UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

October 13, 2009

MEMORANDUM FOR: F/NWR5 - Bruce Suzumoto

FROM: F/NWC3 - John W. Ferguson

SUBJECT: Preliminary survival estimates for passage during the spring migration of juvenile salmonids through Snake and Columbia River reservoirs and dams, 2009

This memorandum summarizes conditions in the Snake and Columbia Rivers and preliminary estimates of survival of PIT-tagged juvenile salmonids passing through reservoirs and dams during the 2009 spring outmigration. It contains the same data as the Memorandum dated September 14, 2009 on the same subject. However, it corrects some format issues that arose when the September 14, 2009 Memorandum was converted from Word to Adobe Acrobat and contains minor edits to the final paragraph. We also provide preliminary estimates of the proportion of Snake River smolts that were transported from Snake River dams in 2009. Our complete detailed analyses and report for the spring migration will be available by the end of the year. As in past years, changes in the database between the time of our annual summer memo and the publication of our final report may result in differences of up to 3 or 4% in estimated survival values.

Summary of Research

For survival studies funded by BPA in 2009, NOAA Fisheries PIT tagged approximately 16,860 river-run hatchery steelhead, 15,230 wild steelhead, and 13,790 wild yearling Chinook salmon for release into the tailrace of Lower Granite Dam. From studies funded by the USACE, we used about 121,000 hatchery yearling Chinook salmon PIT tagged by NOAA Fisheries at Lower Granite Dam for evaluation of "extra" or "latent" mortality related to passage through Snake River dams.

Survival estimates provided in this memorandum are derived from PIT-tag data from fish PIT tagged by or for NOAA Fisheries, as described above, along with fish PIT tagged by others within the Columbia River Basin.

For yearling Chinook salmon from Snake River Basin hatcheries, estimated survival to Lower Granite Dam tailrace has been relatively stable since 1998 (Figure 1, Table 1). Mean estimated survival was a composite of production releases from hatcheries Dworshak, Kooskia, Lookingglass/Imnaha Weir, Rapid River, McCall/Knox Bridge, Pahsimeroi, and Sawtooth and has ranged from 54.9 to 69.7% since 1998. Mean estimated survival to Lower Granite Dam tailrace for the index hatchery release groups in 2009 was 59.0%.

Estimated survival for Snake River yearling Chinook salmon (hatchery and wild combined) in 2009 was close to the 6-year average (2003-2008) in every reach (Table 2, Figures 2 and 3). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace in 2009 was 78.8% (95% CI: 77.4, 80.2%). Mean estimated survival in 2009 from McNary Dam tailrace to Bonneville Dam tailrace was 70.6% (95% CI: 63.7, 77.5%). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to Bonneville Dam tailrace in 2009 was 55.6% (95% CI: 50.1, 61.1%). Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 95.7%, based on fish PIT tagged at and released from the Snake River trap. The combined yearling Chinook salmon survival estimate from the trap to the Bonneville Dam tailrace in 2009 was 53.2% (95% CI: 47.9, 58.5%).

For Snake River steelhead (hatchery and wild combined), mean estimated survival in 2009 was higher than the 6-year average in every reach, although not all mean survival estimates were higher than previous individual years (Table 3, Figures 2 and 3). Mean estimated survival for steelhead from Lower Granite Dam tailrace to McNary Dam tailrace in 2009 was 80.0% (95% CI: 77.3, 82.7%). This estimate was higher than those in all years from 1995-2008, with statistical significance[1] in all years after 1997. Mean estimated survival in 2009 from McNary Dam tailrace to Bonneville Dam tailrace was 86.4% (95% CI: 71.5, 101.2%). The 2009 McNary-to-Bonneville estimate was higher than those from 1998-2008. Mean estimated survival from Lower Granite Dam

[1] Statistical significance informally assessed by examining whether confidence intervals overlap.

tailrace to Bonneville Dam tailrace was 69.1% (95% CI: 56.9, 81.3%), which is significantly higher than that in years after 1998. Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 100% (actual model calculation was 100.2%), based on fish PIT tagged at and released from the Snake River trap. The combined steelhead survival estimate from the trap to the Bonneville Dam tailrace in 2009 was 69.3% (95% CI: 57.0, 81.6%).

For PIT-tagged hatchery yearling Chinook salmon originating from the upper Columbia River in 2009, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 84.3% (95% CI: 63.7, 105.0%; see Table 4). This is the highest survival estimate in the historical data set for this group in the McNary to Bonneville reach (2002-2008, no estimate possible in 2005 or 2006). It is significantly higher than estimates from both 2004 and 2008.

For PIT-tagged hatchery steelhead originating from the upper Columbia River in 2009, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 72.5% (95% CI: 52.1, 92.9%; Table 5). This is also the highest point estimate we have seen for this group in the McNary to Bonneville reach (2002-2008, no estimate possible in 2002, 2006, or 2008). It is significantly higher than only that in 2007. For fish released from upper Columbia River hatcheries, we cannot estimate survival in reaches upstream from McNary Dam (other than the overall reach from release to McNary Dam tailrace) because of limited PIT-tag detection capabilities at Mid-Columbia River PUD dams.

Table 6 shows estimated survival for hatchery sockeye salmon from Snake River Basin release sites to the tailraces of Lower Granite Dam and McNary Dam for 2007-2009.

Our preliminary estimates of the proportion transported of non-tagged wild and hatchery spring-summer Chinook salmon smolts are 40% and 38%, respectively. For steelhead, the estimates are 46% and 43% for wild and hatchery smolts, respectively. These estimates represent the proportion of smolts that arrived at Lower Granite Dam that were subsequently transported, either from Lower Granite Dam or from one of the downstream collector dams. The estimates for both hatchery and wild Chinook are lower than those in 2008 and higher than those in 2007. The estimates for both hatchery and wild steelhead are lower than

those in 2008 and similar to those in 2007. The differences among years for both Chinook and steelhead are mostly due to differences in timing of the smolt migrations and differences in collection probabilities at the collector dams.

Discussion

Snake River flow volume was near average throughout April and May 2009 (Figure 4), with the exception of a surge in flow from April 20-30. Flow increased fairly steadily from early to late May. Flow in 2009 was higher than that in 2008 during April, and then was similar to that in 2008 during May. Mean spill as a percentage of flow at the Snake River Dams in 2009 was close to the average of recent years and remained fairly constant throughout the season (Figure 5). Spill percentages in 2009 were much like those in 2006 until mid-May, from which point they were more like 2007. Spill percentages in 2009 were lower than those in 2008 for most of the season. Water temperatures in the Snake River were on the low side of recent years during April, but became more similar to the average of recent years during May (Figure 6).

Operations at most dams in 2009 were similar to those in 2008. One exception occurred at Little Goose Dam which had an operating temporary spillway weir (TSW) in 2009. The removable spillway weir (RSW) at Lower Monumental Dam and the TSW at John Day Dam were in their second year of operation in 2009. Also a new spillway guidance wall at the The Dalles Dam was partially completed during winter of 2008.

Within the season, estimated survival from Lower Granite Dam to McNary Dam for daily groups of yearling Chinook remained relatively constant from early April through the end of May, except for a increase over 1-2 week period in late May (Figure 7). A series of peaks in the smolt passage index at Lower Granite corresponded with periods of increased flow. Estimated survival from Lower Granite Dam to McNary Dam for daily groups of steelhead was variable across the season (Figure 8).

The high estimated survival of steelhead through the hydropower system in 2009 is particularly noteworthy. Reaches with unusually high estimated survival were Lower Granite tailrace to Little Goose tailrace, and John Day tailrace to Bonneville tailrace. Unusually high annual estimated survival in these reaches combined with high estimated survival in other reaches

resulted in a hydropower system survival estimate of 69.3%. We can only speculate about reasons for the increased survival at this point. One possible contributing factor is the new TSW at Little Goose Dam. Assuming passage survival was higher through the TSW and steelhead were disproportionately attracted to it as a passage route, the result would be an increase in survival at Little Goose Dam. The survival estimate from Lower Granite to Little Goose in 2009 was the highest we have recorded, which suggests the TSW may have contributed. Results from a radio-telemetry study conducted there in 2009 may inform this conjecture, but results are not yet available.

Timing of steelhead smolt passage at Lower Granite Dam in 2009 was much earlier than in 2007 and 2008 (see Figure 9). By 30 April 2009, approximately 44% of the steelhead run had passed Lower Granite Dam. In contrast, only about 18% of the run had passed by the same date in both 2007 and 2008. If the yearly total smolt index counts from Figure 9 are taken as estimates of migrating population sizes, then the total number of migrating steelhead was higher in 2009 compared to 2007 and 2008. Daily survival estimates were relatively high during the early peak in the steelhead migration in 2009 (Figure 8). Because transportation did not begin in the Snake River until 1 May at Lower Granite Dam (5 May at Little Goose Dam and 8 May at Lower Monumental Dam), most of those fish were not transported, leaving a much larger number of steelhead migrating in-river in 2009 than in 2007 or 2008. As we have demonstrated in previous reports, if the total number of fish lost to predation remained relatively constant between years, years with more fish migrating downstream will lead to higher survival estimates, as the proportion of PIT-tagged fish taken by predators would decrease. Other possible factors contributing to increased steelhead survival include a reported reduction from 2008 in avian predation at John Day Dam, and the presence of the partially completed spillway guidance wall at The Dalles Dam. We will gather further supporting information from other studies conducted in 2009 before we develop a final report in late 2009.

cc: F/NWC3 - Smith
F/NWC3 – Muir
F/NWC3 – Faulkner
F/NWC3 - Zabel
F/NWC3 – Williams

Table 1. Mean estimated survival and standard error (s.e.) for yearling Chinook salmon released at Snake River Basin and Upper Columbia River hatcheries to Lower Granite Dam tailrace (LGR) and McNary Dam tailrace (MCN), 2007 through 2009.

	2007		2008		2009	
Hatchery	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)
Dworshak	0.817 (0.007)	0.662 (0.004)	0.737 (0.011)	0.534 (0.016)	0.693 (0.007)	0.539 (0.010)
Kooskia	0.654 (0.015)	0.523 (0.019)	0.631 (0.015)	0.509 (0.052)	0.628 (0.012)	0.466 (0.023)
Lookingglass (Catherine Cr.)	0.340 (0.007)	0.285 (0.009)	0.455 (0.008)	0.379 (0.028)	0.370 (0.006)	0.299 (0.013)
Lookingglass (Grande Ronde)	0.495 (0.022)	0.396 (0.024)	0.416 (0.016)	0.352 (0.050)	0.444 (0.022)	0.295 (0.036)
Lookingglass (Imnaha River)	0.682 (0.010)	0.582 (0.010)	0.694 (0.008)	0.518 (0.022)	0.698 (0.009)	0.550 (0.018)
Lookingglass (Lostine River)	0.594 (0.013)	0.482 (0.016)	0.600 (0.012)	0.480 (0.036)	0.585 (0.010)	0.476 (0.024)
McCall (Johnson Cr.)	0.319 (0.024)	0.260 (0.014)	0.330 (0.030)	0.317 (0.052)	0.309 (0.019)	0.326 (0.072)
McCall (Knox Bridge)	0.554 (0.007)	0.474 (0.006)	0.578 (0.007)	0.403 (0.013)	0.513 (0.005)	0.412 (0.008)
Rapid River	0.748 (0.004)	0.616 (0.005)	0.801 (0.004)	0.593 (0.012)	0.726 (0.005)	0.636 (0.010)
Entiat	---	0.321 (0.035)	---	---	---	---
Winthrop	---	0.492 (0.022)	---	0.574 (0.074)	---	0.372 (0.043)
Leavenworth	---	0.594 (0.011)	---	0.567 (0.022)	---	0.478 (0.020)

Table 2. Mean estimated survival and standard error (s.e.) through various reaches of the Snake and Columbia River hydropower system for yearling Chinook salmon originating in the Snake River, 2003 through 2009. Hatchery and wild fish combined.

Reach	2003	2004	2005	2006	2007	2008	Mean 2003-08	2009
Snake Trap-LGR	0.993 (0.023)	0.893 (0.009)	0.919 (0.015)	0.952 (0.011)	0.943 (0.028)	0.992 (0.018)	0.949 (0.008)	0.957 (0.010)
LGR-LGO	0.946 (0.005)	0.923 (0.004)	0.919 (0.003)	0.923 (0.003)	0.938 (0.006)	0.939 (0.006)	0.931 (0.002)	0.941 (0.007)
LGO-LMO	0.916 (0.011)	0.875 (0.012)	0.886 (0.006)	0.934 (0.004)	0.957 (0.010)	0.950 (0.011)	0.920 (0.004)	0.985 (0.011)
LMO-MCN	0.904 (0.017)	0.818 (0.018)	0.903 (0.010)	0.887 (0.008)	0.876 (0.012)	0.878 (0.016)	0.878 (0.006)	0.853 (0.014)
MCN-JD	0.893 (0.017)	0.809 (0.028)	0.772 (0.029)	0.881 (0.020)	0.920 (0.016)	1.073 (0.058)	0.891 (0.013)	0.865 (0.043)
JD-BON	0.818 (0.036)	0.735 (0.092)	1.028 (0.132)	0.944 (0.030	0.824 (0.043)	0.558 (0.082)	0.818 (0.032)	0.824 (0.045)
LGR-MCN	0.731 (0.010)	0.666 (0.011)	0.732 (0.009)	0.764 (0.007)	0.783 (0.006)	0.782 (0.011)	0.743 (0.004)	0.788 (0.007)
MCN-BON	0.728 (0.030)	0.594 (0.074)	0.788 (0.092)	0.842 (0.021)	0.763 (0.044)	0.594 (0.066)	0.718 (0.024)	0.706 (0.035)
LGR-BON	**0.532 (0.023)**	**0.395 (0.050)**	**0.577 (0.068)**	**0.643 (0.017)**	**0.597 (0.035)**	**0.465 (0.052)**	**0.535 (0.018)**	**0.556 (0.028)**
Snake Trap-BON	**0.528 (0.023)**	**0.353 (0.045)**	**0.530 (0.063)**	**0.612 (0.016)**	**0.563 (0.037)**	**0.461 (0.052)**	**0.508 (0.017)**	**0.532 (0.027)**

Table 3. Mean estimated survival and standard error (s.e.) through various reaches of the Snake and Columbia River hydropower system steelhead originating in the Snake River, 2003 through 2009. Hatchery and wild fish combined.

Reach	2003	2004	2005	2006	2007	2008	Mean 2003-08	2009
Snake Trap-LGR	0.932 (0.015)	0.948 (0.004)	0.967 (0.004)	0.920 (0.013)	1.016 (0.026)	0.995 (0.018)	0.963 (0.006)	1.002 (0.011)
LGR-LGO	0.947 (0.005)	0.860 (0.006)	0.940 (0.004)	0.956 (0.004)	0.887 (0.009)	0.935 (0.007)	0.921 (0.002)	0.977 (0.006)
LGO-LMO	0.898 (0.012)	0.820 (0.014)	0.867 (0.009)	0.911 (0.006)	0.911 (0.022)	0.961 (0.014)	0.895 (0.006)	0.937 (0.009)
LMO-MCN	0.708 (0.018)	0.519 (0.035)	0.722 (0.023)	0.808 (0.017)	0.852 (0.030)	0.776 (0.017)	0.731 (0.010)	0.870 (0.016)
MCN-JD	0.879 (0.032)	0.465 (0.078)	0.595 (0.040)	0.795 (0.045)	0.988 (0.098)	0.950 (0.066)	0.779 (0.026)	0.950 (0.026)
JD-BON	0.630 (0.066)	-----	-----	0.813 (0.083)	0.579 (0.059)	0.742 (0.045)	0.691 (0.026)	0.910 (0.080)
LGR-MCN	0.597 (0.013)	0.379 (0.023)	0.593 (0.018)	0.702 (0.016)	0.694 (0.020)	0.716 (0.015)	0.614 (0.007)	0.800 (0.014)
MCN-BON	0.518 (0.015)	-----	-----	0.648 (0.079)	0.524 (0.064)	0.671 (0.034)	0.590 (0.022)	0.864 (0.076)
LGR-BON	**0.309 (0.011)**	-----	-----	**0.455 (0.056)**	**0.364 (0.045)**	**0.480 (0.026)**	**0.402 (0.016)**	**0.691 (0.062)**
Snake Trap-BON	**0.288 (0.011)**	-----	-----	**0.418 (0.052)**	**0.369 (0.047)**	**0.478 (0.028)**	**0.388 (0.016)**	**0.693 (0.063)**

Table 4. Mean estimated survival and standard error (s.e.) through reaches of the lower Columbia River hydropower system for yearling Chinook salmon originating in the upper Columbia River, 2005 through 2009. All estimates are for hatchery fish only.

Reach	2005	2006	2007	2008	2009
Release-MCN	0.546 (0.048) [a]	0.499 (0.039) [a]	0.512 (0.050) [a]	0.503 (0.015)[b]	0.493 (0.012)
MCN-JD	0.801 (0.056)	0.861 (0.060)	0.919 (0.049)	1.200 (0.080)[b]	0.852 (0.044)
JD-BON	NA	NA	0.780 (0.166)	0.496 (0.097)[b]	0.989 (0.129)
MCN-BON	NA	NA	0.709 (0.157)	0.593 (0.112)[b]	0.843 (0.105)

a. mean of estimates for fish released from Entiat, Winthrop, and Leavenworth hatcheries.
b. pooled estimates for fish released from East Bank, Leavenworth, Wells, and Winthrop hatcheries.

Table 5. Mean estimated survival and standard error (s.e.) through reaches of the lower Columbia River hydropower system for steelhead originating in the upper Columbia River, 2005 through 2009. All estimates are for hatchery fish only.

Reach	2005	2006	2007	2008	2009
Release-MCN	0.449 (0.080)[a]	0.497 (0.057)[b]	0.467 (0.058)[c]	0.519 (0.017)[d]	0.521 (0.019)
MCN-JD	0.749 (0.047)	0.826 (0.092)	0.799 (0.038)	NA	0.799 (0.049)
JD-BON	0.755 (0.167)	NA	0.459 (0.019)	NA	0.908 (0.133)
MCN-BON	0.533 (0.119)	NA	0.392 (0.059)	NA	0.725 (0.104)

a. mean of estimates for fish from Chelan, East Bank, Ringold, Wells, and Winthrop hatcheries released at various locations.
b. mean of estimates for fish from Turtle Rock hatchery released in Chiwawa and Wenatchee rivers and in Nason Creek.
c. mean of estimates for fish from Chelan and East Bank hathceries released in the Wenatchee River and fish from Turtle Rock hatchery released in Chiwawa and Wenatchee rivers and in Nason Creek.
d. pooled estimates for fish from Winthrop hatchery, East Bank hatchery released in the Wenatchee River, and fish from Turtle Rock hatchery released in Chiwawa and Wenatchee rivers and in Nason Creek.

Table 6. Estimated survival and standard error (s.e.) for hatchery sockeye salmon from release sites in the Snake River Basin to Lower Granite Dam tailrace (LGR) and McNary Dam tailrace (MCN) for migration years 2007 through 2009.

Release Site	Release Month	2007		2008		2009	
		Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)	Survival to LGR (s.e.)	Survival to MCN (s.e.)
Alturus Lake	Sep-Oct	0.174 (0.019)	0.129 (0.023)	0.248 (0.021)	0.203 (0.068)	0.183 (0.019)	0.129 (0.033)
Pettit Lake	Sep-Oct	0.123 (0.024)	0.088 (0.042)	0.281 (0.044)	0.222 (0.139)	0.370 (0.028)	0.306 (0.108)
Redfish Lake	Sep-Oct	0.204 (0.026)	0.173 (0.040)	0.207 (0.033)	0.163 (0.068)	0.096 (0.016)	0.144 (0.132)
Redfish Lk, Cr. Trap	May	0.571 (0.070)	0.259 (0.080)	0.455 (0.038)	0.243 (0.051)	0.288 (0.020)	0.180 (0.029)
Sawtooth Trap	May	0.776 (0.133)	0.363 (0.076)	0.449 (0.074)	0.661 (0.346)	0.467 (0.006)	0.347 (0.015)

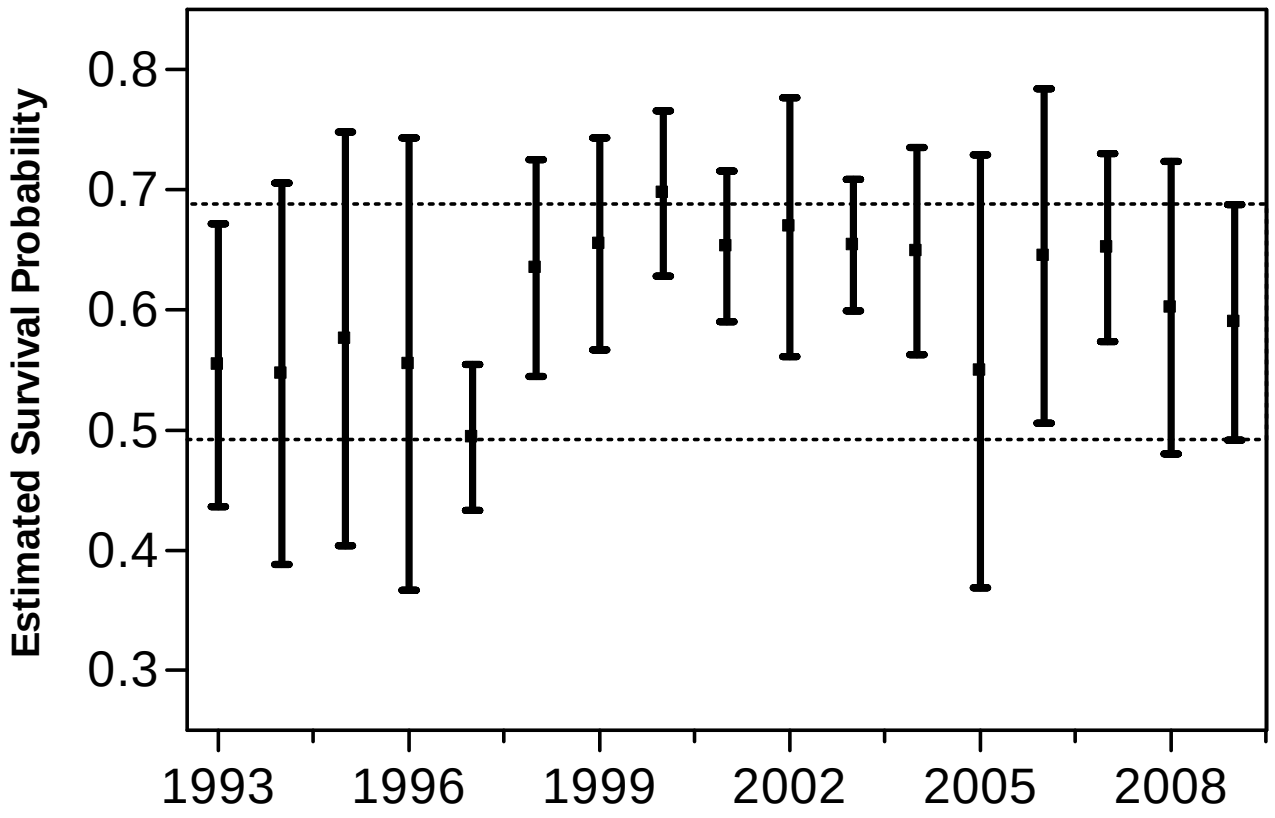

Figure 1. Annual average survival estimates for PIT-tagged yearling Chinook salmon released from Snake River Basin hatcheries, 1993-2009. Hatcheries used for average (index groups) are those with PIT-tag releases through a long series of years. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are the 2009 confidence interval endpoints and are shown for comparison to other years.

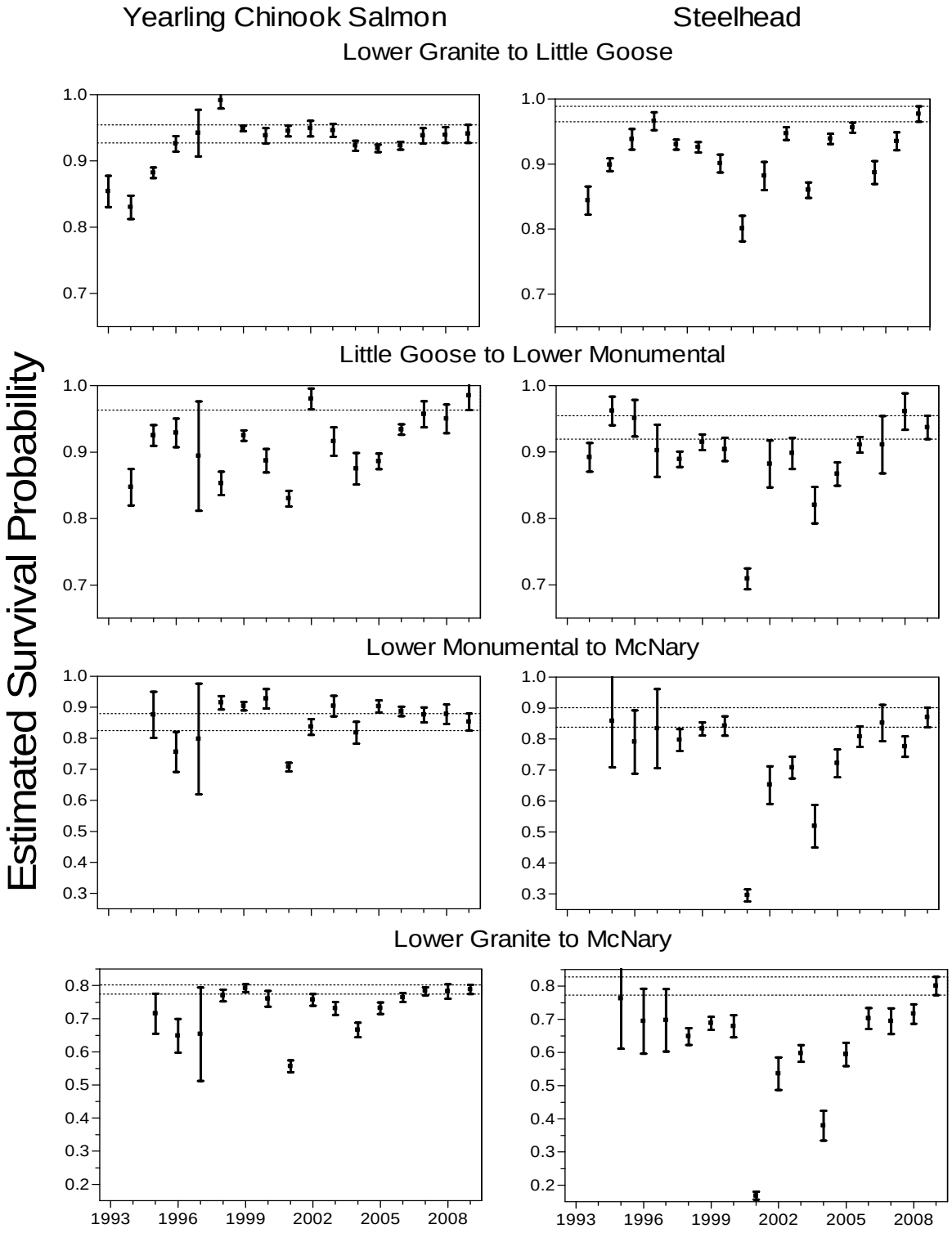

Figure 2. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2009 estimates.

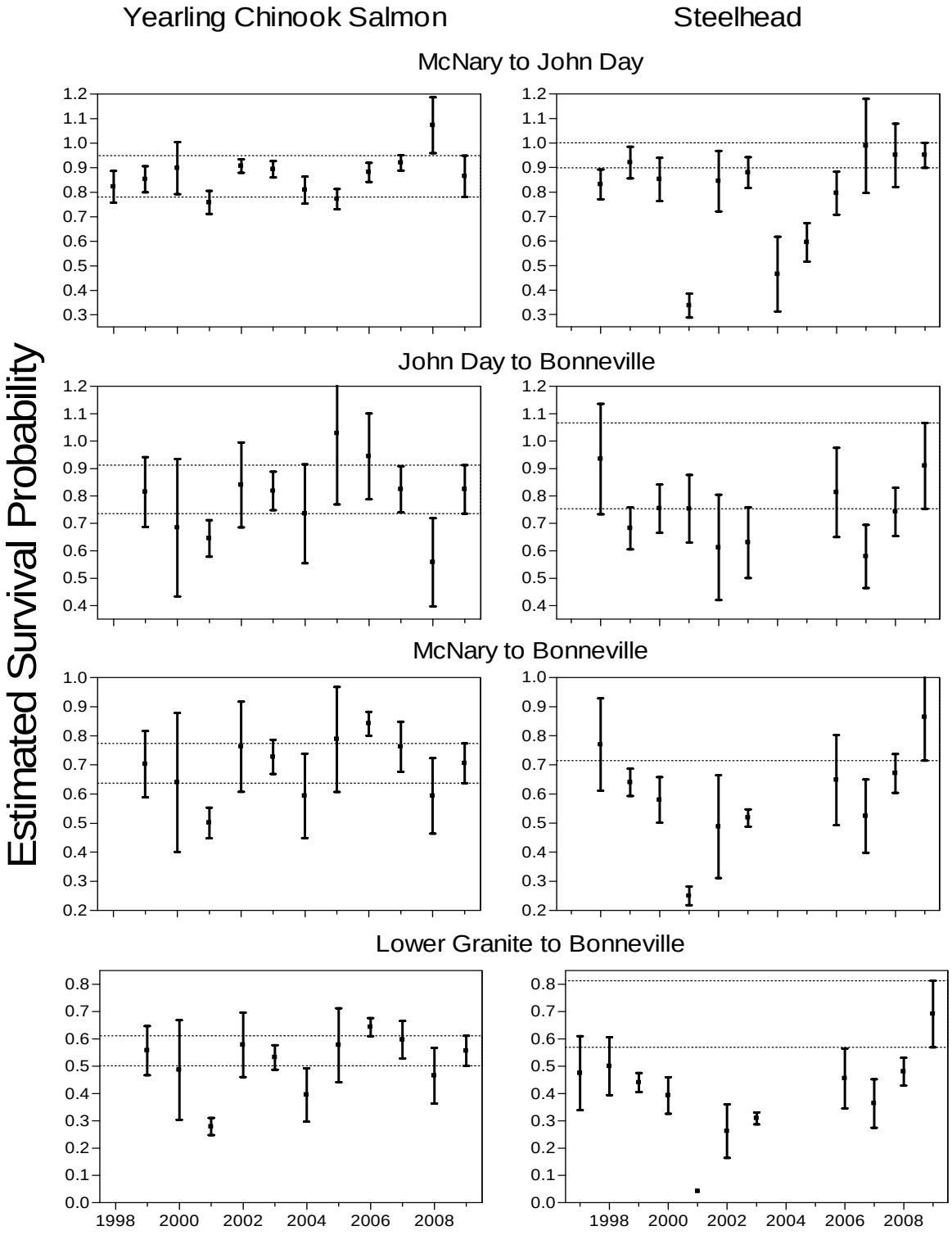

Figure 3. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead, hatchery and wild fish combined. Vertical bars represent 95% confidence intervals. Horizontal dashed lines are 95% confidence interval endpoints for 2009 estimates.

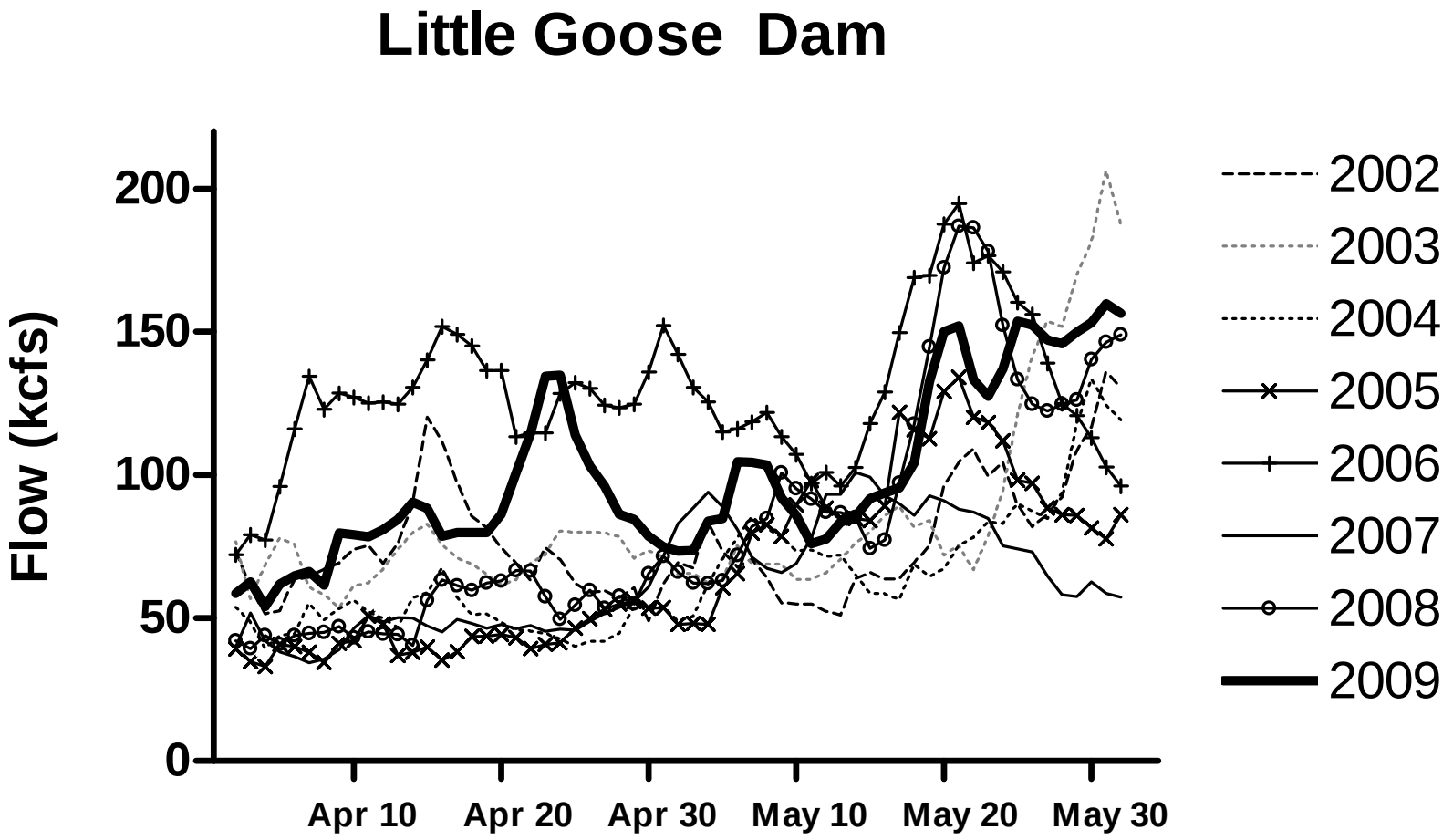

Figure 4. Snake River flow (kcfs) measured at Little Goose Dam during April and May, 2002-2009.

.

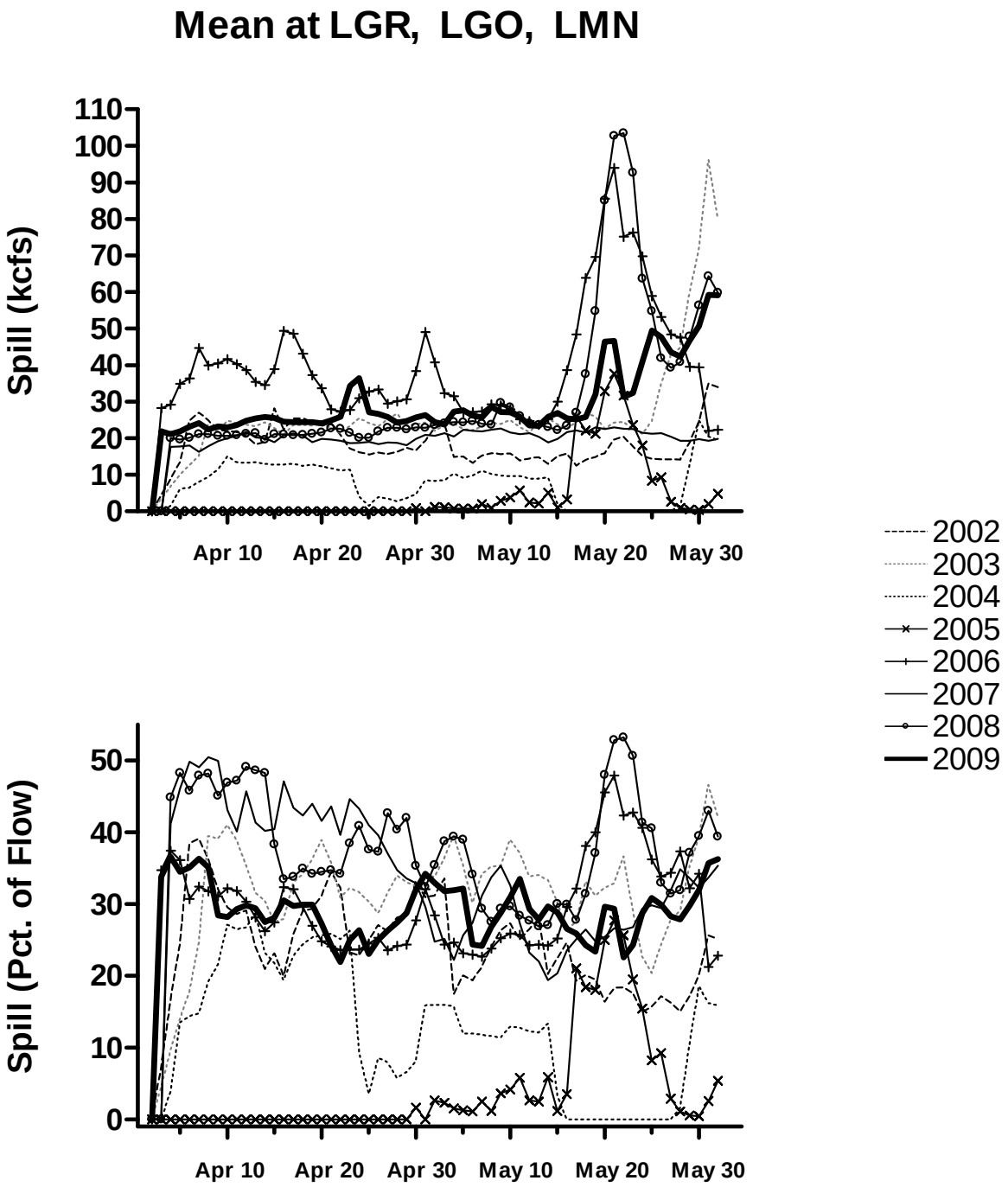

Figure 5. Mean spill (top=kcfs; bottom=percentage of total flow) at Snake River dams during April and May, 2002-2009.

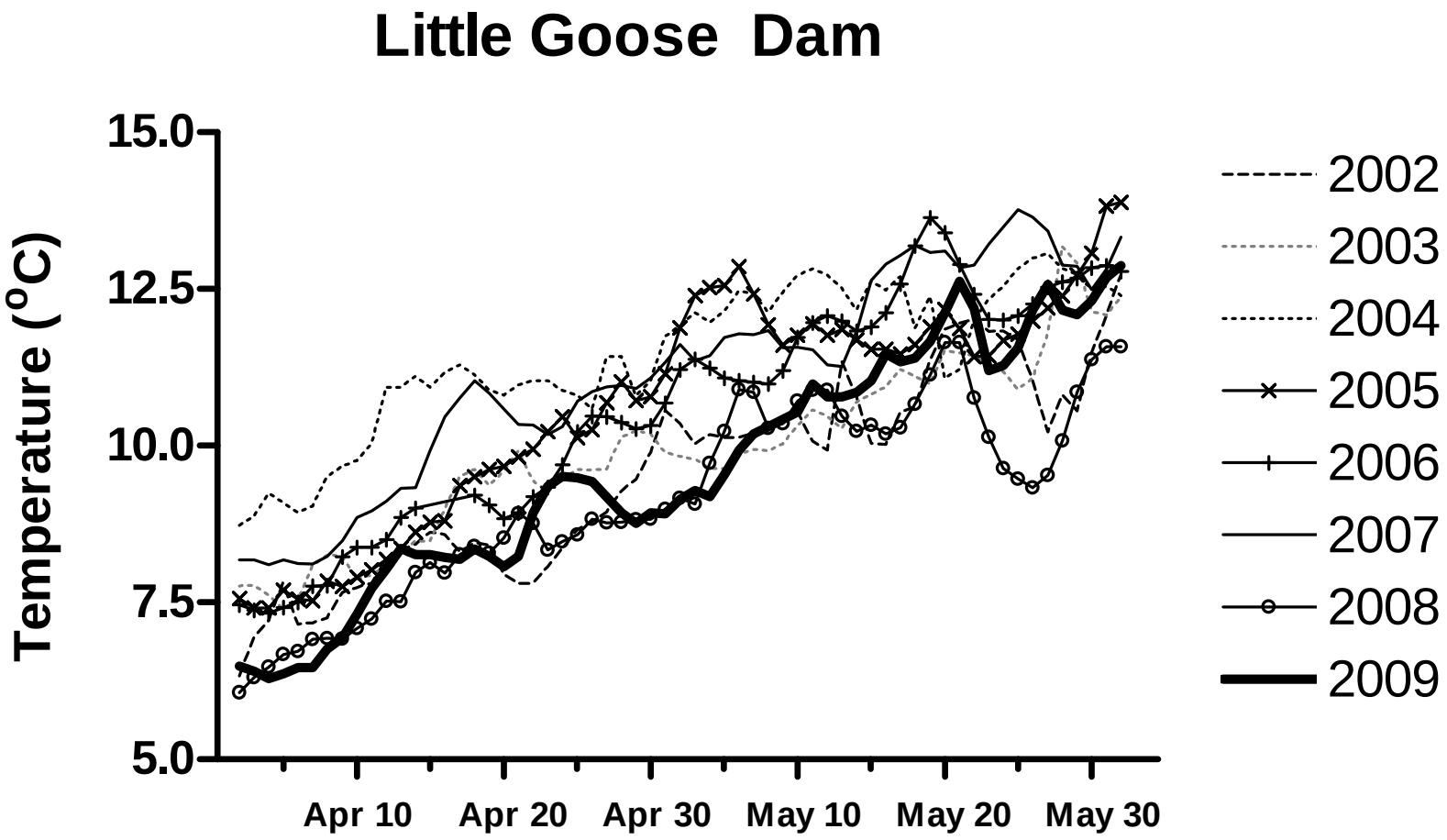

Figure 6. Snake River water temperature (°C) measured at Little Goose Dam during April and May, 2002-2009.

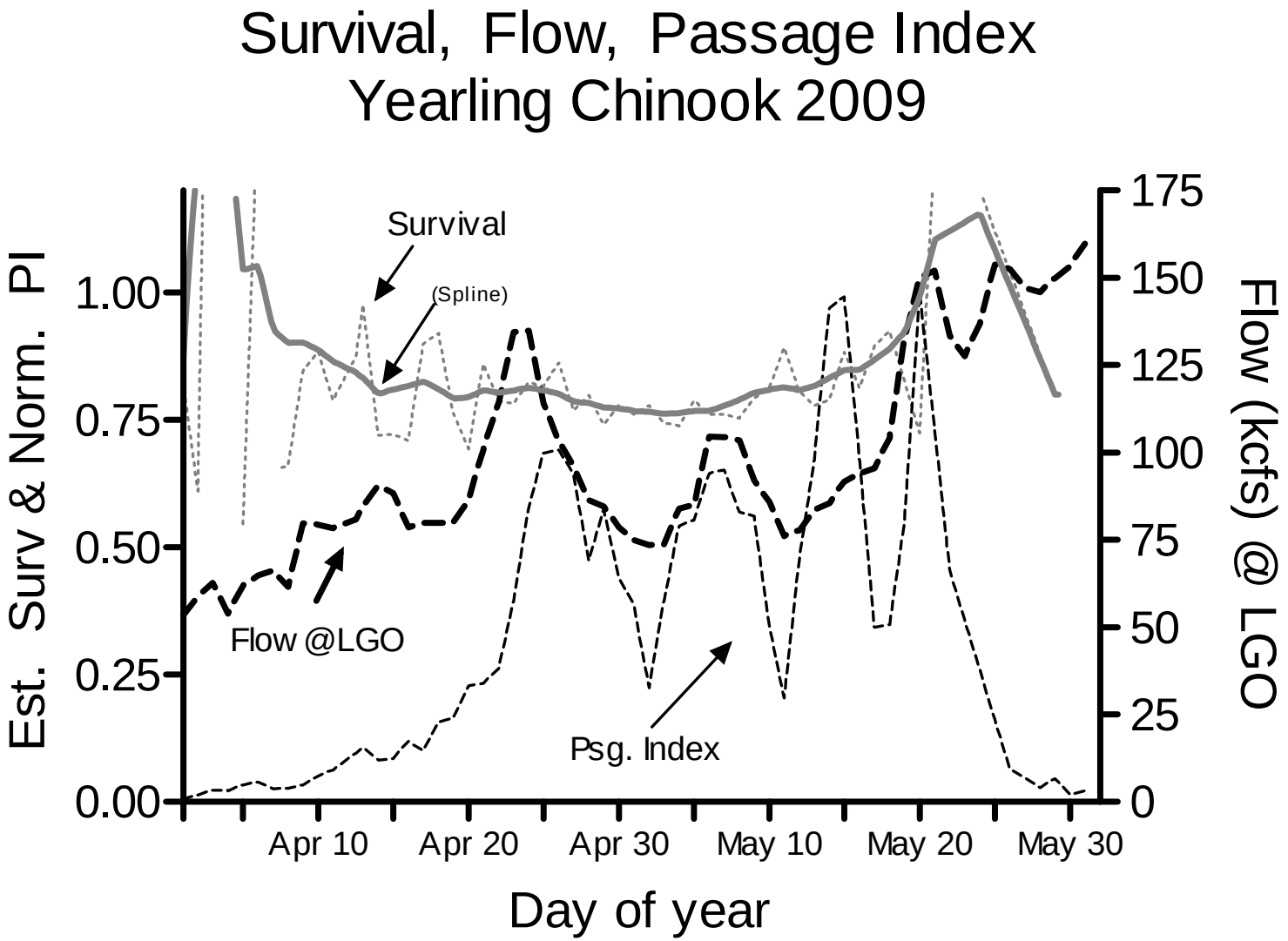

Figure 7. Estimated survival probability for yearling Chinook salmon from Lower Granite Dam to McNary Dam, flow volume at Little Goose Dam, and passage index at Lower Granite Dam (normalized: peak day = 1.0) by day of year, 2009. A curve showing a spline smooth of estimated survival is included.

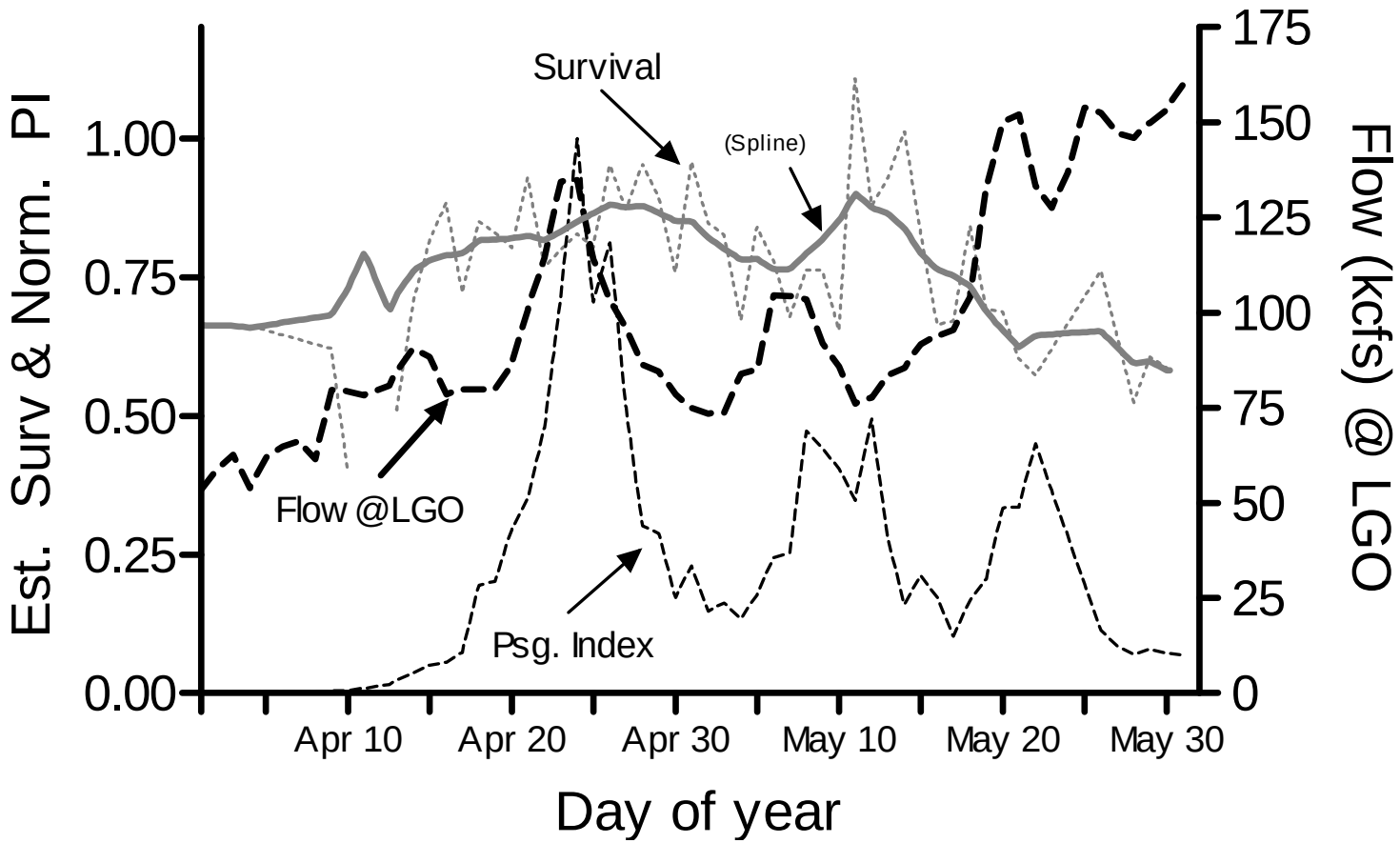

Figure 8. Estimated survival probability for steelhead from Lower Granite Dam to McNary Dam, flow volume at Little Goose Dam, and passage index at Lower Granite Dam (normalized: peak day = 1.0) by day of year, 2009. A curve showing a spline smooth of estimated survival is included.

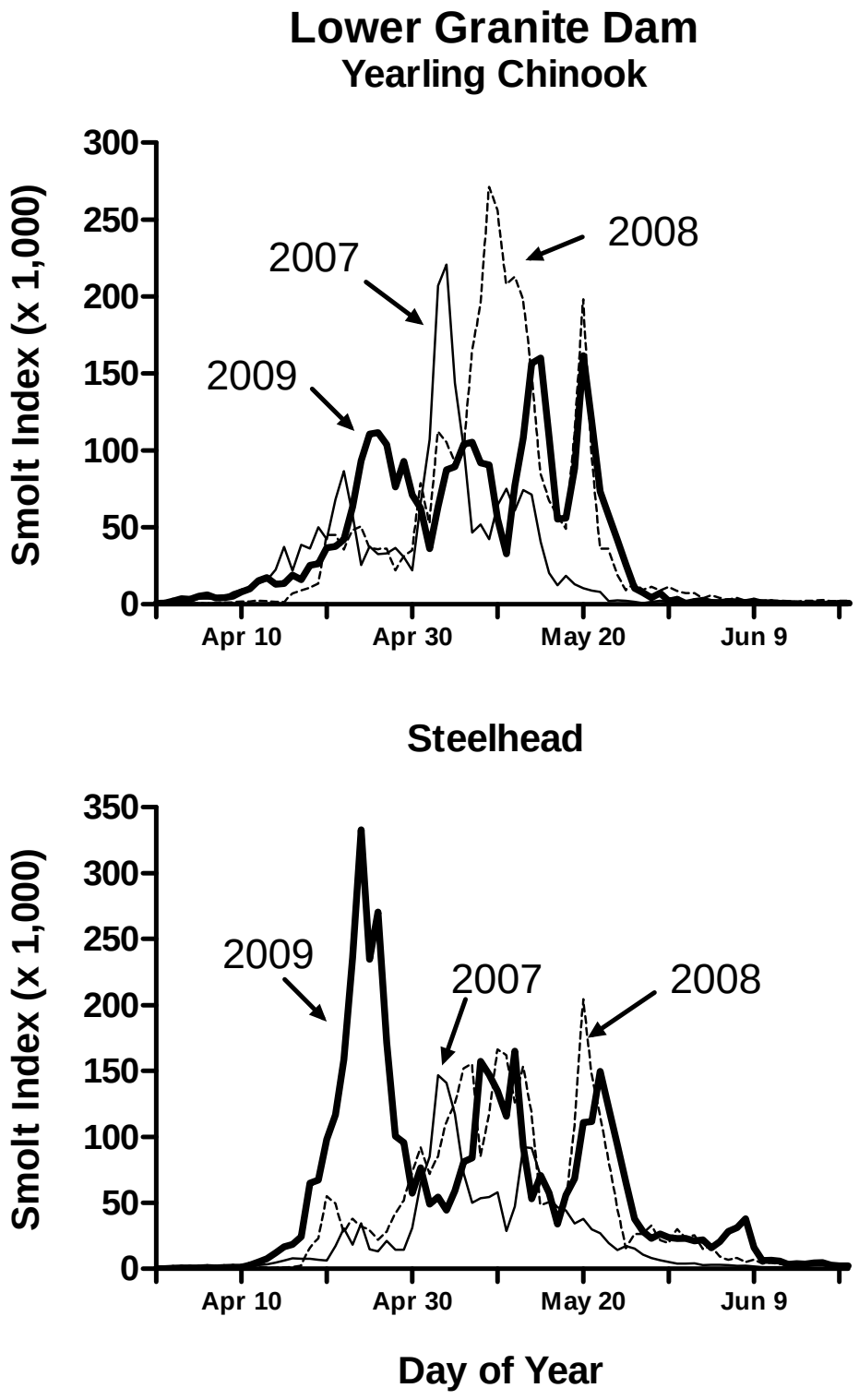

Figure 9. Smolt index in thousands at Lower Granite Dam 2007-2009 for hatchery and wild combined yearling Chinook and steelhead.