SURVIVAL ESTIMATES FOR THE PASSAGE OF JUVENILE SALMONIDS THROUGH SNAKE AND COLUMBIA RIVER DAMS AND RESERVOIRS, 1999

Prepared by:

Steven G. Smith
William D. Muir
Gordon A. Axel
Richard W. Zabel
John G. Williams

Fish Ecology Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

and

John R. Skalski
School of Fisheries
Center for Quantitative Science
University of Washington
Seattle, Washington 98195

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EXECUTIVE SUMMARY

In 1999, the National Marine Fisheries Service (NMFS) and the University of Washington completed the seventh year of a study to estimate survival of juvenile salmonids (*Oncorhynchus* spp.) passing through dams and reservoirs on the Snake and Columbia Rivers. We did not mark any yearling chinook salmon (*O. tshawytscha*) or steelhead (*O. mykiss*) for reach survival estimation in 1999 because sufficient numbers of each species were already marked with passive integrated transponder (PIT) tags and released from Snake River Basin hatcheries (mostly for the Multi-State Comparative Survival Study) and released from Lower Granite Dam for a NMFS Transportation Evaluation Study.

For the transportation study, actively migrating yearling chinook salmon and steelhead smolts (hatchery and wild) were collected at Lower Granite Dam, PIT tagged, and released to continue their downstream migration. PIT-tagged smolts were recorded at detection facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams. PIT-tagged smolts were also detected using the PIT-tag detector trawl operated in the Columbia River estuary, and additional PIT tags were recovered from bird colonies in the Columbia River estuary.

Survival estimates were calculated using a statistical model for single-release, multiple-recapture data. We evaluated post-detection bypass survival for river-run subyearling fall chinook salmon at McNary Dam during the summer migration (test of a single-release model assumption) and reach survival for subyearling fall chinook salmon from McNary Dam tailrace to the tailrace of John Day Dam.

Research objectives in 1999 were 1) to estimate reach and project survival in the Snake and Columbia Rivers throughout the yearling chinook salmon and steelhead migrations, 2) to evaluate the survival-estimation models under prevailing operational and environmental conditions, 3) to estimate post-detection bypass survival for subyearling fall chinook salmon at McNary Dam and 4) to estimate reach survival for subyearling fall chinook salmon from McNary Dam tailrace to the tailrace of John Day Dam.

This report provides 1999 reach survival and travel time estimates for PIT-tagged yearling chinook salmon and steelhead (hatchery and wild) in the Snake and Columbia Rivers, reach survival in the Columbia River for PIT-tagged subyearling fall chinook salmon, and post-detection bypass survival for subyearling fall chinook salmon at McNary Dam. The results are reported primarily in tables and figures with minimal explanation of methodology. Methodology and statistical models used in the analyses were the same as in previous study years, and details are provided in previous annual reports cited in the text.

Precise survival estimates for most of the 1999 yearling chinook salmon and steelhead migrations were obtained. Hatchery (80% of yearling chinook salmon and 86% of steelhead in the analyses were hatchery-reared) and wild (20% of yearling chinook salmon and 14% of steelhead were wild) fish were combined in the analyses. Estimated survival probabilities from

the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.949 for yearling chinook salmon and 0.926 for steelhead. For individual reaches, average estimated survival probabilities were as follows for yearling chinook salmon and steelhead respectively: from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.925 and 0.915; from Lower Monumental Dam tailrace to McNary Dam tailrace, 0.904 and 0.833; from McNary Dam tailrace to John Day Dam tailrace, 0.853 and 0.920; and from John Day Dam tailrace to Bonneville Dam tailrace, 0.814 and 0.682. The average overall estimates of survival probabilities for yearling chinook salmon and steelhead from Lower Granite Dam tailrace to Bonneville Dam tailrace were 0.557 and 0.440 respectively.

At McNary Dam, average post-detection bypass survival probability for subyearling fall chinook salmon was 0.988 (s.e. 0.027), and survival from the tailrace of McNary Dam to the tailrace of John Day Dam was 0.775 (s.e. 0.019).

We will continue analyses of relationships among survival probabilities, travel times, and environmental factors to provide information needed for recovery efforts. Results of these analyses will be published, primarily as peer-reviewed articles in scientific journals, as they become available.

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INTRODUCTION

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

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

In 1999, NMFS and UW completed the seventh year of the study. Research objectives were 1) to estimate reach and project survival in the Snake and Columbia Rivers throughout the yearling chinook salmon and steelhead migrations, 2) to evaluate the survival-estimation models under prevailing operational and environmental conditions, 3) to estimate post-detection bypass survival for subyearling fall chinook salmon at McNary Dam, and 4) to estimate reach survival for subyearling fall chinook salmon from McNary Dam tailrace to the tailrace of John Day Dam..

METHODS

Experimental Design

A statistical model for single-release, multiple-recapture data (hereafter called the Single-Release, or SR Model) was used to estimate survival probabilities for releases of PIT-tagged yearling chinook salmon and steelhead from Snake River Basin hatcheries and traps and from Lower Granite Dam in 1999 (Cormack 1964, Jolly 1965, Seber 1965). Background information and underlying statistical theory for the SR Model are described by Iwamoto et al. (1994).

During the 1999 migration season, automatic PIT-tag detectors (Prentice et al. 1990a,b,c) were operational in the juvenile bypass systems at Lower Granite (RKm 695), Little Goose (RKm 635), Lower Monumental (RKm 589), McNary (RKm 470), John Day (RKm 347), and Bonneville (RKm 234) Dams (Fig. 1). Most PIT-tagged fish tagged above Lower Granite Dam in 1999 were from the Multi-State Comparative Survival Study, and when detected at Lower Granite Dam, the majority were transported, though many were diverted to the tailrace of the dam to continue their migration. Most PIT-tagged fish detected at dams below Lower Granite Dam were diverted back to the river by slide gates (rather than being barged or trucked downstream), which allowed for the possibility of detection of a particular fish at more than one downstream site (Marsh et al. 1999). PIT-tag detections from the PIT-tag detector trawl below Bonneville Dam were also used in survival estimation.

We used the records of downstream PIT-tag detections in the SR Model to estimate survival from the point of release to Lower Granite Dam tailrace, from Lower Granite Dam tailrace to Little Goose Dam tailrace, from Little Goose Dam tailrace to Lower Monumental Dam tailrace, from Lower Monumental Dam tailrace to McNary Dam tailrace, from McNary Dam tailrace to John Day Dam tailrace, and from John Day Dam tailrace to Bonneville Dam tailrace.

Lower Granite Dam Tailrace Release Groups

During 1999, no yearling chinook salmon or steelhead were PIT tagged specifically for this study, because sufficient numbers were already PIT tagged and released at Lower Granite Dam for the NMFS Transportation Evaluation Study. Also, large numbers were tagged upstream from Lower Granite Dam for other studies, notably the Multi-State Comparative Survival Study. For the transportation study, yearling chinook salmon and steelhead (both hatchery and wild) were PIT tagged at Lower Granite Dam throughout the migration season and released to the tailrace daily. Fish were tagged in numbers approximately proportional to overall arrival numbers. For yearling chinook salmon and steelhead tagged above Lower Granite Dam, and then detected at Lower Granite Dam and returned to the tailrace, we created daily ™release groupsš by species according to the day of detection at Lower Granite Dam. These groups were then combined with the fish tagged and released each day at Lower Granite Dam from the transportation study. Daily tailrace release groups were also pooled into weekly groups. For daily and weekly groups leaving Lower Granite Dam, we estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace.

McNary Dam Tailrace Release Groups

For yearling chinook salmon and steelhead tagged at all locations above McNary Dam, and then detected at McNary Dam and returned to the tailrace, we created daily ™release groupsš by species according to the day of detection at McNary Dam. Daily tailrace release groups were then 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.

For both species, weighted mean estimates of survival from McNary Dam tailrace to Bonneville Dam tailrace were multiplied by the weighted mean estimate from Lower Granite Dam tailrace to McNary Dam tailrace to obtain an overall estimated mean survival probability from Lower Granite Dam tailrace to Bonneville Dam tailrace.

Hatchery and Trap Releases

In 1999, 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 fish to provide estimates of survival for yearling chinook salmon, sockeye salmon, and steelhead from release to the Snake River trap (yearling chinook salmon only), from release to the tailrace of Lower Granite Dam, and reaches downstream. In the course of characterizing the various hatchery releases, preliminary analyses were performed to determine whether data from multiple releases could be pooled to increase sample sizes. We neither intended nor attempted to analyze the experiments for which the hatchery releases were made.

For each hatchery, each set of releases was examined to determine suitability for survival analysis, and release groups were pooled where appropriate. The SR Model was applied to each resulting data set to estimate the same probabilities as for our Lower Granite Dam tailrace releases. Survival estimates were not calculated for releases of hatchery and wild chinook salmon PIT tagged as parr because release and detection numbers were not sufficient. Survival was also estimated for releases of wild and hatchery PIT-tagged yearling chinook salmon and steelhead from the Salmon, Snake, and Imnaha River traps to Lower Granite Dam tailrace and points downstream.

McNary Dam Post-Detection Bypass Survival

To evaluate post-detection bypass survival at McNary Dam (survival through the bypass system including outfall), a series of paired releases of PIT-tagged subyearling fall chinook salmon was made between 23 June and 20 July. Subyearling fall chinook salmon were collected at the McNary Dam juvenile collection system, sorted by Smolt Monitoring Program staff, and PIT tagged. Most fish tagged were wild fish from the Hanford Reach, although origin could not be determined for each individual because not all hatchery fall chinook salmon were fin-clipped. To minimize handling biases, fish for both release groups were tagged simultaneously and personnel were rotated between tagging stations when half of each release group was tagged. Fish handling methods such as water-to-water transfers and pre-anesthesia were used to minimize damage and stress to fish during the sorting and tagging process. Tagged fish were returned through a water-filled pipe to 712-L holding tanks mounted on trucks. Holding tanks were aerated and supplied with flow-through water. Fish were held for a minimum of 24 hours for recovery and determination of post-tagging mortality. Holding density did not exceed 850 fish per tank.

Fish were released in two locations at McNary Dam: 1) in a gatewell (bypass groups); and 2) less than 1 km downstream from the dam (tailrace reference groups). There were 26 replicate groups of subyearling fall chinook salmon for each release location. Bypass groups were released through a 10.2-cm-diameter hose that was 27.4-m in length. The hose was tethered so that fish entered the center of the gatewell (8A), approximately 1 m below the surface. Bypass groups were released between 0700 and 0800 PST.

Fish released in the tailrace were trucked downstream to the Umatilla Marina, transferred via 10.2-cm-diameter hose to a partially filled 712-L tank mounted on a barge, and taken back upstream to within 1 km of the bypass outfall for release (Fig. 2). To compensate for delay in the bypass system for fish released in the gatewell, tailrace groups were released about 5 hours after the bypass groups (between 1145 and 1340 PST). Thus, downstream mixing of fish from bypass and tailrace groups was more likely.

Data Analysis

Tagging and detection data were retrieved from the PIT Tag Information System (PTAGIS) maintained by the Pacific States Marine Fisheries Commission.[1] 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 (™capture historyš) indicating at which dams the tagged fish was detected and at which it was not detected. Methods for data retrieval, database quality assurance/control, and construction of capture histories were the same as those used in past years (Iwamoto et al. 1994; Muir et al. 1995, 1996; Smith et al. 1998, 2000; Hockersmith et al. 1999).

Tests of Assumptions

As in past years, an important objective of the studies in 1999 was to test the statistical validity of the SR Model as applied to the data generated from PIT-tagged juvenile salmonids in the Snake and Columbia Rivers. Validity of the model was tested by evaluating critical assumptions, and all were generally met during 1999.

Daily detection distributions at John Day and Bonneville Dams for bypass and tailrace groups released at McNary Dam were compared using Kolmogorov-Smirnov tests of homogeneity to ensure that release groups had similar passage timing. Because the Kolmogorov-Smirnov test is highly sensitive to violations of equal mixing, significant test statistics did not necessarily mean that the groups were not sufficiently mixed for valid survival estimation. When significant differences between distributions were found, the passage distributions were examined visually to see how different passage timing was. Based on visual examination and information on passage conditions at John Day and Bonneville Dams, we determined whether the distribution differences were likely to cause important biological differences.

Survival Estimation

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

When estimates for a particular river section or passage route were available from more than one release or pair of releases, the estimates were often combined using a weighted average. 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; lower survival estimates tend to have smaller estimated variance.

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[1] Pacific States Marine Fisheries Commission, PIT Tag Operations Center, 45 SE 82nd Drive, Suite 100, Gladstone, OR 97207.

Consequently, if inverse estimated absolute variance were used in weighting, lower survival estimates would tend to have disproportionate influence, biasing the resulting weighted mean toward the lower survival estimates.

All survival analyses were performed using the statistical computer program SURPH (™Survival with Proportional Hazardsš) for analyzing release-recapture data, developed at the University of Washington (Skalski et al. 1993, Smith et al. 1994).

For McNary Dam bypass survival, the number of fish from a particular tailrace or bypass group that were detected at least once at John Day and Bonneville Dams was divided by the total number of fish released in that group to calculate the detected proportion. For each pair of release groups, relative survival of the bypass group was estimated as the ratio of the detected proportion of the bypass group to that of the tailrace group. The series of relative survival estimates was averaged using the geometric mean. Survival probability from the tailrace of McNary Dam to the tailrace of John Day Dam was estimated for the tailrace groups using the SR Model.

Travel Time

Travel times were calculated for yearling chinook salmon and steelhead from 1) Lower Granite Dam to Little Goose Dam, 2) Little Goose Dam to Lower Monumental Dam, 3) Lower Monumental Dam to McNary Dam, 4) Lower Granite Dam to McNary Dam, and 5) Lower Granite Dam to Bonneville Dam. Travel time between any two dams was calculated for each fish detected at both dams as the time elapsed (days) between last detection at the upstream dam and first detection at the downstream dam. Thus, ™travel timeš 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 before entry into the bypass system.

To facilitate comparisons among the four river sections, we also calculated rate of migration in each section (kilometers per day). Lengths of the river sections are 60 km from Lower Granite Dam to Little Goose Dam, 46 km from Little Goose Dam to Lower Monumental Dam, 119 km from Lower Monumental to McNary Dam, 225 km from Lower Granite to McNary Dam, and 461 km from Lower Granite to Bonneville Dam. Rate of migration 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 time and migration rate were determined from the distributions of travel times for individual fish in the group.

The true complete set of travel times for a release group includes travel times of both detected and undetected fish. However, using PIT tags, travel times cannot be determined for fish that traverse a river section but are not detected at both ends of the section. Travel time statistics are computed from travel times for detected fish only, representing a sample of the complete set. During 1999, substantial spill volumes occurred at all dams, in varying amounts, resulting in variable detection rates, as fish passing through spillways are not detected.

RESULTS

Lower Granite Dam

Between 30 March and 14 June 1999, a total of 97,335 yearling chinook salmon (78,059 hatchery origin, 19,276 wild) were either PIT tagged and released upstream from Lower Granite Dam and then detected and returned to the river at the dam, or were PIT tagged at Lower Granite Dam and released in the tailrace for the Transportation Evaluation Study. A total of 78,139 steelhead (66,871 hatchery origin, 11,287 wild, and 1 unknown) were either PIT tagged and released upstream and then detected and returned to the river, or were PIT tagged and released in the tailrace at Lower Granite Dam.

Survival Estimation: Lower Granite and McNary Dam Tailrace Releases

Survival probabilities were estimated for weekly groups of yearling chinook salmon in the tailrace at Lower Granite Dam (tagged either at the dam or upstream) for 11 consecutive weeks, from 30 March to 14 June. Survival estimates (average of estimates for daily groups weighted by inverse estimated relative variance) from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.949 (s.e. 0.002) (Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.925 (s.e. 0.004). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.904 (s.e. 0.007). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.792 (s.e. 0.006). From McNary Dam tailrace to John Day Dam tailrace, estimated survival (weighted average of six weekly groups of fish detected and returned to McNary Dam tailrace) averaged 0.853 (s.e. 0.030) (Table 2). The weighted average survival estimate for yearling chinook salmon from John Day Dam tailrace to Bonneville Dam tailrace was 0.814 (s.e. 0.370). The product of average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall average survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.557 (s.e. 0.046).

Survival probability estimates from Lower Granite Dam tailrace to McNary Dam tailrace were also calculated separately for hatchery and wild yearling chinook salmon, and the results were similar for the two origins (Tables 3 and 4). Estimated survival probabilities for daily Lower Granite Dam tailrace groups of yearling chinook salmon (hatchery and wild combined) are given in Table 5. Detection probability estimates for the weekly groups are also reported (Tables 6 through 9).

Survival probabilities were estimated for weekly groups of steelhead in the tailrace at Lower Granite Dam (tagged either at the dam or upstream) for 11 consecutive weeks, from 30 March to 14 June. Survival estimates (average of estimates for daily groups weighted by inverse estimated relative variance) from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.926 (s.e. 0.004) (Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.915 (s.e. 0.006). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.833 (s.e. 0.011). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.688 (s.e. 0.010). From McNary Dam tailrace to John Day Dam tailrace, estimated survival (weighted average of six weekly groups of fish detected and returned to McNary Dam tailrace) averaged 0.920 (s.e. 0.033) (Table 11). The weighted average survival estimate for steelhead from John Day Dam tailrace to Bonneville Dam tailrace was 0.682 (s.e. 0.039). The product of average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall average survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.440 (s.e. 0.018).

Survival probabilities were estimated separately for hatchery and wild steelhead from Lower Granite Dam tailrace to McNary Dam tailrace (Tables 12 and 13). For steelhead, survival estimates for wild fish were higher through all reaches than for hatchery fish. Estimated survival probabilities for daily release groups of steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam are given in Table 14. Detection probability estimates for the weekly groups were also calculated (Tables 15 through 18).

Survival Estimation: Hatchery Releases

For PIT-tagged hatchery yearling chinook salmon, sockeye salmon, and steelhead released from Snake River Basin hatcheries in 1999, we estimated survival probabilities to the Snake River trap (yearling chinook salmon only), tailrace of Lower Granite Dam, and downstream dams (Tables 19, 20, and 21) and detection probabilities at the detection sites (Tables 22, 23, and 24).

Survival Estimation: Fish Trap Releases

Survival probability estimates for juvenile salmonids PIT tagged and released from Snake River Basin traps in 1999 are shown in Table 25.

Travel Time

Travel time statistics for yearling chinook salmon and juvenile steelhead released in the tailrace of Lower Granite Dam are given in Tables 26 through 29. For both species, migration rates were generally highest in the lower river sections. Migration rates generally increased over time as flows, water temperatures, and levels of spill increased, and presumably, as fish became more smolted.

McNary Dam Post-Detection Bypass Survival

Subyearling fall chinook salmon were PIT tagged at McNary Dam for bypass survival evaluation from 22 June to 19 July (Table 30). Overall, a total of 87,851 juvenile salmonids were collected to provide sufficient subyearling fall chinook salmon for PIT tagging. Mortality for subyearling fall chinook salmon from collection, handling, and PIT-tagging averaged 1.3% (Table 30). Spill levels during the releases ranged from 33 to 55% of total discharge and water temperatures ranged from 15.3 to 18.0°C (Table 31). Fish were removed from the analysis if they were recaptured in the Smolt Monitoring Program sample at McNary Dam after release in the gatewell or if they died prior to release. Median travel times and migration rates for McNary Dam fall chinook salmon release groups are given in Tables 32 through 35. For bypass release groups, median travel times from release into the gatewell to detection in McNary Dam˜s juvenile collection and sampling facility ranged from 0.1 to 1.7 days (Table 32 and Figure 3). This delay within the bypass system resulted in poor mixing at downstream dams for bypass and tailrace release groups on most days (Fig. 4). To offset this delay, tailrace release groups were regrouped by date of last detection at McNary Dam, and survival estimates recalculated based on this regrouping. This resulted in better mixing at downstream dams (Fig. 4). Average survival estimate (geometric mean) of bypass groups (Table 36) relative to that of tailrace groups (Table 37) was 0.961 (s.e. 0.029) before regrouping of the tailrace release groups and 0.988 (s.e. 0.27) after regrouping (Tables 38 and 39).

Survival for tailrace release groups from the tailrace of McNary Dam to the tailrace of John Day Dam averaged 0.775 (s.e. 0.019) (Table 33).

Comparison of Survival Estimates, 1993-1999

Estimates of survival from Snake River Basin hatcheries to Lower Granite Dam tailrace were similar to past years. Over the years of the study, a consistent inverse relationship has been observed between the migration distance from the release site to Lower Granite Dam and estimated survival over that distance (Fig. 5). For 1993-1999 estimates, the negative linear correlation between migration distance and estimated survival is significant ($R^2 = 61\%$, $P < 0.0001$). For yearling chinook salmon and steelhead, estimated survival in 1999 was similar to that seen in previous years through most reaches (Fig. 6). From Lower Granite Dam tailrace to McNary Dam tailrace, survival for yearling chinook salmon was the highest yet measured (1995-1999).

Average per-project survival (one ™projectš is one reservoir/dam combination; also referred to as a ™reachš) was estimated for each year of the study by calculating the geometric mean of estimates from individual reaches. Survival was estimated for between two and seven reaches, or projects, depending on the year. Per-project survival was lowest in 1993 and 1994, the first two years of the study, and higher in later years after the spill program began (Fig. 7).

DISCUSSION

Survival estimates throughout the seven years of this study have generally been higher than estimates of survival obtained in the 1970s. Earlier studies used less sophisticated methods in a river system substantially different from today's (Williams and Matthews 1995), and management strategies should not rely on these outdated system survival estimates. Knowledge of the magnitude, locations, and causes of smolt mortality under present passage conditions and under conditions projected for the future is essential to develop strategies for optimizing smolt survival during migration.

Accurate and precise estimates of system survival from upstream release sites in the Snake River Basin to the tailraces of Lower Granite, Little Goose, Lower Monumental, or McNary Dams can be made using the SR and Paired Release (PR) methodologies with the PIT-tag diversion systems in place and with sufficient release numbers. Estimates of survival can extend to the tailrace of John Day and Bonneville Dams with sufficient sample sizes and with continued PIT-tag detection at Bonneville Dam and downstream locations such as the PIT-tag trawl and bird colonies on islands. Estimating survival over longer reaches will permit further exploration of the relationships among smolt survival, smolt travel time, smolt quality, structural and operational changes at Snake and Columbia River dams, and environmental conditions encountered during migration. Such investigations are ongoing, and results will be published, primarily as peer-reviewed articles in scientific journals, as they become available. Data collected in the first seven years of this study provide valuable baseline information for evaluation of future management strategies.

CONCLUSIONS

1) Precise survival estimates were obtained for yearling chinook salmon (hatchery and wild) from their release points (hatcheries and traps) to Lower Granite Dam and to downstream dams. For yearling chinook salmon (hatchery and wild combined) released from the tailrace of Lower Granite Dam, estimated survival probabilities averaged 0.949 from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, 0.925 from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.904 from Lower Monumental Dam tailrace to McNary Dam tailrace, 0.853 from McNary Dam tailrace to John Day Dam tailrace, and 0.814 from John Day Dam tailrace to Bonneville Dam tailrace.

2) Precise survival estimates were obtained for steelhead (hatchery and wild combined) through these same reaches. Estimated survival probabilities averaged 0.926 from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam, 0.915 from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.833 from Lower Monumental Dam tailrace to McNary Dam tailrace, 0.920 from McNary Dam tailrace to John Day Dam tailrace, and 0.682 from John Day Dam tailrace to Bonneville Dam tailrace.

3) Average estimated survival from Lower Granite Dam tailrace to Bonneville Dam tailrace was 0.557 for yearling chinook salmon and 0.440 for steelhead during 1999.

4) Average estimated survival for subyearling fall chinook salmon passing through the McNary Dam juvenile bypass system during the summer was 0.988 (s.e. 0.027).

5) Estimated survival probabilities for subyearling fall chinook salmon from McNary Dam tailrace to the tailrace of John Day Dam averaged 0.775 (s.e. 0.019).

6) Survival and travel time data collected during this study can be used as baseline data for evaluation of future reservoir drawdowns or other management strategies.

RECOMMENDATIONS

Successful validation of field and statistical methodologies in 1999 formed the basis for the following recommendations for 2000 and future years:

1) The SR (MSR when appropriate) and PR methodologies should be adopted for survival estimation.

2) Hatcheries should be provided with sample size recommendations for their PIT-tag studies so that survival estimates from hatcheries to detection sites at dams can be made with known precision.

3) Future survival studies should continue to be coordinated with other projects to maximize the data-collection effort and minimize study effects on salmonid resources.

4) Improved statistical precision should be accomplished by maximizing the return of PIT-tagged juveniles to the river through increased detector and diverter efficiency.

5) 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 Priest Rapids Dams and more extensive detection at Bonneville Dam. The development of flat-plate detector technology in bypass systems and portable streambed flat-plate detectors for use in tributaries would greatly enhance survival estimation capabilities.

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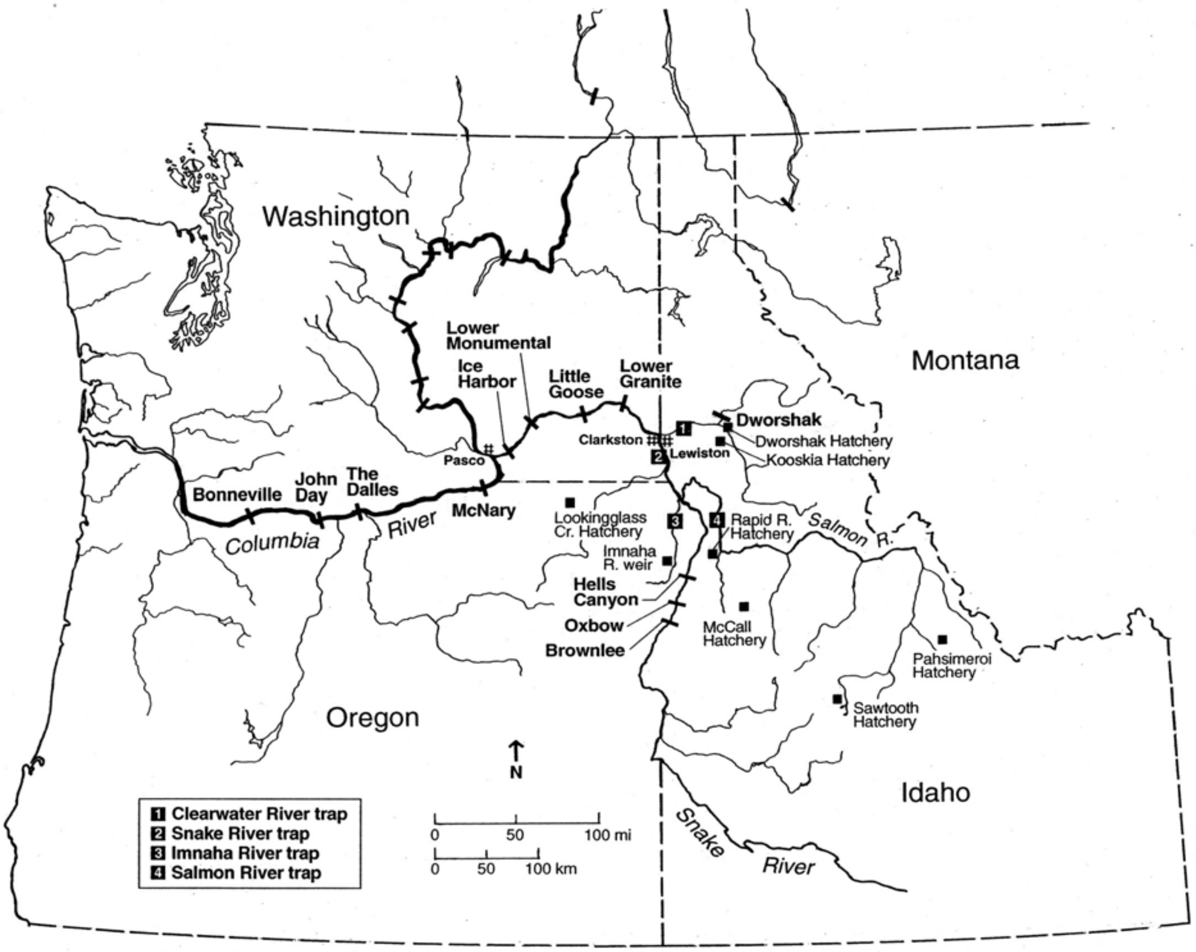
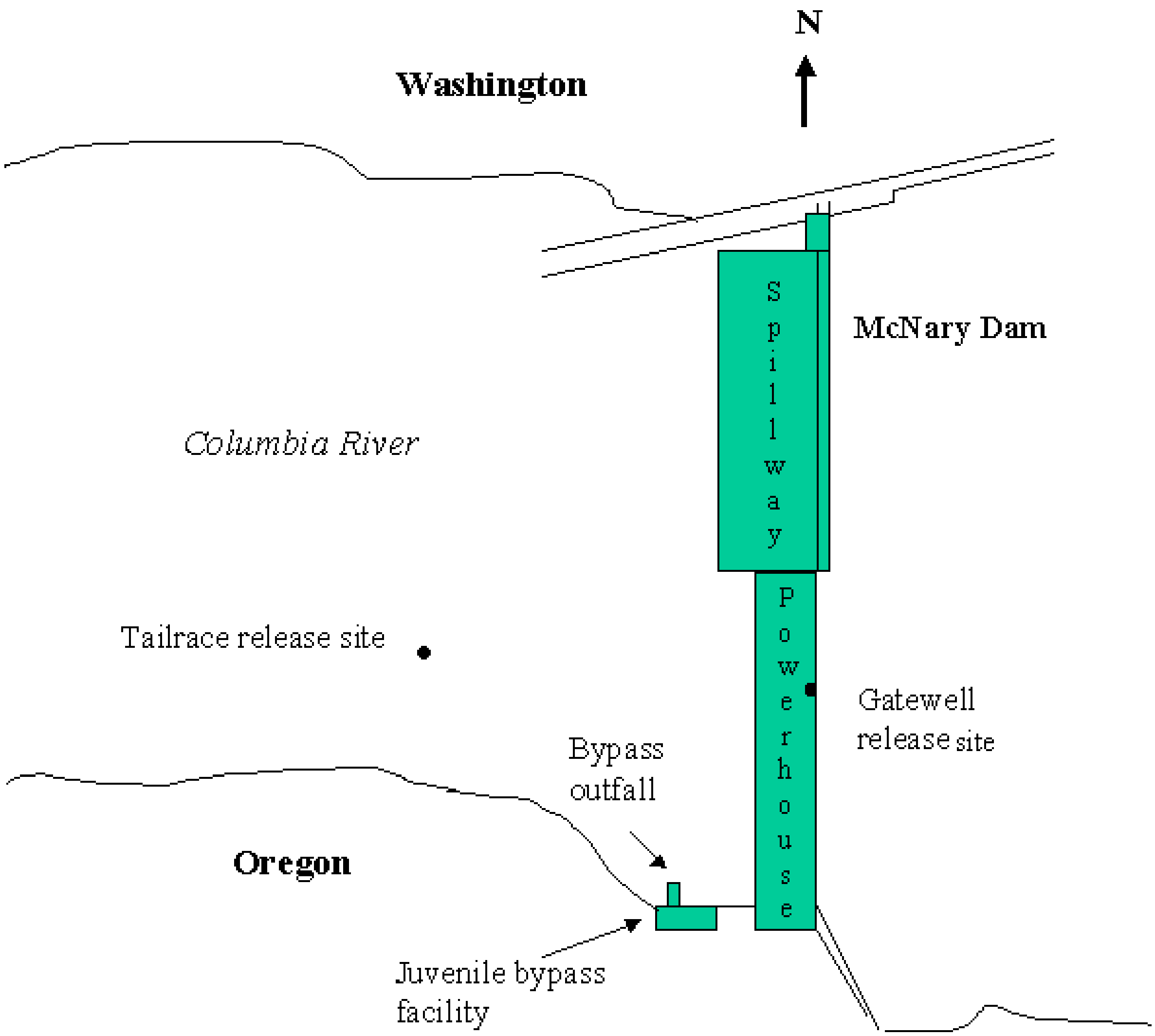


Figure 1. Study area showing release and detection sites.


N
Washington
McNary Dam
Spillway
Columbia River
Powerhouse
Tailrace release site
Gatewell
release site
Bypass
outfall
Oregon
Juvenile bypass
facility

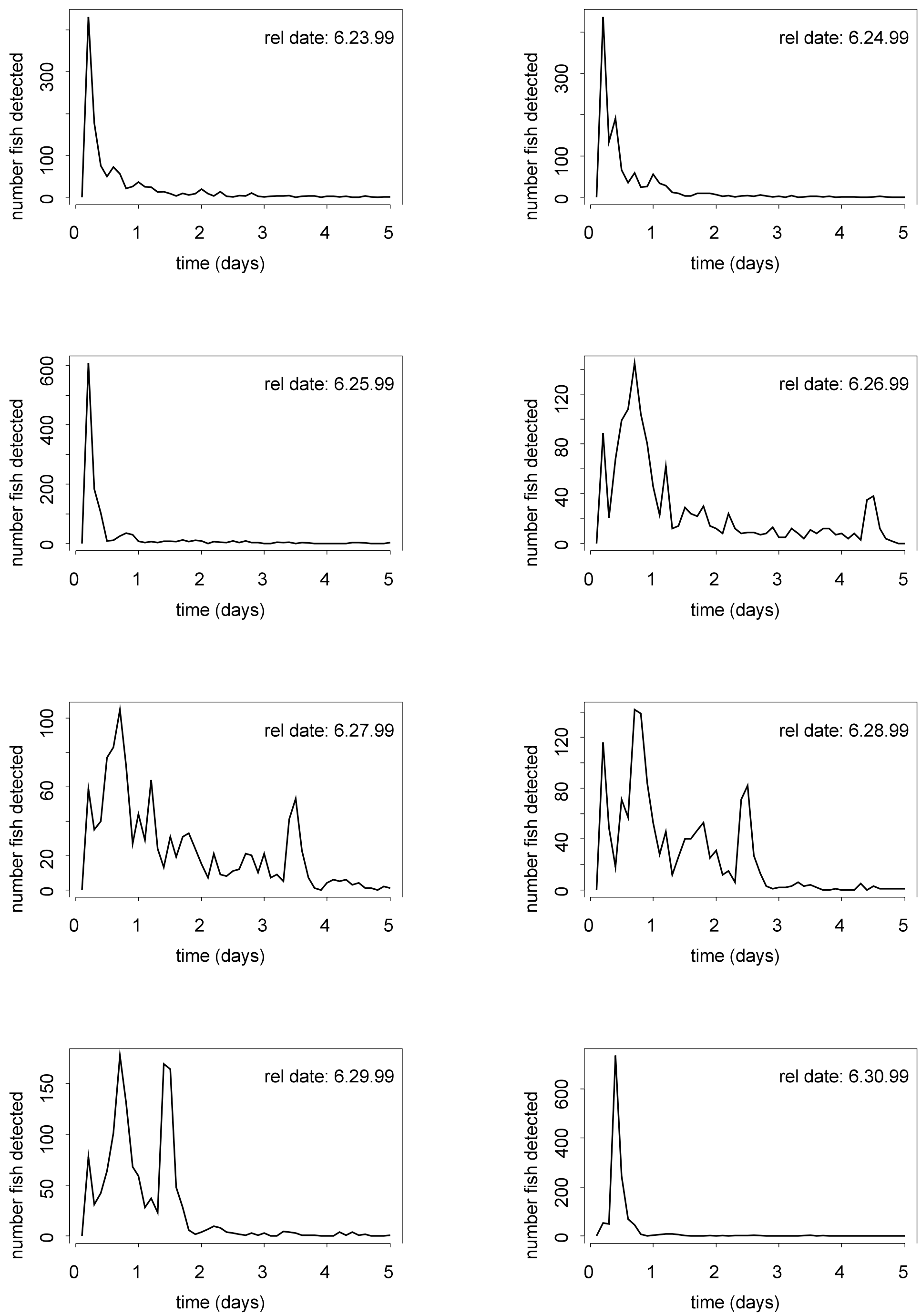


Figure 3. Distributions of time elapsed between release in the gatewell to first detection at McNary Dam for fall chinook salmon.

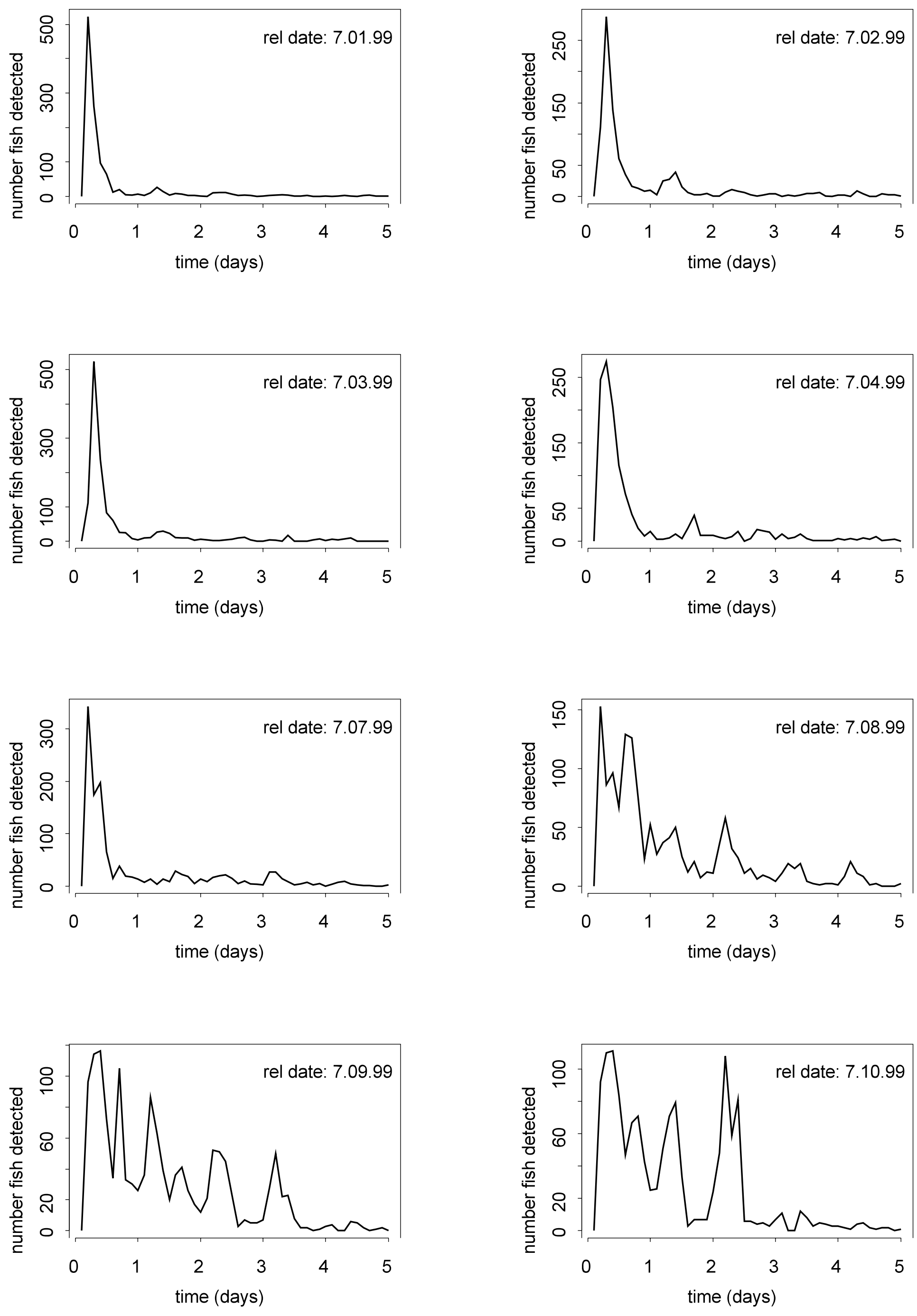


Figure 3. Continued.

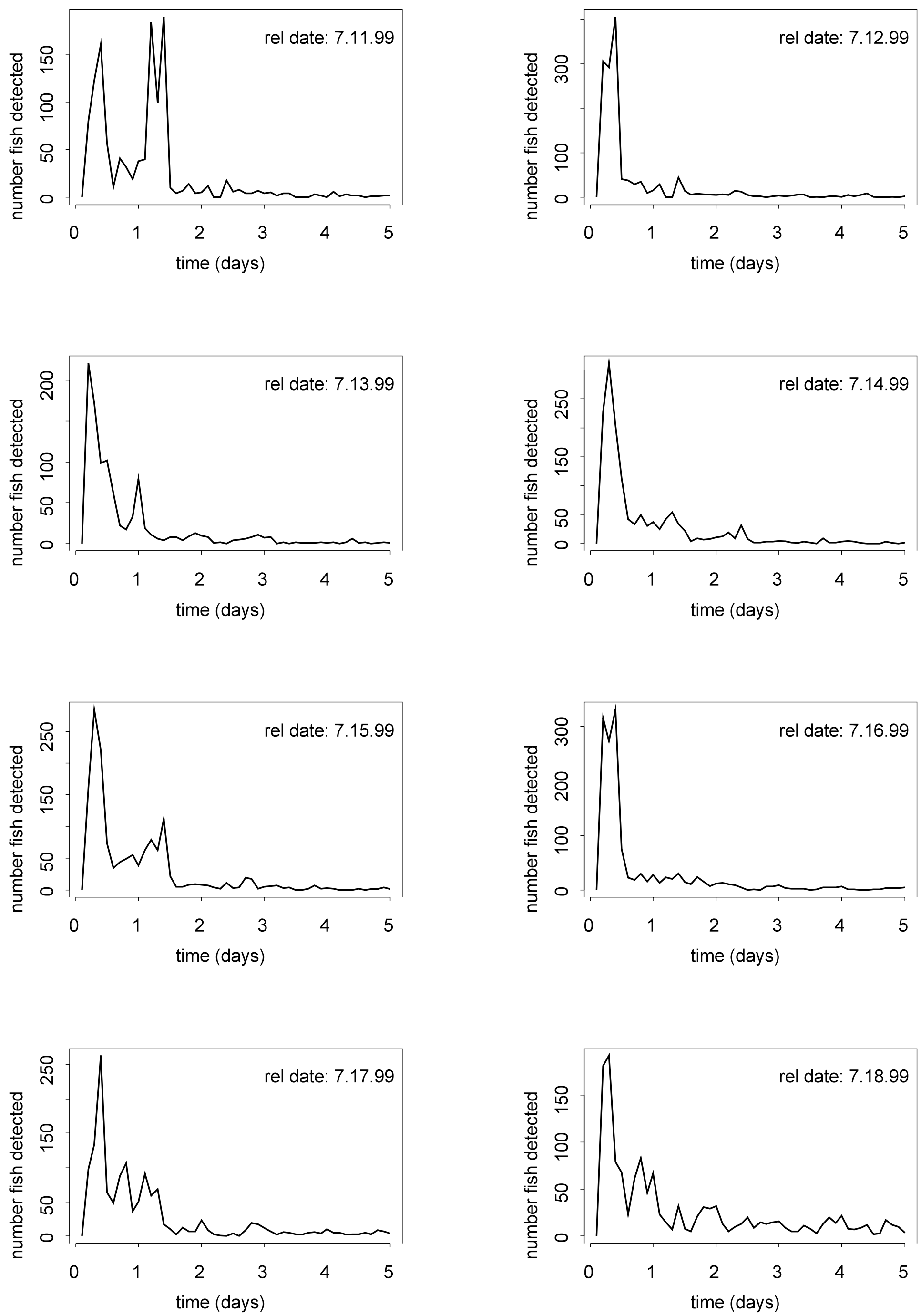


Figure 3. Continued.

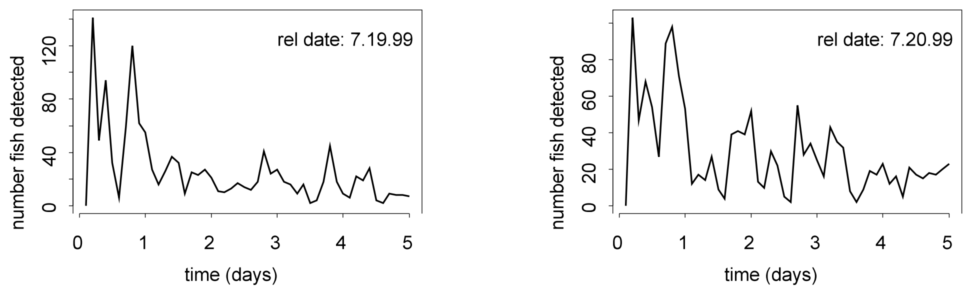


Figure 3. Continued.

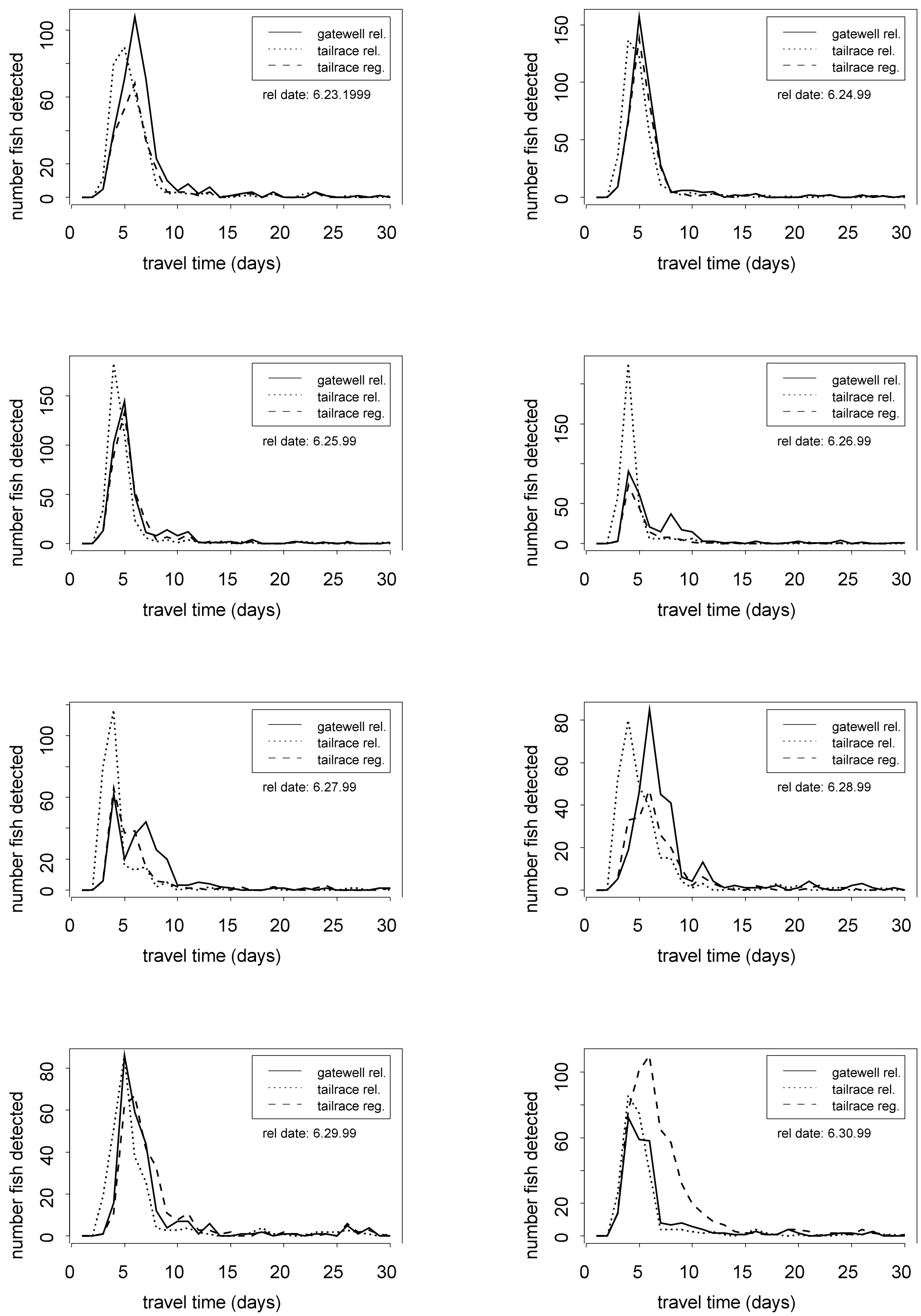


Figure 4. Travel time distributions from McNary Dam to John Day Dam for fall chinook salmon. Gatewell rel. are fish released into the gatewell. Tailrace rel. are fish released into the tailrace. Tailrace reg. are fish released into the gatewell but then regrouped based on last detection date at McNary Dam. For these fish, release date corresponds to the date they left McNary Dam.

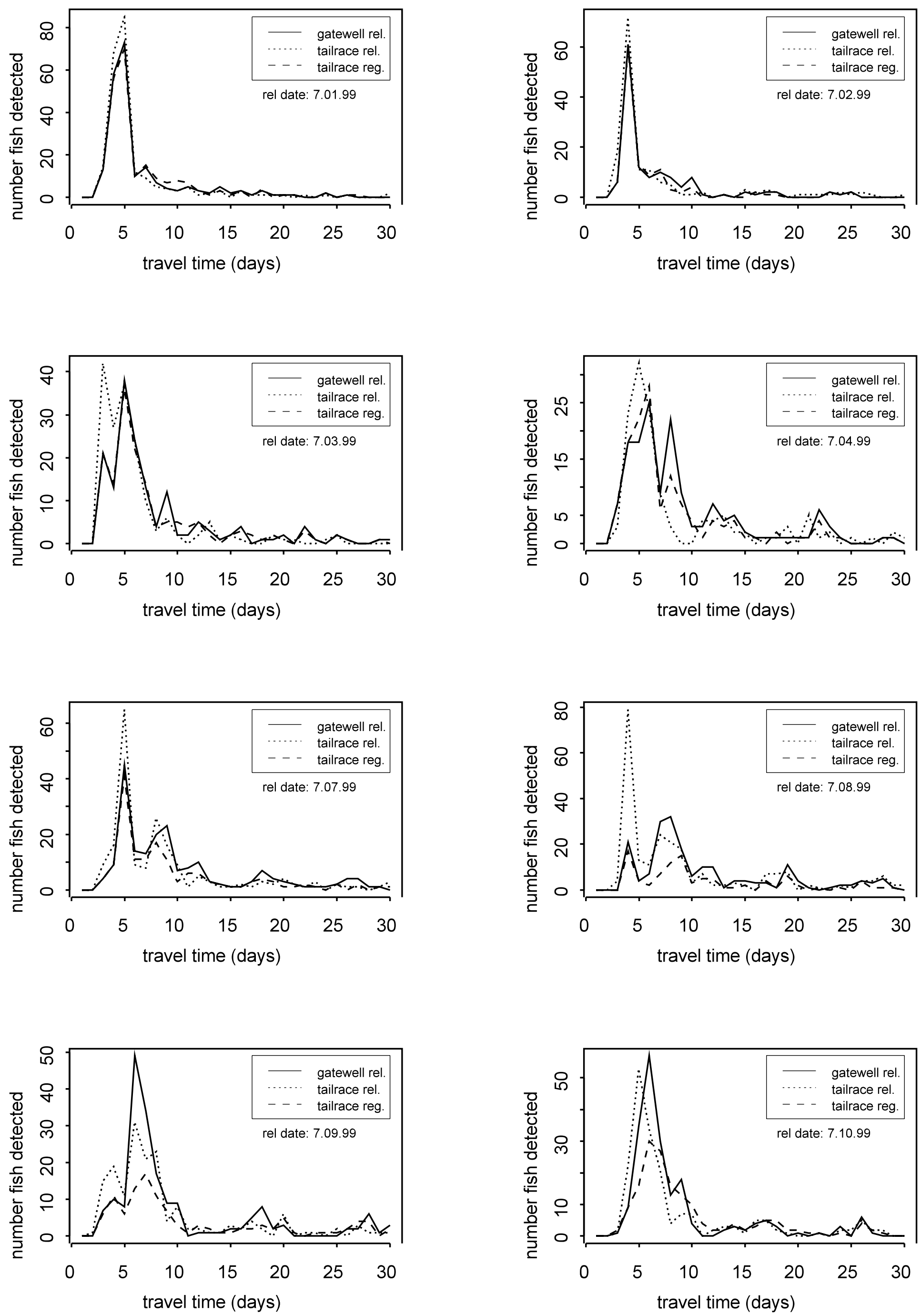


Figure 4. Continued.

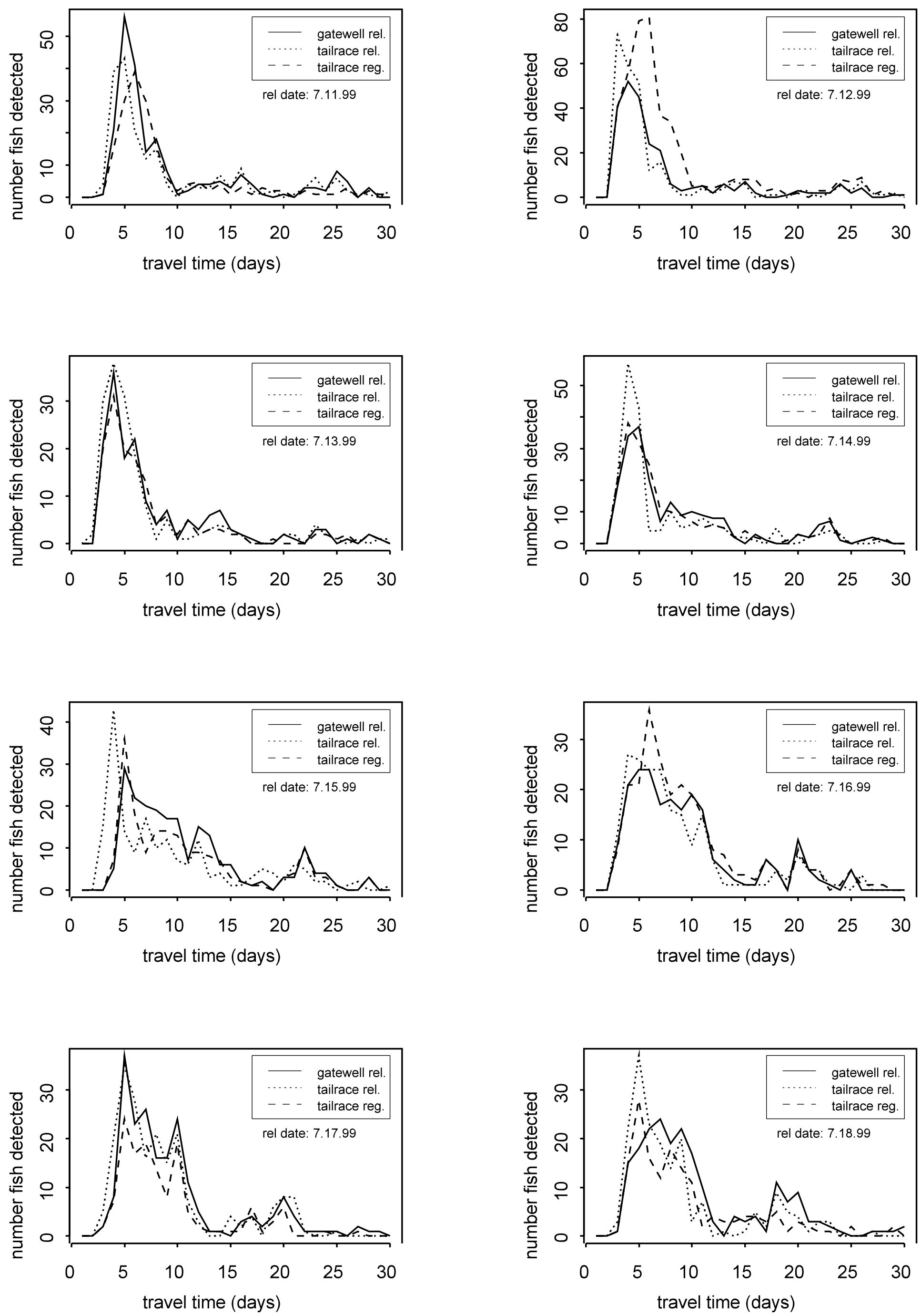


Figure 4. Continued.

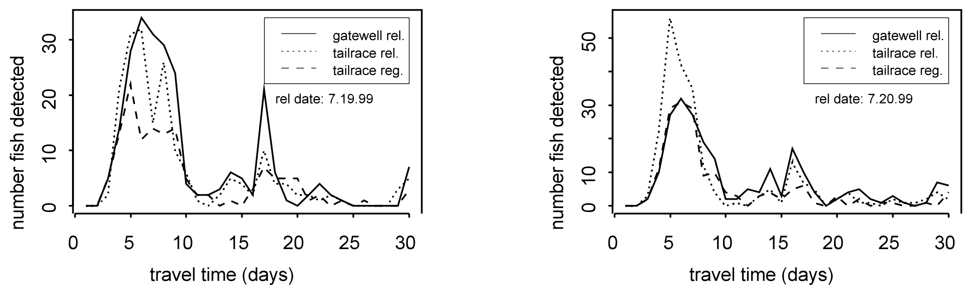


Figure 4. Continued.

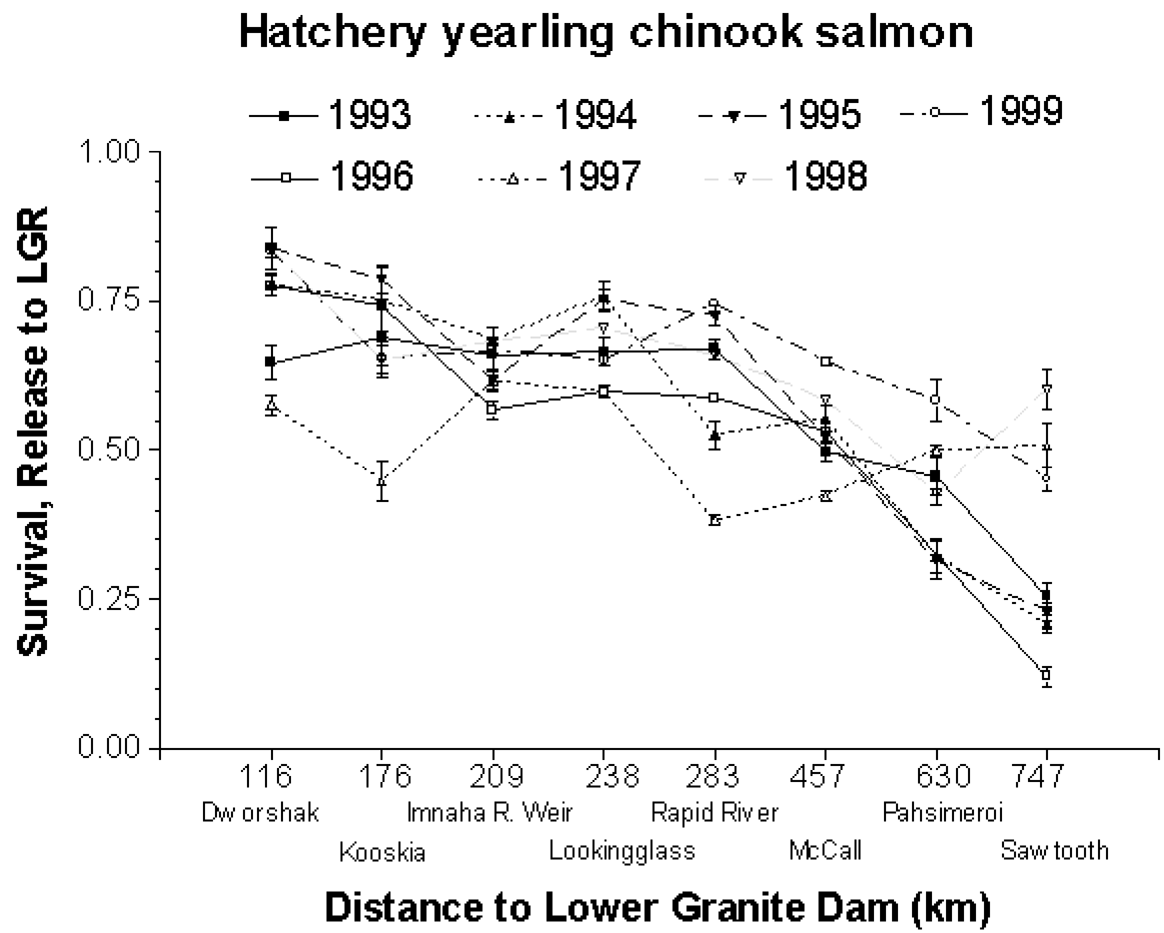


Figure 5. Estimated survival to Lower Granite Dam tailrace for PIT-tagged yearling chinook salmon released from Snake River Basin hatcheries. Distance from release to Lower Granite Dam (km) and standard errors also shown.

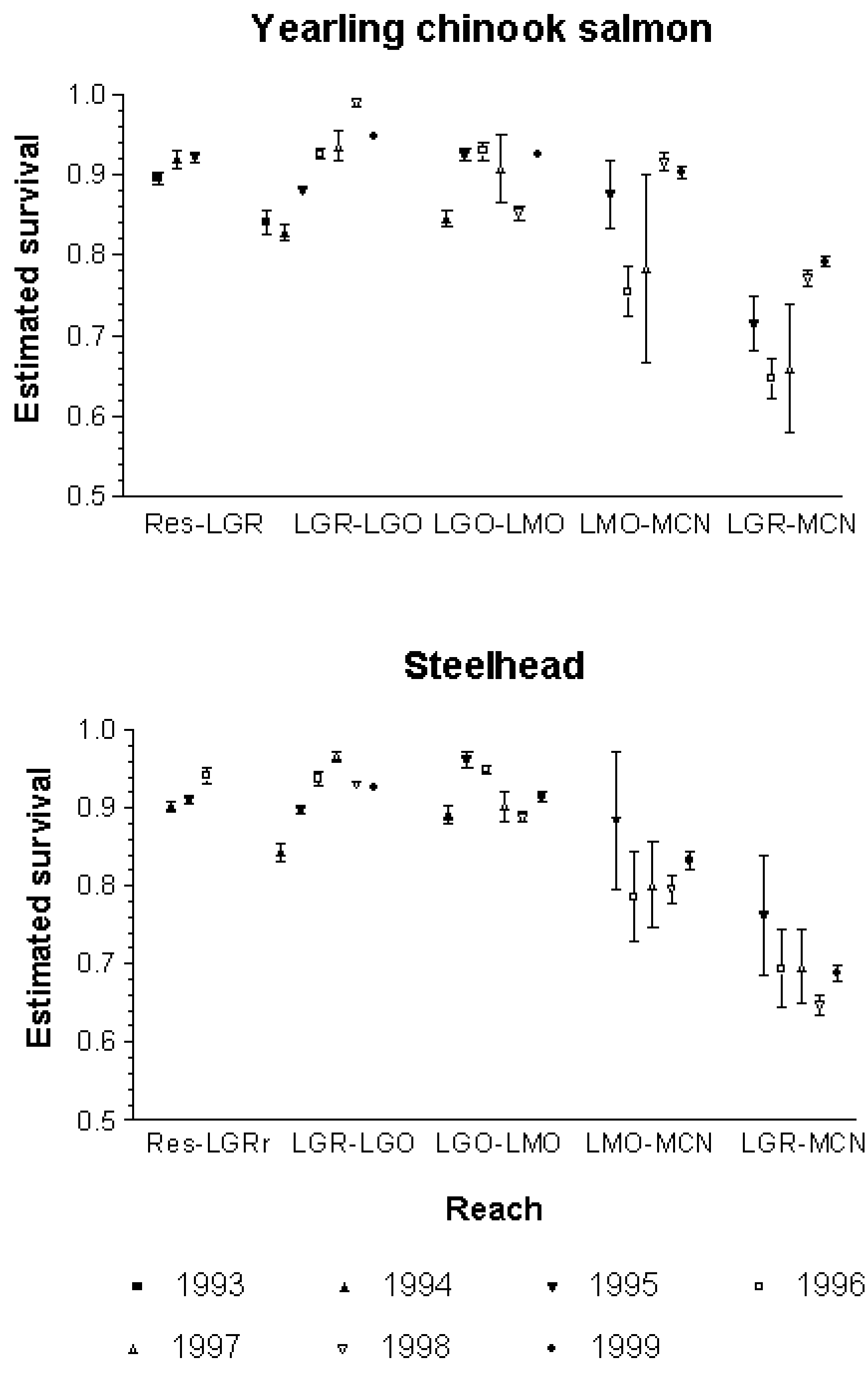


Figure 6. Annual average survival estimates for PIT-tagged yearling chinook salmon and steelhead from Lower Granite Reservoir (Res) to Lower Granite Dam (LGR), to Little Goose Dam (LGO), to Lower Monumental Dam (LMO), and to McNary Dam (MCN).

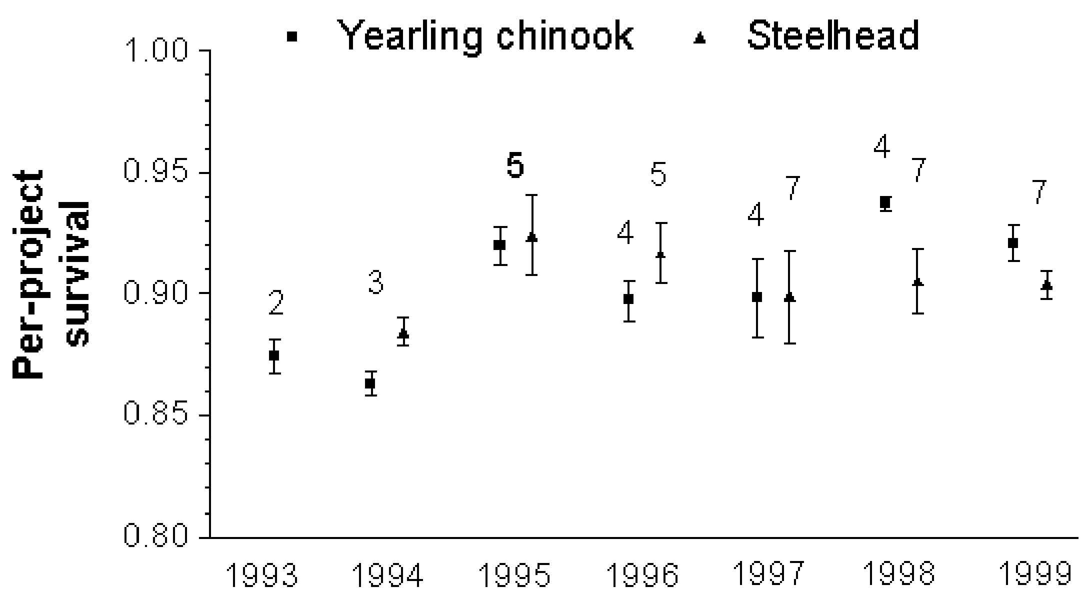


Figure 7. Estimated per-project survival (i.e., per dam/reservoir combination) with standard errors for yearling chinook salmon and steelhead from 1993 through 1999. Number above bar is the number of projects over which survival was estimated.

Table 1. Estimated survival probabilities for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	1,196	0.925 (0.020)	0.942 (0.032)	0.853 (0.040)	0.743 (0.031)
06 Apr - 12 Apr	796	0.951 (0.022)	0.911 (0.032)	0.928 (0.055)	0.804 (0.044)
13 Apr - 19 Apr	2,306	0.944 (0.011)	0.932 (0.022)	0.809 (0.043)	0.712 (0.035)
20 Apr - 26 Apr	21,623	0.944 (0.003)	0.913 (0.007)	0.906 (0.014)	0.781 (0.011)
27 Apr - 03 May	31,272	0.952 (0.003)	0.937 (0.006)	0.891 (0.011)	0.795 (0.009)
04 May - 10 May	22,168	0.947 (0.005)	0.915 (0.009)	0.917 (0.015)	0.795 (0.011)
11 May - 17 May	7,850	0.959 (0.012)	0.898 (0.021)	0.928 (0.035)	0.799 (0.025)
18 May - 24 May	6,016	0.935 (0.016)	0.931 (0.033)	0.915 (0.054)	0.796 (0.040)
25 May - 31 May	2,679	0.893 (0.018)	0.958 (0.034)	0.934 (0.073)	0.799 (0.058)
01 Jun - 07 Jun	516	0.893 (0.024)	0.973 (0.051)	0.853 (0.118)	0.741 (0.097)
08 Jun - 14 Jun	913	0.912 (0.022)	0.929 (0.040)	1.0[a] (0.333)	1.0[a] (0.278)
Weighted Mean[b]		0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.792 (0.006)

[a] Model-based estimate greater than 1.0.

[b] Weighted means of the independent estimates for daily groups (1 April - 31 May), with weights inversely proportional to respective estimated relative variances (see Table 5).

Table 2. Estimated survival probabilities for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT- tagged and released into the tailrace of McNary Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
20 Apr - 26 Apr	1,940	0.777 (0.045)	1.0[a] (0.809)	1.0[a] (0.624)
27 Apr - 03 May	8,436	0.753 (0.025)	0.746 (0.100)	0.562 (0.073)
04 May - 10 May	19,646	0.905 (0.024)	0.681 (0.068)	0.616 (0.059)
11 May - 17 May	24,447	0.846 (0.019)	0.858 (0.080)	0.726 (0.066)
18 May - 24 May	14,413	0.907 (0.037)	0.948 (0.142)	0.859 (0.124)
25 May - 31 May	6,670	0.988 (0.082)	0.911 (0.199)	0.900 (0.182)
Weighted Mean[b]		0.853 (0.030)	0.814 (0.370)	0.704 (0.058)

[a] Model-based estimate greater than 1.0.
[b] Weighted means of the independent estimates for weekly pooled groups (20 April - 31 May), with weights inversely proportional to respective estimated relative variances.

Table 3. Estimated survival probabilities for hatchery yearling chinook salmon detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	383	0.924 (0.050)	0.948 (0.080)	0.834 (0.084)	0.731 (0.058)
06 Apr - 12 Apr	239	0.976 (0.048)	0.966 (0.075)	0.815 (0.101)	0.769 (0.084)
13 Apr - 19 Apr	1,413	0.938 (0.016)	0.936 (0.034)	0.734 (0.055)	0.645 (0.044)
20 Apr - 26 Apr	15,982	0.940 (0.004)	0.918 (0.008)	0.901 (0.017)	0.777 (0.013)
27 Apr - 03 May	25,733	0.953 (0.003)	0.943 (0.007)	0.885 (0.012)	0.795 (0.010)
04 May - 10 May	19,684	0.947 (0.005)	0.915 (0.009)	0.925 (0.016)	0.802 (0.012)
11 May - 17 May	7,166	0.964 (0.013)	0.898 (0.023)	0.943 (0.039)	0.817 (0.028)
18 May - 24 May	5,326	0.944 (0.018)	0.922 (0.037)	0.924 (0.061)	0.805 (0.045)
25 May - 31 May	1,702	0.865 (0.028)	1.0[a] (0.060)	0.801 (0.089)	0.703 (0.070)
01 Jun - 07 Jun	136	0.872 (0.056)	0.946 (0.125)	1.0[a] (0.395)	0.897 (0.311)
08 Jun - 14 Jun	295	0.849 (0.051)	0.869 (0.087)	1.0[a] (0.487)	0.756 (0.354)
Weighted Mean[b]		0.948 (0.003)	0.928 (0.005)	0.899 (0.009)	0.791 (0.007)

[a] Model-based estimate greater than 1.0.

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

Table 4. Estimated survival probabilities for wild yearling chinook salmon detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	813	0.937 (0.021)	0.936 (0.033)	0.855 (0.046)	0.749 (0.036)
06 Apr - 12 Apr	557	0.942 (0.024)	0.892 (0.035)	0.974 (0.066)	0.819 (0.052)
13 Apr - 19 Apr	893	0.962 (0.015)	0.943 (0.029)	0.903 (0.068)	0.818 (0.058)
20 Apr - 26 Apr	5,641	0.960 (0.006)	0.906 (0.011)	0.913 (0.024)	0.794 (0.020)
27 Apr - 03 May	5,539	0.955 (0.006)	0.920 (0.011)	0.914 (0.022)	0.803 (0.017)
04 May - 10 May	2,484	0.956 (0.011)	0.913 (0.023)	0.863 (0.036)	0.753 (0.027)
11 May - 17 May	684	0.945 (0.028)	0.905 (0.050)	0.838 (0.072)	0.716 (0.053)
18 May - 24 May	690	0.919 (0.032)	0.979 (0.073)	0.845 (0.109)	0.760 (0.084)
25 May - 31 May	977	0.982 (0.023)	0.908 (0.038)	1.0[a] (0.118)	0.954 (0.101)
01 Jun - 07 Jun	380	0.903 (0.027)	0.981 (0.055)	0.788 (0.115)	0.698 (0.096)
08 Jun - 14 Jun	618	0.950 (0.024)	0.944 (0.045)	1.0[a] (0.421)	1.0[a] (0.374)
Weighted Mean[b]		0.956 (0.003)	0.917 (0.005)	0.906 (0.016)	0.791 (0.014)

[a] Model-based estimate greater than 1.0.

[b] 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 juvenile chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Estimates based on the Single-Release Model. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; Rel.-Release; Est.-Estimate; s.e.-standard error.

		Survival estimates							
		LGR-LGO		LGO-LMO		LMO-MCN		LGR-MCN	
Rel. Date	N	Est.	s.e	Est.	s.e	Est.	s.e	Est.	s.e
01 Apr 99	311	0.852	(0.036)	0.983	(0.064)	0.844	(0.077)	0.707	(0.055)
02 Apr 99	234	0.979	(0.049)	0.937	(0.079)	0.900	(0.118)	0.826	(0.096)
03 Apr 99	145	0.956	(0.058)	0.892	(0.079)	1.0[a]	(0.182)	0.955	(0.148)
04 Apr 99	136	0.951	(0.058)	0.855	(0.079)	0.953	(0.126)	0.774	(0.096)
05 Apr 99	12	0.833	(0.108)	1.0[a]	(0.145)	0.711	(0.471)	0.667	(0.430)
06 Apr 99	91	0.927	(0.085)	1.0[a]	(0.127)	0.765	(0.125)	0.729	(0.099)
07 Apr 99	68	1.0[a]	(0.055)	0.896	(0.090)	1.0[a]	(0.173)	0.926	(0.148)
08 Apr 99	192	0.946	(0.042)	0.866	(0.056)	1.0[a]	(0.114)	0.927	(0.091)
09 Apr 99	144	0.983	(0.052)	0.881	(0.072)	0.867	(0.103)	0.752	(0.083)
10 Apr 99	127	0.921	(0.048)	0.914	(0.078)	1.0[a]	(0.236)	0.936	(0.193)
11 Apr 99	143	0.923	(0.060)	0.901	(0.086)	0.754	(0.123)	0.627	(0.096)
12 Apr 99	31	0.938	(0.095)	1.0[a]	(0.251)	1.0[a]	(1.286)	1.0[a]	(1.215)
13 Apr 99	140	0.907	(0.039)	0.988	(0.075)	0.743	(0.129)	0.666	(0.108)
14 Apr 99	151	0.993	(0.032)	0.965	(0.065)	0.889	(0.152)	0.852	(0.138)
15 Apr 99	196	0.979	(0.034)	0.880	(0.059)	0.876	(0.141)	0.755	(0.117)
16 Apr 99	222	0.921	(0.030)	0.984	(0.066)	0.813	(0.114)	0.736	(0.094)
17 Apr 99	398	0.918	(0.024)	0.930	(0.050)	0.818	(0.110)	0.698	(0.089)
18 Apr 99	585	0.949	(0.023)	0.904	(0.043)	0.793	(0.078)	0.680	(0.062)
19 Apr 99	614	0.969	(0.029)	0.967	(0.063)	0.805	(0.114)	0.754	(0.098)
20 Apr 99	1,798	0.925	(0.014)	0.897	(0.026)	0.836	(0.053)	0.693	(0.041)
21 Apr 99	3,024	0.942	(0.009)	0.898	(0.017)	1.0[a]	(0.049)	0.849	(0.039)
22 Apr 99	3,429	0.951	(0.008)	0.883	(0.015)	0.871	(0.031)	0.732	(0.025)
23 Apr 99	3,717	0.946	(0.007)	0.921	(0.015)	0.925	(0.034)	0.807	(0.028)
24 Apr 99	3,159	0.932	(0.009)	0.929	(0.017)	0.926	(0.037)	0.802	(0.030)
25 Apr 99	3,343	0.962	(0.009)	0.913	(0.018)	0.881	(0.032)	0.774	(0.025)
26 Apr 99	3,153	0.939	(0.010)	0.934	(0.018)	0.922	(0.036)	0.809	(0.028)
27 Apr 99	4,304	0.948	(0.009)	0.920	(0.015)	0.887	(0.028)	0.774	(0.022)
28 Apr 99	6,234	0.938	(0.007)	0.957	(0.013)	0.887	(0.023)	0.797	(0.019)
29 Apr 99	5,208	0.941	(0.006)	0.950	(0.013)	0.866	(0.024)	0.774	(0.019)
30 Apr 99	3,460	0.950	(0.008)	0.967	(0.017)	0.912	(0.033)	0.838	(0.027)

Table 5. Continued.

		Survival estimates							
		LGR-LGO		LGO-LMO		LMO-MCN		LGR-MCN	
Rel. Date	N	Est.	s.e	Est.	s.e	Est.	s.e	Est.	s.e
01 May 99	4,481	0.966	(0.007)	0.920	(0.015)	0.943	(0.032)	0.838	(0.026)
02 May 99	3,055	0.959	(0.010)	0.924	(0.020)	0.919	(0.039)	0.814	(0.031)
03 May 99	4,530	0.970	(0.009)	0.915	(0.017)	0.855	(0.028)	0.758	(0.021)
04 May 99	4,113	0.954	(0.009)	0.928	(0.019)	0.888	(0.030)	0.786	(0.023)
05 May 99	6,055	0.951	(0.007)	0.913	(0.014)	0.938	(0.024)	0.814	(0.019)
06 May 99	3,019	0.971	(0.013)	0.886	(0.022)	0.929	(0.037)	0.799	(0.028)
07 May 99	1,800	0.928	(0.017)	0.948	(0.033)	0.844	(0.047)	0.743	(0.036)
08 May 99	3,253	0.945	(0.014)	0.934	(0.027)	0.893	(0.044)	0.788	(0.034)
09 May 99	3,479	0.953	(0.014)	0.900	(0.027)	1.0[a]	(0.053)	0.864	(0.040)
10 May 99	449	0.935	(0.043)	0.893	(0.078)	0.958	(0.139)	0.800	(0.103)
11 May 99	1,869	0.946	(0.024)	0.905	(0.043)	0.857	(0.062)	0.734	(0.044)
12 May 99	1,138	0.959	(0.030)	0.895	(0.051)	0.931	(0.082)	0.799	(0.060)
13 May 99	1,243	0.952	(0.027)	0.908	(0.051)	0.937	(0.090)	0.810	(0.067)
14 May 99	1,716	1.000	(0.027)	0.849	(0.045)	0.946	(0.076)	0.804	(0.055)
15 May 99	1,243	0.955	(0.034)	0.947	(0.068)	0.901	(0.102)	0.815	(0.078)
16 May 99	255	0.898	(0.060)	0.903	(0.112)	1.0[a]	(0.313)	1.0[a]	(0.232)
17 May 99	386	0.926	(0.042)	0.958	(0.097)	1.0[a]	(0.160)	0.910	(0.119)
18 May 99	1,782	1.0[a]	(0.031)	0.847	(0.052)	0.886	(0.079)	0.755	(0.056)
19 May 99	1,002	0.914	(0.039)	0.970	(0.087)	0.805	(0.104)	0.714	(0.074)
20 May 99	915	0.929	(0.038)	1.0[a]	(0.106)	0.723	(0.125)	0.708	(0.103)
21 May 99	652	0.899	(0.043)	0.998	(0.120)	0.853	(0.224)	0.766	(0.183)
22 May 99	836	0.876	(0.037)	0.932	(0.083)	0.755	(0.124)	0.617	(0.090)
23 May 99	427	0.834	(0.046)	0.988	(0.120)	1.0[a]	(0.791)	1.0[a]	(0.630)
24 May 99	402	0.999	(0.088)	0.683	(0.095)	1.0[a]	(0.218)	0.780	(0.134)
25 May 99	823	0.833	(0.049)	1.0[a]	(0.088)	0.909	(0.112)	0.767	(0.081)
26 May 99	858	0.913	(0.035)	0.984	(0.069)	0.895	(0.163)	0.805	(0.139)
27 May 99	574	0.923	(0.029)	0.873	(0.056)	0.985	(0.174)	0.793	(0.134)
28 May 99	147	1.0[a]	(0.063)	0.842	(0.094)	0.956	(0.248)	0.836	(0.208)
29 May 99	131	0.883	(0.052)	1.0[a]	(0.127)	0.783	(0.217)	0.742	(0.190)
30 May 99	82	0.926	(0.057)	0.929	(0.102)	1.0[a]	(0.710)	1.0[a]	(0.603)
31 May 99	64	1.0[a]	(0.101)	0.781	(0.118)	1.0[a]	(0.931)	1.0[a]	(0.733)
Weighted Mean[b]:		**0.949**	**(0.002)**	**0.925**	**(0.004)**	**0.904**	**(0.007)**	**0.792**	**(0.006)**

[a] Model-based estimate greater than 1.0.
[b] Weighted means of the independent estimates for daily groups (1 April - 31 May), with weights inversely proportional to respective estimated relative variances.

Table 6. Estimated detection probabilities for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO		LMO		MCN	
30 Mar - 05 Apr	1,196	0.440	(0.017)	0.485	(0.020)	0.503	(0.026)
06 Apr - 12 Apr	796	0.466	(0.021)	0.573	(0.024)	0.446	(0.031)
13 Apr - 19 Apr	2,306	0.599	(0.012)	0.591	(0.016)	0.337	(0.020)
20 Apr - 26 Apr	21,623	0.632	(0.004)	0.564	(0.005)	0.359	(0.006)
27 Apr - 03 May	31,272	0.595	(0.003)	0.511	(0.004)	0.430	(0.006)
04 May - 10 May	22,168	0.528	(0.004)	0.424	(0.005)	0.389	(0.006)
11 May - 17 May	7,850	0.422	(0.008)	0.317	(0.009)	0.324	(0.012)
18 May - 24 May	6,016	0.419	(0.009)	0.267	(0.010)	0.224	(0.013)
25 May - 31 May	2,679	0.406	(0.013)	0.441	(0.017)	0.162	(0.014)
01 Jun - 07 Jun	516	0.593	(0.027)	0.576	(0.036)	0.183	(0.031)
08 Jun - 14 Jun	913	0.513	(0.021)	0.605	(0.028)	0.054	(0.015)

Table 7. Estimated detection probabilities for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of McNary Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	JDA	BON
20 Apr - 26 Apr	1,940	0.390 (0.026)	0.129 (0.060)
27 Apr - 03 May	8,436	0.308 (0.012)	0.320 (0.042)
04 May - 10 May	19,646	0.261 (0.008)	0.257 (0.025)
11 May - 17 May	24,447	0.270 (0.007)	0.220 (0.020)
18 May - 24 May	14,413	0.157 (0.007)	0.198 (0.029)
25 May - 31 May	6,670	0.099 (0.009)	0.165 (0.034)

Table 8. Estimated detection probabilities for hatchery yearling chinook salmon detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Apr	383	0.333 (0.030)	0.358 (0.035)	0.500 (0.048)
06 Apr - 12 Apr	239	0.373 (0.036)	0.528 (0.046)	0.446 (0.059)
13 Apr - 19 Apr	1,413	0.574 (0.016)	0.543 (0.022)	0.332 (0.027)
20 Apr - 26 Apr	15,982	0.614 (0.005)	0.537 (0.006)	0.359 (0.007)
27 Apr - 03 May	25,733	0.580 (0.004)	0.493 (0.005)	0.421 (0.006)
04 May - 10 May	19,684	0.518 (0.004)	0.420 (0.005)	0.386 (0.007)
11 May - 17 May	7,166	0.413 (0.008)	0.305 (0.009)	0.313 (0.012)
18 May - 24 May	5,326	0.407 (0.010)	0.255 (0.011)	0.221 (0.014)
25 May - 31 May	1,702	0.350 (0.017)	0.363 (0.022)	0.170 (0.020)
01 Jun - 07 Jun	136	0.582 (0.056)	0.510 (0.077)	0.172 (0.070)
08 Jun - 14 Jun	295	0.427 (0.039)	0.623 (0.058)	0.058 (0.032)

Table 9. Estimated detection probabilities for wild yearling chinook salmon detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Apr	1,196	0.440 (0.017)	0.485 (0.020)	0.503 (0.026)
06 Apr - 12 Apr	796	0.466 (0.021)	0.573 (0.024)	0.446 (0.031)
13 Apr - 19 Apr	2,306	0.599 (0.012)	0.591 (0.016)	0.337 (0.020)
20 Apr - 26 Apr	21,623	0.632 (0.004)	0.564 (0.005)	0.359 (0.006)
27 Apr - 03 May	31,272	0.595 (0.003)	0.511 (0.004)	0.430 (0.006)
04 May - 10 May	22,168	0.528 (0.004)	0.424 (0.005)	0.389 (0.006)
11 May - 17 May	7,850	0.422 (0.008)	0.317 (0.009)	0.324 (0.012)
18 May - 24 May	6,016	0.419 (0.009)	0.267 (0.010)	0.224 (0.013)
25 May - 31 May	2,679	0.406 (0.013)	0.441 (0.017)	0.162 (0.014)
01 Jun - 07 Jun	516	0.593 (0.027)	0.576 (0.036)	0.183 (0.031)
08 Jun - 14 Jun	913	0.513 (0.021)	0.605 (0.028)	0.054 (0.015)

Table 10. Estimated survival probabilities for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	510	0.825 (0.022)	0.985 (0.037)	0.896 (0.053)	0.727 (0.039)
06 Apr - 12 Apr	908	0.948 (0.019)	1.0[a] (0.034)	0.761 (0.042)	0.726 (0.034)
13 Apr - 19 Apr	2,416	0.955 (0.010)	0.943 (0.018)	0.789 (0.037)	0.711 (0.032)
20 Apr - 26 Apr	10,155	0.941 (0.004)	0.928 (0.008)	0.812 (0.021)	0.709 (0.018)
27 Apr - 03 May	14,700	0.929 (0.004)	0.931 (0.008)	0.795 (0.018)	0.688 (0.014)
04 May - 10 May	14,774	0.893 (0.005)	0.876 (0.010)	0.759 (0.019)	0.594 (0.014)
11 May - 17 May	11,111	0.854 (0.007)	0.847 (0.013)	0.865 (0.025)	0.626 (0.016)
18 May - 24 May	13,092	0.916 (0.006)	0.896 (0.009)	0.932 (0.025)	0.765 (0.020)
25 May - 31 May	8,480	0.955 (0.007)	0.944 (0.013)	0.821 (0.027)	0.740 (0.023)
01 Jun - 07 Jun	987	0.943 (0.015)	0.893 (0.037)	0.542 (0.080)	0.456 (0.065)
08 Jun - 14 Jun	1,006	0.878 (0.021)	0.836 (0.053)	0.579 (0.125)	0.425 (0.088)
Weighted Mean[b]		0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.688 (0.010)

[a] Model-based estimate greater than 1.0.

[b] Weighted means of the independent estimates for daily groups (1 April - 31 May), with weights inversely proportional to respective estimated relative variances (see Table 14).

Table 11. Estimated survival probabilities for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of McNary Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
20 Apr - 26 Apr	331	1.0[a] (0.130)	0.521 (0.193)	0.544 (0.190)
27 Apr - 03 May	1,183	1.0[a] (0.077)	0.574 (0.140)	0.582 (0.135)
04 May - 10 May	2,876	0.942 (0.042)	0.706 (0.113)	0.666 (0.102)
11 May - 17 May	2,023	0.969 (0.060)	0.748 (0.185)	0.725 (0.174)
18 May - 24 May	1,794	0.777 (0.044)	0.892 (0.316)	0.693 (0.243)
25 May - 31 May	4,246	0.915 (0.041)	0.655 (0.127)	0.600 (0.113)
Weighted Mean[b]		0.920 (0.033)	0.682 (0.039)	0.640 (0.024)

[a] Model-based estimate greater than 1.0.

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

Table 12. Estimated survival probabilities for juvenile hatchery steelhead detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	296	0.797 (0.029)	0.979 (0.042)	0.963 (0.078)	0.751 (0.060)
06 Apr - 12 Apr	773	0.945 (0.021)	1.0[a] (0.036)	0.740 (0.044)	0.699 (0.036)
13 Apr - 19 Apr	2,252	0.951 (0.010)	0.946 (0.018)	0.788 (0.037)	0.709 (0.032)
20 Apr - 26 Apr	6,858	0.934 (0.005)	0.925 (0.010)	0.800 (0.024)	0.691 (0.020)
27 Apr - 03 May	12,312	0.927 (0.005)	0.933 (0.009)	0.771 (0.019)	0.667 (0.015)
04 May - 10 May	13,631	0.891 (0.005)	0.878 (0.010)	0.755 (0.020)	0.591 (0.014)
11 May - 17 May	10,190	0.850 (0.007)	0.850 (0.013)	0.862 (0.025)	0.622 (0.017)
18 May - 24 May	11,522	0.915 (0.006)	0.900 (0.010)	0.932 (0.026)	0.768 (0.021)
25 May - 31 May	7,365	0.951 (0.007)	0.937 (0.013)	0.822 (0.029)	0.733 (0.024)
01 Jun - 07 Jun	825	0.944 (0.016)	0.921 (0.042)	0.533 (0.083)	0.463 (0.070)
08 Jun - 14 Jun	847	0.870 (0.024)	0.817 (0.056)	0.593 (0.139)	0.421 (0.095)
Weighted Mean[a]		0.917 (0.009)	0.913 (0.010)	0.816 (0.021)	0.673 (0.019)

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

Table 13. Estimated survival probabilities for juvenile wild steelhead detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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	214	0.861	(0.035)	1.0[a]	(0.071)	0.820	(0.075)	0.710	(0.051)
06 Apr - 12 Apr	135	0.967	(0.052)	0.985	(0.097)	0.869	(0.118)	0.828	(0.089)
13 Apr - 19 Apr	164	1.0[a]	(0.045)	0.914	(0.082)	0.974	(0.338)	0.900	(0.305)
20 Apr - 26 Apr	3,297	0.957	(0.007)	0.935	(0.015)	0.862	(0.048)	0.771	(0.041)
27 Apr - 03 May	2,388	0.938	(0.009)	0.922	(0.018)	0.903	(0.049)	0.780	(0.040)
04 May - 10 May	1,142	0.917	(0.019)	0.846	(0.033)	0.812	(0.066)	0.630	(0.048)
11 May - 17 May	921	0.919	(0.034)	0.813	(0.053)	0.905	(0.112)	0.676	(0.077)
18 May - 24 May	1,570	0.922	(0.017)	0.866	(0.029)	0.931	(0.072)	0.744	(0.055)
25 May - 31 May	1,115	0.980	(0.021)	0.990	(0.044)	0.812	(0.076)	0.788	(0.067)
01 Jun - 07 Jun	162	0.930	(0.036)	0.747	(0.068)	0.597	(0.269)	0.414	(0.185)
08 Jun - 14 Jun	159	0.923	(0.049)	0.930	(0.143)	0.442	(0.224)	0.379	(0.184)
Weighted Mean[b]		0.946	(0.006)	0.918	(0.014)	0.868	(0.016)	0.746	(0.019)

[a] Model-based estimate greater than 1.0.

[b] 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 steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled as necessary to calculate estimates. Estimates based on the Single-Release Model. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam; Rel.-Release; Est.-Estimate; s.e.-standard error.

		Survival estimates							
		LGR-LGO		LGO-LMO		LMO-MCN		LGR-MCN	
Rel. Date	N	Est.	s.e	Est.	s.e	Est.	s.e	Est.	s.e
01 Apr 99	127	0.970	(0.036)	0.947	(0.076)	0.895	(0.099)	0.823	(0.077)
02 Apr 99	71	0.956	(0.061)	0.928	(0.100)	0.978	(0.151)	0.868	(0.123)
03-04 Apr 99	158	0.584	(0.042)	1.0[a]	(0.054)	0.927	(0.093)	0.569	(0.060)
05-06 Apr 99	33	0.848	(0.062)	1.0[a]	(0.162)	0.666	(0.163)	0.728	(0.129)
07 Apr 99	62	1.0[a]	(0.075)	0.976	(0.138)	0.648	(0.108)	0.651	(0.078)
08 Apr 99	264	0.951	(0.035)	1.0[a]	(0.060)	0.831	(0.072)	0.796	(0.058)
09 Apr 99	93	0.935	(0.058)	0.978	(0.101)	0.805	(0.118)	0.737	(0.090)
10 Apr 99	140	1.0[a]	(0.069)	0.926	(0.107)	0.784	(0.144)	0.726	(0.118)
11 Apr 99	310	0.922	(0.029)	1.0[a]	(0.056)	0.788	(0.099)	0.738	(0.086)
12 Apr 99	8	1.0[a]	(0.155)	0.750	(0.217)	1.0[a]	(0.060)	0.879	(0.156)
13 Apr 99	149	0.953	(0.044)	0.940	(0.068)	0.796	(0.110)	0.714	(0.093)
14 Apr 99	121	0.922	(0.036)	1.060	(0.060)	1.0[a]	(0.251)	1.0[a]	(0.238)
15 Apr 99	337	0.951	(0.030)	0.923	(0.044)	0.853	(0.108)	0.748	(0.092)
16 Apr 99	253	0.991	(0.033)	0.929	(0.063)	0.654	(0.091)	0.602	(0.078)
17 Apr 99	873	0.957	(0.016)	0.938	(0.030)	0.771	(0.061)	0.692	(0.052)
18 Apr 99	652	0.946	(0.020)	0.941	(0.035)	0.764	(0.071)	0.680	(0.061)
19 Apr 99	31	0.935	(0.065)	1.0[a]	(0.124)	1.0[a]	(1.102)	1.0[a]	(1.090)
20 Apr 99	780	0.935	(0.015)	0.989	(0.028)	0.857	(0.074)	0.792	(0.066)
21 Apr 99	683	0.942	(0.018)	0.971	(0.037)	0.785	(0.084)	0.718	(0.074)
22 Apr 99	1,429	0.946	(0.010)	0.944	(0.023)	0.807	(0.061)	0.720	(0.052)
23 Apr 99	1,859	0.952	(0.009)	0.921	(0.019)	0.713	(0.042)	0.625	(0.036)
24 Apr 99	1,978	0.937	(0.009)	0.937	(0.018)	0.841	(0.053)	0.738	(0.045)
25 Apr 99	2,104	0.948	(0.010)	0.882	(0.017)	0.881	(0.048)	0.737	(0.039)
26 Apr 99	1,322	0.921	(0.014)	0.928	(0.027)	0.797	(0.057)	0.681	(0.046)
27 Apr 99	1,934	0.927	(0.012)	0.937	(0.023)	0.832	(0.048)	0.723	(0.039)
28 Apr 99	2,536	0.914	(0.012)	0.952	(0.020)	0.792	(0.038)	0.689	(0.031)
29 Apr 99	2,343	0.932	(0.010)	0.924	(0.019)	0.811	(0.044)	0.698	(0.036)
30 Apr 99	1,890	0.926	(0.010)	0.915	(0.021)	0.810	(0.048)	0.686	(0.038)

Table 14. Continued.

		Survival estimates							
		LGR-LGO		LGO-LMO		LMO-MCN		LGR-MCN	
Rel. Date	N	Est.	s.e	Est.	s.e	Est.	s.e	Est.	s.e
01 May 99	2,515	0.936	(0.008)	0.920	(0.019)	0.814	(0.048)	0.701	(0.039)
02 May 99	1,941	0.930	(0.011)	0.958	(0.027)	0.726	(0.048)	0.648	(0.039)
03 May 99	1,541	0.915	(0.015)	0.952	(0.032)	0.753	(0.061)	0.656	(0.049)
04 May 99	2,098	0.881	(0.014)	0.899	(0.025)	0.735	(0.047)	0.583	(0.035)
05 May 99	2,231	0.907	(0.012)	0.889	(0.024)	0.709	(0.044)	0.571	(0.033)
06 May 99	4,077	0.912	(0.009)	0.901	(0.019)	0.774	(0.037)	0.636	(0.028)
07 May 99	2,064	0.886	(0.015)	0.809	(0.025)	0.780	(0.050)	0.559	(0.034)
08 May 99	2,607	0.891	(0.014)	0.843	(0.025)	0.754	(0.046)	0.566	(0.032)
09 May 99	1,584	0.859	(0.016)	0.894	(0.034)	0.828	(0.070)	0.636	(0.050)
10 May 99	113	0.941	(0.088)	0.877	(0.152)	0.632	(0.156)	0.522	(0.106)
11 May 99	2,530	0.844	(0.014)	0.800	(0.025)	0.982	(0.068)	0.663	(0.044)
12 May 99	1,793	0.861	(0.019)	0.816	(0.032)	0.866	(0.063)	0.608	(0.041)
13 May 99	1,726	0.854	(0.018)	0.865	(0.031)	0.884	(0.058)	0.653	(0.039)
14 May 99	2,212	0.845	(0.017)	0.859	(0.029)	0.860	(0.055)	0.624	(0.037)
15 May 99	2,632	0.856	(0.016)	0.894	(0.027)	0.775	(0.042)	0.593	(0.029)
16 May 99	111	0.882	(0.076)	0.851	(0.110)	0.763	(0.157)	0.572	(0.110)
17 May 99	107	0.865	(0.066)	0.929	(0.102)	1.0[a]	(0.391)	0.993	(0.306)
18 May 99	2,976	0.913	(0.013)	0.854	(0.020)	1.0[a]	(0.055)	0.789	(0.041)
19 May 99	1,800	0.909	(0.016)	0.909	(0.026)	0.923	(0.062)	0.763	(0.049)
20 May 99	2,036	0.913	(0.013)	0.898	(0.022)	0.844	(0.051)	0.692	(0.040)
21 May 99	2,311	0.930	(0.012)	0.915	(0.022)	0.840	(0.055)	0.715	(0.045)
22 May 99	2,848	0.907	(0.011)	0.908	(0.018)	0.941	(0.060)	0.774	(0.048)
23 May 99	586	0.933	(0.027)	0.860	(0.045)	1.0[a]	(0.138)	0.847	(0.106)
24 May 99	535	0.969	(0.035)	0.933	(0.068)	0.929	(0.143)	0.839	(0.119)
25 May 99	2,297	0.896	(0.024)	1.0[a]	(0.036)	0.852	(0.043)	0.768	(0.035)
26 May 99	2,549	0.977	(0.012)	0.945	(0.021)	0.871	(0.054)	0.804	(0.048)
27 May 99	3,212	0.951	(0.007)	0.903	(0.018)	0.827	(0.052)	0.710	(0.043)
28 May 99	125	0.921	(0.040)	0.976	(0.118)	0.719	(0.213)	0.647	(0.177)
29 May 99	110	0.991	(0.051)	0.838	(0.097)	0.557	(0.142)	0.462	(0.111)
30 May 99	104	0.995	(0.050)	0.912	(0.140)	0.496	(0.219)	0.450	(0.187)
31 May 99	83	1.0[a]	(0.057)	0.935	(0.136)	0.698	(0.408)	0.667	(0.380)
Weighted Mean[b]:		**0.926**	**(0.004)**	**0.915**	**(0.006)**	**0.833**	**(0.011)**	**0.688**	**(0.010)**

[a] Model-based estimate greater than 1.0.

[b] Weighted means of the independent estimates for daily groups (1 April - 31 May), with weights inversely proportional to respective estimated relative variances.

Table 15. Estimated detection probabilities for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Apr	510	0.587 (0.026)	0.531 (0.031)	0.648 (0.040)
06 Apr - 12 Apr	908	0.463 (0.019)	0.539 (0.023)	0.461 (0.028)
13 Apr - 19 Apr	2,416	0.553 (0.012)	0.697 (0.014)	0.255 (0.016)
20 Apr - 26 Apr	10,155	0.660 (0.005)	0.690 (0.007)	0.214 (0.007)
27 Apr - 03 May	14,700	0.649 (0.005)	0.601 (0.006)	0.256 (0.007)
04 May - 10 May	14,774	0.612 (0.005)	0.552 (0.007)	0.227 (0.007)
11 May - 17 May	11,111	0.524 (0.007)	0.483 (0.008)	0.230 (0.008)
18 May - 24 May	13,092	0.527 (0.005)	0.586 (0.007)	0.166 (0.006)
25 May - 31 May	8,480	0.552 (0.007)	0.546 (0.009)	0.177 (0.007)
01 Jun - 07 Jun	987	0.709 (0.018)	0.726 (0.031)	0.194 (0.033)
08 Jun - 14 Jun	1,006	0.652 (0.021)	0.596 (0.039)	0.119 (0.029)

Table 16. Estimated detection probabilities for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of McNary Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	JDA	BON
20 Apr - 26 Apr	331	0.330 (0.048)	0.500 (0.177)
27 Apr - 03 May	1,183	0.277 (0.025)	0.455 (0.106)
04 May - 10 May	2,876	0.346 (0.018)	0.337 (0.053)
11 May - 17 May	2,023	0.306 (0.022)	0.293 (0.071)
18 May - 24 May	1,794	0.435 (0.027)	0.250 (0.088)
25 May - 31 May	4,246	0.358 (0.018)	0.270 (0.052)

Table 17. Estimated detection probabilities for juvenile hatchery steelhead detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Apr	296	0.594 (0.034)	0.636 (0.041)	0.591 (0.057)
06 Apr - 12 Apr	773	0.463 (0.021)	0.571 (0.025)	0.444 (0.030)
13 Apr - 19 Apr	2,252	0.555 (0.012)	0.698 (0.015)	0.262 (0.016)
20 Apr - 26 Apr	6,858	0.648 (0.007)	0.693 (0.009)	0.228 (0.009)
27 Apr - 03 May	12,312	0.646 (0.005)	0.593 (0.007)	0.255 (0.007)
04 May - 10 May	13,631	0.613 (0.005)	0.551 (0.007)	0.223 (0.007)
11 May - 17 May	10,190	0.531 (0.007)	0.487 (0.008)	0.231 (0.008)
18 May - 24 May	11,522	0.525 (0.006)	0.591 (0.007)	0.165 (0.006)
25 May - 31 May	7,365	0.562 (0.007)	0.562 (0.009)	0.177 (0.008)
01 Jun - 07 Jun	825	0.698 (0.019)	0.707 (0.034)	0.194 (0.035)
08 Jun - 14 Jun	847	0.653 (0.023)	0.605 (0.043)	0.127 (0.034)

Table 18. Estimated detection probabilities for juvenile wild steelhead detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Apr	510	0.587 (0.026)	0.531 (0.031)	0.648 (0.040)
06 Apr - 12 Apr	908	0.463 (0.019)	0.539 (0.023)	0.461 (0.028)
13 Apr - 19 Apr	2,416	0.553 (0.012)	0.697 (0.014)	0.255 (0.016)
20 Apr - 26 Apr	10,155	0.660 (0.005)	0.690 (0.007)	0.214 (0.007)
27 Apr - 03 May	14,700	0.649 (0.005)	0.601 (0.006)	0.256 (0.007)
04 May - 10 May	14,774	0.612 (0.005)	0.552 (0.007)	0.227 (0.007)
11 May - 17 May	11,111	0.524 (0.007)	0.483 (0.008)	0.230 (0.008)
18 May - 24 May	13,092	0.527 (0.005)	0.586 (0.007)	0.166 (0.006)
25 May - 31 May	8,480	0.552 (0.007)	0.546 (0.009)	0.177 (0.007)
01 Jun - 07 Jun	987	0.709 (0.018)	0.726 (0.031)	0.194 (0.033)
08 Jun - 14 Jun	1,006	0.652 (0.021)	0.596 (0.039)	0.119 (0.029)

Table 19. Estimated survival probabilities for PIT-tagged yearling chinook salmon released from hatcheries in 1999. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; SNT-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Hatchery (Release site)	Number released	Rel to SNT	SNT to LGR	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater (Crooked River)	500	NA	NA	0.753 (0.049)	0.932 (0.075)	0.953 (0.095)	0.987 (0.192)	0.660 (0.117)
Clearwater (Powell Pond)	1,000	NA	NA	0.777 (0.031)	0.990 (0.049)	0.942 (0.063)	1.0[a] (0.135)	0.757 (0.088)
Clearwater (Papoose Creek)	749	NA	NA	0.576 (0.036)	0.904 (0.061)	0.897 (0.071)	1.0[a] (0.181)	0.498 (0.079)
Clearwater (Red R. Pond)	500	NA	NA	0.667 (0.051)	0.901 (0.077)	0.915 (0.082)	0.974 (0.152)	0.536 (0.076)
Dworshak	47,844	NA	NA	0.834 (0.011)	0.910 (0.014)	0.951 (0.009)	0.870 (0.013)	0.628 (0.009)
Kooskia	1,000	NA	NA	0.653 (0.031)	0.985 (0.052)	0.919 (0.060)	0.748 (0.072)	0.442 (0.036)
Lookingglass (Imnaha Weir)	22,927	0.674 (0.034)	0.992 (0.052)	0.668 (0.009)	0.917 (0.016)	0.952 (0.016)	0.891 (0.025)	0.519 (0.013)
Lookingglass (L˜glass Hatch.)	44,708	0.679 (0.020)	0.959 (0.030)	0.651 (0.006)	0.940 (0.011)	0.952 (0.008)	0.826 (0.013)	0.481 (0.007)
Lookingglass (Lostine River)	4,958	0.974 (0.183)	0.643 (0.121)	0.626 (0.013)	0.950 (0.021)	0.920 (0.026)	0.899 (0.043)	0.492 (0.021)
McCall	47,985	0.678 (0.032)	0.958 (0.047)	0.649 (0.008)	0.919 (0.015)	0.939 (0.014)	0.918 (0.021)	0.514 (0.011)
Pahsimeroi	500	NA	NA	0.584 (0.035)	0.925 (0.065)	0.834 (0.075)	0.893 (0.120)	0.402 (0.050)
Rapid River	47,812	0.766 (0.032)	0.974 (0.041)	0.746 (0.006)	0.927 (0.011)	0.959 (0.010)	0.904 (0.017)	0.600 (0.010)
Sawtooth	2,966	NA	NA	0.452 (0.019)	0.918 (0.042)	0.923 (0.049)	0.976 (0.091)	0.374 (0.032)

[a] Model-based estimate greater than 1.0.

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from hatcheries in 1999. 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.

Hatchery (Release site/date)	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater (Clear Creek)	598	0.836 (0.034)	0.894 (0.041)	0.949 (0.047)	0.948 (0.138)	0.672 (0.094)
Clearwater (S.F. Clearwater)	300	0.869 (0.053)	0.892 (0.065)	0.984 (0.113)	1.0[a] (0.430)	0.865 (0.313)
Clearwater (Red River)	5,000	0.310 (0.008)	0.996 (0.023)	0.944 (0.036)	0.612 (0.052)	0.179 (0.014)
Dworshak (Apr. 26)	551	0.703 (0.029)	1.0[a] (0.050)	0.817 (0.058)	0.905 (0.179)	0.524 (0.101)
Dworshak (Apr. 28)	502	0.624 (0.027)	0.998 (0.039)	0.914 (0.063)	0.823 (0.158)	0.468 (0.087)
Dworshak (Apr. 30)	551	0.797 (0.034)	1.0[a] (0.055)	0.831 (0.069)	0.673 (0.118)	0.462 (0.075)
Dworshak (Clear Creek)	899	0.729 (0.024)	0.951 (0.034)	0.878 (0.041)	0.933 (0.134)	0.569 (0.080)
Dworshak (Apr. 26) (Clearwater River)	603	0.747 (0.027)	1.0[a] (0.047)	0.809 (0.055)	0.892 (0.169)	0.567 (0.104)
Dworshak (Apr. 28) (Clearwater River)	1,202	0.810 (0.020)	0.955 (0.028)	0.891 (0.039)	0.858 (0.096)	0.592 (0.063)
Dworshak (Apr. 30) (Clearwater River)	303	0.762 (0.040)	0.951 (0.055)	0.924 (0.073)	0.863 (0.149)	0.578 (0.094)
Dworshak (S.F. Clearwater)	898	0.792 (0.023)	0.946 (0.030)	0.960 (0.043)	0.700 (0.073)	0.503 (0.049)
Sawtooth	300	0.785 (0.033)	0.996 (0.045)	1.0[a] (0.081)	0.972 (0.258)	0.813 (0.208)

[a] Model-based estimate greater than 1.0.

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth Hatchery in 1999. 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
Alturus Lake Creek	1,246	0.386 (0.022)	0.892 (0.054)	1.0[a] (0.082)	0.861 (0.168)	0.301 (0.055)
Redfish Lake	1,206	0.153 (0.017)	0.933 (0.109)	0.863 (0.126)	0.647 (0.194)	0.080 (0.023)
Redfish Lake Creek Trap	400	0.423 (0.093)	0.674 (0.178)	0.926 (0.209)	NA	NA
Sawtooth Trap	399	0.485 (0.079)	0.843 (0.157)	1.0[a] (0.280)	0.857 (0.396)	0.454 (0.191)

[a] Model-based estimate greater than 1.0.

Table 22. Estimated detection probabilities for PIT-tagged yearling chinook salmon released from hatcheries in 1999. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: SNT-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Hatchery (Release site)	Number released	SNT	LGR	LGO	LMO	MCN
Clearwater (Crooked River)	500	NA	0.223 (0.025)	0.429 (0.034)	0.362 (0.041)	0.215 (0.044)
Clearwater (Powell Pond)	1,000	NA	0.239 (0.018)	0.455 (0.023)	0.354 (0.027)	0.227 (0.031)
Clearwater (Papoose Creek)	749	NA	0.227 (0.024)	0.545 (0.032)	0.417 (0.039)	0.318 (0.055)
Clearwater (Red R. Pond)	500	NA	0.198 (0.026)	0.464 (0.036)	0.391 (0.042)	0.329 (0.053)
Dworshak	47,844	NA	0.168 (0.003)	0.490 (0.004)	0.415 (0.004)	0.363 (0.006)
Kooskia	1,000	NA	0.210 (0.018)	0.496 (0.025)	0.394 (0.030)	0.430 (0.040)
Lookingglass (Imnaha Weir)	22,927	0.006 (0.001)	0.222 (0.004)	0.538 (0.006)	0.393 (0.007)	0.343 (0.010)
Lookingglass (L˜glass Hatch.)	44,708	0.008 (0.001)	0.239 (0.003)	0.579 (0.004)	0.513 (0.005)	0.389 (0.006)
Lookingglass (Lostine River)	4,958	0.005 (0.001)	0.230 (0.009)	0.531 (0.012)	0.396 (0.013)	0.367 (0.018)
McCall	47,985	0.004 (0.000)	0.216 (0.004)	0.477 (0.005)	0.357 (0.005)	0.291 (0.007)
Pahsimeroi	500	NA	0.363 (0.033)	0.508 (0.039)	0.428 (0.046)	0.375 (0.055)
Rapid River	47,812	0.003 (0.000)	0.281 (0.003)	0.542 (0.004)	0.407 (0.005)	0.328 (0.006)
Sawtooth	2,966	NA	0.195 (0.013)	0.471 (0.019)	0.339 (0.021)	0.277 (0.026)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from hatcheries in 1999. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: SNT-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Hatchery (Release site/date)	Number released	LGR		LGO		LMO		MCN	
Clearwater (Clear Creek)	598	0.284	(0.023)	0.614	(0.027)	0.584	(0.035)	0.185	(0.033)
Clearwater (S.F. Clearwater)	300	0.265	(0.031)	0.656	(0.040)	0.415	(0.056)	0.099	(0.041)
Clearwater (Red River)	5,000	0.318	(0.013)	0.587	(0.016)	0.533	(0.023)	0.195	(0.020)
Dworshak (Apr. 26)	551	0.372	(0.027)	0.522	(0.033)	0.587	(0.043)	0.166	(0.039)
Dworshak (Apr. 28)	502	0.380	(0.029)	0.649	(0.033)	0.566	(0.045)	0.165	(0.039)
Dworshak (Apr. 30)	551	0.262	(0.023)	0.544	(0.031)	0.501	(0.044)	0.203	(0.041)
Dworshak (Clear Creek)	899	0.322	(0.020)	0.610	(0.024)	0.625	(0.032)	0.193	(0.032)
Dworshak (Apr. 26) (Clearwater River)	603	0.344	(0.024)	0.524	(0.030)	0.588	(0.040)	0.157	(0.035)
Dworshak (Apr. 28) (Clearwater River)	1,202	0.335	(0.017)	0.617	(0.020)	0.531	(0.027)	0.178	(0.024)
Dworshak (Apr. 30) (Clearwater River)	303	0.321	(0.034)	0.628	(0.039)	0.521	(0.051)	0.277	(0.056)
Dworshak (S.F. Clearwater)	898	0.344	(0.019)	0.596	(0.022)	0.593	(0.031)	0.256	(0.032)
Sawtooth	300	0.365	(0.033)	0.539	(0.038)	0.575	(0.052)	0.147	(0.045)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from Sawtooth Hatchery in 1999. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: SNT-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	LGR	LGO	LMO	MCN
Alturus Lake Creek	1,246	0.289 (0.024)	0.509 (0.030)	0.446 (0.041)	0.172 (0.037)
Redfish Lake	1,206	0.254 (0.039)	0.454 (0.051)	0.511 (0.075)	0.250 (0.081)
Redfish Lake Creek Trap	400	0.154 (0.043)	0.279 (0.057)	0.388 (0.084)	NA
Sawtooth Trap	399	0.134 (0.032)	0.330 (0.048)	0.255 (0.059)	0.095 (0.045)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 1999. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Hatchery chinook salmon							
Snake	22 Mar - 25 May	5,611	0.800 (0.013)	0.958 (0.019)	0.900 (0.022)	1.0[a] (0.047)	0.697 (0.030)
Salmon	19 Mar - 21 May	4,268	0.930 (0.013)	0.960 (0.017)	0.942 (0.022)	0.875 (0.037)	0.736 (0.027)
Imnaha	08 Mar - 14 May	1,453	0.719 (0.024)	0.908 (0.033)	0.931 (0.040)	0.938 (0.075)	0.571 (0.041)
Wild chinook salmon							
Snake	22 Mar - 25 May	3,628	0.909 (0.012)	0.955 (0.015)	0.927 (0.017)	0.930 (0.035)	0.748 (0.027)
Salmon	18 Mar - 21 May	3,624	0.951 (0.011)	0.973 (0.014)	0.922 (0.015)	0.883 (0.029)	0.752 (0.023)
Imnaha	02 Mar - 20 May	5,181	0.883 (0.010)	0.974 (0.012)	0.909 (0.014)	0.886 (0.027)	0.693 (0.019)
Hatchery steelhead							
Snake	05 Apr - 25 May	2,266	0.825 (0.014)	0.961 (0.021)	0.868 (0.028)	0.915 (0.073)	0.630 (0.048)
Salmon	14 Apr - 21 May	3,990	0.908 (0.012)	0.964 (0.017)	0.891 (0.021)	0.791 (0.041)	0.617 (0.030)
Imnaha	14 Apr - 24 Jun	6,390	0.857 (0.010)	0.937 (0.014)	0.940 (0.021)	0.787 (0.047)	0.594 (0.034)
Wild steelhead							
Snake	23 Mar - 25 May	227	0.816 (0.039)	1.0[a] (0.072)	0.805 (0.086)	1.0[a] (0.237)	0.746 (0.168)
Salmon	23 Mar - 21 May	923	0.910 (0.024)	0.971 (0.033)	0.864 (0.041)	0.914 (0.112)	0.697 (0.081)
Imnaha	24 Mar - 23 Jun	2,449	0.884 (0.016)	0.985 (0.023)	0.876 (0.027)	0.905 (0.063)	0.690 (0.046)

[a] Model-based estimate greater than 1.0.

Table 26. Travel time statistics for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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)				LGR to MCN (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	487	8.1	12.5	19.4	209	2	2.6	3.4	199	4.6	5.8	7.1	418	15.5	19.6	24.8
06 Apr - 12 Apr	353	6	7.6	11.4	174	1.9	2.3	3.1	155	4.4	5.2	6.9	272	12.6	14.9	19.2
13 Apr - 19 Apr	1,305	4.1	5.2	7.2	722	1.5	2	3	315	4	4.9	6.7	534	10.2	12.5	15.9
20 Apr - 26 Apr	12,885	3.6	4.5	6.1	6,539	1.5	2	2.8	3,158	3.6	4.4	5.7	5,771	9.4	11.2	14.1
27 Apr - 03 May	35,408	3.8	4.7	6.3	16,754	1.7	2.1	2.9	9,070	3.4	4.1	5.1	19,406	9.3	11.1	13.5
04 May - 10 May	11,079	3.8	4.5	5.8	4,097	1.8	2.1	2.7	2,564	3.1	3.7	4.6	6,370	9	10.3	12.2
11 May - 17 May	3,176	4	4.8	6	792	1.9	2.3	3	606	2.7	3.1	3.8	1,917	8.7	9.9	11.2
18 May - 24 May	4,712	3	3.6	4.4	1,080	1.2	1.7	2.3	492	2.2	2.6	3.3	2,018	6.8	7.8	8.7
25 May - 31 May	971	2.5	3.4	4.8	408	1.1	1.4	2.1	130	2.4	3	3.5	327	5.7	6.9	8.7
01 Jun - 07 Jun	273	3.7	4.7	5.8	138	1.7	2.4	3.3	34	3.1	3.9	4.5	64	9.4	10.7	12.7
08 Jun - 14 Jun	427	3.5	4.2	5.5	229	2	2.7	3.5	36	3	3.4	4.4	53	8.9	10.6	12.5
15 Jun -21 Jun	428	2.8	3.7	4.8	246	1.6	2	2.7	48	2.7	3.2	4.4	80	7	8.8	10.6

	LGR to BON (days)			
Date at LGR	N	20%	Med.	80%
30 Mar - 05 Apr	159	24	28.1	34.7
06 Apr - 12 Apr	119	19.4	23.7	28.2
13 Apr - 19 Apr	281	16.6	19.5	23.4
20 Apr - 26 Apr	2,806	14.9	17.1	20.5
27 Apr - 03 May	7,708	14.9	17	19.7
04 May - 10 May	2,823	14.1	15.7	17.7
11 May - 17 May	1,015	12.8	14.1	15.6
18 May - 24 May	1,386	9.8	11.2	12.5
25 May - 31 May	223	8.5	9.7	11.5
01 Jun - 07 Jun	55	13.4	14.9	17.4
08 Jun - 14 Jun	113	12.2	13.4	15.4
15 Jun -21 Jun	113	10.6	12.6	16

Table 27. Migration rate statistics for yearling chinook salmon (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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)				LGR to MCN (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	487	3.1	4.8	7.4	209	13.5	18	23.1	199	16.7	20.5	25.6	418	9.1	11.5	14.5
06 Apr - 12 Apr	353	5.3	7.9	10	174	15	20.3	24	155	17.3	22.7	27	272	11.7	15.1	17.9
13 Apr - 19 Apr	1,305	8.4	11.5	14.6	722	15.2	22.4	30.3	315	17.8	24.1	29.6	534	14.2	18	22
20 Apr - 26 Apr	12,885	9.8	13.4	16.7	6,539	16.4	22.8	29.9	3,158	21	26.9	32.8	5,771	15.9	20	23.8
27 Apr - 03 May	35,408	9.5	12.7	15.9	16,754	16	21.5	26.4	9,070	23.4	29	35.1	19,406	16.7	20.3	24.1
04 May - 10 May	11,079	10.4	13.2	15.6	4,097	16.9	21.7	25.7	2,564	26	32.1	37.9	6,370	18.5	21.8	25
11 May - 17 May	3,176	10.1	12.4	14.8	792	15.4	20.3	24.7	606	31.6	38.1	44.7	1,917	20.2	22.8	25.9
18 May - 24 May	4,712	13.5	16.9	19.8	1,080	20.2	27.5	39	492	35.7	44.9	54.1	2,018	25.7	28.8	33
25 May - 31 May	971	12.6	17.8	23.6	408	22	32.4	43	130	34.2	39.5	50	327	25.8	32.6	39.3
01 Jun - 07 Jun	273	10.3	12.7	16.3	138	14	19.5	27.5	34	26.4	30.8	38.1	64	17.7	21.1	23.9
08 Jun - 14 Jun	427	11	14.2	17.2	229	13.2	16.9	23.5	36	27.3	34.6	40.1	53	18	21.1	25.2
15 Jun -21 Jun	428	12.5	16.2	21.4	246	17.3	22.5	29.7	48	27	36.6	44.2	80	21.2	25.7	32.4

	LGR to BON (km/day)			
Date at LGR	N	20%	Med.	80%
30 Mar - 05 Apr	159	13.3	16.4	19.2
06 Apr - 12 Apr	119	16.4	19.4	23.8
13 Apr - 19 Apr	281	19.7	23.6	27.8
20 Apr - 26 Apr	2,806	22.5	27	30.9
27 Apr - 03 May	7,708	23.4	27.1	30.9
04 May - 10 May	2,823	26.1	29.4	32.8
11 May - 17 May	1,015	29.5	32.7	36
18 May - 24 May	1,386	37	41.2	47
25 May - 31 May	223	40.2	47.4	54.3
01 Jun - 07 Jun	55	26.5	30.9	34.4
08 Jun - 14 Jun	113	29.9	34.4	37.7
15 Jun -21 Jun	113	28.8	36.7	43.6

Table 28. Travel time statistics for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1999. 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)				LGR to MCN (days)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	247	5.1	7.4	11.8	95	2	2.7	4	96	4	4.6	5.9	199	11.1	14.1	18.1
06 Apr - 12 Apr	399	4.2	5.4	9.3	217	2.2	3.2	6.2	133	3.4	4.2	5	288	10.1	11.8	15.6
13 Apr - 19 Apr	1,276	3.8	4.8	7.3	818	1.9	3.3	6.6	305	3	3.7	5.3	414	9.8	12.5	18.6
20 Apr - 26 Apr	6,311	2.8	3.4	4.8	3,894	1.6	2.4	4.7	1,020	2.8	3.5	4.8	1,441	8	10.4	14.9
27 Apr - 03 May	8,861	2.7	3.4	4.4	4,859	1.7	2.7	4.9	1,392	2.8	3.4	4.4	2,333	7.6	9.5	13
04 May - 10 May	8,070	3	3.6	4.8	3,837	2.1	3.2	5.9	1,043	2.9	3.4	4.5	1,875	8.7	11	16.5
11 May - 17 May	4,968	3.4	4.4	7.6	2,041	2.1	3	5.2	753	2.5	3.1	3.9	1,548	9.7	11.6	13.9
18 May - 24 May	6,317	2.8	3.6	4.7	3,248	1.2	1.9	2.9	932	2	2.5	3.1	1,630	6.7	8	9.8
25 May - 31 May	4,468	2	2.4	3.2	2,370	1	1.5	3.1	602	2	2.4	3	1,082	5	6	7.8
01 Jun - 07 Jun	660	2.4	2.8	3.6	410	1.3	1.8	3.1	59	2.3	2.8	3.5	80	6.4	7.5	9.3
08 Jun - 14 Jun	576	2.4	2.9	3.7	266	1.4	2	3	27	2.1	2.5	3.1	45	5.9	7.1	7.9
15 Jun -21 Jun	800	2.2	2.6	3	480	1.2	1.7	2.6	50	1.8	2	2.3	74	5.4	6	7.7

	LGR to BON (days)			
Date at LGR	N	20%	Med.	80%
30 Mar - 05 Apr	81	19.5	23.3	28.8
06 Apr - 12 Apr	169	16.6	19.2	26.4
13 Apr - 19 Apr	462	15.4	19.3	24.9
20 Apr - 26 Apr	1,846	12.6	15.4	20
27 Apr - 03 May	2,145	12.4	15.4	19.5
04 May - 10 May	1,758	13.7	16.4	21.3
11 May - 17 May	1,255	14.8	17.7	21.1
18 May - 24 May	1,622	11	12.8	15.4
25 May - 31 May	641	9.2	10.4	13.6
01 Jun - 07 Jun	37	11.8	14.4	17.7
08 Jun - 14 Jun	49	11	12.5	16.4
15 Jun -21 Jun	71	10.2	12.4	16.3

Table 29. Migration rate statistics for juvenile steelhead (hatchery and wild combined) detected and returned to or PIT-tagged and released into the tailrace of Lower Granite Dam in 1998. 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)				LGR to MCN (km/day)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	247	5.1	8.1	11.7	95	11.4	17.2	22.8	96	20.1	25.7	30.1	199	12.5	16	20.2
06 Apr - 12 Apr	399	6.5	11.2	14.4	217	7.4	14.3	20.7	133	23.6	28.5	35.1	288	14.5	19.1	22.2
13 Apr - 19 Apr	1,276	8.2	12.5	15.7	818	7	14	23.8	305	22.5	32.2	39.1	414	12.1	18	23
20 Apr - 26 Apr	6,311	12.6	17.5	21.7	3,894	9.9	18.8	29.1	1,020	24.7	34.2	42.3	1,441	15.1	21.6	28
27 Apr - 03 May	8,861	13.7	17.9	22.1	4,859	9.4	17.2	26.9	1,392	27	35.3	42.5	2,333	17.4	23.8	29.7
04 May - 10 May	8,070	12.5	16.6	19.9	3,837	7.8	14.2	21.8	1,043	26.3	34.5	41.5	1,875	13.6	20.4	25.9
11 May - 17 May	4,968	7.9	13.5	17.8	2,041	8.8	15.1	22	753	30.4	38.8	47.8	1,548	16.2	19.3	23.2
18 May - 24 May	6,317	12.8	16.7	21.3	3,248	15.8	24.3	36.8	932	38.5	48.2	59.5	1,630	23.1	28	33.6
25 May - 31 May	4,468	18.6	24.8	29.4	2,370	15	30.1	45.1	602	39	50.4	60.7	1,082	28.8	37.8	45.3
01 Jun - 07 Jun	660	16.7	21.6	25.2	410	14.7	25	35.1	59	34.2	42.7	50.9	80	24.3	30.1	34.9
08 Jun - 14 Jun	576	16	21	25.2	266	15.1	23.5	32.9	27	38.8	47.8	55.9	45	28.3	31.6	37.9
15 Jun -21 Jun	800	19.7	22.8	26.7	480	18	26.9	39.3	50	51.5	58	66.5	74	29.3	37.4	41.3

	LGR to BON (km/day)			
Date at LGR	N	20%	Med.	80%
30 Mar - 05 Apr	81	16	19.8	23.7
06 Apr - 12 Apr	169	17.4	24	27.8
13 Apr - 19 Apr	462	18.5	23.8	30
20 Apr - 26 Apr	1,846	23	29.8	36.5
27 Apr - 03 May	2,145	23.7	30	37.1
04 May - 10 May	1,758	21.6	28.1	33.6
11 May - 17 May	1,255	21.8	26.1	31.1
18 May - 24 May	1,622	30	35.9	41.9
25 May - 31 May	641	34	44.4	50.2
01 Jun - 07 Jun	37	26	32	39
08 Jun - 14 Jun	49	28	37	42
15 Jun -21 Jun	71	28.3	37.1	45.3

Table 30. Number of fish handled (N) and mortalities while PIT tagging river-run subyearling chinook salmon at McNary Dam for post-detection bypass survival estimates in 1999.

	Hatchery yearlings		River-run subyearlings		Hatchery steelhead		Wild steelhead		Coho		Hatchery sockeye		Wild sockeye	
Date	N	Morts	N	Morts	N	Morts	N	Morts	N	Morts	N	Morts	N	Morts
22 Jun	8	0	2,150	20	13	0	2	0	14	0	0	0	0	0
23 Jun	11	0	3,017	22	14	0	2	0	13	0	0	0	2	0
24 Jun	4	0	3,376	25	9	0	1	0	7	0	1	0	1	0
25 Jun	2	0	2,315	23	2	0	0	0	5	0	0	0	1	0
26 Jun	2	0	1,678	26	3	0	1	0	4	0	2	1	1	0
27 Jun	1	0	2,063	23	4	0	0	0	4	1	0	0	0	0
28 Jun	2	0	2,645	23	1	0	0	0	2	0	1	0	0	0
29 Jun	1	0	1,556	20	0	0	0	0	1	0	0	0	0	0
30 Jun	1	0	1,146	13	0	0	0	0	2	0	0	0	0	0
01 Jul	3	0	1,192	15	0	0	1	0	2	0	0	0	0	0
02 Jul	1	0	1,457	13	1	0	0	0	3	0	0	0	0	0
03 Jul	2	0	4,848	43	8	0	0	0	2	0	0	0	1	0
04 Jul	9	0	11,949	257	14	1	2	0	13	1	5	0	0	0
06 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 Jul	2	0	1,980	45	3	1	1	0	2	0	0	0	0	0
08 Jul	4	0	2,579	22	3	0	0	0	3	0	0	0	1	0
09 Jul	1	0	1,527	15	5	0	0	0	2	0	0	0	1	0
10 Jul	3	0	5,540	30	16	0	0	0	4	0	4	0	1	0
11 Jul	3	0	6,593	30	7	0	0	0	4	0	1	0	0	0
12 Jul	2	0	2,141	34	5	0	0	0	0	0	0	0	0	0
13 Jul	2	0	2,298	33	3	0	0	0	4	0	1	0	1	0
14 Jul	3	0	3,631	51	4	0	0	0	2	0	0	0	0	0
15 Jul	2	1	2,773	48	3	0	0	0	0	0	0	0	2	0
16 Jul	1	0	4,919	82	7	0	0	0	6	0	0	0	1	0
17 Jul	1	0	4,556	91	3	0	0	0	3	0	0	0	2	0
18 Jul	1	0	3,075	56	4	0	0	0	1	0	1	0	1	0
19 Jul	3	0	6,486	100	5	0	1	0	1	1	0	0	2	0
Total	75	1	87,490	1,160	137	2	11	0	104	3	16	1	18	0

Table 31 . Conditions at McNary Dam during juvenile bypass evaluation releases in 1999.

Release date	Total discharge (kcfs)	Spill (kcfs)	Proportion of discharge spilled	Water temperature (°C)
23 June	352.3	195.2	0.554	15.9
24 June	339.7	174.9	0.515	15.8
25 June	328.0	161.5	0.492	15.6
26 June	332.6	169.3	0.509	15.3
27 June	315.3	152.2	0.483	15.5
28 June	292.1	128.0	0.438	15.6
29 June	300.8	136.3	0.453	15.7
30 June	305.5	146.2	0.479	15.8
1 July	295.5	131.8	0.446	15.9
2 July	293.9	130.7	0.445	15.7
3 July	264.1	102.8	0.389	15.6
4 July	261.0	99.7	0.382	15.5
7 July	237.8	77.6	0.326	16.2
8 July	259.8	97.3	0.375	16.6
9 July	252.0	89.7	0.356	16.9
10 July	249.4	87.6	0.351	17.1
11 July	277.9	115.3	0.415	17.4
12 July	251.0	91.5	0.365	17.7
13 July	263.3	104.2	0.396	18.0
14 July	285.9	128.5	0.449	18.0
15 July	277.3	114.4	0.413	17.9
16 July	268.3	109.0	0.406	17.8
17 July	262.9	104.9	0.399	17.6
18 July	250.8	91.8	0.366	17.6
19 July	228.0	94.1	0.413	17.8
20 July	231.6	107.5	0.464	18.0

Table 32. Estimated survival and detection probabilities for run-of-the-river subyearling chinook salmon released into the gatewell of McNary Dam, 1999. Standard errors (s.e.) of the estimates are also provided. REL = release; 1st detect is the first detection at McNary Dam; MCN = McNary Dam; JDA = John Day Dam.

Release	Release	Survival probabilities (standard errors)			Capture probabilities (s.e.)	
date	number	REL-1st detect	1st detect-JDA	REL-JDA	MCN	JDA
Jun 23	1,255	0.999 (0.010)	0.698 (0.058)	0.698 (0.058)	0.932 (0.012)	0.430 (0.039)
Jun 24	1,333	0.987 (0.010)	0.803 (0.075)	0.793 (0.073)	0.932 (0.011)	0.390 (0.039)
Jun 25	1,401	1.0[a] (0.014)	0.736 (0.065)	0.739 (0.065)	0.867 (0.015)	0.373 (0.036)
Jun 26	1,363	0.985 (0.005)	0.866 (0.096)	0.853 (0.094)	0.991 (0.004)	0.254 (0.031)
Jun 27	1,193	0.990 (0.004)	0.728 (0.088)	0.721 (0.088)	0.994 (0.004)	0.287 (0.038)
Jun 28	1,412	0.983 (0.005)	0.698 (0.079)	0.686 (0.078)	0.990 (0.005)	0.311 (0.038)
Jun 29	1,391	0.991 (0.006)	0.707 (0.089)	0.701 (0.088)	0.984 (0.006)	0.276 (0.037)
Jun 30	1,329	0.986 (0.006)	0.656 (0.078)	0.647 (0.077)	0.986 (0.006)	0.318 (0.041)
Jul 1	1,200	0.998 (0.006)	0.780 (0.115)	0.778 (0.115)	0.985 (0.007)	0.246 (0.039)
Jul 2	956	1.0[a] (0.008)	0.751 (0.158)	0.754 (0.158)	0.981 (0.009)	0.205 (0.046)
Jul 3	1,399	1.0[a] (0.007)	0.991 (0.211)	0.993 (0.212)	0.981 (0.008)	0.138 (0.031)
Jul 4	1,348	0.995 (0.006)	0.720 (0.137)	0.716 (0.136)	0.989 (0.006)	0.175 (0.036)
Jul 7	1,306	0.985 (0.005)	0.823 (0.151)	0.811 (0.149)	0.994 (0.004)	0.214 (0.041)
Jul 8	1,443	0.985 (0.004)	0.817 (0.155)	0.804 (0.153)	0.997 (0.003)	0.198 (0.040)
Jul 9	1,456	0.983 (0.006)	0.682 (0.106)	0.670 (0.105)	0.988 (0.006)	0.214 (0.036)
Jul 10	1,446	0.980 (0.005)	0.619 (0.087)	0.606 (0.085)	0.997 (0.003)	0.246 (0.037)
Jul 11	1,332	0.994 (0.008)	0.742 (0.108)	0.738 (0.108)	0.971 (0.009)	0.246 (0.038)
Jul 12	1,482	1.0[a] (0.009)	0.744 (0.106)	0.746 (0.106)	0.958 (0.010)	0.246 (0.037)
Jul 13	1,034	0.996 (0.009)	0.656 (0.150)	0.654 (0.149)	0.978 (0.010)	0.271 (0.064)
Jul 14	1,484	1.0[a] (0.007)	0.891 (0.202)	0.892 (0.202)	0.981 (0.008)	0.174 (0.041)
Jul 15	1,527	0.998 (0.006)	0.714 (0.134)	0.713 (0.134)	0.985 (0.007)	0.227 (0.045)
Jul 16	1,473	0.994 (0.005)	0.938 (0.250)	0.932 (0.249)	0.993 (0.005)	0.175 (0.048)
Jul 17	1,517	0.990 (0.004)	1.0[a] (0.383)	1.0[a] (0.379)	0.996 (0.004)	0.140 (0.049)
Jul 18	1,531	0.986 (0.005)	0.881 (0.261)	0.869 (0.258)	0.993 (0.005)	0.173 (0.052)
Jul 19	1,506	0.993 (0.007)	0.695 (0.188)	0.690 (0.187)	0.986 (0.007)	0.238 (0.066)
Jul 20	1,581	0.994 (0.008)	1.0[a] (0.646)	1.0[a] (0.643)	0.981 (0.008)	0.108 (0.051)
Total/Mean[b]	35,698	0.990 (0.001)	0.750 (0.018)	0.745 (0.018)		

[a] Model-based estimate greater than 1.0.

[b] Weighted arithmetic mean with weights inversely proportional to respective estimated relative variances.

Table 33. Estimated survival and detection probabilities for run-of-the-river subyearling chinook salmon released into the tailrace of McNary Dam, 1999. Standard errors (s.e.) of the estimates are also provided. MCN = McNary Dam; JDA = John Day Dam.

Release date	Release number	Survival prob. (s.e.) MCN-JDA		Capture prob. (s.e.) JDA	
Jun 23	1,176	0.871	(0.100)	0.310	(0.038)
Jun 24	1,242	0.800	(0.069)	0.394	(0.037)
Jun 25	1,286	0.734	(0.059)	0.411	(0.036)
Jun 26	1,263	0.835	(0.076)	0.355	(0.035)
Jun 27	1,090	0.795	(0.082)	0.301	(0.035)
Jun 28	1,321	0.729	(0.080)	0.282	(0.034)
Jun 29	1,302	0.736	(0.088)	0.276	(0.036)
Jun 30	1,203	0.666	(0.072)	0.338	(0.040)
Jul 1	1,109	0.789	(0.123)	0.257	(0.043)
Jul 2	858	0.709	(0.111)	0.250	(0.042)
Jul 3	1,175	0.640	(0.092)	0.231	(0.036)
Jul 4	1,218	0.670	(0.124)	0.165	(0.033)
Jul 7	1,162	0.870	(0.176)	0.198	(0.042)
Jul 8	1,375	0.827	(0.134)	0.211	(0.036)
Jul 9	1,337	0.807	(0.144)	0.158	(0.030)
Jul 10	1,373	0.870	(0.152)	0.163	(0.030)
Jul 11	1,253	0.962	(0.187)	0.167	(0.034)
Jul 12	1,378	0.728	(0.095)	0.278	(0.039)
Jul 13	999	0.723	(0.156)	0.238	(0.054)
Jul 14	1,381	0.601	(0.097)	0.239	(0.041)
Jul 15	1,428	0.660	(0.137)	0.205	(0.044)
Jul 16	1,383	1.0[a]	(0.294)	0.139	(0.039)
Jul 17	1,406	1.0[a]	(0.423)	0.123	(0.043)
Jul 18	1,416	0.974	(0.294)	0.136	(0.042)
Jul 19	1,399	1.0[a]	(0.343)	0.136	(0.045)
Jul 20	1,471	0.872	(0.258)	0.180	(0.054)
Total/Mean[b]	33,004	0.775	(0.019)		

[a] Model-based estimate greater than 1.0.

[b] Weighted arithmetic mean with weights inversely proportional to respective estimated relative variances.

Table 34. Estimated survival and detection probabilities for run-of-the-river subyearling chinook salmon released into the tailrace of McNary Dam and regrouped according to date of first detection at McNary Dam, 1999. Standard errors (s.e.) of the estimates are also provided. MCN = McNary Dam; JDA = John Day Dam.

Release date	Release number	Survival prob. (s.e.) MCN-JDA	Capture prob. (s.e.) JDA
Jun 23	845	0.698 (0.070)	0.408 (0.045)
Jun 24	1095	0.819 (0.082)	0.397 (0.043)
Jun 25	1208	0.687 (0.061)	0.418 (0.040)
Jun 26	784	0.921 (0.142)	0.237 (0.040)
Jun 27	870	0.843 (0.120)	0.256 (0.040)
Jun 28	990	0.763 (0.103)	0.264 (0.039)
Jun 29	1326	0.778 (0.101)	0.268 (0.037)
Jun 30	2424	0.643 (0.049)	0.351 (0.029)
Jul 1	1071	0.821 (0.124)	0.246 (0.040)
Jul 2	741	0.792 (0.165)	0.208 (0.046)
Jul 3	1106	0.877 (0.184)	0.162 (0.036)
Jul 4	1091	0.566 (0.092)	0.216 (0.038)
Jul 7	849	0.723 (0.132)	0.241 (0.047)
Jul 8	727	0.744 (0.201)	0.196 (0.056)
Jul 9	940	0.632 (0.149)	0.197 (0.049)
Jul 10	1245	0.648 (0.107)	0.208 (0.037)
Jul 11	1149	0.922 (0.168)	0.172 (0.033)
Jul 12	2133	0.775 (0.076)	0.270 (0.029)
Jul 13	794	0.932 (0.255)	0.200 (0.057)
Jul 14	1272	0.813 (0.181)	0.197 (0.046)
Jul 15	1103	0.761 (0.151)	0.217 (0.045)
Jul 16	1503	1.0[a] (0.251)	0.162 (0.041)
Jul 17	1041	1.0[a] (0.473)	0.122 (0.051)
Jul 18	1056	0.667 (0.202)	0.229 (0.071)
Jul 19	900	1.0[a] (0.554)	0.133 (0.062)
Jul 20	1025	0.738 (0.225)	0.222 (0.069)
Total/Mean[b]	29,288	0.752 (0.020)	

[a] Model-based estimate greater than 1.0.

[b] Weighted arithmetic mean with weights inversely proportional to respective estimated relative variances.

Table 35. Estimated survival for gatewell release groups relative to estimated survival for tailrace release groups of run-of-the-river subyearling chinook salmon released at McNary Dam, 1999. Standard errors (s.e.) of the estimates are also provided. See text for description of the release groups.

Release date	Gatewell/ tailrace		Tailrace regrouping/ tailrace releases	
	Survival	s.e.	Survival	s.e.
Jun 23	0.801	0.114	0.801	0.122
Jun 24	0.991	0.125	1.024	0.135
Jun 25	1.007	0.120	0.936	0.112
Jun 26	1.022	0.146	1.103	0.197
Jun 27	0.907	0.145	1.060	0.186
Jun 28	0.941	0.149	1.047	0.182
Jun 29	0.952	0.165	1.057	0.187
Jun 30	0.971	0.156	0.965	0.128
Jul 1	0.986	0.212	1.041	0.226
Jul 2	1.063	0.278	1.117	0.291
Jul 3	1.552	0.399	1.370	0.349
Jul 4	1.069	0.283	0.845	0.208
Jul 7	0.932	0.255	0.831	0.226
Jul 8	0.972	0.243	0.900	0.283
Jul 9	0.830	0.197	0.783	0.232
Jul 10	0.697	0.156	0.745	0.179
Jul 11	0.767	0.187	0.958	0.255
Jul 12	1.025	0.198	1.065	0.174
Jul 13	0.905	0.284	1.289	0.449
Jul 14	1.484	0.413	1.353	0.372
Jul 15	1.080	0.303	1.153	0.331
Jul 16	0.863	0.329	0.940	0.346
Jul 17	0.905	0.443	0.946	0.509
Jul 18	0.892	0.378	0.685	0.293
Jul 19	0.648	0.273	1.134	0.636
Jul 20	1.576	0.872	0.846	0.360
Mean[a]	0.961	0.029	0.988	0.027

[a] Weighted geometric mean with weights inversely proportional to respective estimated relative variances.

Table 36. Travel time statistics for juvenile fall chinook salmon PIT tagged and released into the gatewell of McNary Dam in 1999. Abbreviations: REL-Release into gatewell of McNary Dam; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	REL to MCN (days)				MCN to JDA (days)				JDA to BON (days)				REL to BON (days)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
Jun 23	1169	0.0	0.2	0.9	342	3.8	4.9	6.5	72	2.0	2.4	2.9	167	6.6	8.4	9.8
Jun 24	1226	0.0	0.2	0.8	376	3.6	4.4	5.4	62	2.0	2.3	2.8	159	5.7	7.3	8.6
Jun 25	1219	0.0	0.1	0.7	332	3.5	4.2	5.1	69	2.0	2.2	2.5	185	6.2	7.0	8.8
Jun 26	1331	0.4	0.7	2.4	284	3.1	3.7	5.3	51	1.9	2.3	2.8	201	5.9	6.8	9.9
Jun 27	1174	0.4	1.0	2.8	238	3.1	4.1	5.6	41	2.1	2.7	2.9	143	6.4	7.7	10.6
Jun 28	1374	0.4	0.8	2.1	288	3.6	4.7	6.7	46	2.1	2.5	3.2	148	6.8	8.8	11.7
Jun 29	1357	0.4	0.8	1.4	258	3.5	4.6	6.4	40	2.2	2.6	3.2	145	6.7	8.6	11.0
Jun 30	1293	0.3	0.3	0.4	265	3.4	4.5	6.9	42	2.2	2.7	3.4	132	6.0	7.8	11.6
Jul 1	1179	0.0	0.1	0.4	208	3.6	4.4	6.5	30	2.0	2.6	3.0	122	6.6	7.6	10.7
Jul 2	941	0.1	0.2	1.2	132	3.3	3.8	6.5	16	2.2	2.7	3.5	78	5.9	8.0	11.2
Jul 3	1375	0.1	0.2	1.1	158	3.5	4.7	10.2	17	2.1	2.7	3.0	123	6.5	7.7	10.4
Jul 4	1326	0.1	0.3	1.6	152	4.0	5.4	11.8	20	2.2	2.7	3.1	114	6.6	8.1	10.0
Jul 7	1278	0.1	0.3	2.0	196	4.2	6.4	13.7	21	2.0	2.2	2.4	98	6.6	9.6	11.9
Jul 8	1417	0.2	0.6	2.1	196	3.8	7.1	16.1	20	1.9	2.3	2.6	101	6.8	8.6	9.6
Jul 9	1411	0.3	1.0	2.2	189	3.4	5.2	15.3	28	1.7	2.1	2.8	131	6.6	7.7	9.3
Jul 10	1412	0.3	1.1	2.1	200	3.4	4.7	7.7	33	1.9	2.2	2.8	134	6.6	7.6	10.6
Jul 11	1286	0.2	1.1	1.2	216	3.4	5.0	13.1	31	2.0	2.4	2.8	126	5.9	6.9	9.7
Jul 12	1424	0.1	0.2	0.7	240	2.9	4.3	10.0	33	1.9	2.1	2.5	134	4.7	6.6	8.6
Jul 13	1007	0.1	0.3	0.9	159	3.0	4.5	11.0	13	1.8	2.0	2.3	49	4.8	6.7	10.7
Jul 14	1456	0.1	0.3	1.2	203	3.5	5.0	11.0	15	1.9	2.0	2.2	86	5.4	6.9	9.8
Jul 15	1500	1.2	1.4	2.2	210	3.9	6.9	12.4	20	1.9	2.1	3.0	88	6.8	8.7	12.9
Jul 16	1454	0.1	0.2	1.2	210	3.9	6.6	10.8	11	2.0	2.1	2.6	63	6.6	8.8	11.3
Jul 17	1497	0.2	0.6	2.1	215	4.1	6.1	13.7	7	1.9	2.2	2.4	50	6.6	7.7	13.0
Jul 18	1499	0.2	0.8	3.6	213	4.0	6.2	14.9	9	2.4	2.6	2.7	52	7.0	9.9	14.8
Jul 19	1474	0.3	1.3	3.7	240	3.6	5.5	12.4	10	1.8	2.1	2.6	42	6.1	8.8	16.0
Jul 20	1543	0.5	1.7	3.6	226	4.0	5.8	15.5	4	1.8	2.0	2.2	37	6.1	9.7	19.2

Table 37. Travel time statistics for juvenile fall chinook salmon PIT tagged and released into the tailrace of McNary Dam in 1999. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (days)				JDA to BON (days)				MCN to BON (days)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
Jun 23	318	3.6	4.8	6.2	45	2.0	2.4	3.0	145	5.8	7.0	9.4
Jun 24	392	3.5	4.2	5.4	69	2.0	2.2	2.8	175	5.5	6.4	8.0
Jun 25	388	3.4	3.7	4.7	76	2.0	2.3	2.9	185	5.4	6.4	7.5
Jun 26	374	3.1	3.5	4.4	66	2.0	2.3	2.8	186	5.4	6.1	7.4
Jun 27	261	2.6	3.5	4.6	53	2.0	2.3	2.8	176	4.8	5.7	7.2
Jun 28	272	3.1	4.2	5.7	50	2.0	2.4	2.9	177	5.4	6.6	9.3
Jun 29	264	3.6	4.6	6.5	43	2.1	2.6	3.0	156	5.6	6.5	9.5
Jun 30	271	3.4	4.5	5.5	48	2.3	2.8	3.1	142	5.6	7.4	9.7
Jul 1	225	3.5	4.4	6.4	27	2.5	2.8	3.1	105	6.4	7.1	9.4
Jul 2	152	3.4	3.7	7.5	26	2.0	2.5	3.1	104	5.7	6.7	8.9
Jul 3	174	2.7	4.5	6.7	31	2.0	2.6	3.0	134	6.0	7.2	10.4
Jul 4	135	4.4	5.4	13.2	21	2.4	3.0	3.1	127	6.1	7.3	9.0
Jul 7	200	4.2	6.4	11.4	18	2.0	2.2	2.8	91	6.2	7.9	10.8
Jul 8	240	3.4	6.6	16.5	27	2.0	2.1	2.4	128	5.4	7.4	10.0
Jul 9	170	3.9	6.4	11.3	23	1.9	2.2	2.8	146	5.4	6.4	8.8
Jul 10	195	4.5	5.6	13.6	24	1.8	2.0	2.6	147	5.4	6.4	8.6
Jul 11	201	4.0	5.6	15.4	20	2.0	2.2	2.7	120	5.4	6.2	9.4
Jul 12	279	2.9	4.1	11.2	37	1.9	2.1	2.7	133	4.4	5.7	8.5
Jul 13	172	3.1	4.2	11.2	15	2.0	2.1	2.5	63	5.1	6.1	7.7
Jul 14	198	3.5	4.5	11.4	26	2.0	2.2	2.5	109	5.0	6.2	7.9
Jul 15	193	3.5	6.9	16.2	17	2.0	2.3	2.7	83	5.4	6.5	9.6
Jul 16	208	4.4	6.6	10.9	11	2.1	2.3	2.9	79	5.4	7.2	9.4
Jul 17	210	4.6	7.1	10.8	7	1.8	2.0	3.0	57	5.4	6.8	10.2
Jul 18	188	4.5	6.6	15.1	9	2.0	2.3	2.6	66	5.7	6.6	7.5
Jul 19	202	4.6	7.0	16.7	8	1.8	2.0	2.3	59	5.7	6.4	9.7
Jul 20	231	4.4	5.5	15.0	9	1.9	2.0	2.3	50	5.3	6.3	8.7

Table 38. Migration rate statistics for juvenile fall chinook salmon PIT tagged and released into the gatewell of McNary Dam in 1999. Abbreviations: REL-Release into gatewell of McNary Dam; 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)				REL to BON (km/day)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
Jun 23	342	18.9	25.0	32.1	72	39.2	47.7	56.8	167	24.0	27.9	35.8
Jun 24	376	22.8	28.1	34.4	62	40.9	49.1	57.7	159	27.5	32.2	41.1
Jun 25	332	24.2	29.2	34.7	69	44.7	50.4	56.8	185	26.7	34.0	38.2
Jun 26	284	23.3	33.1	39.8	51	40.2	48.5	58.2	201	23.8	34.8	40.1
Jun 27	238	21.9	30.0	39.5	41	38.8	42.3	53.3	143	22.2	30.8	36.6
Jun 28	288	18.4	26.0	33.9	46	35.2	44.7	54.6	148	20.2	26.9	34.9
Jun 29	258	19.3	26.6	34.8	40	35.3	43.1	51.4	145	21.4	27.4	35.3
Jun 30	265	17.9	27.5	36.7	42	32.8	41.9	52.1	132	20.3	30.3	39.6
Jul 1	208	18.9	28.0	34.6	30	37.4	44.1	55.1	122	22.0	30.9	35.6
Jul 2	132	19.0	32.7	36.9	16	32.5	42.0	50.2	78	21.1	29.7	39.9
Jul 3	158	12.0	26.0	34.7	17	37.4	41.5	53.6	123	22.7	30.6	36.3
Jul 4	152	10.4	22.6	30.7	20	36.6	42.3	50.2	114	23.6	29.0	35.5
Jul 7	196	9.0	19.1	29.6	21	46.7	50.4	56.2	98	19.9	24.6	35.6
Jul 8	196	7.7	17.3	32.6	20	44.1	50.0	60.4	101	24.5	27.4	34.6
Jul 9	189	8.0	23.6	36.5	28	40.1	54.9	66.1	131	25.4	30.6	35.7
Jul 10	200	15.9	26.4	35.9	33	39.6	52.3	58.9	134	22.2	31.2	35.8
Jul 11	216	9.4	24.4	36.0	31	40.6	46.5	57.1	126	24.3	34.1	39.8
Jul 12	240	12.3	28.5	43.0	33	45.9	54.1	60.8	134	27.4	35.8	50.4
Jul 13	159	11.2	27.5	41.7	13	49.8	57.9	62.4	49	22.1	35.4	48.9
Jul 14	203	11.2	24.8	35.1	15	50.2	55.1	60.4	86	24.2	34.3	43.4
Jul 15	210	9.9	17.9	31.7	20	38.3	53.3	59.5	88	18.3	27.2	34.9
Jul 16	210	11.4	18.6	31.2	11	43.1	53.3	56.2	63	20.9	26.8	35.5
Jul 17	215	9.0	20.3	30.0	7	46.7	51.6	59.5	50	18.2	30.8	35.7
Jul 18	213	8.2	19.8	30.6	9	41.7	44.0	47.9	52	15.9	23.8	34.0
Jul 19	240	9.9	22.4	33.8	10	43.8	54.3	61.7	42	14.8	26.8	38.6
Jul 20	226	7.9	21.3	31.0	4	52.6	56.2	62.4	37	12.3	24.3	38.8

Table 39. Migration rate statistics for juvenile fall chinook salmon PIT tagged and released into the tailrace of McNary Dam in 1999. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

	MCN to JDA (km/day)				JDA to BON (km/day)				MCN to BON (km/day)			
Date at MCN	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
Jun 23	318	19.8	25.5	34.3	45	37.9	47.5	56.5	145	25.1	33.9	41.0
Jun 24	392	22.8	29.5	34.7	69	40.5	50.7	57.7	175	29.4	36.6	43.2
Jun 25	388	25.9	33.0	36.0	76	39.4	48.7	57.9	185	31.5	36.8	43.3
Jun 26	374	28.0	35.2	39.5	66	39.8	48.5	56.5	186	31.9	38.7	43.5
Jun 27	261	27.0	35.3	46.8	53	40.9	50.0	57.4	176	32.6	41.2	49.6
Jun 28	272	21.6	29.4	40.1	50	39.4	47.1	55.9	177	25.4	36.0	43.5
Jun 29	264	19.0	26.9	34.3	43	37.8	43.8	54.9	156	24.8	36.3	42.0
Jun 30	271	22.3	27.4	35.7	48	36.6	41.1	49.3	142	24.4	31.7	42.4
Jul 1	225	19.3	28.1	35.1	27	36.3	40.2	45.4	105	25.0	33.1	37.0
Jul 2	152	16.5	33.3	36.5	26	36.7	45.9	55.9	104	26.4	35.1	41.5
Jul 3	174	18.3	27.4	45.1	31	37.9	43.3	55.9	134	22.7	32.8	39.2
Jul 4	135	9.3	22.6	27.9	21	36.0	38.0	46.9	127	26.1	32.5	38.6
Jul 7	200	10.8	19.1	29.6	18	39.6	52.3	57.7	91	21.9	29.9	38.2
Jul 8	240	7.5	18.7	36.1	27	47.1	54.6	57.7	128	23.6	31.8	43.4
Jul 9	170	10.9	19.2	31.5	23	41.1	50.9	59.2	146	26.8	36.8	43.3
Jul 10	195	9.0	22.0	27.2	24	44.1	57.1	62.1	147	27.4	36.6	43.7
Jul 11	201	8.0	22.2	30.9	20	42.0	51.4	57.9	120	25.1	38.0	43.8
Jul 12	279	11.0	29.8	41.8	37	41.4	53.3	59.8	133	27.8	41.4	53.0
Jul 13	172	11.0	28.9	39.7	15	45.9	53.6	57.4	63	30.7	38.5	46.4
Jul 14	198	10.8	27.6	35.1	26	45.7	51.4	56.8	109	29.8	38.1	47.3
Jul 15	193	7.6	17.9	35.4	17	42.3	48.9	56.5	83	24.6	36.4	43.6
Jul 16	208	11.3	18.6	28.0	11	39.4	48.5	53.1	79	25.0	32.9	43.5
Jul 17	210	11.4	17.3	27.0	7	38.2	55.1	61.4	57	23.2	35.0	43.4
Jul 18	188	8.1	18.6	27.2	9	44.1	48.9	56.8	66	31.6	35.6	41.3
Jul 19	202	7.4	17.7	26.8	8	49.3	56.5	61.7	59	24.4	36.6	41.6
Jul 20	231	8.2	22.3	27.6	9	49.6	57.7	58.5	50	27.1	37.5	44.2