Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2007

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EXECUTIVE SUMMARY

In 2007, the National Marine Fisheries Service completed the fifteenth year of a study to estimate survival and travel time of juvenile salmonids *Oncorhynchus* spp. passing through dams and reservoirs on the Snake and Columbia Rivers. All estimates were derived from detections of fish tagged with passive integrated transponder (PIT) tags. We PIT tagged and released a total of 19,352 hatchery steelhead *O. mykiss*, 11,286 wild steelhead, and 14,576 wild yearling Chinook salmon *O. tshawytscha* at Lower Granite Dam in the Snake River.

In addition, we utilized fish PIT tagged by other agencies at traps and hatcheries upstream from the hydropower system and at sites within the hydropower system in both the Snake and Columbia Rivers. These included 55,074 yearling Chinook salmon tagged at Lower Granite Dam for evaluation of "extra" or "latent" mortality related to passage through Snake River dams. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, and Bonneville Dams and in the PIT-tag detector trawl operated in the Columbia River estuary. Survival estimates were calculated using a statistical model for tag-recapture data from single release groups (the "single-release model").

Primary research objectives in 2007 were to:

1) estimate reach survival and travel time in the Snake and Columbia Rivers throughout the migration period of yearling Chinook salmon and steelhead,
2) evaluate relationships between survival estimates and migration conditions, and
3) evaluate the survival estimation models under prevailing conditions.

This report provides reach survival and travel time estimates for 2007 for PIT-tagged yearling Chinook salmon (hatchery and wild), hatchery sockeye salmon *O. nerka*, hatchery coho salmon *O. kisutch*, and steelhead (hatchery and wild) in the Snake and Columbia Rivers. Additional details on the methodology and statistical models used are provided in previous reports cited here.

Survival and detection probabilities were estimated precisely for most of the 2007 yearling Chinook salmon and steelhead migrations. Hatchery and wild fish were combined in some of the analyses. For yearling Chinook salmon, overall percentages for combined release groups used in survival analyses in the Snake River were 84% hatchery-reared and 16% wild. For steelhead, the overall percentages were 64% hatchery-reared and 36% wild.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.938 for yearling Chinook salmon and 0.887 for steelhead. Respective average survival estimates for yearling Chinook salmon and steelhead through the following reaches were 0.957 and 0.911 from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.876 and 0.852 from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam), 0.920 and 0.988 from McNary Dam tailrace to John Day Dam tailrace, and 0.824 and 0.579 from John Day Dam tailrace to Bonneville Dam tailrace (including passage through The Dalles Dam).

Combining average estimates from the Snake River smolt trap to Lower Granite Dam, from Lower Granite Dam to McNary Dam, and from McNary Dam to Bonneville Dam, estimated average survival through the entire hydropower system from the head of Lower Granite reservoir to the tailrace of Bonneville Dam (eight projects) was 0.563 (s.e. 0.037) for Snake River yearling Chinook salmon and 0.369 (s.e. 0.047) for steelhead during 2007.

For yearling spring Chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.659 (s.e. 0.028) for East Bank Hatchery fish released from Chiwawa Pond to 0.260 (s.e. 0.068) for fish released from Wells Hatchery.

For steelhead released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.659 (s.e. 0.046) for fish from Turtle Rock Hatchery released in the Wenatchee River to 0.179 (s.e. 0.017) for fish from Cassimer Bar Hatchery released in the Okanagon River. Survival of sockeye salmon released to the Wenatchee River from East Bank Hatchery through this reach was 0.299 (s.e. 0.013).

During 2007, flows were relatively low, especially when compared to flows during the 2006 migration year. The index for flow calculated for steelhead was the lowest measured in the last six years, very near the flow index of 2001.

Yearling Chinook salmon hydropower system survival (Snake River trap to Bonneville Dam tailrace) in 2007 was the second highest estimated in the last 15 years. The highest estimated was in 2006. Steelhead hydropower system survival was also lower compared to 2006 survival, but was higher than in 2001 through 2003 (survival could not be estimated through the entire hydropower system in 2004 and 2005). High survival was estimated despite the low flows experienced during 2007.

This was likely a result of a larger number of steelhead migrating below Lower Monumental Dam than occurred in previous years under low-flow conditions. This larger number of fish resulted from a combination of factors: high spill levels in 2007 compared to other recent low flow years (2001 and 2004), the addition of a surface spill device (removable spillway weir) at Lower Granite Dam, and a delayed start to barge transport operations. As a result, survival estimates were higher through the Snake River in 2007, in part due to lower predation rates on PIT-tagged smolts by avian predators near the confluence of the Snake and Columbia Rivers.

Yearling Chinook salmon and steelhead travel times through the hydropower system were relatively fast considering the low flows experienced during 2007, likely a result of spill and use of surface collectors at several projects.

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INTRODUCTION

Accurate and precise survival estimates are needed for depressed stocks of juvenile Chinook *Oncorhynchus tshawytscha*, sockeye salmon *O. nerka*, and steelhead *O. mykiss* that migrate through reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia Rivers. To develop recovery strategies that will optimize smolt survival during migration, knowledge of the magnitude, locations, and causes of smolt mortality is needed. Such knowledge is necessary for strategies applied under present passage conditions as well as under conditions projected for the future (Williams and Matthews 1995; Williams et al. 2001).

From 1993 through 2006, the National Marine Fisheries Service (NMFS) developed survival estimates for these stocks using detections of PIT-tagged (Prentice et al. 1990a) juvenile salmonids passing through Snake River dams and reservoirs (Iwamoto et al. 1994; Muir et al. 1995, 1996, 2001a,b, 2003; Smith et al. 1998, 2000a,b, 2003, 2005, 2006; Hockersmith et al. 1999; Zabel et al. 2001, 2002; Faulkner et al. 2007). In 2007, NMFS completed the fifteenth year of the study.

Research objectives in 2007 were to:

1) estimate reach survival and travel time in the Snake and Columbia Rivers throughout the yearling Chinook salmon and steelhead migrations,
2) evaluate relationships between survival estimates and migration conditions, and
3) evaluate the performance of the survival-estimation models under prevailing operational and environmental conditions.

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

METHODS

Experimental Design

The single-release (SR) model was used to estimate survival for groups of PIT-tagged yearling Chinook salmon, sockeye salmon, and steelhead (Cormack 1964; Jolly 1965; Seber 1965; Skalski 1998; Skalski et al. 1998; Muir et al. 2001a). Iwamoto et al. (1994) presented background information and underlying statistical theory pertaining to the SR model. In 2007, PIT-tagged fish used for survival estimates were released from hatcheries, traps, and Lower Granite Dam in the Snake River Basin, and from hatcheries and dams in the Upper Columbia River.

During the 2007 migration season, automatic PIT-tag detectors (Prentice et al. 1990a,b,c) were operational in the juvenile bypass systems at the following seven dams: Lower Granite (rkm 695), Little Goose (rkm 635), Lower Monumental (rkm 589), Ice Harbor (rkm 538), McNary (rkm 470), John Day (rkm 347), and Bonneville (rkm 234) Dams (Figure 1). The farthest downstream site of PIT-tag detections was in the Columbia River estuary between rkm 65 and 84, where a pair trawl towed a PIT-tag detector (Ledgerwood et al. 2004). During spring 2007, the corner collector at Bonneville Dam Second Powerhouse was operated with its PIT tag detection system. Sufficient PIT tag detections at this site allowed survival estimation through the reach from John Day tailrace to Bonneville Dam tailrace for both yearling Chinook salmon and steelhead.

A large proportion of PIT-tagged yearling Chinook salmon used in this analysis were released in the Snake River above Lower Granite Dam for a multi-agency comparative survival study (CSS) (Schaller et al. 2007). In addition, we utilized about 55,074 yearling Chinook salmon PIT tagged at Lower Granite Dam and released into the tailrace there for evaluation of "extra" or "latent" mortality related to passage through Snake River dams (Marsh et al. 2006). All other PIT-tagged fish detected at dams were diverted back to the river by slide gates, which allowed for the possibility of detection of a particular fish at more than one downstream site (Marsh et al. 1999).

For fish released in the Snake River Basin, we used records of downstream PIT-tag detections with the SR model to estimate survival in the following seven reaches:

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

- Lower Monumental Dam tailrace to Ice Harbor Dam tailrace
- Ice Harbor Dam tailrace to McNary Dam tailrace
- McNary Dam tailrace to John Day Dam tailrace
- John Day Dam tailrace to Bonneville Dam tailrace

The PIT-tag detection system in the Ice Harbor Dam juvenile bypass facility began operating in 2005. Because of the high level of spill at this dam, too few smolts were detected there to partition survival between Lower Monumental and McNary Dams in 2005. However, in 2006 and 2007 there were sufficient detections at Ice Harbor to partition survival through this reach**.**

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

- Point of release to the tailrace of McNary Dam
- McNary Dam tailrace to John Day Dam tailrace
- John Day Dam tailrace to Bonneville Dam tailrace

Lower Granite Dam Tailrace Release Groups

During 2007, hatchery and wild steelhead and wild yearling Chinook salmon were collected at the Lower Granite Dam juvenile facility, PIT tagged, and released to the tailrace for survival estimates. Fish were collected in approximate proportion to the numbers arriving at Lower Granite Dam during the migration season. However, in the early and late periods of the season, we tagged relatively more fish in order to provide sufficient numbers for analysis over these periods. No hatchery yearling Chinook salmon were PIT tagged specifically for this study because the numbers of fish PIT tagged and released from Snake River Basin hatcheries, traps, and for other studies were sufficient for analysis. Further, we used 55,074 yearling Chinook salmon that were tagged at Lower Granite Dam for evaluation of "extra" or "latent" mortality related to passage through Snake River dams.

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

McNary Dam Tailrace Release Groups

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

Hatchery and Trap Release Groups

In 2007, most hatcheries in the Snake River Basin released PIT-tagged fish as part of research separate from the NMFS survival study. We analyzed data from hatchery releases of PIT-tagged yearling Chinook salmon, sockeye salmon, coho salmon *O. kisutch*, and steelhead to provide survival estimates and detection probabilities from release to the tailrace of Lower Granite Dam and to points downstream. We estimated survival to the tailrace of McNary Dam for yearling spring Chinook salmon released from Cle Elum, Wells, Winthrop, Entiat, Leavenworth, and East Bank hatcheries. Survival to McNary Dam was also estimated for steelhead released from Turtle Rock, Chelan, East Bank, and Cassimer Bar hatcheries in the Upper Columbia River Basin, for Coho salmon released from Cascade, Eagle Creek, Willard, and Yakima hatcheries, and for sockeye salmon released from East Bank Hatchery. In the course of characterizing the various hatchery releases, preliminary analyses were performed to determine whether data from multiple release groups could be pooled to increase sample sizes.

We estimated survival to Lower Granite Dam tailrace and points downstream for releases of wild and hatchery PIT-tagged yearling Chinook salmon and steelhead from the Salmon (White Bird), Snake, and Clearwater River traps, and many more smolt traps throughout the Snake River Basin.

Data Analysis

Tagging and detection data were uploaded to, and later retrieved from, the PIT Tag Information System (PTAGIS), a regional database maintained by the Pacific States Marine Fisheries Commission (PSMFC 1996). Data were examined for erroneous records, inconsistencies, and data anomalies. Records were eliminated where appropriate, and all eliminated PIT-tag codes were recorded with the reasons for their elimination. For each remaining PIT-tag code, we constructed a record ("detection

history") indicating all locations at which the tagged fish had been detected and all locations at which it had not been detected. Methods for data retrieval, database quality assurance/control, and construction of detection histories were the same as those used in past years (see Iwamoto et al. 1994 for detail).

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

Tests of Assumptions

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

Survival Estimation

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

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

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

Survival Estimates from Point of Release to Bonneville Dam

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

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

Travel Time and Migration Rate

Travel times of yearling Chinook salmon and steelhead were calculated for the following reaches:

1) Lower Granite Dam to Little Goose Dam (60 km)
2) Little Goose Dam to Lower Monumental Dam (46 km)
3) Lower Monumental Dam to McNary Dam (199 km)
4) Lower Granite Dam to McNary Dam (225 km)
5) Lower Granite Dam to Bonneville Dam (461 km)
6) McNary Dam to John Day Dam (123 km)
7) John Day Dam to Bonneville Dam (113 km)
8) McNary Dam to Bonneville Dam (236 km).

Travel time between any two dams was calculated for each fish detected at both dams as the number of days between last detection at the upstream dam (generally at a PIT-tag detector close enough to the outfall site that fish arrived in the tailrace within minutes after detection) and first detection at the downstream dam. Travel time included

the time required to move through the reservoir to the forebay of the downstream dam and any delay associated with residence in the forebay, gatewells, or collection channel prior to detection in the juvenile bypass system.

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

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

Comparison of Annual Survival Estimates

We made two comparisons of 2007 results to those obtained in previous years of the NMFS survival study. First, we related migration distance to survival estimates from specific hatcheries to Lower Granite Dam. Second, we compared season-wide survival estimates for specific reaches across years.

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

Annual travel time and reach survival estimates were compared across years to investigate relationships with general flow and spill conditions during the spring migration. Trends within the 2007 season were also examined.

RESULTS

Lower Granite Dam Tagging and Release Information

During 2007, a total of 125,147 yearling Chinook salmon (104,602 hatchery origin, 20,485 wild) were detected and released or PIT tagged and released to the river in the tailrace of Lower Granite Dam. Steelhead we tagged at Lower Granite Dam and released to the tailrace were combined with those released upstream, detected at the dam, and returned to the river, for a total of 32,610 (20,724 hatchery origin and 11,886 wild).

For both species, not all detections were included in the analyses because some fish passed Lower Granite Dam early or late in the season, when sample sizes were too small to produce reliable survival or travel time estimates. Survival estimates for wild and hatchery fish combined were predominately based on fish of hatchery origin for yearling Chinook salmon (84% hatchery) and steelhead (64% hatchery) during 2007.

Survival Estimation

Tests of Assumptions

Assumption tests for 2007 indicated more significant differences between observed and expected detection proportions than would be expected by chance alone. In many cases, sample sizes were such that the contingency table-based tests had power to detect cases where violations had minimal effect on survival estimates. We present a detailed discussion of the assumption tests, the extent of violations, possible reasons for the occurrence of the violations, and their implications in the Appendix.

Snake River Yearling Chinook Salmon

Survival probabilities were estimated for weekly groups of yearling Chinook salmon released to the tailrace of Lower Granite Dam for 10 consecutive weeks from 23 March through 31 May. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.938 (s.e. 0.006; Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.957 (s.e. 0.010). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.876 (s.e. 0.012). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.783 (s.e. 0.006).

We estimated survival probabilities for weekly groups of yearling Chinook salmon released in the tailrace at McNary Dam for eight consecutive weeks from 20 April through 14 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.920 (s.e. 0.016; Table 2). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 0.824 (s.e. 0.043). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.763 (s.e. 0.044).

The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.597 (s.e. 0.035). Estimated survival probability through Lower Granite reservoir and Dam for Snake River wild and hatchery Chinook salmon released from the Snake River trap was 0.943 (s.e. 0.028). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River yearling Chinook salmon was 0.563 (s.e. 0.037).

We also calculated separate survival probability estimates for weekly groups of hatchery and wild yearling Chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace (Tables 3 and 4). Weighted mean survival estimates for hatchery and wild yearling Chinook salmon were similar for the combined reach from the tailrace of Lower Granite Dam to the tailrace of McNary Dam in 2007.

Estimated survival probabilities for daily release groups of yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam did not show any consistent increase or decrease through Snake River reaches during the 2007 migration season (Table 5; Figure 2).

Estimates of detection probability varied throughout the season for most weekly groups as flows and spill levels changed (Tables 6-9). Detection probabilities were generally highest at McNary and John Day Dams.

Snake River Steelhead

We estimated survival probabilities for weekly groups of steelhead from the tailrace of Lower Granite Dam for eight consecutive weeks from 6 April through 31 May. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.887 (s.e. 0.009; Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.911 (s.e. 0.022). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.852

(s.e. 0.030). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.694 (s.e. 0.020).

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of McNary Dam for six consecutive weeks from 20 April through 31 May. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.988 (s.e. 0.098; Table 11). Estimated survival from John Day Dam tailrace to Bonneville Dam tailrace averaged 0.579 (s.e. 0.059), and for the combined reach from McNary Dam tailrace to Bonneville Dam tailrace, 0.524 (s.e. 0.064).

The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.364 (s.e. 0.050). Estimated survival probability through Lower Granite reservoir and Dam for Snake River wild and hatchery steelhead released from the Snake River trap was 1.016 (s.e. 0.026). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River steelhead was 0.369 (0.047).

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

Similar to yearling Chinook salmon, estimated survival probabilities for daily release groups of steelhead (hatchery and wild combined) detected and released to the tailrace of Lower Granite Dam did not show any consistent increase or decrease through Snake River reaches during the 2006 migration season (Table 14; Figure 3).

Estimates of detection probability at Snake River dams for the weekly steelhead groups varied throughout the season as the level of spill changed (Tables 15-18). Detection probability estimates were generally lowest at McNary, John Day, and Bonneville Dams.

Snake River Hatchery Release Groups

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

salmon, estimated survival from release to Lower Granite Dam tailrace was highest for fish released from the Clearwater Hatcheries' Red River Pond (0.816) and lowest for fish released from McCall Hatchery into Johnson Creek (0.319). For sockeye salmon, estimated survival from release to Lower Granite Dam tailrace ranged from 0.776 from the Sawtooth trap to 0.338 from Redfish Lake Creek trap for fish PIT-tagged and released in the spring. Estimated survival was lower for sockeye salmon PIT-tagged and release the previous fall (0.123 to 0.204).

Snake River Smolt Trap Release Groups

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

Upper Columbia River Hatchery Release Groups

Survival probability estimates for PIT-tagged hatchery yearling Chinook salmon, coho salmon, sockeye, and steelhead from release at Upper Columbia River hatcheries to the tailrace of McNary Dam and dams downstream varied among hatcheries and release locations (Table 27) as did detection probability estimates (Table 28). For yearling spring Chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.659 (s.e. 0.028) for East Bank Hatchery fish released from Chiwawa Pond to 0.260 (s.e. 0.068) for fish released from Wells Hatchery.

For steelhead released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.659 (s.e. 0.046) for fish from Turtle Rock Hatchery released in the Wenatchee River to 0.179 (s.e. 0.017) for fish from Cassimer Bar Hatchery released in the Okanagon River. Survival of sockeye salmon released to the Wenatchee River from East Bank Hatchery through this reach was 0.299 (s.e. 0.013).

Travel Time and Migration Rate

Travel time estimates for yearling Chinook salmon and juvenile steelhead released in the tailraces of Lower Granite and McNary Dams varied throughout the season (Tables 29-36). For both species, estimated migration rates were generally highest in the lower river sections. Estimated migration rates for yearling Chinook salmon generally increased over time as flow and water temperature increased, and

presumably as fish became more smolted, while travel time for steelhead was faster than in recent years and changed little through the season (Figure 4). Travel time estimates for yearling Chinook salmon from Lower Granite to McNary Dam decreased during early- to mid-April independent of flow (i.e., estimated travel times decreased considerably without corresponding changes in flow) whereas travel time estimates for steelhead did not (Figure 5).

Tagging Details for Fish PIT Tagged at Lower Granite Dam

We PIT-tagged and released 19,352 hatchery steelhead, 11,286 wild steelhead, and 14,576 wild yearling Chinook salmon from 10 April through 16 June at Lower Granite Dam for survival estimates (Table 37-39). Total mortalities of hatchery steelhead, wild steelhead, and yearling Chinook salmon were 17, 3, and 37, respectively. Each of these numbers represented less than 1% of the total number of fish handled.

Comparison of Annual Survival Estimates

Estimates of yearling Chinook salmon survival from Snake River Basin hatcheries to Lower Granite Dam tailrace for 2007 were similar to those made in past recent years for most hatcheries. The mean of the hatchery estimates was higher compared to the long-term mean (Table 40), though the difference is not statistically significant. Over the years of the study, we have consistently observed an inverse relationship between the migration distance from the release site to Lower Granite Dam and the estimated survival through that reach (Figure 6). For 1993-2007 estimates, the negative linear correlation between migration distance and average estimated survival was significant ($R^2 = 0.948$, $P < 0.001$).

For yearling Chinook salmon and steelhead (hatchery and wild combined), estimated survival in 2007 was similar to that estimated in 2006 through the Lower Granite Dam to McNary Dam reach but lower from the McNary Dam to Bonneville Dam reach (Table 41-43; Figures 7-8). Steelhead estimated survival was depressed through the John Day Dam to Bonneville Dam reach, but was improved in the Lower Monumental to McNary Dam reach (Table 42; Figures 7-8).

For yearling Chinook salmon, estimated mean survival for all years combined was similar through each of the Snake River reaches and from John Day Dam to Bonneville Dam reach in the Columbia River (0.90-0.93), but was lower through the McNary to John Day Reach on the Columbia River (0.85; Table 41). For steelhead, estimated mean survival across years showed a slight decline through successive reaches, but similar to yearling Chinook salmon, was lowest through the McNary to John Day reach (0.75), the reach with the longest reservoir (Table 42).

For several years, we have combined empirical survival estimates for yearling Chinook salmon and steelhead over various reaches to derive estimates of survival throughout the entire Snake River hydropower system, from the head of Lower Granite reservoir (Snake River smolt trap) to the tailrace of Bonneville Dam (Table 43). Data were sufficient for these estimates starting in 1999 for yearling Chinook and 1997 for steelhead, but were not sufficient through the final reach for steelhead in 2004 and 2005 when the new corner collector (without PIT tag interrogation) was operated at Bonneville Dam's second powerhouse. In 2006, a new PIT tag interrogation system was operated in the corner collector increasing the detection probability at this site. For yearling Chinook salmon in 2007, estimated hydropower system survival was 0.563 (95% C.I. 0.491-0.636), the second highest survival estimate to date. For steelhead, estimated hydropower system survival was 0.369 (95% C.I. 0.277-0.461), higher than that estimated from 2001-2003 (estimates not available for 2004-2005), and lower than estimated from 1997-2000, and in 2006.

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

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

The average flow exposure index in 2007 for yearling Chinook salmon (85.9 kcfs) and steelhead (81.4 kcfs) were much lower than in 2006 (130.5 and 135.4 kcfs, respectively), without an obvious peak as observed in most years (Figure 9 and 10).

In 2007, transport was delayed until 2 May at Lower Granite Dam, 9 May at Little Goose Dam, and 12 May at Lower Monumental Dam. Until these dates, smolts collected at Snake River dams were bypassed back to the river.

In comparisons among years, yearling Chinook salmon and steelhead estimated travel times between Lower Granite and Bonneville Dams in 2007 were similar to past years through most of the season, but were considerably faster than observed in 2001 (Figure 4).

Survival Estimates from Point of Release to McNary Dam

In 2007, estimated survival to McNary Dam was generally lower for yearling spring Chinook salmon released at hatcheries in the Upper Columbia River than for their counterparts released in the Snake River (Tables 19 and 27). For Upper Columbia River fish, average survival to McNary Dam was estimated at 0.594 (0.011) for fish from Leavenworth Hatchery (4 projects; 564 km) and 0.321 (0.035) for fish from Entiat Hatchery (5 projects; 559 km) in the Upper Columbia River. For Snake River fish released at Dworshak Hatchery (5 projects; 575 km), average survival to McNary Dam was estimated at 0.662 (0.004).

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

Partitioning Survival Between Lower Monumental and Ice Harbor Dams

Although a PIT-tag detection system was operational at Ice Harbor Dam in 2005, the high spill rate there resulted in low numbers of fish entering the bypass system for detection. Thus, we were still unable to partition survival between Lower Monumental and McNary Dams into reach-specific estimates in 2005. However, sufficient detections occurred in 2006 and 2007 to partition survival estimates through the individual reaches (Tables 44 and 45). Estimated survival for yearling Chinook salmon was 0.930 (s.e. 0.017) from the tailrace of Lower Monumental Dam to the tailrace of Ice Harbor dam and 0.959 (s.e. 0.030) from Ice Harbor Dam tailrace to McNary Dam tailrace. For steelhead, estimated survival through these reaches was 0.902 (s.e. 0.026) and 0.953 (s.e. 0.033), respectively.

DISCUSSION

Flow volume was considerably lower and water was less turbid during the spring migration in 2007 than in 2006, which had high flows and turbid water throughout the migration (Faulkner et al. 2007). Despite moderately low flows during 2007, estimated travel times through the system were similar to other recent years, although migration for steelhead was slower than in 2006. For yearling Chinook salmon, estimated survival through the hydropower system was the second highest yet observed; about 56% from the Snake River trap to Bonneville Dam tailrace. For steelhead, estimated survival through the hydropower system was lower, at about 37%.

Between Lower Monumental Dam and McNary Dam, where steelhead survival has been depressed since 2001, estimated steelhead survival was higher in 2007 than in recent years. Loss of PIT-tagged steelhead to piscivorous birds in the McNary pool in 2007 was the lowest since 1998 (indexed by the percentage of tags detected in bird colonies). Loss to birds was also relatively low in 2006. The decrease in percentage of smolts taken by birds was due in part to an increase in the total number of smolts (tagged and untagged) remaining in the river, which resulted from increased spill and initiation of the smolt transportation program later in the year (see below for more on avian predation and total numbers of smolts).

Migration conditions and associated hydropower system survival estimates from 2005 through 2007 show suggestive correlations among flow, spill, and estimated survival. In spring 2005, flows were low during early- to mid-April, but increased substantially from late April through the remainder of the migration season, resulting in an annual flow index for yearling Chinook salmon of 95.3 kcfs. Spill did not occur (i.e., transportation was maximized) in 2005 at Lower Granite, Little Goose, and Lower Monumental Dams until 17 May, when flows exceeded powerhouse capacities. By that time, most of the yearling Chinook salmon migration had passed. Spill continued through about 27 May at Lower Granite and Lower Monumental Dams, while spill ended at Little Goose Dam on 23 May.

In contrast, 2006 was a high-flow year (annual flow index of 130.5 for yearling Chinook salmon), and spill was provided throughout the migration. The 2007 migration season was a relatively low-flow year (annual flow index of 85.9 for yearling Chinook salmon), with spill again provided throughout the migration. Estimated hydropower system survival for yearling Chinook salmon was highest in 2006 at 61.2% (high flow with spill), but similar between 2005 at 53.0% (moderately low flow, very limited spill) and 2007 at 56.3% (moderately low flow, with spill).

For steelhead we could not make the same annual comparisons, because operation of the corner collector at Bonneville Dam decreased detection efficiencies in 2005, and hydropower system survival could not be estimated for that year. However, we can compare estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace from 2005 through 2007. Estimated survival was lowest in 2005 (59.3%), but similar in 2006 (70.2%) and 2007 (69.4%). For yearling Chinook salmon, estimated survival through this reach was 73.2, 76.4, and 78.3% in 2005, 2006, and 2007, respectively. Thus, spill may have directly or indirectly provided greater benefit to migrating steelhead than for yearling Chinook salmon.

Because juvenile diversion screens have higher collection efficiency for steelhead than for Chinook, when there is no spill almost all (95% or more) non PIT-tagged steelhead are barged from Lower Granite, Little Goose, or Lower Monumental Dam. Fish that remain in the river to migrate downstream of Lower Monumental dam are the very small percentage (tagged and untagged) that passed through turbines at all three collector dams, those released from hatcheries or tributaries downstream of Lower Granite Dam, and PIT-tagged fish that were intentionally returned to the river from the bypass system at collector dams. Because of transportation, the total number of smolts remaining in the river decreases as the population moves downstream. Guidance efficiency of the turbine intake screens is lower for Chinook salmon, so the number of Chinook salmon remaining in the river does not decrease as quickly, as more of them pass through turbines.

Analyses based on early data (1973-1979) suggested that increases in spill directly increased survival (Sims and Ossiander 1981). From our own research, estimated survival through the Snake River was lower in 1993 and 1994, when spill occurred only in excess of powerhouse capacity, than it was in subsequent years, after the 1995 BiOp (NMFS 1995) prescribed spill at all dams. Estimated survival was lowest during the 2001 migration, when spill was eliminated or severely reduced at all dams. However, demonstrating positive correlation between spill and survival within a single migration season has been more problematic (Smith et al. 2002; Zabel et al. 2002; Williams et al. 2005).

Predation is one factor that unquestionably directly affects survival of migrating smolts (Collis et al. 2002). Avian piscivores are abundant along the Columbia River downstream of the confluence with the Snake River, and bird population sizes and consumption rates are well monitored. Crescent Island, in the McNary Dam reservoir, harbors the second largest Caspian tern *Hydroprogne caspia* colony in North America (about 500 breeding pairs annually on average in the last 10 years), as well as large populations of gulls *Larus* spp. Other avian piscivores reside within the McNary pool,

including the American white pelican *Pelecanus erythrorhynchos,* cormorant *Phalacrocorax auritus,* and heron *Ardea alba, A. herodias,* and *Nycticorax nycticorax.* Steelhead smolts are particularly susceptible to predation by birds. For example,Collis et al. (2001) reported over 15% of the tags from PIT-tagged steelhead detected at Bonneville Dam in 1998 were later found on estuarine bird colonies, while only 2% of the tags from PIT-tagged yearling Chinook salmon were found.

For 10 years, the sites of bird colonies in McNary pool have been sampled for deposited PIT tags after the end of the nesting season, and we have combined bird-colony detection data with records of detection and return-to-river at Lower Monumental Dam. Assuming that PIT-tagged fish that remain in the river downstream of Lower Monumental Dam are representative of the untagged population that remains in the river, the percentage of smolts detected at the dam that are later recovered on a bird colony represents an estimate of the proportion of the entire smolt population that was consumed by birds. (Actually, it is a minimum estimate, as not all remains of smolts consumed are deposited with PIT tags recoverable on the colony site).

From smolts detected and returned to the river at Lower Monumental Dam, the percentage of tags later found on bird colonies upstream from McNary Dam is higher for steelhead than for Chinook, and highly variable from year to year (Table 47). Overall survival estimates for steelhead in the reach from Lower Monumental to McNary Dam (Table 42) have been strongly negatively correlated with the percentage of Lower Monumental-detected PIT tags recovered on bird colonies (Figure 11) ($R^2 = 0.934$, $P < 0.001$; excluding 2003 when only Crescent Island was sampled). There is also a negative correlation for yearling Chinook salmon ($R^2 = 0.884$; $P < 0.001$; excluding 2003) (Figure 11), although percentages detected on bird colonies have been much lower.

Roby et al. (2008) provide estimates of the breeding population size and salmonid consumption rates of the Caspian tern colony on Crescent Island for 2000 through 2007. The peak number of breeding pairs was in 2001 with 720 pairs and breeding pairs have generally declined since then, to 355 pairs in 2007. The estimated total consumption of steelhead by the colony generally tracked the fluctuations in breeding population size, with the highest estimates of approximately 160,000 steelhead smolts consumed in 2001 and 2002, followed by fairly constant estimates ranging between 48,000 to 58,000 between 2003 and 2006, and then an estimate of 74,000 in 2007.

The variation in the estimates of total steelhead consumption is not enough to explain all the variation in the percentage of steelhead PIT tags recovered. The estimate of total steelhead consumption in 2004 was about 1.25 times greater than that in 2007, but there was greater than a fivefold difference between the percentages of steelhead PIT

tags recovered in 2004 compared to 2007. Total steelhead consumption is less variable because it largely depends on the dietary needs for energy and nutrients of the bird colonies, which are relatively stable from year to year because the bird colony sizes have not fluctuated widely (maximum 2-fold difference). The percentage of PIT tags recovered from bird colonies (and by extension, the mortality rate due to bird predation of the population as a whole) varies annually to a much greater degree because it depends both on the total bird take and on the total number of smolts remaining in the river; a quantity that varies much more than does bird take.

It follows that if the total consumption requirement of the bird colonies were constant in absolute terms (i.e., they must take a fixed *number* of smolts to sustain the colony and fledge young), then the mortality rate (*proportion*) due to bird predation would depend on the total number of smolts in the river. Moreover, the effect on survival of additional fish remaining in river would diminish as the total number increased (Figure 12). In fact, from 1998 through 2007, the percentage of PIT tags recovered from McNary pool bird colonies has been negatively correlated with estimates of the total number of steelhead smolts remaining in the river downstream of Lower Monumental Dam (our unpublished estimates using the methods of Sandford and Smith 2002), and the relationship between overall survival and the total number of smolts in the river generally shows the predicted curved pattern (Figure 13).

Many factors affect the number of smolts remaining in the river downstream of Lower Monumental Dam in any given year, but the major influence is the collection and transportation of smolts from Snake River dams. During years when transportation was maximized (e.g. 2001, 2004, and 2005), an extremely high proportion (as high as 99%) of steelhead smolts were transported, and we estimated that only about 350,000-530,000 steelhead smolts entered the tailrace below Lower Monumental Dam. In 2006 and 2007, greater numbers of smolts remained in the river. During 2006, about 60% of non-PIT-tagged yearling Chinook salmon and about 75% of non PIT-tagged steelhead were transported, and we estimated that 850,000 steelhead smolts remained in-river. During 2007, even fewer non-PIT-tagged yearling Chinook salmon (25%) and steelhead (41%) were transported, because the start of transportation was later in the Snake River, and spill continued at the same time as transportation. We estimated that 1,500,000 steelhead smolts remained in the river in 2007.

Estimated in-river survival was higher in 2006 and 2007 than in the years (2001, 2004, and 2005) when transport was maximized, and much less water was spilled. Direct effects of spillway passage have been suggested as the reason for the increase in survival for in-river migrants, but it is very likely that the simple increase in total number of smolts remaining in the river in 2006 and 2007 resulted in a smaller overall proportion of

smolts taken by avian predators. This was an indirect effect of increased spill in those years, but there are other management options for keeping more fish in the river, including transporting fewer fish that enter the bypass system at upstream dams, releasing more hatchery fish downstream of Lower Monumental Dam, increasing turbine passage, etc. All of these are likely to decrease the mortality rate of in-river migrants due to predation by birds, but will ultimately lead to fewer adult returns unless the overall life-cycle survival probability for in-river migrants exceeds that for fish that are removed from the river for transport.

Results from the 2007 studies provide estimates of survival only during the downstream portion of the migration. We will analyze these data in conjunction with adult returns over the next three years to determine whether variations in spill, flow, temperature, and passage-route produce patterns in smolt-to-adult survival consistent with those observed during the downstream migration phase.

RECOMMENDATIONS

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

2) Estimates of survival from hatcheries to Lower Granite Dam suggest that substantial mortality occurs upstream from the Snake and Clearwater River confluence. Efforts to identify where this mortality occurs should continue.

3) Increasing the number of detection facilities in the Columbia River Basin will improve survival investigations. We recommend installation of detectors and diversion systems at The Dalles and Upper Columbia River dams. Although there is now a PIT-tag detection system in the juvenile bypass facility at Ice Harbor Dam, because of the high rate of spill, too few fish are detected for survival estimation in some years. Development of flat-plate and full-flow detector technology in bypass systems and other suitable locations at dams (including spillways), and portable streambed flat-plate detectors for use in tributaries would greatly enhance survival estimation capabilities.

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TABLES

Table 1. Estimated survival probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
23 Mar–29 Mar	56	0.720 (0.121)	1.714 (1.359)	0.508 (0.431)	0.627 (0.178)
30 Mar–05 Apr	268	0.749 (0.086)	0.869 (0.262)	1.069 (0.331)	0.696 (0.094)
06 Apr–12 Apr	3,134	0.919 (0.029)	0.897 (0.075)	0.882 (0.072)	0.727 (0.020)
13 Apr–19 Apr	9,142	0.921 (0.022)	1.006 (0.056)	0.835 (0.045)	0.774 (0.013)
20 Apr–26 Apr	15,956	0.962 (0.018)	0.895 (0.023)	0.940 (0.019)	0.809 (0.010)
27 Apr–03 May	34,853	0.932 (0.011)	0.968 (0.020)	0.911 (0.018)	0.822 (0.008)
04 May–10 May	33,902	0.900 (0.008)	0.994 (0.014)	0.859 (0.012)	0.768 (0.008)
11 May–17 May	25,878	0.975 (0.010)	0.966 (0.019)	0.796 (0.016)	0.750 (0.008)
18 May–24 May	1,786	0.944 (0.048)	1.038 (0.128)	0.796 (0.100)	0.780 (0.044)
25 May–31 May	172	0.875 (0.158)	NA	NA	NA
Weighted mean*		**0.938 (0.006)**	**0.957 (0.010)**	**0.876 (0.012)**	**0.783 (0.006)**

* Weighted means of the independent estimates for daily groups (25 March –31 May), with weights inversely proportional to respective estimated relative variances (see Table 5).

Table 2. Estimated survival probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Daily groups pooled weekly. Estimates based on the single-release model. Standard errors in parentheses. .

Date at McNary	Number released	McNary to John Day Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
20 Apr–26 Apr	1,344	0.955 (0.076)	0.763 (0.268)	0.729 (0.249)
27 Apr–03 May	11,709	0.872 (0.018)	0.940 (0.113)	0.820 (0.097)
04 May–10 May	37,880	0.960 (0.015)	0.877 (0.057)	0.841 (0.053)
11 May–17 May	28,473	0.921 (0.018)	0.860 (0.069)	0.792 (0.062)
18 May–24 May	16,429	0.906 (0.021)	0.609 (0.057)	0.552 (0.050)
25 May–31 May	2,310	0.712 (0.068)	0.875 (0.414)	0.623 (0.288)
01 Jun–07 Jun	695	0.728 (0.112)	1.116 (1.058)	0.813 (0.761)
08 Jun–14 Jun	607	0.655 (0.124)	0.452 (0.230)	0.296 (0.140)
Weighted mean*		**0.920 (0.016)**	**0.824 (0.043)**	**0.763 (0.044)**

* Weighted means of the independent estimates for weekly pooled groups (20 April–14 June), with weights inversely proportional to respective estimated relative variances.

Table 3. Estimated survival probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
30 Mar–05 Apr	125	0.867 (0.260)	0.693 (0.316)	0.885 (0.351)	0.532 (0.106)
06 Apr–12 Apr	1,176	0.908 (0.067)	0.800 (0.103)	1.059 (0.121)	0.769 (0.039)
13 Apr–19 Apr	4,266	0.907 (0.039)	1.101 (0.100)	0.817 (0.070)	0.817 (0.022)
20 Apr–26 Apr	13,226	0.962 (0.022)	0.890 (0.026)	0.943 (0.022)	0.808 (0.011)
27 Apr–03 May	31,229	0.931 (0.012)	0.982 (0.024)	0.906 (0.020)	0.828 (0.009)
04 May–10 May	31,195	0.896 (0.009)	1.000 (0.015)	0.858 (0.013)	0.769 (0.008)
11 May–17 May	22,745	0.976 (0.012)	0.968 (0.021)	0.786 (0.017)	0.742 (0.009)
18 May–24 May	640	0.970 (0.082)	0.938 (0.164)	0.934 (0.174)	0.850 (0.091)
Weighted mean*		**0.931 (0.013)**	**0.977 (0.015)**	**0.869 (0.021)**	**0.788 (0.013)**

* Weighted means of the independent estimates for weekly pooled groups (30 March–24 May), with weights inversely proportional to respective estimated relative variances.

Table 4. Estimated survival probabilities for Snake River wild yearling Chinook salmon detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
23 Mar– 29 Mar	45	0.608 (0.109)	1.518 (1.163)	0.438 (0.368)	0.404 (0.125)
30 Mar–05 Apr	143	0.752 (0.084)	0.667 (0.096)	1.688 (0.264)	0.846 (0.153)
06 Apr–12 Apr	1,958	0.924 (0.032)	0.971 (0.110)	0.789 (0.089)	0.708 (0.023)
13 Apr–19 Apr	4,876	0.924 (0.026)	0.939 (0.066)	0.859 (0.058)	0.745 (0.015)
20 Apr–26 Apr	2,730	0.985 (0.033)	0.902 (0.043)	0.921 (0.038)	0.818 (0.022)
27 Apr–03 May	3,624	0.966 (0.024)	0.906 (0.039)	0.893 (0.038)	0.782 (0.020)
04 May–10 May	2,707	0.967 (0.024)	0.951 (0.035)	0.858 (0.034)	0.788 (0.022)
11 May–17 May	3,133	0.994 (0.024)	0.969 (0.040)	0.840 (0.039)	0.809 (0.026)
18 May–24 May	1,146	0.928 (0.060)	1.123 (0.196)	0.718 (0.126)	0.749 (0.049)
25 May–31 May	123	0.812 (0.144)	NA	NA	NA
Weighted mean*		**0.958 (0.013)**	**0.935 (0.018)**	**0.885 (0.038)**	**0.773 (0.013)**

* Weighted means of the independent estimates for weekly pooled groups (23 March–31 May), with weights inversely proportional to respective estimated relative variances.

Table 5. Estimated survival probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled as necessary to calculate estimates. Estimates based on the single–release model. Standard errors in parentheses. Abbreviations: LGR–Lower Granite Dam; Little Goose–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
25 Mar–03 Apr	169	0.735 (0.092)	1.062 (0.526)	0.786 (0.408)	0.613 (0.107)
04–05 Apr	155	0.705 (0.096)	1.121 (0.418)	0.967 (0.380)	0.765 (0.131)
06 Apr	82	0.766 (0.102)	1.371 (0.957)	0.623 (0.445)	0.654 (0.099)
07 Apr	82	1.312 (0.408)	0.417 (0.142)	1.364 (0.155)	0.746 (0.114)
08 Apr	179	1.176 (0.254)	0.662 (0.307)	0.947 (0.397)	0.738 (0.090)
09 Apr	812	0.842 (0.046)	1.323 (0.267)	0.648 (0.132)	0.722 (0.036)
10 Apr	866	0.939 (0.060)	0.738 (0.102)	0.993 (0.128)	0.688 (0.034)
11 Apr	813	0.916 (0.051)	0.840 (0.117)	0.975 (0.134)	0.750 (0.041)
12 Apr	300	1.112 (0.190)	0.723 (0.235)	1.008 (0.292)	0.810 (0.092)
13 Apr	601	0.908 (0.100)	1.060 (0.254)	0.766 (0.172)	0.738 (0.051)
14 Apr	846	0.990 (0.083)	1.023 (0.194)	0.957 (0.180)	0.970 (0.073)
15 Apr	632	0.904 (0.102)	1.142 (0.297)	0.802 (0.199)	0.829 (0.057)
16 Apr	748	0.863 (0.077)	1.260 (0.317)	0.694 (0.171)	0.754 (0.047)
17 Apr	2,116	0.882 (0.037)	0.900 (0.086)	0.967 (0.088)	0.769 (0.026)
18 Apr	2,675	0.959 (0.042)	1.016 (0.109)	0.770 (0.079)	0.750 (0.021)
19 Apr	1,524	0.911 (0.054)	0.992 (0.129)	0.837 (0.103)	0.757 (0.027)
20 Apr	793	1.074 (0.162)	0.680 (0.150)	1.083 (0.177)	0.791 (0.050)
21 Apr	1,053	0.932 (0.094)	0.756 (0.100)	1.169 (0.103)	0.823 (0.041)
22 Apr	1,122	0.965 (0.094)	0.919 (0.134)	0.900 (0.109)	0.798 (0.036)
23 Apr	6,062	0.972 (0.029)	0.889 (0.035)	0.943 (0.029)	0.815 (0.016)
24 Apr	948	0.837 (0.050)	1.150 (0.109)	0.776 (0.071)	0.747 (0.037)
25 Apr	5,402	0.960 (0.029)	0.876 (0.034)	0.965 (0.032)	0.812 (0.018)
26 Apr	576	1.177 (0.176)	0.800 (0.150)	0.891 (0.109)	0.840 (0.055)
27 Apr	5,568	0.944 (0.022)	0.955 (0.034)	0.858 (0.030)	0.773 (0.017)
28 Apr	748	1.013 (0.090)	0.890 (0.124)	0.956 (0.115)	0.862 (0.055)
29 Apr	387	0.923 (0.079)	1.059 (0.203)	0.807 (0.163)	0.789 (0.073)
30 Apr	5,391	0.901 (0.021)	0.980 (0.041)	0.905 (0.038)	0.798 (0.018)
01 May	1,792	0.933 (0.036)	0.925 (0.068)	1.012 (0.075)	0.873 (0.034)
02 May	11,976	0.955 (0.023)	0.970 (0.048)	0.900 (0.042)	0.835 (0.014)
03 May	8,991	0.979 (0.031)	0.980 (0.058)	0.881 (0.048)	0.846 (0.018)

Table 5. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
04 May	8,807	0.882 (0.025)	1.032 (0.040)	0.895 (0.030)	0.815 (0.017)
05 May	5,918	0.915 (0.031)	1.026 (0.047)	0.833 (0.033)	0.782 (0.020)
06 May	1,102	0.862 (0.056)	0.975 (0.082)	0.898 (0.072)	0.755 (0.045)
07 May	4,640	0.904 (0.020)	0.942 (0.029)	0.875 (0.031)	0.745 (0.021)
08 May	1,527	0.944 (0.033)	0.968 (0.051)	0.735 (0.043)	0.671 (0.029)
09 May	5,932	0.917 (0.014)	0.998 (0.027)	0.827 (0.027)	0.756 (0.018)
10 May	5,976	0.933 (0.016)	0.919 (0.026)	0.875 (0.027)	0.750 (0.017)
11 May	6,212	0.939 (0.018)	1.012 (0.044)	0.775 (0.034)	0.736 (0.015)
12 May	6,698	0.997 (0.021)	0.968 (0.044)	0.772 (0.035)	0.746 (0.016)
13 May	1,257	0.910 (0.045)	1.242 (0.124)	0.685 (0.070)	0.774 (0.039)
14 May	6,189	1.002 (0.026)	0.900 (0.035)	0.815 (0.030)	0.735 (0.017)
15 May	4,569	0.979 (0.026)	0.923 (0.038)	0.855 (0.037)	0.772 (0.023)
16 May	506	0.995 (0.060)	0.976 (0.107)	0.930 (0.125)	0.904 (0.088)
17 May	447	1.002 (0.073)	0.968 (0.145)	0.819 (0.136)	0.795 (0.080)
18 May	466	1.092 (0.093)	1.097 (0.229)	0.710 (0.159)	0.851 (0.099)
19 May	247	0.956 (0.111)	1.310 (0.488)	0.578 (0.223)	0.724 (0.106)
20 May	218	1.008 (0.156)	0.640 (0.165)	1.230 (0.303)	0.793 (0.122)
21 May	162	0.846 (0.168)	0.780 (0.233)	1.331 (0.411)	0.878 (0.201)
22 May	343	0.975 (0.169)	1.016 (0.384)	0.716 (0.256)	0.710 (0.088)
23 May	160	0.656 (0.122)	1.231 (0.889)	0.792 (0.570)	0.639 (0.107)
24–31 May	362	0.816 (0.090)	1.611 (1.321)	0.660 (0.545)	0.868 (0.121)
Weighted mean*		**0.938 (0.006)**	**0.957 (0.010)**	**0.876 (0.012)**	**0.783 (0.006)**

* Weighted means of the independent estimates for daily groups (25 March –31 May), with weights inversely proportional to respective estimated relative variances.

Table 6. Estimated detection probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
23 Mar–29 Mar	56	0.422 (0.099)	0.062 (0.058)	0.312 (0.116)
30 Mar–05 Apr	268	0.294 (0.045)	0.072 (0.029)	0.353 (0.059)
06 Apr–12 Apr	3,134	0.228 (0.011)	0.046 (0.006)	0.417 (0.015)
13 Apr–19 Apr	9,142	0.158 (0.005)	0.051 (0.004)	0.400 (0.009)
20 Apr–26 Apr	15,956	0.119 (0.003)	0.159 (0.004)	0.398 (0.006)
27 Apr–03 May	34,853	0.144 (0.003)	0.082 (0.002)	0.340 (0.004)
04 May–10 May	33,902	0.190 (0.003)	0.214 (0.003)	0.358 (0.005)
11 May–17 May	25,878	0.214 (0.003)	0.135 (0.003)	0.392 (0.005)
18 May–24 May	1,786	0.202 (0.014)	0.057 (0.008)	0.345 (0.023)
25 May–31 May	172	0.213 (0.050)	NA	0.281 (0.080)

Table 7. Estimated detection probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
20 Apr–26 Apr	1,344	0.443 (0.038)	0.128 (0.045)
27 Apr–03 May	11,709	0.526 (0.012)	0.144 (0.017)
04 May–10 May	37,880	0.368 (0.006)	0.155 (0.010)
11 May–17 May	28,473	0.343 (0.007)	0.142 (0.011)
18 May–24 May	16,429	0.415 (0.010)	0.198 (0.018)
25 May–31 May	2,310	0.338 (0.034)	0.114 (0.054)
01 Jun–07 Jun	695	0.356 (0.058)	0.105 (0.099)
08 Jun–14 Jun	607	0.292 (0.059)	0.285 (0.138)

Table 8. Estimated detection probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
30 Mar–05 Apr	125	0.148 (0.056)	0.140 (0.061)	0.356 (0.089)
06 Apr–12 Apr	1,176	0.157 (0.016)	0.067 (0.011)	0.358 (0.024)
13 Apr–19 Apr	4,266	0.134 (0.008)	0.063 (0.006)	0.353 (0.012)
20 Apr–26 Apr	13,226	0.106 (0.004)	0.151 (0.004)	0.392 (0.007)
27 Apr–03 May	31,229	0.133 (0.003)	0.074 (0.002)	0.334 (0.004)
04 May–10 May	31,195	0.184 (0.003)	0.208 (0.003)	0.351 (0.005)
11 May–17 May	22,745	0.207 (0.004)	0.122 (0.003)	0.392 (0.006)
18 May–24 May	640	0.210 (0.024)	0.082 (0.017)	0.289 (0.036)

Table 9. Estimated detection probabilities for Snake River wild yearling Chinook Salmon detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
23 Mar–29 Mar	45	0.584 (0.122)	0.108 (0.097)	0.444 (0.166)
30 Mar–05 Apr	143	0.400 (0.062)	0.017 (0.017)	0.351 (0.078)
06 Apr–12 Apr	1,958	0.271 (0.014)	0.036 (0.006)	0.452 (0.019)
13 Apr–19 Apr	4,876	0.180 (0.008)	0.039 (0.004)	0.439 (0.012)
20 Apr–26 Apr	2,730	0.173 (0.009)	0.197 (0.010)	0.425 (0.015)
27 Apr–03 May	3,624	0.236 (0.009)	0.153 (0.008)	0.388 (0.013)
04 May–10 May	2,707	0.248 (0.010)	0.269 (0.012)	0.425 (0.016)
11 May–17 May	3,133	0.257 (0.010)	0.220 (0.010)	0.390 (0.015)
18 May–24 May	1,146	0.197 (0.018)	0.043 (0.009)	0.376 (0.029)
25 May–31 May	123	0.290 (0.068)	NA	0.421 (0.113)

Table 10. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	754	0.813 (0.039)	1.158 (0.313)	0.776 (0.239)	0.731 (0.110)
13 Apr–19 Apr	2,717	0.852 (0.024)	1.004 (0.080)	0.784 (0.082)	0.670 (0.049)
20 Apr–26 Apr	4,468	0.862 (0.019)	0.880 (0.031)	0.965 (0.066)	0.732 (0.046)
27 Apr–03 May	6,966	0.900 (0.016)	1.008 (0.045)	0.853 (0.055)	0.774 (0.038)
04 May–10 May	6,484	0.907 (0.016)	0.906 (0.033)	0.729 (0.048)	0.599 (0.034)
11 May–17 May	6,591	0.891 (0.020)	0.886 (0.049)	0.840 (0.080)	0.662 (0.053)
18 May–24 May	4,479	0.851 (0.040)	0.974 (0.158)	0.708 (0.169)	0.587 (0.106)
25 May–31 May	151	0.550 (0.140)	0.812 (0.731)	NA	NA
Weighted mean*		**0.887 (0.009)**	**0.911 (0.022)**	**0.852 (0.030)**	**0.694 (0.020)**

* Weighted means of the independent estimates for daily groups (26 March–31 May), with weights inversely proportional to respective estimated relative variances (see Table 14).

Table 11. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at McNary Dam	Number released	McNary to John Day Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
20 Apr–26 Apr	541	1.749 (0.557)	0.345 (0.325)	0.603 (0.534)
27 Apr–03 May	893	0.986 (0.167)	0.464 (0.177)	0.457 (0.157)
04 May–10 May	2,242	1.004 (0.108)	0.711 (0.168)	0.713 (0.150)
11 May–17 May	1,781	0.985 (0.186)	0.419 (0.120)	0.413 (0.089)
18 May–24 May	1,136	0.700 (0.150)	0.652 (0.251)	0.457 (0.147)
25 May–31 May	464	0.417 (0.204)	0.658 (0.503)	0.274 (0.161)
Weighted mean*		**0.988 (0.098)**	**0.579 (0.059)**	**0.524 (0.064)**

* 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 Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	463	0.846 (0.048)	0.949 (0.260)	0.857 (0.279)	0.688 (0.126)
13 Apr–19 Apr	1,837	0.855 (0.026)	0.981 (0.079)	0.750 (0.086)	0.629 (0.055)
20 Apr–26 Apr	4,073	0.873 (0.020)	0.854 (0.030)	0.961 (0.069)	0.716 (0.048)
27 Apr–03 May	4,215	0.885 (0.020)	0.996 (0.056)	0.968 (0.102)	0.853 (0.078)
04 May–10 May	3,529	0.911 (0.020)	0.873 (0.041)	0.701 (0.062)	0.557 (0.043)
11 May–17 May	3,974	0.894 (0.023)	0.886 (0.062)	0.840 (0.112)	0.666 (0.078)
18 May–24 May	2,541	0.802 (0.046)	1.054 (0.219)	0.719 (0.220)	0.607 (0.141)
25 May–31 May	92	0.489 (0.154)	0.476 (0.406)	NA	NA
Weighted mean*		**0.881 (0.010)**	**0.897 (0.022)**	**0.856 (0.047)**	**0.680 (0.039)**

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

Table 13. Estimated survival probabilities for juvenile Snake River wild steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single-release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	291	0.754 (0.067)	2.762 (2.539)	0.372 (0.356)	0.775 (0.202)
13 Apr–19 Apr	880	0.912 (0.071)	1.049 (0.292)	0.748 (0.224)	0.716 (0.092)
20 Apr–26 Apr	395	0.689 (0.069)	1.419 (0.282)	0.785 (0.193)	0.768 (0.128)
27 Apr–03 May	2,751	0.922 (0.024)	0.898 (0.062)	0.951 (0.080)	0.787 (0.043)
04 May–10 May	2,955	0.900 (0.027)	0.948 (0.054)	0.755 (0.074)	0.644 (0.054)
11 May–17 May	2,617	0.877 (0.035)	0.872 (0.078)	0.869 (0.118)	0.665 (0.073)
18 May–24 May	1,938	0.937 (0.076)	0.863 (0.225)	0.666 (0.251)	0.538 (0.152)
25 May–31 May	59	0.633 (0.264)	NA	NA	NA
Weighted mean*		**0.896 (0.018)**	**0.939 (0.051)**	**0.854 (0.039)**	**0.730 (0.027)**

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

Table 14. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled as necessary to calculate estimates. Estimates based on the single–release model. Standard errors in parentheses. Abbreviations: LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
26 Mar–12 Apr	781	0.818 (0.040)	1.147 (0.310)	0.765 (0.234)	0.717 (0.106)
13–16 Apr	104	0.796 (0.107)	0.527 (0.144)	1.367 (0.539)	0.573 (0.205)
17 Apr	1,055	0.830 (0.032)	1.087 (0.133)	0.706 (0.111)	0.637 (0.067)
18 Apr	1,351	0.887 (0.041)	1.004 (0.124)	0.786 (0.125)	0.699 (0.077)
19 Apr	207	0.853 (0.105)	0.881 (0.224)	1.050 (0.410)	0.789 (0.255)
20 Apr	26	0.654 (0.159)	1.867 (1.519)	0.536 (0.589)	0.654 (0.487)
21 Apr	65	1.072 (0.438)	0.750 (0.443)	1.031 (0.723)	0.829 (0.470)
22 Apr	56	0.756 (0.268)	1.031 (0.689)	0.390 (0.253)	0.304 (0.112)
23 Apr	2,101	0.878 (0.028)	0.892 (0.047)	0.973 (0.099)	0.762 (0.071)
24 Apr	2,058	0.857 (0.027)	0.850 (0.042)	0.982 (0.100)	0.716 (0.068)
25–26 Apr	162	0.792 (0.095)	1.010 (0.207)	0.853 (0.224)	0.682 (0.135)
27 Apr	226	0.965 (0.094)	0.879 (0.141)	1.040 (0.271)	0.882 (0.200)
28 Apr	54	1.006 (0.385)	0.818 (0.463)	1.500 (1.430)	1.235 (1.067)
29 Apr	59	0.723 (0.154)	0.691 (0.254)	0.987 (0.328)	0.493 (0.121)
30 Apr	849	0.985 (0.045)	0.754 (0.076)	1.160 (0.168)	0.861 (0.100)
01 May	3,191	0.883 (0.022)	1.008 (0.067)	0.820 (0.087)	0.730 (0.062)
02 May	1,443	0.884 (0.030)	1.217 (0.144)	0.682 (0.096)	0.734 (0.059)
03 May	1,144	0.890 (0.049)	1.089 (0.134)	0.992 (0.190)	0.963 (0.150)
04 May	971	0.799 (0.053)	1.139 (0.143)	0.857 (0.155)	0.780 (0.112)
05 May	269	0.992 (0.139)	1.069 (0.262)	0.485 (0.166)	0.514 (0.140)
06 May	214	0.720 (0.062)	1.450 (0.293)	0.632 (0.262)	0.659 (0.240)
07 May	1,365	0.884 (0.032)	0.902 (0.063)	0.878 (0.139)	0.701 (0.103)
08 May	921	0.924 (0.040)	0.802 (0.066)	0.754 (0.130)	0.559 (0.088)
09 May	1,496	0.948 (0.034)	0.855 (0.065)	0.752 (0.113)	0.610 (0.082)
10 May	1,248	0.952 (0.036)	0.801 (0.065)	0.609 (0.075)	0.464 (0.046)
11 May	1,126	0.829 (0.031)	0.762 (0.067)	1.310 (0.300)	0.828 (0.177)
12 May	275	0.960 (0.086)	0.766 (0.203)	0.675 (0.300)	0.496 (0.180)

Table 14. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
13 May	327	1.003 (0.087)	1.121 (0.303)	0.803 (0.412)	0.903 (0.398)
14 May	865	0.851 (0.059)	1.094 (0.184)	0.584 (0.136)	0.544 (0.094)
15 May	1,405	0.907 (0.049)	0.955 (0.126)	0.764 (0.158)	0.661 (0.110)
16 May	1,142	0.894 (0.046)	0.948 (0.134)	0.780 (0.175)	0.660 (0.120)
17 May	1,451	0.974 (0.058)	0.799 (0.113)	0.854 (0.210)	0.665 (0.139)
18 May	881	0.926 (0.071)	1.041 (0.262)	0.748 (0.309)	0.721 (0.241)
19–20 May	243	0.741 (0.109)	0.800 (0.309)	1.594 (1.587)	0.945 (0.878)
21–22 May	1,353	0.964 (0.094)	1.530 (0.739)	0.622 (0.416)	0.917 (0.431)
23–31 May	2,153	0.782 (0.062)	0.909 (0.246)	0.584 (0.208)	0.415 (0.101)
Weighted mean*		**0.887 (0.009)**	**0.911 (0.022)**	**0.852 (0.030)**	**0.694 (0.020)**

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

Table 15. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	754	0.543 (0.032)	0.048 (0.015)	0.187 (0.033)
13 Apr–19 Apr	2,717	0.422 (0.016)	0.135 (0.012)	0.193 (0.017)
20 Apr–26 Apr	4,468	0.320 (0.010)	0.368 (0.013)	0.141 (0.011)
27 Apr–03 May	6,966	0.407 (0.009)	0.163 (0.008)	0.182 (0.010)
04 May–10 May	6,484	0.372 (0.009)	0.335 (0.012)	0.198 (0.013)
11 May–17 May	6,591	0.402 (0.011)	0.197 (0.011)	0.126 (0.011)
18 May–24 May	4,479	0.338 (0.018)	0.072 (0.012)	0.078 (0.015)
25 May–31 May	151	0.458 (0.124)	0.138 (0.127)	NA

Table 16. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
20 Apr–26 Apr	541	0.115 (0.038)	0.202 (0.180)
27 Apr–03 May	893	0.199 (0.036)	0.261 (0.092)
04 May–10 May	2,242	0.152 (0.018)	0.206 (0.044)
11 May–17 May	1,781	0.097 (0.020)	0.256 (0.057)
18 May–24 May	1,136	0.108 (0.026)	0.243 (0.080)
25 May–31 May	464	0.083 (0.045)	0.286 (0.171)

Table 17. Estimated detection probabilities for juvenile Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	463	0.580 (0.040)	0.067 (0.022)	0.174 (0.038)
13 Apr–19 Apr	1,837	0.478 (0.018)	0.180 (0.017)	0.177 (0.019)
20 Apr–26 Apr	4,073	0.331 (0.011)	0.391 (0.014)	0.132 (0.011)
27 Apr–03 May	4,215	0.412 (0.012)	0.201 (0.012)	0.105 (0.011)
04 May–10 May	3,529	0.424 (0.013)	0.359 (0.017)	0.190 (0.017)
11 May–17 May	3,974	0.451 (0.014)	0.208 (0.015)	0.103 (0.013)
18 May–24 May	2,541	0.367 (0.023)	0.073 (0.016)	0.088 (0.022)
25 May–31 May	92	0.533 (0.175)	0.250 (0.216)	NA

Table 18. Estimated detection probabilities for juvenile Snake River wild steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	291	0.483 (0.052)	0.016 (0.015)	0.211 (0.061)
13 Apr–19 Apr	880	0.282 (0.027)	0.043 (0.013)	0.232 (0.034)
20 Apr–26 Apr	395	0.206 (0.031)	0.153 (0.033)	0.253 (0.049)
27 Apr–03 May	2,751	0.401 (0.014)	0.123 (0.010)	0.280 (0.018)
04 May–10 May	2,955	0.310 (0.013)	0.309 (0.018)	0.209 (0.020)
11 May–17 May	2,617	0.330 (0.016)	0.184 (0.017)	0.161 (0.020)
18 May–24 May	1,938	0.296 (0.026)	0.070 (0.018)	0.066 (0.020)
25 May–31 May	59	0.375 (0.171)	NA	NA

Table 19. Estimated survival probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Clearwater Hatchery						
Crooked River	15,460	0.657 (0.016)	0.957 (0.054)	0.961 (0.082)	0.956 (0.069)	0.578 (0.012)
Powell Pond	14,970	0.774 (0.016)	0.906 (0.053)	1.041 (0.103)	0.913 (0.078)	0.667 (0.013)
Red River Pond	14,967	0.816 (0.022)	0.892 (0.055)	1.035 (0.099)	0.889 (0.074)	0.670 (0.016)
Dworshak Hatchery						
N.F. Clearwater River	104,186	0.817 (0.007)	0.931 (0.012)	0.956 (0.015)	0.911 (0.013)	0.662 (0.004)
Kooskia Hatchery						
Kooksia Hatchery	9,892	0.654 (0.015)	0.819 (0.064)	0.950 (0.127)	1.028 (0.116)	0.523 (0.019)
Lookingglass Hatchery						
Catherine Creek Pond	20,828	0.340 (0.007)	0.933 (0.037)	0.993 (0.057)	0.902 (0.052)	0.285 (0.009)
Grande Ronde P. (3/19)	496	0.361 (0.046)	1.016 (0.204)	0.812 (0.200)	1.019 (0.246)	0.303 (0.053)
Grande Ronde P. (4/2)	1,481	0.541 (0.025)	0.956 (0.072)	0.858 (0.086)	0.966 (0.093)	0.429 (0.028)
Imnaha Weir	20,888	0.682 (0.010)	0.908 (0.025)	0.972 (0.038)	0.968 (0.036)	0.582 (0.010)
Lostine Pond (3/16)	2,432	0.533 (0.024)	0.877 (0.056)	1.184 (0.131)	0.797 (0.090)	0.441 (0.023)
Lostine Pond (4/7)	4,011	0.631 (0.016)	0.970 (0.042)	0.986 (0.067)	0.843 (0.060)	0.509 (0.022)

Table 19. Continued.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
			McCall Hatchery			
Johnson Creek	12,060	0.319 (0.024)	0.960 (0.162)	0.980 (0.256)	0.864 (0.200)	0.260 (0.014)
Knox Bridge	52,128	0.554 (0.007)	0.972 (0.023)	1.019 (0.033)	0.864 (0.024)	0.474 (0.006)
			Pahsimeroi Hatchery			
Pahsimeroi Pond	498	0.530 (0.038)	1.216 (0.241)	0.816 (0.228)	0.884 (0.204)	0.465 (0.054)
			Rapid River Hatchery			
Rapid River H.	104,672	0.748 (0.004)	0.937 (0.010)	0.968 (0.013)	0.908 (0.012)	0.616 (0.005)
			Sawtooth Hatchery			
Sawtooth H.	14,942	0.581 (0.015)	0.969 (0.054)	0.954 (0.071)	0.908 (0.060)	0.488 (0.015)

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Clearwater Hatchery						
S.F. Clearwater River	300	0.859 (0.158)	0.884 (0.194)	0.779 (0.175)	2.458 (2.362)	1.454 (1.371)
Crooked River Pond	599	0.805 (0.058)	0.956 (0.092)	0.872 (0.125)	0.758 (0.236)	0.508 (0.145)
Lolo Creek	300	0.787 (0.106)	0.880 (0.149)	0.840 (0.174)	0.931 (0.402)	0.542 (0.215)
Meadow Creek	300	0.870 (0.092)	0.840 (0.114)	0.942 (0.194)	0.846 (0.392)	0.582 (0.245)
Mill Creek	299	0.495 (0.059)	0.759 (0.120)	1.466 (0.890)	0.180 (0.149)	0.099 (0.054)
Red River Pond	600	0.753 (0.069)	1.093 (0.143)	1.200 (0.360)	0.313 (0.146)	0.309 (0.112)
Dworshak Hatchery						
N.F. Clearwater River	1,491	0.838 (0.043)	0.876 (0.054)	0.897 (0.059)	0.798 (0.103)	0.525 (0.061)
Hagerman Hatchery						
Little Salmon River	597	0.899 (0.074)	0.800 (0.084)	1.121 (0.205)	0.628 (0.176)	0.506 (0.111)
East Fork Salmon R.	290	1.074 (0.137)	0.636 (0.115)	0.732 (0.230)	1.250 (1.198)	0.624 (0.571)
Sawtooth Hatchery	298	0.596 (0.085)	0.970 (0.178)	0.840 (0.228)	1.574 (1.058)	0.765 (0.481)
Yankee Fork	300	0.588 (0.065)	1.068 (0.204)	2.037 (1.925)	NA	NA
Irrigon Hatchery						
Big Canyon Facility	595	0.799 (0.093)	0.880 (0.139)	1.013 (0.242)	1.220 (0.841)	0.870 (0.569)
Little Sheep Facility	295	0.604 (0.047)	1.163 (0.129)	1.517 (0.498)	0.439 (0.297)	0.467 (0.279)
Wallowa H. (4/8)	5,370	0.734 (0.078)	1.264 (0.362)	0.754 (0.420)	0.691 (0.399)	0.484 (0.124)
Wallowa H. (4/28)	1,786	0.676 (0.222)	2.093 (1.896)	NA	NA	NA

Table 20. Continued.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
			Magic Valley Hatchery			
East Fork Salmon R.	300	0.934 (0.143)	0.615 (0.121)	1.280 (0.500)	NA	NA
Little Salmon R.	300	0.826 (0.075)	1.095 (0.152)	1.220 (0.382)	0.443 (0.249)	0.488 (0.233)
Salmon R. (rkm 385)	293	0.929 (0.103)	1.030 (0.165)	0.850 (0.222)	0.494 (0.203)	0.401 (0.136)
Salmon R. (rkm 476)	300	0.796 (0.099)	1.062 (0.174)	1.128 (0.312)	0.806 (0.534)	0.768 (0.470)
Salmon R. (rkm 506)	297	0.793 (0.103)	1.207 (0.222)	0.988 (0.318)	1.745 (1.730)	1.651 (1.564)
Slate Creek (4/18)	293	0.640 (0.071)	0.852 (0.128)	0.917 (0.258)	1.079 (0.603)	0.539 (0.267)
Slate Creek (5/1)	292	0.609 (0.058)	0.931 (0.130)	0.839 (0.235)	0.750 (0.326)	0.356 (0.126)
Squaw Creek	972	0.691 (0.036)	0.972 (0.074)	0.711 (0.098)	0.918 (0.283)	0.439 (0.125)
Valley Creek	299	0.941 (0.107)	0.773 (0.118)	1.015 (0.383)	0.598 (0.432)	0.441 (0.272)
Yankee Fork	298	1.092 (0.189)	0.468 (0.100)	0.778 (0.202)	1.540 (1.027)	0.613 (0.384)
			Niagara Springs Hatchery			
Hells Canyon Dam	289	0.866 (0.173)	0.792 (0.203)	0.675 (0.271)	1.367 (0.832)	0.633 (0.308)
Little Salmon R.	592	0.970 (0.076)	0.840 (0.087)	0.861 (0.122)	0.963 (0.294)	0.676 (0.188)
Pahsimeroi Weir	297	1.464 (0.330)	0.543 (0.142)	0.797 (0.197)	1.670 (1.119)	1.057 (0.673)

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from Snake River Basin hatcheries released in 2007. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; Little Goose-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Release date	Number released	Release to LGR	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN	Release to MCN
Eagle Creek NFH								
Redfish Lk Cr Trap	08 May 07	330	0.338 (0.121)	NA	NA	NA	NA	NA
Oxbow Hatchery								
Redfish Lk Cr Trap	08 May 07	1,020	0.571 (0.070)	2.770 (1.101)	0.326 (0.155)	0.502 (0.210)	0.454 (0.151)	0.259 (0.080)
Sawtooth Hatchery								
Alturus Lake	02 Oct 06	1,016	0.174 (0.019)	0.890 (0.126)	0.903 (0.159)	0.922 (0.196)	0.741 (0.139)	0.129 (0.023)
Pettit Lake	02 Oct 06	1,021	0.123 (0.024)	1.350 (0.606)	0.547 (0.381)	0.963 (0.701)	0.712 (0.357)	0.088 (0.042)
Redfish Lake	02 Oct 06	1,016	0.204 (0.026)	0.873 (0.156)	0.783 (0.171)	1.238 (0.340)	0.846 (0.212)	0.173 (0.040)
Sawtooth Trap	08 May 07	909	0.776 (0.133)	0.686 (0.175)	0.826 (0.256)	0.824 (0.264)	0.468 (0.126)	0.363 (0.076)

Table 22. Estimated detection probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Clearwater Hatchery		
Crooked River Pond	15,460	0.162 (0.005)	0.110 (0.006)	0.087 (0.006)	0.333 (0.008)
Powell Pond	14,970	0.147 (0.004)	0.114 (0.007)	0.075 (0.006)	0.330 (0.008)
Red River Pond	14,967	0.164 (0.006)	0.117 (0.007)	0.087 (0.007)	0.314 (0.008)
			Dworshak Hatchery		
N.F. Clearwater River	104,186	0.142 (0.002)	0.127 (0.002)	0.094 (0.002)	0.348 (0.003)
			Kooskia Hatchery		
Kooskia Hatchery	9,892	0.259 (0.008)	0.233 (0.018)	0.147 (0.015)	0.416 (0.014)
			Lookingglass Hatchery		
Catherine Creek Pond	20,828	0.312 (0.008)	0.213 (0.009)	0.149 (0.009)	0.339 (0.012)
Grande Ronde P. (3/19)	496	0.234 (0.041)	0.163 (0.038)	0.138 (0.038)	0.315 (0.063)
Grande Ronde P. (4/2)	1,481	0.326 (0.021)	0.189 (0.019)	0.136 (0.017)	0.360 (0.028)
Imnaha Weir	20,888	0.242 (0.005)	0.177 (0.005)	0.126 (0.005)	0.343 (0.008)
Lostine Pond (3/16)	2,432	0.218 (0.015)	0.180 (0.014)	0.074 (0.010)	0.348 (0.022)
Lostine Pond (4/7)	4,011	0.323 (0.012)	0.203 (0.011)	0.125 (0.010)	0.328 (0.017)

Table 22. Continued.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			McCall Hatchery		
Johnson Creek	12,060	0.214 (0.017)	0.137 (0.020)	0.114 (0.024)	0.352 (0.017)
Knox Bridge	52,128	0.220 (0.004)	0.116 (0.003)	0.101 (0.003)	0.350 (0.005)
			Pahsimeroi Hatchery		
Pahsimeroi Pond	498	0.402 (0.038)	0.086 (0.023)	0.078 (0.023)	0.343 (0.048)
			Rapid River Hatchery		
Rapid River H.	104,672	0.280 (0.002)	0.167 (0.002)	0.134 (0.002)	0.330 (0.003)
			Sawtooth Hatchery		
Sawtooth H.	14,942	0.307 (0.009)	0.197 (0.010)	0.166 (0.010)	0.327 (0.011)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Clearwater Hatchery		
S.F. Clearwater River	300	0.097 (0.026)	0.321 (0.050)	0.324 (0.070)	0.029 (0.028)
Crooked River Pond	599	0.205 (0.023)	0.398 (0.035)	0.313 (0.046)	0.103 (0.034)
Lolo Creek	300	0.157 (0.031)	0.366 (0.050)	0.259 (0.056)	0.076 (0.036)
Meadow Creek	300	0.207 (0.033)	0.440 (0.050)	0.312 (0.067)	0.114 (0.054)
Mill Creek	299	0.338 (0.052)	0.565 (0.077)	0.185 (0.115)	0.250 (0.153)
Red River Pond	600	0.177 (0.024)	0.335 (0.039)	0.162 (0.049)	0.107 (0.045)
			Dworshak Hatchery		
N.F. Clearwater River	1,491	0.158 (0.013)	0.411 (0.020)	0.376 (0.026)	0.156 (0.022)
			Hagerman Hatchery		
Little Salmon R.	597	0.196 (0.023)	0.446 (0.036)	0.188 (0.037)	0.161 (0.041)
East Fork Salmon R.	290	0.234 (0.038)	0.458 (0.065)	0.257 (0.082)	0.046 (0.044)
Sawtooth Hatchery	298	0.174 (0.037)	0.368 (0.058)	0.208 (0.060)	0.054 (0.037)
Yankee Fork	300	0.306 (0.046)	0.396 (0.074)	0.052 (0.049)	0.000 (0.000)
			Irrigon Hatchery		
Big Canyon Facility	595	0.160 (0.025)	0.293 (0.038)	0.211 (0.049)	0.036 (0.025)
Little Sheep Facility	295	0.309 (0.040)	0.408 (0.052)	0.188 (0.063)	0.061 (0.042)
Wallowa H. (4/8)	5,370	0.179 (0.020)	0.235 (0.061)	0.165 (0.074)	0.066 (0.017)
Wallowa H. (4/28)	1,786	0.198 (0.066)	0.144 (0.117)	NA	0.073 (0.034)

Table 23. Continued

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
		Magic Valley Hatchery			
East Fork Salmon R.	300	0.189 (0.037)	0.435 (0.062)	0.174 (0.070)	NA
Little Salmon R.	300	0.234 (0.034)	0.349 (0.048)	0.180 (0.057)	0.077 (0.043)
Salmon R. (rkm 385)	293	0.187 (0.031)	0.346 (0.049)	0.222 (0.058)	0.114 (0.048)
Salmon R. (rkm 476)	300	0.151 (0.029)	0.339 (0.048)	0.181 (0.052)	0.040 (0.028)
Salmon R. (rkm 506)	297	0.144 (0.029)	0.298 (0.049)	0.169 (0.054)	0.027 (0.027)
Slate Creek (4/18)	293	0.277 (0.043)	0.467 (0.063)	0.212 (0.065)	0.107 (0.058)
Slate Creek (5/1)	292	0.343 (0.046)	0.460 (0.064)	0.229 (0.069)	0.200 (0.080)
Squaw Creek	972	0.296 (0.022)	0.449 (0.033)	0.312 (0.043)	0.115 (0.036)
Valley Creek	299	0.210 (0.034)	0.517 (0.060)	0.192 (0.075)	0.095 (0.064)
Yankee Fork	298	0.187 (0.039)	0.486 (0.066)	0.250 (0.071)	0.074 (0.050)
		Niagara Springs Hatchery			
Hells Canyon Dam	289	0.124 (0.032)	0.318 (0.060)	0.100 (0.045)	0.080 (0.044)
Little Salmon R.	592	0.188 (0.022)	0.403 (0.034)	0.279 (0.041)	0.100 (0.032)
Pahsimeroi Weir	297	0.090 (0.025)	0.344 (0.052)	0.203 (0.052)	0.042 (0.029)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from Snake River Basin hatcheries released in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Release date	Number released	Lower Granite	Little Goose	Lower Monumental	McNary
Eagle Creek National Fish Hatchery						
Redfish Lk Cr Trap	08 May 07	330	0.215 (0.085)	NA	0.167 (0.108)	NA
Oxbow Hatchery						
Redfish Lk Cr Trap	08 May 07	1,020	0.187 (0.028)	0.043 (0.017)	0.081 (0.026)	0.062 (0.024)
Sawtooth Hatchery						
Alturus Lake	02 Oct 06	1,016	0.317 (0.044)	0.276 (0.047)	0.251 (0.050)	0.308 (0.064)
Pettit Lake	02 Oct 06	1,021	0.286 (0.064)	0.120 (0.056)	0.077 (0.051)	0.150 (0.080)
Redfish Lake	02 Oct 06	1,016	0.270 (0.043)	0.241 (0.046)	0.169 (0.043)	0.291 (0.073)
Sawtooth Trap	08 May 07	909	0.113 (0.023)	0.109 (0.025)	0.078 (0.023)	0.137 (0.034)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2007. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; Little Goose-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Number released	Release to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Release to MCN
			Wild Chinook salmon				
American River	20 Mar-31 May	703	0.475 (0.050)	0.888 (0.122)	0.737 (0.141)	1.295 (0.262)	0.402 (0.053)
Catherine Creek	02 Feb-26 May	364	0.310 (0.036)	1.095 (0.296)	0.667 (0.192)	1.504 (0.200)	0.341 (0.059)
Crooked Fork Cr	23 Mar-28 May	109	0.574 (0.122)	1.202 (0.545)	0.641 (0.397)	1.061 (0.670)	0.469 (0.204)
Clearwater	11 Mar-09 May	658	0.811 (0.046)	0.833 (0.077)	1.043 (0.198)	0.794 (0.154)	0.559 (0.040)
Crooked River	19 Mar-31 May	400	0.370 (0.058)	0.870 (0.167)	0.764 (0.196)	1.290 (0.390)	0.318 (0.070)
Grande Ronde	07 Mar-26 May	2,571	0.891 (0.022)	0.995 (0.053)	0.920 (0.088)	0.891 (0.082)	0.726 (0.028)
Imnaha (early)	08 Mar-31 May	6,635	0.840 (0.014)	0.913 (0.029)	1.003 (0.056)	0.892 (0.049)	0.686 (0.018)
Imnaha (late)	01 Jun-21 Jun	864	0.394 (0.139)	1.031 (0.454)	NA	NA	NA
Johnson Creek	05 Mar-17 May	339	0.454 (0.048)	0.925 (0.144)	1.014 (0.218)	0.775 (0.171)	0.330 (0.049)
Knox Bridge	08 Mar-30 May	1,950	0.389 (0.020)	0.911 (0.072)	0.957 (0.119)	0.945 (0.126)	0.320 (0.027)
Lemhi River Weir	09 Mar-26 May	166	0.753 (0.127)	0.752 (0.190)	1.889 (1.509)	0.478 (0.395)	0.511 (0.091)
Lostine River	20 Feb-09 May	505	0.615 (0.054)	0.996 (0.194)	1.227 (0.503)	0.648 (0.262)	0.487 (0.070)
Marsh Creek	21 Mar-21 May	78	0.603 (0.394)	0.659 (0.506)	1.125 (0.798)	0.656 (0.482)	0.293 (0.097)
Minam	20 Feb-09 May	217	0.560 (0.066)	0.972 (0.210)	1.231 (0.590)	0.774 (0.404)	0.518 (0.100)
Pahsimeroi	06 Mar-31 May	1,200	0.414 (0.033)	0.970 (0.135)	1.083 (0.309)	0.740 (0.204)	0.322 (0.029)
Red River	19 Mar-31 May	922	0.336 (0.045)	0.980 (0.177)	0.827 (0.256)	0.930 (0.296)	0.253 (0.040)
Salmon	10 Mar-11 May	5,201	0.796 (0.017)	1.003 (0.047)	0.826 (0.060)	0.962 (0.060)	0.634 (0.018)
Sawtooth	20 Mar-31 May	569	0.581 (0.050)	0.731 (0.102)	1.069 (0.213)	1.141 (0.250)	0.518 (0.075)
Snake	23 Mar-25 May	379	0.903 (0.062)	1.691 (0.493)	0.441 (0.145)	0.912 (0.146)	0.614 (0.061)
Spoolcart*	07 Mar-23 May	501	0.376 (0.039)	0.981 (0.212)	0.816 (0.306)	0.882 (0.352)	0.265 (0.060)

Table 25. Continued.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
				Wild steelhead			
American River	21 Mar-30 May	86	0.349 (0.122)	0.622 (0.304)	0.750 (0.564)	NA	NA
Asotin Creek	08 Apr-31 May	1,818	0.410 (0.039)	NA	NA	NA	NA
Catherine Creek	02 Mar-31 May	349	0.089 (0.027)	0.881 (0.447)	NA	NA	NA
Crooked Fork Cr	26 Mar-31 May	331	0.795 (0.067)	0.959 (0.116)	0.811 (0.177)	0.892 (0.230)	0.552 (0.093)
Clearwater	11 Mar-09 May	1,060	0.966 (0.061)	0.986 (0.112)	0.651 (0.123)	0.961 (0.195)	0.596 (0.075)
Grande Ronde	10 Mar-24 May	369	0.944 (0.091)	0.980 (0.170)	0.742 (0.190)	0.660 (0.232)	0.453 (0.125)
Imnaha (early)	11 Mar-31 May	6,524	0.832 (0.023)	0.916 (0.044)	0.844 (0.076)	1.008 (0.136)	0.649 (0.067)
Imnaha (late)	01 Jun-21 Jun	668	0.693 (0.418)	0.403 (0.322)	NA	NA	NA
Knox Bridge	10 Mar-31 May	647	0.074 (0.020)	2.000 (1.816)	NA	NA	NA
Lookingglass Cr	27 Mar-30 May	299	0.335 (0.057)	1.725 (0.674)	0.456 (0.264)	0.546 (0.338)	0.144 (0.062)
Minam River	08 Mar-31 May	295	0.413 (0.131)	2.184 (2.034)	0.262 (0.278)	0.629 (0.484)	0.148 (0.082)
Pahsimeroi	07 Mar 31 May	647	0.063 (0.014)	2.500 (2.183)	NA	NA	NA
Salmon	17 Mar-11 May	407	0.879 (0.081)	0.985 (0.136)	1.091 (0.350)	0.875 (0.345)	0.826 (0.204)
Snake	23 Mar-25 May	964	1.050 (0.056)	0.765 (0.070)	1.137 (0.182)	0.789 (0.190)	0.720 (0.138)
Spoolcart*	07 Mar-08 May	600	0.252 (0.037)	1.193 (0.335)	0.640 (0.298)	1.833 (1.833)	0.352 (0.320)
				Hatchery Chinook salmon			
Grande Ronde	18 Mar-23 May	1,406	0.872 (0.039)	0.849 (0.057)	1.190 (0.121)	0.749 (0.079)	0.660 (0.036)
Salmon	15 Mar-11 May	3,937	0.755 (0.021)	0.923 (0.043)	0.933 (0.055)	0.941 (0.050)	0.612 (0.019)
Snake	23 Mar-25 May	1,666	0.949 (0.031)	0.960 (0.055)	1.014 (0.082)	0.761 (0.061)	0.703 (0.032)
				Hatchery steelhead			
Grande Ronde	05 May-23 May	1,528	0.977 (0.050)	0.860 (0.059)	0.857 (0.077)	1.273 (0.306)	0.917 (0.209)
Imnaha	11 Apr-19 May	1,492	0.970 (0.045)	0.882 (0.057)	0.951 (0.098)	1.006 (0.237)	0.818 (0.176)
Salmon	31 Mar-11 May	2,298	0.966 (0.040)	0.864 (0.048)	0.862 (0.073)	0.925 (0.157)	0.665 (0.101)
Snake	23 Mar-25 May	2,545	0.997 (0.029)	0.880 (0.040)	0.870 (0.069)	1.133 (0.216)	0.864 (0.153)

* Grande Ronde River

Table 26. Estimated detection probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Trap	Release dates	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Wild Chinook salmon			
American River	20 Mar-31 May	703	0.198 (0.029)	0.259 (0.035)	0.071 (0.021)	0.327 (0.050)
Catherine Creek	02 Feb-26 May	364	0.372 (0.055)	0.162 (0.055)	0.136 (0.045)	0.389 (0.081)
Crooked Fork Creek	23 Mar-28 May	109	0.288 (0.080)	0.176 (0.085)	0.171 (0.095)	0.273 (0.134)
Clearwater	11 Mar-09 May	658	0.288 (0.025)	0.314 (0.031)	0.118 (0.026)	0.480 (0.042)
Crooked River	19 Mar-31 May	400	0.202 (0.044)	0.309 (0.056)	0.114 (0.041)	0.320 (0.079)
Grande Ronde	07 Mar-26 May	2,571	0.322 (0.012)	0.237 (0.014)	0.112 (0.012)	0.392 (0.019)
Imnaha (early)	08 Mar-31 May	6,635	0.335 (0.008)	0.230 (0.009)	0.107 (0.007)	0.388 (0.012)
Imnaha (late)	01 Jun-21 Jun	864	0.074 (0.029)	0.147 (0.041)	NA	0.286 (0.066)
Johnson Creek	05 Mar-17 May	339	0.325 (0.047)	0.221 (0.045)	0.176 (0.044)	0.444 (0.074)
Knox Bridge	08 Mar-30 May	1,950	0.359 (0.023)	0.259 (0.024)	0.142 (0.021)	0.384 (0.037)
Lemhi River Weir	09 Mar-26 May	166	0.240 (0.055)	0.233 (0.061)	0.056 (0.048)	0.394 (0.085)
Lostine River	20 Feb-09 May	505	0.351 (0.039)	0.216 (0.044)	0.080 (0.034)	0.333 (0.057)
Marsh Creek	21 Mar-21 May	78	0.106 (0.082)	0.276 (0.120)	0.185 (0.134)	0.571 (0.187)
Minam	20 Feb-09 May	217	0.329 (0.054)	0.195 (0.053)	0.138 (0.069)	0.343 (0.080)
Pahsimeroi	06 Mar-31 May	1,200	0.222 (0.024)	0.196 (0.030)	0.069 (0.021)	0.373 (0.040)
Red River	19 Mar-31 May	922	0.158 (0.029)	0.215 (0.036)	0.053 (0.021)	0.370 (0.063)
Salmon	10 Mar-11 May	5,201	0.281 (0.009)	0.196 (0.010)	0.114 (0.009)	0.419 (0.014)
Sawtooth	20 Mar-31 May	569	0.354 (0.038)	0.329 (0.045)	0.182 (0.042)	0.373 (0.063)
Snake	23 Mar-25 May	379	0.356 (0.035)	0.108 (0.034)	0.235 (0.042)	0.520 (0.059)
Spoolcart*	07 Mar-23 May	501	0.420 (0.051)	0.250 (0.059)	0.167 (0.062)	0.312 (0.082)

Table 26. Continued.

Trap	Release dates	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Wild steelhead			
American River	05 May-23 May	86	0.333 (0.136)	0.375 (0.171)	0.143 (0.132)	NA
Asotin Creek	11 Apr-19 May	1,818	0.344 (0.036)	NA	NA	0.163 (0.056)
Catherine Creek	31 Mar-11 May	349	0.419 (0.139)	0.270 (0.136)	NA	NA
Crooked Fork Creek	23 Mar-25 May	331	0.247 (0.033)	0.395 (0.047)	0.155 (0.040)	0.262 (0.054)
Clearwater	18 Mar-23 May	1,060	0.199 (0.018)	0.311 (0.032)	0.166 (0.030)	0.246 (0.036)
Grande Ronde	15 Mar-11 May	369	0.264 (0.035)	0.228 (0.040)	0.228 (0.054)	0.167 (0.054)
Imnaha (early)	23 Mar-25 May	6,524	0.310 (0.010)	0.370 (0.015)	0.214 (0.018)	0.148 (0.017)
Imnaha (late)	21 Mar-30 May	668	0.080 (0.050)	0.363 (0.177)	NA	0.500 (0.354)
Knox Bridge	08 Apr-31 May	647	0.333 (0.103)	0.062 (0.060)	NA	0.333 (0.192)
Lookingglass Creek	02 Mar-31 May	299	0.269 (0.060)	0.171 (0.069)	0.183 (0.091)	0.200 (0.103)
Minam River	26 Mar-31 May	295	0.205 (0.073)	0.104 (0.092)	0.195 (0.114)	0.182 (0.116)
Pahsimeroi	11 Mar-09 May	647	0.490 (0.112)	0.125 (0.114)	NA	NA
Salmon	10 Mar-24 May	407	0.221 (0.030)	0.307 (0.040)	0.077 (0.027)	0.177 (0.048)
Snake	11 Mar-31 May	964	0.310 (0.022)	0.260 (0.025)	0.166 (0.027)	0.170 (0.036)
Spoolcart*	01 Jun-21 Jun	600	0.344 (0.059)	0.338 (0.087)	0.282 (0.116)	0.091 (0.087)
			Hatchery Chinook salmon			
Grande Ronde	05 May-23 May	1,406	0.228 (0.016)	0.196 (0.016)	0.100 (0.012)	0.320 (0.022)
Salmon	11 Apr-19 May	3,937	0.240 (0.010)	0.136 (0.008)	0.111 (0.008)	0.375 (0.015)
Snake	31 Mar-11 May	1,666	0.276 (0.014)	0.185 (0.013)	0.138 (0.013)	0.379 (0.022)
			Hatchery steelhead			
Grande Ronde	05 May-23 May	1,528	0.188 (0.014)	0.350 (0.021)	0.290 (0.026)	0.066 (0.016)
Imnaha	11 Apr-19 May	1,492	0.211 (0.014)	0.390 (0.022)	0.228 (0.024)	0.068 (0.016)
Salmon	31 Mar-11 May	2,298	0.186 (0.011)	0.401 (0.018)	0.233 (0.021)	0.101 (0.017)
Snake	23 Mar-25 May	2,545	0.280 (0.012)	0.392 (0.017)	0.253 (0.020)	0.079 (0.015)

* Grande Ronde River

Table 27. Estimated survival probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2007. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: Rel-Release site; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Hatchery	Release site	Number released	Rel to MCN	MCN to JDA	JDA to BON	MCN to BON	Rel to BON
			Yearling Chinook salmon				
Cle Elum	Yakima R. (rkm 27)	12,860	0.334 (0.009)	0.930 (0.049)	0.715 (0.152)	0.665 (0.139)	0.222 (0.046)
Cle Elum	Yakima R. (rkm 325)	12,931	0.285 (0.008)	0.837 (0.047)	0.869 (0.234)	0.727 (0.194)	0.207 (0.055)
Cle Elum	Jack Creek Pond	12,959	0.296 (0.008)	0.858 (0.047)	0.759 (0.194)	0.651 (0.164)	0.193 (0.048)
East Bank	Chiwawa Pond (4/13)	4,988	0.636 (0.028)	0.896 (0.081)	0.721 (0.212)	0.645 (0.185)	0.410 (0.117)
East Bank	Chiwawa Pond (5/1)	4,992	0.659 (0.028)	1.041 (0.094)	0.569 (0.133)	0.592 (0.132)	0.390 (0.086)
Entiat	Entiat Hatchery	999	0.321 (0.035)	0.642 (0.116)	NA	NA	NA
Leavenworth	Leavenworth Hatchery	14,968	0.594 (0.011)	0.868 (0.033)	0.908 (0.136)	0.789 (0.117)	0.468 (0.069)
Wells	Wells Hatchery (5/17)	5,983	0.267 (0.042)	1.012 (0.322)	0.626 (0.604)	0.634 (0.593)	0.169 (0.156)
Wells	Wells Hatchery (6/15)	5,882	0.260 (0.068)	4.511 (4.610)	NA	NA	NA
Winthrop	Winthrop NFH	3,833	0.492 (0.022)	0.857 (0.083)	0.838 (0.356)	0.718 (0.300)	0.354 (0.147)
			Sockeye salmon				
East Bank	Wenatchee R. (rkm 9)	14,859	0.299 (0.013)	1.013 (0.087)	0.837 (0.134)	0.848 (0.125)	0.253 (0.036)
			Steelhead				
Cassimer Bar	Okanagon R.	9,878	0.179 (0.017)	0.921 (0.213)	0.457 (0.179)	0.421 (0.145)	0.075 (0.025)
Cassimer Bar	Omak Creek	9,911	0.260 (0.022)	0.708 (0.114)	0.580 (0.150)	0.411 (0.096)	0.107 (0.024)
Chelan	Wenatchee R (rkm 0)	1,497	0.338 (0.074)	0.756 (0.250)	0.713 (0.380)	0.539 (0.281)	0.182 (0.087)
East Bank	Wenatchee R. (rkm 0)	1,563	0.386 (0.119)	0.903 (0.459)	1.037 (1.059)	0.936 (0.925)	0.361 (0.339)
Turtle Rock	Chiwawa River	4,164	0.534 (0.059)	0.810 (0.143)	0.864 (0.278)	0.700 (0.217)	0.374 (0.109)
Turtle Rock	Nason Creek	7,306	0.424 (0.033)	1.155 (0.174)	0.475 (0.115)	0.549 (0.120)	0.233 (0.048)
Turtle Rock	Wenatchee R. (rkm 75)	13,629	0.659 (0.046)	1.040 (0.122)	0.662 (0.118)	0.689 (0.115)	0.454 (0.069)

Table 27. Continued.

Hatchery	Release Site	Number released	Rel to MCN	MCN to JDA	JDA to BON	MCN to BON	Rel to BON
			Coho Salmon				
Cascade	Leavenworth Hatchery	2,879	0.269 (0.030)	0.659 (0.118)	1.116 (0.498)	0.736 (0.322)	0.198 (0.084)
Cascade	Nason Creek	3,408	0.334 (0.044)	0.879 (0.170)	0.778 (0.335)	0.684 (0.291)	0.228 (0.093)
Cascade	Wenatchee R. (rkm 76)	3,130	0.474 (0.060)	0.916 (0.178)	0.814 (0.282)	0.745 (0.252)	0.353 (0.111)
Eagle Creek	Natches River (rkm 10)	2,464	0.322 (0.034)	1.256 (0.301)	0.836 (0.577)	1.050 (0.696)	0.338 (0.222)
Eagle Creek	Natches River (rkm 62)	2,481	0.449 (0.106)	0.593 (0.195)	NA	NA	NA
Eagle Creek	Yakima River (rkm 75)	1,246	0.545 (0.046)	0.840 (0.127)	0.590 (0.256)	0.495 (0.209)	0.270 (0.112)
Eagle Creek	Yakima River (rkm 256)	2,479	0.090 (0.025)	0.923 (0.528)	0.339 (0.250)	0.312 (0.187)	0.028 (0.015)
Willard	Leavenworth Hatchery	9,038	0.422 (0.030)	1.049 (0.139)	0.582 (0.119)	0.610 (0.112)	0.257 (0.044)
Willard	Nason Creek (4/27)	3,494	0.334 (0.050)	0.767 (0.179)	0.850 (0.349)	0.652 (0.260)	0.218 (0.081)
Willard	Nason Creek (5/7)	3,992	0.298 (0.043)	0.830 (0.182)	1.105 (0.585)	0.917 (0.479)	0.273 (0.137)
Willard	Wenatchee R. (rkm 76)	3,116	0.439 (0.087)	0.711 (0.205)	0.975 (0.629)	0.694 (0.445)	0.305 (0.186)
Yakima	Natches River (rkm 10)	2,398	0.239 (0.030)	0.781 (0.189)	1.255 (1.208)	0.979 (0.928)	0.234 (0.220)
Yakima	Natches River (rkm 62)	2,484	0.162 (0.021)	1.174 (0.413)	0.501 (0.479)	0.588 (0.533)	0.095 (0.086)
Yakima	Yakima River (rkm 75)	2,498	0.527 (0.025)	0.821 (0.086)	0.860 (0.462)	0.706 (0.375)	0.372 (0.197)
Yakima	Yakima River (rkm 256)	1,201	0.082 (0.030)	0.587 (0.325)	NA	NA	NA

Table 28. Estimated detection probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2007. Estimates based on the single-release model. Standard errors in parentheses.

Hatchery	Release Site	Number released	McNary Dam	John Day Dam	Bonneville Dam
		Yearling Chinook salmon			
Cle Elum	Yakima R. (rkm 27)	12,860	0.337 (0.011)	0.428 (0.022)	0.145 (0.031)
Cle Elum	Yakima R. (rkm 325)	12,931	0.336 (0.012)	0.462 (0.024)	0.122 (0.033)
Cle Elum	Jack Creek Pond	12,959	0.363 (0.012)	0.448 (0.024)	0.151 (0.038)
East Bank	Chiwawa Pond (4/13)	4,988	0.266 (0.014)	0.262 (0.022)	0.167 (0.048)
East Bank	Chiwawa Pond (5/1)	4,992	0.259 (0.013)	0.239 (0.020)	0.189 (0.042)
Entiat	Entiat Hatchery	999	0.328 (0.042)	0.536 (0.085)	NA
Leavenworth	Leavenworth Hatchery	14,968	0.323 (0.008)	0.384 (0.014)	0.150 (0.022)
Wells	Wells Hatchery (5/17)	5,983	0.120 (0.020)	0.074 (0.021)	0.143 (0.132)
Wells	Wells Hatchery (6/15)	5,882	0.074 (0.020)	0.012 (0.012)	NA
Winthrop	Winthrop NFH	3,833	0.318 (0.017)	0.396 (0.036)	0.099 (0.042)
		Sockeye salmon			
East Bank	Wenatchee R. (rkm 9)	14,859	0.229 (0.011)	0.136 (0.011)	0.20 (0.029)
		Steelhead			
Cassimer Bar	Okanagon R.	9,878	0.220 (0.023)	0.103 (0.023)	0.201 (0.068)
Cassimer Bar	Omak Creek	9,911	0.197 (0.018)	0.127 (0.019)	0.247 (0.055)
Chelan	Wenatchee R (rkm 0)	1,497	0.115 (0.029)	0.126 (0.035)	0.303 (0.146)
East Bank	Wenatchee R. (rkm 0)	1,563	0.084 (0.028)	0.076 (0.033)	0.102 (0.096)
Turtle Rock	Chiwawa River	4,164	0.112 (0.014)	0.100 (0.016)	0.220 (0.065)
Turtle Rock	Nason Creek	7,306	0.140 (0.012)	0.095 (0.013)	0.262 (0.055)
Turtle Rock	Wenatchee River (rkm 75)	13,629	0.079 (0.006)	0.067 (0.007)	0.198 (0.030)

Table 28. Continued.

Hatchery	Release Site	Number released	McNary Dam	John Day Dam	Bonneville Dam
			Coho salmon		
Cascade	Leavenworth Hatchery	2,879	0.212 (0.027)	0.186 (0.031)	0.255 (0.110)
Cascade	Nason Creek	3,408	0.104 (0.016)	0.118 (0.020)	0.333 (0.136)
Cascade	Wenatchee R. (rkm 76)	3,130	0.096 (0.014)	0.091 (0.016)	0.294 (0.093)
Eagle Creek	Natches River (rkm 10)	2,464	0.228 (0.027)	0.136 (0.032)	0.125 (0.083)
Eagle Creek	Natches River (rkm 62)	2,481	0.079 (0.020)	0.147 (0.036)	NA
Eagle Creek	Yakima River (rkm 75)	1,246	0.270 (0.028)	0.332 (0.046)	0.275 (0.116)
Eagle Creek	Yakima River (rkm 256)	2,479	0.188 (0.056)	0.097 (0.053)	0.400 (0.219)
Willard	Leavenworth Hatchery	9,038	0.134 (0.011)	0.077 (0.010)	0.309 (0.053)
Willard	Nason Creek (4/27)	3,494	0.103 (0.018)	0.090 (0.019)	0.297 (0.111)
Willard	Nason Creek (5/7)	3,992	0.098 (0.016)	0.093 (0.018)	0.232 (0.117)
Willard	Wenatchee R. (rkm 76)	3,116	0.066 (0.015)	0.067 (0.016)	0.250 (0.153)
Yakima	Natches River (rkm 10)	2,398	0.251 (0.035)	0.231 (0.052)	0.100 (0.095)
Yakima	Natches River (rkm 62)	2,484	0.296 (0.043)	0.157 (0.054)	0.170 (0.155)
Yakima	Yakima River (rkm 75)	2,498	0.381 (0.021)	0.409 (0.041)	0.135 (0.072)
Yakima	Yakima River (rkm 256)	1,201	0.192 (0.077)	0.345 (0.159)	NA

Table 29. Travel time statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2007. 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 (d)				LGO to LMO (d)				LMO to MCN (d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
23 Mar–29 Mar	17	12.2	16.3	19.1	2	2.8	3.1	3.3	0	NA	NA	NA
30 Mar–05 Apr	59	10.9	13.2	15.9	4	2.9	4.0	5.3	4	4.3	5.2	12.2
06 Apr–12 Apr	658	6.8	8.2	13.3	23	2.9	3.8	14.2	33	3.1	4.0	5.2
13 Apr–19 Apr	1,332	6.0	7.4	10.3	54	2.8	4.0	5.6	82	3.0	3.8	5.0
20 Apr–26 Apr	1,821	6.0	7.2	9.1	275	1.7	2.1	2.7	667	2.8	3.2	4.1
27 Apr–03 May	4,693	4.1	4.8	6.2	475	1.6	1.9	2.5	692	2.8	3.2	4.1
04 May–10 May	5,792	4.4	5.2	6.3	1,369	1.3	1.6	2.1	1,877	2.6	3.0	3.7
11 May–17 May	5,395	3.9	4.7	5.8	660	1.3	1.7	2.2	924	2.6	3.1	4.0
18 May–24 May	340	3.9	4.7	6.1	12	1.4	1.6	2.0	25	3.0	3.4	4.2
25 May–31 May	32	4.2	5.3	6.1	0	NA	NA	NA	0	NA	NA	NA

	LGR to MCN (d)				LGR to BON (d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%
23 Mar–29 Mar	10	25.2	32.1	34.3	2	41.3	47.5	53.6
30 Mar–05 Apr	56	22.1	25.0	28.4	13	26.8	29.3	34.4
06 Apr–12 Apr	904	16.4	20.1	26.3	245	24.1	28.8	33.4
13 Apr–19 Apr	2,657	12.4	15.0	19.9	795	18.5	21.8	27.2
20 Apr–26 Apr	4,853	11.0	12.3	14.7	1,429	15.9	17.7	20.4
27 Apr–03 May	9,508	8.7	9.9	11.6	3,196	12.9	14.1	16.0
04 May–10 May	9,133	8.9	9.9	11.2	2,766	12.8	14.0	15.7
11 May–17 May	7,476	8.0	9.0	10.4	2,006	11.7	13.0	14.8
18 May–24 May	471	8.7	10.7	13.0	123	12.3	15.0	17.2
25 May–31 May	44	9.8	10.9	13.0	9	13.2	13.7	14.7

Table 30. Migration rate statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2007. Abbreviations: LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam; BON–Bonneville Dam; N–Number of fish observed; Med–Median.

	LGR to LGO (km/d)				LGO to LMO (km/d)				LMO to MCN (km/d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
23 Mar–29 Mar	17	3.1	3.7	4.9	2	13.8	15.0	16.4	0	NA	NA	NA
30 Mar–05 Apr	59	3.8	4.6	5.5	4	8.6	11.4	15.8	4	9.7	22.9	27.6
06 Apr–12 Apr	658	4.5	7.3	8.8	23	3.3	12.0	16.1	33	22.9	29.5	38.5
13 Apr–19 Apr	1,332	5.8	8.1	9.9	54	8.2	11.5	16.7	82	23.9	31.1	39.7
20 Apr–26 Apr	1,821	6.6	8.4	9.9	275	17.2	22.1	26.4	667	28.9	37.1	42.7
27 Apr–03 May	4,693	9.7	12.5	14.5	475	18.8	23.7	29.1	692	29.2	36.6	43.3
04 May–10 May	5,792	9.5	11.5	13.7	1,369	22.0	27.9	35.7	1,877	32.1	39.1	46.5
11 May–17 May	5,395	10.3	12.7	15.5	660	21.3	27.5	34.8	924	29.9	37.9	45.8
18 May–24 May	340	9.9	12.8	15.3	12	22.4	28.6	31.7	25	28.0	35.5	39.0
25 May–31 May	32	9.9	11.4	14.4	0	NA	NA	NA	0	NA	NA	NA

	LGR to MCN (km/d)				LGR to BON (km/d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%
23 Mar–29 Mar	10	6.6	7.0	8.9	2	8.6	9.7	11.2
30 Mar–05 Apr	56	7.9	9.0	10.2	13	13.4	15.7	17.2
06 Apr–12 Apr	904	8.5	11.2	13.8	245	13.8	16.0	19.2
13 Apr–19 Apr	2,657	11.3	15.0	18.2	795	16.9	21.1	25.0
20 Apr–26 Apr	4,853	15.3	18.3	20.4	1,429	22.6	26.1	28.9
27 Apr–03 May	9,508	19.4	22.8	25.9	3,196	28.8	32.6	35.8
04 May–10 May	9,133	20.1	22.6	25.4	2,766	29.3	32.9	36.1
11 May–17 May	7,476	21.5	25.0	28.3	2,006	31.2	35.6	39.3
18 May–24 May	471	17.3	21.0	25.9	123	26.8	30.7	37.5
25 May–31 May	44	17.3	20.6	22.9	9	31.4	33.6	35.0

Table 31. Travel time statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Abbreviations: N–number of fish on which statistics are based; Med.-median.

Date at Lower	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Granite Dam	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr–19 Apr	20	4.8	5.7	9.6	1	2.2	2.2	2.2	3	5.6	5.9	6.7
20 Apr–26 Apr	568	4.7	5.6	7.1	51	1.8	1.9	2.3	125	6.7	7.2	8.2
27 Apr–03 May	5,374	4.0	4.7	5.7	731	1.8	2.0	2.3	1,376	5.7	6.4	7.8
04 May–10 May	13,366	3.9	4.5	5.4	1,803	1.6	1.8	2.1	4,920	5.1	5.9	6.9
11 May–17 May	8,985	3.7	4.3	5.0	1,090	1.5	1.7	2.0	3,191	5.0	5.4	6.3
18 May–24 May	6,169	3.5	4.0	4.7	751	1.6	1.7	2.0	1,789	4.9	5.3	6.0
25 May–31 May	556	3.7	4.5	5.2	54	1.6	1.8	2.0	163	5.0	5.4	6.4
01 Jun–07 Jun	180	3.4	3.9	4.7	22	1.4	1.5	1.9	59	4.9	5.3	5.9
08 Jun–14 Jun	116	3.4	3.9	4.7	15	1.5	1.6	1.9	51	4.8	5.2	6.0
15 Jun–21 Jun	18	3.3	3.4	4.3	2	2.3	2.4	2.6	14	4.9	5.2	6.2

Table 32. Migration rate statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2007. Abbreviations: N–number of fish on which statistics are based; Med.–median.

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr–19 Apr	20	12.8	21.8	25.4	1	51.8	51.8	51.8	3	35.1	40.0	42.3
20 Apr–26 Apr	568	17.3	22.1	26.0	51	49.6	58.2	63.8	125	28.6	32.6	35.1
27 Apr–03 May	5,374	21.4	26.2	30.4	731	48.3	56.5	64.6	1,376	30.4	37.0	41.2
04 May–10 May	13,366	22.7	27.6	31.3	1,803	54.3	63.1	71.1	4,920	34.3	39.9	45.9
11 May–17 May	8,985	24.7	28.7	33.3	1,090	57.1	66.1	73.4	3,191	37.6	43.5	47.4
18 May–24 May	6,169	26.1	30.5	34.9	751	56.5	65.7	72.9	1,789	39.3	44.5	48.2
25 May–31 May	556	23.7	27.4	32.9	54	55.4	62.8	71.5	163	37.0	43.5	47.0
01 Jun–07 Jun	180	26.3	31.9	36.5	22	58.9	76.4	80.1	59	39.9	44.8	48.4
08 Jun–14 Jun	116	26.0	31.5	36.5	15	60.8	70.6	74.8	51	39.7	45.7	49.0
15 Jun–21 Jun	18	28.5	36.0	37.5	2	44.1	46.3	48.9	14	38.2	45.0	48.0

Table 33. Travel time statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. 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 (d)				LGO to LMO (d)				LMO to MCN (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	333	4.9	6.0	7.5	18	3.1	7.5	14.5	3	2.7	3.7	4.8
13 Apr–19 Apr	977	4.7	5.8	8.6	138	3.0	6.2	9.5	44	2.4	2.8	3.4
20 Apr–26 Apr	1,234	5.7	7.6	9.1	391	2.1	3.2	4.9	169	2.2	2.6	3.0
27 Apr–03 May	2,555	3.5	4.0	4.7	406	1.9	2.6	6.2	141	2.2	2.6	3.1
04 May–10 May	2,187	4.3	4.7	5.7	684	1.8	2.2	3.2	252	2.4	2.8	3.3
11 May–17 May	2,359	3.5	4.2	5.0	413	1.7	2.2	3.9	97	2.1	2.6	3.1
18 May–24 May	1,286	3.8	4.7	6.7	86	1.8	2.4	3.5	11	2.8	3.5	4.0
25 May–31 May	38	3.9	4.8	7.1	5	3.3	3.8	5.2	0	NA	NA	NA

	LGR to MCN (d)				LGR to BON (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	98	11.1	12.6	16.9	77	17.2	21.0	28.9
13 Apr–19 Apr	341	10.8	12.4	16.9	270	16.8	20.1	24.5
20 Apr–26 Apr	446	10.8	12.4	15.3	525	15.8	17.4	20.4
27 Apr–03 May	953	8.1	9.0	11.4	696	12.0	13.4	18.3
04 May–10 May	733	8.4	9.6	11.0	482	13.1	15.1	19.3
11 May–17 May	532	7.5	8.7	11.6	552	12.3	14.3	18.8
18 May–24 May	201	9.3	11.4	13.7	212	13.8	17.0	23.3
25 May–31 May	5	10.9	12.4	12.9	2	15.0	15.4	15.8

Table 34. Migration rate statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. 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/d)				LGO to LMO (km/d)				LMO to MCN (km/d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	333	8.0	10.0	12.2	18	3.2	6.1	15.0	3	24.8	31.9	43.8
13 Apr–19 Apr	977	6.9	10.4	12.8	138	4.8	7.4	15.4	44	35.1	43.1	49.0
20 Apr–26 Apr	1,234	6.6	7.9	10.6	391	9.5	14.2	21.9	169	39.7	45.8	54.1
27 Apr–03 May	2,555	12.9	15.1	16.9	406	7.4	17.6	24.2	141	38.6	45.9	53.1
04 May–10 May	2,187	10.5	12.7	13.8	684	14.5	20.8	25.6	252	36.3	42.0	49.4
11 May–17 May	2,359	12.0	14.3	17.0	413	11.8	20.7	27.1	97	38.5	45.4	56.4
18 May–24 May	1,286	9.0	12.7	16.0	86	13.0	19.1	25.4	11	29.8	33.9	42.7
25 May–31 May	38	8.4	12.5	15.4	5	8.8	12.1	13.8	0	NA	NA	NA

	LGR to MCN (km/d)				LGR to BON (km/d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	98	13.3	17.8	20.3	77	15.9	21.9	26.8
13 Apr–19 Apr	341	13.3	18.1	20.8	270	18.8	22.9	27.4
20 Apr–26 Apr	446	14.7	18.2	20.9	525	22.6	26.5	29.1
27 Apr–03 May	953	19.8	25.0	27.8	696	25.1	34.4	38.5
4 May–10 May	733	20.4	23.5	26.8	482	23.8	30.6	35.2
11 May–17 May	532	19.4	25.9	29.9	552	24.6	32.1	37.5
18 May–24 May	201	16.4	19.7	24.2	212	19.8	27.1	33.5
25 May–31 May	5	17.5	18.2	20.5	2	29.2	29.9	30.7

Table 35. Travel time statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at McNary Dam in 2007. Abbreviations: N–Number of fish on which statistics are based; Med.–Median.

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr–19 Apr	14	4.5	8.0	13.7	2	1.5	1.8	2.0	11	6.0	6.9	14.2
20 Apr–26 Apr	109	5.4	8.0	13.4	7	1.4	1.5	2.3	66	6.2	8.1	13.7
27 Apr–03 May	175	3.9	5.1	7.0	22	1.3	1.4	1.6	106	5.1	6.1	7.4
04 May–10 May	341	3.5	4.1	5.0	46	1.4	1.5	1.6	330	4.9	5.7	6.9
11 May–17 May	170	4.0	4.7	6.0	16	1.3	1.5	1.8	188	5.0	6.0	8.1
18 May–24 May	86	4.0	4.6	6.1	15	1.5	1.7	2.0	126	5.2	6.3	9.1
25 May–31 May	16	4.5	5.0	7.4	2	1.6	1.7	1.7	36	5.8	7.1	14.0
01 Jun–07 Jun	8	4.3	5.5	10.9	3	1.6	1.8	2.8	20	5.7	7.2	13.2
08 Jun–14 Jun	4	4.6	4.7	4.8	3	1.9	1.9	2.9	10	6.4	7.8	12.8

Table 36. Migration rate statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at McNary Dam in 2007. Abbreviations: N–Number of fish on which statistics are based; Med.–Median.

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr–19 Apr	14	9.0	15.5	27.2	2	55.9	64.6	76.4	11	16.6	34.2	39.0
20 Apr–26 Apr	109	9.1	15.4	22.7	7	48.3	74.3	81.3	66	17.2	29.1	37.8
27 Apr–03 May	175	17.6	24.0	31.7	22	71.1	78.5	85.0	106	31.9	38.5	46.4
04 May–10 May	341	24.5	29.7	35.2	46	68.9	74.8	81.3	330	34.4	41.2	48.3
11 May–17 May	170	20.7	26.5	30.9	16	63.1	76.4	84.3	188	29.0	39.7	46.7
18 May–24 May	86	20.1	26.9	31.0	15	57.4	66.5	76.4	126	25.8	37.7	45.2
25 May–31 May	16	16.7	24.6	27.3	2	65.7	67.7	69.8	36	16.9	33.1	40.6
01 Jun–07 Jun	8	11.3	22.4	28.9	3	40.6	63.1	72.4	20	17.9	32.9	41.4
08 Jun–14 Jun	4	25.4	26.5	26.8	3	39.4	59.2	60.8	10	18.5	30.3	37.0

Table 37. Number of PIT–tagged hatchery steelhead released at Lower Granite Dam by day for survival estimates in 2007. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost tags	Release date	Number released	Mortalities	Lost tags
10–Apr	96			17–May	466		
11–Apr	97			18–May	739	1	2
12–Apr	260			19–May	365		
18–Apr	711		1	23–May	731	1	
19–Apr	929			24–May	449		
20–Apr	109	1		25–May	574		
24–Apr	1,871	1		30–May	299	1	
25–Apr	2,013	2		31–May	299		1
26–Apr	3			1–Jun	313	1	
28–Apr	2			2–Jun	141		
1–May	26			5–Jun	151		
2–May	2,714	6		6–Jun	172		
3–May	296			7–Jun	153		
4–May	464			8–Jun	138	1	
5–May	228			9–Jun	38		
8–May	583	1		12–Jun	81		1
9–May	328			13–Jun	80		
10–May	793	1		14–Jun	81		
11–May	707			15–Jun	81		
12–May	805			16–Jun	77		
15–May	257		1				
16–May	632			Total	19,352	17	6

Table 38. Number of PIT–tagged wild steelhead released at Lower Granite Dam by day for survival estimates in 2007. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost tags	Release date	Number released	Mortalities	Lost tags
10–Apr	533			17–May	471		
11–Apr	15			18–May	522		
12–Apr	200			19–May	386		
18–Apr	291			23–May	472		
19–Apr	377			24–May	416		
20–Apr	71			25–May	469		
24–Apr	172			30–May	171		
25–Apr	17			31–May	173	1	
26–Apr	79			1–Jun	116		
28–Apr	185			2–Jun	114		
1–May	675			5–Jun	72		
2–May	254			6–Jun	60		
3–May	816			7–Jun	79	1	
4–May	232	1		8–Jun	44		
5–May	412			9–Jun	82		
8–May	605		1	12–Jun	69		
9–May	396			13–Jun	58		
10–May	529			14–Jun	41		
11–May	407			15–Jun	35		
12–May	161			16–Jun	39		
15–May	392						
16–May	574			Total	11,286	3	1

Table 39. Number of PIT–tagged wild yearling Chinook salmon released at Lower Granite Dam by day for survival estimates in 2007. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost tags
10–Apr	564	2		17–May	271		
11–Apr	508	2	1	18–May	174	4	
12–Apr	611	1		19–May	222		1
18–Apr	1,131	2	1	23–May	264		
19–Apr	1,615	6		24–May	100		
20–Apr	798			25–May	131		
24–Apr	941	4		30–May	79		
25–Apr	213			31–May	85		
26–Apr	585	3	2	1–Jun	33		
28–Apr	1,087	6	2	2–Jun	23		
1–May	278						
2–May	306						
3–May	425						
4–May	410	1					
5–May	331	1					
8–May	277						
9–May	350						
10–May	354						
11–May	634	1					
12–May	264	1					
15–May	587	1					
16–May	925			Total	14,576	37	7

Table 40. Estimated survival for yearling Chinook salmon from selected Snake River Basin hatcheries to the tailrace of Lower Granite Dam, 1993–2007. Distance from each hatchery to Lower Granite Dam in parentheses in header. Standard errors in parentheses following each survival estimate.

Year	Dworshak (116)	Kooskia (176)	Lookingglass* (209)	Rapid River (283)	McCall (457)	Pahsimeroi (630)	Sawtooth (747)	Mean
1993	0.647 (0.028)	0.689 (0.047)	0.660 (0.025)	0.670 (0.017)	0.498 (0.017)	0.456 (0.032)	0.255 (0.023)	0.554 (0.060)
1994	0.778 (0.020)	0.752 (0.053)	0.685 (0.021)	0.526 (0.024)	0.554 (0.022)	0.324 (0.028)	0.209 (0.014)	0.547 (0.081)
1995	0.838 (0.034)	0.786 (0.024)	0.617 (0.015)	0.726 (0.017)	0.522 (0.011)	0.316 (0.033)	0.230 (0.015)	0.576 (0.088)
1996	0.776 (0.017)	0.744 (0.010)	0.567 (0.014)	0.588 (0.007)	0.531 (0.007)	C	0.121 (0.017)	0.555 (0.096)
1997	0.576 (0.017)	0.449 (0.034)	0.616 (0.017)	0.382 (0.008)	0.424 (0.008)	0.500 (0.008)	0.508 (0.037)	0.494 (0.031)
1998	0.836 (0.006)	0.652 (0.024)	0.682 (0.006)	0.660 (0.004)	0.585 (0.004)	0.428 (0.021)	0.601 (0.033)	0.635 (0.046)
1999	0.834 (0.011)	0.653 (0.031)	0.668 (0.009)	0.746 (0.006)	0.649 (0.008)	0.584 (0.035)	0.452 (0.019)	0.655 (0.045)
2000	0.841 (0.009)	0.734 (0.027)	0.688 (0.011)	0.748 (0.007)	0.689 (0.010)	0.631 (0.062)	0.546 (0.030)	0.697 (0.035)
2001	0.747 (0.002)	0.577 (0.019)	0.747 (0.003)	0.689 (0.002)	0.666 (0.002)	0.621 (0.016)	0.524 (0.023)	0.653 (0.032)
2002	0.819 (0.011)	0.787 (0.036)	0.667 (0.012)	0.755 (0.003)	0.592 (0.006)	0.678 (0.053)	0.387 (0.025)	0.669 (0.055)
2003	0.720 (0.008)	0.560 (0.043)	0.715 (0.012)	0.691 (0.007)	0.573 (0.006)	0.721 (0.230)	0.595 (0.149)	0.654 (0.028)
2004	0.821 (0.003)	0.769 (0.017)	0.613 (0.004)	0.694 (0.003)	0.561 (0.002)	0.528 (0.017)	0.547 (0.018)	0.648 (0.044)
2005	0.823 (0.003)	0.702 (0.021)	0.534 (0.004)	0.735 (0.002)	0.603 (0.003)	0.218 (0.020)	0.220 (0.020)	0.549 (0.092)
2006	0.853 (0.007)	0.716 (0.041)	0.639 (0.014)	0.764 (0.004)	0.634 (0.006)	0.262 (0.024)	0.651 (0.046)	0.645 (0.071)
2007	0.817 (0.007)	0.654 (0.015)	0.682 (0.010)	0.748 (0.004)	0.554 (0.007)	0.530 (0.038)	0.581 (0.015)	0.652 (0.040)
Mean	**0.782 (0.021)**	**0.682 (0.024)**	**0.652 (0.014)**	**0.675 (0.027)**	**0.576 (0.018)**	**0.484 (0.042)**	**0.430 (0.046)**	**0.618 (0.031)**

* Released at Imnaha River Weir.

Table 41. Annual weighted means of survival probability estimates for yearling Chinook salmon (hatchery and wild combined), 1993–2007. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.828 (0.013)	0.854 (0.012)						
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)					
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.925 (0.009)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.940 (0.009)	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.929 (0.014)	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.954 (0.015)	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
2006	0.952 (0.011)	0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.942	0.881 (0.020)	0.944 (0.030	0.972
2007	0.943 (0.028)	0.938 (0.006)	0.957 (0.010)	0.876 (0.012)	0.978	0.920 (0.016)	0.824 (0.043)	0.908
Mean	**0.932 (0.011)**	**0.924 (0.010)**	**0.903 (0.011)**	**0.855 (0.019)**	**0.927**	**0.851 (0.018)**	**0.815 (0.040)**	**0.901**
Excl. 2001	0.930 (0.011)	0.922 (0.011)	0.908 (0.011)	0.867 (0.015)	0.934	0.862 (0.017)	0.836 (0.038)	0.913

Table 42. Annual weighted means of survival probability estimates for steelhead (hatchery and wild combined), 1993–2007. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.905 (0.006)							
1994	NA	0.844 (0.011)	0.892 (0.011)					
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.924 (0.009)	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.908 (0.011)	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.964 (0.013)	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.911 (0.007)	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
2005	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
2006	0.920 (0.013)	0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.899	0.795 (0.045)	0.813 (0.083)	0.902
2007	1.016 (0.026)	0.887 (0.009)	0.911 (0.022)	0.852 (0.030)	0.955	0.988 (0.098)	0.579 (0.059)	0.761
Mean	**0.942 (0.009)**	**0.905 (0.013)**	**0.887 (0.016)**	**0.732 (0.045)**	**0.851**	**0.751 (0.067)**	**0.720 (0.042)**	**0.846**
Excl. 2001	0.945 (0.009)	0.913 (0.011)	0.900 (0.010)	0.768 (0.029)	0.877	0.797 (0.055)	0.715 (0.048)	0.843

Table 43. Hydropower system survival estimates derived by combining empirical survival estimates from various reaches for Snake River yearling Chinook salmon and steelhead (hatchery and wild combined), 1997–2007. Standard errors in parentheses. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; BON–Bonneville Dam.

	Yearling Chinook Salmon			Steelhead		
Year	Trap–LGR	LGR–BON	Trap–BON	Trap–LGR	LGR–BON	Trap–BON
1997	NA	NA	NA	0.964 (0.015)	0.474 (0.069)	0.457 (0.067)
1998	0.925 (0.009)	NA	NA	0.924 (0.009)	0.500 (0.054)	0.462 (0.050)
1999	0.940 (0.009)	0.557 (0.046)	0.524 (0.043)	0.908 (0.011)	0.440 (0.018)	0.400 (0.016)
2000	0.929 (0.014)	0.486 (0.093)	0.452 (0.087)	0.964 (0.013)	0.393 (0.034)	0.379 (0.032)
2001	0.954 (0.015)	0.279 (0.016)	0.266 (0.015)	0.911 (0.007)	0.042 (0.003)	0.038 (0.003)
2002	0.953 (0.022)	0.578 (0.060)	0.551 (0.057)	0.895 (0.015)	0.262 (0.050)	0.234 (0.045)
2003	0.993 (0.023)	0.532 (0.023)	0.528 (0.023)	0.932 (0.015)	0.309 (0.011)	0.288 (0.011)
2004	0.893 (0.009)	0.395 (0.050)	0.353 (0.045)	0.948 (0.004)	NA	NA
2005	0.919 (0.015)	0.577 (0.068)	0.530 (0.063)	0.967 (0.004)	NA	NA
2006	0.952 (0.011)	0.643 (0.017)	0.612 (0.016)	0.920 (0.013)	0.455 (0.056)	0.418 (0.052)
2007	0.943 (0.028)	0.597 (0.035)	0.563 (0.037)	1.016 (0.026)	0.364 (0.045)	0.369 (0.047)

Table 44. Estimated survival and detection probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

		Survival probability		
Date at Lower Granite	Number released	Lower Monumental to Ice Harbor Dam	Ice Harbor to McNary Dam	Detection probability Ice Harbor Dam
23 Mar–29 Mar	56	0.333 (0.272)	1.524 (0.349)	0.048 (0.046)
30 Mar–05 Apr	268	0.667 (0.192)	1.604 (0.179)	0.020 (0.014)
06 Apr–12 Apr	3,134	0.784 (0.085)	1.119 (0.089)	0.021 (0.004)
13 Apr–19 Apr	9,142	0.893 (0.068)	0.956 (0.057)	0.021 (0.002)
20 Apr–26 Apr	15,956	0.954 (0.027)	0.999 (0.026)	0.066 (0.003)
27 Apr–03 May	34,853	0.983 (0.028)	0.944 (0.024)	0.042 (0.002)
04 May–10 May	33,902	0.932 (0.020)	0.922 (0.020)	0.068 (0.002)
11 May–17 May	25,878	0.864 (0.027)	0.923 (0.026)	0.043 (0.002)
18 May–24 May	1,786	0.721 (0.120)	1.108 (0.150)	0.032 (0.006)
Weighted mean*		**0.930 (0.017)**	**0.959 (0.030)**	**0.044 (0.006)**

* Weighted means of the independent estimates for weekly pooled groups (23 March –24 May), with weights inversely proportional to respective estimated relative variances.

Table 45. Estimated survival and detection probabilities for Snake River Steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Survival probability		Detection probability
		Lower Monumental to Ice Harbor Dam	Ice Harbor Dam to McNary Dam	Ice Harbor Dam
06 Apr–12 Apr	754	0.881 (0.528)	0.965 (0.546)	0.009 (0.006)
13 Apr–19 Apr	2,717	0.837 (0.152)	0.962 (0.174)	0.025 (0.006)
20 Apr–26 Apr	4,468	0.933 (0.074)	1.050 (0.102)	0.066 (0.007)
27 Apr–03 May	6,966	0.904 (0.076)	0.988 (0.088)	0.048 (0.005)
04 May–10 May	6,484	0.828 (0.071)	0.871 (0.085)	0.064 (0.006)
11 May–17 May	6,591	1.040 (0.140)	0.805 (0.120)	0.036 (0.005)
18 May–24 May	4,479	0.838 (0.243)	0.977 (0.306)	0.024 (0.007)
Weighted mean*		**0.902 (0.026)**	**0.953 (0.033)**	**0.039 (0.007)**

* Weighted means of the independent estimates for weekly pooled groups (06 April –24 May), with weights inversely proportional to respective estimated relative variances.

Table 46. Average survival estimates (with standard errors in parentheses) from McNary Dam tailrace to Bonneville Dam tailrace for various spring–migrating salmonid stocks (hatchery and wild combined) in 2007 that were detected and returned to the tailrace at McNary Dam. For each reach, the survival estimate represents a weighted average of daily or weekly estimates (some of which are presented in other tables in this document). Dam release sites are in tailraces. Abbreviations: Sp–spring Chinook salmon; Sp–Su–spring/summer; S–F–summer/fall Chinook salmon.

Stock	Initial release location	Number released from McNary Dam	Survival estimates (standard errors)		
			McNary to John Dam Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
Snake R. Chinook (Sp–Su)	Snake River sites[a]	99,447	0.920 (0.016)	0.824 (0.043)	0.763 (0.044)
U. Columbia Chinook (S–F)	Upper Columbia sites[b]	7,223	0.891 (0.033)	0.862 (0.145)	0.761 (0.138)
U. Columbia Chinook (S–F)	Yakima River sites[c]	6,070	0.832 (0.031)	0.772 (0.220)	0.578 (0.206)
Upper Columbia Coho	Upper Columbia sites	1,204	0.811 (0.094)	1.365 (0.279)	1.142 (0.158)
Upper Columbia Coho	Yakima River sites	1,638	0.853 (0.095)	0.453 (0.094)	0.424 (0.048)
Snake River Steelhead	Snake River sites	7,057	0.988 (0.098)	0.579 (0.059)	0.524 (0.064)
Upper Columbia Steelhead	Upper Columbia sites	3,032	0.821 (0.170)	0.530 (0.091)	0.408 (0.047)

a. Snake River sites include any release sites on the Snake River or its tributaries.
b. Upper Columbia sites include any release sites on the Columbia River or its tributaries that are above the confluence with the Yakima River.
c. Yakima River sites include any release sites on the Yakima River or its tributaries.

Table 47. Percentage of PIT–tagged smolts (wild and hatchery combined) detected at Lower Monumental Dam later detected on McNary pool bird colonies, 1998-2007.

Year	Yearling Chinook salmon	Steelhead
1998	0.49	4.20
1999	0.90	4.51
2000	0.98	3.66
2001	5.59	21.06
2002	1.62	10.09
2003[a]	1.06	3.71
2004[b]	2.08	19.42
2005	1.37	9.15
2006	0.92	4.81
2007	0.80	3.59

[a] Only Crescent Island Caspian tern colony sampled.

[b] Only Crescent Island and Foundation Island colonies sampled.

FIGURES

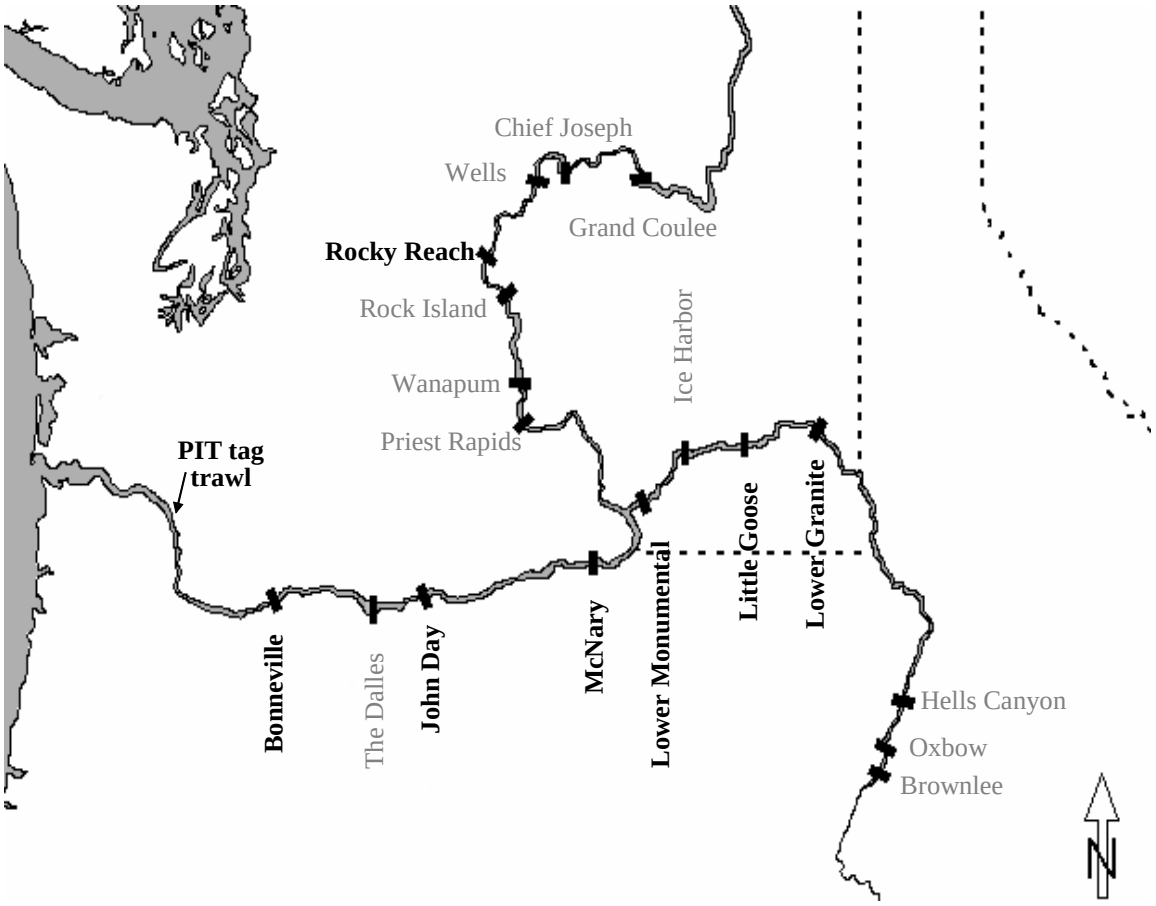

Figure 1. Study area showing sites with PIT-tag detection facilities (names in black), including dams and the PIT-tag trawl in the Columbia River estuary. Dams with names in gray do not have detection facilities.

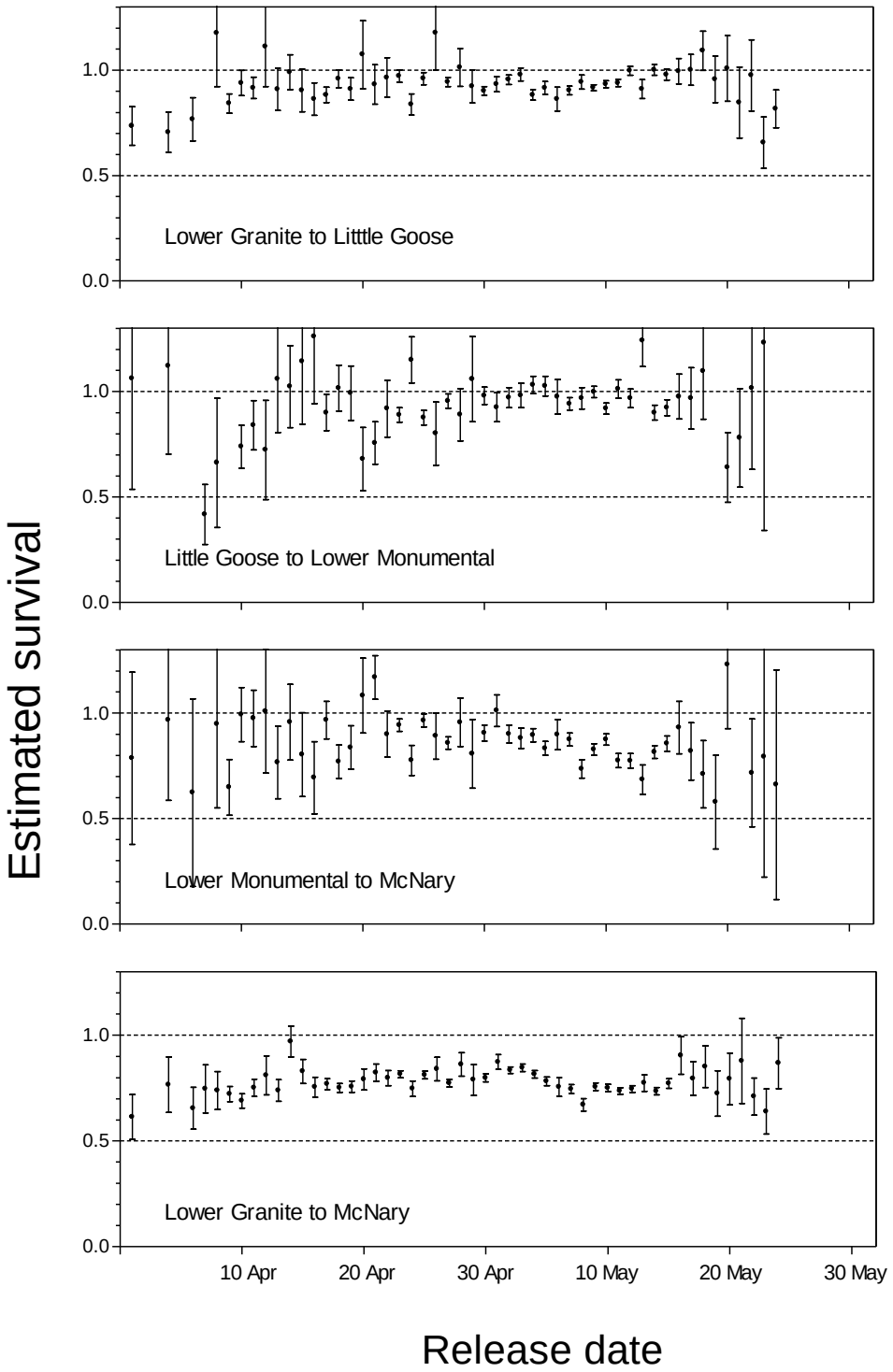

Figure 2. Estimated survival through various reaches vs. release date at Lower Granite Dam for daily release groups of Snake River yearling Chinook salmon, 2007. Bars extend one standard error above and below point estimates.

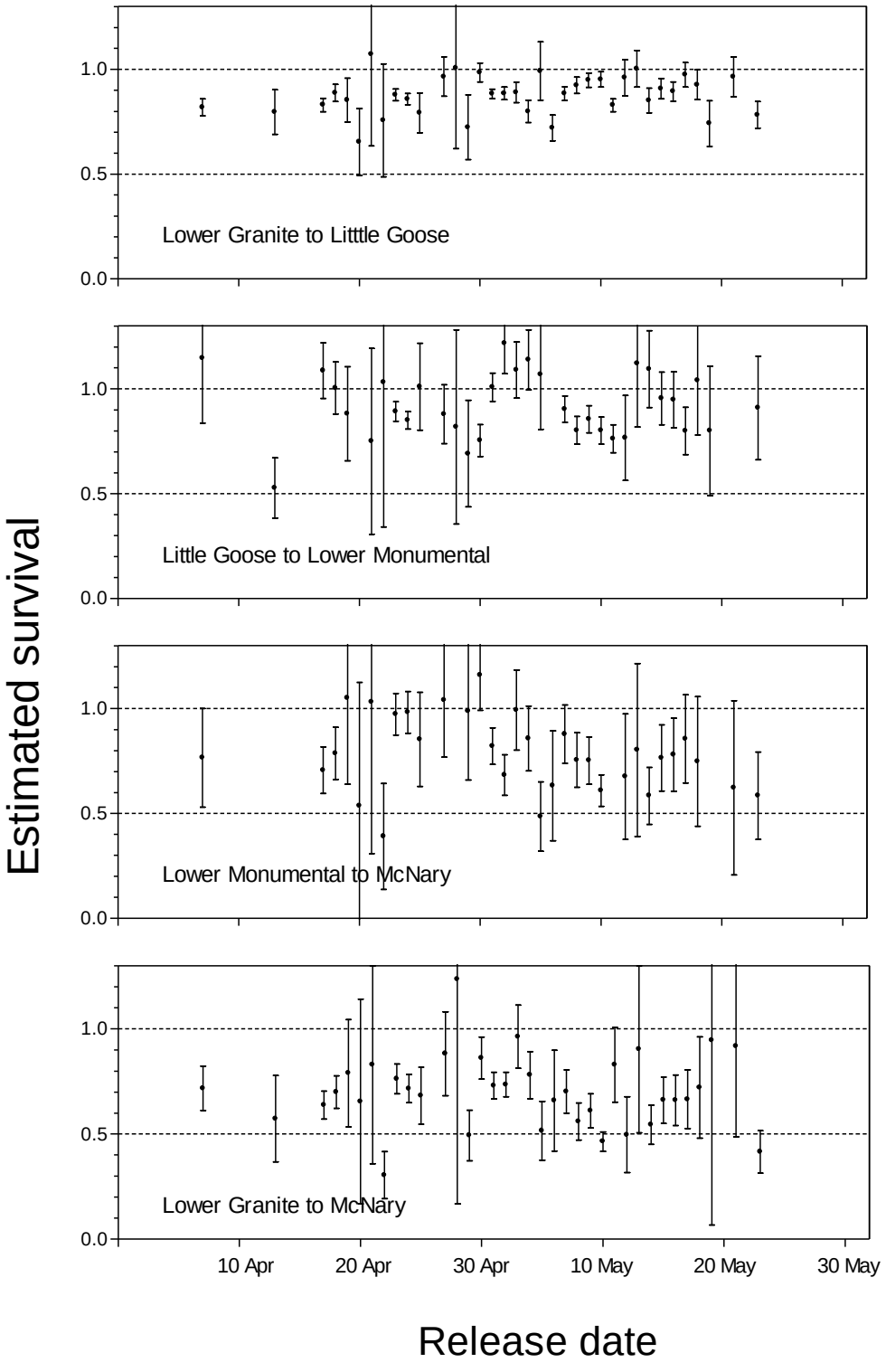

Figure 3. Estimated survival through various reaches versus release date at Lower Granite Dam for daily release groups of Snake River steelhead, 2007. Bars extend one standard error above and below point estimates.

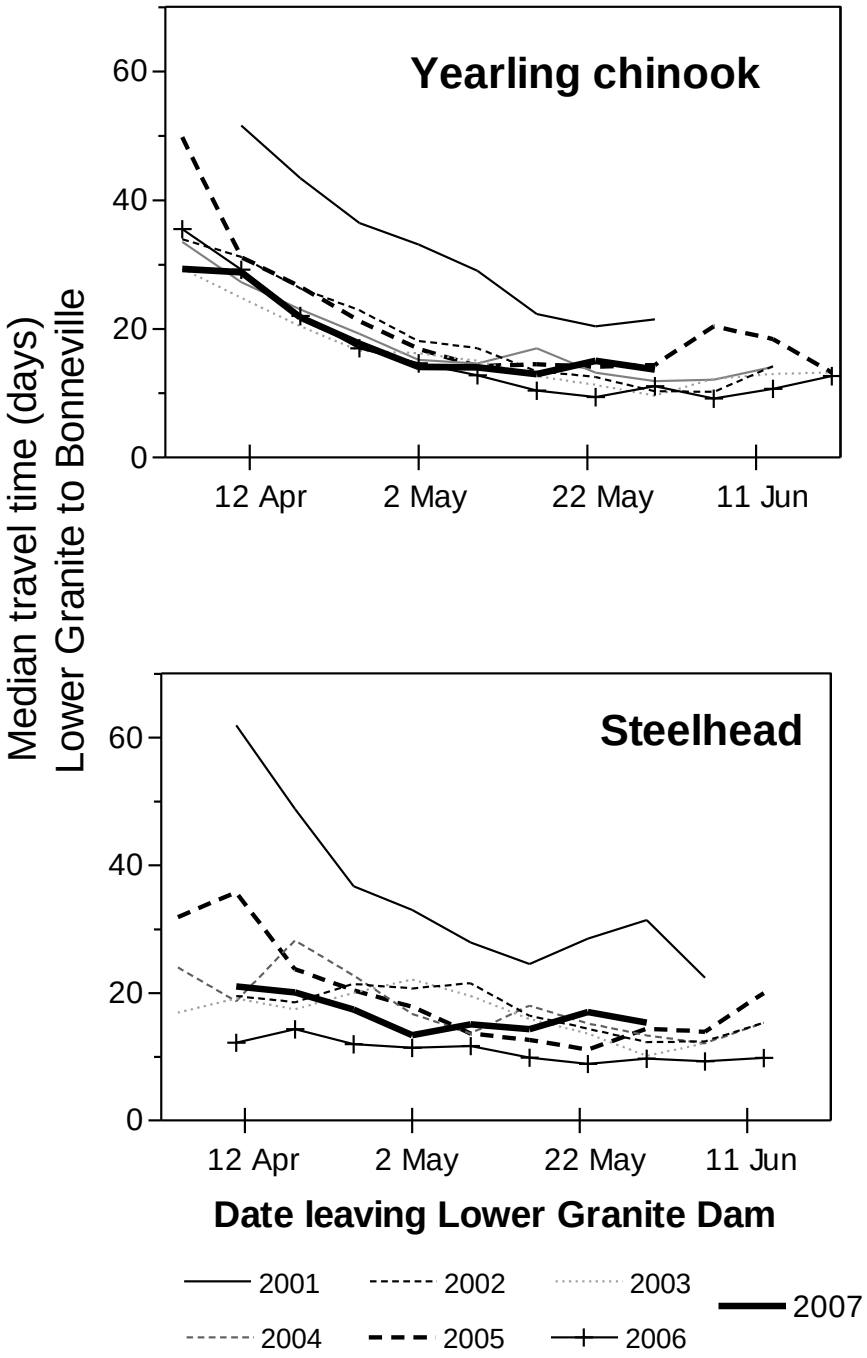

Figure 4. Median travel time (days) from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead from Lower Granite Dam, 2001-2007.

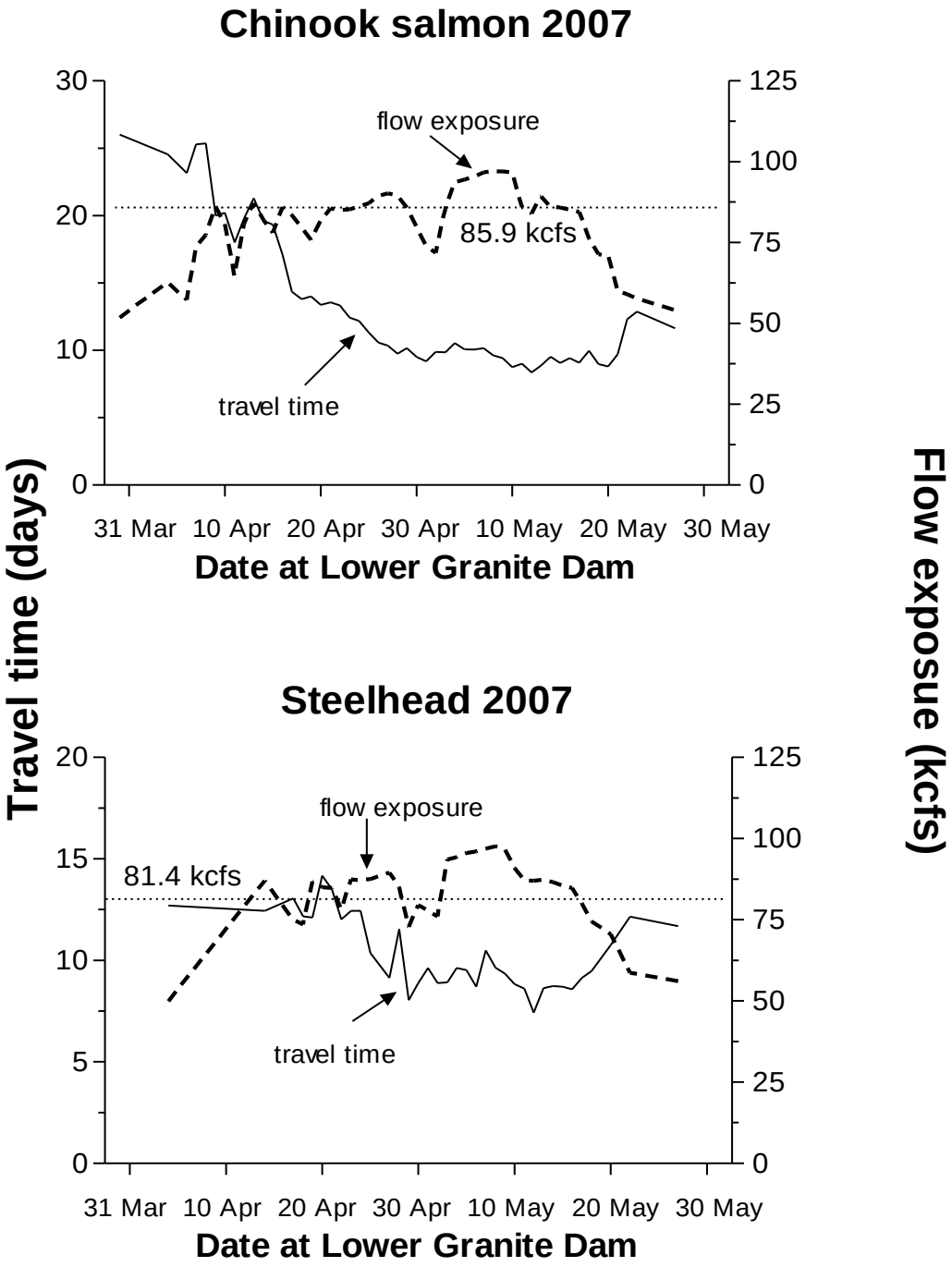

Figure 5. Travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Granite Dam (kcfs) for daily groups of PIT-tagged fish during 2007. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

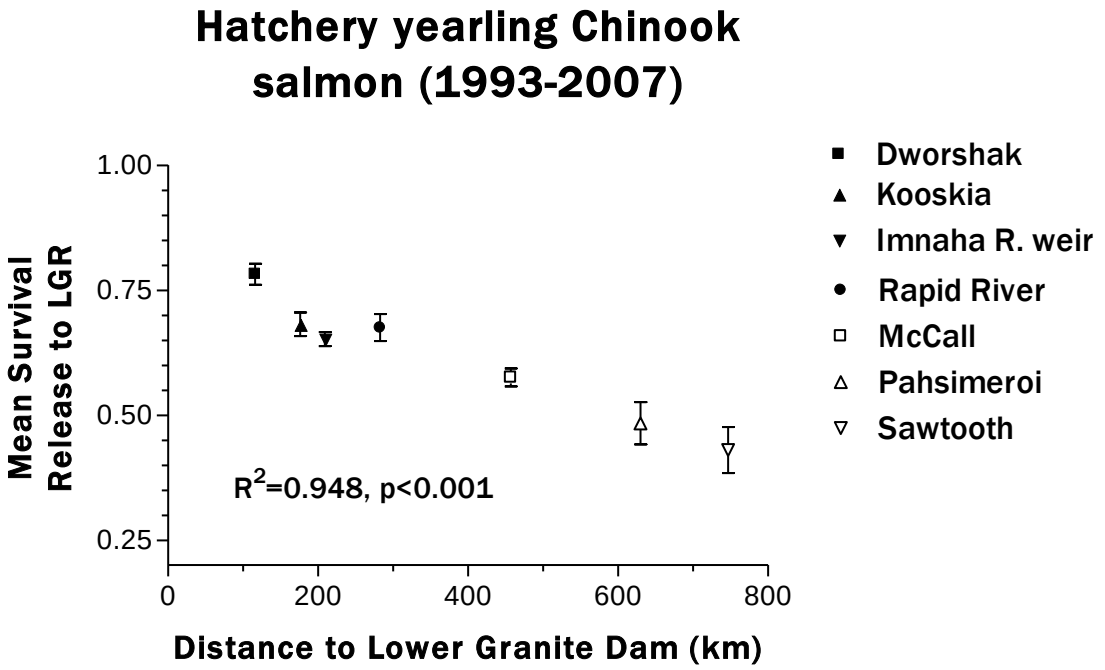

Figure 6. Estimated survival with standard errors from release at Snake River Basin hatcheries to Lower Granite Dam tailrace, 1993-2007 vs distance (km) to Lower Granite Dam. The correlation between survival and migration distance is also shown.

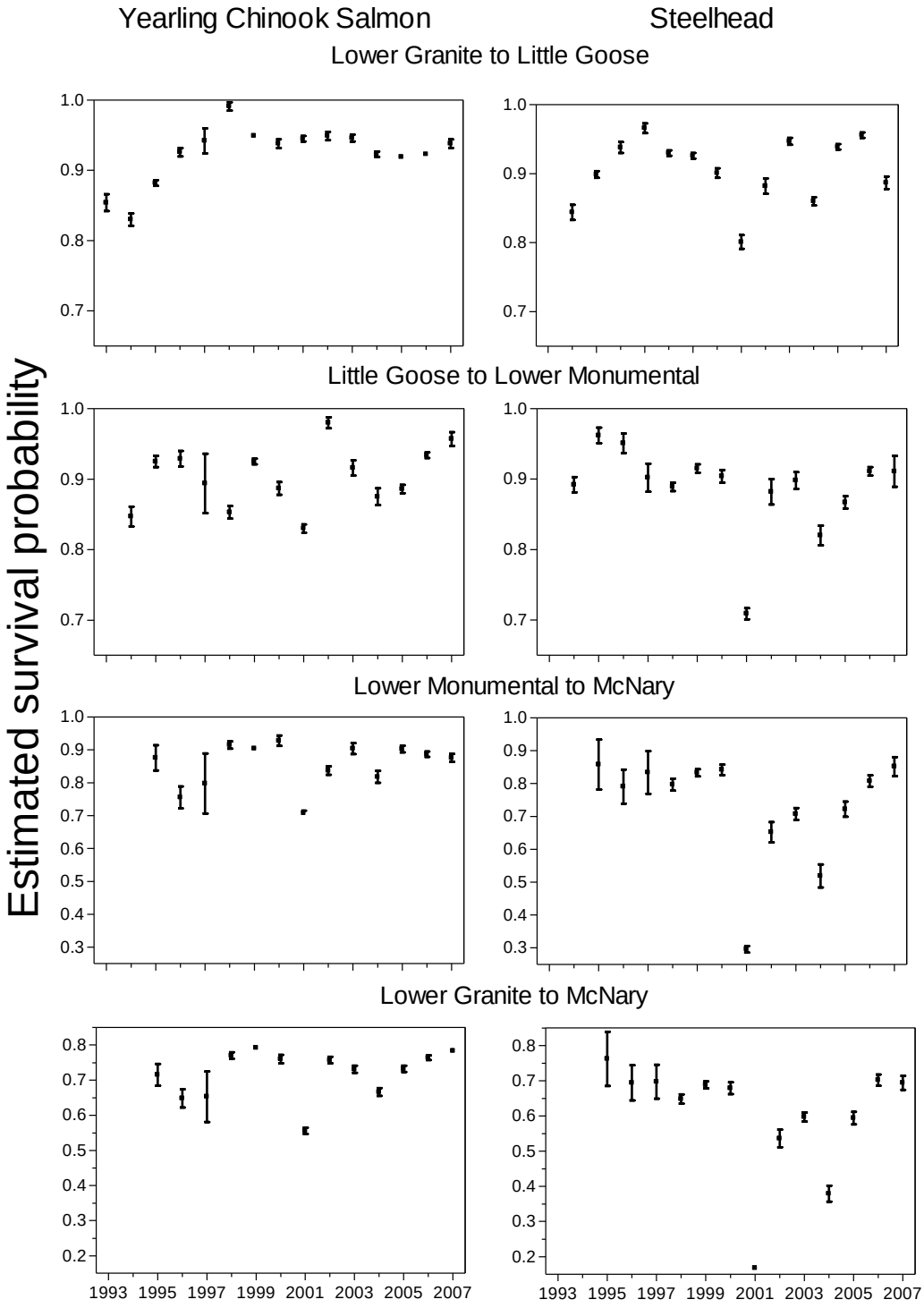

Figure 7. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead through Snake River reaches, 1993-2007. Estimates are from tailrace to tailrace with standard errors.

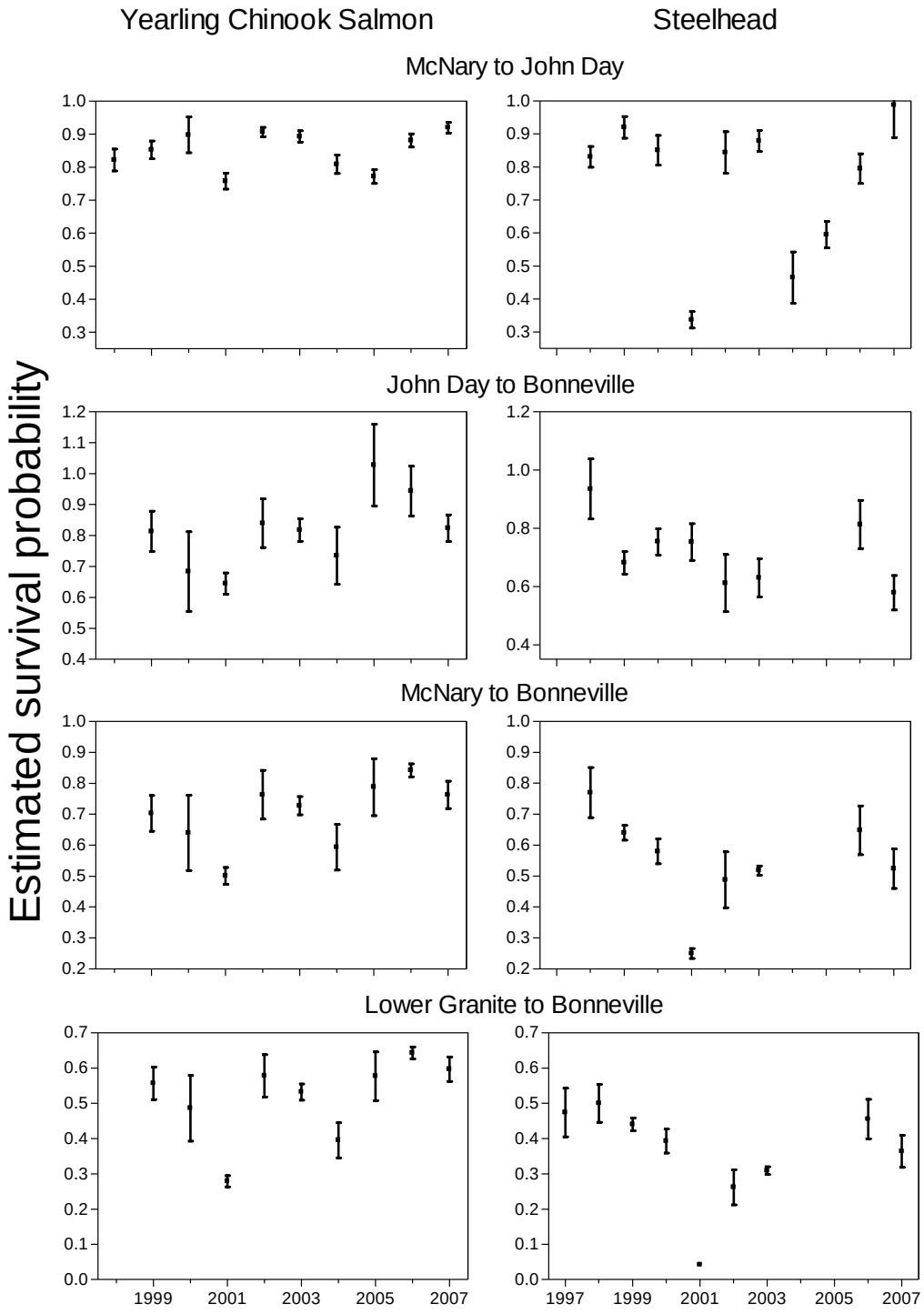

Figure 8. Annual average survival estimates for PIT-tagged Snake River yearling Chinook salmon and steelhead through Columbia River reaches and from Lower Granite Dam to Bonneville Dam, 1993-2007. Estimates are from tailrace to tailrace with standard errors.

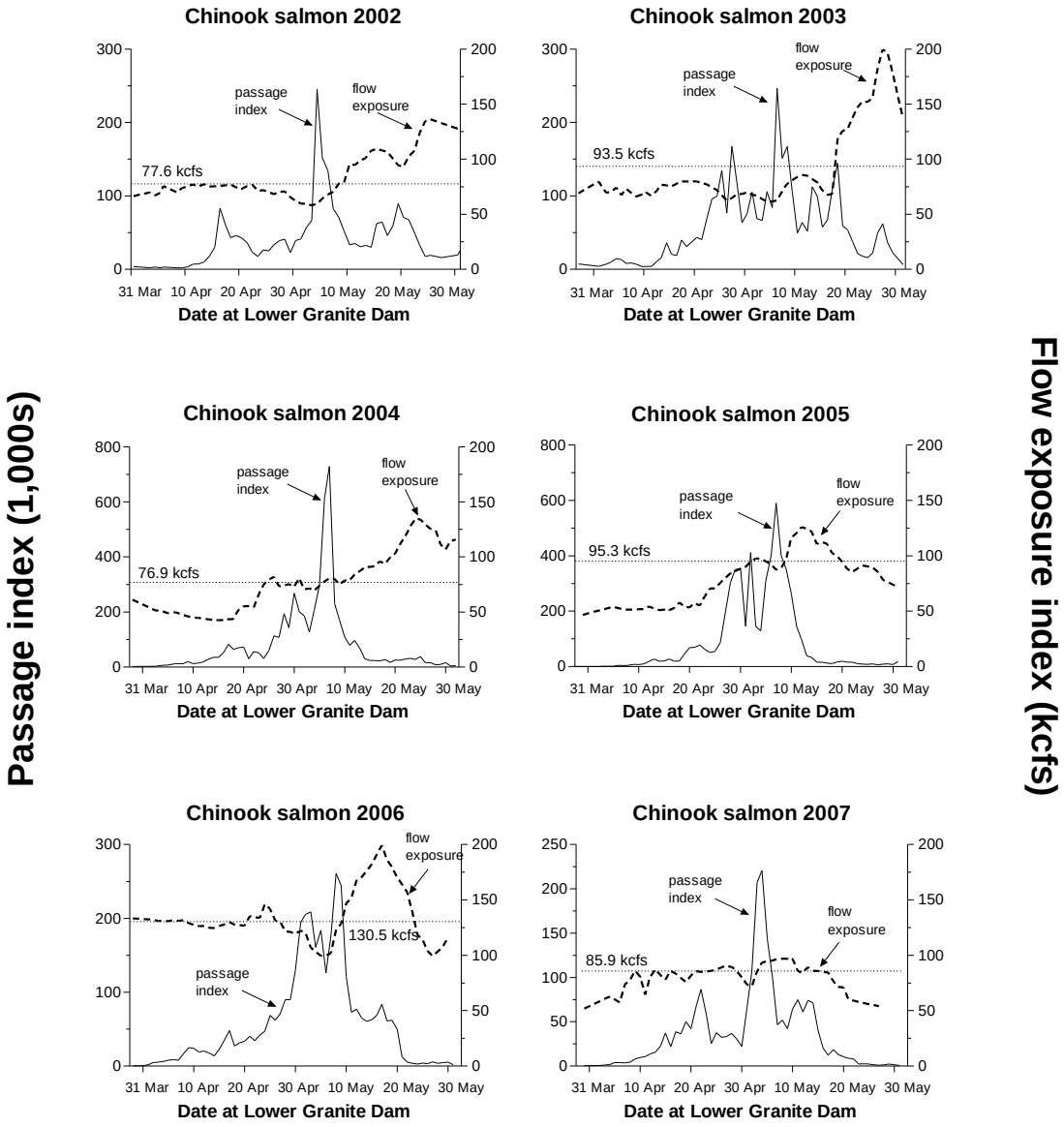

Figure 9. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged yearling Chinook salmon passing Lower Granite Dam from 2002 through 2007. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

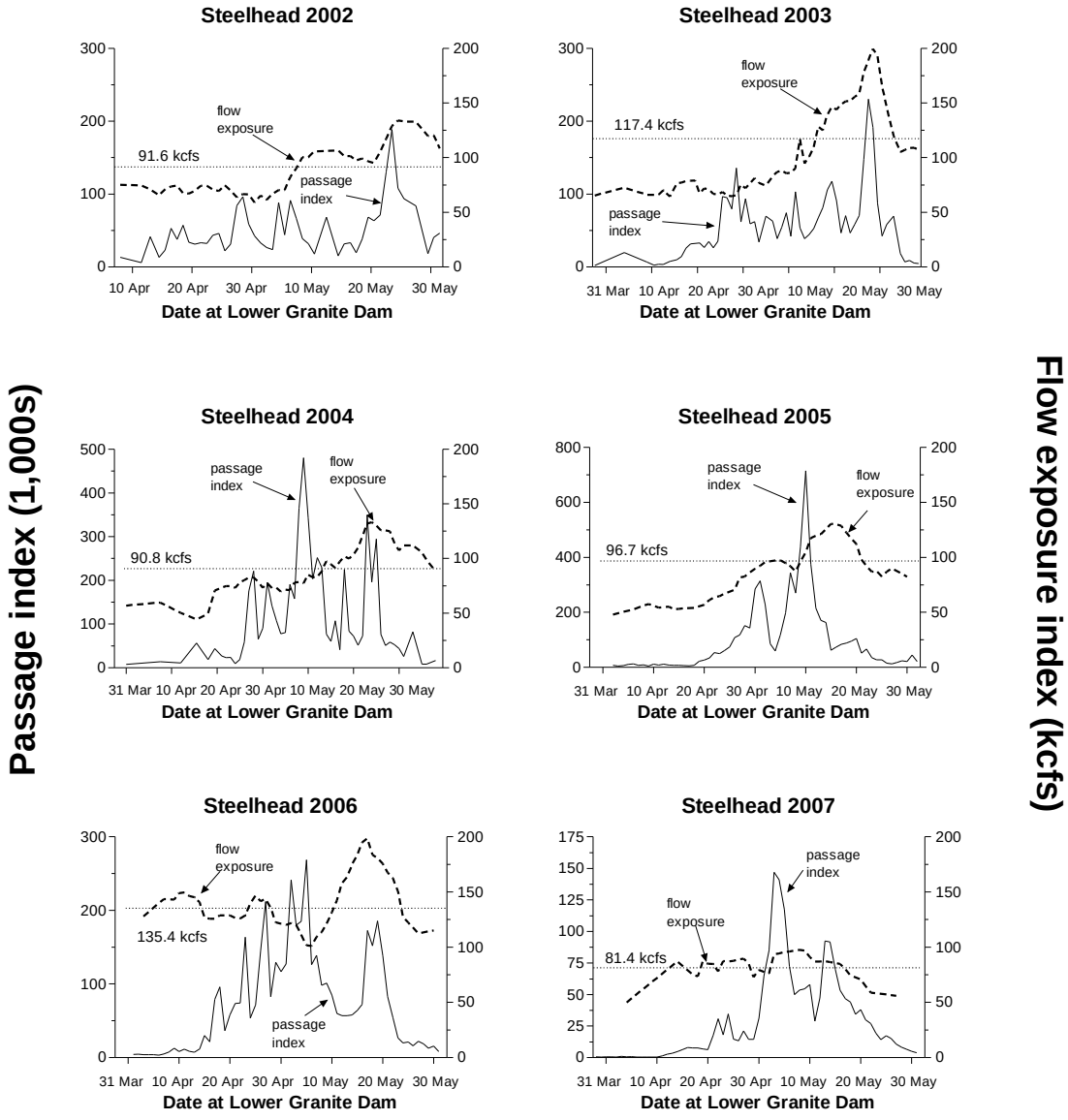

Figure 10. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged steelhead passing Lower Granite Dam from 2002 through 2007. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

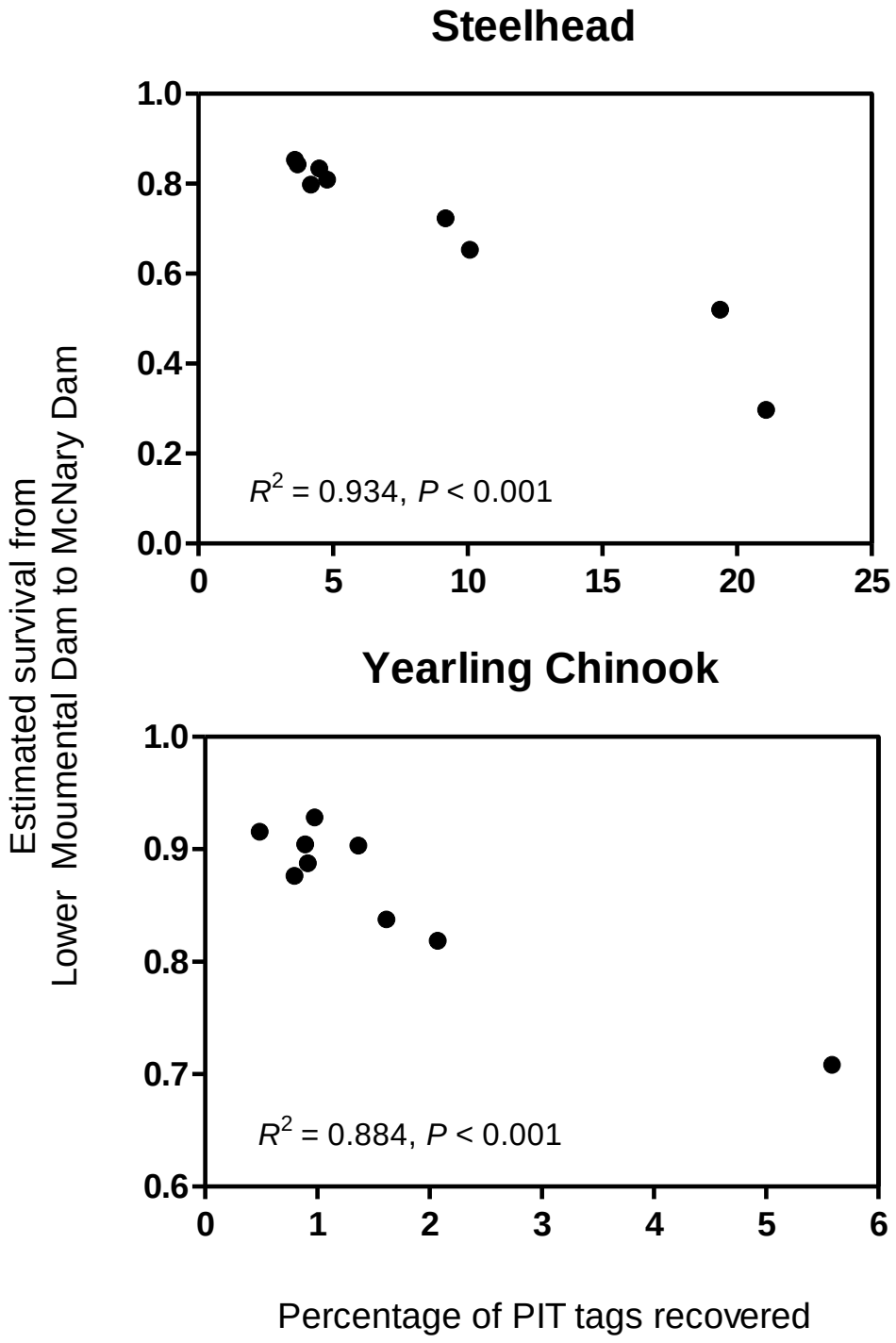

Figure 11. Estimated survival between Lower Monumental and McNary Dams versus percentage of Lower Monumental Dam-detected PIT tags recovered on bird colonies, 1998-2007 (excluding 2003, which had incomplete recovery).

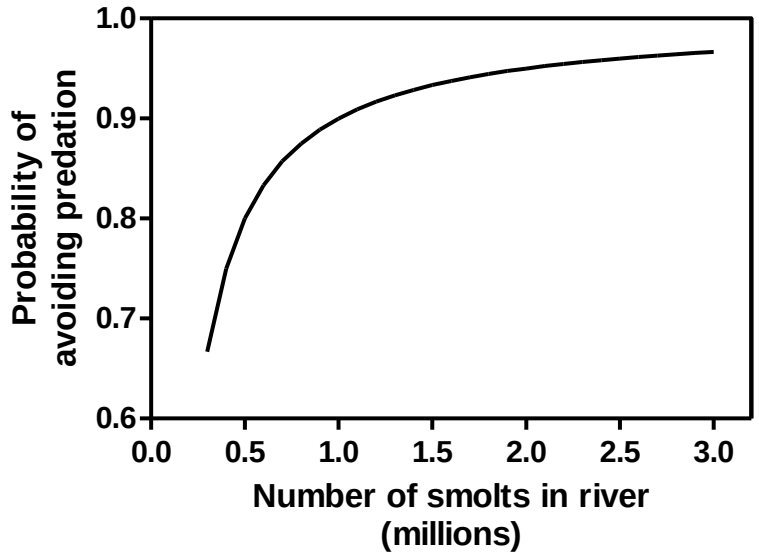

Figure 12. Idealized illustration of effect of total smolt population size on probability of avoiding predation. Assumes constant take of 100,000 smolts over range of population sizes.

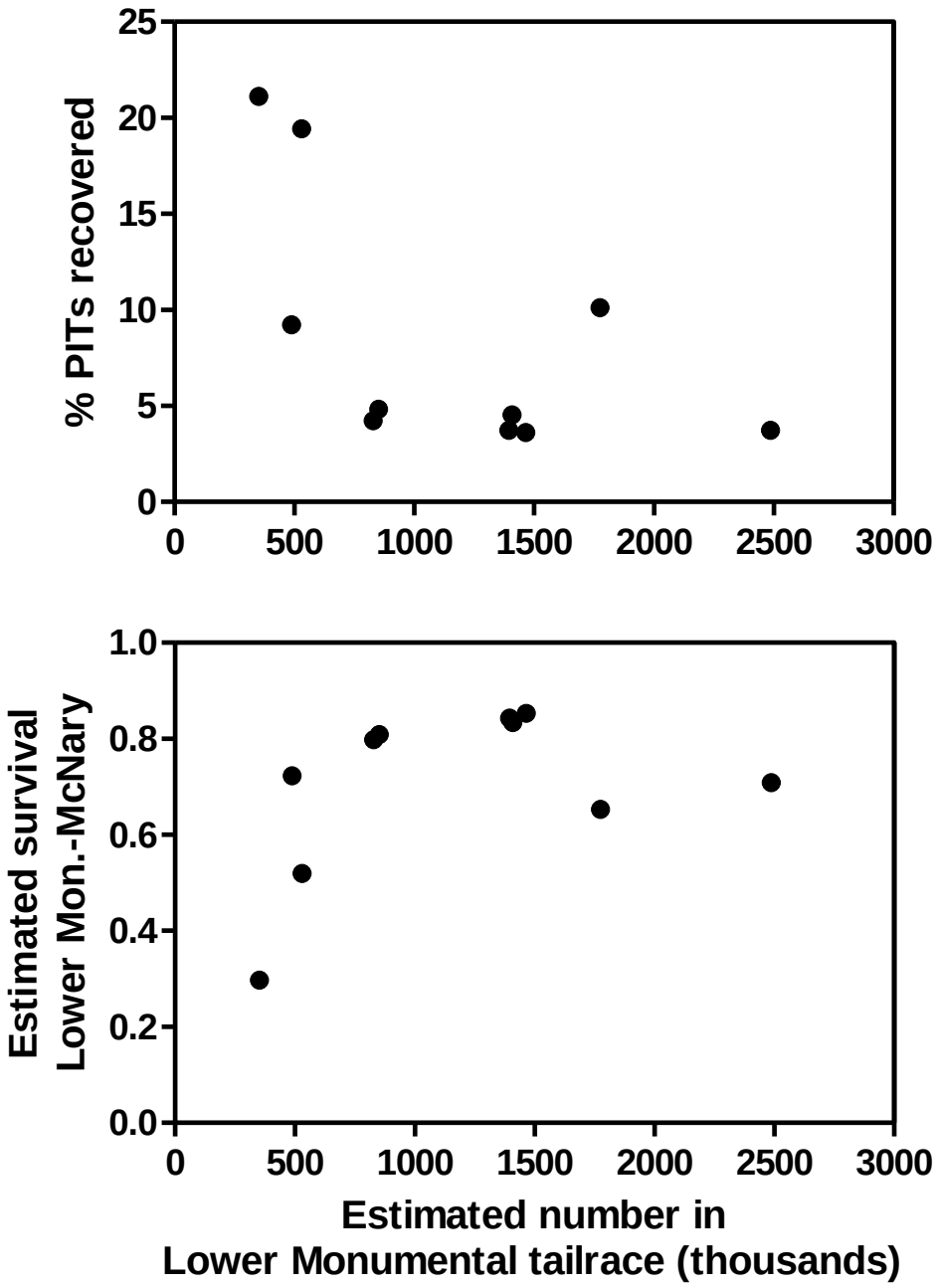

Figure 13. Relationship between percentage of Lower Monumental Dam-detected PIT tags (steelhead) recovered on bird colonies (top) and estimated overall steelhead survival between Lower Monumental and McNary Dams versus estimated number of steelhead in the tailrace of Lower Monumental Dam, 1998-2007.

APPENDIX

Tests of Model Assumptions

Background

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

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

A1) Fish in a single group of tagged fish have common event probabilities (each conditional detection or survival probability is common to all fish in the group).
A2) Event probabilities for each individual fish are independent from those for all other fish.
A3) Each event probability for an individual fish is conditionally independent from all other probabilities.

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

Methods

We used the methods presented by Burnham et al. (1997; pp 71-77) to assess the goodness-of-fit of the SR model to observed detection history data. In these tests, we compiled a series of contingency tables from detection history data for each group of tagged fish, and used χ^2 tests to identify systematic deviations from what was expected if the assumptions were met. We applied the tests to weekly groups of yearling Chinook salmon and steelhead (hatchery and wild combined) leaving Lower Granite and McNary dams (Snake River-origin fish only) in 2007 (i.e., the fish used for survival estimates reported in Tables 1, 2, 10, and 11).

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

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

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

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

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

In this table, all fish that were detected somewhere below Little Goose Dam are cross-classified according to their history at Little Goose Dam and according to their first detection site below Little Goose Dam (e.g., n_{11} is the number of fish not detected at Little Goose Dam that were first detected downstream at Lower Monumental Dam). If all assumptions were met, the counts for fish detected at LGO should be in constant proportion to those for fish not detected (i.e., n_{11}/n_{21}, n_{12}/n_{22}, and n_{13}/n_{23} should be equal). Because this table counts only fish detected below LGO (i.e., all fish survived LGO passage), differential *direct* mortality for fish detected and not detected at LGO will not cause violations of Test 2.C2 by itself. However, differential *indirect* mortality related to LGO passage could cause violations if differences are not expressed until fish are below LMO. Behavioral response to guidance at LGO could cause violations of Test 2.C2: if fish detected at LGO become more likely to be detected downstream, then they will tend to have more first downstream detections at LMO. If detected fish at LGO become less likely to be detected downstream, then they will have fewer first detections at LMO. Inherent differences among fish could also cause violations of Test 2.C2, and would be difficult to distinguish from behavioral responses.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Test 3.SR3	Detected at Trawl	
df = 1	Yes	No
Detected at BON,	n_{11}	n_{12}
Detected at BON,	n_{21}	n_{22}

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

Results

For weekly Lower Granite Dam release groups in 2007 there were more significant ($\alpha = 0.05$) tests than expected by chance alone for both yearling Chinook salmon and steelhead (Appendix Table 1). There were 10 weekly groups of yearling Chinook salmon. For these, the overall sum of the χ^2 test statistics was significant 4 times. For 8 steelhead groups, the overall test was significant 2 times. Counting all individual component tests (i.e., 2.C2, 3.SR3, etc.), 12 tests of 41 (29%) were significant for yearling Chinook salmon and 5 of 36 (14%) were significant for steelhead (Appendix Tables 1-3). Significant tests occurred with about equal frequency.

We diagnosed the patterns in the contingency tables that led to significant tests and results were similar to those we reported in past years: in 14 of the 17 significant cases (individual component tests) for Lower Granite Dam groups of yearling Chinook salmon and steelhead, and in all of the most highly significant cases, there was evidence that fish previously detected were more likely to be detected again at downstream dams.

Significant contingency table test results were far less common (1 significant test of 21) for weekly groups from McNary Dam (Appendix Tables 4-6).

Discussion

We believe that inherent differences in detectability (guidability) of fish within a release group are the most likely cause of the patterns we observed in the contingency table tests in 2007, as in previous years. Zabel et al. (2002) provided evidence of inherent differences related to length of fish at tagging, and similar observations were made in 2007 data. Fish size probably does not explain all inherent differences, but it appears to explain some. The relationship between length at tagging and detection probability at Little Goose Dam, the first dam encountered after release by fish in these data sets (all fish in the data set were detected at Lower Granite Dam; Little Goose Dam is the first encountered after leaving LGR), suggests that the heterogeneity is inherent, and not a behavioral response.

As in previous years (Zabel et al. 2002), results in 2007 lead us to conclude, as did Burnham et al. (1987), that a reasonable amount of heterogeneity in the survival and detection process did not seriously affect the performance of estimators of survival.

Appendix Table 1. Number of tests of goodness of fit to the single release model conducted for weekly release groups of yearling Chinook salmon and steelhead (hatchery and wild combined) from Lower Granite Dam, and number of significant ($\alpha = 0.05$) test results, 2007.

	Test 2.C2		Test 2.C3		Test 3.SR3		Test 3.Sm3		Test 3.SR4		Test 2 sum		Test 3 sum		**Test 2 + 3**	
Species	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	**No.**	**sig.**
Chinook	9	3	8	1	7	2	7	3	10	3	9	3	10	4	**10**	**4**
Steelhead	8	1	7	1	7	2	7	0	7	1	8	1	7	2	**8**	**2**
Total	17	4	15	2	14	4	14	3	17	4	17	4	17	6	**18**	**6**

Appendix Table 2. Results of tests of goodness of fit to the single release model for release groups of yearling Chinook salmon (hatchery and wild) from Lower Granite to McNary Dam in 2007.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
23 Mar–29 Mar	2.64	0.45	2.24	0.33	2.24	0.33	NA	NA
30 Mar–05 Apr	7.49	0.19	5.77	0.12	2.57	0.28	3.20	0.07
06 Apr–12 Apr	10.47	0.11	0.15	0.99	0.04	0.98	0.11	0.74
13 Apr–19 Apr	7.41	0.29	2.08	0.56	0.75	0.69	1.33	0.25
20 Apr–26 Apr	41.77	<0.001	37.40	<0.001	32.94	<0.001	4.46	0.04
27 Apr–03 May	98.56	<0.001	86.37	<0.001	86.35	<0.001	0.03	0.87
04 May–10 May	77.28	<0.001	52.78	<0.001	49.17	<0.001	3.61	0.06
11 May–17 May	13.72	0.03	3.24	0.36	2.89	0.24	0.35	0.55
18 May–24 May	9.51	0.15	5.30	0.15	5.18	0.08	0.12	0.73
25 May–31 May	0.002	0.97	NA	NA	NA	NA	NA	NA
Total (d.f.)	268.9 (51)	<0.001	195.3 (26)	<0.001	182.1 (18)	<0.001	13.2 (8)	0.11

Appendix Table 2. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
23 Mar–29 Mar	0.40	0.53	NA	NA	NA	NA	0.40	0.53
30 Mar–05 Apr	1.72	0.42	NA	NA	NA	NA	1.72	0.19
06 Apr–12 Apr	10.32	0.02	3.21	0.07	0.01	0.92	7.10	0.008
13 Apr–19 Apr	5.33	0.15	0.35	0.55	4.72	0.03	0.26	0.61
20 Apr–26 Apr	4.37	0.22	1.74	0.19	0.10	0.75	2.53	0.11
27 Apr–03 May	12.19	0.007	0.05	0.83	10.18	0.001	1.96	0.16
04 May–10 May	24.50	<0.001	8.27	0.004	6.72	0.01	9.52	0.002
11 May–17 May	10.47	<0.001	4.02	0.045	1.86	0.17	4.59	0.03
18 May–24 May	4.20	<0.001	1.11	0.29	0.49	0.48	2.60	0.11
25 May–31 May	0.00	0.97	NA	NA	NA	NA	0.00	0.97
Total (d.f.)	73.5 (25)	<0.001	18.7 (8)	0.016	24.1 (7)	0.001	30.7 (10)	0.001

Appendix Table 3. Results of tests of goodness of fit to the single release model for release groups of juvenile steelhead (hatchery and wild) from Lower Granite to McNary Dam in 2007.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	2.88	0.82	1.66	0.65	1.13	0.57	0.53	0.47
13 Apr–19 Apr	2.82	0.83	2.25	0.52	2.16	0.34	0.09	0.77
20 Apr–26 Apr	11.57	0.07	3.53	0.32	1.33	0.51	2.19	0.14
27 Apr–03 May	19.96	0.003	0.10	0.99	0.07	0.97	0.03	0.85
04 May–10 May	20.26	0.002	16.58	0.001	6.43	0.04	10.15	0.001
11 May–17 May	6.35	0.39	1.53	0.68	1.32	0.52	0.21	0.65
18 May–24 May	4.33	0.63	1.40	0.71	0.76	0.69	0.65	0.42
25 May–31 May	1.17	0.28	1.17	0.28	1.17	0.28	NA	NA
Total (d.f.)	69.3 (43)	0.007	28.2 (22)	0.17	14.4 (15)	0.50	13.8 (7)	0.054

Appendix Table 3. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	1.22	0.75	0.01	0.91	0.90	0.34	0.31	0.58
13 Apr–19 Apr	0.57	0.90	0.45	0.50	0.08	0.78	0.04	0.84
20 Apr–26 Apr	8.05	0.045	3.86	0.049	1.02	0.31	3.16	0.08
27 Apr–03 May	19.86	<0.001	11.81	0.001	0.38	0.54	7.67	0.01
04 May–10 May	3.67	0.30	0.24	0.63	2.31	0.13	1.13	0.29
11 May–17 May	4.82	0.19	1.75	0.19	0.96	0.33	2.11	0.15
18 May–24 May	2.93	0.40	0.14	0.71	2.36	0.13	0.43	0.51
25 May–31 May	NA	NA	NA	NA	NA	NA	NA	NA
Total (d.f.)	41.1 (21)	0.005	18.3 (7)	0.011	8.0 (7)	0.33	14.8 (7)	0.038

Appendix Table 4. Number of tests of goodness of fit to the single release model conducted for weekly release groups of yearling Chinook salmon and steelhead (hatchery and wild combined) from McNary Dam, and number of significant (a = 0.05) test results, 2007.

	Test 2.C2		Test 3.SR3		Test 2 + 3	
Species	No.	sig.	No.	sig.	No.	sig.
Chinook	8	0	6	1	8	0
Steelhead	4	0	3	0	4	0
Total	12	0	9	1	12	0

Appendix Table 5. Results of tests of goodness of fit to the single release model for release groups of yearling Chinook salmon (hatchery and wild) from McNary to Bonneville Dam in 2007.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
20 Apr–26 Apr	4.17	0.13	1.82	0.18	2.35	0.13
27 Apr–03 May	2.29	0.32	1.12	0.29	1.18	0.28
04 May–10 May	0.04	0.98	0.04	0.83	0.00	0.98
11 May–17 May	4.68	0.10	0.03	0.86	4.64	0.03
18 May–24 May	2.46	0.29	1.87	0.17	0.59	0.44
25 May–31 May	0.15	0.93	0.00	0.98	0.15	0.70
01 Jun–07 Jun	0.78	0.38	0.78	0.38	NA	NA
08 Jun–14 Jun	0.07	0.80	0.07	0.80	NA	NA
Total (d.f.)	14.6 (14)	0.40	5.7 (8)	0.68	8.9 (6)	0.18

Appendix Table 6. Results of tests of goodness of fit to the single release model for release groups of steelhead (hatchery and wild) from McNary to Bonneville Dam in 2007.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
20 Apr–26 Apr	NA	NA	NA	NA	NA	NA
27 Apr–03 May	2.42	0.30	0.75	0.39	1.67	0.20
04 May–10 May	2.53	0.28	2.26	0.13	0.27	0.60
11 May–17 May	1.17	0.56	1.09	0.30	0.08	0.78
18 May–24 May	1.05	0.31	1.05	0.31	NA	NA
25 May–31 May	NA	NA	NA	NA	NA	NA
Total (d.f.)	7.17 (7)	0.41	5.16 (4)	0.27	2.02 (3)	0.57