Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2008

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EXECUTIVE SUMMARY

In 2008, the National Marine Fisheries Service completed the sixteenth year of a study to estimate survival and travel time of juvenile salmonids *Oncorhynchus* spp. passing through dams and reservoirs on the Snake and Columbia Rivers. All estimates were derived from detections of fish tagged with passive integrated transponder (PIT) tags. We PIT tagged and released a total of 18,565 hatchery steelhead *O. mykiss*, 15,991 wild steelhead, and 9,714 wild yearling Chinook salmon *O. tshawytscha* at Lower Granite Dam in the Snake River.

In addition, we utilized fish PIT tagged by other agencies at traps and hatcheries upstream from the hydropower system and at sites within the hydropower system in both the Snake and Columbia Rivers. These included 122,061 yearling Chinook salmon tagged at Lower Granite Dam for evaluation of 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 2008 were to:

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

This report provides reach survival and travel time estimates for 2008 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 2008 yearling Chinook salmon and steelhead migrations. Hatchery and wild fish were combined in some of the analyses. For yearling Chinook salmon, overall percentages for combined release groups used in survival analyses in the Snake River were 80% hatchery-reared and 20% wild. For steelhead, the overall percentages were 65% hatchery-reared and 35% wild.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.939 for yearling Chinook salmon and 0.935 for steelhead. Reaches of river were measured from tailrace to tailrace, and respective average survival estimates for yearling Chinook salmon and steelhead through the following reaches were:

	Yearling Chinook salmon	Steelhead
Little Goose to Lower Monumental Dam	0.950	0.961
Lower Monumental to McNary Dam[a]	0.878	0.776
McNary to John Day Dam	1.073[b]	0.950
John Day to Bonneville Dam[c]	0.558	0.742

[a] A two-project reach, as it includes passage through Ice Harbor Dam.
[b] Survival estimates greater than 1.0 can result from the statistical model of the data, but clearly true survival cannot exceed 1.0.
[c] A two-project reach, as it includes 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 0.461 (se 0.052) for Snake River yearling Chinook salmon and 0.478 (se 0.028) for steelhead during 2008.

For yearling spring Chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.630 for East Bank Hatchery fish released from Chiwawa Pond to 0.255 for Cle Elum Hatchery fish released from Jack Creek Pond.

For steelhead released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace ranged from 0.623 for fish from Turtle Rock Hatchery released in the Wenatchee River to 0.028 for fish from Cassimer Bar Hatchery released in Omak Creek.

During 2008, flows were near the historic average for most of April, but increased to above average for most of May. Spill percentages in 2008 were much like those in 2007 until mid-May, when a sharp increase in flow corresponded with an increase in spill. In contrast, spill percentages dropped off in May 2007. Water temperatures in 2008 were lower than in most recent years because of below-normal air temperatures in April and cold melt water from a late-season thaw of larger-than-average snowpack.

For Snake River yearling Chinook salmon, estimated survival through the entire hydropower system (Snake River trap to Bonneville Dam tailrace) in 2008 was slightly below the average for the last 10 years. For Snake River steelhead, estimated survival through the hydropower system in 2008 was the highest estimated in the last 12 years (in 2004 and 2005 survival could not be estimated through the entire hydropower system).

In 2008, survival estimates in the two consecutive reaches downstream from McNary Dam for yearling Chinook salmon strongly suggested that the data did not conform to assumptions of the statistical model, leading to problematic estimates. From McNary Dam tailrace to John Day Dam tailrace estimated survival exceeded 100%, which was not only considerably greater than any estimate previously observed for the reach, it was obviously an impossible value for true survival. Simultaneously, average survival estimate from John Day Dam tailrace to Bonneville Dam tailrace was considerably lower than observed in recent years.

The pattern of an extremely high estimate in the first reach followed by an extremely low estimate in the second reach will result when fish that were detected at one dam (John Day Dam in this case) are less likely to be detected at the next dam (Bonneville Dam) than their counterparts that were not detected at the first dam. Though definitive evidence is not available, we believe the most likely mechanism in 2008 was greater mortality in the tailrace of John Day Dam for detected fish (i.e., those that went through the bypass system) than for non-detected fish (i.e., those that passed via spillway or turbine).

When such "post-detection bypass mortality" occurs, mortality in the tailrace is essentially assigned to the wrong one of the two reaches. In this case, the result of the misassignment was to lower the survival estimate in the reach from John Day to Bonneville Dam and conversely increase the estimate from McNary to John Day Dam. However, the survival estimate for the combined reach from McNary Dam tailrace to Bonneville Dam tailrace was not biased (provided there was no post-detection bypass mortality at Bonneville Dam).

In 2008, yearling Chinook salmon and steelhead migration rates through the hydropower system were faster (i.e., travel times shorter) than average, especially for steelhead, likely because of higher water velocities, relatively high spill proportions, and the use of surface collectors at most projects.

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

From 1993 through 2007, the National Marine Fisheries Service (NMFS) estimated survival for these stocks using detections of PIT-tagged (Prentice et al. 1990a) juvenile salmonids passing through Snake River dams and reservoirs (Iwamoto et al. 1994; Muir et al. 1995, 1996, 2001a,b, 2003; Smith et al. 1998, 2000a,b, 2003, 2005, 2006; Hockersmith et al. 1999; Zabel et al. 2001, 2002; Faulkner et al. 2007, 2008). In 2008, NMFS completed the sixteenth year of the study.

Research objectives in 2008 were to:

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

METHODS

Experimental Design

The single-release (SR) model was used to estimate survival for groups of PIT-tagged yearling Chinook salmon, sockeye salmon, coho 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 2008, 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 2008 migration season, automatic PIT-tag detectors (Prentice et al. 1990a,b,c) were operated in 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; Figure 1).

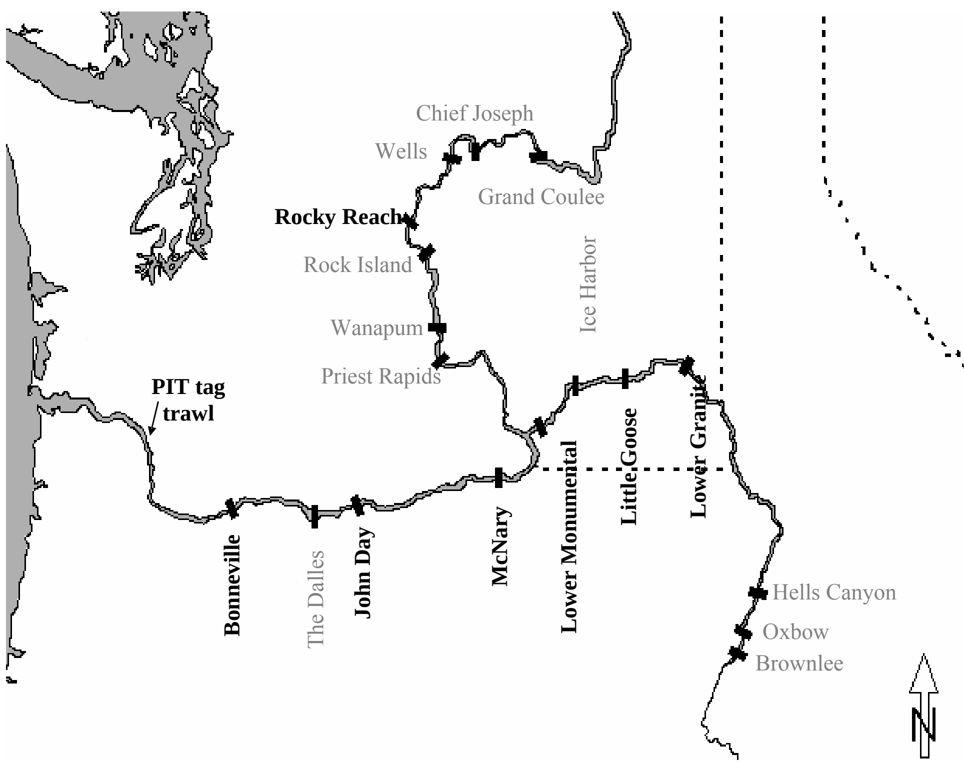

Figure 1. Study area showing sites with PIT-tag detection facilities (names in black), including dams and the PIT-tag trawl in the Columbia River estuary. Dams with names in gray do not have detection facilities.

The PIT-tag detection site farthest downstream 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 2008, the corner collector at Bonneville Dam Second Powerhouse was operated with a PIT tag detection system. Detections at Bonneville Dam and the pair trawl were sufficient to estimate survival through the reach from John Day tailrace to Bonneville Dam tailrace for both yearling Chinook salmon and steelhead.

A large proportion of PIT-tagged yearling Chinook salmon used in this analysis were released in the Snake River upstream from Lower Granite Dam for the multi-agency Comparative Survival Study (Schaller et al. 2007). In addition, we utilized about 122,061 yearling Chinook salmon PIT tagged at Lower Granite Dam as part of evaluation of latent mortality related to passage through Snake River dams (Marsh et al. 2006).

Note that of those 122,061, we used 50,803 non-trucked (reference) fish released to Lower Granite tailrace for our Lower Granite release groups. The remaining 71,258 fish were trucked and released to the tailrace of either Lower Granite (42,431) or Ice Harbor Dam (28,827). These latter groups from the latent mortality study were included in our McNary release groups (formed by detection date at McNary Dam) if they were subsequently detected and returned to the river at McNary Dam. Most PIT-tagged fish detected at dams downstream from Lower Granite Dam were diverted back to the river, 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 (upstream from Lower Granite Dam), 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 (60 km)
- Little Goose Dam tailrace to Lower Monumental Dam tailrace (46 km)
- Lower Monumental Dam tailrace to Ice Harbor Dam tailrace (51 km)
- Ice Harbor Dam tailrace to McNary Dam tailrace (68 km)
- McNary Dam tailrace to John Day Dam tailrace (123 km)
- John Day Dam tailrace to Bonneville Dam tailrace (112 km)

The PIT-tag detection system in the Ice Harbor Dam juvenile bypass facility began operating in 2005. Because of the high level of spill at this dam, too few smolts were detected there to partition survival between Lower Monumental and McNary Dams in 2005. However, in 2006-2008 there were sufficient detections at Ice Harbor to partition survival through this reach.

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

- Point of release to the tailrace of McNary Dam
- McNary Dam tailrace to John Day Dam tailrace (123 km)
- John Day Dam tailrace to Bonneville Dam tailrace (112 km)

Lower Granite Dam Tailrace Release Groups

During 2008, 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 the express purpose of estimating their subsequent survival. 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 numbers of hatchery yearling Chinook PIT tagged and released from Snake River Basin hatcheries, traps, and for other studies were sufficient for analysis downstream from Lower Granite Dam. For Lower Granite Dam release groups we also used 50,803 yearling Chinook salmon tagged and released (non-trucked group) at Lower Granite Dam for a study to evaluate 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" of fish detected at Lower Granite Dam 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 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. (Data were too sparse to estimate survival for daily groups).

Hatchery and Trap Release Groups

In 2008, 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. For fish released in the Upper Columbia River basin, we estimated survival to the tailrace of McNary Dam for yearling spring Chinook salmon released from Cle Elum, East Bank, Leavenworth, Wells, and Winthrop Hatcheries. We also estimated survival to McNary Dam for steelhead from Cassimer Bar, East Bank, Turtle Rock, and Winthrop Hatcheries, and for coho salmon from Cascade, Eagle Creek, Prosser, and Willard. In the course of characterizing the various hatchery releases, we conducted preliminary analyses to determine whether data from related 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 Columbia Basin PIT Tag Information System (PTAGIS), a regional database maintained by the Pacific States Marine Fisheries Commission (PTAGIS 2008). 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. Very few records (<0.1%) were eliminated. 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 this time. It is possible, for a variety of reasons, that data in the PTAGIS database may be updated in the future. Thus, future estimates provided by NMFS or employed in future analyses may differ slightly from those presented here.

Tests of Assumptions

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

Survival Estimation

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

When estimates for a particular river section or passage route were available from more than one release group, the estimates were often combined using a weighted average (Muir et al. 2001a). Weights were inversely proportional to the respective estimated relative variance (coefficient of variation squared). The variance of an estimated survival probability from the SR model is a function of the estimate itself. Consequently, lower survival estimates tend to have smaller estimated variance. Therefore, we did not use the inverse estimated absolute variance in weighting, because lower survival estimates would have disproportionate influence, and the resulting weighted mean would be 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 calculating weighted average survival estimated over shorter reaches for daily or weekly release groups using the 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 to McNary Dam by the weighted mean estimate for weekly groups from McNary to Bonneville Dam to obtain overall estimated mean survival probability from Lower Granite to Bonneville Dam. Finally, we multiplied this result by the estimated survival to Lower Granite Dam for fish released from the Snake River 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

We calculated travel times of yearling Chinook salmon and steelhead 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 (119 km)
4) Lower Granite Dam to McNary Dam (225 km)
5) Lower Granite Dam to Bonneville Dam (461 km)
6) McNary Dam to John Day Dam (123 km)
7) John Day Dam to Bonneville Dam (113 km)
8) McNary Dam to Bonneville Dam (236 km)

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

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

The true complete set of travel times for a release group includes travel times of both detected and non-detected fish. However, using PIT tags, travel time 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 the dam via the juvenile bypass system.

Comparison of Annual Survival Estimates

We made two comparisons of 2008 results to those obtained in previous years of the NMFS survival study. First, we related migration distance to survival estimates from release at specific hatcheries to Lower Granite Dam. Second, we compared season-wide survival estimates for specific reaches across years.

Salmonid Passage Timing In Relation to Flow

For each daily group of PIT-tagged yearling Chinook salmon from Lower Granite Dam we calculated an index of Snake River flow exposure. For each daily group, the index was equal to the average daily flow at Lower Monumental Dam during the period between the 25th and 75th percentiles of PIT-tag detection at Lower Monumental Dam. Thus, values of the exposure index are very similar to those of daily average flow at the dam during this period. We also calculated an annual average exposure index, which was the weighted average of the indices for the daily groups, with weights equal to the number of PIT-tagged fish released in each group.

Estimates of Proportion of Population Transported

To estimate the proportion of non-tagged fish that were transported, we proceeded through the following steps:

1. Compile daily collection counts at Lower Granite Dam from the Smolt Monitoring Program (fpc.org).

2. Use PIT-tag data to derive daily estimates of detection probability at Lower Granite Dam using method of Sandford and Smith (2002). Virtually every PIT-tagged fish in the collection system is detected, thus the probability of detecting a PIT-tagged fish on a given day is equivalent to the probability of entering the collection system.

3. For each day, divide the collection count by the detection probability to get an estimate of the total number of fish passing Lower Granite Dam that day. This also gives rise to estimates of the number of fish in the Lower Granite Dam collection system and the number of fish that passed via other routes that day.

4. For each daily group of PIT-tagged fish leaving Lower Granite Dam (i.e. detected and returned to the river), estimate the number of "Lower Granite equivalents" that were next detected (i.e. next entered a collection system) at Little Goose Dam and the number that passed Little Goose undetected and next entered a collection system at Lower Monumental Dam. We varied the daily estimated travel time between Lower Granite and downstream dams to take into account that earlier fish travel slower than later fish.

5. Assume that for the group of untagged fish arriving at Lower Granite Dam on a given day, the proportions of fish first collected at Lower Granite, Little Goose, and Lower Monumental Dam are the same as those of the group of PIT-tagged fish arriving on that day. (The number of PIT-tagged fish that arrived at Lower Granite but were not detected is estimated from daily detection probability estimates from step 2.)

6. For each daily group of fish arriving at Lower Granite Dam, estimate the proportion of those that entered the collection system at each collector dam and were transported from that dam. For Lower Granite Dam groups arriving after the transportation starting date at a collector dams, the proportion transported is 100%. For groups arriving before the starting date, the estimated proportion of the daily Lower Granite Dam group transported depends on the travel time distribution (i.e., a certain percentage of each group arrived before transportation began).

7. For each daily group of the run-at-large, calculate the product of three quantities:
   (i) estimated number of fish in the group (step 3);
   (ii) estimated proportion of fish first entering the collection system at each dam (step 4/5); and
   (iii) estimated proportion of fish entering the collection system that were transported (step 6).

   This gives the estimated total Lower Granite Dam equivalents from each group that were transported from each dam.

8. Sum all estimated numbers transported and divide by the total population estimate to derive the estimated percentage transported for the season.

RESULTS

Lower Granite Dam Tagging and Release Information

During 2008, a total of 83,008 yearling Chinook salmon (66,558 hatchery origin, 16,450 wild) were detected and returned or PIT tagged and released to the river in the tailrace of Lower Granite Dam. A total of 52,243 (33,978 hatchery origin and 18,265 wild) steelhead were detected and returned or PIT tagged and released to the river in the tailrace of Lower Granite Dam.

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 based predominantly on fish of hatchery origin for (80% of yearling Chinook salmon and 65% of steelhead) during 2008.

Survival Estimation

Tests of Assumptions

Assumption tests for 2008 indicated more significant differences between observed and expected proportions of fish in different detection-history categories than would be expected by chance alone. In many cases, sample sizes were such that the contingency table-based tests had power to detect violations that had only 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 nine consecutive weeks from 6 April through 7 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.939 (se 0.006; Table 1). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.950 (se 0.011). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.878 (se 0.016). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, survival averaged 0.782 (se 0.001).

We estimated survival probabilities for weekly groups of yearling Chinook salmon released in the tailrace at McNary Dam for seven consecutive weeks from 27 April through 14 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 1.073 (se 0.058; Table 2). From John Day Dam tailrace to Bonneville Dam tailrace estimated survival averaged 0.558 (se 0.082). For the combined reach from McNary Dam to Bonneville Dam, estimated survival averaged 0.594 (se 0.066).

The product of the average estimates from Lower Granite to McNary Dam and from McNary to Bonneville Dam provided an overall survival estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace of 0.465 (se 0.052). Estimated survival probability through Lower Granite reservoir and dam for Snake River wild and hatchery Chinook salmon released from the Snake River trap was 0.992 (se 0.018). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River yearling Chinook salmon was 0.461 (se 0.052).

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 were similar for hatchery and wild yearling Chinook salmon for the combined reach from the tailrace of Lower Granite Dam to the tailrace of McNary Dam in 2008.

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 2008 migration season (Table 5; Figure 2).

Estimates of detection probability varied throughout the season for most weekly groups as flow volumes, spill levels, and degrees of smoltification changed (Tables 6-9). Detection probabilities were generally highest at Little Goose Dam and lowest at Lower Monumental, John Day, and Bonneville Dams.

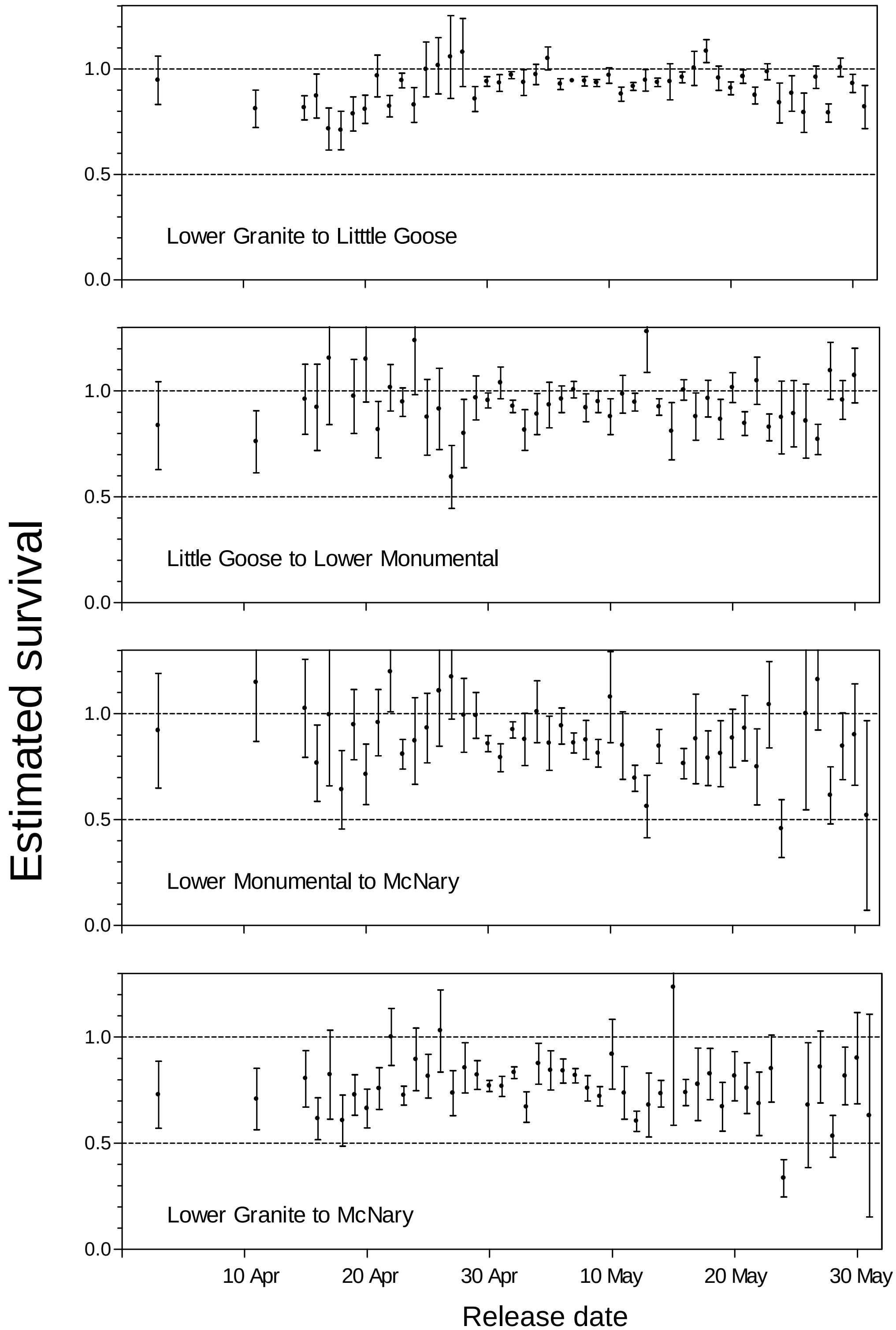

Figure 2. Estimated survival through various reaches vs. release date at Lower Granite Dam for daily release groups of Snake River yearling Chinook salmon, 2008. Bars extend one standard error above and below point estimates.

Snake River Steelhead

We estimated survival probabilities for weekly groups of steelhead from the tailrace of Lower Granite Dam for ten consecutive weeks from 6 April through 14 June. Survival estimates from Lower Granite Dam tailrace to Little Goose Dam tailrace averaged 0.935 (se 0.007; Table 10). From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.961 (se 0.014). From Lower Monumental Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.776 (se 0.017). For the combined reach from Lower Granite Dam tailrace to McNary Dam tailrace, estimated survival averaged 0.716 (se 0.015).

We estimated survival probabilities for weekly groups of steelhead released in the tailrace of McNary Dam for seven consecutive weeks from 20 April through 7 June. From McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.950 (se 0.066; Table 11). Estimated survival from John Day Dam tailrace to Bonneville Dam tailrace averaged 0.742 (se 0.045), and for the combined reach from McNary Dam tailrace to Bonneville Dam tailrace, 0.671 (se 0.034).

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 0.480 (se 0.026). Estimated survival probability through Lower Granite reservoir and dam for Snake River wild and hatchery steelhead released from the Snake River trap was 0.995 (se 0.018). Thus, estimated survival probability through all eight hydropower projects encountered by Snake River steelhead was 0.478 (se 0.028).

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 through most individual reaches and the reaches combined were similar for wild and hatchery steelhead.

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 2008 migration season (Table 14; Figure 3).

Estimates of detection probability at Snake River dams for weekly steelhead groups varied throughout the season as flow volumes, spill levels, and degrees of smoltification changed (Tables 15-18). Detection probability estimates were generally highest at Little Goose and John Day Dam, and lowest at Bonneville Dam.

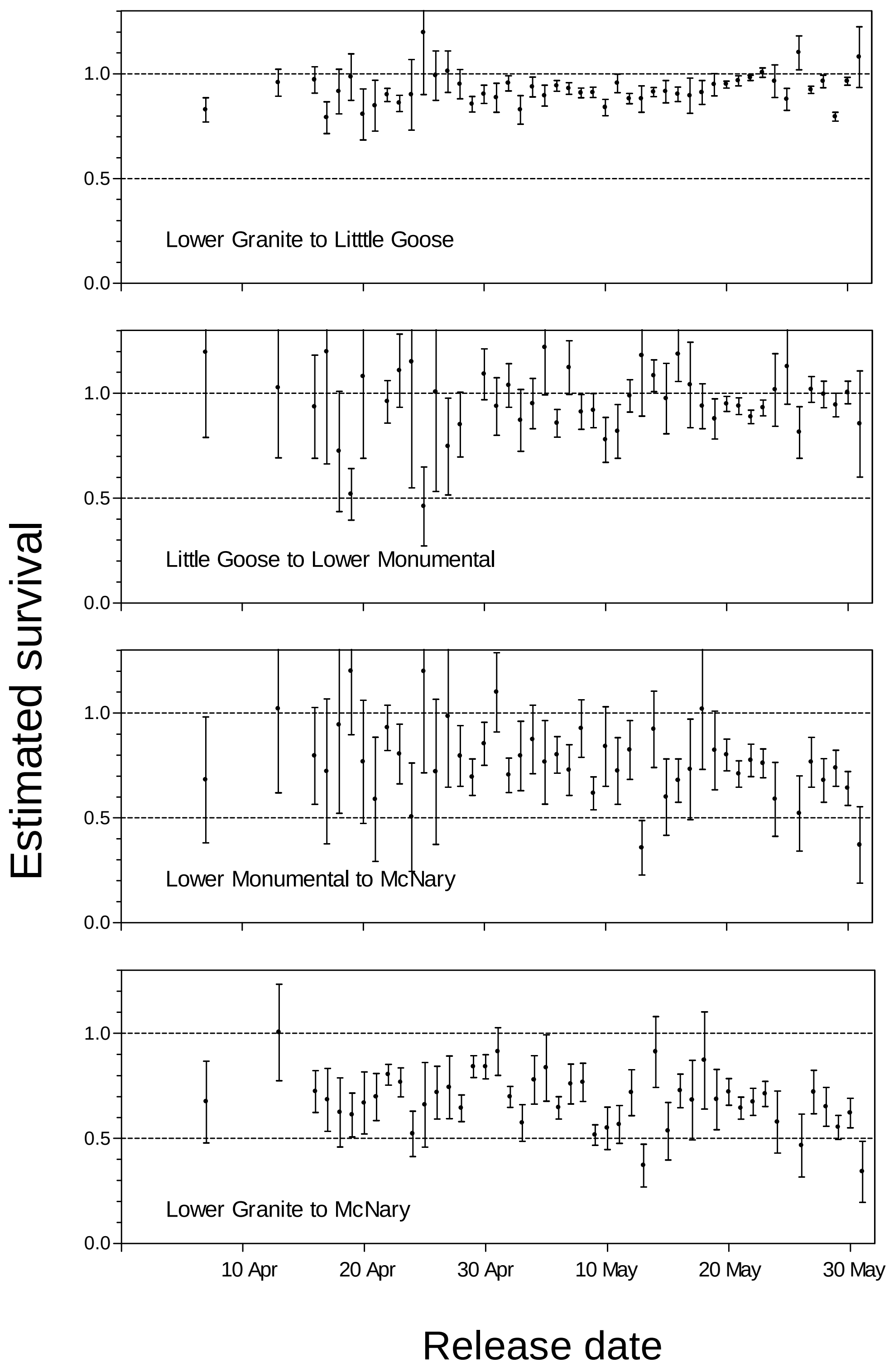

Figure 3. Estimated survival through various reaches versus release date at Lower Granite Dam for daily release groups of Snake River steelhead, 2008. Bars extend one standard error above and below point estimates.

Snake River Hatchery Release Groups

Survival probabilities were estimated for PIT-tagged hatchery yearling Chinook, sockeye salmon, and steelhead from release at Snake River Basin hatcheries to the tailrace of Lower Granite Dam and to downstream dams. These estimates varied among hatcheries and release locations (Tables 19-21), as did estimated detection probabilities among detection sites (Tables 22-24). For yearling Chinook salmon, estimated survival from release to Lower Granite Dam tailrace was highest for fish released from Rapid River Hatchery (0.801) and lowest for fish from Clearwater Hatchery released into Crooked River Pond (0.225). For steelhead, estimated survival from release to Lower Granite Dam tailrace ranged from 0.923 for fish from Hagerman Hatchery released to the Little Salmon River, to 0.494 for fish from Clearwater Hatchery released to Mill Creek. For sockeye salmon, estimated survival from release to Lower Granite Dam tailrace ranged from 0.449 from Sawtooth trap to 0.455 from Redfish Lake Creek trap for fish PIT-tagged and released in spring. Estimated survival was lower for sockeye salmon PIT-tagged and released in fall 2006 (0.207 to 0.281).

Snake River Smolt Trap Release Groups

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

Upper Columbia River Hatchery Release Groups

Survival probability estimates for PIT-tagged hatchery yearling Chinook, coho salmon, and steelhead from release at Upper Columbia River hatcheries to the tailrace of McNary Dam and dams downstream varied among hatcheries and release locations (Table 27), as did detection probability estimates (Table 28). For yearling spring Chinook released in the Upper Columbia River, estimated survival from release to McNary Dam tailrace ranged from 0.630 (se 0.040) for East Bank Hatchery fish released to Chiwawa Pond to 0.272 (se 0.014) for Cle Elum Hatchery fish released to Easton Pond.

For Upper Columbia River steelhead, estimated survival from release to McNary Dam tailrace ranged from 0.623 (se 0.033) for fish from Turtle Rock Hatchery released to the Wenatchee River to 0.028 (se 0.014) for fish from Cassimer Bar Hatchery released to Omak Creek. For Upper Columbia River coho, estimated survival from release to McNary Dam tailrace ranged from 0.607 (se 0.041) for fish from Cascade Hatchery released to Butcher Creek Pond in the Wenatchee River basin, to 0.108 (se 0.028) for fish from Prosser Hatchery released to Holmes Pond in the Yakima River Basin.

Travel Time and Migration Rate

Travel time estimates for yearling Chinook salmon and juvenile steelhead released in the tailraces of Lower Granite and McNary Dams varied throughout the season (Tables 29-36). For both species, estimated migration rates were generally highest in the lower river sections. Estimated travel times from Lower Granite Dam to Bonneville Dam for yearling Chinook salmon in 2008 were longer (migration rates slower) than recent years earlier in the season, then approached average later in the season. Steelhead travel times were among the shortest (migration rates fastest) observed in recent years (Figure 4). The observed increases in migration rates for yearling Chinook salmon and steelhead over the season generally coincided with increases in flow and water temperature, and presumably with increased levels of smoltification (Figure 5).

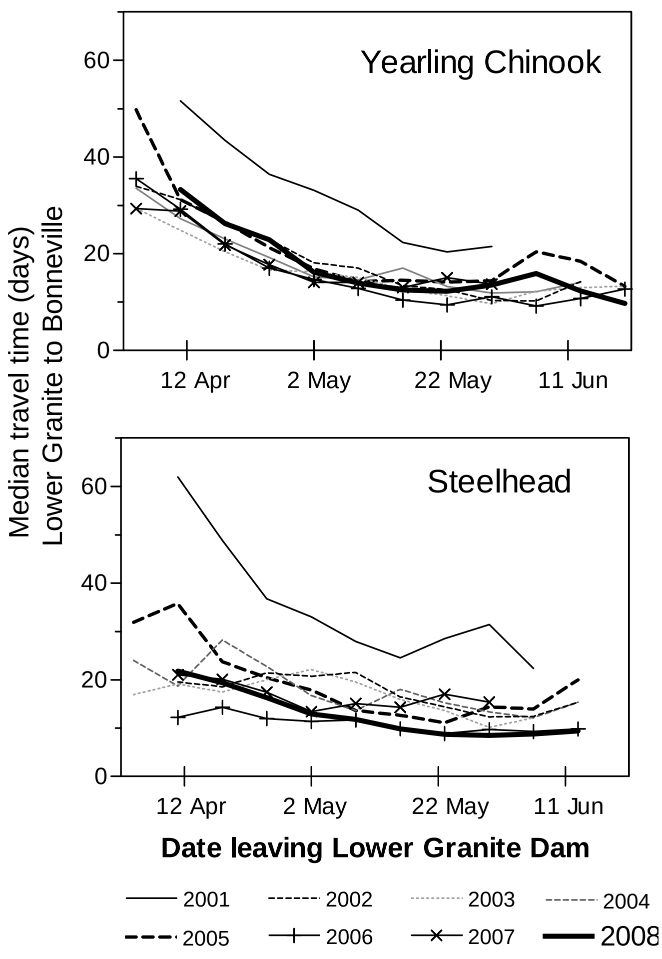

Figure 4. Median travel time (days) from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead from Lower Granite Dam, 2001-2008.

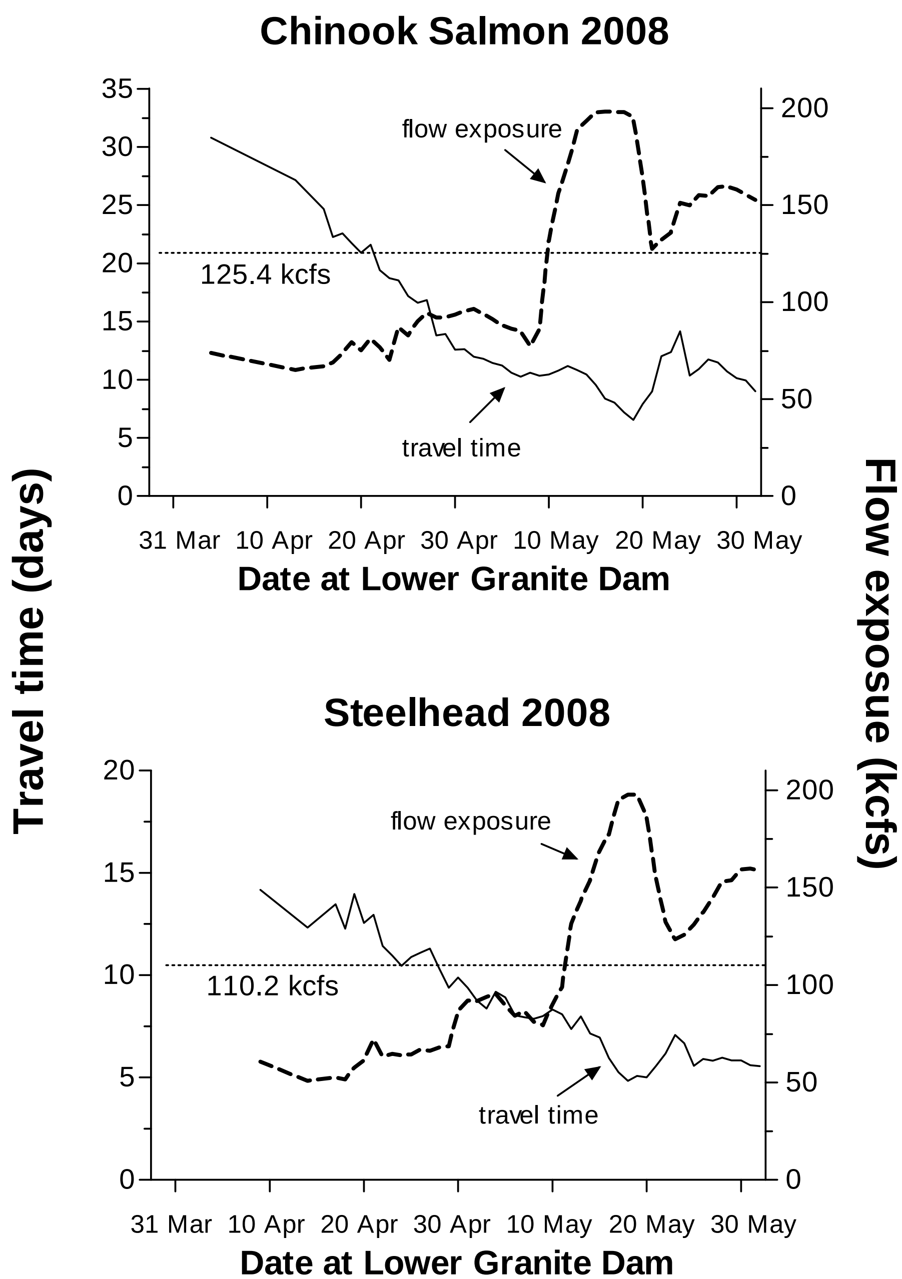

Figure 5. Travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged fish during 2008. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

Tagging Details for Fish PIT Tagged at Lower Granite Dam

We PIT tagged and released 18,565 hatchery steelhead, 15,991 wild steelhead, and 9,714 wild yearling Chinook salmon from 9 April through 14 June at Lower Granite Dam for survival estimates (Table 37-39). Total mortalities of hatchery steelhead, wild steelhead, and yearling Chinook salmon were 20, 1, and 18, respectively. Each of these numbers represented well under 1% of the total fish handled.

Comparison of Annual Survival Estimates

For yearling Chinook salmon, estimates of survival in 2008 from most Snake River Basin hatcheries to Lower Granite Dam tailrace were similar to those made in recent years. The mean of the hatchery estimates for 2008 was lower than the long-term mean (Table 40), though the difference was not statistically significant. Over the years of the study, we have consistently observed an inverse relationship between migration distance from the release site to Lower Granite Dam and estimated survival through that reach (Figure 6). For 1998-2008 estimates, the negative linear correlation between migration distance and average estimated survival was significant (R^2 = 0.860, P = 0.003).

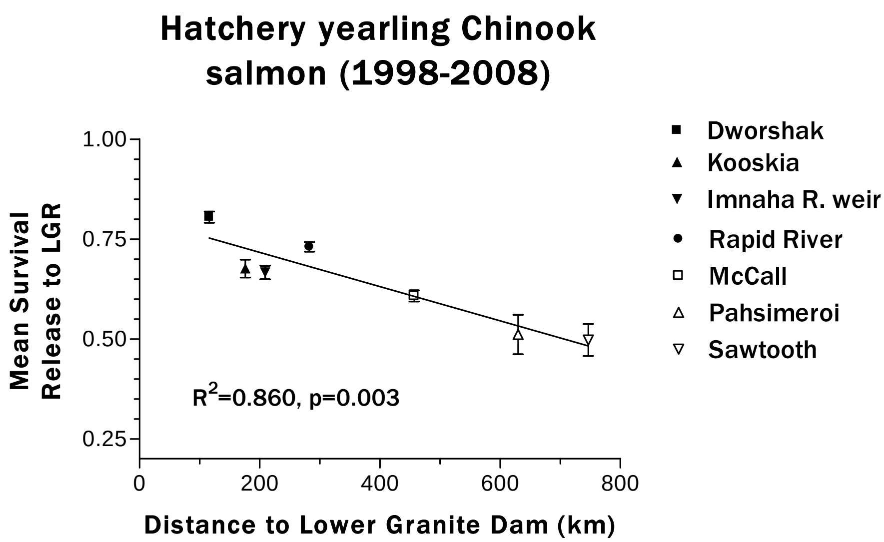

Figure 6. Estimated survival with standard errors from release at Snake River Basin hatcheries to Lower Granite Dam tailrace, 1998-2008 vs. distance (km) to Lower Granite Dam. The correlation between survival and migration distance is also shown.

For yearling Chinook salmon (hatchery and wild combined), estimated survival in 2008 was similar to that estimated in 2007 through the Lower Granite Dam to McNary Dam reach, but lower from the McNary Dam to Bonneville Dam reach (Tables 41 and 43; Figures 7-8). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace in 2008 was 0.782 (95% CI 0.760-0.804). This estimate was the second highest of our data series for the Lower Granite-to-McNary reach, although survival in this reach in 2008 was not significantly different than in 2006 and 2007. Mean estimated survival in 2008 from McNary Dam tailrace to Bonneville Dam tailrace was 0.594 (95% CI 0.464-0.723). This is one of the lowest estimates in our series for McNary to Bonneville, but large sampling variation for estimates in this reach each year makes most differences nonsignificant.

For steelhead (hatchery and wild combined), mean estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace in 2008 was 0.716 (95% CI 0.687-0.745), similar to the estimates for this reach in 2006 and 2007. The 2008 estimate was significantly higher than in 2001 through 2005, but was not significantly different from that in 2006 or 2007. Mean estimated survival in 2008 from McNary Dam tailrace to Bonneville Dam tailrace was 0.671 (95% CI 0.604-0.738). The McNary-to-Bonneville estimate was significantly higher in 2008 than in 2001 and 2003, but not statistically different than in other years.

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 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. However, operation of a new corner collection system began at Bonneville Dam Second Powerhouse in 2004, and though the system was effective at passing fish, it contained no PIT-tag monitors. In 2004 and 2005, detection data through the final reach were no longer sufficient for estimates of steelhead survival. Beginning in 2006, a new PIT tag interrogation system in the corner collector increased detection probability at this site.

For yearling Chinook salmon in 2008, estimated survival through the entire hydropower system was 0.461 (95% CI 0.359-0.563), which was the third lowest of our data series, exceeded only by the estimates for 2001 and 2004. Low estimated survival from John Day to Bonneville in 2008 was the reason for the low estimate for the entire system. For steelhead, estimated hydropower system survival was 0.478 (95% CI 0.423-0.533), which was the highest in any year of our data series (1997-2003, 2006-2008).

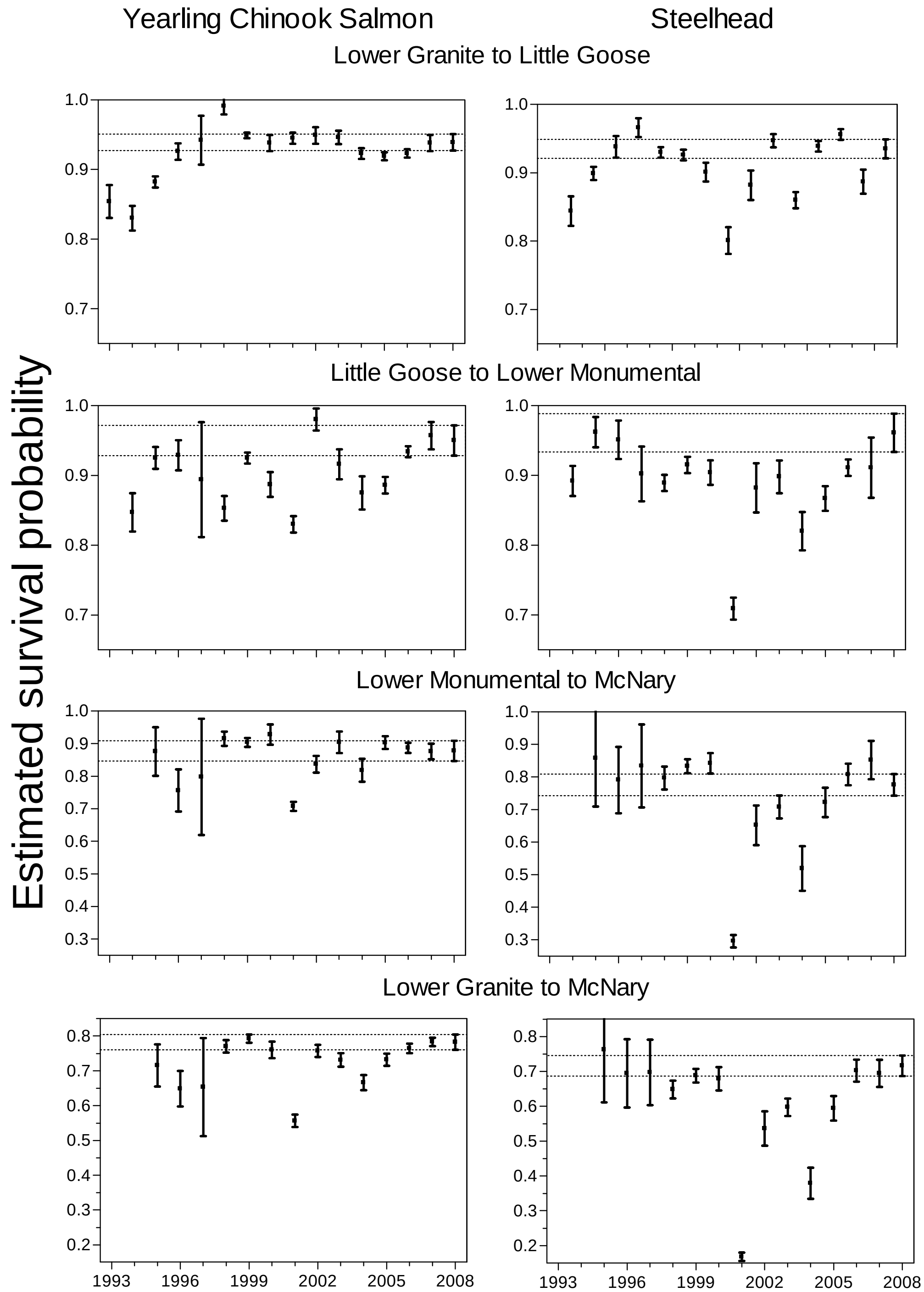

Figure 7. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead through Snake River reaches, 1993-2008. Estimates are from tailrace to tailrace. Vertical bars represent 95% CIs. Horizontal dashed lines are 95% CI endpoints for 2008 estimates.

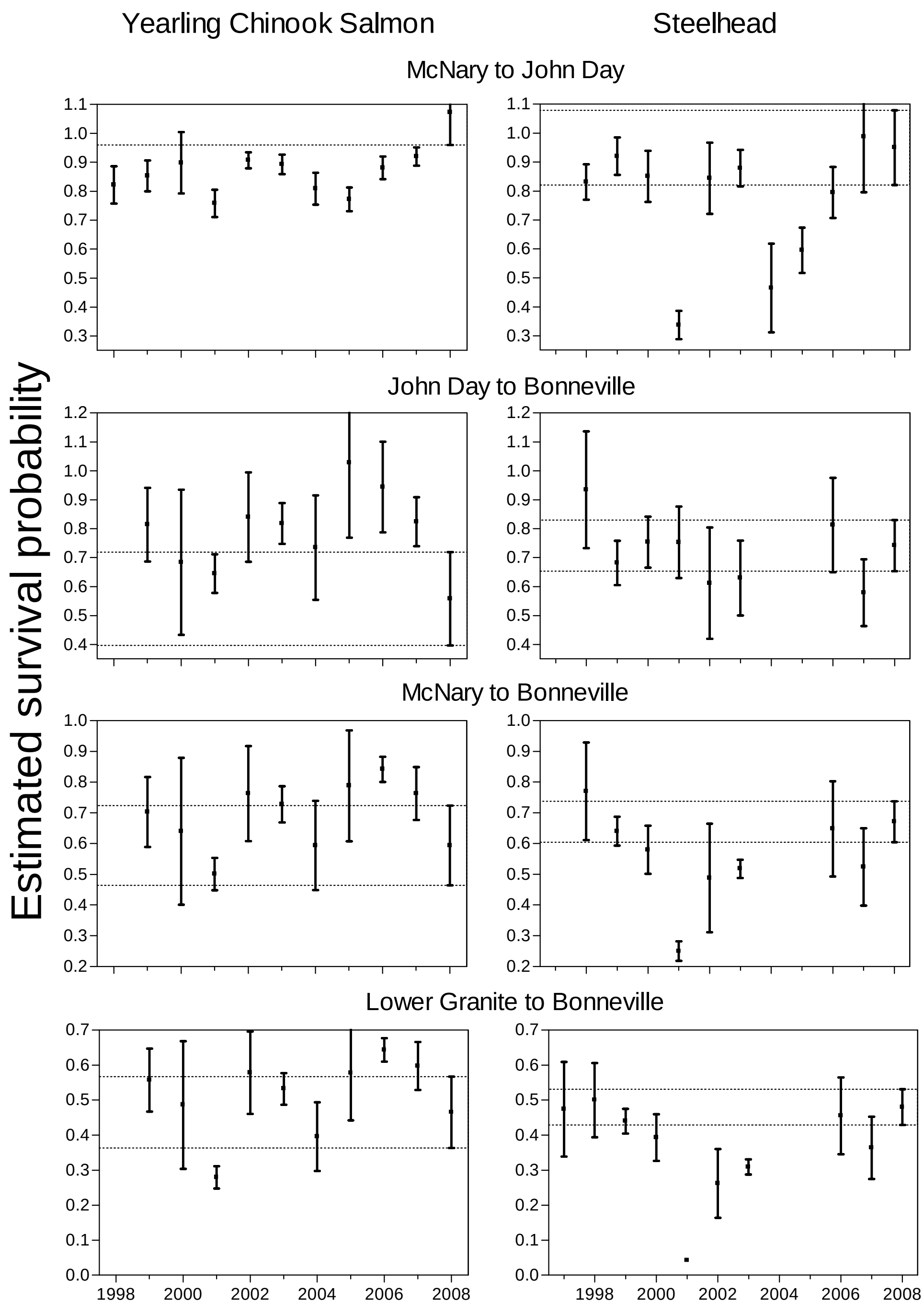

Figure 8. Annual average survival estimates for PIT-tagged Snake River yearling Chinook salmon and steelhead through Columbia River reaches and from Lower Granite Dam to Bonneville Dam, 1993-2008. Estimates are from tailrace to tailrace. Vertical bars represent 95% CIs. Horizontal dashed lines are 95% CI endpoints for 2008 estimates.

Survival Estimates from Point of Release to McNary Dam

In 2008, estimated survival to McNary Dam was generally lower for yearling spring Chinook salmon released at hatcheries in the Upper Columbia River than for their counterparts released in the Snake River (Tables 19 and 27). For Upper Columbia River fish, average estimated survival to McNary Dam was 0.567 (0.022) for fish from Leavenworth Hatchery (4 projects; 330 km) and 0.371 (0.038) for fish from Wells Hatchery (5 projects; 360 km). For Snake River fish released at Dworshak Hatchery (5 projects; 341 km), average estimated survival to McNary Dam was 0.534 (0.016).

Estimated survival to the tailrace of McNary Dam was also generally higher for steelhead from Snake River Basin hatcheries, than for their counterparts from Upper Columbia hatcheries passing a similar number of dams (Tables 20 and 27). For Upper Columbia River fish, average estimated survival to McNary Dam was 0.623 (0.033) for fish from Turtle Rock Hatchery released in the Wenatchee River (4 projects; 361 km) and 0.376 (0.040) for fish from Winthrop Hatchery (6 projects; 454 km). For Snake River steelhead released at Dworshak Hatchery (5 projects; 341 km), average estimated survival to McNary Dam was 0.620 (0.019).

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 unable to partition survival between Lower Monumental and McNary Dams into reach-specific estimates in 2005. However, sufficient detections occurred in 2006-2008 to partition survival estimates through the individual reaches (Tables 44 and 45). In 2008, estimated survival for yearling Chinook salmon was 0.931 (se 0.025) from the tailrace of Lower Monumental Dam to the tailrace of Ice Harbor dam and 0.938 (se 0.028) from Ice Harbor Dam tailrace to McNary Dam tailrace. For steelhead, estimated survival through these reaches was 0.926 (se 0.019) and 0.836 (se 0.022), respectively.

Salmonid Passage Timing In Relation to Flow

Average flow exposure indices for yearling Chinook salmon (125.4 kcfs) and steelhead (110.2 kcfs) were higher in 2008 than in 2007 (85.9 and 81.4 kcfs, respectively). The flow index for daily groups had an obvious peak in May, as observed in most other years (Figures 9 and 10).

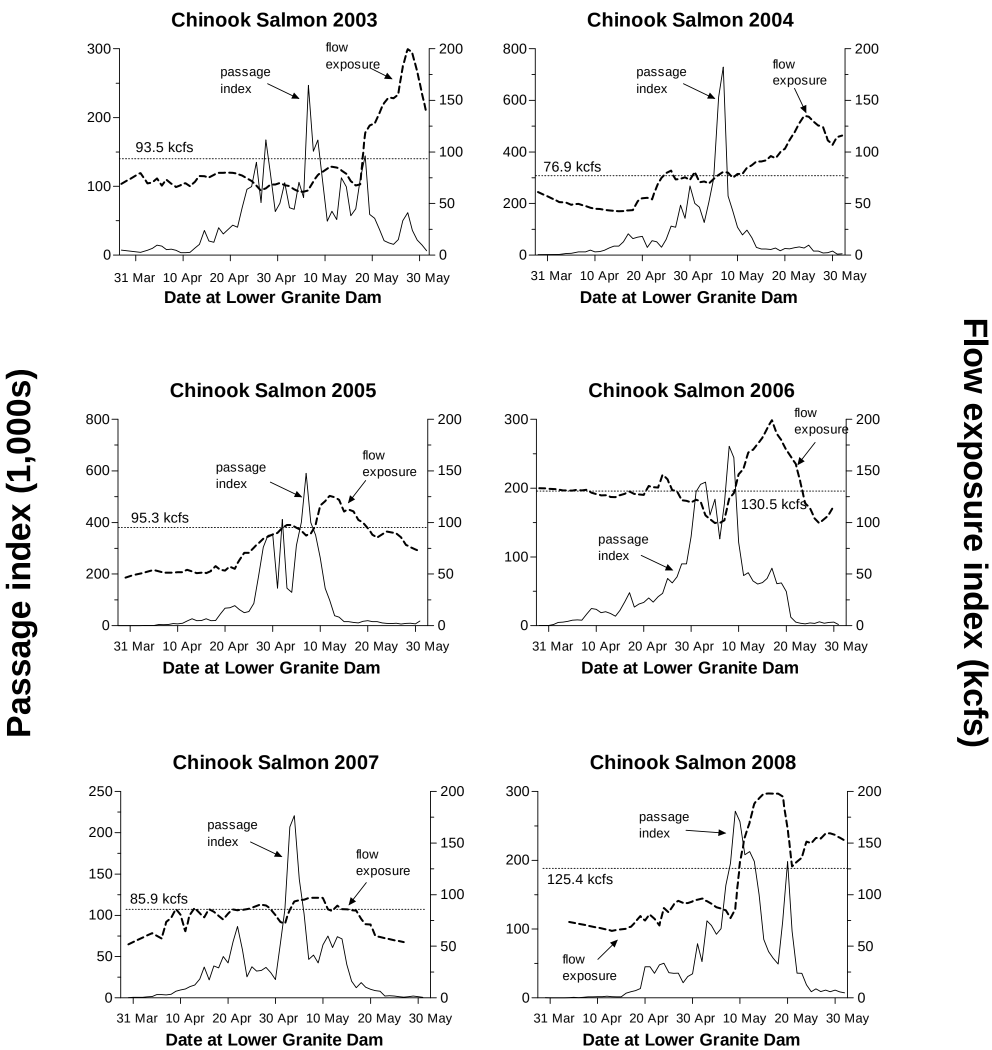

Figure 9. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged yearling Chinook salmon passing Lower Granite Dam from 2003 through 2008. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

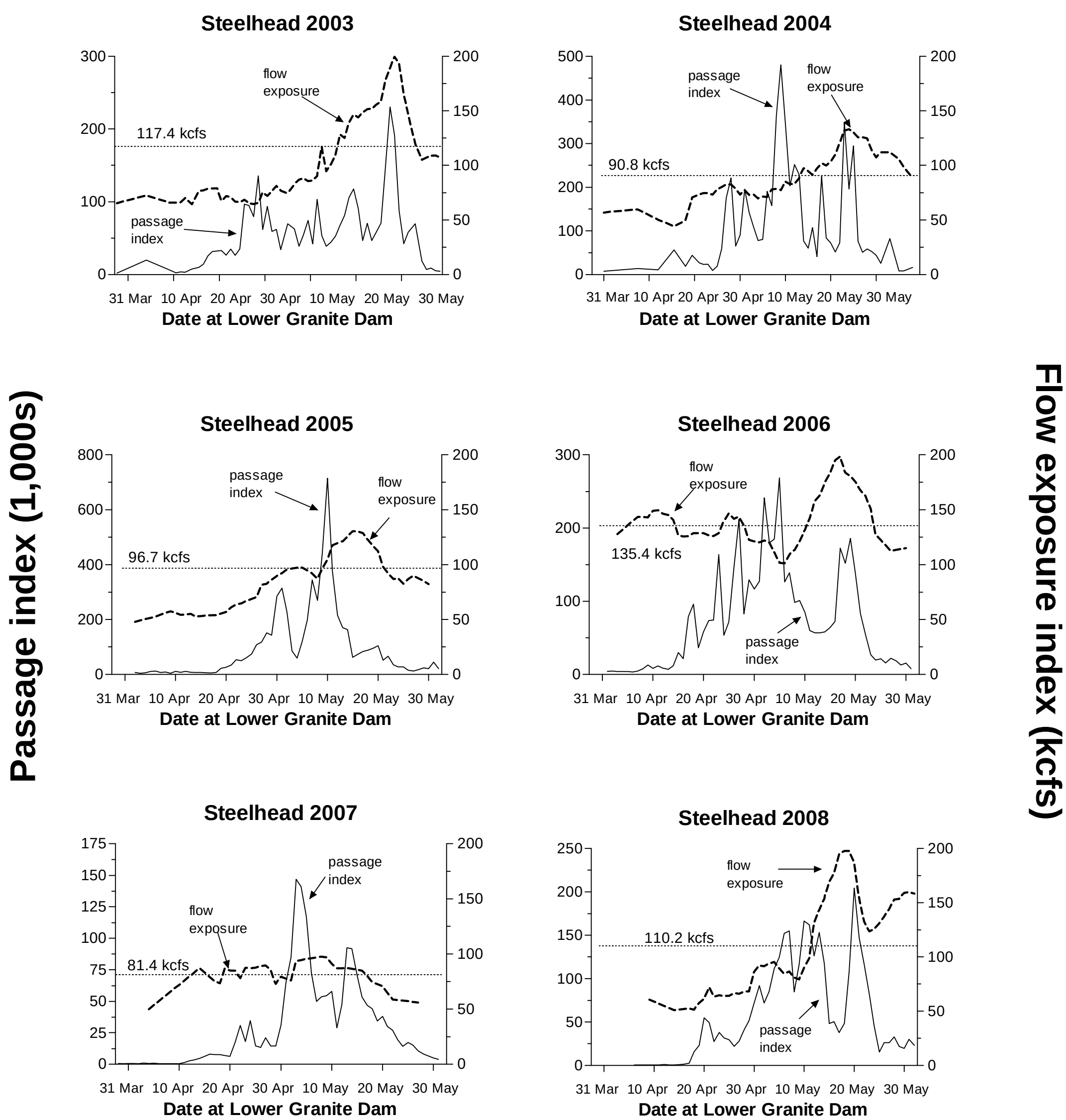

Figure 10. Passage index (per 1,000 fish) and flow exposure index (kcfs) for daily groups of PIT-tagged steelhead passing Lower Granite Dam from 2003 through 2008. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group.

Estimates of Proportion of Population Transported

In 2008, smolt transportation began on 1 May at Lower Granite Dam, 10 May at Little Goose Dam, and 13 May at Lower Monumental Dam. Until these dates, smolts collected at Snake River dams were bypassed back to the river. The estimated proportion of non-tagged spring/summer Chinook salmon smolts transported across the entire season in 2008 was 54.3% for wild fish and 45.3% hatchery fish. For non-tagged steelhead, the estimated proportions transported were 50.5 and 46.6% for wild and hatchery smolts, respectively. These estimates represent the proportion of smolts that arrived at Lower Granite Dam and subsequently transported either from Lower Granite or from one of the downstream collector dams. For both species the two lowest estimated proportions transported (hatchery and wild fish combined) in the 1995-2008 period occurred in 2007 and 2008 (Figure 11).

Survival estimates presented in this report are based on PIT-tagged fish that remained in-river. These fish either passed through turbines or spillways, or were intentionally returned to the river after detection in bypass systems. (PIT-tagged fish that were transported provide survival information up until the point of transportation, but not downstream from that point). When considering the implications of in-river survival probability for populations of Snake River salmonids, it is important to remember that in recent years, around half of non-tagged fish were removed from the river for transportation. In years before 2007 well over half of the populations at large was transported. Only fish that remained in the river were subject to the reach survival probabilities presented in this report; survival of transported fish is affected by entirely different factors.

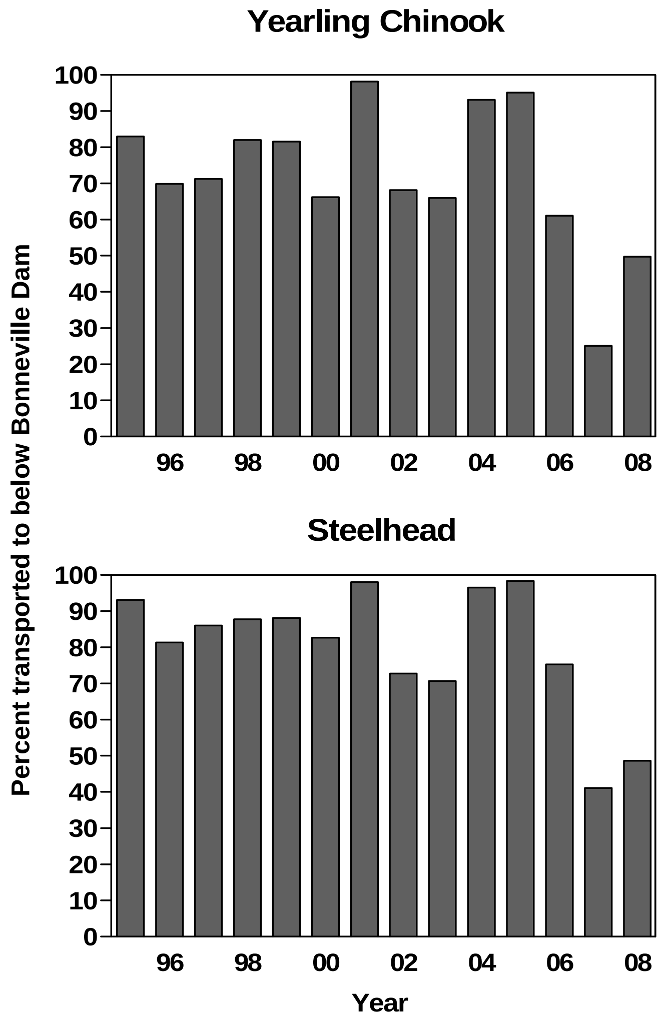

Figure 11. Estimated percent of yearling Chinook salmon and steelhead (hatchery and wild combined) transported to below Bonneville Dam by year (1995-2008).

DISCUSSION

Snake River flow volume was near average throughout April 2008, but increased to above average for most of May due to late-season thaw of larger-than-average snowpack. The large influx of cold melt water also made April and May water temperatures the coldest seen in the Snake River in recent years. Compared to recent water years, the overall flow volume and seasonal pattern of flow in 2008 were most like 1998 and 2003. However, water temperatures in 2008 were lower than either of those years. Mean spill as a percentage of flow at Snake River Dams in 2008 was among the highest in recent years and remained high throughout the season. Spill percentages in 2008 were much like those in 2007 until mid-May, when a sharp increase in flow corresponded with an increase in spill. In contrast, spill percentages dropped off in May 2007. The combination of high spill, cold water, and average flow early in the season, followed by high flow in May, distinguished 2008 from other recent water years.

Estimated travel times through the system for yearling Chinook were similar to other recent years, but travel times for steelhead were among the shortest (migration rates fastest) in recent years, particularly early in the migration season when flows were still low. For yearling Chinook salmon, estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace in 2008 was among the highest observed. However, estimated survival through the hydropower system was slightly below average for the last 10 years, at about 46% from the Snake River trap to Bonneville Dam tailrace. Below-average system survival estimates for yearling Chinook salmon resulted from low estimated survival (56%) from John Day Dam tailrace to Bonneville Dam tailrace. For steelhead, estimated survival through the hydropower system was about 48%, the highest observed in the last 10 years.

Migration conditions and associated hydropower system survival estimates from 2005 through 2008 show suggestive correlations among flow, spill, and estimated survival. In spring 2005, flows were low during early to mid-April, but increased substantially from late April through the remainder of the migration season, resulting in an annual flow index of 95.3 kcfs during the migration of yearling Chinook salmon. Spill did not occur (i.e., transportation was maximized) in 2005 at Lower Granite, Little Goose, and Lower Monumental Dams until 17 May, when flows exceeded powerhouse capacities. By that time, most yearling Chinook salmon had passed. Spill continued through about 27 May at Lower Granite and Lower Monumental Dam, while spill ended on 23 May at Little Goose Dam.

In contrast, 2006 and 2008 were high-flow years (annual flow index of 130.5 and 125.4, respectively for yearling Chinook salmon), and spill was provided throughout the migration seasons. The 2007 migration season was a relatively low-flow year (annual flow index of 85.9 for yearling Chinook salmon), with spill again provided throughout the migration. Estimated hydropower system survival for yearling Chinook salmon was highest in 2006 at 61.2% (high flow with spill), but similar between 2005 at 53.0% (moderately low flow, very limited spill) and 2007 at 56.3% (moderately low flow, with spill). Estimated survival was lowest in 2008 (46.1%) among these years for yearling Chinook salmon, even though it was a high flow, high spill year.

For steelhead we could not make the same annual comparisons, because operation of the corner collector at Bonneville Dam decreased detection efficiencies in 2005, and hydropower system survival could not be estimated for that year. However, we can compare estimated survival from Lower Granite Dam tailrace to McNary Dam tailrace from 2005 through 2008. Estimated survival was lowest in 2005 (59.3%), but similar in 2006 (70.2%), 2007 (69.4%), and 2008 (71.6%). For yearling Chinook salmon, estimated survival through this reach was 73.2, 76.4, 78.3 and 78.2% in 2005, 2006, 2007, and 2008, respectively. Thus, spill may have directly or indirectly provided greater benefit to migrating steelhead than to yearling Chinook salmon.

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

Predation is one factor that unquestionably directly affects survival of migrating smolts (Collis et al. 2002). Avian piscivores are abundant along the Columbia River downstream from its confluence with the Snake River, and bird population sizes and consumption rates are well monitored. Crescent Island, in the McNary Dam reservoir, harbors the second largest Caspian tern *Hydroprogne caspia* colony in North America (about 500 breeding pairs annually on average in the last 10 years), as well as large populations of gulls *Larus* spp. Other avian piscivores reside within the McNary pool, including the American white pelican *Pelecanus erythrorhynchos*, cormorant *Phalacrocorax auritus*, and heron *Ardea alba, A. herodias*, and *Nycticorax nycticorax.* Steelhead smolts are particularly susceptible to predation by birds. For example, Collis et al. (2001) reported over 15% of the tags from PIT-tagged steelhead detected at Bonneville Dam in 1998 were later found on estuarine bird colonies, while only 2% of the tags from PIT-tagged yearling Chinook salmon were found.

Between Lower Monumental Dam and McNary Dam, steelhead survival was depressed during 2001-2005, but higher during 2006-2008. The proportion of PIT-tagged steelhead lost to piscivorous birds in McNary pool was lower during 2006-2008 than during 2001-2005 (indexed by the percentage of tags detected in bird colonies; Table 47). This decreased percentage of smolts taken by birds was due in part to an increase in the total number of smolts (tagged and untagged) remaining in the river, which in turn resulted from increased spill and a delayed initiation of the smolt transportation program. A negative and significant correlation was found between estimated survival from Lower Monumental to McNary Dam tailrace and the percentage of PIT tags recovered from both yearling Chinook salmon and steelhead (Figure 12).

The estimated proportion of smolts transported was higher in 2008 than in 2007, particularly for yearling Chinook salmon. The primary reason was that smolts migrated later in 2008 than in 2007. Transportation began at about the same time at all dams in both years, but in 2008 , a smaller proportion of fish passed the dams before transport was initiated. In particular, for wild Chinook salmon in 2007, there was a very large peak of passage at Lower Granite Dam around 20 April, a time when smolts were not being collected and transported. No such peak in passage occurred in 2008. Another difference between 2007 and 2008 is the larger discrepancy between the percentages for hatchery and wild fish of the same species, especially for Chinook salmon. For Chinook salmon, it appears that more wild fish were transported than their hatchery counterparts in 2008 because they were more likely to be collected (higher detection probability) on any given day. For steelhead, the difference seems related more to a slightly earlier migration of hatchery than of wild fish.

One of the more notable findings in 2008 was the low estimated survival from McNary to Bonneville Dam for Snake River Chinook salmon. This estimate had two components: a very high estimate from McNary to John Day Dam, and a very low estimate from John Day to Bonneville Dam. We suspect that there are two reasons for the low estimate of survival for the overall reach and for the pattern observed in these two components. First, survival in the reach from John Day to Bonneville Dam was truly lower than in past years. Second, violation(s) of assumptions of the single-release recapture model occurred, resulting in overestimation of survival from McNary to John Day and underestimation from John Day to Bonneville.

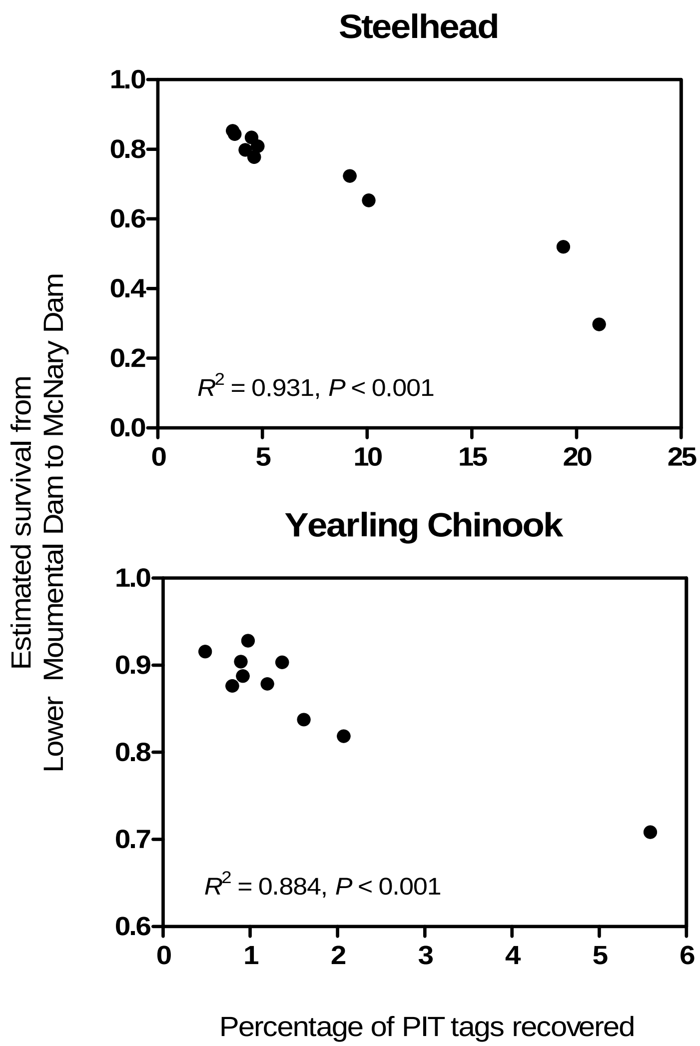

Figure 12. Estimated survival between Lower Monumental and McNary Dams versus percentage of Lower Monumental Dam-detected PIT tags recovered on bird colonies, 1998-2008 (excluding 2003, which had incomplete recovery effort).

There is are several likely explanations for lower actual survival from John Day to Bonneville Dam. High flow in the Lower Columbia resulted in a large accumulation of debris at Bonneville Dam. In particular, debris on the juvenile bypass intake screens reportedly resulted in increased fish descaling and direct mortality, especially for Chinook salmon. This problem was most pronounced during the first three weeks of May. The screens were removed from all of the second powerhouse units from 23 May until 19 June. Over the same period, the proportion of flow entering the powerhouses increased. Removal of the screens and increased turbine flow would have resulted in more fish passing through turbines, a passage route usually associated with relatively higher mortality. The combination of debris-related direct and indirect mortality followed by increased turbine mortality could have contributed to lower estimated survival in the John Day-to-Bonneville reach for Chinook salmon of both Columbia and Snake River origin. Because of behavioral differences, steelhead were more likely to pass through the spillway or corner collector, and were probably less affected than Chinook salmon.

There is also anecdotal evidence that in the tailraces of both John Day Dam and The Dalles Dam, the number of gulls preying on smolts was the highest seen in recent years. The new temporary spillway weirs (TSWs) at John Day Dam are suspected to have altered the hydrodynamics in the tailrace and created an upwelling in the center of the spillway downstream from the avian predation barriers. Predation by gulls was concentrated in that zone. It is also possible that the change in hydrodynamics created zones of increased predation by fish in John Day Dam tailrace. Higher predation at The Dalles Dam and in the tailrace of John Day Dam could have further reduced survival from John Day Dam to Bonneville Dam.

However, increased mortality between John Day and Bonneville Dam is not enough by itself to cause the pattern of high estimated survival from McNary Dam to John Day Dam and low estimated survival from John Day Dam to Bonneville Dam for yearling Chinook salmon. The two survival estimates are statistically correlated (negatively), and truly low survival in combination with small sample sizes does make such a pattern more likely to occur by chance. However, the observed estimates in 2008 had relatively high precision. Moreover, the pattern of high survival estimates between McNary and John Day Dam with low estimates for between John Day and Bonneville Dam also occurred for Snake River steelhead and for yearling Chinook salmon from the upper Columbia River.

This observed pattern was also consistent with the occurrence of differential mortality between detected and non-detected fish downstream from John Day Dam (sometimes referred to as "post-detection mortality.") This would occur if fish leaving the juvenile bypass facility at John Day Dam were more likely to pass into zones of increased predation than were non-bypassed fish. It is also possible that hydrodynamics in the tailrace of John Day Dam caused the differential post-detection mortality. In either case, if fish detected at John Day Dam incurred greater mortality immediately after detection, either in the tailrace before remixing with non-detected fish, or in the bypass system itself, the result would be an underestimate of detection probability at John Day Dam. An underestimate of detection probability at John Day would result in an overestimate of survival probability from McNary to John Day Dam.

However, if downstream mortality rates were equal for detected and non-detected fish at Bonneville Dam, then the resultant survival probability estimate from McNary to Bonneville Dam would have been unbiased. This would hold even if there had been post-detection mortality at John Day Dam; only the two component estimates are biased, the first too high and the second too low.

Unfortunately, it is not possible to use detection-history data to statistically detect differential post-detection mortality that occurs between the detection site of interest and the next downstream detection site. Identification of differential post-detection mortality requires knowledge of the fate of individual non-detected fish in the tailrace of the detection dam of interest and downstream. The fate of fish not detected at the site of interest is only known for those fish detected again downstream, and not for those never detected again. Therefore, none of the assumption tests described in the Appendix allow us to assess differential post-detection mortality between a detection site of interest and the next downstream detection site. We can only speculate whether differential post-detection mortality occurred in 2008 based on the pattern of observed survival estimates and anecdotal evidence regarding conditions in the lower dam tailraces.

In earlier years of this study, experiments were conducted to evaluate the assumption of post-detection bypass mortality at Lower Granite, Little Goose, Lower Monumental, and McNary Dams. Evaluations using paired releases of PIT tagged smolts into the bypass and tailrace at each dam found little or no evidence of post-detection mortality (Muir et al. 2001a). However, no such evaluation has been conducted at John Day Dam to test this assumption, partly because no mortality was found experimentally at upstream dams, and partly because the lack of sufficient PIT-tag detection capabilities downstream from John Day Dam would require prohibitively large sample sizes. Yet-to-be completed analyses of dam passage studies using acoustic tags at John Day and Bonneville Dams (which included bypass releases), and PIT-tag data on bird predation may shed light on the situation.

Results from the 2008 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 3 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 Dam and Upper Columbia River dams. Although there is now a PIT-tag detection system in the juvenile bypass facility at Ice Harbor Dam, because of the high rate of spill, too few fish are detected for survival estimation in some years. Development of flat-plate and full-flow detector technology in bypass systems and other suitable locations at dams (including spillways), as well as portable streambed flat-plate detectors for use in tributaries, would greatly enhance knowledge of juvenile salmonid survival.

TABLES

Table 1. Estimated survival probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	395	0.936 (0.086)	0.751 (0.126)	0.956 (0.185)	0.671 (0.101)
13 Apr–19 Apr	1,834	0.771 (0.035)	1.040 (0.093)	0.886 (0.092)	0.710 (0.054)
20 Apr–26 Apr	5,121	0.924 (0.024)	0.953 (0.046)	0.899 (0.051)	0.791 (0.034)
27 Apr–03 May	20,544	0.951 (0.012)	0.936 (0.020)	0.892 (0.024)	0.794 (0.016)
04 May–10 May	26,631	0.948 (0.008)	0.957 (0.023)	0.871 (0.031)	0.790 (0.021)
11 May–17 May	21,230	0.940 (0.011)	0.952 (0.022)	0.778 (0.038)	0.696 (0.031)
18 May–24 May	4,611	0.950 (0.016)	0.936 (0.031)	0.861 (0.062)	0.766 (0.050)
25 May–31 May	1,185	0.914 (0.021)	0.949 (0.045)	0.911 (0.094)	0.790 (0.074)
01 Jun–07 Jun	993	0.898 (0.025)	0.856 (0.052)	1.269 (0.203)	0.974 (0.148)
Weighted mean*		**0.939 (0.006)**	**0.950 (0.011)**	**0.878 (0.016)**	**0.782 (0.011)**

* Weighted means of the independent estimates for daily groups (06 April –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 2008. Daily groups pooled weekly. Estimates based on the single-release model. Standard errors in parentheses. .

Date at McNary	Number released	McNary to John Day Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
27 Apr–03 May	588	1.103 (0.190)	0.507 (0.167)	0.559 (0.156)
04 May–10 May	7,576	0.983 (0.054)	0.761 (0.080)	0.748 (0.067)
11 May–17 May	24,299	1.195 (0.060)	0.379 (0.036)	0.453 (0.036)
18 May–24 May	13,541	1.175 (0.099)	0.682 (0.189)	0.802 (0.212)
25 May–31 May	3,244	0.731 (0.084)	NA	NA
01 Jun–07 Jun	1,239	0.962 (0.164)	0.795 (0.544)	0.764 (0.507)
08 Jun–14 Jun	716	0.747 (0.202)	0.640 (0.606)	0.478 (0.434)
Weighted mean*		**1.073 (0.058)**	**0.558 (0.082)**	**0.594 (0.066)**

* Weighted means of the independent estimates for weekly pooled groups (27 April–14 June), with weights inversely proportional to respective estimated relative variances.

Table 3. Estimated survival probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
13 Apr–19 Apr	1,012	0.680 (0.048)	1.190 (0.164)	0.864 (0.139)	0.699 (0.084)
20 Apr–26 Apr	3,836	0.921 (0.030)	0.933 (0.055)	0.891 (0.062)	0.765 (0.040)
27 Apr–03 May	16,963	0.949 (0.014)	0.933 (0.023)	0.915 (0.028)	0.811 (0.019)
04 May–10 May	22,382	0.947 (0.009)	0.977 (0.028)	0.854 (0.035)	0.789 (0.024)
11 May–17 May	19,374	0.944 (0.012)	0.957 (0.025)	0.769 (0.040)	0.695 (0.033)
18 May–24 May	2,269	1.009 (0.034)	0.901 (0.058)	0.890 (0.116)	0.808 (0.095)
25 May–31 May	270	0.901 (0.069)	0.972 (0.156)	0.801 (0.236)	0.702 (0.181)
Weighted mean*		**0.945 (0.011)**	**0.952 (0.013)**	**0.873 (0.021)**	**0.785 (0.016)**

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

Table 4. Estimated survival probabilities for Snake River wild yearling Chinook salmon detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	322	0.984 (0.092)	0.732 (0.124)	0.969 (0.189)	0.698 (0.105)
13 Apr–19 Apr	822	0.857 (0.049)	0.942 (0.110)	0.922 (0.125)	0.744 (0.071)
20 Apr–26 Apr	1,285	0.941 (0.041)	1.008 (0.082)	0.921 (0.089)	0.873 (0.062)
27 Apr–03 May	3,581	0.954 (0.027)	0.965 (0.044)	0.811 (0.043)	0.746 (0.030)
04 May–10 May	4,249	0.964 (0.017)	0.946 (0.042)	0.908 (0.060)	0.828 (0.043)
11 May–17 May	1,856	0.932 (0.026)	0.946 (0.053)	0.823 (0.107)	0.726 (0.088)
18 May–24 May	2,342	0.948 (0.018)	0.953 (0.036)	0.838 (0.071)	0.757 (0.059)
25 May–31 May	915	0.931 (0.022)	0.947 (0.046)	0.928 (0.101)	0.818 (0.082)
01 Jun–07 Jun	887	0.895 (0.026)	0.866 (0.054)	1.235 (0.204)	0.957 (0.150)
Weighted mean*		**0.941 (0.008)**	**0.944 (0.013)**	**0.879 (0.030)**	**0.786 (0.020)**

* Weighted means of the independent estimates for weekly pooled groups (06 April–07 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 2008. Daily groups pooled as necessary to calculate estimates. Estimates based on the single–release model. Standard errors in parentheses. Abbreviations: LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; MCN-McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
29 Mar–08 Apr	216	0.946 (0.115)	0.836 (0.208)	0.920 (0.271)	0.728 (0.158)
09–14 Apr	305	0.810 (0.089)	0.761 (0.147)	1.148 (0.279)	0.708 (0.145)
15 Apr	277	0.816 (0.057)	0.961 (0.165)	1.026 (0.232)	0.804 (0.133)
16 Apr	358	0.872 (0.104)	0.922 (0.204)	0.766 (0.180)	0.616 (0.098)
17 Apr	264	0.716 (0.100)	1.155 (0.313)	0.995 (0.336)	0.823 (0.210)
18 Apr	298	0.709 (0.091)	1.336 (0.348)	0.641 (0.185)	0.607 (0.120)
19 Apr	556	0.787 (0.081)	0.974 (0.175)	0.948 (0.166)	0.727 (0.095)
20 Apr	553	0.809 (0.067)	1.150 (0.202)	0.714 (0.143)	0.664 (0.092)
21 Apr	552	0.967 (0.099)	0.817 (0.133)	0.958 (0.156)	0.758 (0.099)
22 Apr	636	0.823 (0.051)	1.015 (0.110)	1.198 (0.188)	1.001 (0.134)
23 Apr	2,071	0.945 (0.035)	0.948 (0.067)	0.809 (0.070)	0.725 (0.045)
24 Apr	409	0.829 (0.082)	1.238 (0.255)	0.872 (0.205)	0.895 (0.148)
25 Apr	516	0.998 (0.130)	0.876 (0.178)	0.933 (0.164)	0.816 (0.103)
26 Apr	384	1.016 (0.133)	0.915 (0.192)	1.107 (0.261)	1.029 (0.193)
27 Apr	481	1.056 (0.197)	0.594 (0.149)	1.174 (0.200)	0.736 (0.106)
28 Apr	513	1.078 (0.161)	0.799 (0.162)	0.993 (0.174)	0.856 (0.118)
29 Apr	1,340	0.857 (0.060)	0.967 (0.104)	0.991 (0.108)	0.822 (0.068)
30 Apr	7,871	0.940 (0.022)	0.955 (0.036)	0.858 (0.038)	0.770 (0.026)
01 May	1,618	0.933 (0.040)	1.039 (0.075)	0.792 (0.066)	0.768 (0.047)
02 May	8,136	0.971 (0.017)	0.928 (0.029)	0.924 (0.039)	0.833 (0.028)
03 May	585	0.935 (0.061)	0.816 (0.096)	0.879 (0.123)	0.670 (0.072)
04 May	806	0.974 (0.048)	0.890 (0.097)	1.009 (0.146)	0.875 (0.096)
05 May	1,140	1.050 (0.055)	0.934 (0.108)	0.861 (0.128)	0.844 (0.092)
06 May	2,536	0.928 (0.025)	0.961 (0.063)	0.943 (0.085)	0.841 (0.057)
07 May	9,415	0.944 (0.012)	1.006 (0.040)	0.862 (0.048)	0.819 (0.033)
08 May	2,837	0.942 (0.023)	0.920 (0.066)	0.876 (0.091)	0.759 (0.060)
09 May	8,064	0.934 (0.017)	0.949 (0.050)	0.813 (0.066)	0.721 (0.046)
10 May	1,833	0.969 (0.037)	0.880 (0.084)	1.078 (0.216)	0.919 (0.165)
11 May	1,851	0.880 (0.034)	0.985 (0.090)	0.850 (0.159)	0.737 (0.124)
12 May	6,609	0.917 (0.018)	0.947 (0.041)	0.695 (0.062)	0.604 (0.048)

Table 5. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
13 May	922	0.947 (0.052)	1.280 (0.191)	0.562 (0.148)	0.680 (0.150)
14 May	6,265	0.937 (0.019)	0.925 (0.039)	0.846 (0.079)	0.733 (0.063)
15 May	450	0.940 (0.086)	0.810 (0.136)	1.621 (0.882)	1.235 (0.649)
16 May	4,414	0.961 (0.026)	1.005 (0.049)	0.765 (0.072)	0.738 (0.062)
17 May	719	1.003 (0.081)	0.879 (0.112)	0.882 (0.212)	0.777 (0.171)
18 May	1,452	1.084 (0.054)	0.964 (0.086)	0.790 (0.130)	0.827 (0.121)
19 May	537	0.956 (0.058)	0.866 (0.095)	0.812 (0.156)	0.672 (0.115)
20 May	921	0.908 (0.030)	1.016 (0.071)	0.884 (0.137)	0.816 (0.116)
21 May	697	0.964 (0.031)	0.846 (0.055)	0.931 (0.154)	0.759 (0.119)
22 May	323	0.874 (0.040)	1.048 (0.111)	0.749 (0.180)	0.686 (0.150)
23 May	585	0.986 (0.038)	0.828 (0.063)	1.043 (0.203)	0.851 (0.158)
24 May	96	0.839 (0.094)	0.875 (0.172)	0.457 (0.137)	0.335 (0.088)
25 May	69	0.884 (0.084)	0.893 (0.156)	2.870 (2.635)	2.265 (2.055)
26 May	82	0.793 (0.093)	0.857 (0.175)	1.000 (0.453)	0.679 (0.294)
27 May	259	0.960 (0.053)	0.771 (0.072)	1.161 (0.238)	0.859 (0.169)
28 May	206	0.791 (0.043)	1.096 (0.134)	0.614 (0.134)	0.533 (0.098)
29 May	338	1.007 (0.045)	0.958 (0.091)	0.847 (0.158)	0.817 (0.136)
30 May	200	0.932 (0.043)	1.073 (0.129)	0.901 (0.240)	0.901 (0.215)
31 May	31	0.819 (0.103)	1.482 (0.586)	0.519 (0.447)	0.630 (0.478)
Weighted mean*		**0.939 (0.006)**	**0.950 (0.011)**	**0.878 (0.016)**	**0.782 (0.011)**

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

Table 6. Estimated detection probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	395	0.354 (0.041)	0.200 (0.036)	0.306 (0.054)
13 Apr–19 Apr	1,834	0.339 (0.019)	0.171 (0.016)	0.328 (0.028)
20 Apr–26 Apr	5,121	0.295 (0.010)	0.190 (0.010)	0.323 (0.016)
27 Apr–03 May	20,544	0.246 (0.004)	0.204 (0.005)	0.325 (0.008)
04 May–10 May	26,631	0.446 (0.005)	0.154 (0.004)	0.212 (0.006)
11 May–17 May	21,230	0.334 (0.005)	0.287 (0.007)	0.106 (0.005)
18 May–24 May	4,611	0.404 (0.010)	0.394 (0.014)	0.162 (0.012)
25 May–31 May	1,185	0.534 (0.019)	0.443 (0.024)	0.219 (0.025)
01 Jun–07 Jun	993	0.566 (0.022)	0.415 (0.028)	0.159 (0.027)

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 2008. Daily groups pooled weekly. Estimates based on the single-release model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
27 Apr–03 May	588	0.191 (0.036)	0.300 (0.087)
04 May–10 May	7,576	0.136 (0.008)	0.238 (0.022)
11 May–17 May	24,299	0.109 (0.006)	0.228 (0.019)
18 May–24 May	13,541	0.125 (0.011)	0.073 (0.019)
25 May–31 May	3,244	0.296 (0.035)	NA (NA)
01 Jun–07 Jun	1,239	0.224 (0.040)	0.096 (0.064)
08 Jun–14 Jun	716	0.183 (0.052)	0.150 (0.138)

Table 8. Estimated detection probabilities for Snake River hatchery yearling Chinook salmon detected and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
13 Apr–19 Apr	1,012	0.339 (0.029)	0.185 (0.025)	0.288 (0.039)
20 Apr–26 Apr	3,836	0.288 (0.012)	0.189 (0.011)	0.304 (0.018)
27 Apr–03 May	16,963	0.246 (0.005)	0.197 (0.005)	0.312 (0.008)
04 May–10 May	22,382	0.441 (0.006)	0.141 (0.005)	0.202 (0.007)
11 May–17 May	19,374	0.326 (0.005)	0.275 (0.007)	0.104 (0.006)
18 May–24 May	2,269	0.322 (0.015)	0.331 (0.020)	0.137 (0.018)
25 May–31 May	270	0.415 (0.044)	0.335 (0.056)	0.188 (0.056)

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 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	322	0.350 (0.042)	0.202 (0.038)	0.319 (0.057)
13 Apr–19 Apr	822	0.349 (0.026)	0.158 (0.022)	0.365 (0.040)
20 Apr–26 Apr	1,285	0.312 (0.019)	0.192 (0.017)	0.372 (0.030)
27 Apr–03 May	3,581	0.243 (0.010)	0.238 (0.011)	0.383 (0.018)
04 May–10 May	4,249	0.462 (0.011)	0.207 (0.011)	0.254 (0.015)
11 May–17 May	1,856	0.409 (0.016)	0.388 (0.022)	0.123 (0.017)
18 May–24 May	2,342	0.466 (0.014)	0.440 (0.018)	0.180 (0.017)
25 May–31 May	915	0.560 (0.021)	0.465 (0.027)	0.226 (0.027)
01 Jun–07 Jun	887	0.567 (0.023)	0.416 (0.030)	0.161 (0.028)

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 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	336	0.831 (0.058)	1.192 (0.405)	0.708 (0.314)	0.701 (0.205)
13 Apr–19 Apr	2,790	0.930 (0.034)	0.830 (0.114)	0.928 (0.144)	0.716 (0.061)
20 Apr–26 Apr	6,436	0.884 (0.023)	1.014 (0.081)	0.852 (0.074)	0.763 (0.034)
27 Apr–03 May	9,433	0.919 (0.020)	1.069 (0.056)	0.795 (0.046)	0.781 (0.026)
04 May–10 May	9,397	0.921 (0.012)	0.933 (0.037)	0.776 (0.046)	0.666 (0.030)
11 May–17 May	6,635	0.902 (0.013)	1.060 (0.045)	0.729 (0.057)	0.697 (0.046)
18 May–24 May	8,200	0.958 (0.009)	0.927 (0.018)	0.770 (0.035)	0.684 (0.029)
25 May–31 May	5,568	0.912 (0.010)	0.994 (0.028)	0.689 (0.045)	0.624 (0.038)
01 Jun–07 Jun	2,494	0.951 (0.014)	0.851 (0.033)	0.628 (0.058)	0.508 (0.043)
08 Jun–14 Jun	918	0.792 (0.036)	1.090 (0.203)	0.545 (0.160)	0.470 (0.107)
Weighted mean*		**0.935 (0.007)**	**0.961 (0.014)**	**0.776 (0.017)**	**0.716 (0.015)**

* Weighted means of the independent estimates for daily groups (06 April–14 June), 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 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at McNary Dam	Number released	McNary to John Day Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
20 Apr–26 Apr	329	0.857 (0.217)	0.356 (0.158)	0.305 (0.110)
27 Apr–03 May	1,612	0.942 (0.100)	0.706 (0.198)	0.665 (0.173)
04 May–10 May	4,569	0.860 (0.041)	0.802 (0.077)	0.690 (0.058)
11 May–17 May	3,729	1.101 (0.104)	0.654 (0.142)	0.720 (0.140)
18 May–24 May	2,420	1.070 (0.129)	0.690 (0.380)	0.739 (0.396)
25 May–31 May	1,280	1.704 (0.351)	0.367 (0.255)	0.625 (0.415)
01 Jun–07 Jun	844	0.906 (0.138)	0.492 (0.226)	0.446 (0.194)
Weighted mean*		**0.950 (0.066)**	**0.742 (0.045)**	**0.671 (0.034)**

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

Table 12. Estimated survival probabilities for juvenile Snake River hatchery steelhead detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
06 Apr–12 Apr	332	0.828 (0.058)	1.198 (0.406)	0.706 (0.313)	0.701 (0.205)
13 Apr–19 Apr	2,643	0.923 (0.035)	0.818 (0.114)	0.949 (0.150)	0.716 (0.061)
20 Apr–26 Apr	5,567	0.884 (0.024)	0.998 (0.084)	0.858 (0.078)	0.757 (0.035)
27 Apr–03 May	8,319	0.928 (0.021)	1.056 (0.058)	0.791 (0.048)	0.775 (0.028)
04 May–10 May	6,626	0.914 (0.014)	0.917 (0.043)	0.753 (0.054)	0.630 (0.035)
11 May–17 May	4,734	0.912 (0.015)	1.022 (0.048)	0.732 (0.068)	0.683 (0.055)
18 May–24 May	3,386	0.955 (0.017)	0.906 (0.031)	0.766 (0.060)	0.662 (0.048)
25 May–31 May	1,438	0.934 (0.019)	0.975 (0.051)	0.638 (0.079)	0.580 (0.066)
01 Jun–07 Jun	621	0.931 (0.026)	0.943 (0.073)	0.602 (0.101)	0.528 (0.080)
08 Jun–14 Jun	291	0.836 (0.068)	1.603 (0.708)	0.294 (0.177)	0.394 (0.158)
Weighted mean*		**0.922 (0.007)**	**0.960 (0.022)**	**0.769 (0.024)**	**0.717 (0.023)**

* Weighted means of the independent estimates for weekly pooled groups (06 April –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 2008. Daily groups pooled weekly. Estimates based on the single-release model. Standard errors in parentheses.

Date at Lower Granite	Number released	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Lower Granite to McNary Dam
13 Apr–19 Apr	147	1.021 (0.191)	0.851 (0.518)	0.947 (0.784)	0.823 (0.487)
20 Apr–26 Apr	869	0.872 (0.060)	1.177 (0.309)	0.812 (0.238)	0.833 (0.123)
27 Apr–03 May	1,114	0.846 (0.058)	1.181 (0.195)	0.807 (0.146)	0.806 (0.080)
04 May–10 May	2,771	0.938 (0.022)	0.956 (0.072)	0.817 (0.084)	0.732 (0.055)
11 May–17 May	1,901	0.878 (0.028)	1.155 (0.112)	0.720 (0.107)	0.730 (0.084)
18 May–24 May	4,814	0.967 (0.011)	0.938 (0.021)	0.772 (0.042)	0.700 (0.036)
25 May–31 May	4,130	0.905 (0.012)	0.999 (0.034)	0.708 (0.055)	0.640 (0.045)
01 Jun–07 Jun	1,873	0.958 (0.017)	0.821 (0.036)	0.636 (0.070)	0.501 (0.051)
08 Jun–14 Jun	626	0.774 (0.043)	0.944 (0.191)	0.690 (0.234)	0.504 (0.139)
Weighted mean*		**0.937 (0.013)**	**0.947 (0.025)**	**0.748 (0.019)**	**0.692 (0.029)**

* Weighted means of the independent estimates for weekly pooled groups (13 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 2008. Daily groups pooled as necessary to calculate estimates. Estimates based on the single–release model. Standard errors in parentheses. Abbreviations: LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
05–10 Apr	329	0.828 (0.057)	1.196 (0.406)	0.681 (0.300)	0.674 (0.194)
11–15 Apr	558	0.958 (0.064)	1.027 (0.334)	1.020 (0.400)	1.004 (0.230)
16 Apr	816	0.972 (0.063)	0.936 (0.246)	0.795 (0.231)	0.723 (0.100)
17 Apr	288	0.791 (0.075)	1.198 (0.534)	0.721 (0.346)	0.683 (0.149)
18 Apr	471	0.915 (0.107)	0.723 (0.287)	0.943 (0.422)	0.624 (0.164)
19 Apr	665	0.984 (0.110)	0.518 (0.123)	1.200 (0.304)	0.612 (0.104)
20 Apr	415	0.806 (0.122)	1.080 (0.391)	0.768 (0.293)	0.668 (0.148)
21 Apr	495	0.848 (0.121)	1.398 (0.707)	0.588 (0.296)	0.697 (0.112)
22 Apr	3,378	0.900 (0.032)	0.960 (0.102)	0.930 (0.109)	0.803 (0.050)
23 Apr	1,354	0.859 (0.039)	1.109 (0.175)	0.805 (0.142)	0.766 (0.070)
24 Apr	242	0.900 (0.168)	1.150 (0.602)	0.504 (0.259)	0.522 (0.108)
25 Apr	173	1.196 (0.295)	0.460 (0.189)	1.198 (0.483)	0.660 (0.202)
26 Apr	379	0.992 (0.118)	1.006 (0.473)	0.720 (0.347)	0.718 (0.125)
27 Apr	554	1.011 (0.099)	0.747 (0.231)	0.984 (0.338)	0.743 (0.149)
28 Apr	874	0.951 (0.070)	0.851 (0.155)	0.795 (0.145)	0.644 (0.064)
29 Apr	2,634	0.855 (0.037)	1.417 (0.167)	0.694 (0.088)	0.841 (0.052)
30 Apr	2,248	0.903 (0.044)	1.091 (0.122)	0.853 (0.103)	0.841 (0.058)
01 May	887	0.886 (0.069)	0.938 (0.137)	1.099 (0.190)	0.913 (0.113)
02 May	1,842	0.955 (0.037)	1.038 (0.103)	0.703 (0.082)	0.697 (0.050)
03 May	394	0.828 (0.068)	0.871 (0.148)	0.796 (0.166)	0.574 (0.086)
04 May	663	0.937 (0.047)	0.951 (0.120)	0.873 (0.164)	0.778 (0.115)
05 May	632	0.896 (0.050)	1.218 (0.226)	0.765 (0.200)	0.836 (0.158)
06 May	2,401	0.942 (0.026)	0.858 (0.066)	0.800 (0.087)	0.647 (0.053)
07 May	1,406	0.930 (0.028)	1.123 (0.128)	0.727 (0.121)	0.759 (0.094)
08 May	1,778	0.909 (0.024)	0.911 (0.083)	0.926 (0.137)	0.766 (0.091)
09 May	1,909	0.911 (0.024)	0.918 (0.081)	0.617 (0.078)	0.516 (0.048)
10 May	608	0.839 (0.039)	0.778 (0.107)	0.840 (0.190)	0.548 (0.101)

Table 14. Continued.

Date at LGR	Number released	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN
11 May	664	0.955 (0.044)	0.819 (0.128)	0.724 (0.159)	0.566 (0.090)
12 May	1,865	0.882 (0.024)	0.988 (0.077)	0.824 (0.140)	0.718 (0.109)
13 May	275	0.880 (0.063)	1.181 (0.290)	0.357 (0.130)	0.371 (0.102)
14 May	1,635	0.912 (0.022)	1.084 (0.076)	0.922 (0.182)	0.912 (0.169)
15 May	290	0.915 (0.053)	0.975 (0.169)	0.599 (0.183)	0.534 (0.137)
16 May	1,512	0.902 (0.035)	1.187 (0.131)	0.678 (0.103)	0.727 (0.080)
17 May	394	0.896 (0.084)	1.041 (0.204)	0.731 (0.240)	0.682 (0.190)
18 May	743	0.911 (0.057)	0.939 (0.107)	1.019 (0.287)	0.871 (0.231)
19 May	401	0.949 (0.053)	0.878 (0.095)	0.822 (0.188)	0.685 (0.144)
20 May	2,595	0.949 (0.017)	0.949 (0.036)	0.800 (0.075)	0.721 (0.064)
21 May	1,473	0.967 (0.024)	0.939 (0.039)	0.709 (0.063)	0.644 (0.053)
22 May	1,329	0.981 (0.013)	0.887 (0.032)	0.774 (0.078)	0.674 (0.064)
23 May	1,585	1.006 (0.023)	0.931 (0.038)	0.760 (0.069)	0.712 (0.060)
24 May	74	0.965 (0.077)	1.016 (0.173)	0.588 (0.176)	0.577 (0.148)
25 May	74	0.878 (0.052)	1.127 (0.179)	1.725 (1.569)	1.707 (1.528)
26 May	126	1.101 (0.081)	0.814 (0.123)	0.521 (0.180)	0.466 (0.150)
27 May	1,364	0.924 (0.017)	1.019 (0.061)	0.765 (0.118)	0.720 (0.103)
28 May	1,238	0.963 (0.030)	0.995 (0.064)	0.679 (0.104)	0.651 (0.092)
29 May	1,446	0.795 (0.021)	0.944 (0.056)	0.737 (0.086)	0.553 (0.057)
30 May	1,281	0.965 (0.018)	1.004 (0.054)	0.640 (0.081)	0.620 (0.071)
31 May	39	1.079 (0.146)	0.854 (0.254)	0.370 (0.182)	0.342 (0.145)
Weighted mean*		**0.935 (0.007)**	**0.961 (0.014)**	**0.776 (0.017)**	**0.716 (0.015)**

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

Table 15. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	336	0.566 (0.048)	0.065 (0.026)	0.105 (0.037)
13 Apr–19 Apr	2,790	0.367 (0.016)	0.041 (0.007)	0.108 (0.012)
20 Apr–26 Apr	6,436	0.290 (0.010)	0.045 (0.004)	0.153 (0.008)
27 Apr–03 May	9,433	0.275 (0.008)	0.081 (0.005)	0.196 (0.008)
04 May–10 May	9,397	0.539 (0.008)	0.170 (0.008)	0.172 (0.009)
11 May–17 May	6,635	0.490 (0.010)	0.207 (0.010)	0.092 (0.008)
18 May–24 May	8,200	0.472 (0.007)	0.488 (0.010)	0.157 (0.008)
25 May–31 May	5,568	0.560 (0.009)	0.416 (0.013)	0.148 (0.011)
01 Jun–07 Jun	2,494	0.624 (0.013)	0.526 (0.021)	0.239 (0.023)
08 Jun–14 Jun	918	0.587 (0.031)	0.168 (0.033)	0.135 (0.035)

Table 16. Estimated detection probabilities for juvenile Snake River steelhead (hatchery and wild combined) detected and released to the tailrace at McNary Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at McNary Dam	Number released	John Day Dam	Bonneville Dam
20 Apr–26 Apr	329	0.571 (0.048)	0.066 (0.026)
27 Apr–03 May	1,612	0.369 (0.017)	0.040 (0.007)
04 May–10 May	4,569	0.289 (0.010)	0.046 (0.005)
11 May–17 May	3,729	0.283 (0.008)	0.083 (0.005)
18 May–24 May	2,420	0.548 (0.010)	0.188 (0.010)
25 May–31 May	1,280	0.652 (0.026)	0.474 (0.040)
01 Jun–07 Jun	844	0.567 (0.054)	0.121 (0.056)

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 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
06 Apr–12 Apr	332	0.571 (0.048)	0.066 (0.026)	0.107 (0.037)
13 Apr–19 Apr	2,643	0.369 (0.017)	0.040 (0.007)	0.110 (0.012)
20 Apr–26 Apr	5,567	0.289 (0.010)	0.046 (0.005)	0.156 (0.009)
27 Apr–03 May	8,319	0.283 (0.008)	0.083 (0.005)	0.195 (0.009)
04 May–10 May	6,626	0.548 (0.010)	0.188 (0.010)	0.158 (0.010)
11 May–17 May	4,734	0.510 (0.011)	0.236 (0.012)	0.088 (0.009)
18 May–24 May	3,386	0.432 (0.012)	0.455 (0.016)	0.139 (0.012)
25 May–31 May	1,438	0.582 (0.017)	0.456 (0.026)	0.151 (0.021)
01 Jun–07 Jun	621	0.652 (0.026)	0.474 (0.040)	0.231 (0.041)
08 Jun–14 Jun	291	0.567 (0.054)	0.121 (0.056)	0.129 (0.060)

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 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Little Goose Dam	Lower Monumental Dam	McNary Dam
13 Apr–19 Apr	147	0.340 (0.075)	0.065 (0.043)	0.069 (0.047)
20 Apr–26 Apr	869	0.304 (0.026)	0.036 (0.011)	0.126 (0.022)
27 Apr–03 May	1,114	0.208 (0.019)	0.065 (0.012)	0.205 (0.024)
04 May–10 May	2,771	0.520 (0.015)	0.135 (0.012)	0.205 (0.018)
11 May–17 May	1,901	0.437 (0.018)	0.141 (0.015)	0.103 (0.014)
18 May–24 May	4,814	0.497 (0.009)	0.509 (0.013)	0.168 (0.011)
25 May–31 May	4,130	0.552 (0.011)	0.402 (0.015)	0.147 (0.012)
01 Jun–07 Jun	1,873	0.614 (0.016)	0.546 (0.025)	0.243 (0.028)
08 Jun–14 Jun	626	0.595 (0.038)	0.186 (0.041)	0.137 (0.042)

Table 19. Estimated survival probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Clearwater Hatchery						
Crooked River Pond	996	0.225 (0.028)	1.054 (0.174)	0.678 (0.157)	2.586 (1.752)	0.416 (0.272)
Crooked River Trap	11,974	0.506 (0.021)	0.894 (0.058)	0.988 (0.095)	0.870 (0.115)	0.389 (0.038)
Powell Pond	33,747	0.348 (0.014)	0.941 (0.083)	0.822 (0.093)	0.863 (0.075)	0.233 (0.014)
Red River Pond	11,976	0.649 (0.045)	0.822 (0.076)	0.797 (0.080)	0.938 (0.128)	0.399 (0.040)
Selway River	8,317	0.696 (0.020)	0.915 (0.058)	0.915 (0.083)	0.995 (0.088)	0.580 (0.039)
Dworshak Hatchery						
NF Clearwater River	49,384	0.737 (0.011)	0.899 (0.021)	0.880 (0.027)	0.915 (0.036)	0.534 (0.016)
Kooskia Hatchery	3,950	0.624 (0.020)	0.841 (0.100)	0.970 (0.183)	0.823 (0.122)	0.419 (0.047)
Kooskia Hatchery						
Kooskia Hatchery	5,949	0.631 (0.015)	0.838 (0.070)	1.157 (0.168)	0.832 (0.110)	0.509 (0.052)
Lookingglass Hatchery						
Catherine Creek Pond	20,716	0.455 (0.008)	0.914 (0.027)	1.007 (0.051)	0.906 (0.080)	0.379 (0.028)
Grande Ronde P. (3/17)	995	0.362 (0.021)	1.012 (0.069)	0.900 (0.109)	1.322 (0.361)	0.435 (0.111)
Grande Ronde P. (4/7)	987	0.473 (0.026)	0.954 (0.063)	1.169 (0.152)	0.593 (0.121)	0.312 (0.052)
Imnaha Weir	20,750	0.694 (0.008)	0.964 (0.022)	0.885 (0.034)	0.875 (0.047)	0.518 (0.022)
Lookingglass Hatchery	993	0.723 (0.032)	1.027 (0.072)	0.946 (0.128)	0.873 (0.178)	0.614 (0.101)
Lostine Pond (3/19)	3,143	0.552 (0.016)	0.914 (0.038)	0.882 (0.066)	0.910 (0.113)	0.405 (0.043)

Table 19. Continued.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Lookingglass Hatchery (cont.)						
Lostine Pond (4/10)	3,282	0.647 (0.017)	0.943 (0.037)	0.938 (0.062)	0.977 (0.116)	0.559 (0.059)
McCall Hatchery						
Johnson Creek	11,957	0.330 (0.030)	0.782 (0.100)	1.293 (0.232)	0.952 (0.228)	0.317 (0.052)
Knox Bridge	51,661	0.578 (0.007)	0.899 (0.018)	1.001 (0.032)	0.774 (0.033)	0.403 (0.013)
Pahsimeroi Hatchery						
Pahsimeroi Pond	14,806	0.447 (0.011)	0.922 (0.053)	0.909 (0.090)	0.822 (0.089)	0.308 (0.023)
Rapid River Hatchery						
Rapid River H.	117,544	0.801 (0.004)	0.987 (0.012)	0.870 (0.018)	0.862 (0.024)	0.593 (0.012)
Sawtooth Hatchery						
Sawtooth H.	14,925	0.336 (0.012)	0.986 (0.063)	0.874 (0.093)	0.909 (0.140)	0.263 (0.031)

Table 20. Estimated survival probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Clearwater Hatchery						
S.F. Clearwater (4/7)	937	0.779 (0.044)	1.151 (0.138)	0.851 (0.202)	0.795 (0.198)	0.607 (0.092)
S.F. Clearwater (4/15)	4,739	0.851 (0.027)	0.923 (0.049)	0.922 (0.095)	0.942 (0.111)	0.682 (0.052)
Crooked River Pond	5,882	0.650 (0.024)	0.916 (0.049)	1.126 (0.110)	0.721 (0.120)	0.483 (0.066)
Lolo Creek	995	0.862 (0.080)	0.834 (0.118)	1.262 (0.319)	0.638 (0.196)	0.578 (0.114)
Meadow Creek	896	0.796 (0.072)	0.932 (0.123)	1.049 (0.258)	0.920 (0.322)	0.716 (0.190)
Mill Creek	900	0.494 (0.086)	0.652 (0.173)	0.576 (0.218)	0.649 (0.435)	0.120 (0.070)
Red River Pond	5,676	0.596 (0.022)	0.934 (0.055)	0.956 (0.108)	0.732 (0.142)	0.390 (0.063)
Dworshak Hatchery						
Clear Creek	5,102	0.681 (0.019)	0.906 (0.044)	0.917 (0.098)	0.824 (0.103)	0.466 (0.039)
S.F. Clearwater	5,763	0.761 (0.021)	0.922 (0.043)	1.026 (0.098)	0.793 (0.096)	0.571 (0.048)
Dworshak NFH	17,909	0.827 (0.010)	0.950 (0.019)	0.991 (0.040)	0.796 (0.037)	0.620 (0.019)
Hagerman Hatchery						
Little Salmon (3/31-4/2)	4,264	0.923 (0.024)	0.899 (0.043)	0.874 (0.081)	0.983 (0.125)	0.712 (0.070)
Little Salmon (4/7-4/10)	4,491	0.702 (0.021)	0.881 (0.046)	0.997 (0.122)	0.644 (0.100)	0.397 (0.042)
Little Salmon (4/14)	3,136	0.610 (0.027)	0.973 (0.083)	0.690 (0.103)	0.721 (0.133)	0.295 (0.040)
East Fork Salmon R.	5,191	0.723 (0.031)	0.909 (0.055)	0.993 (0.083)	0.789 (0.124)	0.515 (0.070)
Sawtooth Trap (4/17-4/22)	6,624	0.889 (0.026)	0.899 (0.044)	1.013 (0.092)	0.833 (0.102)	0.674 (0.061)
Sawtooth Trap (5/5)	3,262	0.816 (0.025)	0.987 (0.050)	0.872 (0.073)	1.192 (0.241)	0.838 (0.156)
Yankee Fork	394	0.731 (0.065)	1.211 (0.160)	0.872 (0.191)	1.579 (1.064)	1.218 (0.780)

Table 20. Continued.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
			Irrigon Hatchery			
Big Canyon Fac. (4/9)	2,973	0.767 (0.034)	0.902 (0.071)	1.020 (0.149)	0.714 (0.135)	0.504 (0.071)
Big Canyon Fac. (4/29)	2,981	0.765 (0.042)	1.008 (0.093)	0.834 (0.123)	0.953 (0.195)	0.613 (0.099)
Big Sheep Creek	5,668	0.825 (0.023)	0.905 (0.057)	0.817 (0.105)	0.972 (0.140)	0.593 (0.061)
Little Sheep Facility	9,207	0.864 (0.034)	0.896 (0.065)	0.760 (0.087)	0.904 (0.122)	0.531 (0.053)
Wallowa H. (4/6)	7,828	0.830 (0.030)	0.875 (0.087)	0.797 (0.142)	0.921 (0.144)	0.533 (0.056)
Wallowa H. (4/26)	2,681	0.828 (0.113)	1.333 (0.449)	0.563 (0.246)	0.772 (0.216)	0.480 (0.097)
			Lyons Ferry Hatchery			
Cottonwood Pond	3,999	0.842 (0.040)	0.820 (0.084)	1.251 (0.247)	0.834 (0.164)	0.720 (0.094)
			Magic Valley Hatchery			
East Fork Salmon R.	4,251	0.769 (0.022)	0.965 (0.046)	0.928 (0.090)	0.994 (0.179)	0.685 (0.107)
East Fork Salmon Trap	1,299	0.779 (0.044)	0.935 (0.082)	1.144 (0.222)	0.473 (0.150)	0.394 (0.098)
Little Salmon R.	4,689	0.854 (0.023)	0.853 (0.039)	1.061 (0.103)	0.627 (0.078)	0.484 (0.041)
Pahsimeroi R. Trap	599	0.862 (0.076)	0.820 (0.117)	1.093 (0.315)	0.487 (0.159)	0.376 (0.068)
Salmon R. (rkm 347)	1,397	0.820 (0.038)	0.938 (0.077)	0.783 (0.124)	0.943 (0.188)	0.567 (0.082)
Salmon R. (rkm 385)	1,396	0.816 (0.044)	0.873 (0.086)	1.309 (0.348)	0.636 (0.199)	0.593 (0.110)
Salmon R. (rkm 476)	1,196	0.845 (0.043)	1.020 (0.103)	0.963 (0.217)	0.854 (0.268)	0.709 (0.168)
Salmon R. (rkm 506)	1,591	0.819 (0.041)	0.886 (0.076)	1.448 (0.324)	0.555 (0.152)	0.583 (0.097)
Salmon R. (rkm 547)	1,263	0.759 (0.040)	1.018 (0.091)	1.047 (0.196)	0.668 (0.184)	0.540 (0.116)
Slate Creek (4/18)	1,841	0.760 (0.034)	0.953 (0.068)	0.965 (0.129)	0.693 (0.152)	0.485 (0.085)
Squaw Creek	10,867	0.743 (0.012)	1.012 (0.026)	0.860 (0.046)	0.941 (0.096)	0.608 (0.054)

Table 20. Continued.

Release site	Number released	Release to Lower Granite Dam	Lower Granite to Little Goose Dam	Little Goose to Lower Monumental Dam	Lower Monumental to McNary Dam	Release to McNary Dam
Magic Valley Hatchery (cont.)						
Squaw Pond	1,493	0.612 (0.037)	0.952 (0.085)	0.906 (0.131)	0.929 (0.267)	0.490 (0.124)
Valley Creek	996	0.922 (0.066)	0.839 (0.088)	1.260 (0.281)	0.621 (0.206)	0.605 (0.146)
Yankee Fork	1,592	0.776 (0.039)	0.942 (0.063)	0.992 (0.100)	0.631 (0.136)	0.458 (0.086)
Niagara Springs Hatchery						
Hells Canyon Dam	300	0.858 (0.056)	0.970 (0.089)	0.914 (0.142)	0.637 (0.148)	0.485 (0.091)
Little Salmon R.	599	0.874 (0.041)	1.133 (0.094)	0.724 (0.113)	0.738 (0.161)	0.529 (0.090)
Pahsimeroi R. Trap	295	0.834 (0.070)	0.874 (0.103)	1.151 (0.278)	0.744 (0.295)	0.625 (0.201)

Table 21. Estimated survival probabilities for PIT-tagged juvenile sockeye salmon from Snake River Basin hatcheries released in 2008. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; Little Goose-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Release site	Release date	Number released	Release to LGR	LGR to LGO	LGO to LMO	LMO to MCN	LGR to MCN	Release to MCN
Oxbow Hatchery								
Sawtooth Trap	07 May 08	999	0.449 (0.074)	0.842 (0.180)	1.881 (0.554)	0.929 (0.543)	1.472 (0.803)	0.661 (0.346)
Sawtooth Hatchery								
Alturus Lake	03 Oct 07	1,002	0.248 (0.021)	1.183 (0.113)	0.793 (0.108)	0.873 (0.307)	0.819 (0.278)	0.203 (0.068)
Pettit Lake	03 Oct 07	992	0.281 (0.044)	0.872 (0.150)	0.752 (0.130)	1.207 (0.772)	0.791 (0.507)	0.222 (0.139)
Redfish Lake	03 Oct 07	989	0.207 (0.033)	0.903 (0.151)	0.786 (0.112)	1.109 (0.474)	0.788 (0.345)	0.163 (0.068)
Redfish L. Cr. Trap	07 May 08	993	0.455 (0.038)	1.048 (0.105)	0.969 (0.115)	0.525 (0.121)	0.534 (0.118)	0.243 (0.051)

Table 22. Estimated detection probabilities for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Clearwater Hatchery		
Crooked River Pond	996	0.205 (0.035)	0.327 (0.051)	0.240 (0.056)	0.048 (0.033)
Crooked River Trap	11,974	0.216 (0.010)	0.368 (0.016)	0.253 (0.021)	0.152 (0.016)
Powell Pond	33,747	0.238 (0.010)	0.269 (0.020)	0.168 (0.011)	0.237 (0.015)
Red River Pond	11,976	0.160 (0.012)	0.330 (0.017)	0.270 (0.022)	0.151 (0.016)
Selway River	8,317	0.261 (0.009)	0.274 (0.016)	0.184 (0.012)	0.240 (0.017)
			Dworshak Hatchery		
NF Clearwater River	49,384	0.187 (0.003)	0.282 (0.005)	0.200 (0.006)	0.196 (0.006)
Kooskia Hatchery	3,950	0.297 (0.013)	0.310 (0.037)	0.205 (0.023)	0.251 (0.028)
			Kooskia Hatchery		
Kooskia Hatchery	5,949	0.305 (0.010)	0.345 (0.029)	0.195 (0.018)	0.209 (0.022)
			Lookingglass Hatchery		
Catherine Creek Pond	20,716	0.314 (0.007)	0.413 (0.010)	0.276 (0.014)	0.145 (0.012)
Grande Ronde P. (3/17)	995	0.372 (0.030)	0.451 (0.036)	0.306 (0.041)	0.139 (0.039)
Grande Ronde P. (4/7)	987	0.330 (0.026)	0.440 (0.032)	0.261 (0.037)	0.219 (0.042)
Imnaha Weir	20,750	0.385 (0.006)	0.388 (0.008)	0.245 (0.009)	0.232 (0.011)

Table 22. Continued.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
		Lookingglass Hatchery (cont.)			
Lookingglass H.	993	0.338 (0.022)	0.362 (0.028)	0.180 (0.026)	0.216 (0.039)
Lostine Pond (3/19)	3,143	0.360 (0.015)	0.424 (0.019)	0.240 (0.020)	0.200 (0.024)
Lostine Pond (4/10)	3,282	0.351 (0.013)	0.368 (0.016)	0.251 (0.018)	0.164 (0.019)
		McCall Hatchery			
Johnson Creek	11,957	0.200 (0.019)	0.419 (0.028)	0.230 (0.036)	0.125 (0.021)
Knox Bridge	51,661	0.293 (0.004)	0.348 (0.006)	0.219 (0.007)	0.208 (0.007)
		Pahsimeroi Hatchery			
Pahsimeroi Pond	14,806	0.386 (0.011)	0.350 (0.018)	0.180 (0.016)	0.226 (0.018)
		Rapid River Hatchery			
Rapid River H.	117,544	0.415 (0.003)	0.366 (0.004)	0.263 (0.005)	0.204 (0.005)
		Sawtooth Hatchery			
Sawtooth H.	14,925	0.327 (0.013)	0.382 (0.019)	0.288 (0.026)	0.148 (0.019)

Table 23. Estimated detection probabilities for PIT-tagged juvenile steelhead released from Snake River Basin hatcheries in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Clearwater Hatchery		
S.F. Clearwater (4/7)	937	0.270 (0.022)	0.310 (0.037)	0.083 (0.020)	0.146 (0.028)
S.F. Clearwater (4/15)	4,739	0.226 (0.010)	0.332 (0.016)	0.080 (0.009)	0.132 (0.012)
Crooked River Pond	5,882	0.243 (0.011)	0.438 (0.017)	0.213 (0.020)	0.110 (0.017)
Lolo Creek	995	0.239 (0.026)	0.354 (0.036)	0.115 (0.030)	0.139 (0.032)
Meadow Creek	896	0.236 (0.026)	0.445 (0.040)	0.129 (0.033)	0.119 (0.035)
Mill Creek	900	0.252 (0.048)	0.432 (0.076)	0.319 (0.108)	0.133 (0.088)
Red River Pond	5,676	0.260 (0.012)	0.435 (0.020)	0.221 (0.024)	0.100 (0.018)
			Dworshak Hatchery		
Clear Creek	5,102	0.281 (0.011)	0.416 (0.018)	0.105 (0.012)	0.170 (0.017)
S.F. Clearwater	5,763	0.276 (0.010)	0.408 (0.016)	0.127 (0.013)	0.161 (0.015)
Dworshak NFH	17,909	0.284 (0.005)	0.400 (0.008)	0.120 (0.005)	0.205 (0.008)
			Hagerman Hatchery		
Little Salmon (3/31-4/2)	4,264	0.280 (0.010)	0.388 (0.017)	0.146 (0.014)	0.100 (0.012)
Little Salmon (4/7-4/10)	4,491	0.305 (0.012)	0.420 (0.020)	0.144 (0.018)	0.124 (0.016)
Little Salmon (4/14)	3,136	0.315 (0.017)	0.354 (0.027)	0.182 (0.026)	0.138 (0.023)
East Fork Salmon R.	5,191	0.202 (0.011)	0.367 (0.016)	0.297 (0.023)	0.094 (0.015)
Sawtooth Trap (4/17-4/22)	6,624	0.261 (0.010)	0.356 (0.014)	0.125 (0.011)	0.089 (0.010)
Sawtooth Trap (5/5)	3,262	0.309 (0.013)	0.453 (0.019)	0.340 (0.027)	0.071 (0.015)
Yankee Fork	394	0.194 (0.028)	0.431 (0.049)	0.400 (0.079)	0.067 (0.046)

Table 23. Continued

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
		Irrigon Hatchery			
Big Canyon Fac. (4/9)	2,973	0.280 (0.015)	0.416 (0.027)	0.210 (0.028)	0.112 (0.019)
Big Canyon Fac. (4/29)	2,981	0.290 (0.018)	0.454 (0.028)	0.233 (0.030)	0.101 (0.019)
Big Sheep Creek	5,668	0.288 (0.010)	0.423 (0.024)	0.173 (0.019)	0.100 (0.012)
Little Sheep Facility	9,207	0.255 (0.011)	0.403 (0.022)	0.274 (0.023)	0.109 (0.012)
Wallowa H. (4/6)	7,828	0.224 (0.010)	0.369 (0.034)	0.168 (0.020)	0.109 (0.012)
Wallowa H. (4/26)	2,681	0.235 (0.033)	0.269 (0.078)	0.155 (0.033)	0.093 (0.019)
		Lyons Ferry Hatchery			
Cottonwood Pond	3,999	0.257 (0.014)	0.400 (0.035)	0.108 (0.017)	0.128 (0.018)
		Magic Valley Hatchery			
East Fork Salmon R.	4,251	0.309 (0.012)	0.479 (0.018)	0.205 (0.020)	0.075 (0.013)
East Fork Salmon Trap	1,299	0.295 (0.021)	0.464 (0.032)	0.220 (0.043)	0.077 (0.025)
Little Salmon R.	4,689	0.311 (0.011)	0.427 (0.017)	0.166 (0.016)	0.145 (0.015)
Pahsimeroi R. Trap	599	0.273 (0.031)	0.405 (0.047)	0.147 (0.043)	0.143 (0.038)
Salmon R. (rkm 347)	1,397	0.320 (0.020)	0.435 (0.032)	0.174 (0.028)	0.158 (0.028)
Salmon R. (rkm 385)	1,396	0.291 (0.020)	0.367 (0.033)	0.075 (0.021)	0.103 (0.023)
Salmon R. (rkm 476)	1,196	0.322 (0.022)	0.370 (0.034)	0.121 (0.028)	0.082 (0.023)
Salmon R. (rkm 506)	1,591	0.303 (0.019)	0.391 (0.029)	0.102 (0.023)	0.112 (0.022)
Salmon R. (rkm 547)	1,263	0.310 (0.022)	0.458 (0.034)	0.185 (0.035)	0.104 (0.027)
Slate Creek (4/18)	1,841	0.294 (0.018)	0.465 (0.026)	0.275 (0.036)	0.112 (0.024)
Squaw Creek	10,867	0.349 (0.007)	0.511 (0.011)	0.275 (0.015)	0.096 (0.010)

Table 23. Continued

Release site	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
		Magic Valley Hatchery (cont.)			
Squaw Pond	1,493	0.276 (0.022)	0.462 (0.031)	0.285 (0.041)	0.087 (0.026)
Valley Creek	996	0.261 (0.024)	0.477 (0.034)	0.181 (0.041)	0.119 (0.033)
Yankee Fork	1,592	0.214 (0.016)	0.517 (0.024)	0.416 (0.041)	0.117 (0.027)
		Niagara Springs Hatchery			
Hells Canyon Dam	300	0.295 (0.034)	0.472 (0.045)	0.280 (0.049)	0.183 (0.046)
Little Salmon R.	599	0.313 (0.025)	0.384 (0.034)	0.186 (0.032)	0.142 (0.031)
Pahsimeroi R. Trap	295	0.292 (0.037)	0.431 (0.049)	0.177 (0.047)	0.107 (0.041)

Table 24. Estimated detection probabilities for PIT-tagged juvenile sockeye salmon from Snake River Basin hatcheries released in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Release site	Release date	Number released	Lower Granite	Little Goose	Lower Monumental	McNary
			Oxbow Hatchery			
Sawtooth Trap	07 May 08	999	0.094 (0.020)	0.140 (0.026)	0.092 (0.026)	0.029 (0.016)
			Sawtooth Hatchery			
Alturus Lake	03 Oct 07	1,002	0.165 (0.026)	0.400 (0.041)	0.469 (0.061)	0.138 (0.052)
Pettit Lake	03 Oct 07	992	0.111 (0.025)	0.415 (0.048)	0.431 (0.072)	0.053 (0.036)
Redfish Lake	03 Oct 07	989	0.107 (0.027)	0.434 (0.050)	0.511 (0.071)	0.123 (0.057)
Redfish L. Cr. Trap	07 May 08	993	0.133 (0.019)	0.311 (0.029)	0.404 (0.046)	0.143 (0.037)

Table 25. Estimated survival probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2008. Estimates based on the single-release model. Standard errors in parentheses. Abbreviations: LGR-Lower Granite Dam; Little Goose-Little Goose Dam; LMO-Lower Monumental Dam; MCN-McNary Dam.

Trap	Release dates	Number released	Release to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Release to MCN
			Wild Chinook Salmon				
American River	26 Mar-31 May	471	0.280 (0.050)	0.796 (0.177)	1.601 (0.629)	2.304 (2.315)	0.822 (0.762)
Catherine Creek	13 Feb-14 May	484	0.368 (0.044)	1.112 (0.190)	1.235 (0.523)	0.421 (0.207)	0.213 (0.058)
Crooked Fork Cr	23 Mar-07 May	160	0.575 (0.141)	0.923 (0.295)	0.780 (0.217)	0.960 (0.390)	0.398 (0.139)
Clearwater	13 Mar-05 May	568	0.906 (0.049)	1.006 (0.121)	1.011 (0.231)	0.584 (0.149)	0.538 (0.084)
Crooked River	16 Apr-15 May	110	0.461 (0.077)	1.757 (0.705)	0.778 (0.631)	0.533 (0.621)	0.336 (0.277)
Grande Ronde	06 Mar-16 May	2,427	0.938 (0.022)	0.982 (0.052)	0.850 (0.068)	0.912 (0.093)	0.715 (0.059)
Imnaha	01 Mar-28 May	3,256	0.853 (0.017)	0.896 (0.032)	1.045 (0.066)	0.849 (0.076)	0.679 (0.048)
Johnson Creek	19 Mar-11 May	503	0.592 (0.039)	0.965 (0.070)	1.026 (0.119)	0.966 (0.252)	0.566 (0.136)
Knox Bridge	28 Feb-05 May	926	0.564 (0.032)	0.955 (0.065)	0.906 (0.076)	0.864 (0.162)	0.422 (0.074)
Lemhi River Weir	12 Mar-31 May	59	0.508 (0.065)	1.579 (0.827)	1.333 (1.356)	NA	NA
Lostine River	03 Mar-14 May	499	0.690 (0.041)	1.107 (0.123)	0.768 (0.135)	0.897 (0.246)	0.525 (0.125)
Marsh Creek	23 Mar-31 May	172	0.649 (0.118)	0.916 (0.220)	0.979 (0.399)	0.480 (0.254)	0.280 (0.093)
Minam	03 Mar-10 May	494	0.597 (0.038)	0.975 (0.100)	0.949 (0.151)	0.769 (0.180)	0.424 (0.081)
Pahsimeroi (early)	28 Feb-31 May	416	0.591 (0.057)	0.998 (0.153)	1.007 (0.254)	0.751 (0.243)	0.446 (0.109)
Pahsimeroi (late)	01 Jun-30 Jun	365	0.444 (0.074)	1.016 (0.272)	1.327 (0.862)	1.040 (0.921)	0.622 (0.396)
Red River	23 Apr-15 May	324	0.299 (0.108)	0.727 (0.369)	0.267 (0.114)	NA	NA
Salmon	10 Mar-15 May	5,802	0.882 (0.013)	0.934 (0.029)	1.049 (0.059)	0.853 (0.071)	0.737 (0.048)
Sawtooth	23 Mar-30 May	356	0.651 (0.082)	0.938 (0.159)	1.750 (0.674)	0.918 (0.597)	0.982 (0.492)
Snake	01 Apr-19 May	1,686	0.955 (0.036)	0.969 (0.059)	0.924 (0.080)	0.803 (0.115)	0.687 (0.081)
Spoolcart*	12 Mar-10 May	508	0.408 (0.032)	1.018 (0.078)	1.031 (0.127)	0.627 (0.146)	0.269 (0.056)

Table 25. Continued.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
				Wild Sockeye Salmon			
Alturas Lake Cr	02 May-09 Jun	423	0.598 (0.101)	0.804 (0.148)	0.843 (0.131)	0.461 (0.116)	0.187 (0.042)
Redfish Lake Cr	25 Apr-14 Jun	499	0.383 (0.068)	0.852 (0.181)	0.724 (0.139)	0.942 (0.317)	0.223 (0.071)
				Wild Steelhead			
American River	27 Mar-25 May	54	0.778 (0.175)	0.870 (0.287)	0.576 (0.216)	NA	NA
Asotin Creek	15 Apr-25 May	1,034	0.775 (0.084)	1.617 (1.236)	0.234 (0.223)	1.000 (0.375)	0.293 (0.092)
Catherine Creek	13 Feb-29 May	567	0.128 (0.025)	0.820 (0.181)	0.876 (0.179)	0.703 (0.182)	0.064 (0.016)
Clearwater	13 Mar-05 May	748	1.092 (0.070)	0.778 (0.098)	1.162 (0.274)	1.122 (0.367)	1.108 (0.286)
Crooked Fork Cr	24 Mar-07 May	767	0.749 (0.032)	0.872 (0.053)	1.004 (0.133)	0.783 (0.165)	0.513 (0.088)
Crooked River	16 Apr-17 May	123	0.786 (0.116)	0.817 (0.147)	0.855 (0.144)	1.158 (0.539)	0.636 (0.288)
Grande Ronde	16 Mar-16 May	952	0.938 (0.033)	0.979 (0.060)	0.933 (0.126)	0.882 (0.182)	0.756 (0.124)
Imnaha	29 Feb-29 May	2,470	0.900 (0.021)	0.943 (0.034)	1.038 (0.078)	0.738 (0.079)	0.650 (0.052)
Johnson Creek	28 Feb-31 May	129	0.258 (0.060)	0.709 (0.189)	0.573 (0.186)	1.556 (1.196)	0.163 (0.127)
Lemhi River Weir	15 Mar-31 May	1,484	0.104 (0.015)	0.866 (0.131)	0.882 (0.184)	0.706 (0.249)	0.056 (0.017)
Lookingglass Cr	13 Feb-14 May	229	0.702 (0.095)	0.813 (0.162)	NA	NA	NA
Lostine River	03 Mar-14 May	463	0.214 (0.035)	1.104 (0.301)	0.516 (0.230)	0.606 (0.364)	0.074 (0.035)
Minam River	03 Mar-15 May	545	0.428 (0.046)	1.016 (0.184)	0.778 (0.251)	0.533 (0.236)	0.181 (0.058)
Pahsimeroi	28 Feb- 31 May	377	0.350 (0.055)	0.865 (0.148)	1.006 (0.197)	0.710 (0.299)	0.216 (0.084)
Rapid River	10 Mar-30 May	358	0.561 (0.042)	1.226 (0.177)	0.837 (0.301)	1.892 (1.368)	1.090 (0.686)
Salmon	10 Mar-15 May	376	0.859 (0.051)	1.044 (0.109)	1.182 (0.339)	0.530 (0.182)	0.562 (0.116)
Snake	03 Apr-19 May	1,414	0.951 (0.029)	0.961 (0.049)	1.040 (0.131)	0.684 (0.115)	0.650 (0.076)
Spoolcart*	06 Mar-15 May	541	0.602 (0.038)	0.909 (0.074)	1.417 (0.286)	0.547 (0.155)	0.424 (0.086)
				Hatchery Chinook Salmon			
Grande Ronde	23 Mar-02 May	1,414	0.826 (0.025)	0.993 (0.051)	0.780 (0.062)	1.150 (0.170)	0.735 (0.098)
Salmon	15 Mar-07 May	3,999	0.842 (0.015)	1.004 (0.032)	0.972 (0.058)	0.805 (0.070)	0.662 (0.045)
Snake	01 Apr-25 May	3,044	0.991 (0.021)	0.940 (0.031)	0.989 (0.054)	0.832 (0.072)	0.767 (0.055)

Table 25. Continued.

Trap	Release dates	Number released	Rel to LGR	LGR to LGO	LGO to LMO	LMO to MCN	Rel to MCN
				Hatchery Sockeye Salmon			
Alturas Lake Cr	03 May-01 Jun	215	0.568 (0.077)	1.287 (0.217)	0.794 (0.156)	0.996 (0.502)	0.578 (0.280)
Redfish Lake Cr	20 Apr-15 Jun	678	0.474 (0.056)	0.854 (0.118)	1.163 (0.242)	0.753 (0.324)	0.355 (0.137)
				Hatchery Steelhead			
Grande Ronde	10 Apr-08 May	3,600	0.934 (0.021)	0.971 (0.033)	0.863 (0.059)	0.866 (0.083)	0.678 (0.049)
Salmon	03 Apr-15 May	2,682	0.908 (0.023)	0.877 (0.034)	1.129 (0.107)	0.747 (0.101)	0.672 (0.067)
Snake	01 Apr-19 May	3,541	1.016 (0.024)	0.897 (0.031)	1.006 (0.064)	0.837 (0.084)	0.768 (0.062)

* Grande Ronde River

Table 26. Estimated detection probabilities for juvenile salmonids released from fish traps in Snake River Basin in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Trap	Release dates	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
Wild Chinook Salmon						
American River	26 Mar-31 May	471	0.212 (0.050)	0.356 (0.066)	0.157 (0.067)	0.047 (0.045)
Catherine Creek	13 Feb-14 May	484	0.252 (0.042)	0.434 (0.066)	0.142 (0.063)	0.250 (0.082)
Crooked Fork Cr	23 Mar-07 May	160	0.217 (0.067)	0.375 (0.082)	0.366 (0.101)	0.222 (0.098)
Clearwater	13 Mar-05 May	568	0.373 (0.029)	0.326 (0.040)	0.191 (0.042)	0.299 (0.054)
Crooked River	16 Apr-15 May	110	0.217 (0.064)	0.232 (0.101)	0.286 (0.203)	0.167 (0.152)
Grande Ronde	06 Mar-16 May	2,427	0.406 (0.014)	0.334 (0.018)	0.267 (0.020)	0.287 (0.027)
Imnaha	01 Mar-28 May	3,256	0.399 (0.012)	0.388 (0.015)	0.242 (0.016)	0.274 (0.022)
Johnson Creek	19 Mar-11 May	503	0.249 (0.028)	0.512 (0.038)	0.355 (0.047)	0.176 (0.048)
Knox Bridge	28 Feb-05 May	926	0.239 (0.022)	0.449 (0.030)	0.480 (0.041)	0.199 (0.041)
Lemhi River Weir	12 Mar-31 May	59	0.433 (0.090)	0.267 (0.166)	0.219 (0.183)	NA (NA)
Lostine River	03 Mar-14 May	499	0.378 (0.032)	0.361 (0.044)	0.315 (0.053)	0.159 (0.046)
Marsh Creek	23 Mar-31 May	172	0.206 (0.052)	0.498 (0.085)	0.312 (0.126)	0.286 (0.121)
Minam	03 Mar-10 May	494	0.400 (0.036)	0.373 (0.043)	0.341 (0.055)	0.338 (0.073)
Pahsimeroi (early)	28 Feb-31 May	416	0.289 (0.038)	0.290 (0.046)	0.164 (0.043)	0.243 (0.066)
Pahsimeroi (late)	01 Jun-30 Jun	365	0.235 (0.049)	0.249 (0.063)	0.055 (0.037)	0.077 (0.052)
Red River	23 Apr-15 May	324	0.176 (0.073)	0.318 (0.122)	0.250 (0.108)	NA (NA)
Salmon	10 Mar-15 May	5,802	0.439 (0.009)	0.400 (0.013)	0.270 (0.015)	0.227 (0.017)
Sawtooth	23 Mar-30 May	356	0.237 (0.040)	0.461 (0.054)	0.190 (0.076)	0.097 (0.053)
Snake	01 Apr-19 May	1,686	0.286 (0.015)	0.381 (0.021)	0.377 (0.030)	0.212 (0.029)
Spoolcart*	12 Mar-10 May	508	0.236 (0.032)	0.490 (0.043)	0.433 (0.059)	0.246 (0.061)

Table 26. Continued.

Trap	Release dates	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Wild Sockeye Salmon			
Alturas Lake Cr	02 May-09 Jun	423	0.099 (0.025)	0.424 (0.048)	0.474 (0.073)	0.424 (0.101)
Redfish Lake Cr	25 Apr-14 Jun	499	0.136 (0.034)	0.307 (0.053)	0.409 (0.072)	0.201 (0.073)
			Wild Steelhead			
American River	27 Mar-25 May	54	0.286 (0.092)	0.431 (0.131)	0.507 (0.162)	NA
Asotin Creek	15 Apr-25 May	1,034	0.346 (0.041)	0.194 (0.146)	0.276 (0.072)	0.231 (0.066)
Catherine Creek	13 Feb-29 May	567	0.290 (0.071)	0.536 (0.088)	0.431 (0.106)	0.250 (0.097)
Clearwater	13 Mar-05 May	748	0.327 (0.027)	0.342 (0.039)	0.108 (0.026)	0.119 (0.034)
Crooked Fork Cr	24 Mar-07 May	767	0.412 (0.026)	0.525 (0.033)	0.215 (0.033)	0.165 (0.034)
Crooked River	16 Apr-17 May	123	0.248 (0.056)	0.552 (0.074)	0.545 (0.098)	0.176 (0.092)
Grande Ronde	16 Mar-16 May	952	0.366 (0.020)	0.410 (0.027)	0.153 (0.023)	0.126 (0.024)
Imnaha	29 Feb-29 May	2,470	0.335 (0.012)	0.428 (0.016)	0.175 (0.015)	0.197 (0.019)
Johnson Creek	28 Feb-31 May	129	0.421 (0.113)	0.636 (0.145)	0.444 (0.166)	0.143 (0.132)
Lemhi River Weir	15 Mar-31 May	1,484	0.175 (0.037)	0.545 (0.062)	0.318 (0.074)	0.200 (0.073)
Lookingglass Cr	13 Feb-14 May	229	0.317 (0.055)	0.583 (0.083)	NA	0.364 (0.145)
Lostine River	03 Mar-14 May	463	0.313 (0.064)	0.405 (0.104)	0.344 (0.139)	0.238 (0.138)
Minam River	03 Mar-15 May	545	0.326 (0.044)	0.357 (0.061)	0.279 (0.086)	0.205 (0.080)
Pahsimeroi	28 Feb- 31 May	377	0.159 (0.039)	0.438 (0.060)	0.404 (0.084)	0.154 (0.071)
Rapid River	10 Mar-30 May	358	0.438 (0.043)	0.448 (0.067)	0.218 (0.081)	0.080 (0.054)
Salmon	10 Mar-15 May	376	0.365 (0.034)	0.380 (0.043)	0.096 (0.030)	0.173 (0.044)
Snake	03 Apr-19 May	1,414	0.342 (0.016)	0.422 (0.022)	0.121 (0.017)	0.158 (0.022)
Spoolcart*	06 Mar-15 May	541	0.338 (0.032)	0.473 (0.040)	0.169 (0.038)	0.204 (0.048)
			Hatchery Chinook Salmon			
Grande Ronde	23 Mar-02 May	1,414	0.380 (0.018)	0.374 (0.021)	0.289 (0.024)	0.177 (0.026)
Salmon	15 Mar-07 May	3,999	0.395 (0.011)	0.332 (0.012)	0.191 (0.012)	0.226 (0.017)
Snake	01 Apr-25 May	3,044	0.306 (0.011)	0.362 (0.013)	0.241 (0.014)	0.212 (0.017)

Table 26. Continued.

Trap	Release dates	Number released	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	McNary Dam
			Hatchery Sockeye Salmon			
Alturas Lake Cr	03 May-01 Jun	215	0.106 (0.031)	0.295 (0.052)	0.468 (0.082)	0.115 (0.063)
Redfish Lake Cr	20 Apr-15 Jun	678	0.158 (0.027)	0.398 (0.043)	0.250 (0.054)	0.143 (0.059)
			Hatchery Steelhead			
Grande Ronde	10 Apr-08 May	3,600	0.271 (0.010)	0.414 (0.014)	0.137 (0.011)	0.134 (0.012)
Salmon	03 Apr-15 May	2,682	0.313 (0.012)	0.446 (0.017)	0.118 (0.013)	0.120 (0.014)
Snake	01 Apr-19 May	3,541	0.255 (0.009)	0.406 (0.013)	0.155 (0.011)	0.108 (0.010)

* Grande Ronde River

Table 27. Estimated survival probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2008. 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	13,962	0.366 (0.016)	1.037 (0.099)	0.566 (0.124)	0.586 (0.120)	0.215 (0.043)
Cle Elum	Easton Pond	11,967	0.272 (0.014)	1.101 (0.138)	0.598 (0.219)	0.659 (0.232)	0.179 (0.062)
Cle Elum	Jack Creek Pond	13,990	0.255 (0.011)	1.085 (0.111)	0.424 (0.100)	0.460 (0.101)	0.117 (0.025)
East Bank	Chiwawa Pond	9,894	0.630 (0.040)	0.926 (0.107)	0.927 (0.454)	0.859 (0.416)	0.541 (0.260)
Leavenworth	Leavenworth NFH	15,967	0.567 (0.022)	1.350 (0.131)	0.349 (0.088)	0.471 (0.113)	0.267 (0.063)
Wells	Wells Hatchery	5,983	0.371 (0.038)	1.034 (0.228)	0.385 (0.180)	0.398 (0.173)	0.148 (0.063)
Winthrop	Winthrop NFH	2,987	0.575 (0.074)	1.084 (0.282)	1.128 (0.802)	1.223 (0.839)	0.703 (0.474)
			Steelhead				
Cassimer Bar	Omak Creek	6,985	0.028 (0.014)	1.30 (1.381)	NA	NA	NA
East Bank	Wenatchee River	3,329	0.413 (0.056)	1.11 (0.249)	NA	NA	NA
Turtle Rock	Chiwawa River	3,667	0.503 (0.046)	1.66 (0.321)	NA	NA	NA
Turtle Rock	Nason Creek	8,065	0.495 (0.030)	1.16 (0.125)	1.608 (0.910)	1.862 (1.047)	0.922 (0.516)
Turtle Rock	Wenatchee River	14,671	0.623 (0.033)	1.09 (0.094)	1.153 (0.357)	1.262 (0.387)	0.786 (0.237)
Winthrop	Winthrop NFH	4,915	0.376 (0.040)	2.18 (0.503)	0.313 (0.143)	0.682 (0.286)	0.256 (0.104)

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	Butcher Creek Pond	5,741	0.607 (0.041)	1.146 (0.168)	0.962 (0.471)	1.102 (0.526)	0.670 (0.316)
Cascade	Leavenworth NFH	5,604	0.565 (0.035)	1.415 (0.209)	1.320 (0.922)	1.868 (1.285)	1.056 (0.724)
Cascade	Rolfing Pond	2,892	0.457 (0.046)	1.127 (0.232)	0.491 (0.259)	0.554 (0.280)	0.253 (0.126)
Eagle Creek	Holmes Pond	2,508	0.180 (0.032)	1.567 (0.639)	0.573 (0.575)	0.898 (0.852)	0.162 (0.151)
Eagle Creek	Lost Creek Pond	2,524	0.334 (0.043)	1.726 (0.520)	0.744 (0.738)	1.285 (1.234)	0.429 (0.409)
Eagle Creek	Prosser Hatchery	854	0.536 (0.134)	1.696 (0.812)	NA	NA	NA
Eagle Creek	Stiles Pond	2,504	0.364 (0.047)	1.070 (0.268)	0.752 (0.512)	0.805 (0.529)	0.293 (0.189)
Prosser	Easton Pond	2,493	0.220 (0.027)	1.081 (0.308)	0.946 (0.662)	1.022 (0.675)	0.225 (0.147)
Prosser	Holmes Pond	2,491	0.108 (0.028)	0.947 (0.480)	0.739 (0.746)	0.700 (0.661)	0.076 (0.069)
Prosser	Lost Creek Pond	2,488	0.322 (0.048)	0.836 (0.205)	1.422 (0.987)	1.188 (0.810)	0.382 (0.255)
Prosser	Stiles Pond	2,480	0.305 (0.041)	1.005 (0.283)	1.100 (0.640)	1.105 (0.599)	0.337 (0.178)
Willard	Leavenworth NFH	5,828	0.497 (0.039)	1.021 (0.146)	1.381 (0.955)	1.409 (0.966)	0.700 (0.476)
Willard	Rolfing Pond	3,000	0.397 (0.047)	0.858 (0.172)	1.286 (0.718)	1.103 (0.603)	0.438 (0.234)
Willard	Winthrop NFH	6,719	0.271 (0.025)	1.166 (0.200)	2.362 (2.332)	2.754 (2.700)	0.746 (0.728)

Table 28. Estimated detection probabilities for PIT-tagged yearling Chinook salmon and steelhead from upper-Columbia River hatcheries released in 2008. Estimates based on the single-release model. Standard errors in parentheses.

Hatchery	Release Site	Number released	McNary Dam	John Day Dam	Bonneville Dam
Yearling Chinook Salmon					
Cle Elum	Clark Flat Pond	13,962	0.237 (0.011)	0.174 (0.016)	0.157 (0.032)
Cle Elum	Easton Pond	11,967	0.242 (0.014)	0.177 (0.021)	0.131 (0.046)
Cle Elum	Jack Creek Pond	13,990	0.299 (0.014)	0.196 (0.020)	0.220 (0.049)
East Bank	Chiwawa Pond	9,894	0.114 (0.008)	0.202 (0.020)	0.065 (0.031)
Leavenworth	Leavenworth NFH	15,967	0.182 (0.008)	0.151 (0.014)	0.133 (0.032)
Wells	Wells Hatchery	5,983	0.161 (0.018)	0.088 (0.018)	0.268 (0.114)
Winthrop	Winthrop NFH	2,987	0.135 (0.019)	0.087 (0.021)	0.078 (0.053)
Steelhead					
Cassimer Bar	Omak Creek	6,985	0.097 (0.053)	0.059 (0.057)	NA
East Bank	Wenatchee River	3,329	0.095 (0.015)	0.174 (0.033)	NA
Turtle Rock	Chiwawa River	3,667	0.125 (0.014)	0.141 (0.025)	NA
Turtle Rock	Nason Creek	8,065	0.132 (0.010)	0.200 (0.019)	0.054 (0.030)
Turtle Rock	Wenatchee River	14,671	0.100 (0.006)	0.160 (0.012)	0.077 (0.024)
Winthrop	Winthrop NFH	4,915	0.101 (0.013)	0.093 (0.020)	0.152 (0.063)

Table 28. Continued.

Hatchery	Release Site	Number released	McNary Dam	John Day Dam	Bonneville Dam
			Coho Salmon		
Cascade	Butcher Creek Pond	5,741	0.178 (0.013)	0.115 (0.016)	0.098 (0.046)
Cascade	Leavenworth NFH	5,604	0.187 (0.013)	0.126 (0.018)	0.054 (0.037)
Cascade	Rolfing Pond	2,892	0.180 (0.020)	0.125 (0.024)	0.252 (0.126)
Eagle Creek	Holmes Pond	2,508	0.159 (0.033)	0.113 (0.044)	0.111 (0.105)
Eagle Creek	Lost Creek Pond	2,524	0.151 (0.023)	0.110 (0.031)	0.083 (0.080)
Eagle Creek	Prosser Hatchery	854	0.092 (0.026)	0.086 (0.037)	NA
Eagle Creek	Stiles Pond	2,504	0.168 (0.024)	0.133 (0.031)	0.154 (0.100)
Prosser	Easton Pond	2,493	0.258 (0.036)	0.128 (0.036)	0.128 (0.084)
Prosser	Holmes Pond	2,491	0.167 (0.048)	0.121 (0.057)	0.143 (0.132)
Prosser	Lost Creek Pond	2,488	0.150 (0.025)	0.172 (0.037)	0.091 (0.061)
Prosser	Stiles Pond	2,480	0.184 (0.028)	0.084 (0.023)	0.150 (0.080)
Willard	Leavenworth NFH	5,828	0.142 (0.013)	0.178 (0.023)	0.065 (0.044)
Willard	Rolfing Pond	3,000	0.156 (0.021)	0.142 (0.026)	0.126 (0.068)
Willard	Winthrop NFH	6,719	0.147 (0.016)	0.157 (0.024)	0.041 (0.040)

Table 29. Travel time statistics for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to the tailrace at Lower Granite Dam in 2007. Abbreviations: LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam; BON–Bonneville Dam; N–Number of fish on which statistics are based; Med.–Median.

	LGR to LGO (d)				LGO to LMO (d)				LMO to MCN (d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	131	11.9	14.8	24.6	11	1.8	3.4	4.3	14	4.7	6.5	8.8
13 Apr–19 Apr	479	6.7	11.0	19.1	40	3.0	4.5	6.3	53	4.2	5.9	8.3
20 Apr–26 Apr	1,394	7.1	9.8	14.6	154	2.3	3.0	4.0	198	4.1	5.7	7.7
27 Apr–03 May	4,795	5.1	6.1	8.2	821	1.7	2.3	3.1	1,014	3.6	4.5	5.9
04 May–10 May	11,247	4.0	4.9	6.3	1,479	1.7	2.2	3.0	561	3.4	4.3	5.2
11 May–17 May	6,665	4.2	5.3	6.7	1,715	1.0	1.3	1.9	409	2.4	3.0	4.0
18 May–24 May	1,772	2.8	4.3	6.6	611	1.2	1.7	2.5	210	2.6	3.5	5.2
25 May–31 May	578	3.5	4.3	5.5	234	1.3	1.7	2.6	84	3.2	4.0	5.1
01 Jun–07 Jun	504	3.5	4.6	5.9	175	1.3	1.8	2.4	58	3.7	5.5	6.9
08 Jun–14 Jun	29	2.6	3.2	3.8	4	1.6	2.3	2.5	2	3.8	4.4	5.0
15 Jun–21 Jun	33	2.4	3.1	4.4	7	1.2	1.5	1.6	2	3.0	3.3	33

	LGR to MCN (d)				LGR to BON (d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	70	24.7	29.1	32.1	35	30.8	33.3	36.2
13 Apr–19 Apr	344	17.6	21.9	27.5	122	22.9	26.2	30.1
20 Apr–26 Apr	1,137	16.1	18.5	22.5	434	20.3	22.9	25.6
27 Apr–03 May	5,083	10.4	12.3	15.2	1,850	14.6	16.2	18.2
04 May–10 May	4,250	9.3	10.5	11.9	1,093	12.8	13.9	16.5
11 May–17 May	1,511	8.0	9.6	11.9	1,177	10.8	12.5	14.2
18 May–24 May	534	6.5	9.2	13.9	229	9.3	12.2	18.7
25 May–31 May	194	8.8	10.6	12.9	97	11.6	13.5	16.9
01 Jun–07 Jun	148	9.4	11.9	16.1	87	13.6	15.9	21.8
08 Jun–14 Jun	21	7.6	8.2	10.0	17	10.1	12.3	14.2
15 Jun–21 Jun	13	6.5	7.0	7.5	14	8.8	9.7	12.1

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

	LGR to LGO (km/d)				LGO to LMO (km/d)				LMO to MCN (km/d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	131	2.4	4.1	5.1	11	10.6	13.7	25.3	14	13.6	18.4	25.4
13 Apr–19 Apr	479	3.1	5.5	9.0	40	7.2	10.2	15.4	53	14.4	20.1	28.4
20 Apr–26 Apr	1,394	4.1	6.1	8.5	154	11.6	15.2	19.7	198	15.5	21.0	28.8
27 Apr–03 May	4,795	7.4	9.8	11.8	821	14.6	20.4	26.7	1,014	20.1	26.3	33.4
04 May–10 May	11,247	9.5	12.3	15.1	1,479	15.5	21.3	27.1	561	22.7	27.9	34.6
11 May–17 May	6,665	8.9	11.4	14.4	1,715	24.2	34.6	46.0	409	29.5	39.8	49.6
18 May–24 May	1,772	9.0	14.1	21.4	611	18.6	26.7	38.0	210	22.7	33.6	45.2
25 May–31 May	578	10.8	14.0	17.2	234	17.9	27.5	35.1	84	23.3	29.6	36.8
01 Jun–07 Jun	504	10.2	13.2	17.3	175	19.5	26.3	35.7	58	17.2	21.8	31.9
08 Jun–14 Jun	29	15.7	18.9	23.0	4	18.1	19.9	27.9	2	24.0	27.3	31.6
15 Jun–21 Jun	33	13.6	19.4	25.4	7	28.2	31.5	39.7	2	32.1	35.7	40.3

	LGR to MCN (km/d)				LGR to BON (km/d)			
Date at Lower Granite	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	70	7.0	7.7	9.1	35	12.7	13.8	15.0
13 Apr–19 Apr	344	8.2	10.3	12.8	122	15.3	17.6	20.1
20 Apr–26 Apr	1,137	10.0	12.2	14.0	434	18.0	20.2	22.7
27 Apr–03 May	5,083	14.8	18.2	21.5	1,850	25.4	28.5	31.5
04 May–10 May	4,250	18.8	21.4	24.1	1,093	28.0	33.1	36.2
11 May–17 May	1,511	19.0	23.4	28.2	1,177	32.4	36.8	42.5
18 May–24 May	534	16.2	24.6	34.4	229	24.7	37.8	49.4
25 May–31 May	194	17.4	21.2	25.7	97	27.4	34.2	39.8
01 Jun–07 Jun	148	13.9	18.8	23.8	87	21.2	29.0	33.9
08 Jun–14 Jun	21	22.5	27.3	29.6	17	32.5	37.6	45.8
15 Jun–21 Jun	13	29.8	32.0	34.7	14	38.3	47.5	52.2

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

Date at Lower	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Granite Dam	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr–03 May	124	4.8	6.2	7.9	19	1.8	2.0	2.2	98	6.6	7.5	9.0
04 May–10 May	1,010	3.5	4.3	5.5	197	1.6	1.8	2.2	1,345	4.8	5.4	6.5
11 May–17 May	3,177	3.1	3.9	4.6	270	1.4	1.6	1.9	2,500	4.5	4.9	5.7
18 May–24 May	1,986	2.5	3.0	3.5	91	1.2	1.4	1.6	787	3.6	3.9	4.5
25 May–31 May	703	2.7	3.2	4.0	37	1.2	1.3	1.5	137	3.6	4.1	4.8
01 Jun–07 Jun	267	2.7	3.2	4.1	20	1.3	1.4	1.7	90	3.8	4.3	5.1
08 Jun–14 Jun	98	3.0	3.6	4.2	9	1.6	1.6	1.8	51	3.7	4.7	5.4
15 Jun–21 Jun	37	2.9	3.1	3.5	3	1.3	1.4	1.5	44	3.5	4.1	4.5
22 Jun–21 Jun	14	2.3	2.5	3.0	3	1.1	1.1	1.3	22	3.3	3.5	4.5

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

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
27 Apr–03 May	124	15.5	19.9	25.4	19	51.6	57.7	61.1	98	26.3	31.6	35.9
04 May–10 May	1,010	22.5	28.9	35.7	197	52.1	61.4	68.9	1,345	36.5	43.4	48.9
11 May–17 May	3,177	26.7	31.8	39.4	270	60.4	69.8	81.3	2,500	41.3	47.9	51.9
18 May–24 May	1,986	35.1	40.9	48.2	91	72.4	83.7	91.9	787	52.8	61.1	64.7
25 May–31 May	703	30.6	38.9	45.7	37	75.8	85.6	95.0	137	49.0	57.7	64.8
01 Jun–07 Jun	267	30.1	38.2	45.7	20	66.9	83.7	89.7	90	46.2	54.8	62.6
08 Jun–14 Jun	98	29.4	34.4	41.7	9	62.8	68.5	72.4	51	43.6	50.0	64.1
15 Jun–21 Jun	37	35.7	39.0	42.9	3	77.4	81.9	85.6	44	52.7	57.0	66.7
22 Jun–21 Jun	14	40.5	48.2	54.2	3	89.0	99.1	100.0	22	51.9	68.0	71.5

Table 33. Travel time statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Abbreviations: LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam; BON–Bonneville Dam; N-Number of fish on which statistics are based; Med.–Median.

	LGR to LGO (d)				LGO to LMO (d)				LMO to MCN (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	158	5.9	7.3	10.6	14	2.0	2.7	6.7	4	4.2	4.7	5.0
13 Apr–19 Apr	951	3.6	4.5	6.3	30	2.2	2.9	5.6	9	4.3	5.2	6.0
20 Apr–26 Apr	1,652	4.0	5.0	6.7	87	2.0	2.6	4.6	42	3.3	3.8	5.3
27 Apr–03 May	2,383	3.5	5.0	7.9	194	1.2	1.9	3.0	118	2.5	3.0	3.6
04 May–10 May	4,667	3.1	4.0	5.8	745	1.1	1.5	2.4	170	2.5	3.0	3.5
11 May–17 May	2,932	3.0	4.0	5.0	705	1.0	1.3	2.0	81	1.7	2.0	2.6
18 May–24 May	3,709	2.3	2.7	3.4	1,693	1.0	1.2	1.8	412	2.0	2.2	2.7
25 May–31 May	2,845	2.6	2.9	3.4	1,180	0.9	1.1	1.9	203	1.6	1.9	2.4
01 Jun–07 Jun	1,480	2.5	2.9	3.4	659	0.8	1.0	1.7	153	1.7	2.0	2.5
08 Jun–14 Jun	427	2.7	3.0	3.5	74	0.9	1.1	1.4	9	1.9	2.6	3.5

	LGR to MCN (d)				LGR to BON (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	24	11.1	14.2	17.2	54	18.7	21.8	30.1
13 Apr–19 Apr	189	10.4	13.0	15.9	583	16.8	19.4	21.8
20 Apr–26 Apr	700	9.8	11.0	13.7	1,315	14.8	16.3	18.4
27 Apr–03 May	1,328	8.1	9.3	10.9	1,586	11.8	12.9	14.7
04 May–10 May	1,039	7.0	8.0	9.5	781	10.7	11.8	13.5
11 May–17 May	411	5.2	6.9	8.2	439	8.6	9.8	11.3
18 May–24 May	844	5.3	6.2	7.5	505	7.6	8.7	9.9
25 May–31 May	490	5.1	5.8	7.2	267	7.7	8.5	9.9
01 Jun–07 Jun	286	5.0	5.9	7.1	119	7.8	8.8	10.3
08 Jun–14 Jun	55	5.7	6.3	7.3	58	8.6	9.4	10.6

Table 34. Migration rate statistics for juvenile Snake River steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2007. Abbreviations: LGR–Lower Granite Dam; LGO–Little Goose Dam; LMO–Lower Monumental Dam; MCN–McNary Dam; BON–Bonneville Dam; N-Number of fish on which statistics are based; Med.–Median.

	LGR to LGO (km/d)				LGO to LMO (km/d)				LMO to MCN (km/d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	158	5.7	8.3	10.2	14	6.9	17.2	23.1	4	23.8	25.5	28.4
13 Apr–19 Apr	951	9.5	13.2	16.7	30	8.2	16.1	20.7	9	19.7	23.1	27.9
20 Apr–26 Apr	1,652	8.9	12.0	15.0	87	10.0	17.4	22.8	42	22.5	31.5	36.5
27 Apr–03 May	2,383	7.6	12.1	17.0	194	15.5	24.6	38.0	118	33.4	39.8	47.6
04 May–10 May	4,667	10.4	15.2	19.2	745	19.2	30.5	41.8	170	34.0	39.8	46.7
11 May–17 May	2,932	12.1	15.2	20.3	705	22.9	35.7	47.9	81	45.1	58.0	69.2
18 May–24 May	3,709	17.8	22.2	26.0	1,693	25.7	38.7	47.9	412	44.6	53.8	60.7
25 May–31 May	2,845	17.9	20.8	23.3	1,180	24.2	40.4	52.3	203	49.4	62.0	72.1
01 Jun–07 Jun	1,480	17.7	21.0	24.1	659	27.4	44.2	54.1	153	48.2	59.2	71.3
08 Jun–14 Jun	427	17.1	19.7	22.5	74	33.1	42.6	50.5	9	33.6	46.1	62.6

	LGR to MCN (km/d)				LGR to BON (km/d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%
06 Apr–12 Apr	24	13.1	15.9	20.3	54	15.3	21.1	24.7
13 Apr–19 Apr	189	14.1	17.3	21.5	583	21.1	23.8	27.4
20 Apr–26 Apr	700	16.5	20.4	22.9	1,315	25.0	28.2	31.2
27 Apr–03 May	1,328	20.6	24.2	27.8	1,586	31.4	35.8	39.0
04 May–10 May	1,039	23.7	28.0	32.0	781	34.1	39.1	43.1
11 May–17 May	411	27.3	32.8	43.6	439	40.7	46.9	53.5
18 May–24 May	844	30.0	36.0	42.4	505	46.7	53.0	60.8
25 May–31 May	490	31.4	38.5	43.8	267	46.6	54.0	59.9
01 Jun–07 Jun	286	31.7	38.3	44.6	119	44.8	52.4	58.8
08 Jun–14 Jun	55	30.9	35.5	39.4	58	43.3	48.9	53.6

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

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr–26 Apr	48	4.9	6.4	10.7	9	1.9	2.0	2.7	60	6.0	7.1	7.9
27 Apr–03 May	206	4.1	5.6	7.5	53	1.5	1.7	1.9	403	5.4	6.0	7.0
04 May–10 May	736	3.0	3.8	4.8	207	1.4	1.5	1.7	1,154	4.1	4.7	5.2
11 May–17 May	521	3.0	3.5	4.5	70	1.1	1.3	1.5	580	3.7	4.2	4.8
18 May–24 May	532	2.1	2.9	3.8	42	1.0	1.1	1.2	223	3.2	3.5	3.9
25 May–31 May	419	2.2	3.0	4.2	16	1.1	1.1	1.3	76	3.3	3.7	4.0
01 Jun–07 Jun	221	2.1	2.9	3.9	21	1.1	1.2	1.4	79	3.3	3.7	4.5
08 Jun–14 Jun	77	2.4	2.9	3.9	6	1.3	1.4	1.7	34	3.2	3.7	4.8
15 Jun–21 Jun	14	2.1	2.6	3.3	2	1.4	1.6	1.8	20	3.5	3.7	4.6

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

	McNary to John Day Dam (d)				John Day to Bonneville Dam (d)				McNary to Bonneville Dam (d)			
Date at LGR	N	20%	Med.	80%	N	20%	Med.	80%	N	20%	Med.	80%
20 Apr–26 Apr	48	11.5	19.2	24.9	9	42.0	56.2	58.2	60	29.9	33.2	39.1
27 Apr–03 May	206	16.5	21.8	29.7	53	59.8	66.5	75.3	403	33.6	39.4	43.4
04 May–10 May	736	25.4	31.9	40.6	207	66.9	75.3	83.7	1,154	45.0	50.0	57.8
11 May–17 May	521	27.4	35.3	41.4	70	74.8	85.0	98.3	580	49.2	55.5	63.1
18 May–24 May	532	31.9	42.9	58.3	42	92.6	100.9	109.7	223	59.9	66.5	72.8
25 May–31 May	419	29.4	40.7	55.2	16	85.6	101.8	105.6	76	58.3	64.0	70.7
01 Jun–07 Jun	221	31.9	42.9	57.2	21	83.7	95.0	106.6	79	52.8	63.6	72.0
08 Jun–14 Jun	77	31.6	42.1	50.4	6	65.3	79.0	86.3	34	48.9	63.8	72.6
15 Jun–21 Jun	14	37.7	47.1	59.4	2	63.5	70.6	79.6	20	51.0	63.4	68.0

Table 37. Number of PIT–tagged hatchery steelhead released at Lower Granite Dam by day for survival estimates in 2008. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost tags	Release date	Number released	Mortalities	Lost tags
9–Apr	122	-	-	29–May	263	-	-
10–Apr	196	-	-	30–May	259	-	-
16–Apr	514	2	-	31–May	220	-	-
17–Apr	693	3	-	3–Jun	132	1	-
23–Apr	2,646	4	2	4–Jun	131	-	-
24–Apr	986	-	-	5–Jun	130	-	-
30–Apr	1,500	1	-	6–Jun	129		
1-May	994	1	-	7–Jun	128	-	-
2–May	72	-	-	10–Jun	80	-	-
3–May	1,121	2	-	11–Jun	81	1	-
7–May	1,161	-	-	12–Jun	80	-	-
8–May	455	-	-	13–Jun	83	1	-
9–May	637	1	-	14–Jun	78		
10–May	876	-	-				
13–May	940	1	-				
15–May	928	-	-				
17–May	779	-	-				
21–May	693	1	-				
22–May	346	-	-				
23–May	249	-	-				
24–May	557	1	-				
28–May	306	-	-	Total	18,565	20	2

Table 38. Number of PIT–tagged wild steelhead released at Lower Granite Dam by day for survival estimates in 2008. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost tags	Release date	Number released	Mortalities	Lost tags
9–Apr	1	-	-	29–May	918	-	-
10–Apr	2	-	-	30–May	1,116	-	-
16–Apr	8	-	-	31–May	1,027	-	-
17–Apr	51	-	-	3–Jun	503	-	-
23–Apr	415	1	-	4–Jun	539	-	-
24–Apr	198	-	1	5–Jun	317	-	-
30–Apr	128	-	-	6–Jun	360		
1-May	151	-	-	7–Jun	477	-	1
2–May	358	-	-	10–Jun	167	-	-
3–May	197	-	-	11–Jun	262	-	-
7–May	735	-	-	12–Jun	148	-	-
8–May	302	-	-	13–Jun	195	-	-
9–May	377	-	-	14–Jun	136	-	-
10–May	231	-	-				
13–May	334	-	-				
15–May	360	-	-				
17–May	520	-	-				
21–May	1,584	-	-				
22–May	968	-	1				
23–May	962	-	-				
24–May	949	-	-				
28–May	995	-	1	Total	15,991	1	4

Table 39. Number of PIT–tagged wild yearling Chinook salmon released at Lower Granite Dam by day for survival estimates in 2008. Also included are tagging mortalities and lost tags by date.

Release date	Number released	Mortalities	Lost Tags	Release date	Number released	Mortalities	Lost tags
9–Apr	97	-	-	29–May	141	-	-
10–Apr	76	-	-	30–May	263	-	-
16–Apr	182	-	-	31–May	158	1	-
17–Apr	152	-	2	3–Jun	169	-	-
23–Apr	112	-	-	4–Jun	273	-	-
24–Apr	150	1	-	5–Jun	276	-	-
30–Apr	118	-	-	6–Jun	318	-	-
1-May	453	1	-	7–Jun	75	-	-
2–May	814	1	-	10–Jun	-	-	-
3–May	733	3	-	11–Jun	-	-	-
7–May	868	-	-	12–Jun	-	-	-
8–May	677	-	-	13–Jun	-	-	-
9–May	503	-	-	14–Jun	-	-	-
10–May	327	-	-				
13–May	172	1	-				
15–May	463	-	-				
17–May	224	-	-				
21–May	523	2	-				
22–May	533	2	-				
23–May	171	4	-				
24–May	475	2	-				
28–May	218	-	-	Total	9,714	18	2

Table 40. Estimated survival for yearling Chinook salmon from selected Snake River Basin hatcheries to the tailrace of Lower Granite Dam, 1993–2008. Distance (km) from each hatchery to Lower Granite Dam in parentheses in header. Standard errors in parentheses following each survival estimate.

Year	Dworshak (116)	Kooskia (176)	Lookingglass* (209)	Rapid River (283)	McCall (457)	Pahsimeroi (630)	Sawtooth (747)	Mean
1993	0.647 (0.028)	0.689 (0.047)	0.660 (0.025)	0.670 (0.017)	0.498 (0.017)	0.456 (0.032)	0.255 (0.023)	0.554 (0.060)
1994	0.778 (0.020)	0.752 (0.053)	0.685 (0.021)	0.526 (0.024)	0.554 (0.022)	0.324 (0.028)	0.209 (0.014)	0.547 (0.081)
1995	0.838 (0.034)	0.786 (0.024)	0.617 (0.015)	0.726 (0.017)	0.522 (0.011)	0.316 (0.033)	0.230 (0.015)	0.576 (0.088)
1996	0.776 (0.017)	0.744 (0.010)	0.567 (0.014)	0.588 (0.007)	0.531 (0.007)	—	0.121 (0.017)	0.555 (0.096)
1997	0.576 (0.017)	0.449 (0.034)	0.616 (0.017)	0.382 (0.008)	0.424 (0.008)	0.500 (0.008)	0.508 (0.037)	0.494 (0.031)
1998	0.836 (0.006)	0.652 (0.024)	0.682 (0.006)	0.660 (0.004)	0.585 (0.004)	0.428 (0.021)	0.601 (0.033)	0.635 (0.046)
1999	0.834 (0.011)	0.653 (0.031)	0.668 (0.009)	0.746 (0.006)	0.649 (0.008)	0.584 (0.035)	0.452 (0.019)	0.655 (0.045)
2000	0.841 (0.009)	0.734 (0.027)	0.688 (0.011)	0.748 (0.007)	0.689 (0.010)	0.631 (0.062)	0.546 (0.030)	0.697 (0.035)
2001	0.747 (0.002)	0.577 (0.019)	0.747 (0.003)	0.689 (0.002)	0.666 (0.002)	0.621 (0.016)	0.524 (0.023)	0.653 (0.032)
2002	0.819 (0.011)	0.787 (0.036)	0.667 (0.012)	0.755 (0.003)	0.592 (0.006)	0.678 (0.053)	0.387 (0.025)	0.669 (0.055)
2003	0.720 (0.008)	0.560 (0.043)	0.715 (0.012)	0.691 (0.007)	0.573 (0.006)	0.721 (0.230)	0.595 (0.149)	0.654 (0.028)
2004	0.821 (0.003)	0.769 (0.017)	0.613 (0.004)	0.694 (0.003)	0.561 (0.002)	0.528 (0.017)	0.547 (0.018)	0.648 (0.044)
2005	0.823 (0.003)	0.702 (0.021)	0.534 (0.004)	0.735 (0.002)	0.603 (0.003)	0.218 (0.020)	0.220 (0.020)	0.549 (0.092)
2006	0.853 (0.007)	0.716 (0.041)	0.639 (0.014)	0.764 (0.004)	0.634 (0.006)	0.262 (0.024)	0.651 (0.046)	0.645 (0.071)
2007	0.817 (0.007)	0.654 (0.015)	0.682 (0.010)	0.748 (0.004)	0.554 (0.007)	0.530 (0.038)	0.581 (0.015)	0.652 (0.040)
2008	0.737 (0.011)	0.631 (0.015)	0.694 (0.008)	0.801 (0.004)	0.578 (0.007)	0.447 (0.011)	0.336 (0.012)	0.603 (0.062)
Mean	**0.779 (0.019)**	**0.678 (0.023)**	**0.655 (0.014)**	**0.683 (0.026)**	**0.576 (0.017)**	**0.483 (0.039)**	**0.423 (0.043)**	**0.612 (0.014)**

* Released at Imnaha River Weir.

Table 41. Annual weighted means of survival probability estimates for yearling Chinook salmon (hatchery and wild combined), 1993–2008. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.828 (0.013)	0.854 (0.012)						
1994	0.935 (0.023)	0.830 (0.009)	0.847 (0.010)					
1995	0.905 (0.010)	0.882 (0.004)	0.925 (0.008)	0.876 (0.038)	0.936			
1996	0.977 (0.025)	0.926 (0.006)	0.929 (0.011)	0.756 (0.033)	0.870			
1997	NA	0.942 (0.018)	0.894 (0.042)	0.798 (0.091)	0.893			
1998	0.925 (0.009)	0.991 (0.006)	0.853 (0.009)	0.915 (0.011)	0.957	0.822 (0.033)		
1999	0.940 (0.009)	0.949 (0.002)	0.925 (0.004)	0.904 (0.007)	0.951	0.853 (0.027)	0.814 (0.065)	0.902
2000	0.929 (0.014)	0.938 (0.006)	0.887 (0.009)	0.928 (0.016)	0.963	0.898 (0.054)	0.684 (0.128)	0.827
2001	0.954 (0.015)	0.945 (0.004)	0.830 (0.006)	0.708 (0.007)	0.841	0.758 (0.024)	0.645 (0.034)	0.803
2002	0.953 (0.022)	0.949 (0.006)	0.980 (0.008)	0.837 (0.013)	0.915	0.907 (0.014)	0.840 (0.079)	0.917
2003	0.993 (0.023)	0.946 (0.005)	0.916 (0.011)	0.904 (0.017)	0.951	0.893 (0.017)	0.818 (0.036)	0.904
2004	0.893 (0.009)	0.923 (0.004)	0.875 (0.012)	0.818 (0.018)	0.904	0.809 (0.028)	0.735 (0.092)	0.857
2005	0.919 (0.015)	0.919 (0.003)	0.886 (0.006)	0.903 (0.010)	0.950	0.772 (0.029)	1.028 (0.132)	1.014
2006	0.952 (0.011)	0.923 (0.003)	0.934 (0.004)	0.887 (0.008)	0.942	0.881 (0.020)	0.944 (0.030	0.972
2007	0.943 (0.028)	0.938 (0.006)	0.957 (0.010)	0.876 (0.012)	0.936	0.920 (0.016)	0.824 (0.043)	0.908
2008	0.992 (0.018)	0.939 (0.006)	0.950 (0.011)	0.878 (0.016)	0.937	1.073 (0.058)	0.558 (0.082)	0.750
Mean	**0.936 (0.011)**	**0.925 (0.010)**	**0.906 (0.011)**	**0.856 (0.017)**	**0.925**	**0.871 (0.026)**	**0.789 (0.044)**	**0.885**

Table 42. Annual weighted means of survival probability estimates for steelhead (hatchery and wild combined), 1993–2008. Standard errors in parentheses. Reaches with asterisks comprise two dams and reservoirs (i.e., two projects); the following column gives the square root (i.e., geometric mean) of the two–project estimate to facilitate comparison with other single–project estimates. Simple arithmetic means across all years, and across all years excluding 2001 are given. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; Little Goose–Little Goose Dam; LMO–Lower Monumental Dam; IHR–Ice Harbor Dam; MCN–McNary Dam; JDA–John Day Dam; TDA–The Dalles Dam; BON–Bonneville Dam.

Year	Trap–LGR	LGR–LGO	LGO–LMO	LMO–MCN*	LMO–IHR IHR–MCN	MCN–JDA	JDA–BON*	JDA–TDA TDA–BON
1993	0.905 (0.006)							
1994	NA	0.844 (0.011)	0.892 (0.011)					
1995	0.945 (0.008)	0.899 (0.005)	0.962 (0.011)	0.858 (0.076)	0.926			
1996	0.951 (0.015)	0.938 (0.008)	0.951 (0.014)	0.791 (0.052)	0.889			
1997	0.964 (0.015)	0.966 (0.006)	0.902 (0.020)	0.834 (0.065)	0.913			
1998	0.924 (0.009)	0.930 (0.004)	0.889 (0.006)	0.797 (0.018)	0.893	0.831 (0.031)	0.935 (0.103)	0.967
1999	0.908 (0.011)	0.926 (0.004)	0.915 (0.006)	0.833 (0.011)	0.913	0.920 (0.033)	0.682 (0.039)	0.826
2000	0.964 (0.013)	0.901 (0.006)	0.904 (0.009)	0.842 (0.016)	0.918	0.851 (0.045)	0.754 (0.045)	0.868
2001	0.911 (0.007)	0.801 (0.010)	0.709 (0.008)	0.296 (0.010)	0.544	0.337 (0.025)	0.753 (0.063)	0.868
2002	0.895 (0.015)	0.882 (0.011)	0.882 (0.018)	0.652 (0.031)	0.807	0.844 (0.063)	0.612 (0.098)	0.782
2003	0.932 (0.015)	0.947 (0.005)	0.898 (0.012)	0.708 (0.018)	0.841	0.879 (0.032)	0.630 (0.066)	0.794
2004	0.948 (0.004)	0.860 (0.006)	0.820 (0.014)	0.519 (0.035)	0.720	0.465 (0.078)	NA	NA
2005	0.967 (0.004)	0.940 (0.004)	0.867 (0.009)	0.722 (0.023)	0.850	0.595 (0.040)	NA	NA
2006	0.920 (0.013)	0.956 (0.004)	0.911 (0.006)	0.808 (0.017)	0.899	0.795 (0.045)	0.813 (0.083)	0.902
2007	1.016 (0.026)	0.887 (0.009)	0.911 (0.022)	0.852 (0.030)	0.923	0.988 (0.098)	0.579 (0.059)	0.761
2008	0.995 (0.018)	0.935 (0.007)	0.961 (0.014)	0.776 (0.017)	0.881	0.950 (0.066)	0.742 (0.045)	0.861
Mean	**0.943 (0.009)**	**0.907 (0.012)**	**0.892 (0.016)**	**0.735 (0.042)**	**0.851**	**0.769 (0.063)**	**0.722 (0.037)**	**0.848**

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), 1997–2008. Standard errors in parentheses. Abbreviations: Trap–Snake River Trap; LGR–Lower Granite Dam; BON–Bonneville Dam.

	Yearling Chinook Salmon			Steelhead		
Year	Trap–LGR	LGR–BON	Trap–BON	Trap–LGR	LGR–BON	Trap–BON
1997	NA	NA	NA	0.964 (0.015)	0.474 (0.069)	0.457 (0.067)
1998	0.925 (0.009)	NA	NA	0.924 (0.009)	0.500 (0.054)	0.462 (0.050)
1999	0.940 (0.009)	0.557 (0.046)	0.524 (0.043)	0.908 (0.011)	0.440 (0.018)	0.400 (0.016)
2000	0.929 (0.014)	0.486 (0.093)	0.452 (0.087)	0.964 (0.013)	0.393 (0.034)	0.379 (0.032)
2001	0.954 (0.015)	0.279 (0.016)	0.266 (0.015)	0.911 (0.007)	0.042 (0.003)	0.038 (0.003)
2002	0.953 (0.022)	0.578 (0.060)	0.551 (0.057)	0.895 (0.015)	0.262 (0.050)	0.234 (0.045)
2003	0.993 (0.023)	0.532 (0.023)	0.528 (0.023)	0.932 (0.015)	0.309 (0.011)	0.288 (0.011)
2004	0.893 (0.009)	0.395 (0.050)	0.353 (0.045)	0.948 (0.004)	NA	NA
2005	0.919 (0.015)	0.577 (0.068)	0.530 (0.063)	0.967 (0.004)	NA	NA
2006	0.952 (0.011)	0.643 (0.017)	0.612 (0.016)	0.920 (0.013)	0.455 (0.056)	0.418 (0.052)
2007	0.943 (0.028)	0.597 (0.035)	0.563 (0.037)	1.016 (0.026)	0.364 (0.045)	0.369 (0.047)
2008	0.992 (0.018)	0.465 (0.052)	0.461 (0.052)	0.995 (0.018)	0.480 (0.026)	0.478 (0.028)

Table 44. Estimated survival and detection probabilities for Snake River yearling Chinook salmon (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

		Survival probability		
Date at Lower Granite	Number released	Lower Monumental to Ice Harbor Dam	Ice Harbor to McNary Dam	Detection probability Ice Harbor Dam
06 Apr–12 Apr	395	1.579 (0.386)	0.607 (0.164)	0.098 (0.027)
13 Apr–19 Apr	1,834	1.268 (0.155)	0.688 (0.089)	0.099 (0.013)
20 Apr–26 Apr	5,121	0.845 (0.041)	1.070 (0.058)	0.177 (0.009)
27 Apr–03 May	20,544	0.946 (0.024)	0.935 (0.027)	0.144 (0.004)
04 May–10 May	26,631	0.938 (0.032)	0.931 (0.035)	0.105 (0.004)
11 May–17 May	21,230	0.921 (0.033)	0.843 (0.046)	0.139 (0.005)
18 May–24 May	4,611	0.929 (0.050)	0.910 (0.074)	0.180 (0.011)
25 May–31 May	1,185	0.778 (0.069)	1.110 (0.133)	0.163 (0.018)
01 Jun–07 Jun	993	0.963 (0.117)	1.224 (0.230)	0.138 (0.020)
Weighted mean*		**0.931 (0.025)**	**0.938 (0.028)**	**0.131 (0.008)**

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

Table 45. Estimated survival and detection probabilities for Snake River Steelhead (hatchery and wild combined) detected and released to or PIT tagged and released to the tailrace at Lower Granite Dam in 2008. Daily groups pooled weekly. Estimates based on the single–release model. Standard errors in parentheses.

Date at Lower Granite Dam	Number released	Survival probability: Lower Monumental to Ice Harbor Dam	Survival probability: Ice Harbor Dam to McNary Dam	Detection probability Ice Harbor Dam
06 Apr–12 Apr	336	0.652 (0.377)	1.239 (0.709)	0.022 (0.015)
13 Apr–19 Apr	2,790	1.605 (0.495)	0.581 (0.171)	0.011 (0.004)
20 Apr–26 Apr	6,436	0.930 (0.093)	0.983 (0.084)	0.042 (0.004)
27 Apr–03 May	9,433	0.973 (0.055)	0.865 (0.045)	0.096 (0.005)
04 May–10 May	9,397	0.961 (0.046)	0.812 (0.047)	0.162 (0.007)
11 May–17 May	6,635	0.880 (0.048)	0.881 (0.070)	0.158 (0.009)
18 May–24 May	8,200	0.920 (0.027)	0.817 (0.040)	0.254 (0.009)
25 May–31 May	5,568	0.930 (0.053)	0.752 (0.060)	0.144 (0.009)
01 Jun–07 Jun	2,494	0.812 (0.069)	0.769 (0.088)	0.162 (0.016)
08 Jun–14 Jun	918	1.031 (0.306)	0.583 (0.201)	0.079 (0.023)
Weighted mean*		**0.926 (0.019)**	**0.836 (0.022)**	**0.074 (0.023)**

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

Table 46. Average survival estimates (with standard errors in parentheses) from McNary Dam tailrace to Bonneville Dam tailrace for various spring–migrating salmonid stocks (hatchery and wild combined) in 2008. For each reach, the survival estimate represents either a weighted average of weekly estimates (indicated by *), or a single seasonal estimate for pooled release cohorts. Number released for single pooled estimates (no asterisk) is from points above McNary. Dam release sites are in tailraces. Abbreviations: Sp–spring Chinook salmon; Sp–Su–spring/summer; S–F–summer/fall Chinook salmon.

			Survival estimates (standard errors)		
Stock	Release location	Number released	McNary to John Day Dam	John Day to Bonneville Dam	McNary to Bonneville Dam
Snake R. Chinook (Sp–Su)*	McNary Dam Tailrace	51,203*	1.073 (0.058)	0.558 (0.082)	0.594 (0.066)
U. Columbia Chinook (S–F)	Upper Columbia sites[a]	61,840	1.112 (0.053)	0.583 (0.095)	0.648 (0.102)
U. Columbia Chinook (S–F)	Yakima River sites[b]	51,922	1.016 (0.047)	0.584 (0.071)	0.593 (0.069)
Upper Columbia Coho	Upper Columbia sites	29,784	1.152 (0.077)	1.065 (0.268)	1.227 (0.303)
Upper Columbia Coho	Yakima River sites	18,342	1.204 (0.133)	0.858 (0.245)	1.033 (0.282)
Upper Columbia Sockeye	Upper Columbia sites	5,077	1.071 (0.196)	0.529 (0.232)	0.567 (0.237)
Snake River Steelhead*	McNary Dam Tailrace	14,783*	0.950 (0.066)	0.742 (0.045)	0.671 (0.034)
Upper Columbia Steelhead	Upper Columbia sites	59,405	1.160 (0.056)	0.928 (0.148)	1.077 (0.168)

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

Table 47. Percentage of PIT–tagged smolts (wild and hatchery combined) detected at Lower Monumental Dam later detected on McNary pool bird colonies, 1998-2008.

Year	Yearling Chinook salmon	Steelhead
1998	0.49	4.20
1999	0.90	4.51
2000	0.98	3.66
2001	5.59	21.06
2002	1.62	10.09
2003[a]	1.06	3.71
2004[b]	2.08	19.42
2005	1.37	9.15
2006	0.92	4.81
2007	0.80	3.59
2008	1.20	4.63

[a] Only Crescent Island Caspian tern colony sampled.

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

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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 2008 (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 detection probability (e.g., propensity to be guided by bypass screens); differential mortality between the passage route that is monitored for PIT tags (juvenile collection system) and those that are not (spillways and turbines); behavioral responses to bypass and detection; and differences in passage timing for detected and non-detected fish if such differences result in exposure to different conditions downstream. Using detection information, inherent differences and behavioral responses are virtually indistinguishable. Conceptually, we make the distinction that inherent traits are those that characterized the fish before any hydrosystem experience, while behavioral responses occur as a result of particular hydrosystem experiences. For example, developing a preference for a particular passage route is a behavioral response, while size-related differences in passage-route selection are inherent. Of course, response to passage experience may also depend on inherent characteristics.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

and the second is Test 3.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 2008 there were more significant ($\alpha = 0.05$) tests than expected by chance alone for steelhead, but not yearling Chinook salmon (Appendix Table 1). There were 9 weekly groups of yearling Chinook salmon. For these, the overall sum of the χ^2 test statistics was significant 1 time. For 10 steelhead groups, the overall test was significant 8 times. Counting all individual component tests (i.e., 2.C2, 3.SR3, etc.), 2 tests of 45 (4%) were significant for yearling Chinook salmon and 11 of 50 (22%) were significant for steelhead (Appendix Tables 1-3).

We diagnosed the patterns in the contingency tables that led to significant tests and results were similar to those we reported in past years: in 12 of the 14 significant cases (individual component tests) for Lower Granite Dam groups of yearling Chinook salmon and steelhead, and in all of the most highly significant cases, there was evidence that fish previously detected were more likely to be detected again at downstream dams.

Significant contingency table test results were far less common for weekly groups from McNary Dam (Appendix Tables 4-6). For yearling Chinook salmon, there were 2 significant tests out of the 11 individual component tests, and for steelhead none of the 10 component tests were significant.

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 2008, 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 2008 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.

Another possibility is that correlated changes in spill levels at adjacent dams during passage of a cohort resulted in correlated detection probabilities within subsets of the cohort. For example, suppose that spill is high (spill passage high and detection probability low) at both Little Goose Dam and Lower Monumental Dam while the first half of a cohort is passing those dams, and then spill is low (detection probability high) at both dams while the second half of the cohort passes. In this case, fish detected at Little Goose Dam will be more likely detected at Lower Monumental than those not detected at Little Goose Dam. Correlation among spill proportions across the season at the Snake River dams combined with greater propensity for steelhead to pass through spillways suggest that this phenomenon could help explain the frequent significant contingency table tests for steelhead in the Snake River.

Although the contingency table tests described here do well at detecting most violations of CJS model assumptions, there are instances where assumptions could be violated without resulting in significant tests. A specific example is that of acute differential post-detection mortality, where detected and nondetected fish have a difference in mortality in the period between the detection point of interest and the next detection point. This would violate assumption A3, but the violation is not detectable because all the tests described here condition on known fates of fish either at the site of interest or sites downstream. Detection of differential post-detection mortality requires knowledge of the fate of individual nondetected fish in the tailrace of the detection dam of interest and downstream. The fate of fish not detected at the site of interest is only known for those fish detected again downstream, and not for those never detected again. Therefore, none of the assumptions tests described here can detect differential post-detection mortality that between two adjacent detection sites.

Results in previous years (e.g., Zabel et al. 2002) led 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. We believe this is true again in 2008 for the estimates in Snake River reaches. However, questions remain regarding the survival estimates for Chinook salmon from McNary to Bonneville. The survival estimates observed for that group have a low probability of occurrence in the absence of an assumption violation. We suspect that differential post-detection mortality may have occurred but we lack supporting evidence because there is no way to detect such mortality in the data.

Appendix Table 1. Number of tests of goodness of fit to the single release model conducted for weekly release groups of yearling Chinook salmon and steelhead (hatchery and wild combined) from Lower Granite Dam, and number of significant ($\alpha = 0.05$) test results, 2008.

	Test 2.C2		Test 2.C3		Test 3.SR3		Test 3.Sm3		Test 3.SR4		Test 2 sum		Test 3 sum		**Test 2 + 3**	
Species	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	No.	sig.	**No.**	**sig.**
Chinook	9	1	9	1	9	0	9	0	9	1	9	1	9	0	**9**	**1**
Steelhead	10	8	10	2	10	0	10	1	10	0	10	7	10	0	**10**	**8**
Total	19	9	19	3	19	0	19	1	19	1	19	8	19	0	**19**	**9**

Appendix Table 2. Results of tests of goodness of fit to the single release model for release groups of yearling Chinook salmon (hatchery and wild) from Lower Granite to McNary Dam in 2008.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	5.45	0.49	0.99	0.80	0.98	0.61	0.01	0.92
13 Apr–19 Apr	5.76	0.45	2.06	0.56	1.91	0.39	0.15	0.70
20 Apr–26 Apr	6.65	0.36	2.97	0.40	2.30	0.32	0.67	0.42
27 Apr–03 May	5.00	0.54	3.76	0.29	3.47	0.18	0.28	0.59
04 May–10 May	21.21	0.002	19.17	<0.001	8.97	0.01	10.20	0.001
11 May–17 May	6.57	0.36	0.67	0.88	0.35	0.84	0.32	0.57
18 May–24 May	10.71	0.10	4.44	0.22	2.99	0.22	1.45	0.23
25 May–31 May	7.15	0.31	1.62	0.66	1.60	0.45	0.02	0.89
01 Jun–07 Jun	4.18	0.65	0.77	0.86	0.51	0.77	0.26	0.61
Total (df)	72.68 (54)	0.046	36.45 (27)	0.11	23.09 (18)	0.19	13.36 (9)	0.15

Appendix Table 2. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	4.46	0.22	0.07	0.79	0.23	0.63	4.16	0.041
13 Apr–19 Apr	3.71	0.30	0.35	0.56	0.31	0.58	3.04	0.081
20 Apr–26 Apr	3.68	0.30	0.81	0.37	0.63	0.43	2.23	0.14
27 Apr–03 May	1.24	0.74	0.30	0.58	0.02	0.89	0.92	0.34
04 May–10 May	2.04	0.56	0.30	0.59	1.74	0.19	0.01	0.95
11 May–17 May	5.90	0.12	5.29	0.02	0.08	0.78	0.54	0.46
18 May–24 May	6.27	0.10	2.38	0.12	3.48	0.06	0.42	0.52
25 May–31 May	5.54	0.14	1.23	0.27	2.52	0.11	1.79	0.18
01 Jun–07 Jun	3.41	0.33	1.70	0.19	0.04	0.84	1.67	0.20
Total (df)	36.23 (27)	0.11	12.42 (9)	0.19	9.05 (9)	0.43	14.77 (9)	0.10

Appendix Table 3. Results of tests of goodness of fit to the single release model for release groups of juvenile steelhead (hatchery and wild) from Lower Granite to McNary Dam in 2008.

	Overall		Test 2		Test 2.C2		Test 2.C3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	15.82	0.007	12.30	0.006	6.82	0.033	5.48	0.019
13 Apr–19 Apr	12.77	0.047	10.91	0.012	10.06	0.007	0.85	0.36
20 Apr–26 Apr	35.68	<0.001	34.51	<0.001	28.13	<0.001	6.38	0.012
27 Apr–03 May	31.76	<0.001	31.01	<0.001	27.45	<0.001	3.56	0.059
04 May–10 May	13.20	0.040	7.14	0.068	6.76	0.034	0.38	0.54
11 May–17 May	44.01	<0.001	41.18	<0.001	40.98	<0.001	0.20	0.66
18 May–24 May	24.30	<0.001	19.31	<0.001	18.37	<0.001	0.94	0.33
25 May–31 May	18.46	0.005	12.12	0.007	10.99	0.004	1.13	0.29
01 Jun–07 Jun	8.97	0.18	5.51	0.14	3.28	0.19	2.23	0.14
08 Jun–14 Jun	2.46	0.87	0.37	0.95	0.06	0.97	0.32	0.57
Total (df)	207.42 (59)	<0.001	174.36 (30)	<0.001	152.90 (20)	<0.001	21.46 (10)	0.018

Appendix Table 3. Continued.

	Test 3		Test 3.SR3		Test 3.Sm3		Test 3.SR4	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
06 Apr–12 Apr	3.52	0.17	1.05	0.31	NA	NA	2.47	0.12
13 Apr–19 Apr	1.86	0.60	0.52	0.47	0.16	0.69	1.19	0.28
20 Apr–26 Apr	1.17	0.76	0.01	0.94	0.06	0.81	1.10	0.29
27 Apr–03 May	0.75	0.86	0.74	0.39	0.00	0.97	0.01	0.95
04 May–10 May	6.06	0.11	0.27	0.60	3.62	0.057	2.16	0.14
11 May–17 May	2.83	0.42	0.23	0.64	1.87	0.17	0.73	0.39
18 May–24 May	4.99	0.17	1.90	0.17	3.03	0.082	0.07	0.79
25 May–31 May	6.34	0.10	0.37	0.54	5.88	0.015	0.09	0.77
01 Jun–07 Jun	3.46	0.33	0.36	0.55	2.06	0.15	1.04	0.31
08 Jun–14 Jun	2.09	0.56	1.47	0.23	0.47	0.49	0.15	0.70
Total (df)	33.06 (29)	0.28	6.91 (10)	0.73	17.14 (9)	0.047	9.01 (10)	0.53

Appendix Table 4. Number of tests of goodness of fit to the single release model conducted for weekly release groups of yearling Chinook salmon and steelhead (hatchery and wild combined) from McNary Dam, and number of significant ($\alpha = 0.05$) test results, 2008.

	Test 2.C2		Test 3.SR3		Test 2 + 3	
Species	No.	sig.	No.	sig.	No.	sig.
Chinook	7	1	4	1	7	1
Steelhead	6	0	4	0	6	0
Total	13	1	8	1	13	1

Appendix Table 5. Results of tests of goodness of fit to the single release model for release groups of yearling Chinook salmon (hatchery and wild) from McNary to Bonneville Dam in 2008.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
27 Apr–03 May	2.28	0.32	0.30	0.59	1.99	0.16
04 May–10 May	8.85	0.012	8.57	0.003	0.28	0.60
11 May–17 May	2.19	0.34	0.02	0.89	2.17	0.14
18 May–24 May	1.21	0.55	0.95	0.33	0.26	0.61
25 May–31 May	0.11	0.74	0.11	0.74	NA	NA
01 Jun–07 Jun	0.05	0.83	0.05	0.83	NA	NA
08 Jun–14 Jun	0.00	0.95	0.00	0.95	NA	NA
Total (df)	14.69 (11)	0.20	9.99 (7)	0.19	4.69 (4)	0.32

Appendix Table 6. Results of tests of goodness of fit to the single release model for release groups of steelhead (hatchery and wild) from McNary to Bonneville Dam in 2008.

	Overall		Test 2.C2		Test 3.SR3	
Release	χ^2	*P* value	χ^2	*P* value	χ^2	*P* value
20 Apr–26 Apr	NA	NA	NA	NA	NA	NA
27 Apr–03 May	0.62	0.73	0.59	0.45	0.04	0.85
04 May–10 May	1.98	0.37	1.87	0.17	0.11	0.74
11 May–17 May	2.39	0.30	1.13	0.29	1.26	0.26
18 May–24 May	2.51	0.11	2.51	0.11	NA	NA
25 May–31 May	1.10	0.30	1.10	0.30	NA	NA
01 Jun–07 Jun	1.11	0.57	1.11	0.29	0.01	0.94
Total (df)	9.72 (10)	0.47	8.31 (6)	0.22	1.42 (4)	0.84