



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

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MEMORANDUM FOR: F/NWR5 - Bruce Suzumoto
FROM: F/NWC3 - John W. Ferguson *John W. Ferguson*
SUBJECT: Preliminary survival estimates for passage
during the spring migration of juvenile
salmonids through Snake and Columbia River
reservoirs and dams, 2006

This memorandum summarizes estimated survival of PIT-tagged juvenile salmonids passing through Snake and Columbia River reservoirs and dams during the 2006 migration. Very few additional detections of yearling Chinook salmon and steelhead will occur, so these survival estimates are essentially final. Our complete detailed analyses and report for spring migrants will be available by the end of the year.

Summary of Research

For survival studies funded by BPA in 2006, NOAA Fisheries PIT tagged about 18,500 river-run hatchery steelhead, almost 14,000 wild steelhead, and about 9,700 wild yearling Chinook salmon for release in the tailrace of Lower Granite Dam.

From studies funded by the USACE, we used about 190,000 yearling Chinook PIT tagged 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 those fish PIT tagged by or for the Fish Ecology Division, as described above, along with fish PIT tagged by others within the Columbia River Basin.

Estimated survival in 2006 for yearling Chinook salmon from Snake River Basin hatcheries to Lower Granite Dam tailrace was similar to past years (Table 1). For most hatcheries, estimated survival was higher than in 2004 and 2005. The mean survival of 72% for index groups (release groups that most represent production releases from hatcheries that we've tracked from multiple years—Dworshak, Kooskia, Lookingglass/Imnaha Weir, Rapid River, and McCall/Knox Bridge) was slightly greater than the 69% average for the previous 5 years, 2001-2005.



Estimated survival for Snake River yearling Chinook salmon (hatchery and wild combined) in 2006 was higher than the 5-year average in every reach except Lower Granite-to-Little Goose Dam (Table 2, Figures 1 and 2). Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to McNary Dam tailrace was 75.8%, the highest in the last 6 years. Mean estimated survival for yearling Chinook salmon from Lower Granite Dam tailrace to Bonneville Dam tailrace was 61.1% in 2006, the highest since survival estimates to Bonneville Dam tailrace became possible from PIT-tag data in 1999.

Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 95.1% based on fish PIT tagged at and released from the Snake River trap. Combining this estimate with the estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace provides an in-river survival estimate for yearling Chinook salmon traveling through all the entire hydrosystem (all 8 projects) in 2006 of 58.1%.

For Snake River steelhead (hatchery and wild combined), estimated survival in 2006 was higher than the 5-year average in all reaches (Table 3, Figures 1 and 2). As with yearling Chinook salmon, mean estimated steelhead survival from Lower Monumental Dam to McNary Dam was the highest of the last 6 years. However, for steelhead, the estimated survival for this reach in 2006 remained below the average of the 1995 through 2000 estimates (Figures 1 and 2). Mean estimated survival for steelhead from Lower Granite Dam tailrace to McNary Dam tailrace was 69.2%, higher by almost 10% than any of the previous 5 years.

In 2004 and 2005 we were unable to estimate survival for steelhead through the final reach, John Day Dam tailrace to Bonneville Dam tailrace; PIT-tag detection rates at Bonneville Dam were too low because the new corner collector at the Second Powerhouse was operated to pass fish but without PIT-tag detection capability. (It was possible to estimate Chinook survival to Bonneville Dam despite low detection rates because more PIT-tagged Chinook passed the dam). A new detection system installed in the corner collector in 2006 made steelhead survival estimates to Bonneville Dam tailrace possible again. Mean estimated survival for steelhead from Lower Granite Dam tailrace to Bonneville Dam tailrace was 40.6% in 2006.

Estimated survival for the Lower Granite project (head of reservoir to tailrace) was 91.9%, based on fish PIT tagged at and released from the Snake River trap. Combining this estimate with the estimate from Lower Granite Dam tailrace to Bonneville Dam tailrace provides an in-river survival estimate for steelhead traveling through the entire hydrosystem (all 8 projects) in 2006 of 37.3%.

For PIT-tagged yearling Chinook salmon originating from the upper Columbia River in 2006, estimated survival from McNary Dam tailrace to Bonneville Dam tailrace was 67.8%; higher than in

2004, but lower than in 2002 and 2003 (no estimate was possible in 2005) (Table 4). Estimated survival from McNary Dam tailrace to John Day Dam tailrace in 2006 was 88.9%; slightly higher than the estimate for the same reach for yearling Chinook salmon originating in the Snake River Basin (86.8%). However, estimated survival from John Day Dam tailrace to Bonneville Dam tailrace was considerably lower for upper Columbia River Chinook salmon (74.5%) than for their Snake River counterparts (89.1%)

For PIT-tagged steelhead originating from the upper Columbia River in 2006, data were not sufficient to estimate survival from McNary Dam tailrace to Bonneville Dam tailrace (Table 5). Estimated survival for steelhead migrating from McNary Dam tailrace to John Day Dam tailrace was lower for migrants from the upper Columbia River (79.8%) than for those from the Snake River (84.0%). 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.

Discussion

During most of 2006, Snake River flows were the highest observed in the last 6 years (Figure 3). Flows were particularly high in April relative to recent years. Flow dropped during the first two weeks of May and then increased rapidly, reaching a peak around May 23. In terms of absolute volume, there was more spill at Snake River dams in 2006 than in any of the previous five years (Figure 4, top panel). In terms of percentage of total flow passing via spill, 2006 was similar to 2002 and 2003. A smaller percentage of flow was spilled in 2004, 2005, and in 2001 there was no spill at all in April and May at Lower Granite, Little Goose, and Lower Monumental Dams. Water in the Snake River was generally cooler in 2006 than in 2001, 2004, and 2005, especially in May (Figure 5), but warmer than in 2002 and 2003.

Estimated survival for daily groups of yearling Chinook salmon from Lower Granite Dam to McNary Dam was lowest during the first two weeks of April, averaging about 66.5% (Figure 6). Survival was fairly steady for the subsequent 4 weeks, averaging about 76%. The next week survival dropped back down to around 67%, corresponding in time with a drop in flow. Then, as flow increased to its peak in the last two weeks of May, survival also reached its high for the season, averaging almost 86% for the last two weeks of May. The peak of the passage index at Lower Granite Dam occurred in the first two weeks of May, during the period in which both flow and estimated survival were decreasing.

Though estimated survival in 2006 for steelhead from Lower Monumental Dam tailrace to McNary Dam tailrace was the highest of the last 6 years, it was still lower than any of the 6 years between 1993 and 1998. This is likely due to avian predation, primarily by Caspian terns. In 2001, about 21% of the PIT tagged

steelhead passing Lower Monumental Dam were later detected on McNary pool bird colonies. Losses of PIT-tagged steelhead to avian predators in this reach were lower in 2002 through 2005, but still substantial. Data from PIT-tag surveys on McNary pool bird colonies in 2006 are not yet available.

Higher survival for in-river migrants in 2006 was likely the result of higher flows and greater volumes of water spilled, and the operation of removable spillway weirs at Lower Granite and Ice Harbor dams. Migration speed was greater in 2006 (e.g. median Lower Granite-to-Bonneville travel times were 2 to 3 days shorter in 2006 than in 2005), likely reducing losses to predation in reservoirs. Detection probabilities were lower in 2006, indicating that more fish passed dams via spillways, which likely reduced passage mortality.

It is important to remember that the majority of non-tagged smolts were collected and transported. Our preliminary estimates are that 72.5% of non-tagged spring-summer Chinook salmon smolts and 88.6% of non-tagged steelhead smolts that arrived at Lower Granite Dam were subsequently transported, either from Lower Granite Dam or from one of the downstream collector dams. Survival estimates presented here 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. These estimates are applicable only to the minority of non-tagged smolts that remained in-river.

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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), 2004 through 2006.

Hatchery	2004		2005		2006	
	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	0.821 (0.003)	0.611 (0.015)	0.832 (0.003)	0.659 (0.016)	0.857 (0.012)	0.574 (0.012)
Kooskia	0.769 (0.017)	0.598 (0.065)	0.702 (0.021)	0.405 (0.051)	0.716 (0.041)	0.513 (0.078)
Lookingglass (Catherine Cr.)	0.254 (0.003)	0.204 (0.015)	0.232 (0.003)	0.193 (0.014)	0.333 (0.013)	0.285 (0.032)
Lookingglass (Grande Ronde)	0.514 (0.025)	0.449 (0.130)	0.150 (0.013)	0.096 (0.025)	0.557 (0.081)	0.208 (0.043)
Lookingglass (Imnaha River)	0.613 (0.004)	0.449 (0.201)	0.534 (0.004)	0.447 (0.022)	0.637 (0.010)	0.429 (0.015)
Lookingglass (Lostine River)	0.494 (0.004)	0.362 (0.016)	0.404 (0.005)	0.315 (0.018)	0.379 (0.007)	0.252 (0.011)
McCall (Johnson Cr.)	0.278 (0.004)	0.139 (0.018)	0.349 (0.006)	0.221 (0.024)	0.325 (0.017)	0.235 (0.023)
McCall (Knox Bridge)	0.559 (0.002)	0.397 (0.013)	0.603 (0.003)	0.479 (0.014)	0.635 (0.006)	0.501 (0.014)
Rapid River	0.694 (0.003)	0.462 (0.012)	0.735 (0.002)	0.574 (0.015)	0.758 (0.006)	0.581 (0.013)
Entiat	---	0.569 (0.010)	---	0.635 (0.034)	---	0.515 (0.031)
Winthrop	---	0.492 (0.022)	---	0.469 (0.034)	---	0.416 (0.030)
Leavenworth	---	0.493 (0.022)	---	0.534 (0.014)	---	0.543 (0.014)

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, 2001 through 2006. Hatchery and wild fish combined.

Reach	2001	2002	2003	2004	2005	2006
Snake Trap-LGR	0.954 (0.015)	0.953 (0.022)	0.993 (0.023)	0.893 (0.009)	0.919 (0.015)	0.951 (0.011)
LGR-LGO	0.945 (0.004)	0.949 (0.006)	0.946 (0.005)	0.923 (0.004)	0.919 (0.003)	0.928 (0.002)
LGO-LMO	0.830 (0.006)	0.980 (0.008)	0.916 (0.011)	0.875 (0.012)	0.886 (0.006)	0.933 (0.002)
LMO-MCN	0.708 (0.007)	0.837 (0.013)	0.905 (0.017)	0.818 (0.018)	0.903 (0.010)	0.887 (0.004)
MCN-JD	0.758 (0.024)	0.907 (0.014)	0.893 (0.017)	0.809 (0.028)	0.771 (0.021)	0.868 (0.019)
JD-BON	0.645 (0.034)	0.840 (0.079)	0.818 (0.036)	0.735 (0.092)	1.028 (0.132)	0.891 (0.011)
LGR-MCN	0.556 (0.009)	0.757 (0.009)	0.731 (0.010)	0.666 (0.011)	0.732 (0.009)	0.758 (0.007)
MCN-BON	0.501 (0.027)	0.763 (0.079)	0.728 (0.030)	0.594 (0.074)	0.788 (0.092)	0.806 (0.022)
LGR-BON	0.279 (0.016)	0.578 (0.060)	0.532 (0.023)	0.395 (0.050)	0.577 (0.069)	0.611 (0.018)
Snake Trap-BON	0.266 (0.016)	0.551 (0.059)	0.528 (0.026)	0.353 (0.045)	0.530 (0.063)	0.581 (0.017)

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, 2001 through 2006. Hatchery and wild fish combined.

Reach	2001	2002	2003	2004	2005	2006
Snake Trap-LGR	0.911 (0.007)	0.895 (0.015)	0.932 (0.015)	0.948 (0.004)	0.967 (0.004)	0.919 (0.012)
LGR-LGO	0.801 (0.010)	0.882 (0.011)	0.947 (0.005)	0.860 (0.006)	0.939 (0.004)	0.958 (0.002)
LGO-LMO	0.709 (0.008)	0.882 (0.018)	0.898 (0.012)	0.820 (0.014)	0.867 (0.009)	0.909 (0.004)
LMO-MCN	0.296 (0.010)	0.652 (0.031)	0.708 (0.018)	0.519 (0.035)	0.722 (0.023)	0.776 (0.016)
MCN-JD	0.337 (0.025)	0.844 (0.063)	0.879 (0.032)	0.465 (0.078)	0.595 (0.040)	0.840 (0.048)
JD-BON	0.753 (0.063)	0.612 (0.098)	0.630 (0.066)	-----	-----	0.691 (0.285)
LGR-MCN	0.168 (0.006)	0.536 (0.025)	0.597 (0.013)	0.379 (0.023)	0.593 (0.018)	0.692 (0.017)
MCN-BON	0.250 (0.016)	0.488 (0.090)	0.518 (0.015)	-----	-----	0.587 (0.201)
LGR-BON	0.042 (0.003)	0.262 (0.050)	0.309 (0.011)	-----	-----	0.406 (0.139)
Snake Trap-BON	0.038 (0.003)	0.234 (0.045)	0.288 (0.012)	-----	-----	0.373 (0.128)

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, 2002 through 2006. Hatchery fish only (no wild fish tagged).

Reach	2002	2003	2004	2005	2006
Release-MCN	0.540 (0.020) ^a	0.579 (0.029) ^b	0.505 (0.018) ^c	0.546 (0.048) ^a	0.491 (0.039) ^a
MCN-JD	0.856 (0.012)	0.902 (0.025)	0.741 (0.038)	0.801 (0.056)	0.889 (0.093)
JD-BON	0.867 (0.079)	0.848 (0.091)	0.840 (0.111)	NA	0.745 (0.065)
MCN-BON	0.745 (0.069)	0.767 (0.069)	0.622 (0.063)	NA	0.678 (0.099)

- a. mean of estimates for fish released at Entiat, Winthrop, and Leavenworth hatcheries
- b. mean of estimates for fish released at Entiat and Winthrop hatcheries, and fish from Methow hatchery released in Twisp and Chewuch acclimation ponds.
- c. mean of estimates for fish released at Entiat, Winthrop, and Leavenworth hatcheries, and fish from Methow hatchery released in Twisp and Chewuch acclimation ponds.

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, 2002 through 2006. Hatchery fish only (no wild fish tagged).

Reach	2002	2003	2004	2005	2006
Release-MCN	NA	0.475 (0.020) ^a	0.383 (0.018) ^b	0.449 (0.080) ^b	NA
MCN-JD	NA	0.954 (0.047)	0.786 (0.059)	0.749 (0.047)	0.798 (0.044)
JD-BON	NA	0.786 (0.119)	0.623 (0.168)	0.755 (0.167)	NA
MCN-BON	NA	0.695 (0.108)	0.496 (0.124)	0.533 (0.119)	NA

a. mean of estimates for fish from Chelan, East Bank, Entiat, Leavenworth, Methow, Wells, and Winthrop hatcheries released on various dates at numerous release sites.

b. mean of estimates for fish from Chelan, East Bank, Ringold, Wells, and Winthrop hatcheries released at various locations.

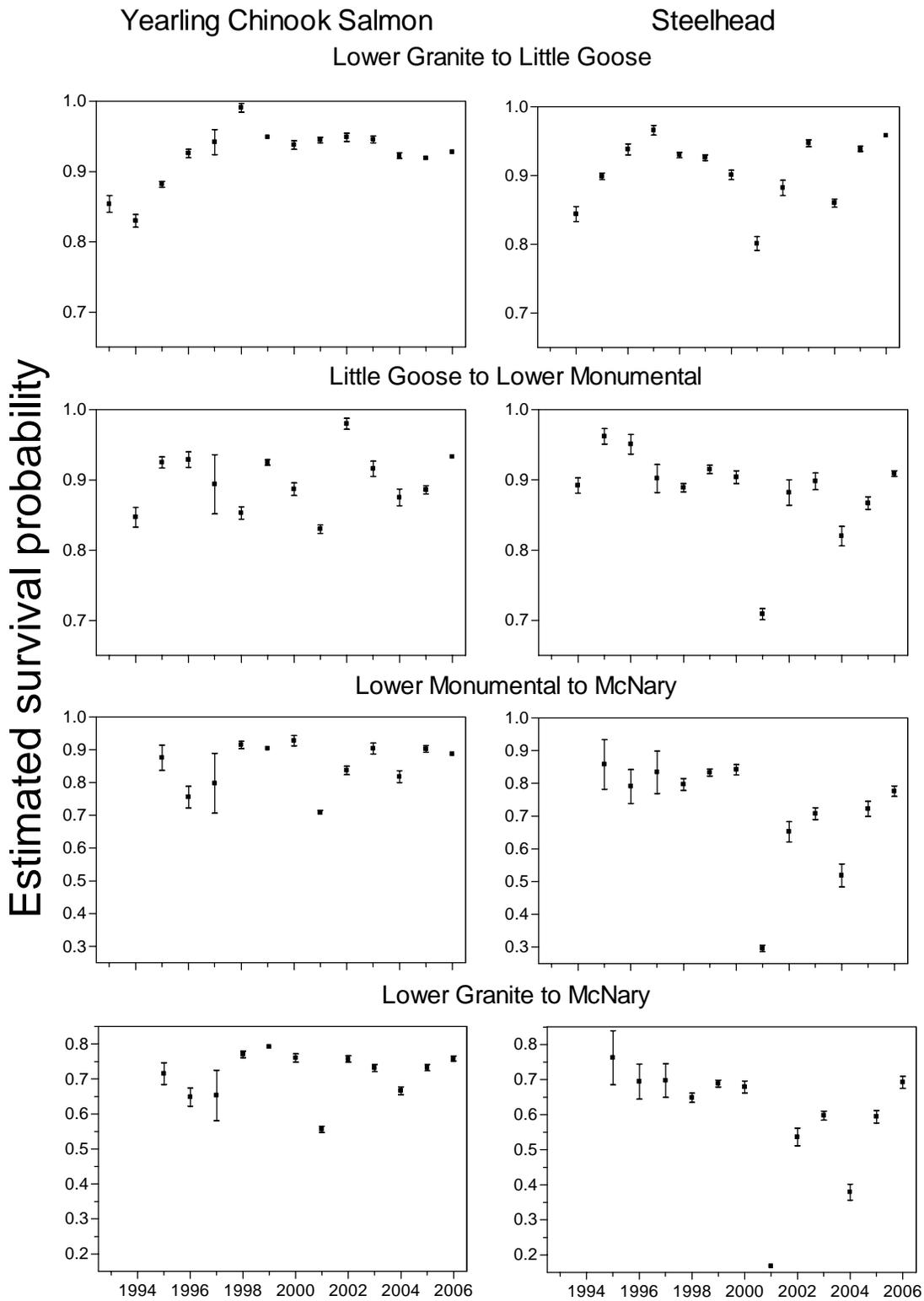


Figure 1. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead, hatchery and wild fish combined. Vertical bars represent plus/minus one standard error.

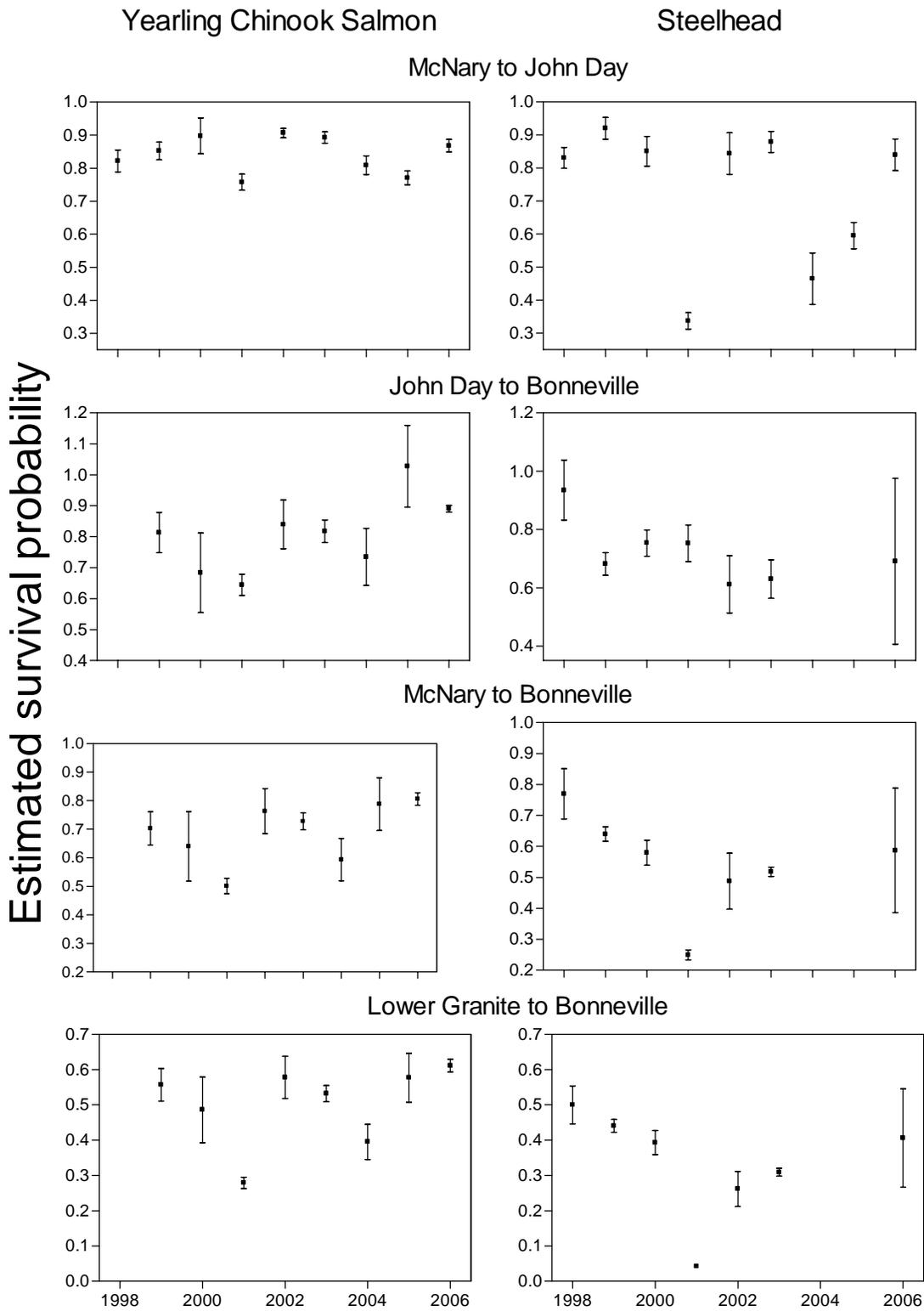


Figure 2. Annual average survival estimates for PIT-tagged yearling Chinook salmon and steelhead, hatchery and wild fish combined. Vertical bars represent plus/minus one standard error.

Little Goose Dam

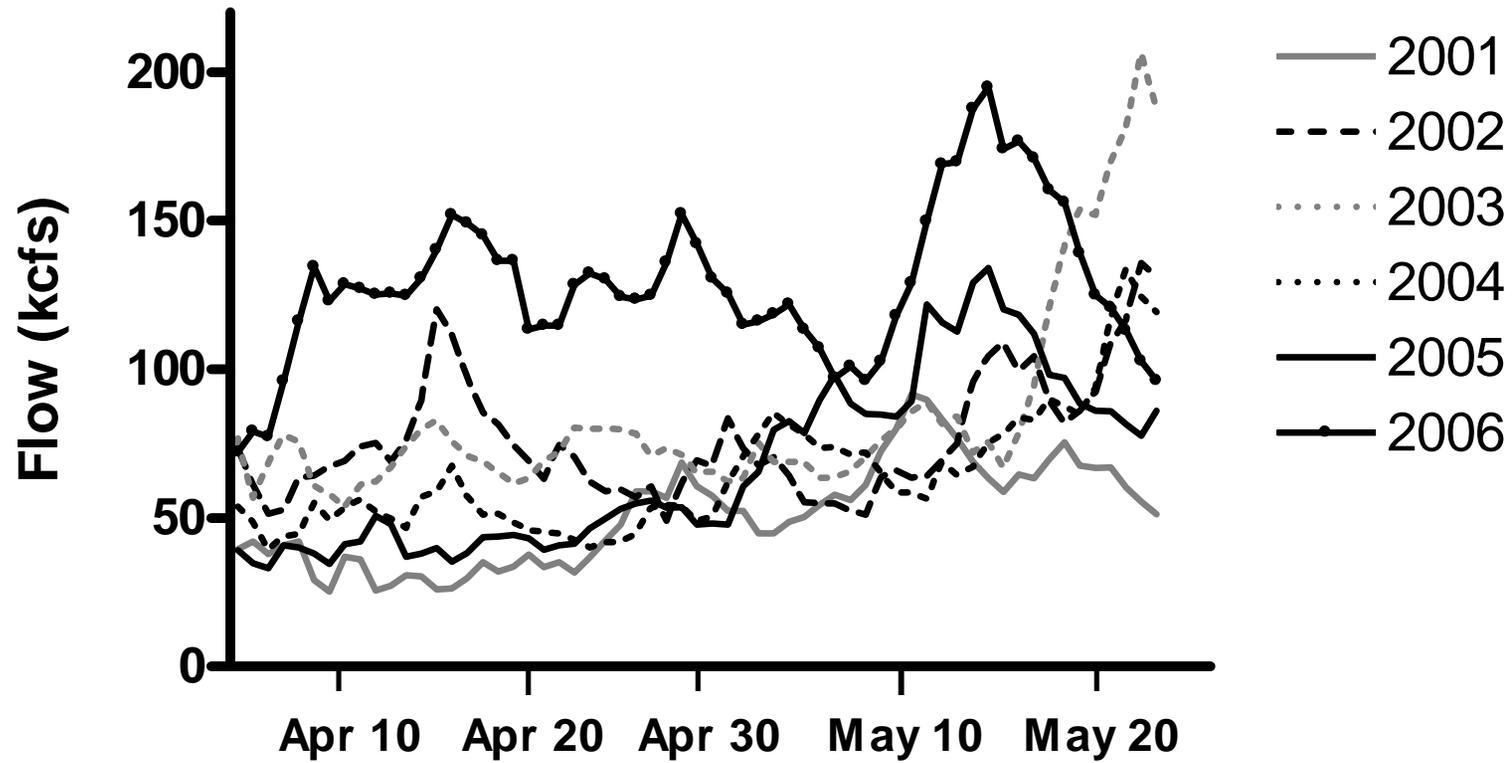


Figure 3. Snake River flow (kcfs) measured at Little Goose Dam during April and May, 2001-2006.

Mean at LGR, LGO, LMN

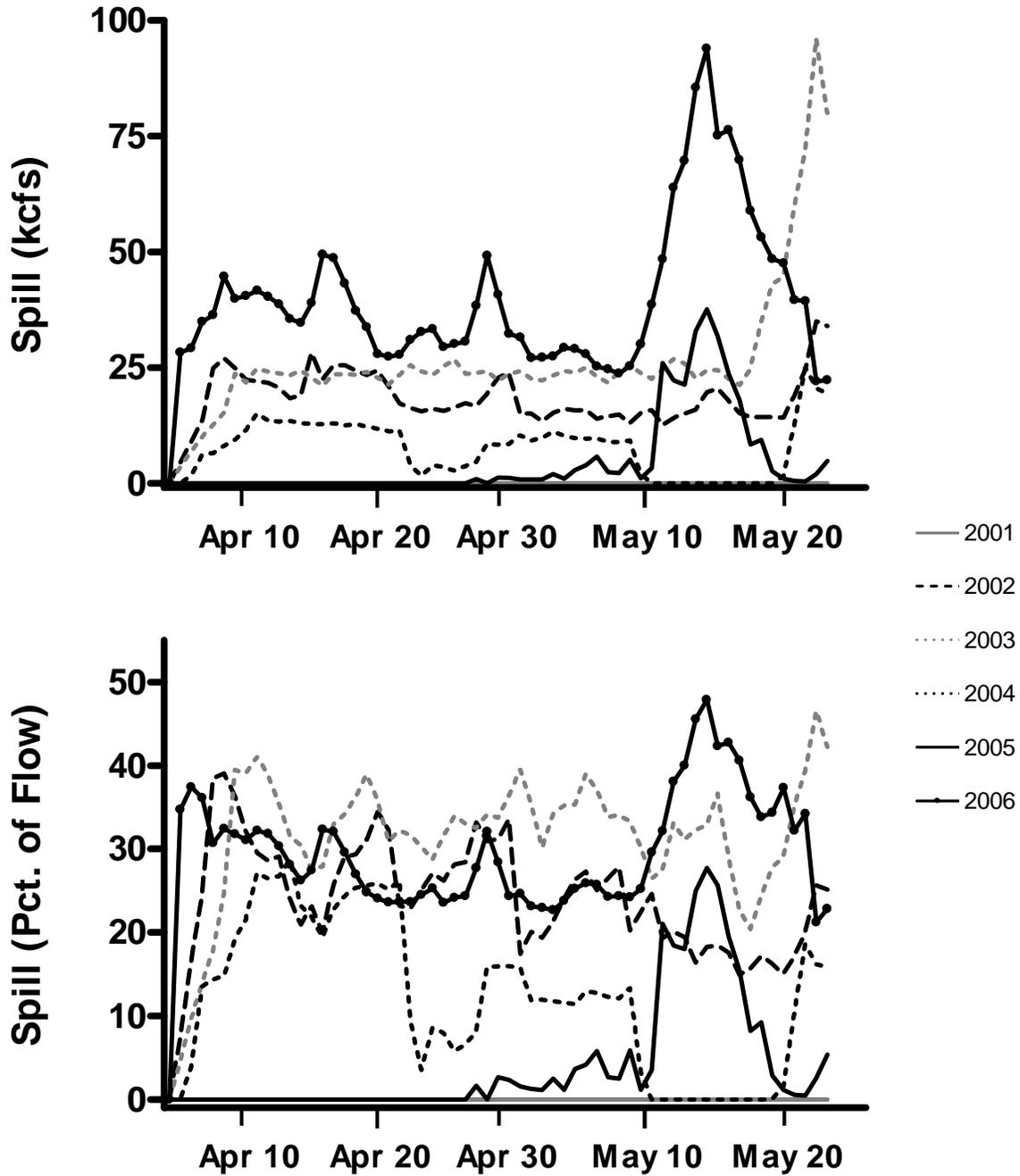


Figure 4. Mean spill (top=kcfs; bottom=percentage of total flow) at Snake River dams during April and May, 2001-2006.

Little Goose Dam

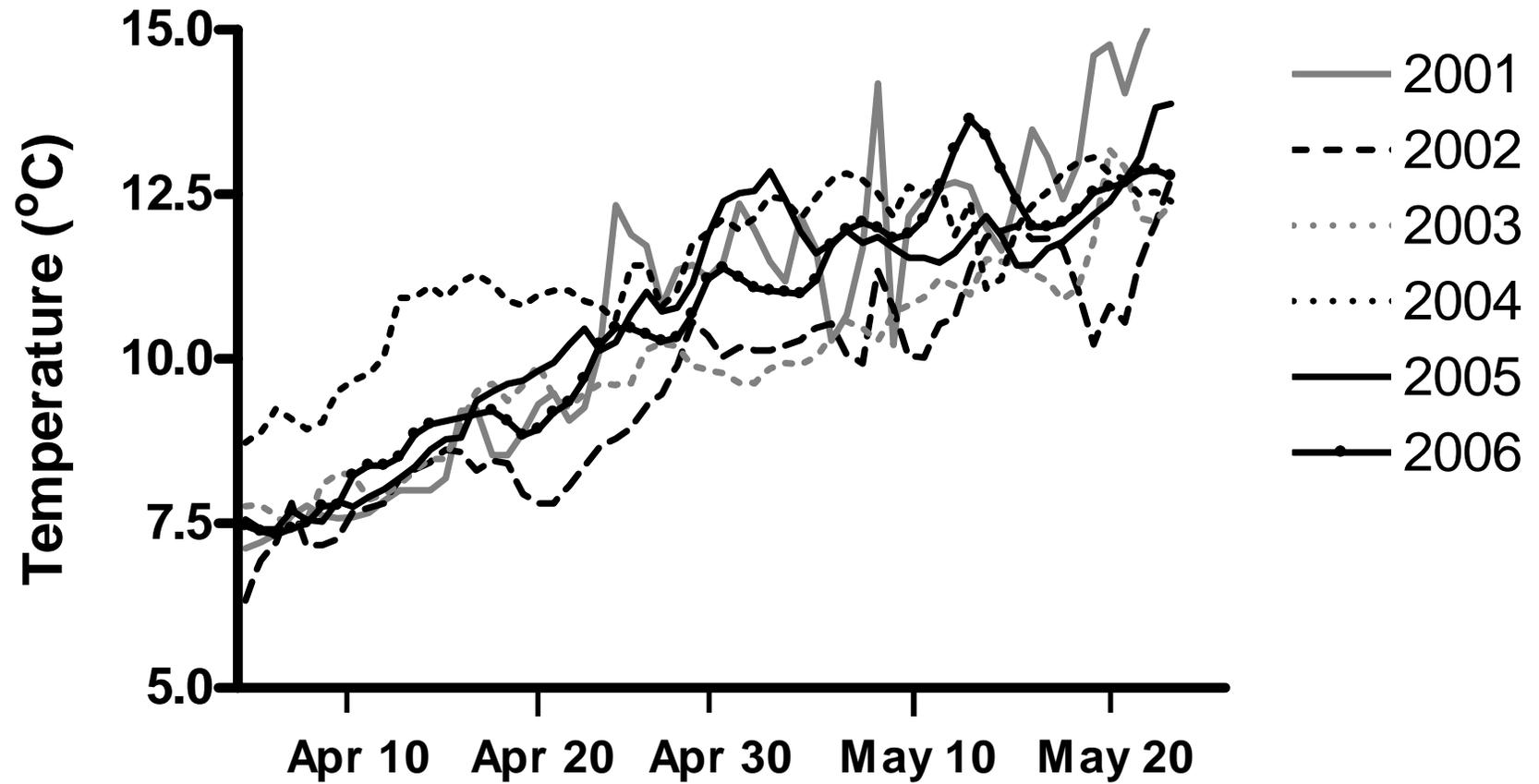


Figure 5. Snake River water temperature (°C) measured at Little Goose Dam during April and May, 2001-2006.

Survival, Flow, Passage Index

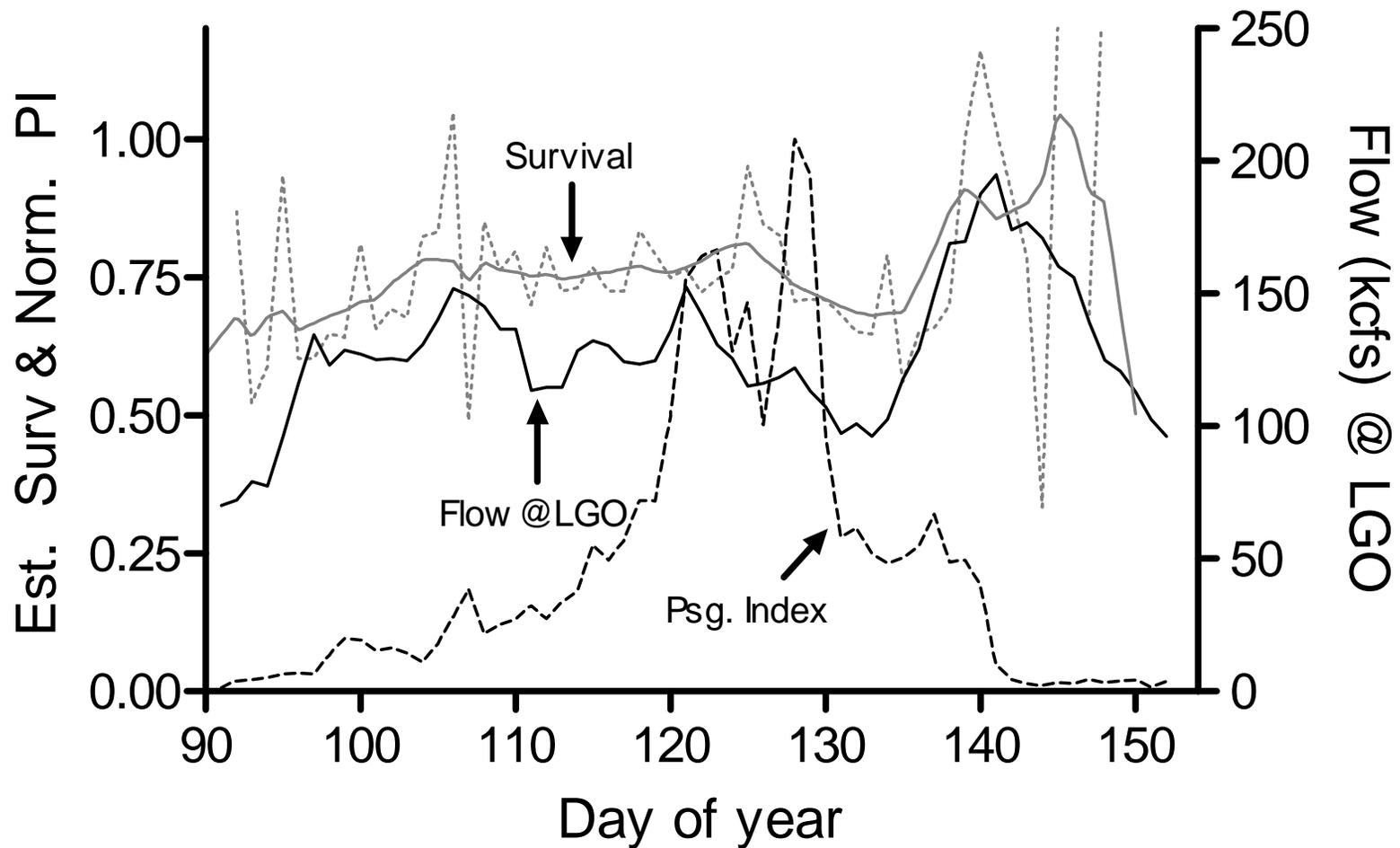


Figure 6. Estimated survival probability for yearling Chinook salmon from Lower Granite Dam to McNary Dam, flow volume at Little Goose Dam, and passage index at Lower Granite Dam (normalized: peak day = 1.0) by day of year, 2006. A curve showing a spline smooth of estimated survival is included.