO	MCN
			Sawtooth Hatchery sockeye salmon			
Alturus Lake	05 Oct 04	1,009	0.433 (0.054)	0.793 (0.045)	NA	NA
Pettit Lake	09 Sep 04	1,013	0.284 (0.040)	0.876 (0.029)	NA	NA
Redfish Lake	29 Sep 04	1,020	0.239 (0.046)	0.690 (0.098)	NA	NA
			Kooskia Hatchery coho salmon			
Kooskia Hatchery	25 Apr 05	1,999	0.624 (0.014)	0.803 (0.017)	0.312 (0.027)	0.116 (0.028)
			Clearwater Hatchery coho salmon			
Eldorado Creek	29 Sep 04	999	0.528 (0.110)	0.778 (0.139)	NA	NA
Lolo Creek	28-29 Sep 04	1,964	0.347 (0.058)	0.765 (0.073)	0.238 (0.119)	NA
			Eagle Creek Hatchery coho salmon			
Clearwater River	9 Mar	1,702	0.601 (0.024)	0.772 (0.031)	0.231 (0.041)	0.263 (0.065)
Potlatch River	7 Mar	1,799	0.631 (0.025)	0.701 (0.035)	0.351 (0.051)	0.111 (0.047)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2005. 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 dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Wild Chinook salmon							
Snake	31 Mar-22 May	361	0.964 (0.034)	0.865 (0.050)	0.878 (0.081)	1.018 (0.290)	0.746 (0.206)
Clearwater	11 Mar–5 May	1,967	0.876 (0.010)	0.860 (0.021)	0.882 (0.049)	0.742 (0.086)	0.493 (0.052)
Grande Ronde	8 Mar–24 May	1,975	0.886 (0.010)	0.928 (0.019)	0.932 (0.044)	0.998 (0.124)	0.765 (0.089)
Imnaha (spring)	4 Mar–31 May	2,913	0.791 (0.009)	0.898 (0.015)	0.927 (0.039)	0.826 (0.070)	0.544 (0.042)
Imnaha (late)	1 Jun–21 Jun	554	0.503 (0.036)	0.715 (0.100)	1.427 (0.627)	0.713 (0.352)	0.366 (0.092)
Salmon	12 Mar–17 May	9,478	0.805 (0.005)	0.914 (0.008)	0.846 (0.019)	0.896 (0.043)	0.558 (0.025)
Minam	8 Mar–26 May	374	0.557 (0.031)	0.881 (0.062)	0.830 (0.120)	0.691 (0.179)	0.282 (0.068)
Elgin (Grande Ronde R.)	8 Mar–25 May	236	0.701 (0.038)	0.818 (0.069)	1.066 (0.188)	0.761 (0.264)	0.464 (0.142)
Crooked River (spring)	16 Mar–31 May	874	0.434 (0.024)	0.878 (0.078)	1.022 (0.205)	1.002 (0.314)	0.390 (0.097)
American River (spring)	16 Mar–31 May	1,124	0.714 (0.019)	0.897 (0.038)	0.905 (0.088)	0.967 (0.182)	0.561 (0.094)
Lostine River	8 Mar–27 May	464	0.550 (0.025)	1.046 (0.061)	0.834 (0.125)	1.169 (0.477)	0.562 (0.219)
Red River (spring)	16 Mar- 31 May	1,618	0.463 (0.018)	0.936 (0.067)	1.514 (0.304)	0.533 (0.129)	0.350 (0.050)
Crooked Fork Cr. (spring)	24 Mar–30 May	277	0.502 (0.033)	0.960 (0.059)	1.010 (0.176)	0.812 (0.218)	0.395 (0.087)
Catherine Creek	3 Mar–3 Jun	406	0.450 (0.046)	0.715 (0.105)	0.740 (0.133)	1.034 (0.361)	0.246 (0.084)
Spoolcart (Grande Ronde)	15 Mar–20 May	615	0.379 (0.021)	0.999 (0.038)	0.844 (0.098)	0.776 (0.192)	0.248 (0.058)
Johnson Creek	2 Mar–15 May	3,900	0.429 (0.009)	0.928 (0.017)	0.926 (0.035)	0.841 (0.062)	0.310 (0.021)
South Fork Salmon R.	3 Mar-15 May	2,530	0.391 (0.011)	0.959 (0.033)	0.891 (0.070)	0.887 (0.126)	0.296 (0.037)
Lemhi River Weir (spring)	4 Mar–29 May	390	0.460 (0.028)	0.922 (0.072)	0.700 (0.093)	1.290 (0.473)	0.383 (0.141)
Pahsimeroi (spring)	1 Mar–31 May	3,439	0.310 (0.010)	0.834 (0.044)	1.070 (0.148)	0.852 (0.178)	0.236 (0.039)
Marsh Creek (spring)	22 Mar-31 May	662	0.308 (0.021)	0.883 (0.058)	1.022 (0.123)	1.211 (0.390)	0.337 (0.104)
East Fork Salmon	1 Apr–30 Apr	370	0.474 (0.030)	0.893 (0.048)	1.102 (0.157)	0.900 (0.265)	0.420 (0.110)
Sawtooth (spring)	21 Mar–31 May	4,065	0.540 (0.011)	0.927 (0.022)	0.952 (0.048)	0.943 (0.117)	0.449 (0.051)

Table 25. Continued.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
			Wild steelhead				
Snake	29 Mar–1 Jun	1,356	0.959 (0.008)	0.945 (0.012)	0.851 (0.046)	0.776 (0.132)	0.598 (0.097)
Clearwater	9 Mar–5 May	1,426	0.946 (0.009)	0.907 (0.019)	0.810 (0.057)	0.645 (0.144)	0.448 (0.096)
Grande Ronde	29 Mar–24 May	978	0.914 (0.012)	0.935 (0.016)	0.840 (0.057)	0.465 (0.077)	0.334 (0.050)
Imnaha (spring)	11 Mar–31 May	4,026	0.821 (0.007)	0.891 (0.009)	0.810 (0.028)	0.752 (0.082)	0.446 (0.047)
Imnaha (late)	1 Jun–21 Jun	414	0.607 (0.036)	0.408 (0.052)	0.395 (0.199)	0.273 (0.220)	0.027 (0.017)
Salmon	31 Mar–16 May	314	0.845 (0.024)	0.945 (0.028)	0.898 (0.118)	1.054 (0.676)	0.756 (0.475)
Lookingglass Creek	28 Feb–16 May	635	0.649 (0.020)	0.980 (0.028)	1.070 (0.218)	0.758 (0.405)	0.516 (0.253)
Minam	21 Mar–26 May	275	0.332 (0.029)	0.970 (0.045)	0.705 (0.143)	0.519 (0.201)	0.118 (0.044)
Lostine River	14 Mar–27 May	175	0.330 (0.038)	0.990 (0.100)	0.768 (0.187)	0.988 (0.683)	0.248 (0.169)
Crooked Fork Creek	30 Mar–31 May	192	0.774 (0.033)	0.918 (0.048)	0.964 (0.179)	0.440 (0.186)	0.301 (0.116)
Catherine Creek	3 Mar–3 Jun	500	0.160 (0.023)	0.820 (0.160)	0.486 (0.189)	NA	NA
Spoolcart (Grande Ronde)	15 Mar–3 Jun	604	0.340 (0.024)	0.781 (0.072)	0.905 (0.165)	0.386 (0.143)	0.093 (0.029)
Johnson Creek	3 Mar–26 May	63	0.516 (0.064)	0.948 (0.060)	0.708 (0.169)	0.577 (0.287)	0.200 (0.096)
Lemhi River Weir	4 Mar–31 May	1,100	0.052 (0.012)	0.714 (0.210)	NA	NA	NA
Pahsimeroi	1 Mar–31 May	1,188	0.105 (0.010)	0.835 (0.098)	0.783 (0.297)	NA	NA
Sawtooth	28 Mar–28 May	138	0.431 (0.045)	0.921 (0.114)	0.911 (0.402)	NA	NA

Table 25. Continued.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
			Hatchery Chinook salmon				
Snake	30 Mar–2 Jun	1,014	0.900 (0.017)	0.899 (0.024)	0.943 (0.055)	0.782 (0.087)	0.597 (0.058)
Grande Ronde	15 Mar–22 May	1,402	0.747 (0.014)	0.878 (0.020)	0.890 (0.055)	1.048 (0.138)	0.613 (0.073)
Lostine River	13 Mar–6 Apr	499	0.441 (0.025)	0.879 (0.050)	1.058 (0.190)	0.663 (0.173)	0.272 (0.055)
Catherine Creek	15 Mar–5 Jun	479	0.209 (0.024)	0.715 (0.081)	1.108 (0.288)	0.510 (0.165)	0.084 (0.019)
Spoolcart (Grande Ronde)	17 Mar–18 Mar	499	0.187 (0.019)	0.947 (0.063)	1.066 (0.183)	0.789 (0.257)	0.149 (0.044)
Salmon	12 Mar–17 May	4,837	0.760 (0.007)	0.924 (0.010)	0.928 (0.030)	0.885 (0.055)	0.576 (0.031)
			Hatchery steelhead				
Snake	29 Mar–2 Jun	3,357	0.970 (0.005)	0.941 (0.007)	0.882 (0.024)	0.870 (0.091)	0.700 (0.071)
Grande Ronde	30 Mar–22 May	1,417	0.858 (0.011)	0.911 (0.014)	0.867 (0.049)	0.772 (0.153)	0.523 (0.100)
Imnaha	13 Apr–31 May	6,368	0.826 (0.006)	0.885 (0.008)	0.824 (0.023)	0.735 (0.067)	0.444 (0.039)
Salmon	21 Mar–17 May	2,625	0.829 (0.009)	0.914 (0.010)	0.861 (0.030)	0.859 (0.114)	0.561 (0.072)

Table 26. Estimated detection probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2005. 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	Number released	LGR	LGO	LMO	MCN
			Wild Chinook salmon			
Snake	31 Mar-22 May	361	0.483 (0.031)	0.862 (0.029)	0.582 (0.065)	0.374 (0.111)
Clearwater	11 Mar–5 May	1,967	0.786 (0.011)	0.827 (0.018)	0.515 (0.035)	0.449 (0.052)
Grande Ronde	8 Mar–24 May	1,975	0.648 (0.013)	0.821 (0.015)	0.488 (0.029)	0.386 (0.049)
Imnaha (spring)	4 Mar–31 May	2,913	0.760 (0.010)	0.801 (0.014)	0.446 (0.023)	0.390 (0.033)
Imnaha (late)	1 Jun–21 Jun	554	0.564 (0.044)	0.290 (0.049)	0.041 (0.023)	0.558 (0.142)
Salmon	12 Mar–17 May	9,478	0.811 (0.005)	0.846 (0.008)	0.497 (0.014)	0.432 (0.021)
Minam	8 Mar–26 May	374	0.648 (0.038)	0.890 (0.040)	0.528 (0.096)	0.667 (0.157)
Elgin (Grande Ronde R.)	8 Mar–25 May	236	0.714 (0.042)	0.754 (0.058)	0.411 (0.093)	0.455 (0.150)
Crooked River (spring)	16 Mar–31 May	874	0.541 (0.033)	0.494 (0.045)	0.164 (0.041)	0.471 (0.121)
American River (spring)	16 Mar–31 May	1,124	0.621 (0.020)	0.724 (0.028)	0.298 (0.038)	0.474 (0.083)
Lostine River	8 Mar–27 May	464	0.681 (0.032)	0.659 (0.052)	0.439 (0.074)	0.314 (0.129)
Red River (spring)	16 Mar- 31 May	1,618	0.553 (0.024)	0.426 (0.033)	0.102 (0.023)	0.573 (0.084)
Crooked Fork Cr. (spring)	24 Mar–30 May	277	0.619 (0.045)	0.797 (0.053)	0.315 (0.081)	0.636 (0.145)
Catherine Creek	3 Mar–3 Jun	406	0.449 (0.054)	0.695 (0.065)	0.473 (0.096)	0.500 (0.177)
Spoolcart (Grande Ronde)	15 Mar–20 May	615	0.563 (0.034)	0.856 (0.036)	0.581 (0.081)	0.583 (0.142)
Johnson Creek	2 Mar–15 May	3,900	0.583 (0.013)	0.814 (0.014)	0.479 (0.024)	0.540 (0.039)
South Fork Salmon R.	3 Mar- 15 May	2,530	0.570 (0.018)	0.673 (0.025)	0.339 (0.032)	0.462 (0.061)
Lemhi River Weir (spring)	4 Mar–29 May	390	0.708 (0.039)	0.720 (0.061)	0.652 (0.086)	0.319 (0.130)
Pahsimeroi (spring)	1 Mar–31 May	3,439	0.667 (0.019)	0.574 (0.031)	0.164 (0.028)	0.417 (0.071)
Marsh Creek (spring)	22 Mar- 31 May	662	0.578 (0.040)	0.780 (0.044)	0.446 (0.075)	0.316 (0.107)
East Fork Salmon	1 Apr–30 Apr	370	0.547 (0.042)	0.753 (0.043)	0.299 (0.055)	0.385 (0.106)
Sawtooth (spring)	21 Mar–31 May	4,065	0.469 (0.012)	0.767 (0.014)	0.431 (0.026)	0.389 (0.047)

Table 26. Continued.

Trap	Release dates	Number released	LGR	LGO	LMO	MCN
			Wild steelhead			
Snake	29 Mar–1 Jun	1,356	0.700 (0.013)	0.900 (0.012)	0.516 (0.031)	0.245 (0.042)
Clearwater	9 Mar–5 May	1,426	0.763 (0.013)	0.911 (0.015)	0.628 (0.048)	0.295 (0.069)
Grande Ronde	29 Mar–24 May	978	0.637 (0.017)	0.891 (0.015)	0.552 (0.041)	0.406 (0.065)
Imnaha (spring)	11 Mar–31 May	4,026	0.693 (0.009)	0.900 (0.008)	0.548 (0.021)	0.239 (0.027)
Imnaha (late)	1 Jun–21 Jun	414	0.788 (0.043)	0.844 (0.083)	0.389 (0.203)	0.556 (0.345)
Salmon	31 Mar–16 May	314	0.667 (0.031)	0.882 (0.028)	0.504 (0.073)	0.167 (0.108)
Lookingglass Creek	28 Feb–16 May	635	0.755 (0.022)	0.898 (0.028)	0.343 (0.077)	0.143 (0.076)
Minam	21 Mar–26 May	275	0.645 (0.052)	0.968 (0.032)	0.694 (0.149)	0.600 (0.219)
Lostine River	14 Mar–27 May	175	0.641 (0.068)	0.802 (0.090)	0.581 (0.161)	0.125 (0.117)
Crooked Fork Creek	30 Mar–31 May	192	0.747 (0.038)	0.941 (0.033)	0.624 (0.134)	0.300 (0.145)
Catherine Creek	3 Mar–3 Jun	500	0.511 (0.074)	0.780 (0.108)	0.762 (0.217)	NA
Spoolcart (Grande Ronde)	15 Mar–3 Jun	604	0.633 (0.043)	0.855 (0.045)	0.633 (0.126)	0.364 (0.145)
Johnson Creek	3 Mar–26 May	63	0.800 (0.073)	0.941 (0.057)	0.642 (0.167)	0.500 (0.250)
Lemhi River Weir	4 Mar–31 May	1,100	0.368 (0.097)	0.867 (0.090)	NA	NA
Pahsimeroi	1 Mar–31 May	1,188	0.644 (0.053)	0.853 (0.070)	0.419 (0.175)	NA
Sawtooth	28 Mar–28 May	138	0.773 (0.061)	0.917 (0.080)	0.400 (0.219)	NA

Table 26. Continued.

Trap	Release dates	Number released	LGR	LGO	LMO	MCN
			Hatchery Chinook salmon			
Snake	30 Mar–2 Jun	1,014	0.515 (0.018)	0.733 (0.020)	0.370 (0.027)	0.464 (0.048)
Grande Ronde	15 Mar–22 May	1,402	0.703 (0.016)	0.778 (0.019)	0.319 (0.025)	0.296 (0.038)
Lostine River	13 Mar–6 Apr	499	0.717 (0.035)	0.693 (0.046)	0.229 (0.050)	0.394 (0.085)
Catherine Creek	15 Mar–5 Jun	479	0.500 (0.063)	0.742 (0.067)	0.243 (0.079)	0.610 (0.125)
Spoolcart (Grande Ronde)	17 Mar–18 Mar	499	0.537 (0.056)	0.710 (0.059)	0.348 (0.076)	0.437 (0.133)
Salmon	12 Mar–17 May	4,837	0.677 (0.008)	0.762 (0.010)	0.327 (0.013)	0.360 (0.021)
			Hatchery steelhead			
Snake	29 Mar–2 Jun	3,357	0.698 (0.008)	0.875 (0.008)	0.602 (0.018)	0.192 (0.021)
Grande Ronde	30 Mar–22 May	1,417	0.690 (0.014)	0.888 (0.013)	0.552 (0.034)	0.194 (0.040)
Imnaha	13 Apr–31 May	6,368	0.631 (0.007)	0.868 (0.007)	0.555 (0.017)	0.206 (0.019)
Salmon	21 Mar–17 May	2,625	0.694 (0.011)	0.891 (0.009)	0.596 (0.023)	0.180 (0.025)

Table 27. Estimated survival probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2005. 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	Release site	Number released	Rel to MCN	MCN to JDA	JDA to BON	MCN to BON	Rel to BON
			Yearling Chinook salmon				
Entiat	Entiat Hatchery	3,730	0.635 (0.034)	0.709 (0.078)	NA	NA	NA
Leavenworth	Leavenworth Hatchery	14,825	0.534 (0.014)	0.747 (0.052)	NA	NA	NA
Winthrop	Winthrop Hatchery	3,600	0.469 (0.034)	0.896 (0.182)	NA	NA	NA
Little White Salmon	S.F. Walla Walla River	995	0.428 (0.063)	0.342 (0.066)	NA	NA	NA
Wells	Wells H. (May)	2,979	0.324 (0.048)	0.647 (0.357)	NA	NA	NA
Wells	Wells H. (June)	2,968	0.395 (0.383)	NA	NA	NA	NA
Bonneville	Umatilla River	600	NA	0.432[a] (0.214)	NA	NA	NA
Irrigon	Imeques Pond	2,090	NA	0.341[a] (0.047)	0.632 (0.411)	NA	0.216 (0.137)
Irrigon	Umatilla River	597	NA	0.189[a] (0.086)	NA	NA	NA
Priest Rapids[bc]	Rock Island D. Tailrace	43,402	0.809 (0.018)	0.894 (0.053)	0.803 (0.141)	0.703 (0.141)	0.567 (0115)
Priest Rapids[bc]	Priest Rapids D. Tailrace	44,293	0.957 (0.021)	0.800 (0.063)	1.021 (0.142)	0.782 (0.107)	0.750 (0.101)

Table 27. Continued.

Hatchery	Release Site	Number released	Rel to MCN	MCN to JDA	JDA to BON	MCN to BON	Rel to BON
			Steelhead				
Turtle Rock[b]	Wells Dam tailrace	39,822	0.429 (0.021)	0.603 (0.060)	NA	NA	NA
Turtle Rock[b]	Rocky Reach D. tailrace	39,993	0.449 (0.026)	0.682 (0.040)	NA	NA	NA
Chelan	Nason Creek	34,826	0.425 (0.016)	0.659 (0.053)	NA	NA	NA
East Bank	Chiwawa River	29,801	0.516 (0.019)	0.721 (0.061)	0.926 (0.528)	0.668 (0.378)	0.344 (0.194)
East Bank	Wenatchee River	30,019	0.519 (0.020)	0.702 (0.065)	NA	NA	NA
Ringold	Ringold Hatchery	60.971	0.698 (0.012)	0.667 (0.033)	0.620 (0.108)	0.414 (0.070)	0.289 (0.049)
Winthrop	Winthrop Hatchery	49,233	0.217 (0.006)	0.683 (0.055)	NA	NA	NA
Wells	Chewuch River (April)	41,010	0.526 (0.016)	0.838 (0.061)	NA	NA	NA
Wells	Chewuch River (May)	8,539	0.126 (0.018)	0.547 (0.170)	NA	NA	NA
Wells	Methow River (April)	89,871	0.374 (0.009)	0.859 (0.047)	0.965 (0.336)	0.829 (0.287)	0.310 (0.107)
Wells	Methow River (May)	10,385	0.189 (0.017)	0.826 (0.240)	NA	NA	NA
Wells	Similkameen R. (April)	26,676	0.463 (0.018)	0.855 (0.089)	1.050 (0.736)	0.898 (0.624)	0.416 (0.289)
Wells	Similkameen R. (May)	13,383	0.379 (0.019)	0.556 (0.068)	NA	NA	NA

Table 27. Continued.

Hatchery	Release Site	Number released	Rel to MCN	MCN to JDA	JDA to BON	MCN to BON	Rel to BON
			Steelhead				
Wells	Twisp Pond	8,912	0.410 (0.025)	0.983 (0.161)	NA	NA	NA
Wells	Twisp River (April)	17,137	0.504 (0.026)	0.822 (0.097)	NA	NA	NA
Wells	Twisp River (May)	18,128	0.208 (0.010)	0.982 (0.157)	NA	NA	NA
			Coho salmon				
Cascade	Leavenworth H.	7,841	0.359 (0.025)	0.590 (0.098)	NA	NA	NA
Eagle Creek	Holmes Pond	4,958	0.230 (0.028)	1.565 (0.543)	NA	NA	NA
Eagle Creek	Stiles Pond	5,005	0.279 (0.031)	0.700 (0.152)	NA	NA	NA
Willard	Leavenworth H.	8,002	0.430 (0.041)	0.854 (0.212)	NA	NA	NA

a. These fish entered the Columbia River downstream of McNary Dam. Estimate is for survival from release to John Day Dam.
b. Weighted average of estimates from series of release groups.
c. Summer-fall Chinook salmon reared to yearling age before release.

Table 28. Estimated detection probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2005. 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	Release Site	Number released	MCN	JDA	BON
		Yearling Chinook salmon			
Entiat	Entiat Hatchery	3,730	0.289 (0.018)	0.295 (0.030)	NA
Leavenworth	Leavenworth Hatchery	14,825	0.388 (0.011)	0.243 (0.017)	NA
Winthrop	Winthrop Hatchery	3,600	0.316 (0.025)	0.158 (0.032)	NA
Little White Salmon	S.F. Walla Walla River	995	0.261 (0.043)	0.690 (0.086)	NA
Wells	Wells H. (May)	2,979	0.325 (0.049)	0.090 (0.049)	NA
Wells	Wells H. (June)	2,968	0.026 (0.026)	NA	NA
Bonneville	Umatilla R.	600	NA	0.212 (0.108)	NA
Irrigon	Imeques Pond	2,090	NA	0.369 (0.053)	0.161 (0.104)
Irrigon	Umatilla R.	597	NA	0.345 (0.160)	
Priest Rapids[bc]	Rock Island D. Tailrace	43,402	0.247 (0.006)	0.121 (0.007)	0.064 (0.014)
Priest Rapids[bc]	Priest Rapids D. Tailrace	44,293	0.223 (0.005)	0.142 (0.007)	0.063 (0.013)

Table 28. Continued.

Hatchery	Release Site	Number released	MCN	JDA	BON
			Steelhead		
Lyons Ferry	Touchet River	9,993	0.239 (0.034)	0.300 (0.082)	NA
Irrigon	Pendleton Pond	300	NA	0.471 (0.167)	NA
Irrigon	Thornhollow Pond	595	NA	0.305 (0.177)	NA
Turtle Rock[b]	Wells Dam tailrace	39,822	0.262 (0.007)	0.352 (0.021)	0.052 (0.019)
Turtle Rock[b]	Rocky Reach Dam tailrace	39,993	0.255 (0.007)	0.350 (0.020)	0.037 (0.015)
Chelan	Nason Creek	34,826	0.210 (0.008)	0.327 (0.023)	0.016 (0.012)
East Bank	Chiwawa River	29,801	0.187 (0.008)	0.326 (0.025)	0.025 (0.014)
East Bank	Wenatchee River	30,019	0.222 (0.009)	0.261 (0.022)	0.015 (0.010)
Ringold	Ringold Hatchery	60,971	0.340 (0.006)	0.215 (0.010)	0.097 (0.017)
Winthrop	Winthrop Hatchery	49,233	0.250 (0.008)	0.355 (0.027)	0.009 (0.009)
Wells	Chewuch River (April)	41,010	0.191 (0.006)	0.277 (0.018)	0.021 (0.012)
Wells	Chewuch River (May)	8,539	0.255 (0.038)	0.308 (0.085)	NA
Wells	Methow River (April)	89,871	0.215 (0.005)	0.272 (0.014)	0.033 (0.012)
Wells	Methow River (May)	10,385	0.284 (0.027)	0.218 (0.060)	NA

Table 28. Continued.

Hatchery	Release Site	Number released	MCN	JDA	BON
			Steelhead		
Wells	Similkameen River (April)	26,676	0.217 (0.009)	0.251 (0.024)	0.022 (0.015)
Wells	Similkameen River (May)	13,383	0.316 (0.017)	0.333 (0.037)	NA
Wells	Twisp Pond	8,912	0.246 (0.016)	0.249 (0.038)	NA
Wells	Twisp River (April)	17,137	0.198 (0.011)	0.263 (0.028)	NA
Wells	Twisp River (May)	18,128	0.361 (0.018)	0.245 (0.038)	NA
			Coho salmon		
Cascade	Leavenworth H.	7,841	0.286 (0.021)	0.186 (0.030)	NA
Eagle Creek	Holmes Pond	4,958	0.183 (0.024)	0.101 (0.034)	NA
Eagle Creek	Stiles Pond	5,005	0.198 (0.024)	0.219 (0.043)	NA
Willard	Leavenworth H.	8,002	0.188 (0.019)	0.091 (0.022)	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 2005. 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	43	10.9	14.9	23.0	20	4.0	7.1	10.5	15	4.5	5.6	7.0
06 Apr-12 Apr	497	12.4	17.1	22.9	210	2.5	3.7	5.6	92	3.9	5.2	6.0
13 Apr-19 Apr	1,382	9.0	12.4	17.4	603	2.4	3.4	5.1	284	4.1	5.3	6.6
20 Apr-26 Apr	3,615	5.4	7.9	12.1	1,258	2.1	3.2	4.7	492	3.5	4.6	6.0
27 Apr–03 May	12,345	4.3	6.1	9.0	3,508	1.6	2.1	3.0	1,343	2.8	3.4	4.2
04 May–10 May	36,359	3.3	4.2	5.7	12,185	1.4	1.9	2.5	5,739	2.6	3.1	3.7
11 May-17 May	8,937	4.1	5.4	7.1	3,221	1.4	1.9	2.6	1,481	2.6	3.2	4.0
18 May-24 May	2,872	3.2	4.3	5.8	1,187	1.6	2.1	3.0	494	2.8	3.4	4.2
25 May-31 May	1,760	3.0	4.1	6.1	566	1.6	2.2	3.1	286	2.8	3.4	4.2
01 Jun-07 Jun	1,398	2.9	4.2	7.4	429	2.0	3.0	6.1	216	3.4	4.2	5.5
08 Jun-14 Jun	442	3.6	4.8	7.1	80	2.2	3.2	5.0	41	3.5	4.0	5.1
15 Jun B 21 Jun	38	2.9	3.9	4.7	0	NA	NA	NA	1	NA	3.2	NA

	LGR to MCN (days)				LGR to BON (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	23	23.2	29.9	32.6	1	NA	49.8	NA
06 Apr-12 Apr	195	24.4	26.6	29.8	54	28.9	31.2	34.3
13 Apr-19 Apr	548	18.7	21.7	24.2	126	24.2	26.5	29.5
20 Apr-26 Apr	1,251	13.4	16.0	19.1	301	18.6	21.2	24.4
27 Apr–03 May	4,204	10.1	12.1	14.9	992	15.0	16.9	19.4
04 May–10 May	15,176	8.2	9.5	11.2	3,085	12.7	14.2	16.4
11 May-17 May	3,956	8.4	10.3	12.6	901	12.8	14.5	16.8
18 May-24 May	1,172	8.1	9.8	12.1	253	12.2	14.1	16.2
25 May-31 May	747	8.2	10.1	16.2	88	12.4	14.4	17.4
01 Jun-07 Jun	718	11.7	18.9	22.6	61	15.9	20.4	25.2
08 Jun-14 Jun	369	12.2	14.3	17.1	20	17.1	18.4	20.7
15 Jun B 21 Jun	241	7.2	8.6	10.2	12	12.4	13.2	14.1

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 2005. 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	43	2.6	4.0	5.5	20	4.4	6.5	11.6	15	17.0	21.2	26.7
06 Apr-12 Apr	497	2.6	3.5	4.8	210	8.3	12.4	18.3	92	19.7	23.1	30.5
13 Apr-19 Apr	1,382	3.5	4.8	6.6	603	9.0	13.5	19.3	284	18.0	22.6	29.0
20 Apr-26 Apr	3,615	5.0	7.6	11.1	1,258	9.9	14.6	21.5	492	19.9	26.2	33.9
27 Apr–03 May	12,345	6.7	9.9	14.0	3,508	15.2	21.5	29.3	1,343	28.5	35.0	41.9
04 May–10 May	36,359	10.6	14.4	18.0	12,185	18.3	24.7	32.6	5,739	31.8	38.4	45.8
11 May-17 May	8,937	8.4	11.1	14.7	3,221	17.8	24.6	32.4	1,481	29.4	37.3	45.1
18 May-24 May	2,872	10.3	13.9	18.8	1,187	15.4	21.8	28.8	494	28.2	35.4	42.2
25 May-31 May	1,760	9.8	14.6	19.9	566	14.6	21.3	28.8	286	28.5	35.4	41.9
01 Jun-07 Jun	1,398	8.1	14.5	20.6	429	7.5	15.6	22.8	216	21.6	28.3	34.5
08 Jun-14 Jun	442	8.4	12.5	16.7	80	9.2	14.6	20.7	41	23.4	30.0	33.7
15 Jun B 21 Jun	38	12.8	15.5	20.7	0	NA	NA	NA	1	NA	37.8	NA

	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	23	6.9	7.5	9.7	1	NA	9.3	NA
06 Apr-12 Apr	195	7.5	8.5	9.2	54	13.5	14.8	16.0
13 Apr-19 Apr	548	9.3	10.3	12.0	126	15.6	17.4	19.0
20 Apr-26 Apr	1,251	11.8	14.0	16.8	301	18.9	21.7	24.8
27 Apr–03 May	4,204	15.1	18.6	22.3	992	23.8	27.3	30.6
04 May–10 May	15,176	20.1	23.6	27.6	3,085	28.1	32.5	36.2
11 May-17 May	3,956	17.9	21.9	26.9	901	27.5	31.8	36.1
18 May-24 May	1,172	18.7	23.0	27.8	253	28.5	32.8	37.8
25 May-31 May	747	13.9	22.4	27.6	88	26.4	32.0	37.0
01 Jun-07 Jun	718	10.0	11.9	19.2	61	18.3	22.6	29.0
08 Jun-14 Jun	369	13.2	15.7	18.4	20	22.3	25.0	27.0
15 Jun-21 Jun	241	22.2	26.2	31.0	12	32.6	34.8	37.2

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 2005. 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 LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr–03 May	32	4.1	4.6	5.7	9	2.1	2.2	2.3	18	6.3	6.5	7.5
04 May–10 May	1,194	3.1	3.6	4.4	129	1.8	2.0	2.4	496	4.8	5.4	6.3
11 May–17 May	2,461	2.7	3.4	4.1	222	1.7	2.0	2.3	1,511	4.2	5.1	5.8
18 May–24 May	668	2.5	3.2	3.8	108	1.8	2.1	2.5	1,223	4.2	4.9	5.4
25 May–31 May	340	2.5	3.1	4.0	33	1.8	2.0	2.4	350	4.1	4.5	5.2
01 Jun–07 Jun	188	2.6	3.4	4.3	18	1.8	2.1	2.3	102	4.5	5.1	5.8
08 Jun–14 Jun	76	3.1	3.5	4.5	3	2.3	2.6	3.4	27	4.4	5.4	6.4
15 JunB21 Jun	53	3.1	3.4	4.2	7	1.7	1.9	2.1	23	4.2	5.0	5.6
22 Jun–28 Jun	113	2.4	2.8	3.3	12	1.6	1.9	2.3	59	4.0	4.4	5.0

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 2005. 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 LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr–03 May	32	21.6	26.7	30.0	9	48.5	51.6	53.1	18	31.4	36.3	37.4
04 May–10 May	1,194	27.8	34.4	39.5	129	47.5	56.2	63.5	496	37.5	43.9	49.1
11 May–17 May	2,461	30.3	36.5	45.7	222	49.1	57.9	66.5	1,511	40.3	46.6	55.5
18 May–24 May	668	32.0	38.8	48.4	108	45.7	54.3	64.6	1,223	43.5	47.9	56.3
25 May–31 May	340	30.8	39.5	49.2	33	46.3	57.9	64.6	350	45.6	52.0	58.0
01 Jun–07 Jun	188	28.8	36.3	47.3	18	49.3	54.6	61.4	102	41.0	46.0	52.8
08 Jun–14 Jun	76	27.6	35.5	39.7	3	32.9	44.1	50.0	27	36.9	43.7	53.5
15 Jun B 21 Jun	53	29.5	36.0	39.8	7	53.8	60.1	65.7	23	42.0	47.5	55.5
22 Jun–28 Jun	113	37.3	43.6	52.1	12	49.3	60.8	70.6	59	47.2	53.3	58.3

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 2005. 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	90	6.2	9.3	21.2	58	3.8	8.6	15.1	4	4.1	5.3	6.8
06 Apr-12 Apr	342	7.5	12.1	20.0	212	3.2	5.6	11.7	27	3.0	3.7	4.6
13 Apr-19 Apr	854	5.8	8.8	13.1	505	3.2	5.7	9.3	68	3.2	3.8	4.8
20 Apr-26 Apr	3,022	3.6	5.4	9.9	1,776	2.6	4.3	7.9	292	2.9	3.4	4.1
27 Apr-03 May	6,703	3.3	5.6	9.3	3,561	1.9	2.8	4.6	641	2.7	3.0	3.8
4 May-10 May	13,195	2.4	3.2	4.5	6,708	1.6	2.1	3.2	1,349	2.6	3.0	3.5
11 May–17 May	7,775	2.3	2.9	4.3	3,928	1.4	2.0	3.0	941	2.4	2.8	3.5
18 May-24 May	3,893	1.5	1.8	2.8	1,980	1.2	1.8	2.7	357	2.4	2.9	3.4
25 May-31 May	2,045	1.7	2.6	3.6	940	1.6	2.1	3.8	118	2.5	2.9	3.3
01 Jun-07 Jun	746	2.0	3.0	5.5	166	1.6	2.1	4.1	20	2.2	2.7	3.0
08 Jun-14 Jun	314	2.7	4.2	7.0	46	1.8	2.3	4.2	3	3.0	3.0	3.6

	LGR to MCN (days)				LGR to BON (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar-05 Apr	10	22.2	26.3	35.3	2	28.6	31.9	35.2
06 Apr-12 Apr	45	20.6	25.5	31.9	5	33.4	35.7	39.8
13 Apr-19 Apr	118	17.2	20.7	25.8	21	22.4	23.7	32.3
20 Apr-26 Apr	449	12.0	15.0	19.0	47	17.4	20.4	24.2
27 Apr-03 May	1,039	9.5	11.7	14.6	76	15.5	17.8	20.8
04 May-10 May	2,049	7.4	8.7	10.8	184	12.1	13.6	16.6
11 May-17 May	1,757	6.5	7.7	9.5	111	11.4	12.6	16.9
18 May-24 May	694	5.4	6.4	7.9	65	10.2	11.1	13.4
25 May-31 May	169	6.0	7.9	10.2	15	13.2	14.4	17.7
01 Jun-07 Jun	63	6.8	18.6	21.6	4	12.8	13.9	16.8
08 Jun-14 Jun	43	13.6	14.9	17.2	2	16.7	20.0	23.4

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 2005. 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%
30 Mar-05 Apr	90	2.8	6.4	9.6	58	3.0	5.3	11.9	4	17.6	22.3	28.7
06 Apr-12 Apr	342	3.0	5.0	8.0	212	3.9	8.2	14.3	27	25.6	32.2	39.9
13 Apr-19 Apr	854	4.6	6.8	10.4	505	5.0	8.0	14.4	68	25.1	30.9	36.6
20 Apr-26 Apr	3,022	6.1	11.1	16.5	1,776	5.8	10.7	18.0	292	29.1	35.3	41.0
27 Apr-03 May	6,703	6.4	10.8	18.0	3,561	10.0	16.4	24.1	641	31.6	39.0	43.6
4 May-10 May	13,195	13.4	18.8	25.5	6,708	14.3	21.5	28.6	1,349	33.6	40.3	46.3
11 May–17 May	7,775	13.9	21.0	26.5	3,928	15.4	23.4	33.8	941	34.3	41.9	50.0
18 May-24 May	3,893	21.5	32.4	40.3	1,980	16.9	26.3	39.3	357	34.9	41.2	49.4
25 May-31 May	2,045	16.5	23.3	34.5	940	12.2	21.8	28.9	118	36.0	41.5	47.8
01 Jun-07 Jun	746	10.9	20.1	29.7	166	11.1	21.8	28.4	20	39.9	43.9	53.6
08 Jun-14 Jun	314	8.6	14.4	22.2	46	10.8	20.1	26.1	3	33.2	39.3	39.7

	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	10	6.4	8.5	10.2	2	13.1	14.5	16.1
06 Apr-12 Apr	45	7.1	8.8	10.9	5	11.6	12.9	13.8
13 Apr-19 Apr	118	8.7	10.9	13.1	21	14.3	19.5	20.6
20 Apr-26 Apr	449	11.8	15.0	18.7	47	19.1	22.6	26.5
27 Apr-03 May	1,039	15.4	19.2	23.7	76	22.2	25.9	29.8
4 May-10 May	2,049	20.8	25.7	30.6	184	27.8	33.8	38.0
11 May–17 May	1,757	23.6	29.2	34.8	111	27.3	36.7	40.5
18 May-24 May	694	28.5	35.4	41.4	65	34.4	41.5	45.3
25 May-31 May	169	22.0	28.6	37.4	15	26.1	32.0	35.0
01 Jun-07 Jun	63	10.4	12.1	32.9	4	27.4	33.1	35.9
08 Jun-14 Jun	43	13.1	15.1	16.6	2	19.7	23.0	27.6

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 2005. 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 LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr-03 May	19	3.8	4.6	6.0	3	1.9	1.9	2.4	7	6.5	6.8	8.1
04 May-10 May	197	3.0	3.6	5.0	9	1.5	1.9	2.2	18	5.1	5.4	6.3
11 May-17 May	468	2.7	3.5	4.6	13	1.5	1.7	1.8	47	4.4	5.4	6.3
18 May-24 May	527	2.8	3.6	5.0	19	1.5	1.6	2.1	59	4.4	5.2	6.2
25 May-31 May	132	2.6	3.4	5.0	6	1.6	1.6	1.9	26	4.4	4.6	5.4

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 2005. 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 LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr-03 May	19	20.5	26.7	32.4	3	46.9	58.2	60.1	7	29.0	34.5	36.3
04 May-10 May	197	24.7	33.7	41.6	9	52.3	60.8	74.8	18	37.5	43.8	46.5
11 May-17 May	468	27.0	35.3	46.1	13	63.5	67.7	77.4	47	37.3	44.0	54.0
18 May-24 May	527	24.7	34.0	43.9	19	54.9	68.5	75.3	59	37.8	45.7	53.6
25 May-31 May	132	24.4	35.8	47.9	6	59.8	68.5	70.6	26	43.7	51.1	53.6

Table 37. Number of PIT-tagged hatchery steelhead released at Lower Granite by day for survival estimates in 2005. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost Tags
12-Apr	101		1	13-May	691	3	5
13-Apr	281		1	14-May	719	1	3
14-Apr	175	-	-	17-May	492	2	2
15-Apr	58	-	-	18-May	509	-	1
16-Apr	64	-	-	19-May	492	-	1
19-Apr	79	-	-	20-May	492	-	3
20-Apr	410	-	-	21-May	335	-	-
21-Apr	351	-	-	24-May	353	-	1
22-Apr	401	-	-	25-May	351	-	-
23-Apr	364	-	-	26-May	363	-	1
26-Apr	643	-	-	27-May	357	-	-
27-Apr	710	-	-	28-May	351	-	1
28-Apr	666	-	-	1-Jun	108	-	-
29-Apr	714	-	-	2-Jun	198	-	1
30-Apr	511	-	-	3-Jun	298	-	1
3-May	1,338	7	-	4-Jun	252	-	1
5-May	697	1	-	7-Jun	209	1	1
6-May	743	5	-	8-Jun	131	-	-
7-May	743	2	1	9-Jun	210	-	-
10-May	679	1	7	10-Jun	210	-	2
11-May	698	4	-	11-Jun	212	-	-
12-May	680	-	-	Total	18,439	27	34

Table 38. Number of PIT-tagged wild steelhead released at Lower Granite by day for survival estimates in 2005. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost Tags
12-Apr	35	-	-	13-May	335	1	-
13-Apr	30	-	-	14-May	331	-	-
14-Apr	36	-	-	17-May	221	-	2
15-Apr	13	-	-	18-May	221	-	-
16-Apr	12	-	-	19-May	235	-	2
19-Apr	20	-	-	20-May	220	1	1
20-Apr	67	-	-	21-May	149	-	-
21-Apr	24	-	-	24-May	161	-	-
22-Apr	42	-	-	25-May	160	-	-
23-Apr	22	-	-	26-May	160	-	-
26-Apr	9	-	-	27-May	165	-	-
27-Apr	18	-	-	28-May	160	-	-
28-Apr	10	-	-	1-Jun	33	-	-
29-Apr	24	-	-	2-Jun	47	-	1
30-Apr	32	-	-	3-Jun	83	-	-
3-May	540	1	-	4-Jun	62	-	-
5-May	344	-	-	7-Jun	16	-	-
6-May	333	3	-	8-Jun	42	-	-
7-May	122	-	-	9-Jun	49	-	-
10-May	95	-	-	10-Jun	52	-	-
11-May	329	-	-	11-Jun	51	-	-
12-May	205	-	-	Total	5,315	6	6

Table 39. Number of PIT-tagged wild yearling Chinook salmon released at Lower Granite by day for survival estimates in 2005. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost Tags
12-Apr	138	-	-	13-May	129	2	1
13-Apr	154	-	-	14-May	201	-	-
14-Apr	210	-	-	17-May	141	-	-
15-Apr	74	-	-	18-May	141	2	-
16-Apr	77	-	-	19-May	145	2	-
19-Apr	78	-	-	20-May	142	-	-
20-Apr	264	-	-	21-May	-	-	-
21-Apr	172	4	-	24-May	127	-	-
22-Apr	181	1	-	25-May	125	-	-
23-Apr	76	-	-	26-May	125	-	-
26-Apr	52	1	-	27-May	126	-	-
27-Apr	117	5	-	28-May	132	-	-
28-Apr	178	3	-	1-Jun	165	1	-
29-Apr	207	3	-	2-Jun	163	1	-
30-Apr	82	2	-	3-Jun	159	-	-
3-May	755	7	-	4-Jun	160	-	-
5-May	265	2	1	7-Jun	136	1	-
6-May	335	2	-	8-Jun	120	-	-
7-May	317	3	-	9-Jun	121	-	-
10-May	219	-	-	10-Jun	121	-	-
11-May	142	5	-	11-Jun	121	-	-
12-May	71	1	-	Total	6,964	48	2

Table 40. Estimated survival for yearling Chinook salmon from selected Snake River Basin hatcheries to the tailrace of Lower Granite Dam, 1993-2005. Distance from each hatchery to Lower Granite Dam in parentheses in header. Standard errors in parentheses following each survival estimate.

Year	Dworshak (116)	Kooskia (176)	Lookingglass* (209)	Rapid River (283)	McCall (457)	Pahsimeroi (630)	Sawtooth (747)	Mean
1993	0.647 (0.028)	0.689 (0.047)	0.660 (0.025)	0.670 (0.017)	0.498 (0.017)	0.456 (0.032)	0.255 (0.023)	0.554 (0.060)
1994	0.778 (0.020)	0.752 (0.053)	0.685 (0.021)	0.526 (0.024)	0.554 (0.022)	0.324 (0.028)	0.209 (0.014)	0.547 (0.081)
1995	0.838 (0.034)	0.786 (0.024)	0.617 (0.015)	0.726 (0.017)	0.522 (0.011)	0.316 (0.033)	0.230 (0.015)	0.576 (0.088)
1996	0.776 (0.017)	0.744 (0.010)	0.567 (0.014)	0.588 (0.007)	0.531 (0.007)	C	0.121 (0.017)	0.555 (0.096)
1997	0.576 (0.017)	0.449 (0.034)	0.616 (0.017)	0.382 (0.008)	0.424 (0.008)	0.500 (0.008)	0.508 (0.037)	0.494 (0.031)
1998	0.836 (0.006)	0.652 (0.024)	0.682 (0.006)	0.660 (0.004)	0.585 (0.004)	0.428 (0.021)	0.601 (0.033)	0.635 (0.046)
1999	0.834 (0.011)	0.653 (0.031)	0.668 (0.009)	0.746 (0.006)	0.649 (0.008)	0.584 (0.035)	0.452 (0.019)	0.655 (0.045)
2000	0.841 (0.009)	0.734 (0.027)	0.688 (0.011)	0.748 (0.007)	0.689 (0.010)	0.631 (0.062)	0.546 (0.030)	0.697 (0.035)
2001	0.747 (0.002)	0.577 (0.019)	0.747 (0.003)	0.689 (0.002)	0.666 (0.002)	0.621 (0.016)	0.524 (0.023)	0.653 (0.032)
2002	0.819 (0.011)	0.787 (0.036)	0.667 (0.012)	0.755 (0.003)	0.592 (0.006)	0.678 (0.053)	0.387 (0.025)	0.669 (0.055)
2003	0.720 (0.008)	0.560 (0.043)	0.715 (0.012)	0.691 (0.007)	0.573 (0.006)	0.721 (0.230)	0.595 (0.149)	0.654 (0.028)
2004	0.821 (0.003)	0.769 (0.017)	0.613 (0.004)	0.694 (0.003)	0.561 (0.002)	0.528 (0.017)	0.547 (0.018)	0.648 (0.044)
2005	0.823 (0.003)	0.702 (0.021)	0.534 (0.004)	0.735 (0.002)	0.603 (0.003)	0.218 (0.020)	0.220 (0.020)	0.549 (0.092)
Mean	0.774 (0.023)	0.681 (0.028)	0.651 (0.016)	0.662 (0.030)	0.573 (0.020)	0.500 (0.045)	0.400 (0.047)	

*. Released at Imnaha River Weir.

Table 41. Annual weighted means of survival probability estimates for yearling Chinook salmon (hatchery and wild combined), 1993-2005. 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: SNKTRP-Snake River Trap; 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	SNKTRP-LGR	LGR-LGO	LGO-LMO	LMO-MCN*	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1993	0.828 (0.013)	0.854 (0.012)						
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)					
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.925 (0.009)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.940 (0.009)	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	0.929 (0.014)	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	0.954 (0.015)	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	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
Mean	**0.929 (0.012)**	**0.923 (0.012)**	**0.896 (0.012)**	**0.850 (0.022)**	**0.921 (0.012)**	**0.839 (0.020)**	**0.795 (0.048)**	**0.889 (0.026)**
Exc. 2001	0.927 (0.013)	0.921 (0.013)	0.902 (0.012)	0.864 (0.018)	0.929 (0.010)	0.851 (0.019)	0.820 (0.048)	0.904 (0.026)

Table 42. Annual weighted means of survival probability estimates for steelhead (hatchery and wild combined), 1993-2005. 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: SNKTRP-Snake River Trap; 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	SNKTRP-LGR	LGR-LGO	LGO-LMO	LMO-MCN*	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1993	0.905 (0.006)							
1994	NA	0.844 (0.011)	0.892 (0.011)					
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.924 (0.009)	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	0.908 (0.011)	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	0.964 (0.013)	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	0.911 (0.007)	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	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
2005	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
Mean	**0.937 (0.008)**	**0.903 (0.014)**	**0.882 (0.019)**	**0.714 (0.052)**	**0.838 (0.035)**	**0.715 (0.078)**	**0.728 (0.048)**	**0.851 (0.028)**
Exc. 2001	0.940 (0.008)	0.912 (0.012)	0.898 (0.012)	0.756 (0.034)	0.867 (0.020)	0.769 (0.064)	0.723 (0.059)	0.847 (0.033)

Table 43. 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), 1997-2005. 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
1997	NA	NA	NA	0.964 (0.015)	0.474 (0.069)	0.457 (0.067)
1998	0.925 (0.009)	NA	NA	0.924 (0.009)	0.500 (0.054)	0.462 (0.050)
1999	0.940 (0.009)	0.557 (0.046)	0.524 (0.043)	0.908 (0.011)	0.440 (0.018)	0.400 (0.016)
2000	0.929 (0.014)	0.486 (0.093)	0.452 (0.087)	0.964 (0.013)	0.393 (0.034)	0.379 (0.032)
2001	0.954 (0.015)	0.279 (0.016)	0.266 (0.015)	0.911 (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)
2003	0.993 (0.023)	0.532 (0.023)	0.528 (0.023)	0.932 (0.015)	0.309 (0.011)	0.288 (0.011)
2004	0.893 (0.009)	0.395 (0.050)	0.353 (0.045)	0.948 (0.004)	NA	NA
2005	0.919 (0.015)	0.577 (0.068)	0.530 (0.063)	0.967 (0.004)	NA	NA

Table 44. Average survival estimates (with standard errors in parentheses) from point of release to Bonneville Dam tailrace for various spring-migrating salmonid stocks in 2005. 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. Dam release sites are in tailraces. 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 estimate (standard errors)				
Stock	Release location	RLS–MCN	MCN-JDA	RLS-JDA	JDA-BON	RLS-BON
Snake R. Chinook (Sp-Su)	Lower Granite Dam	0.732 (0.009)	0.772 (0.021)	0.566 (0.007)	1.028 (0.132)	0.577 (0.068)
U. Columbia R. Chinook (S-F)	Rock Island Dam	0.809 (0.018)	0.894 (0.053)	?	0.803 (0.141)	0.567 (0.115)
U. Columbia R. Chinook (S-F)	Priest Rapids Dam	0.957 (0.021)	0.800 (0.063)	?	1.021 (0.142)	0.750 (0.101)
U. Columbia R. steelhead	Wells Dam	0.429 (0.021)	0.603 (0.060)	?	NA	NA
U. Columbia R. steelhead	Rocky Reach Dam	0.449 (0.026)	0.682 (0.040)	?	NA	NA
Snake R. steelhead	Lower Granite Dam	0.593 (0.018)	0.595 (0.040)	0.353 (0.026)	NA	NA

Table 45. Percentage of PIT-tagged smolts (wild and hatchery combined) detected at Lower Monumental Dam later detected on McNary pool bird colonies, 1998-2005.

Year	Yearling Chinook salmon	Steelhead
1998	0.49	4.20
1999	0.90	4.51
2000	0.98	3.66
2001	5.59	21.06
2002	1.62	10.09
2003[a]	1.06	3.71
2004[b]	2.08	19.42
2005	1.37	9.15

a. Only Crescent Island Caspian tern colony sampled.

b. Only Crescent Island and Foundation Island colonies sampled.

FIGURES

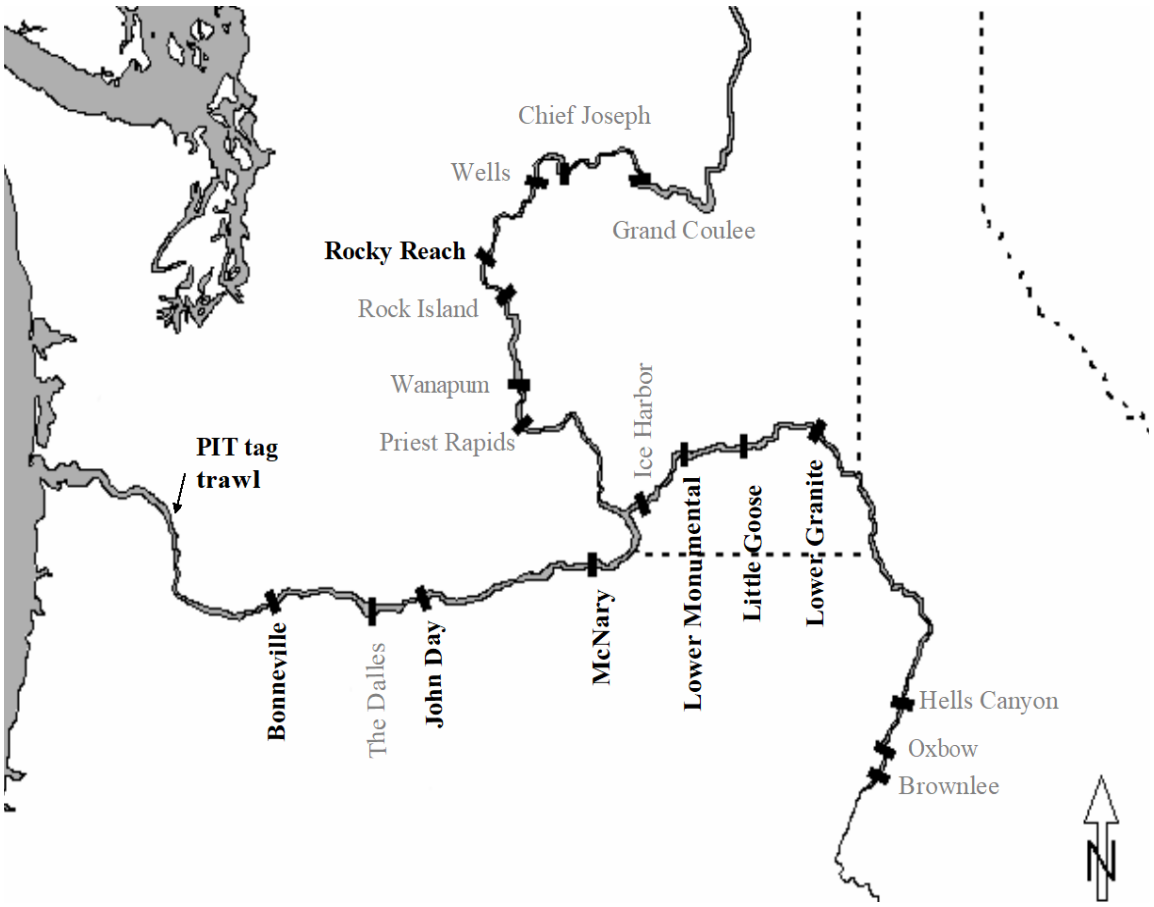

Figure 1. Study area showing sites with PIT-tag detection facilities (names in black), including dams and the PIT-tag trawl in the Columbia River estuary. Dams with names in gray do not have detection facilities.

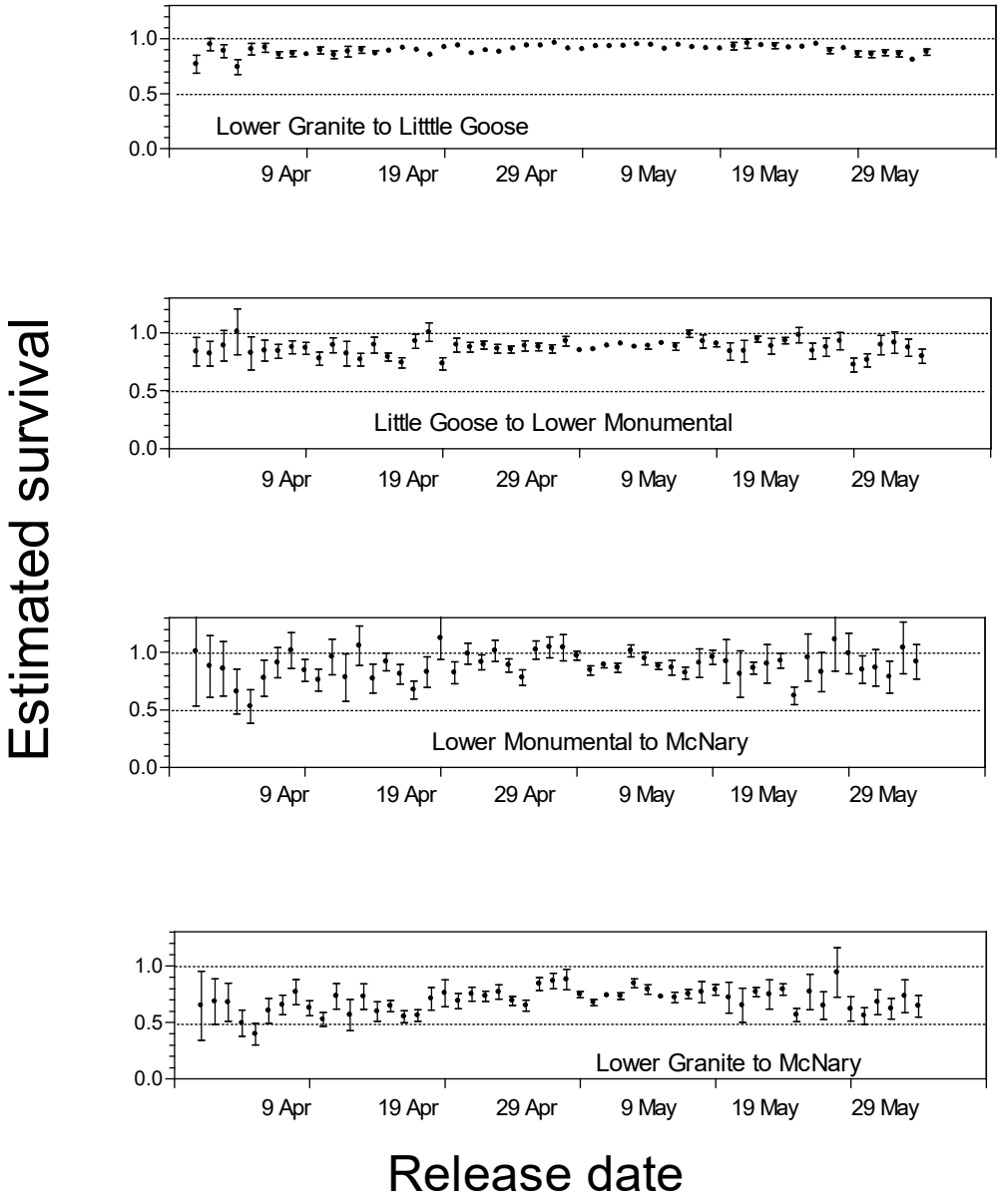

Figure 2. Estimated survival through various reaches vs. release date at Lower Granite Dam for daily release groups of Snake River yearling Chinook salmon, 2005 Bars extend one standard error above and below point estimates.

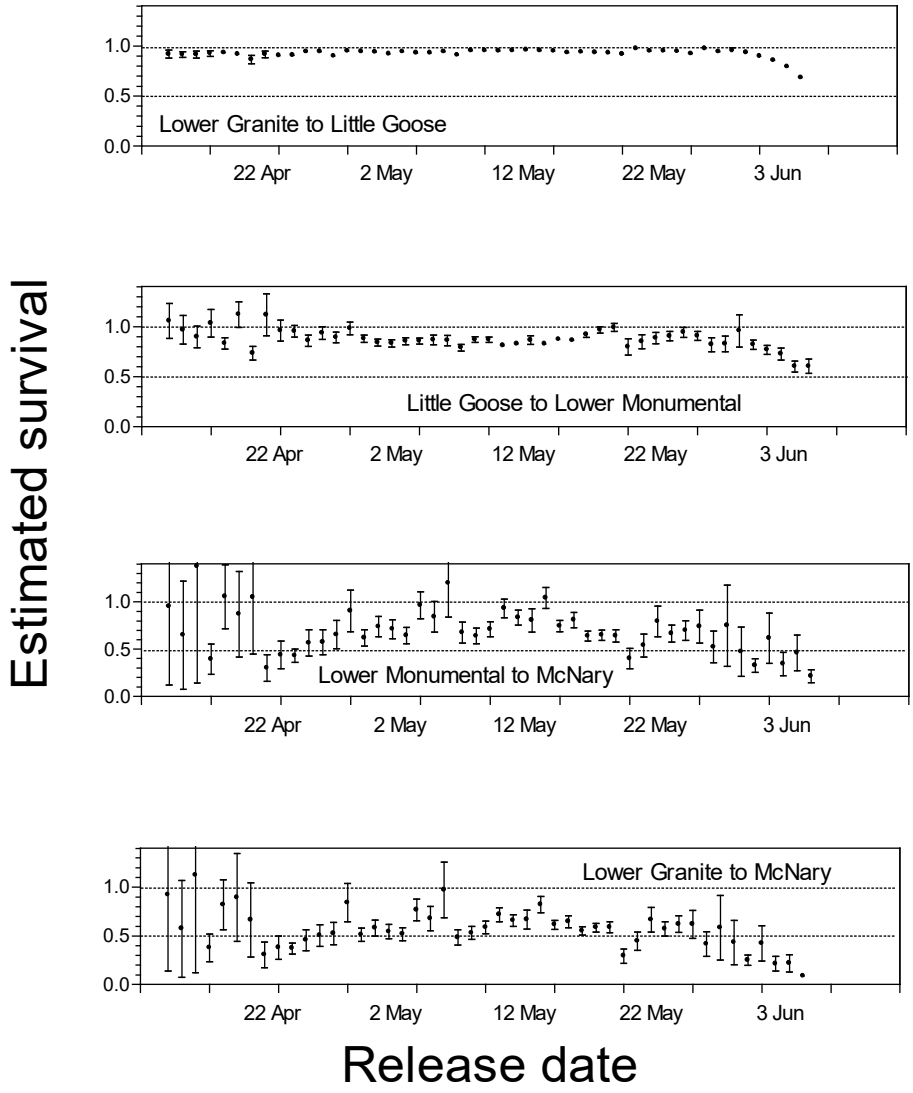

Figure 3. Estimated survival through various reaches versus release date at Lower Granite Dam for daily release groups of Snake River steelhead, 2005. Bars extend one standard error above and below point estimates.

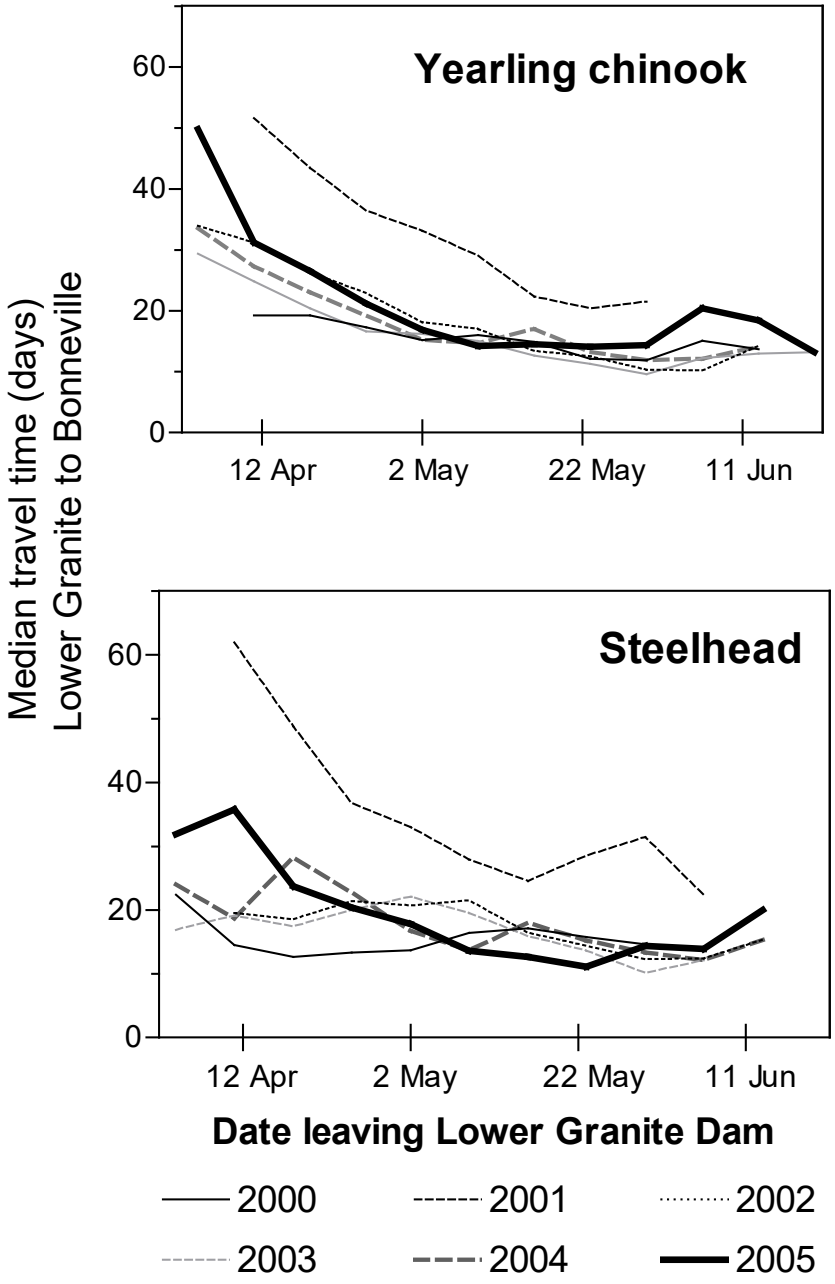

Figure 4. Median travel time (days) from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead from Lower Granite Dam, 2000-2005.

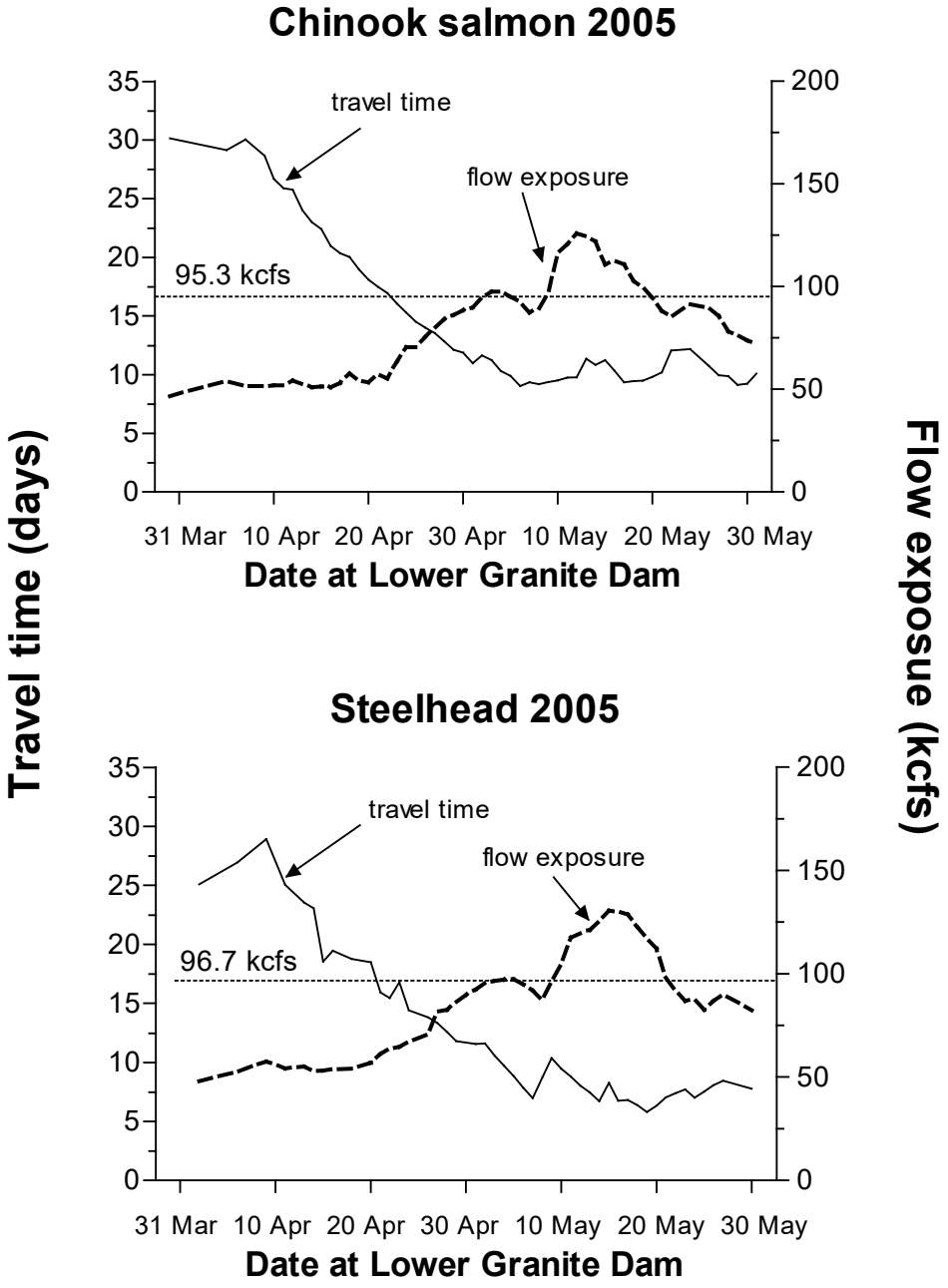

Figure 5. Travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Granite Dam (kcfs) for daily groups of PIT-tagged fish during 2005. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

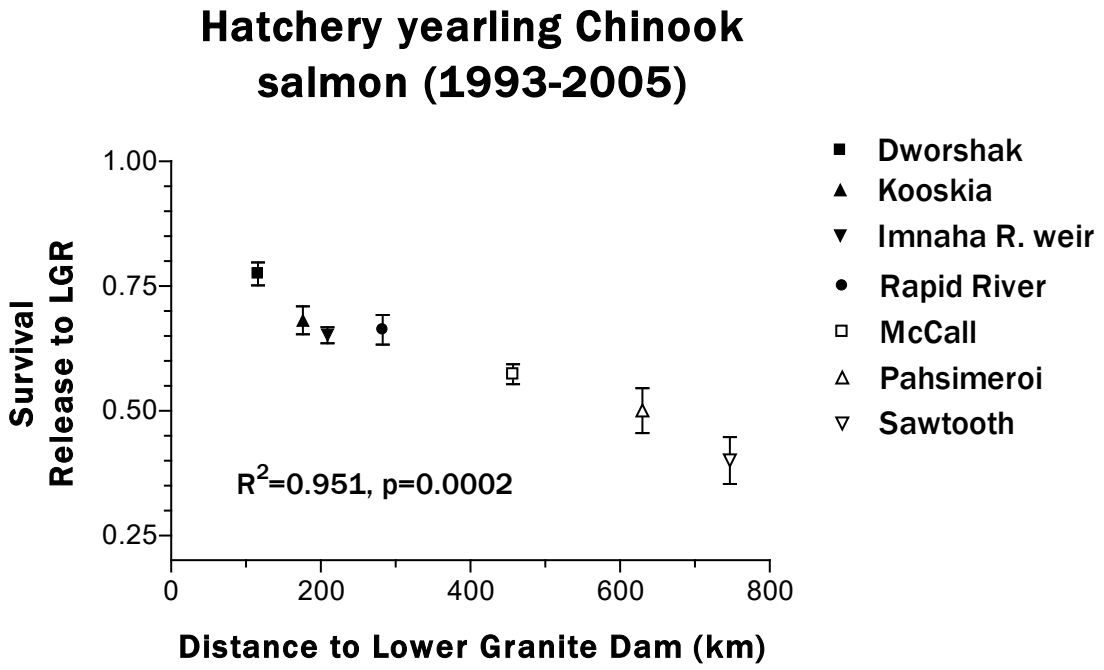

Figure 6. Estimated survival with standard errors from release at Snake River Basin hatcheries to Lower Granite Dam tailrace, 1993-2005 vs distance (km) to Lower Granite Dam. The correlation between survival and migration distance is also shown.

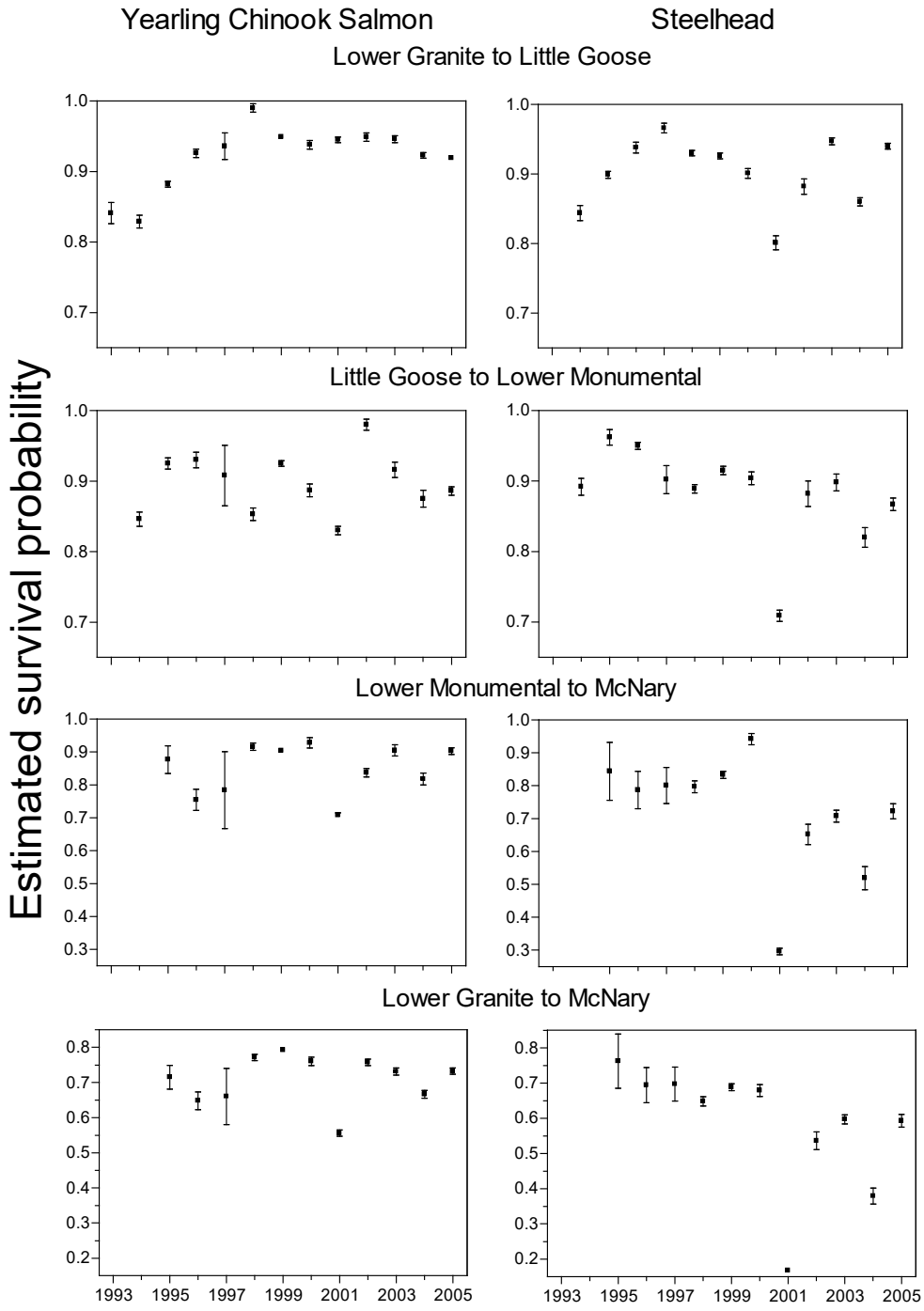

Figure 7. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead through Snake River reaches, 2005. Estimates are from tailrace to tailrace with standard errors.

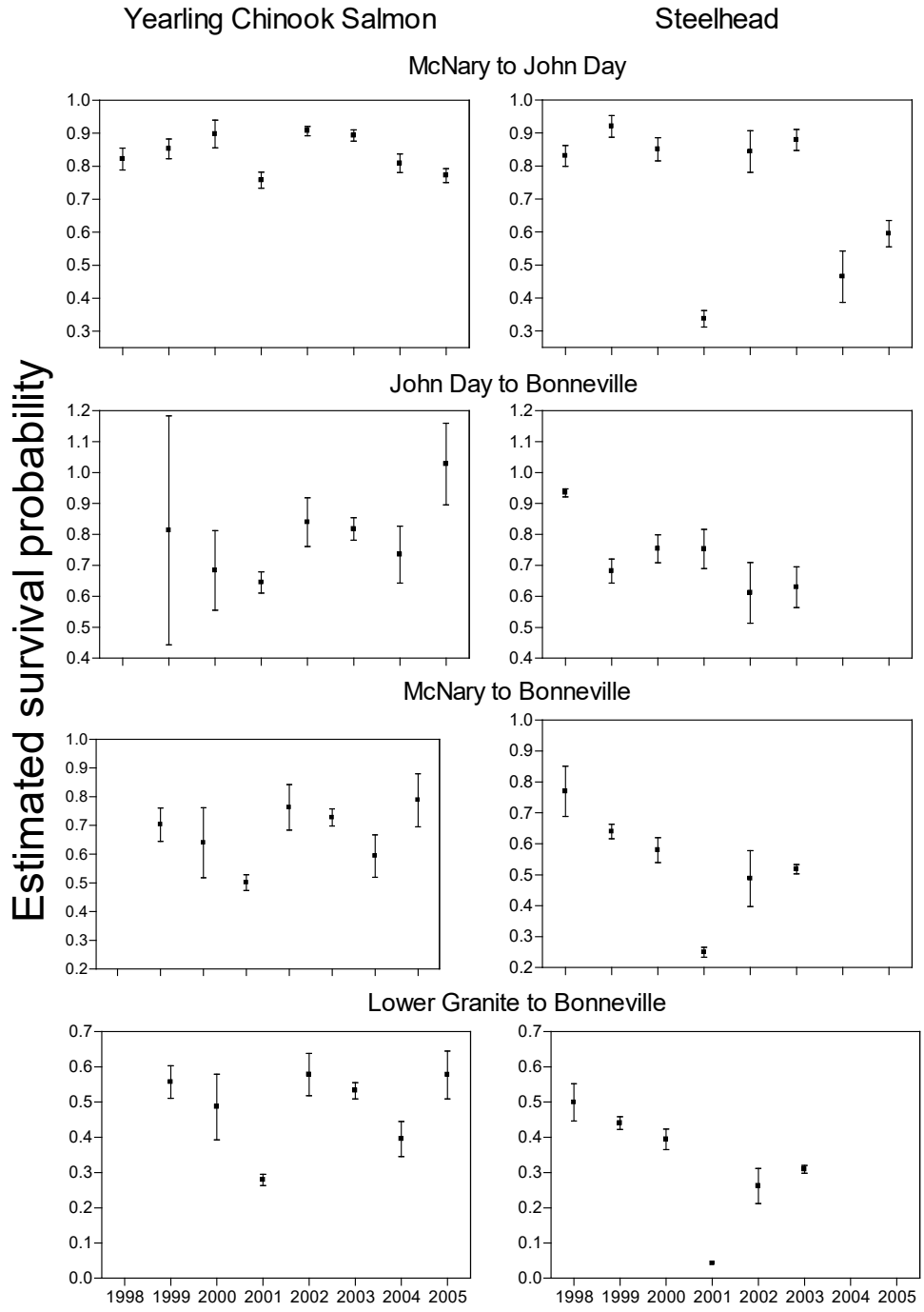

Figure 8. Annual average survival estimates for PIT-tagged Snake River yearling Chinook salmon and steelhead through Columbia River reaches and from Lower Granite Dam to Bonneville Dam, 2005. Estimates are from tailrace to tailrace with standard errors.

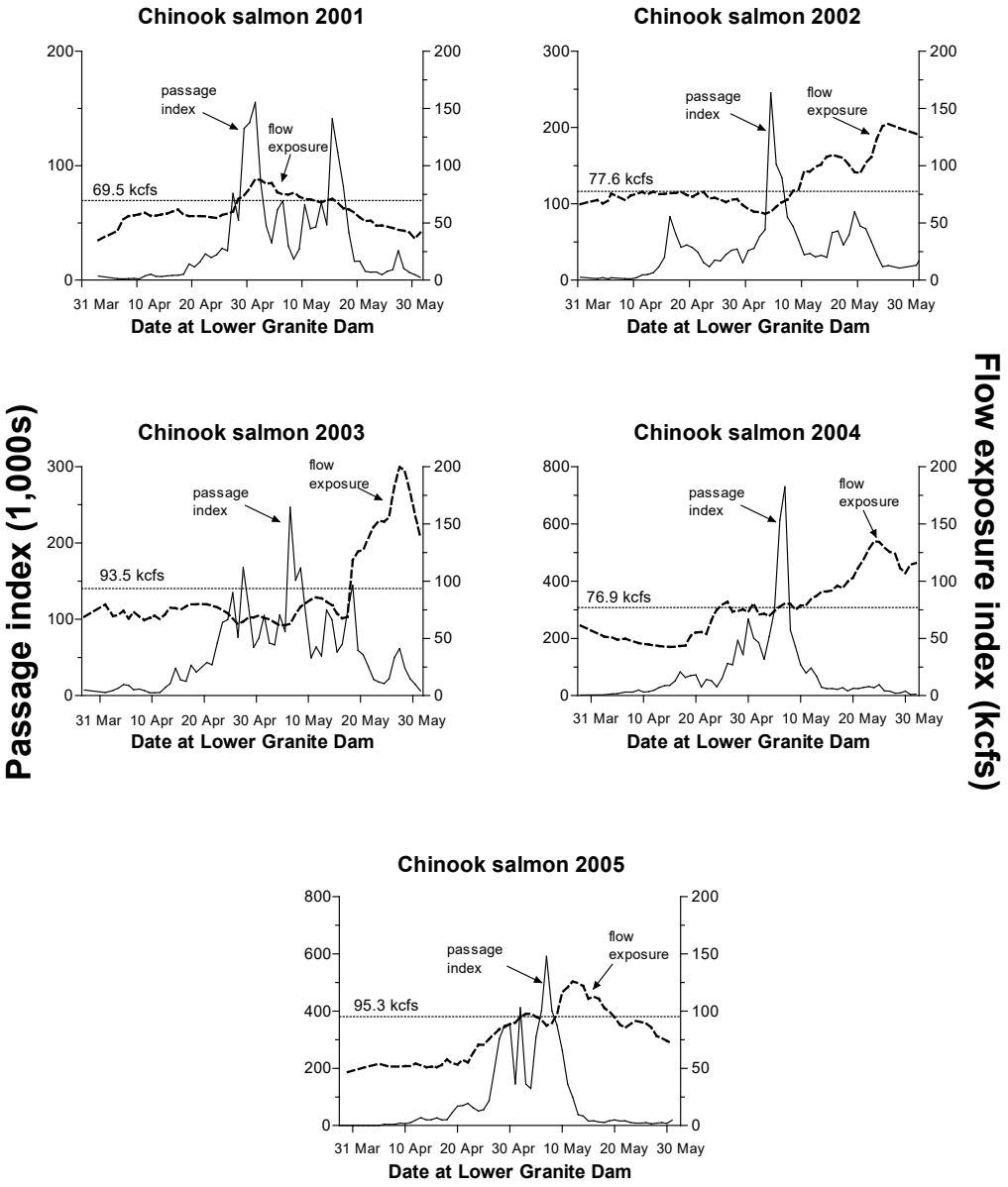

Figure 9. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged yearling Chinook salmon passing Lower Granite Dam from 2001 through 2005. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

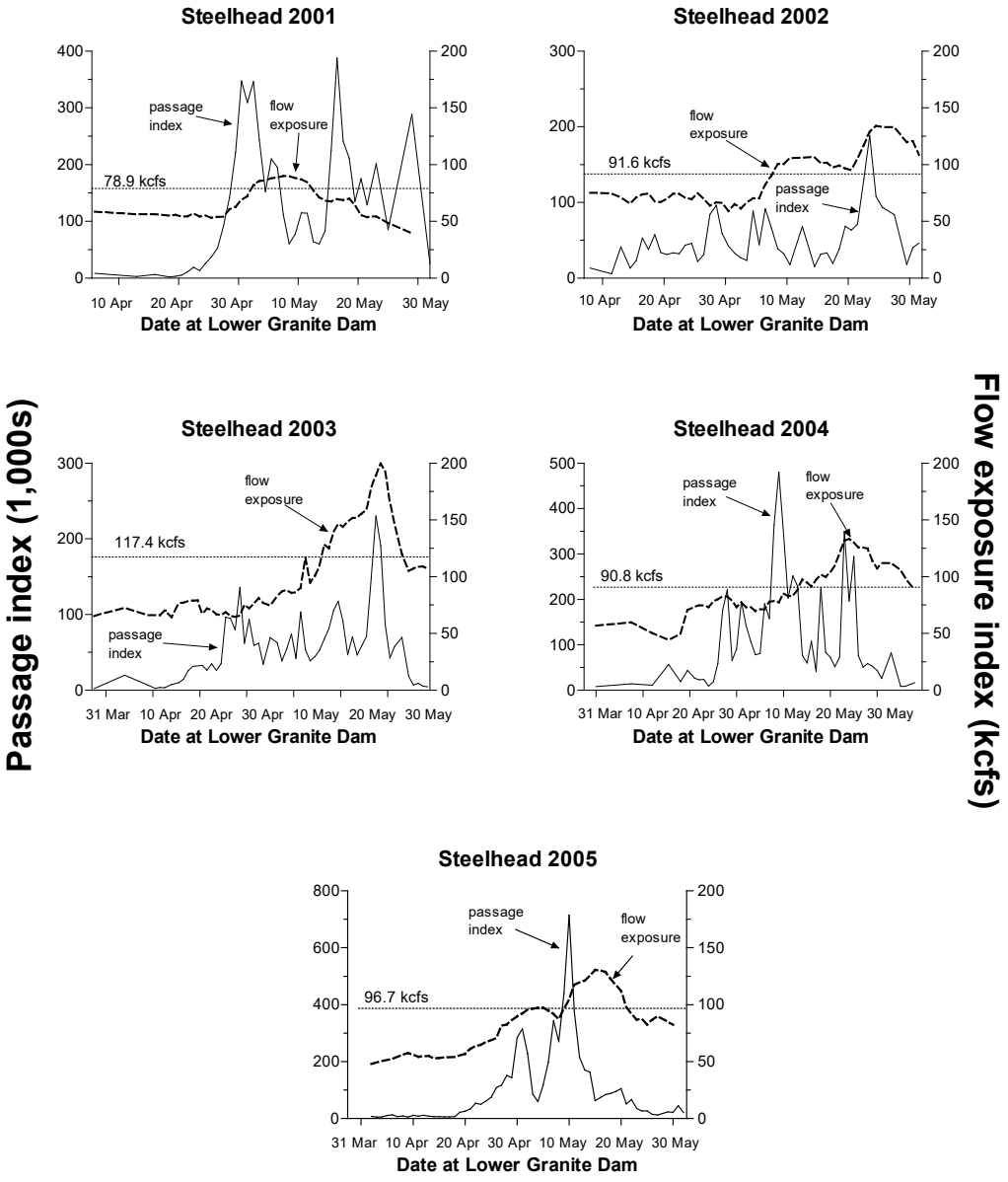

Figure 10. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged steelhead passing Lower Granite Dam from 2001 through 2005. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

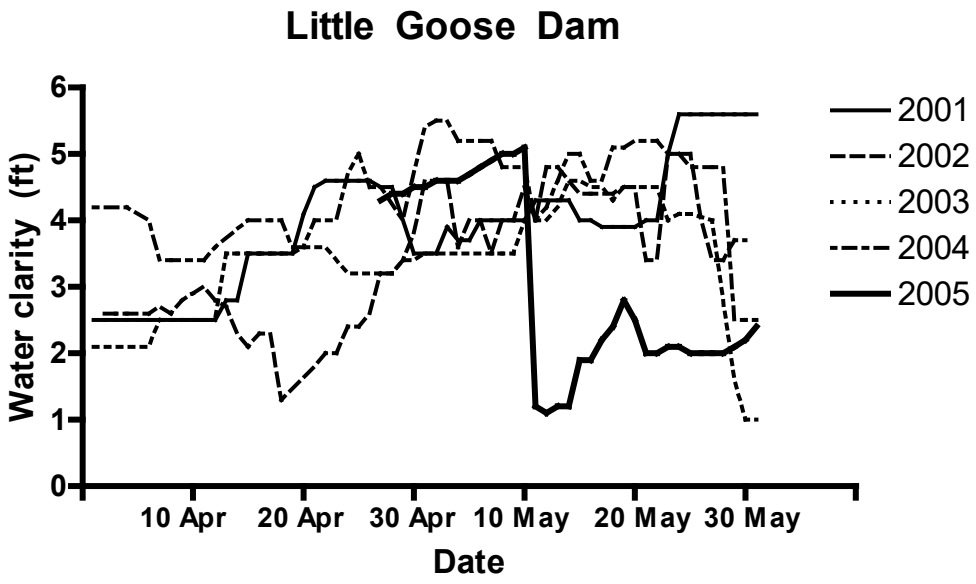

Figure 11. Water clarity (Secchi disk reading in feet) measured at Little Goose Dam, 2001-2005.

APPENDIX: Tests of Model Assumptions

Background

Using the Cormack-Jolly-Seber (CJS), or single-release (SR) model, the passage of a single PIT-tagged salmonid through the hydropower system is modeled as a sequence of events. Examples of such events are survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, and detection at Little Goose Dam. Each event has an associated probability of occurrence (technically, these probabilities are "conditional," as they are defined only if a certain condition is met, for example "probability of detection at Little Goose Dam *given* that the fish survived to Little Goose Dam").

The detection history, then, is the record of the outcomes of the series of events. (The detection history is an imperfect record of outcomes: if the history ends with one or more "zeroes," we cannot distinguish mortality from survival without detection). The SR model represents detection history data for a group of tagged fish as a multinomial distribution: each multinomial cell probability (detection history probability) is a function of the underlying survival and detection event probabilities. Three key assumptions lead to the multinomial cell probabilities used in the SR model:

A1) Fish in a single group of tagged fish have common event probabilities (each conditional detection or survival probability is common to all fish in the group).

A2) Event probabilities for each individual fish are independent from those for all other fish.

A3) Each event probability for an individual fish is conditionally independent from all other probabilities.

For a migrating PIT-tagged fish, assumption A3 implies that detection at any particular dam does not affect (or give information regarding) probabilities of subsequent events. For the group as a whole, this means that detected and nondetected fish at a given dam have the same probability of survival in downstream reaches, and have the same conditional probability of detection at downstream dams.

Methods

We used the methods presented by Burnham et al. (1997; pp 71-77) to assess the goodness-of-fit of the SR model to observed detection history data. In these tests, we compiled a series of contingency tables from detection history data for each group of tagged fish, and used χ^2 tests to identify systematic deviations from what was expected if the assumptions were met. We applied the tests to weekly groups of yearling Chinook salmon and steelhead (hatchery and wild combined) leaving Lower Granite and McNary dams (Snake River-origin fish only) in 2005 (i.e., the fish used for survival estimates reported in Tables 1, 2, 10, and 11).

If goodness-of-fit tests for a series of release groups resulted in more significant tests than expected by chance, we compared observed and expected tables to determine the nature of the violation. While consistent patterns of violations in the assumption testing do not unequivocally pinpoint the cause of the violation, they can be suggestive, and some hypothesized causes may be ruled out.

Potential causes of assumption violations include inherent differences between individuals in survival or detectability (e.g., propensity to be guided by bypass screens); differential mortality between the passage route that is monitored for PIT tags (juvenile collection system) and those that are not (spillways and turbines); behavioral responses to bypass and detection; and differences in passage timing for detected and non-detected fish if such differences result in exposure to different conditions downstream. Using detection information, inherent differences and behavioral responses are virtually indistinguishable. Conceptually, we make the distinction that inherent traits are those that characterized the fish before any hydropower system experience, while behavioral responses occur as a result of particular hydropower project experiences. For example, developing a preference for a particular passage route is a behavioral response, while size-related differences in passage-route selection are inherent. Of course, response to passage experience may also depend on inherent characteristics.

To describe each test we conducted, we follow the nomenclature of Burnham et al. (1987). For release groups from Lower Granite Dam, we analyzed 4-digit detection histories indicating status at Little Goose, Lower Monumental, and McNary Dams, and the final digit for detection anywhere below McNary Dam.

The first test for Lower Granite Dam groups was "Test 2.C2," which is based on the contingency table:

Test 2.C2	First Site detected below LGO		
df = 2	LMN	MCN	JDA or below
Not detected at LGO	n_{11}	n_{12}	n_{13}
Detected at LGO	n_{21}	n_{22}	n_{23}

In this table, all fish that were detected somewhere below Little Goose Dam are cross-classified according to their history at Little Goose Dam and according to their first detection site below Little Goose Dam (e.g., n_{11} is the number of fish not detected at Little Goose Dam that were first detected downstream at Lower Monumental Dam). If all assumptions were met, the counts for fish detected at LGO should be in constant proportion to those for fish not detected (i.e., n_{11}/n_{21}, n_{12}/n_{22}, and n_{13}/n_{23} should be equal).

Because this table counts only fish detected below LGO (i.e., all fish survived LGO passage), differential *direct* mortality for fish detected and not detected at LGO will not cause violations of Test 2.C2 by itself. However, differential *indirect* mortality related to LGO passage could cause violations if differences are not expressed until fish are below LMO. Behavioral response to guidance at LGO could cause violations of Test 2.C2: if fish detected at LGO become more likely to be detected downstream, then they will tend to have more first downstream detections at LMO. If detected fish at LGO become less likely to be detected downstream, then they will have fewer first detections at LMO. Inherent differences among fish could also cause violations of Test 2.C2, and would be difficult to distinguish from behavioral responses.

The second test for Lower Granite Dam groups was Test 2.C3, based on the contingency table:

Test 2.C3	First site detected below LMN	
df = 1	MCN	JDA or below
Not detected at LMN	n_{11}	n_{12}
Detected at LMN	n_{21}	n_{22}

This table and corresponding implications are similar to Test 2.C2. All fish that were detected somewhere below Lower Monumental Dam are cross-classified according to their history at LMN and according to their first detection site below LMN. If the respective counts for fish first detected at McNary are not in the same proportion as those first detected at John Day or below, it could indicate behavioral response to detection at LMN, inherent differences in detectability (i.e., guidability) among tagged fish in the group, or long-term differential mortality caused by different passage routes at LMN.

The next series of tests for Lower Granite Dam groups is called Test 3. The first in the series is called Test 3.SR3, based on the contingency table:

Test 3.SR3	Detected again at MCN or below?	
df = 1	YES	NO
Detected at LMN Not detected at LGO	n_{11}	n_{12}
Detected at LMN Detected at LGO	n_{21}	n_{22}

In this table, all fish detected at LMN are cross-classified according to their status at LGO and whether or not they were detected again downstream from LMN. As with the Test 2 series, differential mortality in different passage routes at LGO will not be detected by this test if all the mortality is expressed before the fish arrive at LMN. Differences in mortality expressed below MCN could cause violations, however, as could behavioral responses (possibly somewhat harder to detect because of the conditioning on detection at LMN) or inherent differences in detectability or survival between fish detected at LGO and those not detected there.

The second test in the Test 3 series is Test 3.Sm3, based on the contingency table:

Test 3.Sm3	Site first detected below LMN	
df = 1	MCN	JDA
Detected at LMN Not detected at LGO	n_{11}	n_{12}
Detected at LMN Detected at LGO	n_{21}	n_{22}

This test is sensitive to the same sorts of differences as Test 3.SR3, but tends to have somewhat less power. Because the table classifies only fish detected somewhere below LMN, it is not sensitive to differences in survival between LMN and MCN.

The final test for Lower Granite Dam groups is Test 3.SR4, based on the contingency table:

Test 3.SR4	Detected at JDA or below?	
df = 1	Yes	No
Detected at MCN, not detected previously	n_{11}	n_{12}
Detected at MCN, also detected previously	n_{21}	n_{22}

This table classifies all fish detected at MCN according to whether they had been detected at least once at LGO and LMN and whether they were detected again below MCN. A significant test indicates that some below-MCN parameter(s) differ between fish detected above MCN and those not detected. The cause of such an assumption violation could be differences in indirect survival associated with detection at LGO and/or LMN (mortality expressed between MCN and the estuary PIT-trawl), inherent differences in survival or detection probabilities, or behavioral responses.

We did not include any contingency table tests when any of the expected cells of the table were less than 1.0, as the test statistic does not sufficiently approximate the asymptotic χ^2 distribution in these cases. (For Test 2.C2, when the expected values in the "LMN" and "MCN" columns were all greater than 1.0, but one or two of the expected values in the "JDA or below" column were less than 1.0, we collapsed the "MCN" and "JDA or below" and calculated a one-degree-of-freedom test of the resulting 2-by-2 table). We combined the two test statistics in the Test 2 series and the three in the Test 3 series and then all tests together in a single overall χ^2 test statistic.

For release groups from McNary Dam, we analyzed 3-digit detection histories indicating status at John Day Dam, Bonneville Dam, and the estuary PIT-trawl.

Only two tests are possible for 3-digit detection histories. The first of these was Test 2.C2, based on the contingency table:

Test 2.C2	First site detected below JDA	
df = 1	BON	Trawl
Not detected at JDA	n_{11}	n_{12}
Detected at JDA	n_{21}	n_{22}

and the second is Test 2.SR3, based on the contingency table:

Test 3.SR3	Detected at Trawl	
df = 1	Yes	No
Detected at BON, not detected at JDA	n_{11}	n_{12}
Detected at BON, detected at JDA	n_{21}	n_{22}

These tests are analogous to Tests 2.C3 and 3.SR4, respectively, for the Lower Granite Dam release groups. Potential causes of violations of the tests for McNary Dam groups are the same as those for Lower Granite Dam groups.

Results

For weekly release groups from Lower Granite Dam in 2005 there were more significant ($\alpha = 0.05$) tests in the Test 2 series than expected by chance alone for both yearling Chinook salmon and steelhead, but not in the Test 3 series (Table A1.1). There were 12 weekly groups of yearling Chinook salmon. For these, the overall sum of the χ^2 test statistics was significant 5 times. For 11 steelhead groups, the overall test was significant 9 times. Counting all individual component tests (i.e., 2.C2, 3.SR3, etc.), 10 tests of 54 (19%) were significant for yearling Chinook salmon and 13 of 45 (29%) were significant for steelhead (Tables A1.1 through A1.3). By far the most frequently significant test was 2.C2, especially for steelhead (21 total tests, 14 significant). For steelhead, only 4 of 35 (11%) component tests other than 2.C2 were significant.

We diagnosed the patterns in the contingency tables that led to significant 2.C2 tests and results were similar to those we reported in past years: in 9 of the 10 significant cases for yearling Chinook salmon and in 11 of the 13 cases for steelhead, there was evidence that fish previously detected were more likely to be detected again at downstream dams.

Significant contingency table test results were far less common (1 significant test of 12) for weekly groups from McNary Dam (Tables A1.4 through A1.6).

Discussion

We believe that inherent differences in detectability (guidability) of fish within a release group are the most likely cause of the patterns we observed in the contingency table tests in 2005, as in previous years. Zabel et al. (2002) provided evidence of inherent differences related to length of fish at tagging, and similar observations were made in 2005 data. Fish size probably does not explain all inherent differences, but it appears to explain some. The relationship between length at tagging and detection probability at Little Goose Dam, the first dam encountered after release by fish in these data sets (all fish in the data set were detected at Lower Granite Dam; Little Goose Dam is the first encountered after leaving LGR), suggests that the heterogeneity is inherent, and not a behavioral response.

With the release sizes used for most of the contingency-table tests of assumptions, the tests are quite sensitive even to small differences in inherent detection probabilities. The regression analyses in Zabel et al. (2002) showed that detection probabilities typically ranged from about 0.5 for the very smallest fish to 0.25 for the largest. Most fish were in a size range for which detection probabilities had a much smaller range; about 0.30-0.40.

The effect of this type of hetereogeneity of detection probabilities, where individual fish are more or less likely to be detected at all of a series of dams, is that detection probabilities at all dams is overestimated, with corresponding underestimation of survival probabilities. We continue to conduct simulation studies to investigate the degree of effect of assumption violations on parameter estimates.

For example, a recent study simulated constant reach survival probailities of 0.9 and individual detection probabilities (equal at all dams for a particular individual) that varied uniformly from 0.50 to 0.24. The effect was that detection probability estimates averaged about 0.381 (instead of the correct average of 0.370), and average survival

estimates for some reaches were as low as 0.884. The estimate of overall survival probability from Lower Granite Dam to McNary Dam averaged 0.642 (instead of the correct average of 0.656).

Using the same survival probabilities and the narrower and more realistic range of 0.32-0.42 for individual detection probability estimates, the average estimated detection probability was 0.372, and overall average survival probability was 0.659, essentially equal to the expected value of 0.656 (i.e. the bias was within the "noise" of sampling variability).

As in previous years (Zabel et al. 2002), results in 2005 lead us to conclude, as did Burnham et al. (1987), that a reasonable amount of heterogeneity in the survival and detection process did not seriously affect the performance of estimators of survival.

Table A1.1. 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, 2005.

	Test 2.C2		Test 2.C3		Test 3.SR3		Test 3.Sm3		Test 3.SR4		Test 2 sum		Test 3 sum		**Test 2 + 3**	
Species	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	**No.**	**sig.**
Chinook	11	5	11	1	11	1	10	0	11	3	11	5	12	2	**12**	**5**
Steelhead	10	9	10	1	10	0	8	1	7	2	11	9	10	1	**11**	**9**
Total	21	14	21	2	21	1	18	1	18	5	22	14	22	3	**23**	**14**

Table A1.2. 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 2005.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
30 Mar-05 Apr	4.26	0.24	2.70	0.26	0.41	0.52	2.28	0.13
06 Apr-12 Apr	4.09	0.67	0.77	0.86	0.64	0.73	0.13	0.72
13 Apr-19 Apr	4.94	0.55	0.38	0.95	0.19	0.91	0.19	0.66
20 Apr-26 Apr	3.68	0.72	2.98	0.40	0.26	0.88	2.72	0.10
27 Apr-03 May	5.26	0.51	2.34	0.51	2.23	0.33	0.11	0.75
04 May-10 May	33.25	<0.001	11.40	0.01	11.27	<0.001	0.13	0.72
11 May-17 May	4.04	0.67	0.83	0.84	0.39	0.83	0.45	0.50
18 May-24 May	27.40	<0.001	23.62	<0.001	23.12	<0.001	0.50	0.48
25 May-31 May	26.37	<0.001	8.89	0.03	6.35	0.04	2.54	0.11
01 Jun-07 Jun	37.65	<0.001	37.37	<0.001	33.06	<0.001	4.31	0.04
08 Jun-14 Jun	28.55	<0.001	25.29	<0.001	22.91	<0.001	2.38	0.12
15 Jun-21 Jun	1.38	0.24	NA	NA	NA	NA	NA	NA
Total (d.f.)	180.9 (64)	<0.001	116.6 (32)	<0.001	100.8 (21)	<0.001	15.7 (11)	0.15

Table A1.2. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
30 Mar-05 Apr	1.57	0.21	1.57	0.21	NA	NA	NA	NA
06 Apr-12 Apr	3.32	0.35	0.44	0.51	0.94	0.33	1.93	0.16
13 Apr-19 Apr	4.57	0.21	0.27	0.60	0.22	0.64	4.07	0.04
20 Apr-26 Apr	0.70	0.87	0.09	0.76	0.05	0.82	0.56	0.46
27 Apr-03 May	2.92	0.40	0.00	0.96	2.92	0.09	0.00	0.97
04 May-10 May	21.86	<0.001	11.35	<0.001	0.52	0.47	9.98	<0.001
11 May-17 May	3.21	0.36	1.21	0.27	0.07	0.79	1.93	0.16
18 May-24 May	3.78	0.29	1.90	0.17	1.35	0.25	0.54	0.46
25 May-31 May	17.49	<0.001	2.05	0.15	3.14	0.08	12.30	<0.001
01 Jun-07 Jun	0.28	0.96	0.02	0.90	0.11	0.74	0.16	0.69
08 Jun-14 Jun	3.26	0.35	0.79	0.37	1.98	0.16	0.49	0.49
15 Jun-21 Jun	1.38	0.24	NA	NA	NA	NA	1.38	0.24
Total (d.f.)	64.3 (32)	0.001	19.7 (11)	0.05	11.3 (10)	0.33	33.3 (11)	<0.001

Table A1.3. 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 2005.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
30 Mar-05 Apr	2.86	0.09	2.86	0.09	NA	NA	2.86	0.09
06 Apr-12 Apr	11.49	0.04	7.96	0.05	7.85	0.02	0.11	0.74
13 Apr-19 Apr	15.35	0.02	11.21	0.01	8.45	0.02	2.76	0.10
20 Apr-26 Apr	19.45	<0.001	8.17	0.04	6.36	0.04	1.82	0.18
27 Apr-03 May	13.72	0.03	9.35	0.03	9.00	0.01	0.35	0.55
04 May-10 May	60.72	<0.001	59.23	<0.001	11.42	<0.001	47.80	<0.001
11 May-17 May	12.66	0.05	9.64	0.02	6.77	0.03	2.87	0.09
18 May-24 May	4.65	0.59	2.92	0.40	2.75	0.25	0.18	0.67
25 May-31 May	11.07	0.03	8.76	0.01	8.74	<0.001	0.02	0.90
01 Jun-07 Jun	40.88	<0.001	36.66	<0.001	36.21	<0.001	0.45	0.50
08 Jun-14 Jun	25.45	<0.001	23.70	<0.001	23.70	<0.001	NA	NA
Total (d.f.)	218.3 (54)	<0.001	180.5 (29)	<0.001	121.2 (19)	<0.001	59.2 (10)	<0.001

Table A.1.3. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
30 Mar-05 Apr	NA	NA	NA	NA	NA	NA	NA	NA
06 Apr-12 Apr	3.53	0.17	0.18	0.67	3.35	0.07	NA	NA
13 Apr-19 Apr	4.14	0.25	0.17	0.68	0.04	0.84	3.92	0.05
20 Apr-26 Apr	11.28	0.01	0.73	0.39	4.53	0.03	6.02	0.01
27 Apr-03 May	4.37	0.22	0.34	0.56	1.85	0.17	2.19	0.14
04 May-10 May	1.49	0.68	0.94	0.33	0.26	0.61	0.30	0.58
11 May-17 May	3.03	0.39	1.25	0.26	1.76	0.19	0.02	0.90
18 May-24 May	1.72	0.63	0.30	0.58	0.07	0.79	1.35	0.25
25 May-31 May	2.32	0.31	2.30	0.13	0.02	0.90	NA	NA
01 Jun-07 Jun	4.22	0.12	1.94	0.16	NA	NA	2.28	0.13
08 Jun-14 Jun	1.75	0.19	1.75	0.19	NA	NA	NA	NA
Total (d.f.)	37.8 (25)	0.048	9.9 (10)	0.45	11.9 (8)	0.16	16.1 (7)	0.02

Table A1.4. 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, 2005.

	Test 2.C2		Test 3.SR3		Test 2 + 3	
Spp.	No.	sig.	No.	sig.	No.	sig.
Chinook	5	0	3	0	5	0
Steelhead	3	0	1	1	3	0
Total	8	0	4	1	8	0

Table A1.5. 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 2005.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
27 Apr-03 May	NA	NA	NA	NA	NA	NA
04 May-10 May	0.76	0.69	0.54	0.46	0.21	0.64
11 May-17 May	0.03	0.98	0.03	0.87	0.01	0.93
18 May-24 May	2.39	0.30	0.60	0.44	1.79	0.18
25 May-31 May	0.50	0.48	0.50	0.48	NA	NA
01 Jun-07 Jun	0.20	0.66	0.20	0.66	NA	NA
Total (d.f.)	3.9 (8)	0.87	1.9 (5)	0.87	2.0 (3)	0.57

Table A1.6. 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 2005.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
27 Apr-03 May	NA	NA	NA	NA	NA	NA
04 May-10 May	1.10	0.30	1.10	0.30	NA	NA
11 May-17 May	4.48	0.11	0.64	0.42	3.84	0.05
18 May-24 May	0.56	0.45	0.56	0.45	NA	NA
Total (d.f.)	6.14 (4)	0.19	2.3 (3)	0.51	3.84 (1)	0.05