

**Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids
through Snake and Columbia River Dams and Reservoirs, 2006**

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EXECUTIVE SUMMARY

In 2006, the National Marine Fisheries Service completed the fourteenth year of a study to estimate survival and travel time of juvenile salmonids *Oncorhynchus* spp. passing through dams and reservoirs on the Snake and Columbia Rivers. All estimates were derived from detections of fish tagged with passive integrated transponder tags (PIT tags). We PIT tagged and released a total of 18,972 hatchery steelhead *O. mykiss*, 14,144 wild steelhead, and 9,717 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 including 151,477 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 2006 were

- 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.
- 3) Evaluate the survival estimation models under prevailing conditions.

This report provides reach survival and travel time estimates for 2006 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 2006 yearling Chinook salmon and steelhead migrations. Hatchery and wild fish were combined in some of the analyses. Overall, the percentages for combined release groups used in survival analyses in the Snake River were 92% hatchery-reared yearling Chinook salmon and 8% wild. For steelhead, the overall percentages were 62% hatchery-reared and 38% wild.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.923 for yearling Chinook salmon and 0.956 for steelhead. Respective average

survival estimates for yearling Chinook salmon and steelhead through the following reaches were 0.934 and 0.911 from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.887 and 0.808 from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam), 0.881 and 0.795 from McNary Dam tailrace to John Day Dam tailrace, and 0.944 and 0.813 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 0.612 (s.e. 0.016) for Snake River yearling Chinook salmon and 0.418 (s.e. 0.052) for steelhead during 2006.

For yearling spring Chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace was 0.554 (s.e. 0.014) for fish released from Leavenworth Hatchery, 0.520 (s.e. 0.031) for fish released from Entiat Hatchery, and 0.423 (s.e. 0.029) for fish released from Winthrop Hatchery.

For steelhead released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.606 (s.e. 0.017) for fish from Turtle Rock Hatchery released in the Wenatchee River to 0.180 (s.e. 0.009) for fish from Cassimer Bar Hatchery released in Stapaloop Creek.

During most of 2006, flows were the highest observed in the last 6 years. Flows were particularly high in April relative to recent years. Flow dropped during the first week of May and then increased rapidly, reaching a peak the third week of May. In terms of absolute volume, there was more spill at Snake River dams in 2006 than any of the previous 6 years. Turbidity was also much higher than normal during 2006.

Compared to 2005, yearling Chinook salmon and steelhead survival in 2006 was higher through most reaches. Hydropower system survival for yearling Chinook salmon was the highest measured from 1999 through 2006. Steelhead hydropower system survival was also improved over that observed in recent years. Steelhead survival from Lower Monumental Dam to McNary Dam, where survival has been poor since 2001, was the highest measured in the last six years, similar to that measured from 1995 through 2000. PIT-tag detections on McNary pool avian bird colonies were lower for steelhead compared to recent years.

Yearling Chinook salmon travel times through the hydropower system were slightly faster for most of the migration season in 2006 compared to recent years, while steelhead travel times were much faster, particularly early in the migration season.

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INTRODUCTION

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

From 1993 through 2005, the National Marine Fisheries Service (NMFS) 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). In 2006, NMFS completed the fourteenth year of the study.

Research objectives in 2006 were:

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

Additionally, as adult return information becomes available, we will evaluate relationships between juvenile survival and subsequent adult returns for fish with different juvenile migration histories. A comprehensive evaluation of data through 2004 was 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, coho 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 2006, 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 2006 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 2006, the corner collector at Bonneville Dam Second Powerhouse was operated with its new PIT tag detection system. Sufficient PIT tag detections at this site allowed survival estimation through the John Day to Bonneville Dam tailrace reach 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). In addition, we utilized 151,477 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. 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, because of the higher flows (resulting in a lower proportion of spill), sufficient detections occurred at Ice Harbor to partition survival through this reach in 2006.

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 2006, 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, almost 190,000 yearling Chinook salmon 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 2006, 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, 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 Little White Salmon (released in the Walla Walla River) hatcheries. Survival to McNary Dam was also estimated for steelhead released from Turtle Rock, and Cassimer Bar hatcheries in the Upper Columbia River Basin and for Coho salmon released from Cascade, Eagle Creek, Willard, and Yakima hatcheries. 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 do not use the inverse estimated absolute variance in weighting because lower survival estimates have disproportionate influence, and the resulting weighted mean is biased toward the lower survival estimates.

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

Survival Estimates from Point of Release to Bonneville Dam

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

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

Travel Time and Migration Rate

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

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

Travel time between any two dams was calculated for each fish detected at both dams as the number of days between last detection at the upstream dam (generally at a PIT-tag detector close enough to the outfall site that fish arrived in the tailrace within minutes after detection) and first detection at the downstream dam. Travel time included the time required to move through the reservoir to the forebay of the downstream dam and any delay associated with residence in the forebay, gatewells, or collection channel prior to detection in the juvenile bypass system.

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

The true complete set of travel times for a release group includes travel times of both detected and non-detected 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. Non-detected 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 2006 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 2006 season were also examined.

RESULTS

Lower Granite Dam Tagging and Release Information

During 2006, a total of 197,621 yearling Chinook salmon (182,190 hatchery origin, 15,431 wild) were detected and released or PIT tagged and released to the river in the tailrace of Lower Granite Dam. Steelhead were 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 41,372 (25,688 hatchery origin and 15,677 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 (92% hatchery) and steelhead (62% hatchery) during 2006.

Survival Estimation

Tests of Assumptions

Assumption tests for 2006 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 11 consecutive weeks from 30 March through 14 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.923 (s.e. 0.003; Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.934 (s.e. 0.004). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.887 (s.e. 0.008). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.764 (s.e. 0.007).

We estimated survival probabilities for weekly groups of yearling Chinook salmon released in the tailrace at McNary Dam for 7 consecutive weeks from 13 April through 31 May. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.881 (s.e. 0.020; Table 2). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 0.944 (s.e. 0.030). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.842 (s.e. 0.021).

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 0.643 (s.e. 0.017; Table 43). Estimated survival probability through Lower Granite reservoir and Dam for Snake River wild and hatchery Chinook salmon released from the Snake River trap was 0.952 (s.e. 0.011). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River yearling Chinook salmon was 0.612 (s.e. 0.016).

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 2006.

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 2006 migration season (Table 5; Figure 2).

Estimates of detection probability varied throughout the season for most weekly groups, generally declining in May as flows and spill levels increased (Tables 6-9). Detection probabilities were lower and more variable at John Day and Bonneville Dams, primarily because of varying levels of spill.

Snake River Steelhead

We estimated survival probabilities for weekly groups of steelhead from the tailrace of Lower Granite Dam for 11 consecutive weeks from 30 March through 14 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.956 (s.e. 0.004; Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.911 (s.e. 0.006). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.808

(s.e. 0.017). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.702 (s.e. 0.016).

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of McNary Dam for 9 consecutive weeks from 13 April through 14 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.795 (s.e. 0.045; Table 11). Estimated survival from John Day Dam tailrace to Bonneville Dam tailrace averaged 0.813 (s.e. 0.083), and for the combined reach from McNary Dam tailrace to Bonneville Dam tailrace, 0.648 (s.e. 0.079).

The product of the average estimates from Lower Granite Dam to McNary Dam and from McNary Dam to Bonneville Dam provided an overall survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.455 (s.e. 0.056; Table 43). Estimated survival probability through Lower Granite reservoir and Dam for Snake River wild and hatchery steelhead released from the Snake River trap was 0.920 (s.e. 0.013). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River steelhead was 0.418 (0.052).

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 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 probabilities were generally lowest at McNary 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).

Snake River Smolt Trap Release Groups

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

Upper Columbia River Hatchery Release Groups

Survival probabilities of PIT-tagged hatchery yearling Chinook salmon, coho salmon, and steelhead from release at Upper Columbia River hatcheries to the tailrace of McNary Dam varied among hatcheries and release locations (Table 27). Detection probabilities at downstream dams were similar for most yearling Chinook salmon, coho salmon, and steelhead from all hatcheries (Table 28).

Travel Time and Migration Rate

Travel time estimates for yearling Chinook salmon and juvenile steelhead released in the tailraces of Lower Granite and McNary Dams varied throughout the season (Tables 29-36). For both species, migration rates were generally highest in the lower river sections. Migration rates 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 for yearling Chinook salmon from Lower Granite to McNary Dam decreased during early- to mid-April independent of flow at Lower Granite (i.e., travel time decreased considerably without corresponding changes in flow) whereas travel time of steelhead did not decrease during that time period (Figure 5).

Tagging Details for fish PIT Tagged at Lower Granite Dam

We PIT-tagged and released 18,972 hatchery steelhead, 14,144 wild steelhead, and 9,717 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, 5, and 57, 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 2006 were similar to those made in past recent years for most hatcheries. Survival was again considerably lower in 2006 for Pahsimeroi hatchery, but improved for Sawtooth hatchery (Table 40). Over the years of the study, we have consistently observed an inverse relationship between the migration distance from the release site to Lower Granite Dam and the estimated survival through that reach (Figure 6). For 1993-2006 estimates, the negative linear correlation between migration distance and average estimated survival was significant ($R^2 = 0.953$, $P = 0.0002$).

For yearling Chinook salmon and steelhead (hatchery and wild combined), estimated survival in 2006 was higher than that estimated in 2005 through most reaches (Table 41-42; Figures 7-8). Estimated survival for steelhead in the McNary to John Day Dam reach for 2006 increased over the relatively low values estimated in 2004-2005 (Table 42; Figures 7-8).

For yearling Chinook salmon, 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 (0.84; Table 41). For steelhead, 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 (0.72), 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 2006, estimated hydropower system survival was 0.612 (s.e. 0.016), the highest survival estimate to date. For steelhead, estimated hydropower system survival was 0.418 (s.e. 0.052), higher than that estimated from 2001-2003 (estimates not available for 2004-2005), and similar to that estimated from 1997-2000.

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 2006 for yearling Chinook salmon (130.5 kcfs) and steelhead (135.4 kcfs) were the highest measured over the last 6 years (Figure 9 and 10), peaking the third week of May. Turbidity was also much higher during the 2006 migration (Figure 11).

Because of forecasted high flows, a spread the risk approach to transportation of smolts was used in 2006, with initiation of transport delayed until 21 April at Lower Granite Dam, 25 April at Little Goose Dam, and 28 April 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 travel time between Lower Granite and Bonneville Dams in 2006 was slightly faster compared to past years during most of the migration, and was much faster than travel time observed during 2001 (Figure 4). For steelhead, travel time between Lower Granite and Bonneville Dams was much faster than in past years, particularly early in the migration.

Survival Estimates from Point of Release to McNary Dam

In 2006, estimated survival to McNary Dam was similar between yearling spring Chinook salmon released at hatcheries in the Upper Columbia River and their counterparts released in the Snake River (Tables 19 and 27). For Upper Columbia River fish, average survival to McNary Dam was estimated at 0.554 (0.014) for fish from Leavenworth Hatchery (4 projects; 330 km) and 0.520 (0.031) for fish from Entiat Hatchery (5 projects; 325 km) in the Upper Columbia River. For Snake River fish released at Dworshak Hatchery (5 projects; 341 km), average survival to McNary Dam was estimated at 0.560 (0.008).

For steelhead from Snake River Basin hatcheries, estimated survival to the tailrace of McNary Dam was also generally similar 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, with the high flow levels in 2006, more flow passed through the Ice Harbor Dam powerhouse increasing PIT tag detection efficiency (Tables 44 and 45). This allowed the estimation of reach specific survival using PIT tags for the first time in this section of the Snake River. Survival for yearling Chinook salmon was 0.912 (s.e. 0.005) from the tailrace of Lower Monumental Dam to the tailrace of Ice Harbor dam and 0.968 (s.e. 0.009) from Ice Harbor Dam tailrace to McNary Dam tailrace. For steelhead, survival through these reaches was 0.918 (s.e. 0.014) and 0.899 (s.e. 0.028), respectively.

DISCUSSION

Migration conditions during 2006 were excellent with high flows and turbid water throughout the migration. As a result, travel times through the system were faster in 2006, particularly for steelhead. Survival through the hydropower system was the highest yet measured for yearling Chinook salmon at about 61% from the Snake River trap to Bonneville Dam tailrace, and was improved as well for steelhead at about 41%. Steelhead survival improved through the Lower Monumental to McNary Dam reach in 2006, where it has been depressed since 2001. The loss of PIT-tagged steelhead to piscivorous birds in the McNary pool decreased to <5% in 2006, likely do to their faster travel time through this reach and more turbid water.

The migration conditions and resulting survival through the hydropower system in 2006 provide an interesting contrast with the 2005 migration. Because 2005 Snake River flow forecasts were below the NMFS BiOp target for providing spill, transportation was maximized at collector dams during the spring migration and spill did not occur at Lower Granite, Little Goose, and Lower Monumental Dams until 17 May, when flows exceeded powerhouse capacities. Spill continued through about 27 May at Lower Granite and Lower Monumental Dams, while at Little Goose Dam, spill ended on 23 May. Flows during spring 2005 were low during early to mid-April, but increased substantially from late April through the remainder of the migration season. The yearling Chinook salmon migration in 2005 was more compressed than in other recent years, and the average flow exposure index was the second highest observed over the last 6 years. Hydropower system survival for yearling Chinook salmon was still the third highest measured (53%) since our PIT-tag survival studies began, even with the limited spill provided.

Analyses based on early data (1973-1979) suggested that increases in spill had the direct effect of increasing survival (Sims and Ossiander 1981). From our own research, estimated survival through the Snake River was lower in 1993 and 1994, when spill occurred only in excess of powerhouse capacity. It increased after spill at all dams was prescribed in the 1995 BiOp (NMFS 1995). Survival was lowest during the 2001 migration, when spill was eliminated or reduced at all dams. However, demonstrating within-season effects of spill has been more problematic (Smith et al. 2002; Zabel et al. 2002; Williams et al. 2005).

During 2006, we estimated the highest survival yet through the hydropower system for yearling Chinook salmon and improved survival for steelhead. Turbidity was high throughout the migration in 2006 and likely contributed to the increased survival. Turbidity was also high during the latter half of the 2005 migration (Figure 11). Greater turbidity could have reduced predation rates on juvenile salmonids by providing protective cover during migration (Gregory

1993; Gregory and Levings 1998). Higher turbidity also likely reduced steelhead vulnerability to sight-feeding birds.

Crescent Island in the McNary Dam reservoir harbors the second largest Caspian tern colony in North America (>600 individuals), as well as large populations of gulls *Larus* spp. (>39,000). Other avian piscivores that reside within the McNary pool include the American white pelican *Pelecanus erythrorhynchos*, cormorant *Phalacrocorax auritus*, and heron *Ardea alba*, *A. herodias*, and *Nycticorax nycticorax* (Collis et al. 2002).

For steelhead, survival improved through the reach from Lower Monumental to McNary Dam compared to years since 2001. Steelhead are particularly susceptible to predation by birds; Collis et al. (2001) reported over 15% of the tags from PIT-tagged steelhead detected at Bonneville Dam in 1998 were later found on estuarine bird colonies, while only 2% of the tags from PIT-tagged yearling Chinook salmon were found. In 1998 the major site of tag recovery was Rice Island, which was then home to the largest Caspian tern *Sterna caspia* colony in North America. Ryan et al. (2002, 2003) and Glabek et al. (2003) reported similar results in subsequent years, as the tern colony was relocated from Rice Island to East Sand Island.

During 2006, <5% of the PIT tags from steelhead detected at Lower Monumental Dam were found on bird colonies upstream from McNary Dam (Table 46). In previous years, additional PIT tags (mostly steelhead) have been detected on gull colonies in the John Day and The Dalles reservoirs as well (Glabek et al. 2003; Ryan et al. 2002). The percentage of detected steelhead PIT tags found on bird colonies upstream from McNary Dam in 2006 was only about 25% of that found in 2001 and 2004, the two recent low flow years when transportation was maximized and voluntary spill was curtailed.

Tag-detection percentages on avian colonies are minimum estimates of loss due to bird predation, because not all tags taken by birds are detected (Collis et al. 2001; Glabek et al. 2003; Ryan et al. 2001). From 1998 to 2006, survival estimates for steelhead in the reach from Lower Monumental to McNary Dam (Table 42) have shown a strong negative correlation with the percentage of smolts detected on bird colonies in the McNary pool ($R^2 = 0.928$, $P < 0.001$; Table 46, excluding 2003 when only Crescent Island was sampled). There has also been a significant negative correlation for yearling Chinook salmon ($R^2 = 0.899$; $P < 0.001$, Table 41), although the percentages detected on bird colonies have been much lower. Estimates of yearling Chinook salmon and steelhead survival between Lower Monumental and Ice Harbor Dams were similar in 2006, but were about 7% lower for steelhead than for yearling Chinook salmon from Ice Harbor Dam tailrace to McNary Dam tailrace, suggesting that most of the avian predation on steelhead is occurring below Ice Harbor Dam.

One factor that might affect our survival estimates is the collection and transportation of smolts from the Snake River, particularly in years when transport is maximized. During years when this occurred (2001, 2004, and 2005), an extremely high proportion (as high as 99%) of non-PIT-tagged smolts were transported, while PIT-tagged fish were returned to the river by slide gates. Thus, by the time fish reach Ice Harbor Dam, relatively few non-tagged fish are available for predators. This likely increases the mortality rate on tagged smolts, resulting in reduced estimates of survival. In years like 2006, when a spread the risk approach to transport is used, greater numbers of non-tagged smolts are returned to the river and likely affect survival estimation to a lesser degree. During 2006, about 60% of yearling Chinook salmon and about 75% of tagged steelhead were transported.

Results from the 2006 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 most 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

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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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar – 05 Apr	798	0.822 (0.037)	0.920 (0.073)	0.985 (0.128)	0.746 (0.085)
06 Apr - 12 Apr	1,782	0.854 (0.018)	0.907 (0.034)	0.884 (0.058)	0.685 (0.040)
13 Apr - 19 Apr	1,674	0.936 (0.015)	0.952 (0.029)	0.837 (0.045)	0.745 (0.035)
20 Apr - 26 Apr	27,426	0.937 (0.004)	0.928 (0.007)	0.886 (0.012)	0.771 (0.010)
27 Apr - 03 May	66,936	0.919 (0.003)	0.929 (0.006)	0.886 (0.010)	0.757 (0.007)
04 May - 10 May	64,487	0.897 (0.006)	0.979 (0.012)	0.882 (0.017)	0.775 (0.013)
11 May - 17 May	32,031	0.908 (0.010)	0.939 (0.021)	0.776 (0.033)	0.661 (0.025)
18 May - 24 May	1,578	0.901 (0.025)	0.864 (0.049)	1.072 (0.132)	0.835 (0.095)
25 May - 31 May	474	0.918 (0.035)	0.990 (0.103)	0.884 (0.190)	0.804 (0.153)
01 Jun - 07 Jun	284	1.009 (0.106)	0.729 (0.168)	0.944 (0.365)	0.695 (0.229)
08 Jun - 14 Jun	151	1.052 (0.149)	1.206 (0.370)	0.503 (0.184)	0.639 (0.150)
Weighted mean^a		0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.764 (0.007)

^a 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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
13 Apr – 19 Apr	227	0.747 (0.192)	NA	NA
20 Apr – 26 Apr	1,945	0.856 (0.066)	0.702 (0.284)	0.601 (0.238)
27 Apr – 03 May	6,824	0.797 (0.033)	1.058 (0.217)	0.843 (0.170)
04 May – 10 May	24,123	0.899 (0.024)	0.933 (0.077)	0.838 (0.065)
11 May – 17 May	27,213	0.904 (0.034)	0.974 (0.123)	0.880 (0.106)
18 May – 24 May	9,596	0.984 (0.089)	0.819 (0.246)	0.806 (0.231)
25 May – 31 May	842	1.046 (0.250)	NA	NA
Weighted mean^a		0.881 (0.020)	0.944 (0.030)	0.842 (0.021)

^a Weighted means of the independent estimates for weekly pooled groups (13 April – 31 May), with weights inversely proportional to respective estimated relative variances.

Table 3. Estimated survival probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar - 05 Apr	711	0.807 (0.041)	0.959 (0.089)	0.923 (0.134)	0.714 (0.088)
06 Apr - 12 Apr	1,210	0.834 (0.025)	0.928 (0.052)	0.873 (0.083)	0.676 (0.056)
13 Apr - 19 Apr	752	0.920 (0.027)	0.998 (0.059)	0.760 (0.071)	0.698 (0.054)
20 Apr - 26 Apr	23,430	0.934 (0.004)	0.931 (0.008)	0.891 (0.014)	0.775 (0.011)
27 Apr - 03 May	62,330	0.918 (0.003)	0.930 (0.006)	0.891 (0.010)	0.761 (0.008)
04 May - 10 May	61,980	0.900 (0.006)	0.982 (0.012)	0.885 (0.018)	0.782 (0.013)
11 May - 17 May	30,884	0.907 (0.010)	0.939 (0.021)	0.779 (0.035)	0.664 (0.026)
18 May - 24 May	727	0.858 (0.037)	0.942 (0.101)	0.887 (0.194)	0.716 (0.140)
25 May - 31 May	80	0.938 (0.143)	0.957 (0.442)	0.554 (0.395)	0.497 (0.275)
01 Jun - 07 Jun	75	0.850 (0.321)	0.392 (0.212)	0.375 (0.171)	0.125 (0.039)
08 Jun - 14 Jun	11	0.682 (0.257)	NA	NA	NA
Weighted mean^a		0.919 (0.004)	0.938 (0.006)	0.885 (0.008)	0.763 (0.009)

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

Table 4. Estimated survival probabilities for Snake River wild yearling Chinook salmon detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar - 05 Apr	87	0.968 (0.088)	0.817 (0.119)	1.235 (0.380)	0.977 (0.289)
06 Apr - 12 Apr	572	0.918 (0.025)	0.905 (0.042)	0.886 (0.078)	0.736 (0.060)
13 Apr - 19 Apr	922	0.956 (0.017)	0.934 (0.032)	0.879 (0.058)	0.785 (0.047)
20 Apr - 26 Apr	3,996	0.962 (0.008)	0.917 (0.014)	0.857 (0.026)	0.756 (0.021)
27 Apr - 03 May	4,606	0.956 (0.007)	0.927 (0.015)	0.838 (0.026)	0.743 (0.021)
04 May - 10 May	2,507	0.940 (0.017)	0.905 (0.033)	0.866 (0.053)	0.737 (0.039)
11 May - 17 May	1,147	1.005 (0.034)	0.900 (0.072)	0.783 (0.114)	0.708 (0.090)
18 May - 24 May	851	0.929 (0.033)	0.852 (0.057)	1.180 (0.176)	0.934 (0.131)
25 May - 31 May	394	0.926 (0.035)	1.008 (0.107)	0.923 (0.209)	0.862 (0.175)
01 Jun - 07 Jun	209	1.097 (0.116)	0.816 (0.214)	0.992 (0.433)	0.888 (0.326)
08 Jun - 14 Jun	140	1.066 (0.159)	1.209 (0.374)	0.523 (0.197)	0.674 (0.171)
Weighted mean^a		0.956 (0.005)	0.919 (0.006)	0.860 (0.017)	0.754 (0.010)

^a Weighted means of the independent estimates for weekly pooled groups (30 March - 21 June), with weights inversely proportional to respective estimated relative variances.

Table 5. Estimated survival probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled as necessary to calculate estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
25 Mar-01 Apr	194	0.861 (0.103)	0.797 (0.171)	0.764 (0.237)	0.524 (0.136)
02 Apr	197	0.750 (0.070)	0.865 (0.114)	1.306 (0.310)	0.848 (0.188)
03 Apr	124	0.774 (0.080)	0.944 (0.175)	0.921 (0.387)	0.673 (0.264)
04 Apr	132	0.817 (0.076)	0.918 (0.155)	0.882 (0.226)	0.661 (0.144)
05 Apr	165	0.888 (0.082)	1.043 (0.189)	1.150 (0.346)	1.066 (0.272)
06 Apr	174	0.834 (0.085)	0.789 (0.116)	0.850 (0.168)	0.559 (0.099)
07 Apr	203	0.953 (0.068)	0.976 (0.131)	0.682 (0.122)	0.634 (0.088)
08 Apr	292	0.838 (0.049)	0.863 (0.085)	0.855 (0.144)	0.618 (0.094)
09 Apr	277	0.814 (0.043)	0.846 (0.077)	0.991 (0.170)	0.683 (0.109)
10 Apr	274	0.863 (0.038)	1.159 (0.117)	0.830 (0.163)	0.830 (0.141)
11 Apr	278	0.861 (0.048)	0.797 (0.072)	0.984 (0.158)	0.675 (0.103)
12 Apr	284	0.874 (0.038)	0.924 (0.071)	0.934 (0.144)	0.753 (0.108)
13 Apr	287	0.892 (0.040)	0.881 (0.065)	0.868 (0.101)	0.682 (0.072)
14 Apr	259	0.940 (0.036)	0.983 (0.075)	1.080 (0.153)	0.998 (0.126)
15 Apr	155	1.007 (0.066)	0.942 (0.147)	0.551 (0.110)	0.522 (0.075)
16 Apr	136	1.012 (0.070)	0.862 (0.098)	0.965 (0.201)	0.842 (0.164)
17 Apr	290	0.887 (0.032)	1.000 (0.073)	0.752 (0.098)	0.666 (0.075)
18 Apr	290	0.965 (0.027)	0.962 (0.057)	0.953 (0.138)	0.884 (0.121)
19 Apr	257	0.948 (0.041)	0.962 (0.081)	0.721 (0.092)	0.658 (0.070)
20 Apr	484	0.971 (0.028)	0.885 (0.047)	0.810 (0.080)	0.696 (0.064)
21 Apr	4,584	0.938 (0.009)	0.946 (0.017)	0.916 (0.031)	0.813 (0.025)
22 Apr	2,895	0.952 (0.011)	0.956 (0.022)	0.876 (0.038)	0.798 (0.031)
23 Apr	317	0.948 (0.038)	0.945 (0.080)	0.683 (0.089)	0.612 (0.067)
24 Apr	7,897	0.938 (0.007)	0.929 (0.014)	0.875 (0.023)	0.763 (0.018)
25 Apr	6,894	0.918 (0.008)	0.930 (0.014)	0.895 (0.025)	0.764 (0.019)
26 Apr	4,355	0.949 (0.010)	0.887 (0.018)	0.895 (0.031)	0.754 (0.023)
27 Apr	6,861	0.904 (0.008)	0.934 (0.016)	0.854 (0.025)	0.721 (0.019)
28 Apr	14,179	0.934 (0.005)	0.941 (0.012)	0.884 (0.020)	0.777 (0.015)
29 Apr	9,027	0.944 (0.007)	0.929 (0.014)	0.936 (0.026)	0.822 (0.020)
30 Apr	1,439	0.908 (0.016)	0.986 (0.040)	0.860 (0.063)	0.769 (0.048)

Table 5. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
01 May	12,795	0.911 (0.006)	0.941 (0.013)	0.868 (0.022)	0.744 (0.017)
02 May	8,376	0.903 (0.008)	0.903 (0.015)	0.864 (0.028)	0.705 (0.020)
03 May	14,259	0.928 (0.008)	0.904 (0.015)	0.918 (0.027)	0.770 (0.020)
04 May	5,562	0.889 (0.013)	0.950 (0.028)	0.907 (0.046)	0.766 (0.034)
05 May	11,211	0.885 (0.013)	0.962 (0.026)	1.069 (0.047)	0.910 (0.034)
06 May	7,394	0.904 (0.016)	0.930 (0.030)	0.946 (0.047)	0.795 (0.033)
07 May	2,647	0.912 (0.033)	0.979 (0.061)	0.990 (0.090)	0.884 (0.067)
08 May	14,775	0.906 (0.014)	0.986 (0.027)	0.827 (0.032)	0.740 (0.024)
09 May	8,830	0.899 (0.017)	0.981 (0.034)	0.800 (0.045)	0.706 (0.034)
10 May	14,068	0.922 (0.015)	0.947 (0.027)	0.846 (0.046)	0.738 (0.036)
11 May	7,749	0.927 (0.021)	0.931 (0.038)	0.751 (0.058)	0.648 (0.044)
12 May	12,547	0.898 (0.016)	0.940 (0.034)	0.789 (0.056)	0.666 (0.043)
13 May	8,300	0.897 (0.019)	0.943 (0.042)	0.788 (0.072)	0.667 (0.056)
14 May	645	0.827 (0.069)	0.992 (0.191)	0.826 (0.322)	0.678 (0.238)
15 May	887	0.900 (0.066)	0.940 (0.137)	0.703 (0.183)	0.595 (0.136)
16 May	965	1.001 (0.066)	1.141 (0.181)	0.718 (0.203)	0.820 (0.198)
17 May	938	0.918 (0.042)	0.882 (0.086)	0.807 (0.130)	0.654 (0.090)
18 May	513	0.852 (0.046)	0.920 (0.128)	0.811 (0.194)	0.636 (0.128)
19 May	607	0.936 (0.046)	0.897 (0.088)	1.236 (0.278)	1.037 (0.216)
20-21 May	278	0.905 (0.054)	0.942 (0.125)	1.314 (0.479)	1.120 (0.386)
22 May	39	0.953 (0.063)	1.128 (0.176)	0.582 (0.193)	0.626 (0.181)
23 May	36	1.049 (0.121)	0.753 (0.187)	1.247 (1.037)	0.984 (0.797)
24 May	105	0.914 (0.071)	0.714 (0.087)	1.234 (0.324)	0.804 (0.211)
25 May	118	0.891 (0.058)	1.113 (0.195)	1.160 (0.518)	1.150 (0.474)
26 May	124	0.984 (0.065)	1.076 (0.210)	1.143 (0.602)	1.210 (0.594)
27-28 May	64	0.878 (0.136)	0.732 (0.222)	1.109 (0.671)	0.713 (0.399)
29 May	58	0.871 (0.083)	1.054 (0.324)	1.083 (0.958)	0.994 (0.827)
30-31 May	110	0.944 (0.088)	0.861 (0.241)	0.500 (0.181)	0.407 (0.101)
Weighted mean^a		0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.764 (0.007)

^a 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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar – 05 Apr	798	0.386 (0.025)	0.316 (0.028)	0.251 (0.033)
06 Apr - 12 Apr	1,782	0.500 (0.016)	0.441 (0.019)	0.327 (0.023)
13 Apr - 19 Apr	1,674	0.549 (0.015)	0.483 (0.018)	0.399 (0.023)
20 Apr - 26 Apr	27,426	0.535 (0.004)	0.478 (0.004)	0.371 (0.006)
27 Apr - 03 May	66,936	0.546 (0.002)	0.415 (0.003)	0.355 (0.004)
04 May - 10 May	64,487	0.316 (0.003)	0.279 (0.003)	0.249 (0.004)
11 May - 17 May	32,031	0.312 (0.004)	0.266 (0.006)	0.112 (0.005)
18 May - 24 May	1,578	0.488 (0.018)	0.356 (0.022)	0.161 (0.021)
25 May - 31 May	474	0.600 (0.032)	0.330 (0.040)	0.185 (0.040)
01 Jun - 07 Jun	284	0.384 (0.050)	0.199 (0.049)	0.125 (0.047)
08 Jun - 14 Jun	151	0.258 (0.051)	0.173 (0.055)	0.307 (0.084)

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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations:MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	JDA	BON
13 Apr – 19 Apr	227	0.407 (0.110)	NA
20 Apr – 26 Apr	1,945	0.389 (0.032)	0.174 (0.070)
27 Apr - 03 May	6,824	0.339 (0.015)	0.141 (0.029)
04 May - 10 May	24,123	0.178 (0.006)	0.218 (0.017)
11 May - 17 May	27,213	0.138 (0.006)	0.137 (0.017)
18 May - 24 May	9,596	0.141 (0.013)	0.070 (0.020)
25 May - 31 May	842	0.188 (0.047)	0.061 (0.059)

Table 8. Estimated detection probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Mar	711	0.375 (0.027)	0.284 (0.030)	0.258 (0.037)
06 Apr - 12 Apr	1,210	0.462 (0.020)	0.364 (0.024)	0.296 (0.029)
13 Apr - 19 Apr	752	0.490 (0.023)	0.392 (0.028)	0.394 (0.036)
20 Apr - 26 Apr	23,430	0.521 (0.004)	0.459 (0.005)	0.364 (0.006)
27 Apr - 03 May	62,330	0.536 (0.003)	0.405 (0.003)	0.348 (0.004)
04 May - 10 May	61,980	0.306 (0.003)	0.273 (0.003)	0.243 (0.005)
11 May - 17 May	30,884	0.305 (0.004)	0.263 (0.006)	0.108 (0.005)
18 May - 24 May	727	0.526 (0.029)	0.287 (0.034)	0.145 (0.032)
25 May - 31 May	80	0.493 (0.094)	0.235 (0.114)	0.222 (0.139)
01 Jun - 07 Jun	75	0.267 (0.114)	0.360 (0.161)	0.111 (0.105)
08 Jun - 14 Jun	11	0.667 (0.272)	NA	0.333 (0.272)

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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar - 05 Mar	87	0.451 (0.068)	0.500 (0.079)	0.214 (0.078)
06 Apr - 12 Apr	572	0.560 (0.025)	0.567 (0.031)	0.375 (0.038)
13 Apr - 19 Apr	922	0.590 (0.019)	0.548 (0.024)	0.403 (0.030)
20 Apr - 26 Apr	3,996	0.611 (0.009)	0.578 (0.011)	0.403 (0.014)
27 Apr - 03 May	4,606	0.657 (0.008)	0.534 (0.011)	0.429 (0.015)
04 May - 10 May	2,507	0.502 (0.013)	0.389 (0.016)	0.358 (0.022)
11 May - 17 May	1,147	0.467 (0.022)	0.305 (0.026)	0.171 (0.025)
18 May - 24 May	851	0.463 (0.024)	0.400 (0.029)	0.172 (0.028)
25 May - 31 May	394	0.614 (0.034)	0.340 (0.042)	0.181 (0.042)
01 Jun - 07 Jun	209	0.406 (0.054)	0.174 (0.050)	0.127 (0.053)
08 Jun - 14 Jun	140	0.241 (0.050)	0.184 (0.058)	0.304 (0.089)

Table 10. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar – 05 Apr	26	0.954 (0.059)	1.382 (0.413)	NA	NA
06 Apr - 12 Apr	374	0.954 (0.023)	0.912 (0.041)	0.870 (0.100)	0.757 (0.084)
13 Apr - 19 Apr	2,142	0.972 (0.008)	0.922 (0.018)	0.882 (0.041)	0.790 (0.035)
20 Apr - 26 Apr	6,590	0.973 (0.006)	0.908 (0.011)	0.808 (0.025)	0.714 (0.021)
27 Apr – 03 May	9,446	0.958 (0.004)	0.926 (0.010)	0.898 (0.028)	0.797 (0.024)
04 May - 10 May	9,186	0.932 (0.006)	0.896 (0.015)	0.712 (0.027)	0.595 (0.021)
11 May - 17 May	6,014	0.906 (0.010)	0.871 (0.021)	0.843 (0.054)	0.665 (0.040)
18 May - 24 May	3,424	0.957 (0.012)	0.970 (0.031)	0.758 (0.050)	0.704 (0.042)
25 May - 31 May	2,273	0.917 (0.015)	0.823 (0.034)	0.522 (0.050)	0.394 (0.035)
01 Jun - 07 Jun	1,626	0.903 (0.026)	0.709 (0.056)	0.689 (0.134)	0.442 (0.080)
08 Jun - 14 Jun	271	0.779 (0.139)	0.626 (0.164)	1.081 (0.417)	0.527 (0.180)
Weighted mean^a		0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.702 (0.016)

^a Weighted means of the independent estimates for daily groups (30 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 2006. Daily groups pooled weekly for McNary to John Day estimates, and biweekly for John Day to Bonneville and McNary to Bonneville estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	MCN to JDA	JDA to BON	MCN to BON
13 Apr - 19 Apr	135	0.696 (0.172)		
20 Apr - 26 Apr	745	0.791 (0.082)	0.565 (0.282)	0.439 (0.215)
27 Apr - 03 May	1,511	0.755 (0.054)		
04 May - 10 May	2,539	0.793 (0.060)	0.845 (0.207)	0.661 (0.158)
11 May - 17 May	1,902	1.050 (0.123)		
18 May - 24 May	1,229	0.634 (0.067)	0.958 (0.531)	0.843 (0.462)
25 May - 31 May	414	1.292 (0.374)		
01 Jun - 07 Jun	87	0.684 (0.238)	NA	NA
08 Jun - 14 Jun	80	1.019 (0.574)	NA	NA
Weighted mean^a		0.795 (0.045)	0.813 (0.083)	0.648 (0.079)

^a Weighted means of the independent estimates for pooled groups, 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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar – 05 Apr	19	0.965 (0.056)	1.385 (0.364)	NA	NA
06 Apr - 12 Apr	130	0.860 (0.039)	0.884 (0.063)	1.065 (0.230)	0.811 (0.173)
13 Apr - 19 Apr	1,566	0.974 (0.010)	0.913 (0.021)	0.879 (0.047)	0.782 (0.040)
20 Apr - 26 Apr	3,426	0.956 (0.008)	0.922 (0.015)	0.785 (0.031)	0.691 (0.026)
27 Apr - 03 May	5,002	0.949 (0.006)	0.920 (0.014)	0.857 (0.035)	0.748 (0.029)
04 May - 10 May	6,154	0.931 (0.008)	0.900 (0.018)	0.715 (0.033)	0.599 (0.025)
11 May - 17 May	4,137	0.916 (0.012)	0.851 (0.023)	0.836 (0.060)	0.651 (0.044)
18 May - 24 May	2,266	0.951 (0.016)	0.982 (0.038)	0.714 (0.056)	0.666 (0.046)
25 May - 31 May	1,654	0.901 (0.017)	0.808 (0.038)	0.551 (0.065)	0.401 (0.044)
01 Jun - 07 Jun	1,186	0.915 (0.032)	0.668 (0.060)	0.661 (0.137)	0.404 (0.078)
08 Jun - 14 Jun	148	1.012 (0.287)	0.582 (0.221)	0.635 (0.236)	0.374 (0.110)
Weighted mean^a		0.945 (0.006)	0.907 (0.013)	0.795 (0.026)	0.682 (0.028)

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

Table 13. Estimated survival probabilities for juvenile Snake River wild steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
06 Apr - 12 Apr	244	1.003 (0.028)	0.926 (0.053)	0.791 (0.108)	0.735 (0.095)
13 Apr - 19 Apr	576	0.968 (0.016)	0.946 (0.035)	0.890 (0.084)	0.814 (0.073)
20 Apr - 26 Apr	3,164	0.991 (0.009)	0.894 (0.017)	0.840 (0.040)	0.744 (0.034)
27 Apr - 03 May	4,444	0.970 (0.006)	0.934 (0.015)	0.950 (0.045)	0.860 (0.039)
04 May - 10 May	3,032	0.934 (0.011)	0.886 (0.026)	0.695 (0.047)	0.576 (0.036)
11 May - 17 May	1,877	0.892 (0.022)	0.943 (0.051)	0.830 (0.114)	0.698 (0.090)
18 May - 24 May	1,158	0.968 (0.020)	0.946 (0.050)	0.830 (0.101)	0.760 (0.084)
25 May - 31 May	619	0.960 (0.030)	0.866 (0.072)	0.455 (0.077)	0.378 (0.057)
01 Jun - 07 Jun	440	0.876 (0.045)	0.847 (0.141)	0.864 (0.450)	0.641 (0.317)
08 Jun - 14 Jun	123	0.576 (0.130)	0.557 (0.193)	NA	NA
Weighted mean^a		0.967 (0.008)	0.917 (0.008)	0.843 (0.037)	0.745 (0.040)

^a Weighted means of the independent estimates for weekly pooled groups (06 April - 14 June), with weights inversely proportional to respective estimated relative variances.

Table 14. Estimated survival probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled as necessary to calculate estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
30 Mar-06 Apr	30	0.972 (0.055)	1.380 (0.442)	0.453 (0.330)	0.608 (0.390)
07-08 Apr	38	0.977 (0.070)	0.894 (0.148)	0.743 (0.221)	0.649 (0.175)
09 Apr	38	0.916 (0.115)	1.099 (0.256)	0.494 (0.202)	0.497 (0.175)
10 Apr	79	0.921 (0.044)	0.870 (0.071)	1.044 (0.218)	0.836 (0.174)
11 Apr	85	0.997 (0.057)	0.775 (0.074)	1.188 (0.446)	0.918 (0.346)
12 Apr	130	0.950 (0.032)	1.015 (0.071)	0.811 (0.149)	0.782 (0.135)
13 Apr	92	1.026 (0.046)	0.937 (0.098)	0.865 (0.200)	0.832 (0.178)
14 Apr	138	0.958 (0.031)	0.931 (0.062)	0.743 (0.119)	0.663 (0.101)
15 Apr	98	1.118 (0.071)	0.784 (0.091)	0.987 (0.232)	0.865 (0.194)
16 Apr	124	0.970 (0.028)	1.017 (0.084)	0.633 (0.112)	0.624 (0.099)
17 Apr	853	0.974 (0.013)	0.914 (0.025)	0.938 (0.066)	0.835 (0.057)
18 Apr	593	0.961 (0.017)	0.932 (0.037)	0.851 (0.078)	0.762 (0.066)
19 Apr	244	0.949 (0.027)	0.926 (0.064)	0.946 (0.159)	0.831 (0.132)
20 Apr	935	0.999 (0.019)	0.888 (0.032)	0.763 (0.055)	0.677 (0.046)
21 Apr	897	0.968 (0.021)	0.930 (0.032)	0.800 (0.061)	0.719 (0.052)
22 Apr	700	0.947 (0.019)	0.952 (0.035)	0.973 (0.105)	0.877 (0.091)
23 Apr	95	0.960 (0.053)	0.969 (0.107)	0.588 (0.134)	0.547 (0.114)
24 Apr	1,461	0.964 (0.010)	0.894 (0.024)	0.751 (0.050)	0.647 (0.041)
25 Apr	1,233	0.969 (0.013)	0.902 (0.026)	0.841 (0.065)	0.735 (0.054)
26 Apr	1,269	0.969 (0.012)	0.919 (0.024)	0.809 (0.057)	0.721 (0.049)
27 Apr	1,833	0.963 (0.009)	0.948 (0.022)	0.954 (0.070)	0.871 (0.061)
28 Apr	1,410	0.966 (0.013)	0.929 (0.028)	0.924 (0.069)	0.829 (0.058)
29 Apr	1,038	0.928 (0.013)	0.914 (0.025)	1.004 (0.087)	0.852 (0.072)
30 Apr	283	0.972 (0.022)	0.872 (0.051)	0.716 (0.097)	0.606 (0.078)
01 May	1,442	0.961 (0.011)	0.924 (0.028)	0.745 (0.059)	0.661 (0.049)
02 May	1,723	0.961 (0.010)	0.920 (0.023)	0.914 (0.064)	0.808 (0.054)
03 May	1,717	0.961 (0.009)	0.909 (0.024)	0.732 (0.059)	0.640 (0.049)

Table 14. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
04 May	1,713	0.952 (0.012)	0.932 (0.029)	0.728 (0.058)	0.646 (0.048)
05 May	1,994	0.942 (0.014)	0.830 (0.032)	0.732 (0.064)	0.571 (0.047)
06 May	960	0.969 (0.020)	0.900 (0.050)	0.794 (0.099)	0.693 (0.078)
07 May	339	0.982 (0.044)	0.984 (0.112)	0.566 (0.120)	0.546 (0.098)
08 May	1,240	0.905 (0.020)	0.851 (0.038)	0.808 (0.082)	0.622 (0.059)
09 May	1,294	0.944 (0.018)	0.906 (0.044)	0.651 (0.062)	0.556 (0.047)
10 May	1,646	0.889 (0.015)	0.936 (0.038)	0.640 (0.059)	0.533 (0.045)
11 May	1,310	0.923 (0.019)	0.875 (0.039)	0.721 (0.078)	0.582 (0.060)
12 May	1,177	0.926 (0.018)	0.872 (0.037)	1.048 (0.171)	0.845 (0.134)
13 May	425	0.911 (0.028)	0.917 (0.073)	0.787 (0.183)	0.658 (0.145)
14 May	195	0.853 (0.049)	0.878 (0.115)	0.824 (0.331)	0.617 (0.238)
15 May	881	0.893 (0.026)	0.871 (0.058)	0.956 (0.226)	0.743 (0.170)
16 May	936	0.953 (0.044)	0.655 (0.051)	0.932 (0.164)	0.581 (0.097)
17 May	1,090	0.949 (0.037)	0.922 (0.071)	0.782 (0.113)	0.684 (0.087)
18 May	867	0.964 (0.033)	0.832 (0.061)	0.952 (0.134)	0.764 (0.097)
19 May	1,254	0.986 (0.028)	0.978 (0.055)	0.727 (0.073)	0.701 (0.062)
20 May	137	1.127 (0.125)	0.850 (0.182)	0.563 (0.174)	0.539 (0.136)
21 May	46	1.014 (0.056)	1.565 (0.434)	0.417 (0.202)	0.661 (0.252)
22 May	55	1.050 (0.075)	0.899 (0.145)	1.320 (0.743)	1.246 (0.681)
23 May	36	1.069 (0.060)	0.816 (0.140)	2.124 (1.827)	1.854 (1.579)
24 May	1,029	0.943 (0.012)	0.939 (0.044)	0.686 (0.087)	0.607 (0.072)
25 May	835	0.969 (0.021)	0.874 (0.050)	0.534 (0.070)	0.453 (0.054)
26-28 May	929	0.926 (0.028)	0.841 (0.062)	0.504 (0.083)	0.393 (0.060)
29-31 May	509	0.817 (0.030)	0.699 (0.067)	0.544 (0.148)	0.311 (0.081)
Weighted mean^a		0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.702 (0.016)

^a Weighted means of the independent estimates for daily groups (30 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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar – 05 Apr	26	0.806 (0.087)	0.444 (0.166)	NA (NA)
06 Apr - 12 Apr	374	0.650 (0.029)	0.686 (0.036)	0.260 (0.038)
13 Apr - 19 Apr	2,142	0.701 (0.012)	0.631 (0.015)	0.281 (0.016)
20 Apr - 26 Apr	6,590	0.624 (0.007)	0.658 (0.009)	0.272 (0.010)
27 Apr - 03 May	9,446	0.732 (0.005)	0.622 (0.008)	0.252 (0.009)
04 May - 10 May	9,186	0.646 (0.006)	0.550 (0.010)	0.280 (0.012)
11 May - 17 May	6,014	0.551 (0.009)	0.482 (0.012)	0.132 (0.010)
18 May - 24 May	3,424	0.574 (0.011)	0.391 (0.014)	0.153 (0.012)
25 May - 31 May	2,273	0.638 (0.014)	0.528 (0.023)	0.160 (0.018)
01 Jun - 07 Jun	1,626	0.600 (0.021)	0.358 (0.030)	0.086 (0.019)
08 Jun - 14 Jun	271	0.218 (0.048)	0.222 (0.055)	0.108 (0.045)

Table 16. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2006. Daily groups pooled weekly for John Day Dam estimates, and biweekly for Bonneville Dam estimates. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam.

Date at MCN	Number released	JDA	BON
13 Apr - 19 Apr	135	0.511 (0.133)	0.254 (0.126)
20 Apr - 26 Apr	745	0.472 (0.052)	
27 Apr - 03 May	1,511	0.472 (0.036)	0.176 (0.043)
04 May - 10 May	2,539	0.296 (0.024)	
11 May - 17 May	1,902	0.269 (0.033)	0.085 (0.047)
18 May - 24 May	1,229	0.532 (0.058)	
25 May - 31 May	414	0.275 (0.082)	NA
01 Jun - 07 Jun	87	0.420 (0.157)	
08 Jun - 14 Jun	80	0.294 (0.174)	NA

Table 17 Estimated detection probabilities for juvenile Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
30 Mar – 05 Apr	19	0.764 (0.103)	0.500 (0.177)	NA
06 Apr - 12 Apr	130	0.769 (0.045)	0.690 (0.061)	0.222 (0.062)
13 Apr - 19 Apr	1,566	0.698 (0.014)	0.629 (0.018)	0.282 (0.019)
20 Apr - 26 Apr	3,426	0.623 (0.010)	0.667 (0.012)	0.291 (0.014)
27 Apr - 03 May	5,002	0.724 (0.008)	0.632 (0.011)	0.274 (0.013)
04 May - 10 May	6,154	0.641 (0.008)	0.550 (0.012)	0.266 (0.013)
11 May - 17 May	4,137	0.575 (0.010)	0.508 (0.015)	0.132 (0.011)
18 May - 24 May	2,266	0.557 (0.014)	0.377 (0.017)	0.147 (0.014)
25 May - 31 May	1,654	0.650 (0.017)	0.540 (0.027)	0.146 (0.021)
01 Jun - 07 Jun	1,186	0.592 (0.025)	0.370 (0.034)	0.100 (0.023)
08 Jun - 14 Jun	148	0.160 (0.054)	0.244 (0.074)	0.167 (0.068)

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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGO	LMO	MCN
06 Apr - 12 Apr	244	0.597 (0.036)	0.685 (0.044)	0.279 (0.048)
13 Apr - 19 Apr	576	0.708 (0.022)	0.636 (0.029)	0.280 (0.032)
20 Apr - 26 Apr	3,164	0.625 (0.010)	0.647 (0.014)	0.250 (0.014)
27 Apr - 03 May	4,444	0.741 (0.008)	0.610 (0.012)	0.229 (0.012)
04 May - 10 May	3,032	0.658 (0.011)	0.551 (0.018)	0.315 (0.022)
11 May - 17 May	1,877	0.491 (0.017)	0.410 (0.024)	0.130 (0.019)
18 May - 24 May	1,158	0.609 (0.019)	0.420 (0.026)	0.168 (0.022)
25 May - 31 May	619	0.607 (0.027)	0.499 (0.044)	0.200 (0.039)
01 Jun - 07 Jun	440	0.623 (0.039)	0.322 (0.057)	0.050 (0.028)
08 Jun - 14 Jun	123	0.310 (0.086)	0.202 (0.082)	NA (NA)

Table 19. Estimated survival probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
Crooked River Pond	300	0.370 (0.045)	1.269 (0.249)	0.768 (0.220)	1.020 (0.538)	0.367 (0.179)
Crooked River	15,278	0.639 (0.021)	0.852 (0.041)	0.980 (0.057)	0.828 (0.069)	0.442 (0.028)
Powell Pond	15,274	0.796 (0.022)	0.802 (0.033)	0.927 (0.044)	1.036 (0.074)	0.612 (0.035)
Red River Pond	14,974	0.524 (0.017)	0.932 (0.048)	0.888 (0.060)	0.981 (0.094)	0.425 (0.031)
Dworshak Hatchery						
N.F. Clearwater River	97,391	0.853 (0.007)	0.815 (0.008)	0.922 (0.009)	0.874 (0.014)	0.560 (0.008)
Kooskia Hatchery						
Clear Creek	800	0.716 (0.041)	0.880 (0.064)	0.917 (0.087)	0.887 (0.151)	0.513 (0.078)
McCall Hatchery						
Johnson Creek	12,058	0.326 (0.017)	0.870 (0.065)	0.953 (0.102)	0.873 (0.126)	0.236 (0.023)
Knox Bridge	51,904	0.634 (0.006)	0.877 (0.013)	0.923 (0.018)	0.979 (0.032)	0.502 (0.014)

Table 19. Continued.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Lookingglass Hatchery						
Catherine Creek Pond	20,963	0.309 (0.007)	0.907 (0.028)	0.929 (0.042)	0.945 (0.076)	0.246 (0.017)
Grande Ronde R. Pond	498	0.559 (0.081)	0.604 (0.101)	1.008 (0.172)	0.614 (0.152)	0.209 (0.043)
Imnaha Weir (3/21)	14,926	0.647 (0.012)	0.838 (0.020)	0.905 (0.026)	0.914 (0.046)	0.448 (0.019)
Imnaha Weir (3/30)	5,706	0.613 (0.021)	0.807 (0.036)	0.955 (0.047)	0.802 (0.063)	0.379 (0.025)
Lookingglass H.	492	0.602 (0.051)	0.884 (0.097)	0.786 (0.100)	0.769 (0.149)	0.322 (0.056)
Lostine Pond (3/10)	10,071	0.329 (0.008)	0.858 (0.023)	0.920 (0.035)	0.779 (0.049)	0.202 (0.011)
Lostine Pond (3/28)	4,171	0.500 (0.013)	0.934 (0.028)	0.892 (0.037)	0.890 (0.063)	0.371 (0.024)
Pahsimeroi Hatchery						
Pahsimeroi Pond	497	0.262 (0.024)	1.092 (0.093)	0.783 (0.102)	1.967 (0.755)	0.440 (0.168)
Rapid River Hatchery						
Rapid River H.	96,975	0.764 (0.004)	0.874 (0.006)	0.934 (0.008)	0.939 (0.015)	0.586 (0.008)
Sawtooth Hatchery						
Sawtooth H.	500	0.646 (0.045)	0.837 (0.074)	0.860 (0.096)	1.420 (0.437)	0.661 (0.196)
Yankee Fork	695	0.646 (0.038)	0.922 (0.073)	0.798 (0.087)	1.049 (0.247)	0.498 (0.110)

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Clearwater Hatchery						
S.F. Clearwater River	295	0.850 (0.035)	1.003 (0.052)	0.821 (0.060)	0.653 (0.100)	0.457 (0.068)
Crooked River Pond	300	0.773 (0.038)	1.020 (0.059)	0.961 (0.111)	0.785 (0.265)	0.595 (0.191)
Crooked River	299	0.708 (0.036)	0.987 (0.049)	0.996 (0.088)	0.904 (0.212)	0.629 (0.140)
Lolo Creek	299	0.750 (0.040)	0.943 (0.053)	1.063 (0.102)	0.584 (0.110)	0.438 (0.073)
Meadow Creek	1,297	0.922 (0.021)	0.938 (0.026)	0.883 (0.036)	0.748 (0.075)	0.571 (0.054)
Mill Creek	1,289	0.686 (0.025)	0.874 (0.035)	0.970 (0.065)	0.560 (0.084)	0.326 (0.044)
Red River Pond	7,253	0.776 (0.009)	0.953 (0.013)	0.923 (0.020)	0.836 (0.045)	0.571 (0.029)
Dworshak Hatchery						
N.F. Clearwater River	1,494	0.740 (0.016)	0.974 (0.022)	0.918 (0.032)	0.707 (0.053)	0.468 (0.033)
Hagerman Hatchery						
Little Salmon River	588	0.226 (0.020)	0.882 (0.058)	0.966 (0.099)	1.395 (0.588)	0.269 (0.112)
East Fork Salmon R.	297	0.811 (0.035)	0.980 (0.049)	0.968 (0.093)	0.743 (0.144)	0.571 (0.100)
Sawtooth Hatchery	295	0.786 (0.039)	0.939 (0.053)	0.787 (0.056)	0.883 (0.133)	0.513 (0.077)
Yankee Fork	295	0.695 (0.036)	1.044 (0.063)	1.028 (0.126)	0.874 (0.274)	0.652 (0.192)

Table 20. Continued.

Release site	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Magic Valley Hatchery						
Lemhi R.	599	0.802 (0.027)	0.995 (0.040)	0.838 (0.055)	0.804 (0.110)	0.537 (0.069)
Little Salmon R.	300	0.723 (0.032)	1.004 (0.042)	0.874 (0.068)	0.780 (0.140)	0.495 (0.085)
Salmon R. (Rkm 385)	597	0.862 (0.025)	0.936 (0.034)	0.911 (0.053)	0.801 (0.100)	0.589 (0.068)
Salmon R. (Rkm 476)	797	0.764 (0.021)	0.994 (0.032)	0.872 (0.053)	0.762 (0.104)	0.504 (0.064)
Salmon R. (Rkm 506)	298	0.800 (0.033)	0.942 (0.045)	0.938 (0.081)	0.695 (0.124)	0.492 (0.080)
Salmon R. (Rkm 567)	299	0.928 (0.041)	0.927 (0.053)	0.887 (0.070)	0.898 (0.156)	0.685 (0.111)
Valley Creek	300	0.843 (0.034)	0.955 (0.048)	0.883 (0.076)	1.046 (0.252)	0.744 (0.173)
Yankee Fork	497	0.716 (0.026)	1.024 (0.043)	0.867 (0.075)	0.597 (0.097)	0.380 (0.056)
Niagara Springs Hatchery						
Hells Canyon Dam	299	0.748 (0.044)	0.879 (0.060)	0.893 (0.077)	0.855 (0.161)	0.502 (0.090)
Little Salmon R.	599	0.251 (0.024)	0.833 (0.080)	0.818 (0.107)	0.826 (0.215)	0.141 (0.036)
Pahsimeroi Weir	298	0.802 (0.038)	0.933 (0.055)	0.935 (0.088)	1.031 (0.285)	0.722 (0.192)

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from the Oxbow and Sawtooth hatcheries and coho salmon from Kooskia and Clearwater hatcheries released in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Release date	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN	Rel to MCN
Oxbow Hatchery sockeye salmon								
Redfish Lk Cr. Trap	10 May 06	1,013	0.588 (0.102)	0.927 (0.221)	0.996 (0.261)	0.701 (0.466)	0.648 (0.424)	0.381 (0.240)
Sawtooth Hatchery sockeye salmon								
Alturus Lake	05 Oct 05	1,011	0.246 (0.042)	0.845 (0.154)	0.843 (0.157)	1.805 (1.206)	1.285 (0.857)	0.315 (0.205)
Pettit Lake	05 Oct 05	1,010	0.470 (0.057)	0.794 (0.106)	0.821 (0.105)	0.800 (0.233)	0.521 (0.154)	0.245 (0.067)
Redfish Lake	05 Oct 05	1,008	0.218 (0.039)	0.772 (0.148)	0.939 (0.184)	0.779 (0.311)	0.565 (0.224)	0.123 (0.045)
Sawtooth Trap	04 May 06	1,012	0.616 (0.052)	0.662 (0.076)	1.142 (0.165)	1.575 (0.748)	1.191 (0.555)	0.733 (0.337)
Clearwater Hatchery coho salmon								
Eldorado Creek	26 Sep 05	1,005	0.096 (0.017)	0.811 (0.166)	2.888 (2.694)	0.294 (0.374)	0.689 (0.603)	0.066 (0.058)
Lolo Creek	26 Sep 05	1,984	0.066 (0.011)	0.718 (0.135)	1.090 (0.319)	0.977 (0.652)	0.764 (0.479)	0.050 (0.031)

Table 22. Estimated detection probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations:LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary.

Release site	Number released	LGR	LGO	LMO	MCN
Clearwater Hatchery					
Crooked River Pond	300	0.288 (0.051)	0.265 (0.060)	0.303 (0.080)	0.158 (0.084)
Crooked River	15,278	0.246 (0.009)	0.390 (0.011)	0.316 (0.016)	0.235 (0.016)
Powell Pond	15,274	0.261 (0.008)	0.404 (0.010)	0.327 (0.014)	0.250 (0.015)
Red River Pond	14,974	0.278 (0.010)	0.360 (0.013)	0.331 (0.018)	0.217 (0.017)
Dworshak Hatchery					
N.F. Clearwater River	97,391	0.187 (0.002)	0.397 (0.003)	0.342 (0.004)	0.274 (0.004)
Kooskia Hatchery					
Clear Creek	800	0.251 (0.022)	0.438 (0.030)	0.352 (0.036)	0.298 (0.050)
McCall Hatchery					
Johnson Creek	12,058	0.229 (0.014)	0.412 (0.019)	0.280 (0.027)	0.212 (0.022)
Knox Bridge	51,904	0.296 (0.004)	0.398 (0.005)	0.349 (0.007)	0.227 (0.007)

Table 22. Continued.

Release site	Number released	LGR	LGO	LMO	MCN
Lookingglass Hatchery					
Catherine Creek Pond	20,963	0.294 (0.008)	0.452 (0.011)	0.338 (0.015)	0.213 (0.016)
Grande Ronde R. Pond	498	0.187 (0.035)	0.454 (0.052)	0.324 (0.062)	0.247 (0.064)
Imnaha Weir (3/21)	14,926	0.266 (0.006)	0.526 (0.009)	0.396 (0.012)	0.313 (0.015)
Imnaha Weir (3/30)	5,706	0.243 (0.011)	0.521 (0.014)	0.395 (0.020)	0.355 (0.026)
Lookingglass H.	492	0.260 (0.032)	0.395 (0.042)	0.414 (0.054)	0.370 (0.071)
Lostine Pond (3/10)	10,071	0.284 (0.010)	0.507 (0.013)	0.346 (0.015)	0.315 (0.020)
Lostine Pond (3/28)	4,171	0.284 (0.012)	0.475 (0.015)	0.366 (0.018)	0.315 (0.023)
Pahsimeroi Hatchery					
Pahsimeroi Pond	497	0.330 (0.044)	0.478 (0.055)	0.444 (0.064)	0.172 (0.070)
Rapid River Hatchery					
Rapid River H.	96,975	0.330 (0.002)	0.467 (0.003)	0.390 (0.004)	0.279 (0.005)
Sawtooth Hatchery					
Sawtooth H.	500	0.309 (0.032)	0.459 (0.040)	0.440 (0.052)	0.148 (0.048)
Yankee Fork	695	0.303 (0.027)	0.428 (0.035)	0.398 (0.044)	0.186 (0.046)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Number released	LGR	LGO	LMO	MCN
Clearwater Hatchery					
S.F. Clearwater River	295	0.383 (0.033)	0.552 (0.038)	0.684 (0.049)	0.200 (0.045)
Crooked River Pond	300	0.341 (0.034)	0.576 (0.041)	0.492 (0.062)	0.115 (0.044)
Crooked River	299	0.326 (0.034)	0.652 (0.039)	0.513 (0.055)	0.175 (0.048)
Lolo Creek	299	0.308 (0.034)	0.649 (0.039)	0.493 (0.057)	0.277 (0.058)
Meadow Creek	1,297	0.280 (0.014)	0.664 (0.018)	0.583 (0.026)	0.279 (0.031)
Mill Creek	1,289	0.285 (0.018)	0.656 (0.022)	0.490 (0.036)	0.235 (0.037)
Red River Pond	7,253	0.285 (0.007)	0.605 (0.008)	0.485 (0.012)	0.186 (0.011)
Dworshak Hatchery					
N.F. Clearwater River	1,494	0.393 (0.016)	0.616 (0.018)	0.611 (0.024)	0.303 (0.027)
Hagerman Hatchery					
Little Salmon R.	588	0.459 (0.048)	0.736 (0.048)	0.582 (0.073)	0.133 (0.062)
East Fork Salmon R.	297	0.390 (0.034)	0.631 (0.039)	0.445 (0.052)	0.208 (0.047)
Sawtooth Hatchery	295	0.384 (0.035)	0.633 (0.040)	0.641 (0.049)	0.200 (0.043)
Yankee Fork	295	0.405 (0.037)	0.515 (0.043)	0.414 (0.057)	0.126 (0.044)

Table 23. Continued.

Release site	Number released	LGR	LGO	LMO	MCN
Magic Valley Hatchery					
Lemhi R.	599	0.358 (0.024)	0.602 (0.029)	0.506 (0.038)	0.192 (0.033)
Little Salmon R.	300	0.442 (0.036)	0.667 (0.039)	0.606 (0.054)	0.253 (0.056)
Salmon R. (Rkm 385)	597	0.416 (0.024)	0.631 (0.027)	0.524 (0.036)	0.239 (0.036)
Salmon R. (Rkm 476)	797	0.455 (0.022)	0.618 (0.025)	0.514 (0.035)	0.198 (0.032)
Salmon R. (Rkm 506)	298	0.499 (0.036)	0.645 (0.039)	0.526 (0.054)	0.238 (0.051)
Salmon R. (Rkm 567)	299	0.342 (0.032)	0.618 (0.037)	0.523 (0.049)	0.241 (0.049)
Valley Creek	300	0.451 (0.034)	0.638 (0.039)	0.535 (0.053)	0.175 (0.048)
Yankee Fork	497	0.458 (0.028)	0.603 (0.034)	0.496 (0.047)	0.213 (0.042)
Niagara Springs Hatchery					
Hells Canyon Dam	299	0.367 (0.037)	0.601 (0.042)	0.554 (0.055)	0.268 (0.059)
Little Salmon R.	599	0.399 (0.048)	0.628 (0.057)	0.499 (0.074)	0.252 (0.076)
Pahsimeroi Weir	298	0.418 (0.036)	0.571 (0.041)	0.462 (0.052)	0.100 (0.034)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from the Oxbow and Sawtooth hatcheries and coho salmon from Kooskia and Clearwater hatcheries released in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Release date	Number released	LGR	LGO	LMO	MCN
Oxbow Hatchery sockeye salmon						
Redfish Lk Cr. Trap	10 May 06	1,013	0.089 (0.019)	0.128 (0.025)	0.211 (0.047)	0.029 (0.020)
Sawtooth Hatchery sockeye salmon						
Alturus Lake	05 Oct 05	1,011	0.089 (0.023)	0.512 (0.052)	0.346 (0.068)	0.062 (0.043)
Pettit Lake	05 Oct 05	1,010	0.105 (0.019)	0.467 (0.038)	0.410 (0.053)	0.183 (0.055)
Redfish Lake	05 Oct 05	1,008	0.114 (0.029)	0.442 (0.054)	0.354 (0.072)	0.185 (0.075)
Sawtooth Trap	04 May 06	1,012	0.234 (0.026)	0.270 (0.030)	0.315 (0.044)	0.055 (0.026)
Clearwater Hatchery coho salmon						
Eldorado Creek	26 Sep 05	1,005	0.258 (0.058)	0.539 (0.091)	0.063 (0.061)	0.077 (0.074)
Lolo Creek	26 Sep 05	1,984	0.214 (0.048)	0.548 (0.073)	0.269 (0.087)	0.143 (0.094)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
Wild Chinook salmon							
American River (spring)	29 Mar-31 May	618	0.514 (0.042)	0.962 (0.110)	1.568 (0.497)	0.622 (0.304)	0.483 (0.180)
American River (late)	01 Jun-31 Jul	274	0.550 (0.074)	0.975 (0.187)	1.074 (0.440)	0.838 (0.401)	0.483 (0.140)
Catherine Creek	01 Mar-15 May	329	0.418 (0.075)	1.173 (0.360)	0.648 (0.264)	0.877 (0.553)	0.279 (0.156)
Crooked Fork Creek	22 Mar-30 May	237	0.570 (0.124)	0.810 (0.232)	1.935 (1.647)	0.217 (0.223)	0.194 (0.096)
Clearwater	09 Mar-05 Apr	499	0.910 (0.072)	0.810 (0.082)	0.904 (0.070)	0.935 (0.119)	0.623 (0.076)
Crooked River	11 Apr-31 May	317	0.587 (0.076)	0.689 (0.119)	1.300 (0.391)	0.668 (0.278)	0.351 (0.104)
Elgin (Grande Ronde R.)	16 Mar-24 May	400	0.746 (0.052)	0.953 (0.097)	1.106 (0.187)	0.651 (0.172)	0.512 (0.102)
Grande Ronde	06 Mar-26 May	3,633	0.908 (0.016)	0.954 (0.026)	0.940 (0.037)	0.856 (0.059)	0.696 (0.041)
Imnaha	02 Mar-31 May	1,086	0.780 (0.042)	1.021 (0.085)	0.887 (0.088)	0.933 (0.148)	0.660 (0.094)
Johnson Creek	03 Mar-29 Apr	2,540	0.560 (0.021)	0.950 (0.044)	0.858 (0.052)	0.878 (0.100)	0.401 (0.041)
Lemhi River Weir	10 Mar-31 May	415	0.668 (0.035)	1.036 (0.077)	0.871 (0.104)	0.772 (0.160)	0.466 (0.085)
Lostine River	20 Mar-31 May	517	0.627 (0.042)	1.032 (0.106)	0.942 (0.176)	0.873 (0.287)	0.533 (0.146)
Minam	21 Mar-14 May	401	0.585 (0.051)	0.965 (0.116)	0.936 (0.185)	1.158 (0.526)	0.612 (0.250)
Pahsimeroi	01 Mar-31 May	4,664	0.409 (0.013)	0.928 (0.037)	0.885 (0.050)	1.003 (0.093)	0.337 (0.028)
Red River	11 Apr-24 May	216	0.471 (0.087)	0.937 (0.268)	0.675 (0.308)	2.469 (2.442)	0.736 (0.670)
Salmon	06 Mar-14 May	5,611	0.906 (0.013)	0.934 (0.019)	0.902 (0.023)	0.853 (0.040)	0.650 (0.028)
Sawtooth	18 Mar-31 May	1,620	0.554 (0.023)	0.990 (0.059)	1.033 (0.120)	0.708 (0.130)	0.401 (0.057)
Snake	28 Mar-17 May	2,661	0.929 (0.019)	0.939 (0.028)	0.920 (0.035)	0.804 (0.056)	0.645 (0.039)
South Fork Salmon	08 Mar-26 Apr	1,470	0.395 (0.026)	0.969 (0.084)	0.879 (0.099)	0.827 (0.144)	0.278 (0.041)
Spoolcart (Grande Ronde R.)	07 Mar-24 Apr	505	0.380 (0.052)	0.882 (0.152)	1.350 (0.461)	0.608 (0.352)	0.276 (0.127)

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							
Catherine Creek	24 Mar-12 May	500	0.249 (0.039)	0.753 (0.130)	1.138 (0.190)	1.895 (1.691)	0.404 (0.355)
Crooked Fork Creek (spring)	23 Mar-31 May	212	0.685 (0.042)	1.019 (0.065)	1.003 (0.119)	0.675 (0.168)	0.472 (0.105)
Fish Creek	14 Mar-30 May	86	0.244 (0.046)	1.044 (0.042)	1.273 (0.577)	NA	NA
Grande Ronde	09 Mar-26 May	1,073	0.906 (0.021)	0.978 (0.028)	0.828 (0.039)	0.902 (0.100)	0.662 (0.070)
Johnson Creek	19 Mar-31 May	99	0.648 (0.064)	0.886 (0.092)	0.928 (0.163)	2.000 (1.806)	1.066 (0.953)
Lookingglass Creek	07 Mar-31 May	292	0.627 (0.049)	1.047 (0.129)	0.823 (0.193)	0.473 (0.191)	0.256 (0.084)
Lostine River	15 Mar-14 May	270	0.215 (0.025)	1.117 (0.069)	1.035 (0.329)	0.817 (0.492)	0.203 (0.106)
Pahsimeroi (spring)	03 Mar-31 May	336	0.110 (0.020)	1.034 (0.174)	1.137 (0.468)	NA	NA
Salmon	04 Apr-14 May	305	0.934 (0.040)	0.941 (0.053)	0.889 (0.074)	0.842 (0.174)	0.659 (0.130)
Sawtooth	24 Mar-31 May	84	0.568 (0.137)	0.831 (0.249)	1.037 (0.253)	1.500 (1.233)	0.734 (0.592)
Snake	31 Mar-17 May	502	0.976 (0.036)	0.924 (0.046)	0.808 (0.056)	0.824 (0.158)	0.600 (0.111)
Spoolcart (Grande Ronde R.)	22 Mar-08 May	500	0.359 (0.029)	1.015 (0.091)	0.735 (0.110)	0.958 (0.339)	0.256 (0.088)
Hatchery Chinook salmon							
Grande Ronde	09 Mar-17 May	1,402	0.789 (0.027)	0.885 (0.037)	0.918 (0.050)	0.956 (0.093)	0.612 (0.053)
Salmon	20 Mar-14 May	3,395	0.903 (0.019)	0.861 (0.024)	0.991 (0.039)	0.817 (0.057)	0.629 (0.038)
Snake	28 Mar-17 May	5,003	0.943 (0.014)	0.917 (0.018)	0.903 (0.024)	0.882 (0.041)	0.689 (0.028)
Hatchery steelhead							
Grande Ronde	01 Apr-06 May	3,606	0.944 (0.010)	0.978 (0.013)	0.889 (0.020)	0.804 (0.040)	0.660 (0.031)
Salmon	03 Apr-14 May	1,225	0.850 (0.018)	0.918 (0.024)	0.929 (0.042)	0.769 (0.089)	0.558 (0.061)
Snake	28 Mar-17 May	2,148	0.909 (0.013)	0.981 (0.020)	0.814 (0.025)	0.769 (0.056)	0.559 (0.039)

Table 26. Estimated detection probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Number released	LGR	LGO	LMO	MCN
Wild Chinook salmon						
American River (spring)	29 Mar-31 May	618	0.308 (0.034)	0.532 (0.049)	0.154 (0.052)	0.156 (0.064)
American River (late)	01 Jun-31 Jul	274	0.232 (0.045)	0.328 (0.061)	0.083 (0.039)	0.225 (0.074)
Catherine Creek	01 Mar-15 May	329	0.226 (0.052)	0.309 (0.084)	0.344 (0.108)	0.111 (0.074)
Crooked Fork Creek	22 Mar-30 May	237	0.222 (0.059)	0.504 (0.086)	0.138 (0.119)	0.154 (0.100)
Clearwater	09 Mar-05 Apr	499	0.247 (0.028)	0.578 (0.035)	0.562 (0.047)	0.436 (0.062)
Crooked River	11 Apr-31 May	317	0.312 (0.050)	0.499 (0.064)	0.208 (0.070)	0.214 (0.078)
Elgin (Grande Ronde R.)	16 Mar-24 May	400	0.358 (0.036)	0.548 (0.045)	0.368 (0.068)	0.343 (0.080)
Grande Ronde	06 Mar-26 May	3,633	0.334 (0.010)	0.561 (0.013)	0.438 (0.019)	0.319 (0.022)
Imnaha	02 Mar-31 May	1,086	0.320 (0.023)	0.543 (0.030)	0.473 (0.042)	0.296 (0.049)
Johnson Creek	03 Mar-29 Apr	2,540	0.253 (0.014)	0.520 (0.020)	0.447 (0.028)	0.264 (0.031)
Lemhi River Weir	10 Mar-31 May	415	0.411 (0.034)	0.541 (0.045)	0.528 (0.064)	0.317 (0.073)
Lostine River	20 Mar-31 May	517	0.345 (0.033)	0.488 (0.047)	0.363 (0.068)	0.242 (0.075)
Minam	21 Mar-14 May	401	0.316 (0.039)	0.551 (0.053)	0.402 (0.082)	0.182 (0.082)
Pahsimeroi	01 Mar-31 May	4,664	0.294 (0.013)	0.468 (0.017)	0.324 (0.020)	0.283 (0.026)
Red River	11 Apr-24 May	216	0.275 (0.064)	0.360 (0.093)	0.192 (0.091)	0.091 (0.087)
Salmon	06 Mar-14 May	5,611	0.336 (0.008)	0.607 (0.010)	0.542 (0.015)	0.372 (0.019)
Sawtooth	18 Mar-31 May	1,620	0.351 (0.020)	0.524 (0.028)	0.333 (0.041)	0.257 (0.043)
Snake	28 Mar-17 May	2,661	0.331 (0.012)	0.623 (0.014)	0.522 (0.022)	0.375 (0.028)
South Fork Salmon	08 Mar-26 Apr	1,470	0.258 (0.024)	0.482 (0.033)	0.422 (0.046)	0.318 (0.054)
Spoolcart (Grande Ronde R.)	07 Mar-24 Apr	505	0.255 (0.044)	0.538 (0.061)	0.239 (0.086)	0.130 (0.070)

Table 26. Continued.

Trap	Release dates	Number released	LGR	LGO	LMO	MCN
Wild steelhead						
Catherine Creek	24 Mar-12 May	500	0.257 (0.052)	0.674 (0.060)	0.546 (0.111)	0.071 (0.069)
Crooked Fork Creek (spring)	23 Mar-31 May	212	0.351 (0.042)	0.682 (0.051)	0.580 (0.082)	0.333 (0.094)
Fish Creek	14 Mar-30 May	86	0.571 (0.108)	0.845 (0.102)	0.400 (0.219)	NA
Grande Ronde	09 Mar-26 May	1,073	0.325 (0.016)	0.640 (0.020)	0.525 (0.028)	0.217 (0.028)
Johnson Creek	19 Mar-31 May	99	0.498 (0.070)	0.717 (0.076)	0.565 (0.116)	0.111 (0.105)
Lookingglass Creek	07 Mar-31 May	292	0.399 (0.044)	0.538 (0.064)	0.501 (0.111)	0.235 (0.103)
Lostine River	15 Mar-14 May	270	0.397 (0.064)	0.704 (0.087)	0.375 (0.140)	0.286 (0.171)
Pahsimeroi (spring)	03 Mar-31 May	336	0.380 (0.088)	0.528 (0.110)	0.336 (0.152)	NA
Salmon	04 Apr-14 May	305	0.330 (0.031)	0.637 (0.037)	0.555 (0.052)	0.190 (0.047)
Sawtooth	24 Mar-31 May	84	0.273 (0.088)	0.560 (0.104)	0.500 (0.144)	0.222 (0.192)
Snake	31 Mar-17 May	502	0.310 (0.024)	0.615 (0.030)	0.606 (0.044)	0.200 (0.043)
Spoolcart (Grande Ronde R.)	22 Mar-08 May	500	0.346 (0.040)	0.701 (0.054)	0.613 (0.088)	0.217 (0.093)
Hatchery Chinook salmon						
Grande Ronde	09 Mar-17 May	1,402	0.274 (0.016)	0.507 (0.020)	0.371 (0.024)	0.317 (0.031)
Salmon	20 Mar-14 May	3,395	0.295 (0.010)	0.437 (0.013)	0.352 (0.016)	0.280 (0.019)
Snake	28 Mar-17 May	5,003	0.286 (0.008)	0.498 (0.010)	0.392 (0.012)	0.303 (0.014)
Hatchery steelhead						
Grande Ronde	01 Apr-06 May	3,606	0.372 (0.009)	0.616 (0.010)	0.572 (0.014)	0.251 (0.015)
Salmon	03 Apr-14 May	1,225	0.420 (0.017)	0.677 (0.019)	0.550 (0.028)	0.215 (0.028)
Snake	28 Mar-17 May	2,148	0.383 (0.012)	0.603 (0.014)	0.596 (0.020)	0.209 (0.018)

Table 27. Estimated survival probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2006. 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	Clark Flat Pond	13,335	0.306 (0.010)	0.908 (0.066)	0.941 (0.311)	0.854 (0.278)	0.261 (0.085)
Cle Elum	Easton Pond	13,320	0.265 (0.011)	0.661 (0.050)	2.812 (1.581)	1.860 (1.041)	0.494 (0.276)
Cle Elum	Jack Pond	13,332	0.192 (0.008)	0.866 (0.076)	0.993 (0.413)	0.860 (0.352)	0.166 (0.068)
Entiat	Entiat Hatchery	3,001	0.520 (0.031)	0.888 (0.112)	2.906 (2.842)	2.580 (2.511)	1.340 (1.302)
Leavenworth	Leavenworth Hatchery	14,700	0.554 (0.014)	0.914 (0.057)	0.759 (0.200)	0.693 (0.179)	0.384 (0.099)
Little White Salmon	S. Fork Walla Walla	1,004	0.227 (0.025)	0.782 (0.177)	NA	NA	NA
Wells	Wells Tailrace (5/12)	2,998	0.388 (0.052)	1.054 (0.318)	NA	NA	NA
Wells	Wells Tailrace (6/14)	2,998	0.358 (0.093)	0.575 (0.259)	NA	NA	NA
Winthrop	Winthrop NFH	4,489	0.423 (0.029)	0.998 (0.156)	1.059 (0.587)	1.057 (0.571)	0.448 (0.240)
Steelhead							
Cassimer Bar	Stapaloop Creek	19,886	0.180 (0.009)	0.591 (0.044)	0.644 (0.136)	0.381 (0.080)	0.069 (0.014)
Turtle Rock	Chiwawa River	3,292	0.475 (0.030)	0.918 (0.093)	NA	NA	NA
Turtle Rock	Nason Creek	8,827	0.411 (0.017)	0.892 (0.059)	0.832 (0.446)	0.742 (0.397)	0.305 (0.163)
Turtle Rock	Wenatchee River	17,918	0.606 (0.017)	0.829 (0.038)	1.666 (0.659)	1.382 (0.546)	0.836 (0.330)

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	6,123	0.422 (0.025)	1.382 (0.205)	0.649 (0.282)	0.897 (0.374)	0.378 (0.156)
Cascade	Nason Creek	2,989	0.471 (0.052)	0.620 (0.109)	0.673 (0.305)	0.417 (0.186)	0.197 (0.085)
Eagle Creek	Natches River (Rkm 10)	2,506	0.276 (0.028)	1.457 (0.346)	0.638 (0.356)	0.929 (0.485)	0.256 (0.132)
Eagle Creek	Natches River (Rkm 62)	2,515	0.408 (0.049)	0.976 (0.228)	0.868 (0.823)	0.847 (0.791)	0.346 (0.320)
Eagle Creek	Prosser Dam	1,231	0.430 (0.037)	0.707 (0.118)	NA	NA	NA
Eagle Creek	Yakima River (Rkm 256)	2,514	0.225 (0.065)	0.369 (0.131)	0.617 (0.352)	0.228 (0.139)	0.051 (0.028)
Eagle Creek	Yakima River (Rkm 289)	2,500	0.031 (0.027)	NA	NA	NA	NA
Willard	Leavenworth Hatchery	5,235	0.448 (0.035)	0.886 (0.128)	0.710 (0.274)	0.629 (0.236)	0.282 (0.104)
Willard	Nason Creek (4/06)	3,495	0.174 (0.026)	1.320 (0.397)	0.687 (0.481)	0.907 (0.601)	0.158 (0.102)
Willard	Nason Creek (4/22)	3,492	0.289 (0.029)	1.288 (0.293)	0.418 (0.229)	0.538 (0.278)	0.156 (0.079)
Willard	Wenatchee R.	6,982	0.458 (0.026)	0.859 (0.092)	0.703 (0.197)	0.604 (0.163)	0.277 (0.073)
Yakima	Natches River (Rkm 10)	2,490	0.289 (0.028)	0.814 (0.141)	0.770 (0.402)	0.626 (0.320)	0.181 (0.091)
Yakima	Natches River (Rkm 62)	2,491	0.361 (0.050)	0.594 (0.130)	0.565 (0.295)	0.336 (0.173)	0.121 (0.060)
Yakima	Yakima River (Rkm 256)	2,512	0.142 (0.021)	0.731 (0.178)	0.663 (0.408)	0.484 (0.291)	0.069 (0.040)
Yakima	Yakima River (Rkm 289)	2,501	0.057 (0.024)	0.339 (0.186)	NA	NA	NA

Table 28. Estimated detection probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2006. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: Rel-Release site; MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam

Hatchery	Release Site	Number released	MCN	JDA	BON
Yearling Chinook salmon					
Cle Elum	Clark Flat Pond	13,335	0.357 (0.013)	0.261 (0.019)	0.144 (0.047)
Cle Elum	Easton Pond	13,320	0.322 (0.014)	0.332 (0.024)	0.053 (0.030)
Cle Elum	Jack Pond	13,332	0.350 (0.016)	0.279 (0.024)	0.146 (0.060)
Entiat	Entiat Hatchery	3,001	0.300 (0.021)	0.240 (0.029)	0.048 (0.047)
Leavenworth	Leavenworth Hatchery	14,700	0.332 (0.009)	0.262 (0.016)	0.119 (0.031)
Little White Salmon	S. Fork Walla Walla	1,004	0.456 (0.055)	0.302 (0.070)	NA
Wells	Wells Tailrace (5/12)	2,998	0.171 (0.025)	0.080 (0.023)	NA
Wells	Wells Tailrace (6/14)	2,998	0.104 (0.028)	0.081 (0.032)	NA
Winthrop	Winthrop NFH	4,489	0.252 (0.020)	0.138 (0.021)	0.124 (0.067)
Steelhead					
Cassimer Bar	Stapaloop Creek	19,886	0.208 (0.012)	0.420 (0.025)	0.252 (0.053)
Turtle Rock	Chiwawa River	3,292	0.169 (0.014)	0.426 (0.037)	NA
Turtle Rock	Nason Creek	8,827	0.165 (0.009)	0.454 (0.025)	0.139 (0.074)
Turtle Rock	Wenatchee River	17,918	0.163 (0.006)	0.396 (0.015)	0.062 (0.024)

Table 28. Continued.

Hatchery	Release Site	Number released	MCN	JDA	BON
Coho salmon					
Cascade	Leavenworth Hatchery	6,123	0.218 (0.015)	0.127 (0.018)	0.133 (0.055)
Cascade	Nason Creek	2,989	0.173 (0.021)	0.231 (0.035)	0.235 (0.103)
Eagle Creek	Natches River (Rkm 10)	2,506	0.224 (0.027)	0.122 (0.028)	0.189 (0.098)
Eagle Creek	Natches River (Rkm 62)	2,515	0.178 (0.024)	0.156 (0.034)	0.130 (0.121)
Eagle Creek	Prosser Dam	1,231	0.385 (0.037)	0.306 (0.050)	NA
Eagle Creek	Yakima River (Rkm 256)	2,514	0.097 (0.031)	0.254 (0.059)	0.405 (0.220)
Eagle Creek	Yakima River (Rkm 289)	2,500	0.143 (0.132)	NA	NA
Willard	Leavenworth Hatchery	5,235	0.175 (0.016)	0.177 (0.023)	0.170 (0.063)
Willard	Nason Creek (4/06)	3,495	0.162 (0.028)	0.128 (0.036)	0.136 (0.090)
Willard	Nason Creek (4/22)	3,492	0.197 (0.023)	0.154 (0.033)	0.204 (0.105)
Willard	Wenatchee R.	6,982	0.212 (0.014)	0.190 (0.019)	0.208 (0.056)
Yakima	Natches River (Rkm 10)	2,490	0.262 (0.029)	0.263 (0.042)	0.218 (0.111)
Yakima	Natches River (Rkm 62)	2,491	0.168 (0.026)	0.278 (0.050)	0.233 (0.118)
Yakima	Yakima River (Rkm 256)	2,512	0.232 (0.040)	0.276 (0.060)	0.290 (0.172)
Yakima	Yakima River (Rkm 289)	2,501	0.154 (0.071)	0.412 (0.156)	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 2006. 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.

Date at LGR	LGR to LGO (days)				LGO to LMO (days)				LMO to MCN (days)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	253	9.2	15.7	28.6	78	2.1	2.8	4.8	52	3.4	4.9	8.0
06 Apr - 12 Apr	761	6.2	10.2	20.6	311	1.7	2.5	4.0	180	3.6	4.3	6.2
13 Apr - 19 Apr	859	4.0	6.0	10.5	396	1.7	2.2	3.1	231	3.5	4.6	6.1
20 Apr - 26 Apr	13,746	4.0	5.2	6.8	6,040	1.5	2.0	2.6	3,581	3.3	4.1	5.3
27 Apr - 03 May	33,594	3.4	4.3	5.3	12,532	1.4	1.8	2.5	7,266	3.1	3.8	4.7
04 May - 10 May	18,255	3.7	4.6	5.8	4,077	1.4	1.9	2.5	2,982	2.6	3.2	4.1
11 May - 17 May	9,084	3.1	3.9	4.8	2,023	1.1	1.4	1.9	610	2.1	2.5	3.2
18 May - 24 May	694	1.8	2.4	3.2	227	0.9	1.2	1.6	79	2.2	2.6	3.5
25 May - 31 May	261	2.6	3.5	4.3	80	1.3	1.7	2.2	23	2.8	3.6	4.2
01 Jun - 07 Jun	110	2.2	2.8	3.7	15	1.2	1.6	2.2	3	2.1	2.1	2.5
08 Jun - 14 Jun	41	1.7	2.2	3.4	7	1.0	1.7	2.2	5	2.7	2.8	3.4
15 Jun - 21 Jun	33	2.5	3.2	4.9	0	NA	NA	NA	0	NA	NA	NA

Date at LGR	LGR to MCN (days)				LGR to BON (days)			
	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	147	17.7	27.5	36.6	50	27.9	35.5	41.4
06 Apr - 12 Apr	399	13.1	20.2	27.6	164	19.9	29.2	34.9
13 Apr - 19 Apr	491	10.5	13.9	19.8	165	16.7	22.0	29.1
20 Apr - 26 Apr	7,653	9.5	11.4	14.2	3,430	14.8	17.0	19.8
27 Apr - 03 May	17,450	8.3	9.9	11.8	8,315	13.2	14.7	16.3
04 May - 10 May	11,462	8.2	9.3	10.8	3,783	11.7	12.8	14.2
11 May - 17 May	2,262	6.5	7.5	8.8	1,565	9.3	10.4	11.5
18 May - 24 May	208	5.2	6.1	7.6	92	8.2	9.4	11.2
25 May - 31 May	67	7.0	8.4	10.1	38	9.9	11.1	12.1
01 Jun - 07 Jun	24	5.7	6.9	8.1	19	8.2	9.2	11.4
08 Jun - 14 Jun	29	5.5	6.7	10.0	17	8.8	10.7	12.6
15 Jun - 21 Jun	21	7.1	8.8	11.7	9	9.0	12.7	13.4

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 2006. 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.

Date at LGR	LGR to LGO (km/day)				LGO to LMO (km/day)				LMO to MCN (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	253	2.1	3.8	6.5	78	9.6	16.3	22.2	52	15.0	24.1	35.4
06 Apr - 12 Apr	761	2.9	5.9	9.7	311	11.5	18.8	27.5	180	19.3	27.4	33.1
13 Apr - 19 Apr	859	5.7	10.0	15.2	396	14.8	20.6	27.5	231	19.6	26.0	34.1
20 Apr - 26 Apr	13,746	8.8	11.6	15.0	6,040	17.6	23.4	29.9	3,581	22.5	28.9	36.5
27 Apr - 03 May	33,594	11.2	14.1	17.9	12,532	18.4	24.9	32.6	7,266	25.1	31.6	38.6
04 May - 10 May	18,255	10.4	13.0	16.4	4,077	18.4	24.6	32.9	2,982	29.1	37.3	46.1
11 May - 17 May	9,084	12.5	15.4	19.4	2,023	24.0	33.1	43.8	610	36.7	47.8	57.2
18 May - 24 May	694	18.5	25.4	33.5	227	28.8	39.3	49.5	79	34.3	44.9	54.8
25 May - 31 May	261	14.0	17.3	22.8	80	21.0	27.1	35.1	23	28.6	33.2	43.3
01 Jun - 07 Jun	110	16.3	21.6	27.0	15	21.1	29.7	37.1	3	48.0	55.9	56.7
08 Jun - 14 Jun	41	17.5	27.1	34.7	7	21.0	27.7	44.2	5	34.7	43.3	44.7
15 Jun - 21 Jun	33	12.2	18.8	24.0	0	NA	NA	NA	0	NA	NA	NA

Date at LGR	LGR to MCN (km/day)				LGR to BON (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	147	6.1	8.2	12.7	50	11.1	13.0	16.5
06 Apr - 12 Apr	399	8.1	11.1	17.2	164	13.2	15.8	23.2
13 Apr - 19 Apr	491	11.4	16.2	21.4	165	15.9	21.0	27.6
20 Apr - 26 Apr	7,653	15.8	19.7	23.8	3,430	23.3	27.1	31.2
27 Apr - 03 May	17,450	19.1	22.7	27.0	8,315	28.2	31.3	35.0
04 May - 10 May	11,462	20.7	24.1	27.6	3,783	32.5	36.0	39.5
11 May - 17 May	2,262	25.6	30.0	34.4	1,565	40.1	44.4	49.4
18 May - 24 May	208	29.6	36.9	43.4	92	41.3	49.2	56.0
25 May - 31 May	67	22.3	26.8	32.0	38	38.0	41.5	46.5
01 Jun - 07 Jun	24	27.6	32.5	39.2	19	40.6	49.9	56.3
08 Jun - 14 Jun	29	22.4	33.6	41.1	17	36.7	42.9	52.4
15 Jun - 21 Jun	21	19.2	25.5	31.8	9	34.3	36.3	51.3

Table 31. Travel time statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2006. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

Date at LGR	MCN to JDA (days)				JDA to BON (days)				MCN to BON (days)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr – 19 Apr	69	3.7	5.3	7.4	7	1.6	1.8	2.9	19	6.1	6.9	9.2
20 Apr – 26 Apr	648	4.1	5.1	6.5	78	1.7	2	2.5	204	5.9	7	9.2
27 Apr – 03 May	1,845	3.3	4	5.4	285	1.6	1.9	2.3	812	4.8	5.8	7.4
04 May – 10 May	3,866	3.2	3.6	4.5	792	1.7	2	2.3	4,417	4.8	5.3	6.2
11 May – 17 May	3,381	2.5	3.3	3.9	458	1.4	1.7	2	3,271	3.8	4.6	5.3
18 May – 24 May	1,328	2.1	2.5	2.8	83	1.2	1.4	1.6	545	3.1	3.3	3.9
25 May – 31 May	166	2.4	2.6	3.4	11	1.3	1.4	1.7	54	3.4	4.2	4.8
01 Jun – 07 Jun	32	2.4	3.1	3.5	2	1.3	1.3	1.4	28	3.5	4.2	4.4
08 Jun – 14 Jun	16	2	2.4	2.7	0	NA	NA	NA	13	3.2	3.5	4
15 Jun – 21 Jun	13	1.8	2.3	2.5	6	1.4	1.7	1.8	19	3.5	3.9	4.6
22 Jun – 28 Jun	15	2.3	2.5	2.6	4	1.4	1.5	1.7	13	3.4	3.7	4.3

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 2006. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

Date at LGR	MCN to JDA (km/day)				JDA to BON (km/day)				MCN to BON (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr – 19 Apr	69	16.6	23.1	33.6	7	39.4	63.5	68.9	19	25.5	34.1	38.8
20 Apr – 26 Apr	648	19.0	24.0	30.3	78	45.4	56.8	66.5	204	25.8	33.7	40.0
27 Apr – 03 May	1,845	22.8	30.8	36.9	285	48.7	60.4	69.3	812	32.0	40.8	49.4
04 May – 10 May	3,866	27.3	34.1	38.2	792	49.6	57.4	65.3	4,417	38.2	44.4	49.2
11 May – 17 May	3,381	31.5	37.6	48.6	458	57.4	67.3	80.1	3,271	44.4	51.4	61.9
18 May – 24 May	1,328	44.1	50.2	58.9	83	70.2	81.9	91.1	545	60.8	70.9	75.4
25 May – 31 May	166	36.6	46.9	51.9	11	68.1	78.5	86.9	54	48.9	56.5	69.8
01 Jun – 07 Jun	32	35.2	39.9	50.4	2	81.3	84.3	86.9	28	53.8	56.5	67.6
08 Jun – 14 Jun	16	45.6	51.7	63.1	0	NA	NA	NA	13	58.3	67.8	74.0
15 Jun – 21 Jun	13	48.6	54.2	70.3	6	62.4	67.7	78.5	19	51.8	60.8	67.4
22 Jun – 28 Jun	15	47.3	49.2	52.8	4	67.7	75.8	81.9	13	55.0	63.1	70.2

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 2006. 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.

Date at LGR	LGR to LGO (days)				LGO to LMO (days)				LMO to MCN (days)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	20	3.2	3.8	5.4	12	2.0	3.4	5.2	2	3.0	3.0	3.0
06 Apr - 12 Apr	232	2.4	3.1	5.2	148	1.3	2.0	4.2	51	2.4	3.1	3.9
13 Apr - 19 Apr	1,459	2.2	2.7	4.2	855	1.2	2.0	4.8	304	2.5	3.2	4.8
20 Apr - 26 Apr	4,001	2.4	2.8	4.3	2,362	1.2	1.9	3.6	843	2.3	2.9	4.0
27 Apr - 03 May	6,629	2.3	2.6	3.4	3,741	1.1	1.7	3.2	1,159	2.2	2.7	3.5
4 May - 10 May	5,535	2.4	2.9	3.9	2,204	1.3	2.0	3.5	686	2.4	2.8	3.5
11 May - 17 May	3,000	2.4	2.6	3.5	1,234	1.1	1.5	2.3	238	1.9	2.2	2.7
18 May - 24 May	1,882	1.8	2.1	2.7	735	0.8	1.1	1.7	153	1.7	2.1	2.6
25 May - 31 May	1,330	2.1	2.6	3.1	564	1.0	1.3	1.8	78	1.8	2.4	3.1
01 Jun - 07 Jun	882	2.5	2.9	3.8	221	1.0	1.3	1.9	29	1.9	2.1	2.9
08 Jun - 14 Jun	46	2.0	2.3	2.8	7	1.0	1.2	1.8	4	2.1	2.3	2.5

Date at LGR	LGR to MCN (days)				LGR to BON (days)			
	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	3	12.3	16.1	18.1	0	NA	NA	NA
06 Apr - 12 Apr	73	6.6	9.3	12.8	26	10.0	12.2	15.6
13 Apr - 19 Apr	473	6.5	9.3	14.9	212	11.3	14.3	21.2
20 Apr - 26 Apr	1,247	6.4	8.0	12.0	504	10.4	12.0	16.2
27 Apr - 03 May	1,820	6.1	7.3	9.7	836	10.0	11.4	13.8
04 May - 10 May	1,284	6.4	7.6	9.6	397	10.2	11.7	13.4
11 May - 17 May	505	5.4	6.4	7.4	202	8.6	9.9	12.0
18 May - 24 May	359	4.4	5.0	6.3	166	7.8	8.9	10.3
25 May - 31 May	136	4.6	6.2	7.6	85	8.4	9.7	10.8
01 Jun - 07 Jun	59	5.5	6.6	7.7	40	8.5	9.3	10.8
08 Jun - 14 Jun	15	4.9	5.4	6.5	13	8.2	9.8	11.0

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 2006. 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.

Date at LGR	LGR to LGO (km/day)				LGO to LMO (km/day)				LMO to MCN (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	20	11.0	15.8	18.9	12	8.8	13.5	22.4	2	39.4	39.7	39.9
06 Apr - 12 Apr	232	11.6	19.2	24.8	148	11.0	23.4	34.8	51	30.4	38.1	49.4
13 Apr - 19 Apr	1,459	14.3	22.5	26.9	855	9.5	22.8	36.8	304	24.7	37.4	46.9
20 Apr - 26 Apr	4,001	14.0	21.1	25.1	2,362	12.9	23.8	36.8	843	29.8	40.8	52.7
27 Apr - 03 May	6,629	17.6	23.4	25.8	3,741	14.6	26.9	40.7	1,159	33.9	43.4	54.8
4 May - 10 May	5,535	15.3	21.0	25.1	2,204	13.2	23.0	35.1	686	34.0	41.8	50.0
11 May - 17 May	3,000	17.0	23.0	25.3	1,234	20.2	30.7	41.8	238	43.4	55.1	64.0
18 May - 24 May	1,882	22.2	28.8	33.3	735	26.7	43.0	56.8	153	45.4	57.5	68.4
25 May - 31 May	1,330	19.0	23.1	29.0	564	26.3	36.2	46.5	78	37.8	49.0	66.5
01 Jun - 07 Jun	882	15.6	20.7	23.8	221	24.6	35.4	45.1	29	41.6	55.9	62.6
08 Jun - 14 Jun	46	21.4	26.0	29.3	7	25.4	39.0	46.9	4	48.6	52.4	56.4

Date at LGR	LGR to MCN (km/day)				LGR to BON (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%
30 Mar - 05 Apr	3	12.5	13.9	18.3	0	NA	NA	NA
06 Apr - 12 Apr	73	17.6	24.1	34.1	26	29.5	37.9	46.1
13 Apr - 19 Apr	473	15.1	24.2	34.6	212	21.7	32.2	40.7
20 Apr - 26 Apr	1,247	18.7	28.1	35.3	504	28.5	38.4	44.5
27 Apr - 03 May	1,820	23.3	30.7	37.1	836	33.4	40.5	46.0
4 May - 10 May	1,284	23.4	29.7	35.0	397	34.4	39.4	45.0
11 May - 17 May	505	30.3	35.2	41.5	202	38.4	46.4	53.5
18 May - 24 May	359	35.8	45.0	51.6	166	44.7	52.0	59.2
25 May - 31 May	136	29.5	36.6	48.6	85	42.6	47.8	55.1
01 Jun - 07 Jun	59	29.1	34.0	41.1	40	42.7	49.7	54.3
08 Jun - 14 Jun	15	34.4	41.7	46.0	13	42.0	46.9	56.4

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 2006. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

Date at LGR	MCN to JDA (days)				JDA to BON (days)				MCN to BON (days)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr - 19 Apr	48	2.5	3.2	3.5	7	1.3	1.5	1.8	13	4.4	4.7	5.3
20 Apr - 26 Apr	278	3.3	3.6	5.4	39	1.4	1.5	1.9	84	4.3	5.1	6.3
27 Apr - 03 May	538	2.5	3.5	5.3	74	1.3	1.4	1.8	160	3.9	4.4	5.6
04 May - 10 May	596	2.6	3.4	4.8	95	1.3	1.5	1.7	311	3.9	4.4	5.4
11 May - 17 May	537	2.6	3.3	4.7	43	1.2	1.4	1.6	160	3.9	4.3	5.1
18 May - 24 May	415	2.4	2.8	4.0	37	1.1	1.3	1.4	66	3.1	3.9	5.2
25 May - 31 May	147	2.4	2.7	3.9	7	1.1	1.3	1.6	26	3.1	3.8	4.2
01 Jun - 07 Jun	25	2.5	2.7	3.9	4	1.2	1.2	1.3	9	2.9	3.4	3.8
08 Jun - 14 Jun	24	1.6	2.4	3.4	2	1.3	1.3	1.4	5	3.3	3.9	4.7

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 2006. Abbreviations: MCN-McNary Dam; JDA-John Day Dam; BON-Bonneville Dam; N-Number of fish on which statistics are based; Med.-Median.

Date at LGR	MCN to JDA (km/day)				JDA to BON (km/day)				MCN to BON (km/day)			
	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
13 Apr - 19 Apr	48	35.0	38.9	49.0	7	61.1	76.9	85.0	13	44.2	49.9	54.0
20 Apr - 26 Apr	278	22.6	34.5	37.0	39	58.2	74.8	83.1	84	37.3	46.2	54.4
27 Apr - 03 May	538	23.2	35.7	48.6	74	62.4	79.0	86.9	160	42.4	53.9	60.4
04 May - 10 May	596	25.7	36.3	47.3	95	67.3	76.4	85.0	311	43.8	53.5	59.9
11 May - 17 May	537	26.4	36.9	47.7	43	68.9	83.7	95.8	160	46.1	55.0	60.7
18 May - 24 May	415	31.0	43.2	51.5	37	81.9	89.0	100.9	66	45.8	60.4	75.2
25 May - 31 May	147	31.5	45.2	52.1	7	69.8	87.6	101.8	26	55.9	62.4	75.9
01 Jun - 07 Jun	25	31.4	45.9	50.2	4	89.0	91.9	93.4	9	61.8	69.8	81.7
08 Jun - 14 Jun	24	36.6	50.4	76.4	2	82.5	85.6	89.0	5	50.5	59.9	70.9

Table 37. Number of PIT-tagged hatchery steelhead released at Lower Granite by day for survival estimates in 2006. 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	32			11-May	662	1	2
11-Apr	24			12-May	676	1	
12-Apr	41			15-May	562		
13-Apr	35			16-May	493		1
14-Apr	41			17-May	489	1	
17-Apr	624			18-May	491		2
18-Apr	350		1	19-May	502		
19-Apr	94			24-May	585	2	
20-Apr	312	1	4	25-May	584		3
21-Apr	349	1	1	26-May	585		3
22-Apr	2			31-May	350		
24-Apr	701		1	1-Jun	353	1	
25-Apr	607	1	5	2-Jun	351		
26-Apr	523	1		5-Jun	134		
27-Apr	523	2		6-Jun	159		
28-Apr	265		1	7-Jun	133		
29-Apr	865	2	3	8-Jun	132		
1-May	554	1		9-Jun	92		
2-May	441	1	2	12-Jun	80		
3-May	626			13-Jun	78		2
4-May	701	1	2	14-Jun	80		
5-May	1,387		2	15-Jun	78		2
8-May	738			16-Jun	86		
9-May	700			Total	18,972	17	37
10-May	702						

Table 38. Number of PIT-tagged wild steelhead released at Lower Granite by day for survival estimates in 2006. 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	23			11-May	422		3
11-Apr	41			12-May	340		
12-Apr	67			13-May	231		
13-Apr	46			15-May	127		
14-Apr	61			16-May	210		
17-Apr	92			17-May	320		
18-Apr	148			18-May	79		
19-Apr	48			19-May	529		
20-Apr	480	2	9	24-May	408		
21-Apr	359			25-May	221		
22-Apr	552	1	1	26-May	260		
24-Apr	636	1		31-May	102		
25-Apr	416			1-Jun	103		
26-Apr	433			2-Jun	91		
27-Apr	1,057	1	1	5-Jun	69		
28-Apr	990			6-Jun	83		
29-Apr	4			7-Jun	78		
1-May	461			8-Jun	114		
2-May	740			9-Jun	92		
3-May	669		3	12-Jun	53		
4-May	657			13-Jun	47		
5-May	306			14-Jun	37		
6-May	560		1	15-Jun	18		
8-May	258			16-Jun	21		
9-May	324			Total	14,144	5	18
10-May	661						

Table 39. Number of PIT-tagged wild yearling Chinook salmon released at Lower Granite by day for survival estimates in 2006. 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	58			11-May	124		
11-Apr	37			12-May	102		
12-Apr	91			13-May	122		
13-Apr	85			15-May	55		
14-Apr	75			16-May	123	2	
17-Apr	138			17-May	191		
18-Apr	69			18-May	33		
19-Apr	74	1		19-May	313	3	1
20-Apr	279	5		24-May	81		
21-Apr	481	2		25-May	87		
22-Apr	629	5	3	26-May	89		
24-Apr	745	5	1	Total	9,717	57	6
25-Apr	679	5					
26-Apr	294	4					
27-Apr	517	4					
28-Apr	943	1	1				
29-Apr	628	1					
1-May	522	5					
2-May	248	10					
3-May	329						
4-May	251	2					
5-May	158						
6-May	380						
8-May	261						
9-May	223	2					
10-May	203						

Table 40. Estimated survival for yearling Chinook salmon from selected Snake River Basin hatcheries to the tailrace of Lower Granite Dam, 1993-2006. 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 ^a (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)	NA	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)	0.505 (0.019)	0.579 (0.017)	0.649 (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)
<u>2006</u>	<u>0.853 (0.007)</u>	<u>0.716 (0.041)</u>	<u>0.639 (0.014)</u>	<u>0.764 (0.004)</u>	<u>0.634 (0.006)</u>	<u>0.262 (0.024)</u>	<u>0.651 (0.046)</u>	<u>0.645 (0.071)</u>
Mean	0.780 (0.022)	0.684 (0.026)	0.650 (0.015)	0.670 (0.028)	0.577 (0.019)	0.480 (0.045)	0.420 (0.048)	

^a Released at Imnaha River Weir.

Table 41. Annual weighted means of survival probability estimates for yearling Chinook salmon (hatchery and wild combined), 1993-2006. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two-project estimate to facilitate comparison with other single-project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: SNKTRP-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; IHR-Ice Harbor Dam; MCN-McNary Dam; JDA-John Day Dam; TDA-The Dalles Dam; BON-Bonneville Dam.

Year	SNKTRP-LGR	LGR-LGO	LGO-LMO	LMO-MCN*	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1993	0.828 (0.013)	0.854 (0.012)						
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)					
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.925 (0.009)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.940 (0.009)	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.929 (0.014)	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.954 (0.015)	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
<u>2006</u>	<u>0.952 (0.011)</u>	<u>0.923 (0.003)</u>	<u>0.934 (0.004)</u>	<u>0.887 (0.008)</u>	<u>0.942</u>	<u>0.881 (0.020)</u>	<u>0.944 (0.030)</u>	<u>0.972</u>
Mean	0.931 (0.011)	0.923 (0.011)	0.899 (0.011)	0.853 (0.020)	0.923 (0.011)	0.844 (0.019)	0.814 (0.045)	0.900 (0.025)
Exc.								
2001	0.929 (0.012)	0.921 (0.012)	0.904 (0.011)	0.866 (0.017)	0.930 (0.009)	0.854 (0.017)	0.838 (0.044)	0.913 (0.024)

Table 42. Annual weighted means of survival probability estimates for steelhead (hatchery and wild combined), 1993-2006. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two-project estimate to facilitate comparison with other single-project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: SNKTRP-Snake River Trap; LGR-Lower Granite Dam; LGO-Little Goose Dam; LMO-Lower Monumental Dam; IHR-Ice Harbor Dam; MCN-McNary Dam; JDA-John Day Dam; TDA-The Dalles Dam; BON-Bonneville Dam.

Year	SNKTRP-LGR	LGR-LGO	LGO-LMO	LMO-MCN*	LMO-IHR IHR-MCN	MCN-JDA	JDA-BON*	JDA-TDA TDA-BON
1993	0.905 (0.006)							
1994	NA	0.844 (0.011)	0.892 (0.011)					
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.924 (0.009)	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.908 (0.011)	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.964 (0.013)	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.911 (0.007)	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
<u>2005</u>	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
<u>2006</u>	<u>0.920 (0.013)</u>	<u>0.956 (0.004)</u>	<u>0.911 (0.006)</u>	<u>0.808 (0.017)</u>	<u>0.899</u>	<u>0.795 (0.045)</u>	<u>0.813 (0.083)</u>	<u>0.902</u>
Mean	0.936 (0.007)	0.907 (0.014)	0.885 (0.018)	0.722 (0.048)	0.843 (0.032)	0.724 (0.069)	0.740 (0.042)	0.858 (0.024)
Exc. 2001	0.938 (0.007)	0.916 (0.011)	0.899 (0.011)	0.760 (0.031)	0.870 (0.019)	0.773 (0.056)	0.738 (0.050)	0.856 (0.029)

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), 1997-2006. Standard errors in parentheses. Abbreviations: Trap-Snake River Trap; LGR-Lower Granite Dam; BON-Bonneville Dam.

Year	Yearling Chinook Salmon			Steelhead		
	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)

Table 44. Estimated survival probabilities for reaches between Lower Monumental and McNary Dams and estimated detection probability at Ice Harbor Dam 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 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; ICH-Ice Harbor Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	Survival Probabilities		Detection Probability
		LMO to ICH	ICH to MCN	ICH
30 Mar – 05 Apr	798	0.953 (0.101)	1.022 (0.147)	0.190 (0.024)
06 Apr - 12 Apr	1,782	0.885 (0.043)	0.991 (0.069)	0.287 (0.018)
13 Apr - 19 Apr	1,674	0.939 (0.040)	0.890 (0.053)	0.303 (0.017)
20 Apr - 26 Apr	27,426	0.922 (0.010)	0.955 (0.015)	0.266 (0.004)
27 Apr - 03 May	66,936	0.897 (0.010)	0.983 (0.013)	0.162 (0.002)
04 May - 10 May	64,487	0.931 (0.020)	0.964 (0.024)	0.085 (0.002)
11 May - 17 May	32,031	0.919 (0.034)	0.904 (0.046)	0.093 (0.004)
18 May - 24 May	1,578	0.901 (0.060)	1.125 (0.141)	0.301 (0.021)
25 May - 31 May	474	1.004 (0.226)	0.948 (0.268)	0.092 (0.024)
01 Jun - 07 Jun	284	0.540 (0.225)	1.700 (0.817)	0.044 (0.025)
08 Jun - 14 Jun	151	0.513 (0.291)	0.943 (0.510)	0.040 (0.028)
Weighted mean^a		0.912 (0.005)	0.968 (0.009)	0.135 (0.020)

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

Table 45. Estimated survival probabilities for reaches between Lower Monumental and McNary Dams and estimated detection probability at Ice Harbor Dam for Snake River yearling steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2006. Daily groups pooled weekly. Estimates based on the Single-Release Model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; ICH-Ice Harbor Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	Survival Probability		Detection Probability
		LMO to ICH	ICH to MCN	ICH
30 Mar – 05 Apr	26	1.286 (1.081)	NA	0.111 (0.105)
06 Apr - 12 Apr	374	0.910 (0.070)	0.955 (0.123)	0.337 (0.036)
13 Apr - 19 Apr	2,142	0.948 (0.030)	0.940 (0.049)	0.330 (0.015)
20 Apr - 26 Apr	6,590	0.935 (0.023)	0.875 (0.032)	0.253 (0.008)
27 Apr – 03 May	9,446	0.918 (0.020)	0.978 (0.034)	0.267 (0.007)
04 May - 10 May	9,186	0.913 (0.034)	0.784 (0.038)	0.175 (0.008)
11 May - 17 May	6,014	0.956 (0.043)	0.892 (0.065)	0.183 (0.010)
18 May - 24 May	3,424	0.882 (0.033)	0.887 (0.059)	0.337 (0.014)
25 May - 31 May	2,273	0.762 (0.051)	0.660 (0.070)	0.278 (0.021)
01 Jun - 07 Jun	1,626	0.494 (0.098)	1.386 (0.353)	0.049 (0.013)
08 Jun - 14 Jun	271	0.851 (0.306)	1.171 (0.529)	0.085 (0.036)
Weighted mean^a		0.918 (0.014)	0.899 (0.028)	0.226 (0.023)

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

Table 46. Percentage of PIT-tagged smolts (wild and hatchery combined) detected at Lower Monumental Dam later detected on McNary pool bird colonies, 1998-2006.

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

^a. Only Crescent Island Caspian tern colony sampled.

^b. Only Crescent Island and Foundation Island colonies sampled.

FIGURES

DRAFT

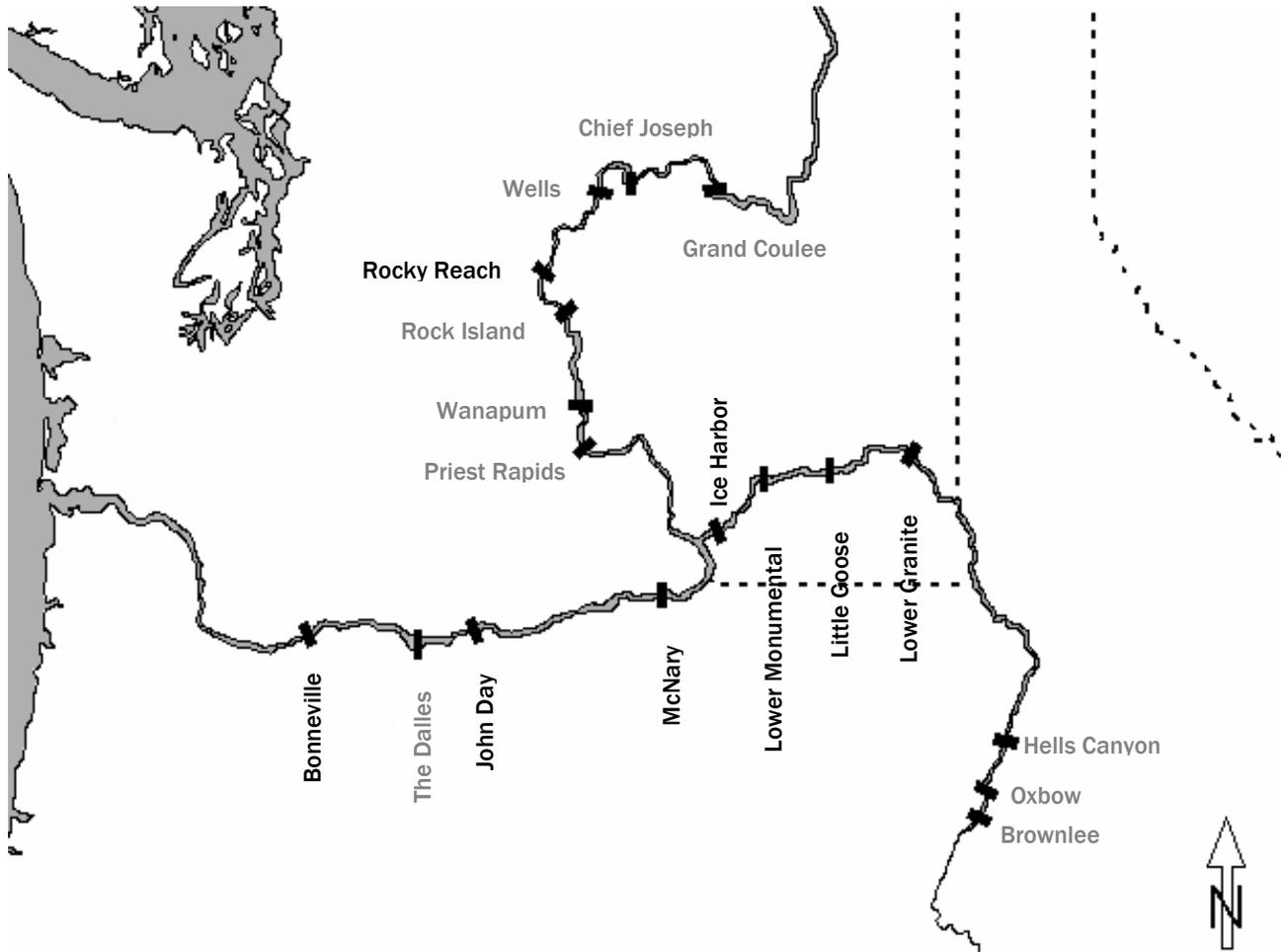


Figure 1. Study area showing sites with PIT-tag detection facilities (names in black), including dams and the PIT-tag trawl in the Columbia River estuary. Dams with names in gray do not have detection facilities.

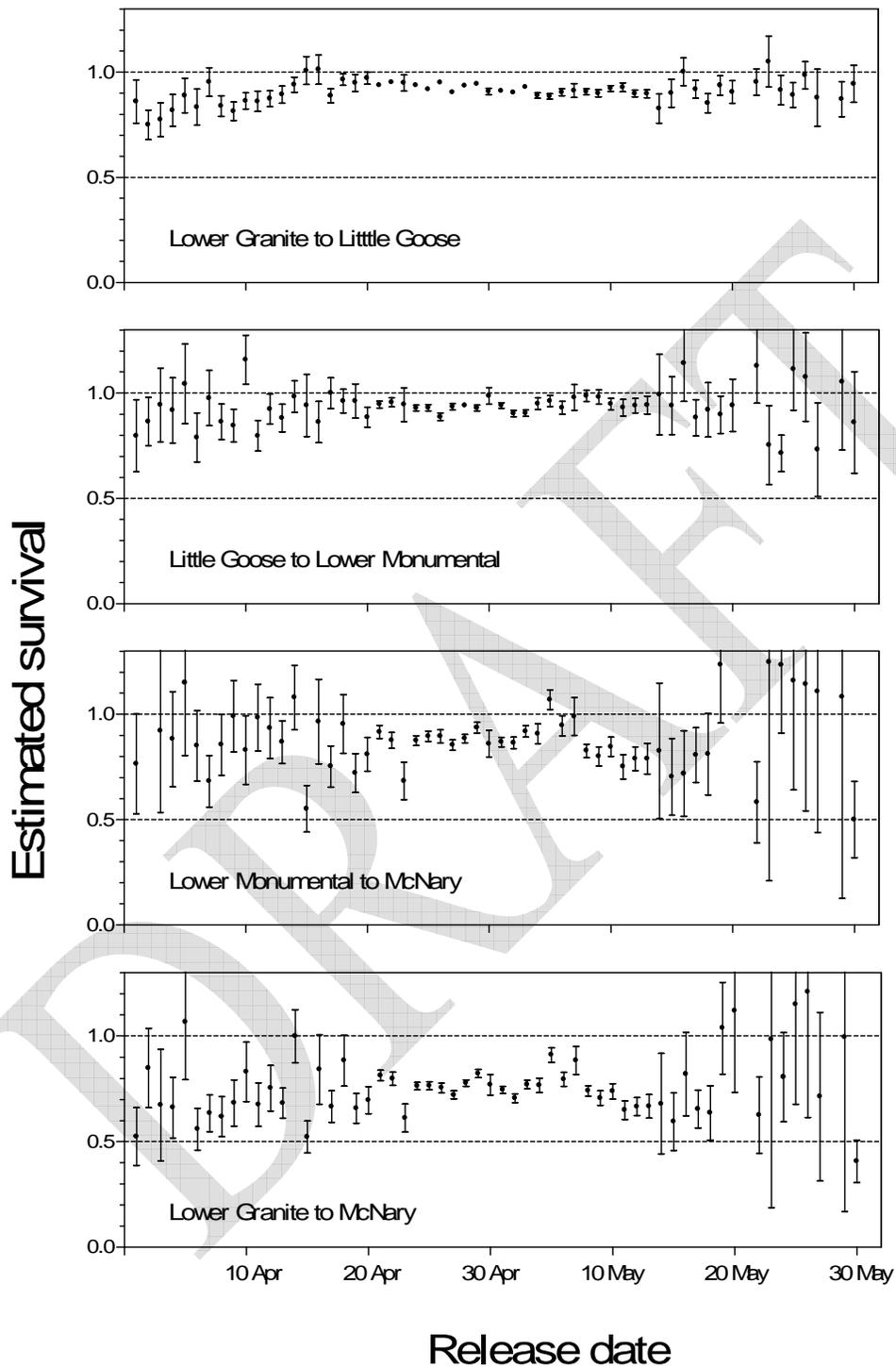


Figure 2. Estimated survival through various reaches vs. release date at Lower Granite Dam for daily release groups of Snake River yearling Chinook salmon, 2006. Bars extend one standard error above and below point estimates.

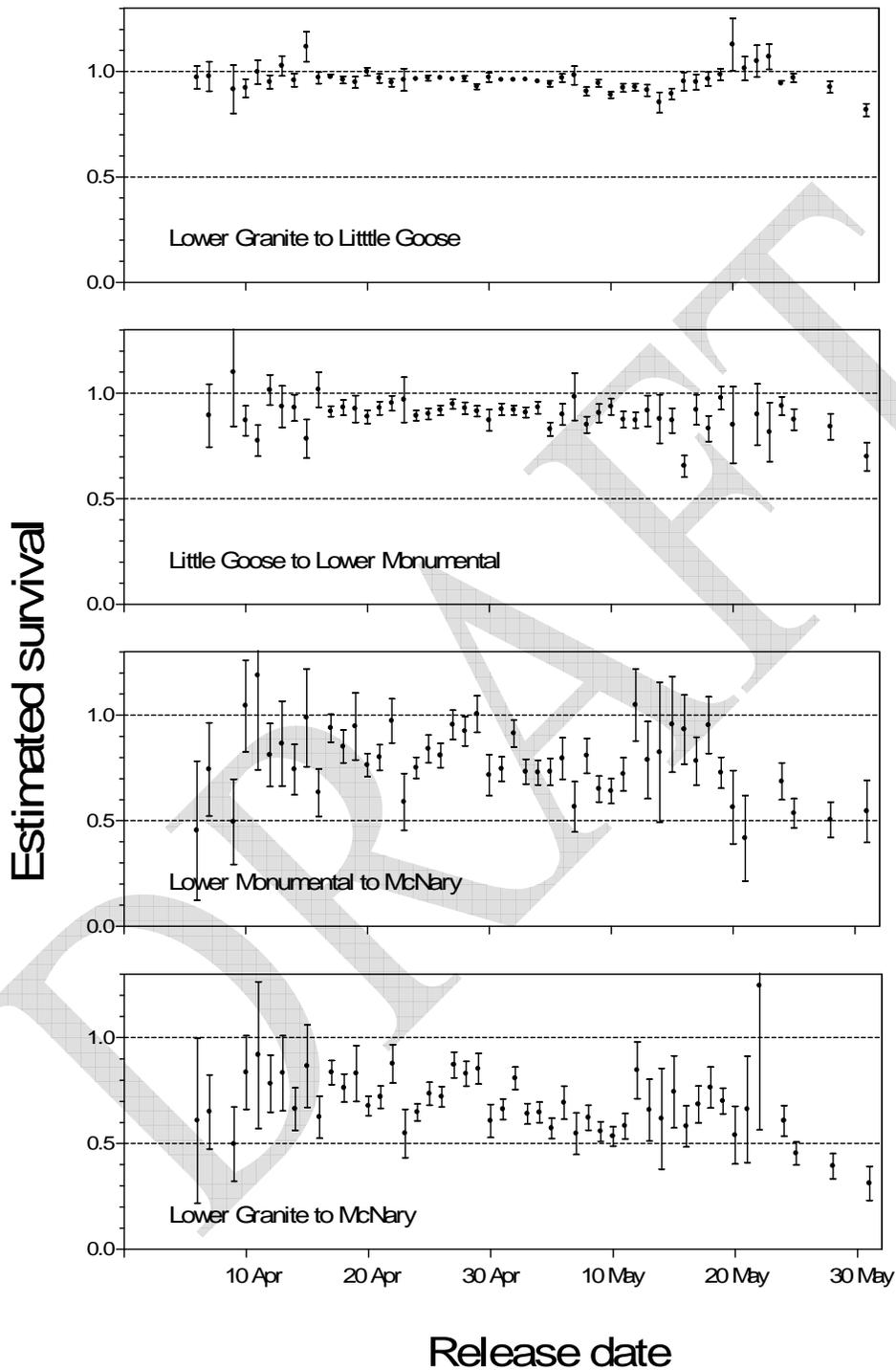


Figure 3. Estimated survival through various reaches versus release date at Lower Granite Dam for daily release groups of Snake River steelhead, 2006. Bars extend one standard error above and below point estimates.

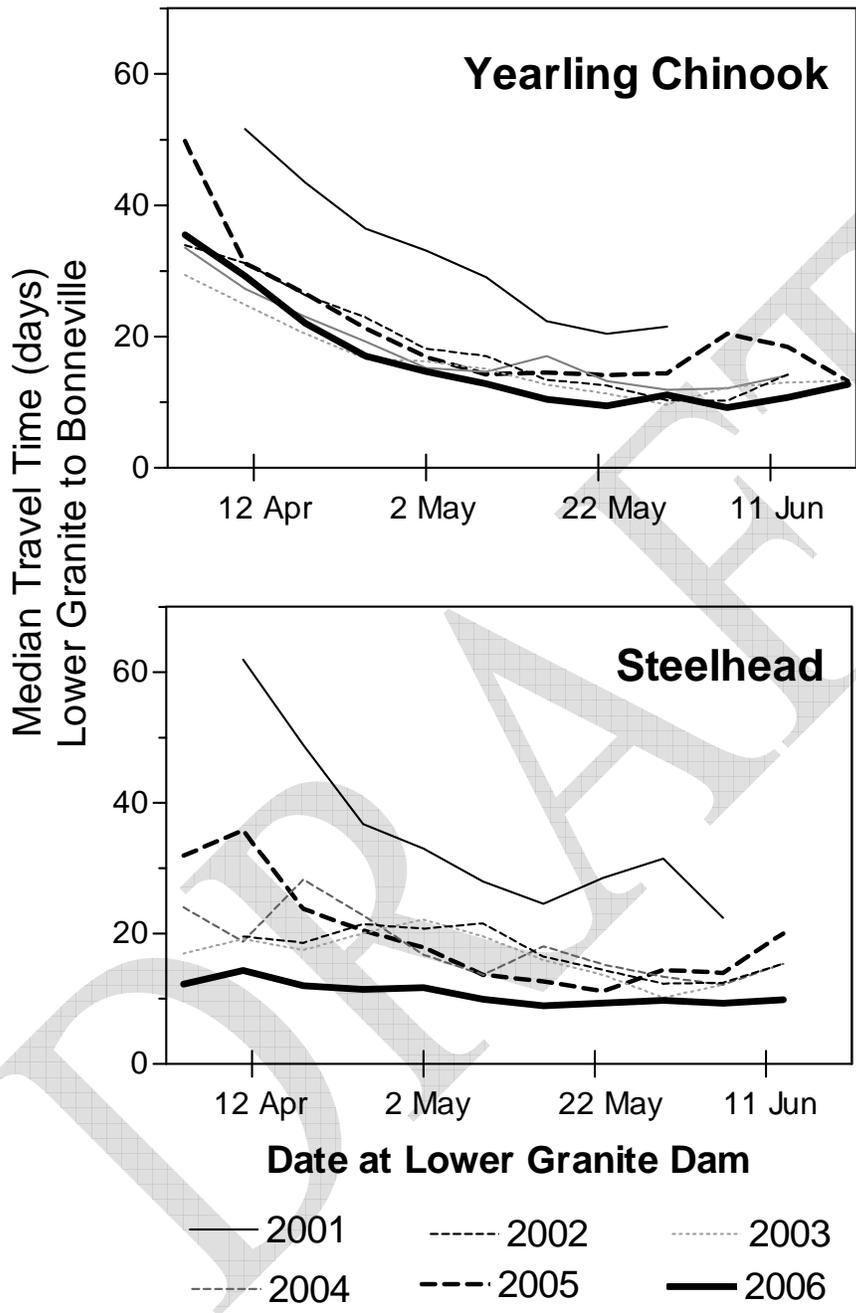


Figure 4. Median travel time (days) from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead from Lower Granite Dam, 2000-2006.

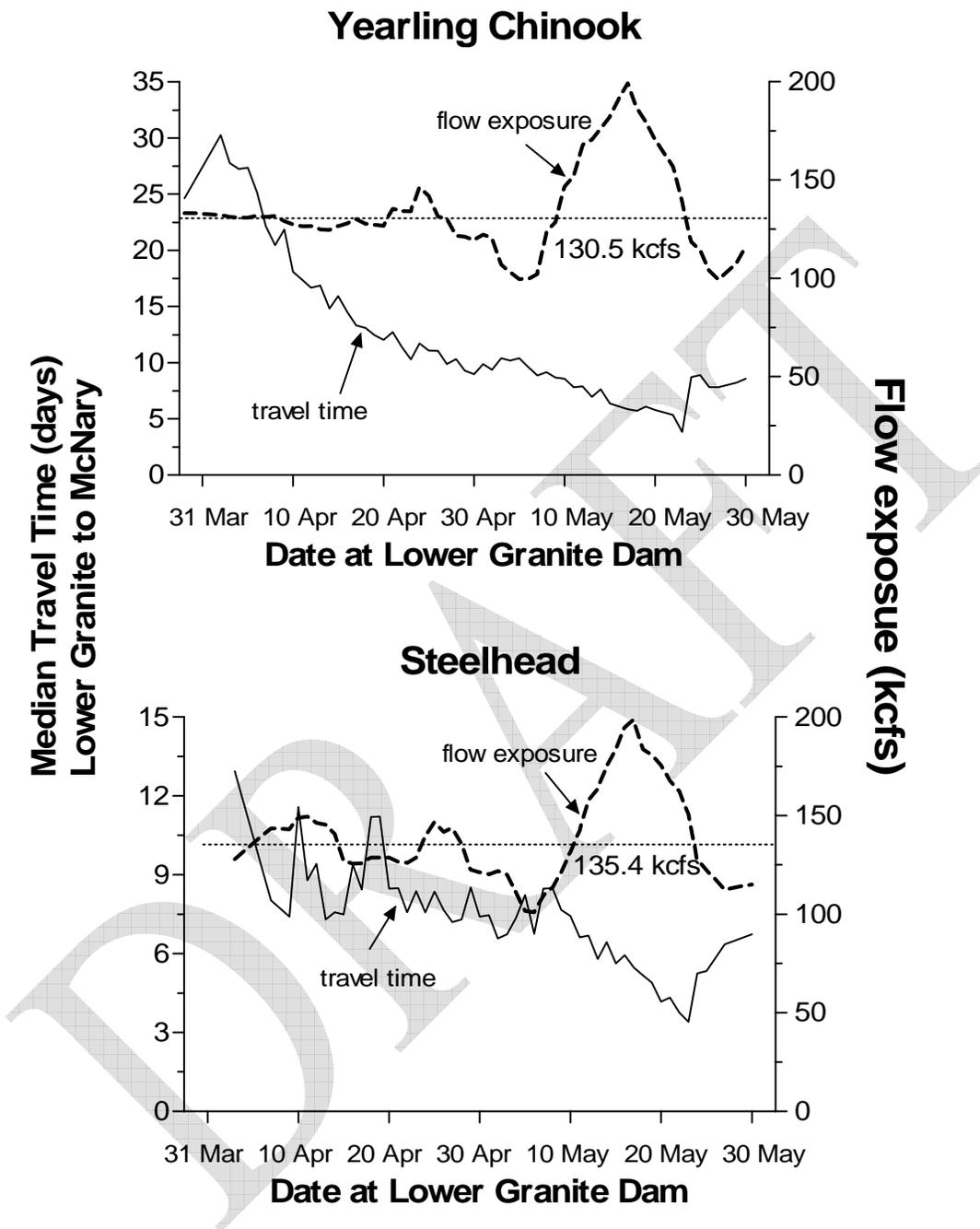


Figure 5. Median travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged fish during 2006. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

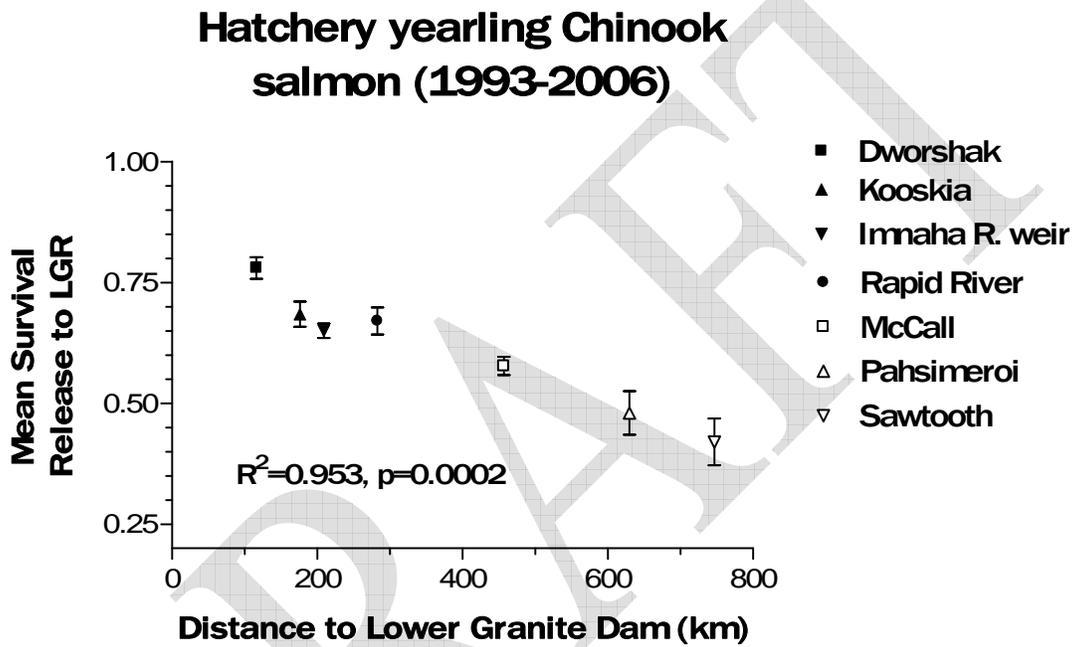


Figure 6. Estimated survival with standard errors from release at Snake River Basin hatcheries to Lower Granite Dam tailrace, 1993-2006 vs distance (km) to Lower Granite Dam. The correlation between survival and migration distance is also shown.

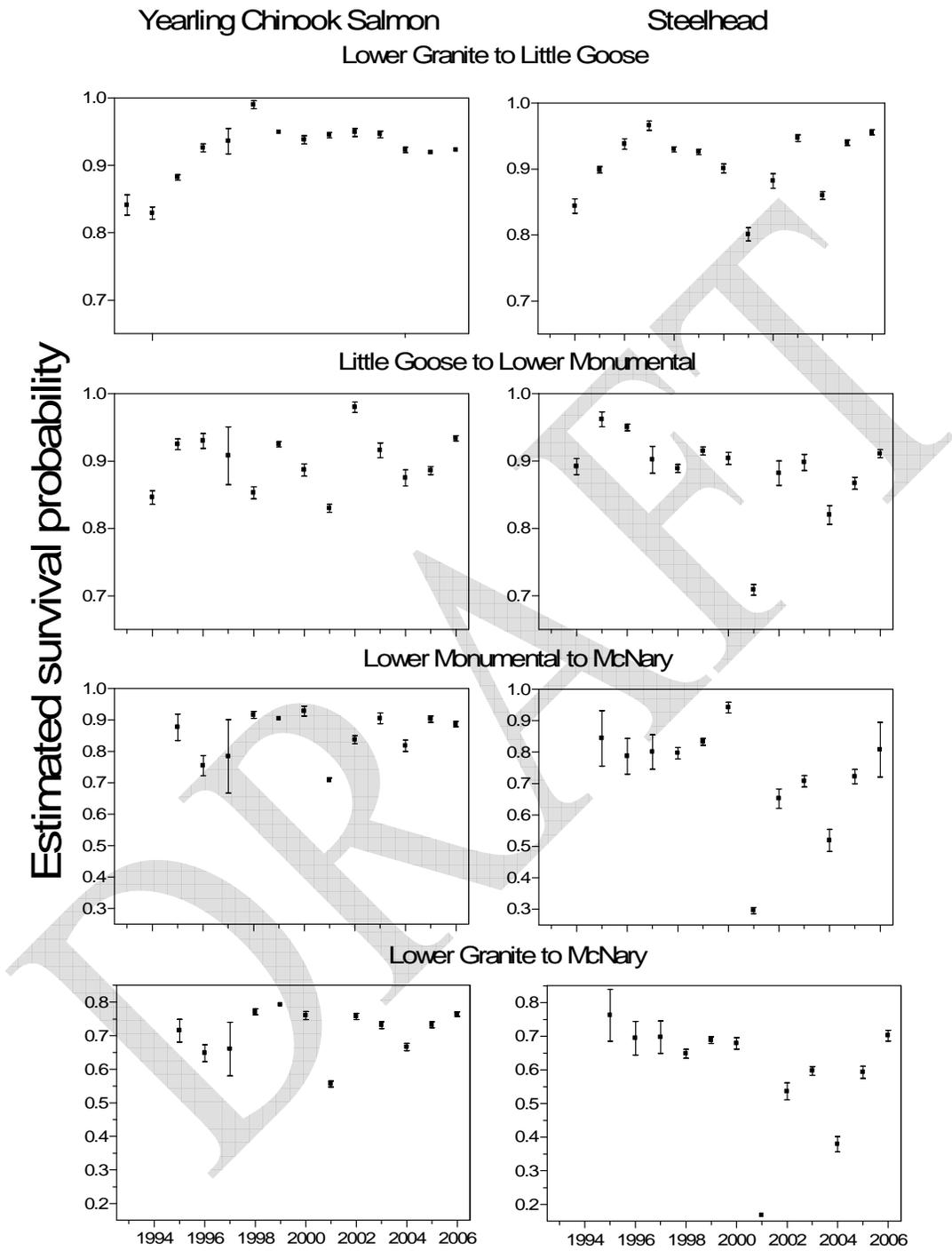


Figure 7. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead through Snake River reaches, 2006. Estimates are from tailrace to tailrace with standard errors.

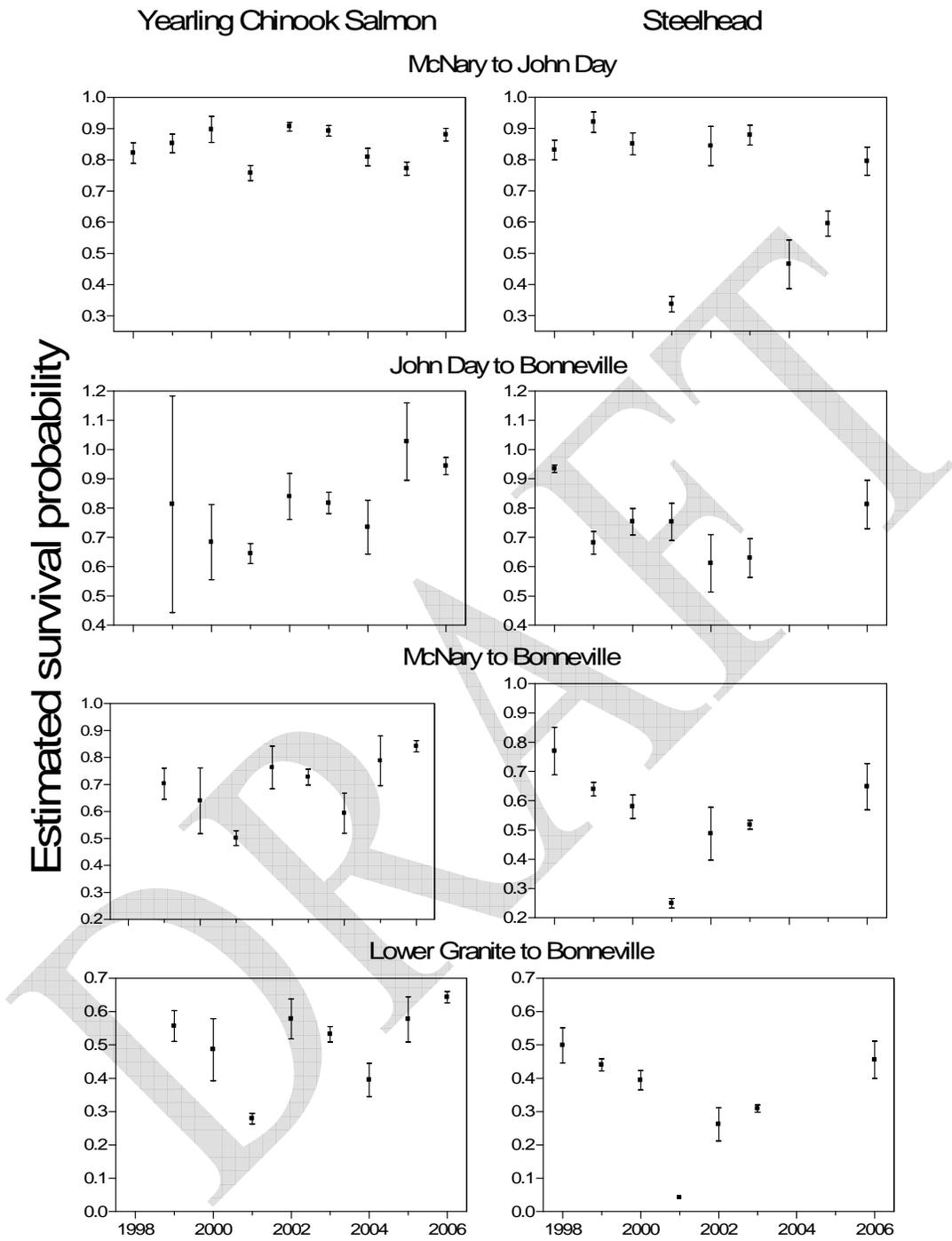


Figure 8. Annual average survival estimates for PIT-tagged Snake River yearling Chinook salmon and steelhead through Columbia River reaches and from Lower Granite Dam to Bonneville Dam, 2006. Estimates are from tailrace to tailrace with standard errors.

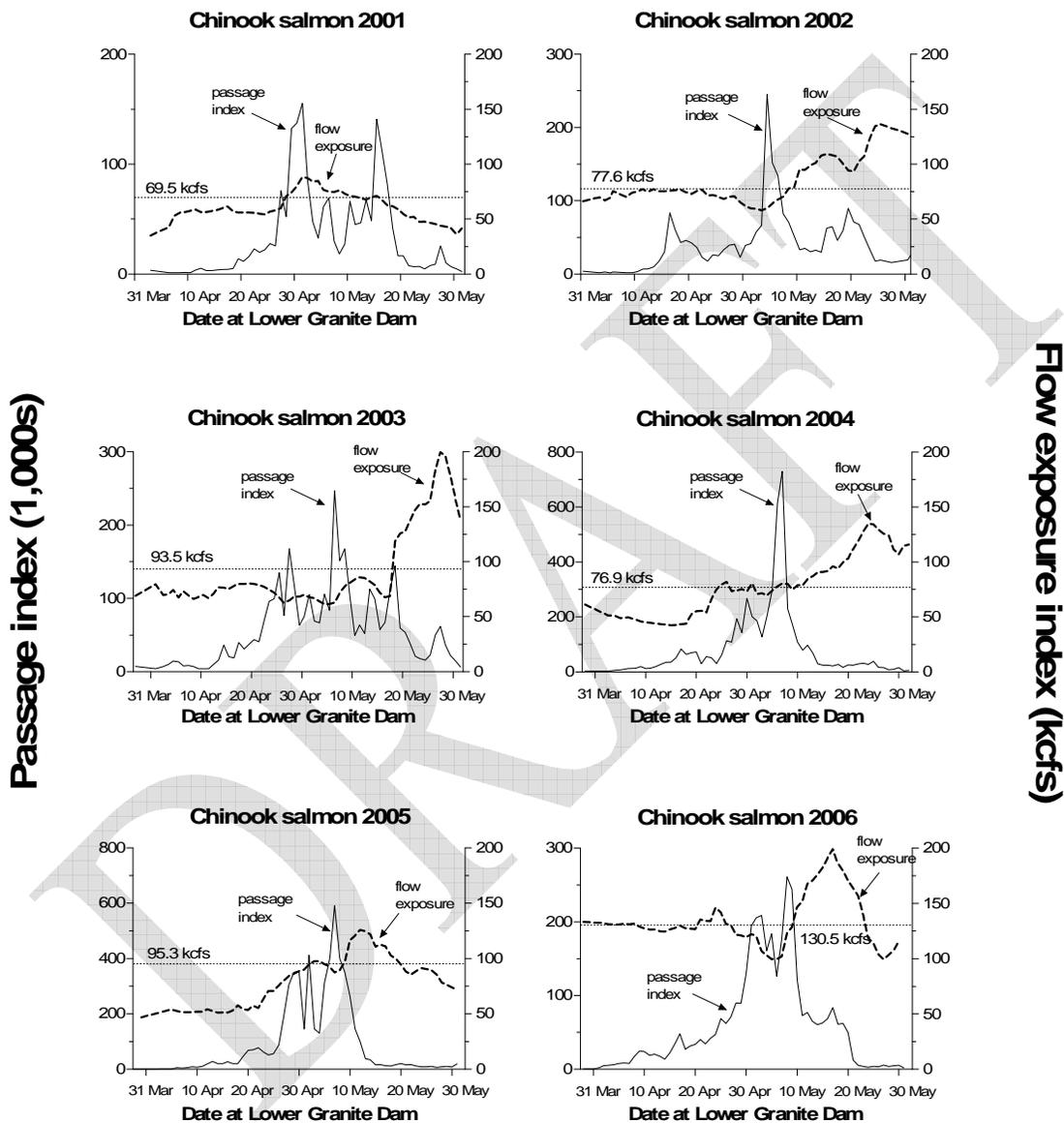


Figure 9. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged yearling Chinook salmon passing Lower Granite Dam from 2001 through 2006. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

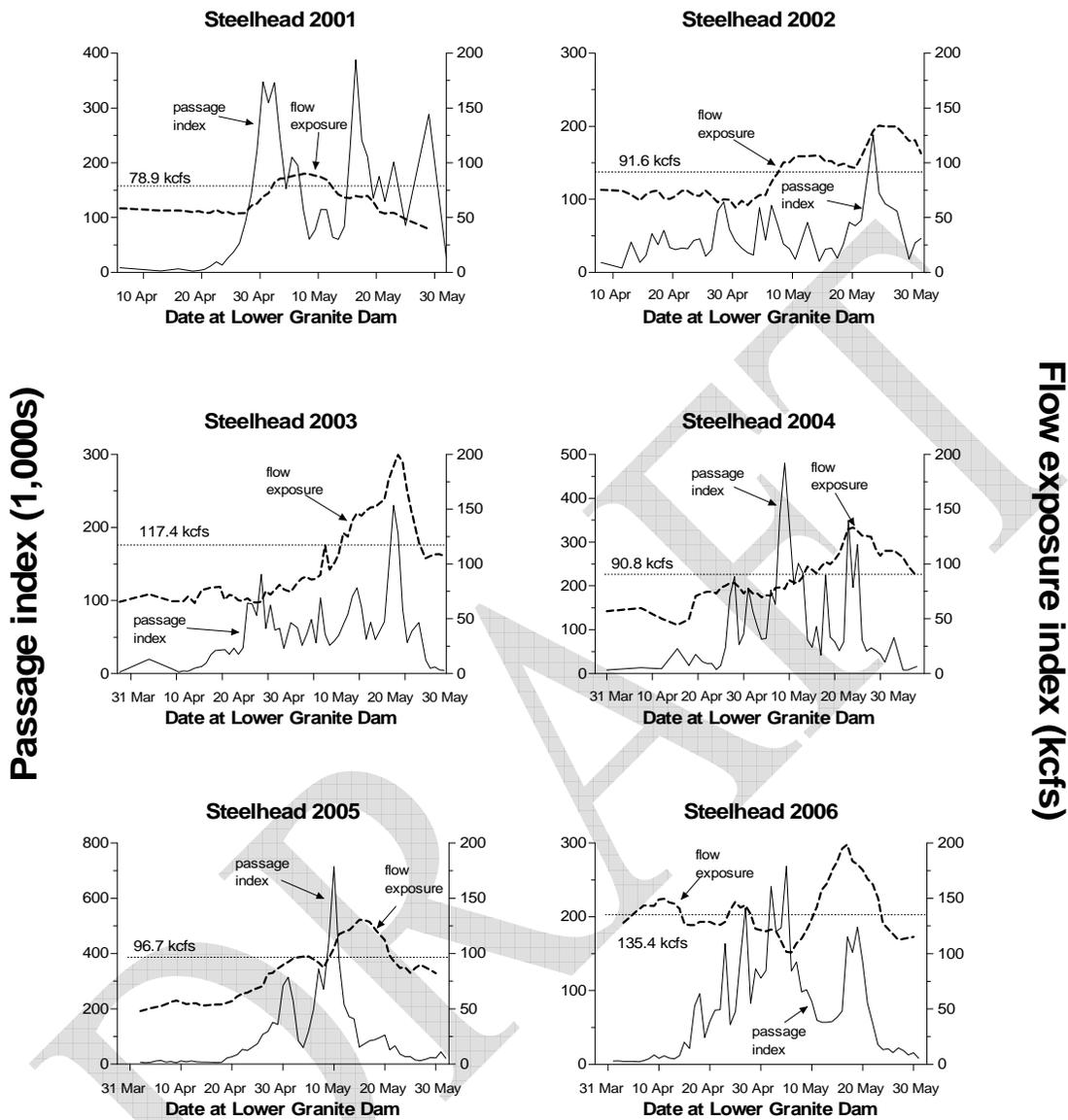


Figure 10. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged steelhead passing Lower Granite Dam from 2001 through 2006. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

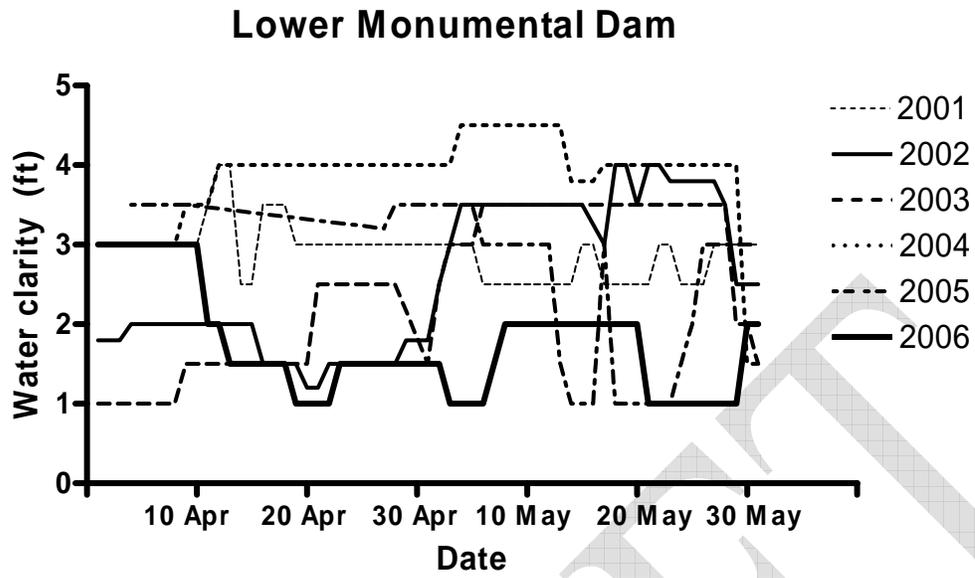


Figure 11. Water clarity (secchi disk reading in feet) measured at Lower Monumental Dam, 2001-2006.

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 2006 (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 df = 1	Site first detected below LMN	
	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 df = 1	Detected at JDA or below?	
	Yes	No
Detected at MCN, not detected previously	n_{11}	n_{12}
Detected at MCN, also detected previously	n_{21}	n_{22}

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

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

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

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

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

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

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

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

Results

For weekly Lower Granite Dam release groups in 2006 there were more significant ($\alpha = 0.05$) tests in the Test 2 series than expected by chance alone for both yearling Chinook salmon and steelhead, but not in the Test 3 series (Table A1.1). There were 11 weekly groups of yearling Chinook salmon. For these, the overall sum of the χ^2 test statistics was significant 3 times. For 11 steelhead groups, the overall test was significant 5 times. Counting all individual component tests (i.e., 2.C2, 3.SR3, etc.), 11 tests of 53 (21%) were significant for yearling Chinook salmon and 14 of 51 (27%) were significant for steelhead (Tables A1.1 through A1.3).

We diagnosed the patterns in the contingency tables that led to significant 2.C2 tests and results were similar to those we reported in past years; there was evidence that fish previously detected were more likely to be detected again at downstream dams. This phenomenon likely contributed to significant results for tests other than 2.C2, as well.

No contingency table test results were significant (0 significant tests of 19) for weekly groups from McNary Dam (Tables A1.4 through A1.6).

Discussion

We believe that inherent differences in detectability (guidability) of fish within a release group are the most likely cause of the patterns we observed in the contingency table tests in 2006, 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 2006 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 2006 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 A1. 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, 2006.

Species	<u>Test 2.C2</u>		<u>Test 2.C3</u>		<u>Test 3.SR3</u>		<u>Test 3.Sm3</u>		<u>Test 3.SR4</u>		<u>Test 2 sum</u>		<u>Test 3 sum</u>		<u>Test 2 + 3</u>	
	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.
Chinook	11	2	11	2	11	2	9	1	11	4	11	2	11	3	11	3
Steelhead	11	3	10	4	11	3	9	3	10	1	11	4	11	2	11	5
Total	22	5	21	6	22	5	18	4	21	5	22	6	22	5	22	8

Appendix Table A2. 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 2006.

Release	<u>Overall</u>		<u>Test 2</u>		<u>Test 2.C2</u>		<u>Test 2.C3</u>	
	χ^2	P value	χ^2	P value	χ^2	P value	χ^2	P value
30 Mar - 05 Apr	6.81	0.34	4.09	0.25	1.41	0.50	2.69	0.10
06 Apr - 12 Apr	8.73	0.19	3.40	0.33	2.50	0.29	0.90	0.34
13 Apr - 19 Apr	6.12	0.41	5.83	0.12	4.26	0.12	1.57	0.21
20 Apr - 26 Apr	10.13	0.12	2.04	0.57	1.73	0.42	0.31	0.58
27 Apr - 03 May	71.99	<0.001	38.09	<0.001	24.55	<0.001	13.55	<0.001
04 May - 10 May	48.65	<0.001	8.69	0.03	4.81	0.09	3.88	0.049
11 May - 17 May	8.79	0.19	2.28	0.52	0.22	0.90	2.06	0.15
18 May - 24 May	13.09	0.04	11.80	0.008	9.62	0.01	2.18	0.14
25 May - 31 May	3.54	0.74	0.50	0.92	0.09	0.95	0.41	0.52
01 Jun - 07 Jun	1.44	0.92	1.08	0.78	0.03	0.99	1.05	0.31
08 Jun - 14	6.23	0.28	5.69	0.13	5.61	0.06	0.08	0.78
Total (d.f.)	185.5 (64)	<0.001	83.49 (33)	<0.001	54.81 (22)	<0.001	22.68 (11)	<0.001

Table A2. Continued.

Release	<u>Test 3</u>		<u>Test 3.SR3</u>		<u>Test 3.Sm3</u>		<u>Test 3.SR4</u>	
	χ^2	P value	χ^2	P value	χ^2	P value	χ^2	P value
30 Mar - 05 Apr	2.72	0.44	0.72	0.40	1.40	0.24	0.60	0.44
06 Apr - 12 Apr	5.33	0.15	3.51	0.06	0.68	0.41	1.14	0.29
13 Apr - 19 Apr	0.28	0.96	0.02	0.89	0.16	0.69	0.11	0.74
20 Apr - 26 Apr	8.09	0.04	2.87	0.09	0.82	0.37	4.41	0.04
27 Apr - 03 May	33.90	<0.001	23.10	<0.001	4.79	0.03	6.01	0.014
04 May - 10 May	39.96	<0.001	25.29	<0.001	1.60	0.21	13.07	<0.001
11 May - 17 May	6.51	0.09	0.03	0.85	0.01	0.91	6.46	0.011
18 May - 24 May	1.28	0.73	0.56	0.45	0.51	0.47	0.21	0.65
25 May - 31 May	3.04	0.39	0.13	0.72	0.54	0.46	2.37	0.12
01 Jun - 07 Jun	0.36	0.83	0.22	0.64	NA	NA	0.14	0.71
08 Jun - 14 Jun	0.55	0.76	0.38	0.54	NA	NA	0.16	0.69
Total (d.f.)	102.0 (31)	<0.001	56.84 (11)	<0.001	10.51 (9)	0.31	34.67 (11)	<0.001

Appendix Table A3. 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 2006.

Release	<u>Overall</u>		<u>Test 2</u>		<u>Test 2.C2</u>		<u>Test 2.C3</u>	
	χ^2	P value	χ^2	P value	χ^2	P value	χ^2	P value
30 Mar - 05 Apr	3.07	0.22	1.81	0.18	1.81	0.18	NA	NA
06 Apr - 12 Apr	2.37	0.88	0.19	0.98	0.15	0.93	0.04	0.85
13 Apr - 19 Apr	15.24	0.02	2.88	0.41	2.49	0.29	0.39	0.53
20 Apr - 26 Apr	18.96	<0.001	15.59	<0.001	9.77	0.008	5.82	0.02
27 Apr - 03 May	25.52	<0.001	19.11	<0.001	10.48	0.005	8.63	<0.001
04 May - 10 May	7.36	0.29	1.93	0.59	1.71	0.43	0.23	0.63
11 May - 17 May	5.17	0.52	0.44	0.93	0.36	0.84	0.09	0.77
18 May - 24 May	24.69	<0.001	15.17	<0.001	10.81	<0.001	4.36	0.04
25 May - 31 May	4.73	0.58	3.80	0.28	1.07	0.59	2.73	0.098
01 Jun - 07 Jun	16.91	0.01	11.14	0.011	3.05	0.22	8.09	<0.001
08 Jun - 14 Jun	6.90	0.23	6.75	0.08	6.25	0.04	0.50	0.48
Total (d.f.)	130.9 (61)	<0.001	78.80 (31)	<0.001	47.95 (21)	<0.001	30.86 (10)	<0.001

Table A3. Continued.

Release	<u>Test 3</u>		<u>Test 3.SR3</u>		<u>Test 3.Sm3</u>		<u>Test 3.SR4</u>	
	χ^2	P value	χ^2	P value	χ^2	P value	χ^2	P value
30 Mar - 05 Apr	1.26	0.26	1.26	0.26	NA	NA	NA	NA
06 Apr - 12 Apr	2.17	0.54	1.15	0.28	0.18	0.67	0.84	0.36
13 Apr - 19 Apr	12.36	0.006	5.49	0.02	5.97	0.02	0.90	0.34
20 Apr - 26 Apr	3.37	0.34	1.24	0.27	1.33	0.25	0.79	0.37
27 Apr - 03 May	6.40	0.09	0.04	0.84	1.60	0.21	4.76	0.03
04 May - 10 May	5.43	0.14	4.81	0.03	0.03	0.87	0.59	0.44
11 May - 17 May	4.73	0.19	3.64	0.06	0.02	0.88	1.06	0.30
18 May - 24 May	9.53	0.02	4.21	0.04	5.05	0.03	0.27	0.61
25 May - 31 May	0.93	0.82	0.23	0.63	0.61	0.44	0.09	0.76
01 Jun - 07 Jun	5.77	0.12	0.09	0.77	5.09	0.02	0.59	0.44
08 Jun - 14 Jun	0.16	0.93	0.09	0.76	NA	NA	0.06	0.80
Total (d.f.)	52.10 (30)	0.007	22.25 (11)	0.02	19.89 (9)	0.02	9.97 (10)	0.44

Appendix Table A4. Number of tests of goodness of fit to the Single Release Model conducted for weekly release groups of yearling Chinook salmon and steelhead (hatchery and wild combined) from McNary Dam, and number of significant ($\alpha = 0.05$) test results, 2006.

Spp.	<u>Test 2.C2</u>		<u>Test 3.SR3</u>		<u>Test 2 + 3</u>	
	#	sig.	#	sig.	#	sig.
Chinook	6	0	5	0	6	0
Steelhead	6	0	2	0	6	0
Total	12	0	7	0	12	0

Appendix Table A5. 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 2006.

Release	<u>Overall</u>		<u>Test 2.C2</u>		<u>Test 3.SR3</u>	
	χ^2	P value	χ^2	P value	χ^2	P value
13 Apr – 19 Apr	NA	NA	NA	NA	NA	NA
20 Apr – 26 Apr	0.49	0.78	0.43	0.51	0.06	0.81
27 Apr - 03 May	3.45	0.18	3.21	0.07	0.25	0.62
04 May - 10 May	3.65	0.16	0.13	0.72	3.52	0.06
11 May - 17 May	2.22	0.33	2.21	0.14	0.01	0.94
18 May - 24 May	2.20	0.33	1.90	0.17	0.31	0.58
25 May - 31 May	0.51	0.48	0.51	0.48	NA	NA
Total (d.f.)	12.5 (11)	0.33	8.37 (6)	0.21	4.14 (5)	0.53

Appendix Table A6. 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 2006.

Release	<u>Overall</u>		<u>Test 2.C2</u>		<u>Test 3.SR3</u>	
	χ^2	P value	χ^2	P value	χ^2	P value
20 Apr – 26 Apr	0.29	0.87	0.04	0.85	0.25	0.62
27 Apr - 03 May	0.14	0.71	0.14	0.71	NA	NA
04 May - 10 May	0.30	0.86	0.30	0.59	0.00	0.98
11 May - 17 May	0.21	0.65	0.21	0.65	NA	NA
18 May - 24 May	0.75	0.39	0.75	0.39	NA	NA
25 May - 31 May	0.01	0.94	0.01	0.94	NA	NA
Total (d.f.)	1.69 (8)	0.99	1.43 (6)	0.96	0.25 (2)	0.88