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24 January 2006

To: David Clugston and Marvin Shutters (USACE)

From: Matt Keefer and Chris Peery (University of Idaho)

Re: Summary of 2003-2004 Hydrosystem escapement, harvest, and unknown loss rates for adult Chinook salmon and steelhead; Letter Report

Introduction: One of the principal objectives of the adult salmon and steelhead radiotelemetry project has been to evaluate fish survival through the monitored Hydrosystem. As such, we summarized Hydrosystem and dam-to-dam escapement estimates for the years 1996-2002 for spring–summer and fall Chinook salmon and steelhead (Keefer et al. 2005a) and for sockeye salmon in 1997 (Naughton et al. 2005). Stock-specific estimates were also calculated for known-origin groups, based on juvenile PIT tags.

The scope of the adult radiotelemetry studies was somewhat reduced during the 2003-2004 migration years, with smaller overall samples and fewer known-origin fish. Monitoring efforts were comparable to the earlier studies, however, allowing us to make escapement estimates using the same methodology as in previous years. This letter report includes Hydrosystem escapement estimates (Bonneville to either Lower Granite or Priest Rapids dams) for the Chinook salmon and steelhead runs tagged in 2003-2004.

Methods: Adult spring, summer, and fall Chinook salmon and steelhead were collected at the Adult Fish Facility (AFF) at Bonneville Dam. Fish were randomly selected, except that an automated PIT-tag detection system in the AFF identified previously PIT-tagged fish; these fish were targeted to provide stock-specific escapement and straying estimates. Chinook salmon were tagged throughout the spring–summer run (April-July) and the fall run (August to early October) and steelhead were tagged from June-September. The 2003 samples were generally in proportion to the runs overall (Appendix Figures 1-3). In 2004, study objectives resulted in less representative tagging of spring–summer Chinook, with a disproportionate number of summer Chinook salmon tagged. River temperatures also prevented strictly representative tagging of fall Chinook salmon and steelhead during the warmest periods in 2004. All fish that did not have juvenile PIT tags received a PIT tag for use as a secondary marker. All fish released ~10 km downstream from Bonneville Dam (both sides of the river).

Final fish distributions and fates were assessed from the combination of telemetry records from fixed receiver sites, mobile tracking efforts, and transmitter returns from fisheries, hatcheries, fish traps, and spawning ground surveys by cooperating agencies. PIT-tag detectors at Columbia and Snake River dams provided additional passage data for fish

that may have regurgitated transmitters, though this extra monitoring had a negligible effect on fate or escapement estimates. (See Keefer et al. 2005a for additional tagging and fate estimation information.)

From the above data sources, fates for radio-tagged fish were arranged into six basic categories: fish either 1) passed the upstream extent of the study area for this analysis (Lower Granite or Priest Rapids dams), 2) were reported harvested in a mainstem fishery, 3) entered a tributary (or the Hanford Reach spawning grounds for fall Chinook salmon), 4) were reported harvested in a tributary fishery, 5) entered a hatchery or trap, or 6) had unknown fate (Table 1). Fish that passed Lower Granite or Priest Rapids dams were considered to have escaped the monitored Hydrosystem regardless of subsequent downstream movement.

Table 1. Notation used in escapement calculations.

Entered reach *i*	E_i		
Passed[1] reach *i*	P_i		
		Fish was last recorded:	
		within reach *i*	downstream from reach *i*
Mainstem fishery		MF_i	MF_d
Tributary		T_i	T_d
Tributary fishery		TF_i	TF_d
Hatchery/trap		H_i	H_d
Unknown fate		U_i	U_d
Escapement 1	Esc_1	$= (P_i + T_i + T_d + H_i + H_d) \bullet (E_i)^{-1}$	
Escapement 2	Esc_2	$= (P_i + T_i + T_d + H_i + H_d + TF_i + TF_d) \bullet (E_i)^{-1}$	
Escapement 3	Esc_3	$= (P_i + T_i + T_d + H_i + H_d + TF_i + TF_d + MF_i + MF_d) \bullet (E_i)^{-1}$	

[1] Subsequent downstream movement ignored

In this summary, the Hydrosystem was bounded by the tops of Bonneville Dam (i.e. fish had to pass Bonneville Dam to be included in the escapement estimate), Lower Granite Dam, and Priest Rapids Dam. As a result, passage at Bonneville Dam and through Lower Granite Reservoir was not included in escapement estimates. (See Letter Report of Keefer and Peery (August, 2004) and Keefer et al. (2005a) for additional assessments of how escapement estimates can be adjusted to include passage of Bonneville Dam).

Managers use escapement indices for multiple purposes, so in the past we have calculated three estimates with progressively less stringent criteria for defining successful escapement. Escapement 1 (Esc_1) is the most basic and most stringent measure and best matches the traditional definition of the term in which all fish harvested from mainstem or tributary sites (downstream from Lower Granite and Priest Rapids dams) and all fish with unknown fates did not escape (Table 1). Escapement 2 (Esc_2) treats fish harvested in Hydrosystem tributaries as successful, but mainstem-harvested fish as unsuccessful, and was therefore a measure of total escapement to tributaries or the upper bounds of the monitored Hydrosystem. Escapement 3 (Esc_3) treats all harvested fish as successful (i.e., mortality was not associated with Hydrosystem operations), and only fish with unknown

fates within the Hydrosystem are considered unsuccessful. Esc_3 eliminates variability associated with harvest and is therefore the best measure of underlying between-year, between-run, and between-stock differences in escapement. Esc_3 also approximates potential escapement through the monitored Hydrosystem in the absence of fisheries. In all estimates, fish that passed the upstream end of a reach or the Hydrosystem are considered to have escaped, regardless of subsequent downstream movement.

Results and Discussion: Hydrosystem escapement estimates for unknown-origin adults were generally within the range observed in previous years (Figure 1). Escapement for spring and summer Chinook salmon in 2003 and 2004 continue what appears to be a declining trend since the peak levels observed during 2001. The reason for the relatively low Esc_3 estimate for the 2004 fall Chinook salmon is unknown, though we note that an unusually high percentage of the unaccounted for fall Chinook salmon were last recorded at the top of McNary Dam. There were no major receiver down times for the two Hanford Reach antennas, and these fish were not recorded during mobile tracking surveys of the Hanford Reach in late fall, suggesting that they most likely did not enter the Reach. We also note that the tagging effort for steelhead in 2004 was quite different than in previous years, with large gaps in tagging during periods of high water temperature (Appendix Table 3). The relatively high Esc_3 estimate for 2004 steelhead may reflect the fact that fewer fish were in-river during what can be a difficult migration environment.

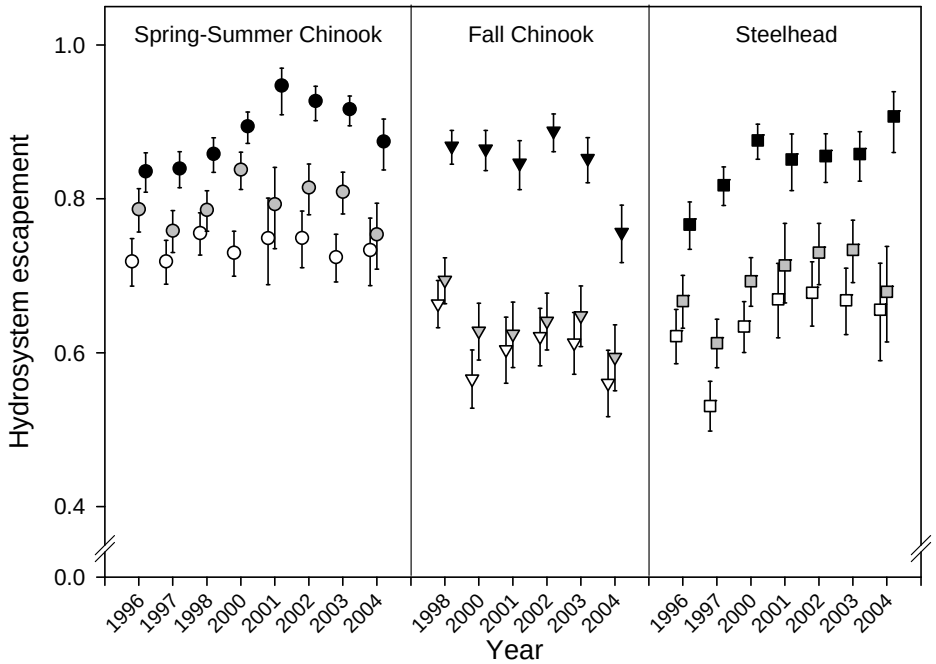


Figure 1. Annual Hydrosystem (Bonneville Dam to Lower Granite or Priest Rapids dams) escapement estimates for unknown-origin radio-tagged spring–summer and fall Chinook salmon and steelhead released downstream from Bonneville Dam. Open symbols = Esc_1, grey symbols = Esc_2, black symbols = Esc_3. Error bars are 95% profile likelihood confidence intervals. Years prior to 2003 are shown for comparison.

Mainstem harvest rates for the unknown-origin groups in 2003-2004 were 11-12% for spring–summer Chinook salmon and 12-23% for fall Chinook salmon and steelhead (Table 2). Harvest rates in tributaries within the monitored Hydrosystem were less than 10% for all species-years. Percentages unaccounted for were 8-13% for spring–summer Chinook salmon, 15-24% for fall Chinook salmon, and 9-14% for steelhead (Table 2). The 24% unaccounted rate for fall Chinook salmon in 2004 was higher than for any other study year.

Table 2. Number of radio-tagged fish and the percent (*n*) in each fate category, with Hydrosystem (top of Bonneville Dam to top of Lower Granite or Priest Rapids dams) escapement estimates for all fish released downstream from Bonneville Dam, for unknown-origin (Unknown) stocks and for known-origin stocks identified by PIT tags, 2003-2004. Includes corrections from PIT-tag-only detections at dams.

Stock	E_i	P_i	T_{i+d}[1]	H_{i+d}	TF_{i+d}	MF_{i+d}	U_{i+d}	Esc_1	Esc_2	Esc_3
2003 Spring-Summer Chinook salmon										
Unknown	801	51 (406)	11 (88)	11 (86)	8 (68)	11 (86)	8 (67)	0.724	0.809	0.916
Wind R.	13		38 (5)	15 (2)	46 (6)			0.539	1.000	1.000
Upper Col	180	79 (142)	3 (5)			9 (17)	9 (16)	0.817	0.817	0.911
Snake R.	85	85 (72)	1 (1)		2 (2)	4 (3)	8 (7)	0.859	0.882	0.918
2004 Spring–summer Chinook salmon										
Unknown	390	59 (232)	7 (26)	7 (28)	2 (8)	12 (47)	13 (49)	0.733	0.754	0.874
Yakima R.	14			57 (8)	43 (6)			1.000	1.000	1.000
Upper Col	35	77 (27)	3 (1)		11 (4)	9 (3)		0.800	0.914	1.000
Snake R.	61	85 (52)			2 (1)	5 (3)	8 (5)	0.853	0.869	0.918
2003 Fall Chinook salmon										
Unknown	563	14 (79)	42 (236)	5 (30)	4 (20)	20 (115)	15 (83)	0.613	0.648	0.853
2004 Fall Chinook salmon										
Unknown	505	10 (48)	43 (217)	4 (18)	3 (17)	16 (82)	24 (123)	0.560	0.594	0.756
PRDH[1]	10	60 (6)	40 (4)					1.000	1.000	1.000
Snake R.	16	75 (12)				6 (1)	19 (3)	0.750	0.750	0.813
2003 Steelhead										
Unknown	458	50 (228)	14 (63)	3 (15)	7 (30)	12 (57)	14 (65)	0.668	0.734	0.858
Snake R.	95	69 (66)	3 (3)	1 (1)	3 (3)	9 (9)	14 (13)	0.737	0.768	0.863
2004 Steelhead										
Unknown	215	43 (93)	17 (36)	6 (12)	2 (5)	23 (49)	9 (20)	0.656	0.679	0.907
Ringold	10	30 (3)		10 (1)	10 (1)	10 (1)	4 (40)	0.400	0.500	0.600
Upper Col	19	63 (12)	5 (1)			21 (4)	11 (2)	0.684	0.984	0.895
Snake R.	34	79 (27)	6 (2)		3 (1)	3 (1)	9 (3)	0.853	0.882	0.912

Because of the smaller sample sizes in 2003-2004, Hydrosystem escapement estimates for known-origin stocks had wider confidence intervals than in previous years, but most values were comparable to previous estimates (Figures 2 and 3). We also made estimates for two new groups of known-origin fish in 2004: fall Chinook salmon tagged at Priest

Rapids Dam Hatchery (PRDH) and steelhead tagged at Ringold Hatchery (RGH). However, only ten fish were collected from each group (Table 2), and we caution that these escapement estimates may not be very meaningful. We also note that some of the PRDH fish were released upstream from Priest Rapid Dam as juveniles, and more then half passed Priest Rapids Dam as adults. These fish were considered successful adult migrants.

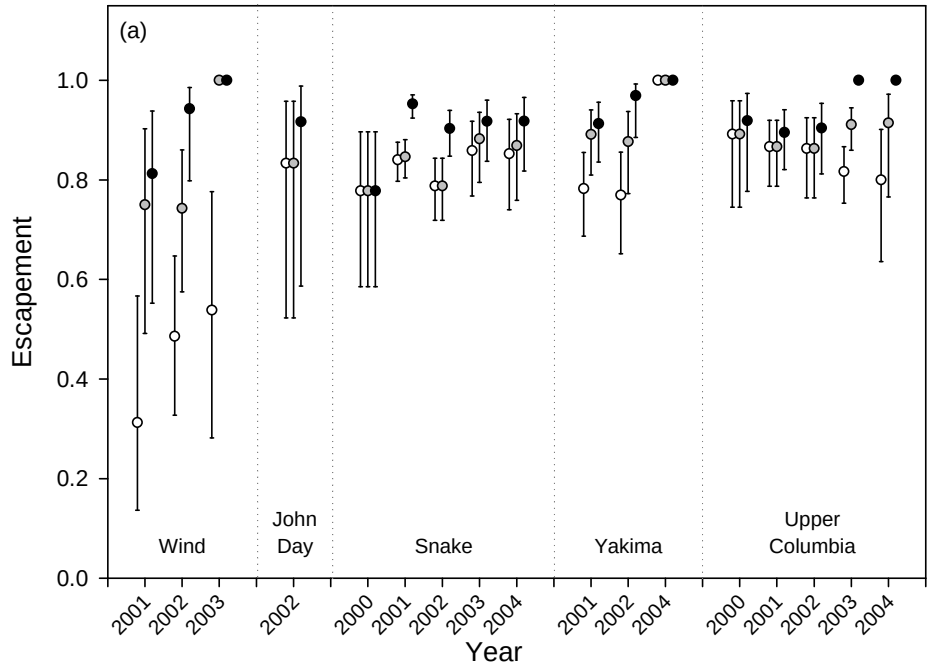


Figure 2. Annual Hydrosystem (Bonneville Dam to Lower Granite or Priest Rapids dams) escapement estimates for known-origin radio-tagged spring–summer Chinook salmon released downstream from Bonneville Dam. Open symbols = Esc_1, grey symbols = Esc_2, black symbols = Esc_3. Error bars are 95% profile likelihood confidence intervals. Years prior to 2003 are shown for comparison.

Two of the Ringold Hatchery steelhead that we designated unaccounted for were last recorded in the Hanford Reach. If these steelhead were considered successful migrants (plausible given their proximity to the hatchery), all three escapement estimates for this group (Table 2 and Figure 3) would increase by 20%.

Several known-origin spring–summer Chinook salmon and steelhead were last recorded straying into non-natal tributary rivers and a few fish were recorded harvested in non-natal rivers. As in previous years, most of the strays entered tributaries to the Bonneville reservoir or the Deschutes or John Day rivers. By our definitions, fish that entered these tributaries were considered escaped (Esc_2 and Esc_3) regardless of their natal destination. Escapement estimates for the known-origin groups would be lower by approximately the percentages noted in Table 2 if strays were treated as unsuccessful migrants. (See Keefer et al. 2005b and 2006 for further details of straying rates.)

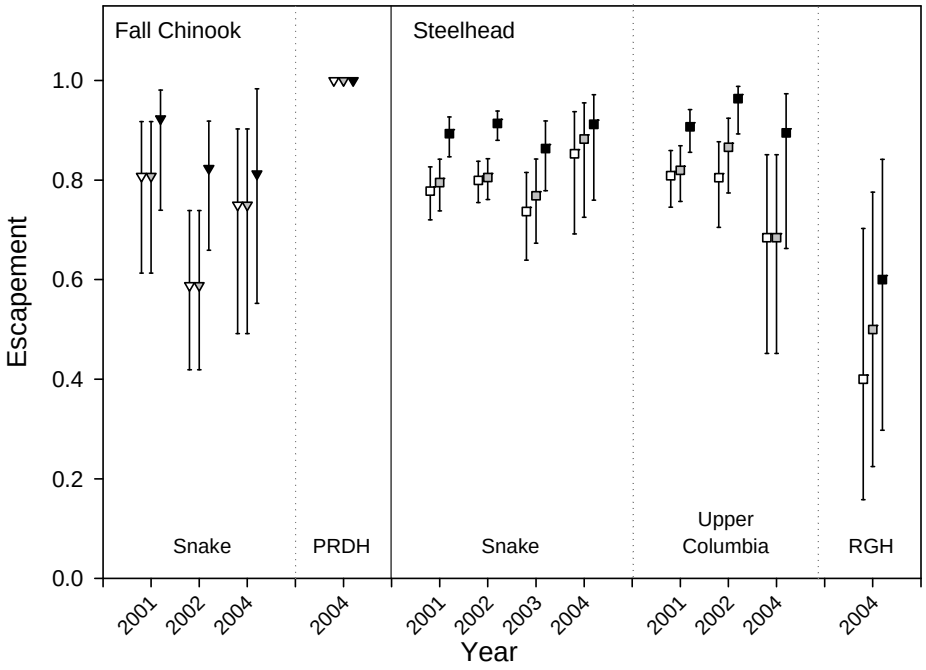


Figure 3. Annual Hydrosystem (Bonneville Dam to Lower Granite or Priest Rapids dams) escapement estimates for unknown-origin radio-tagged fall Chinook salmon and steelhead released downstream from Bonneville Dam. Open symbols = Esc_1, grey symbols = Esc_2, black symbols = Esc_3. Error bars are 95% profile likelihood confidence intervals. Years prior to 2003 are shown for comparison. RGH = Ringold Hatchery. PRDH = Priest Rapids Dam Hatchery.

References:

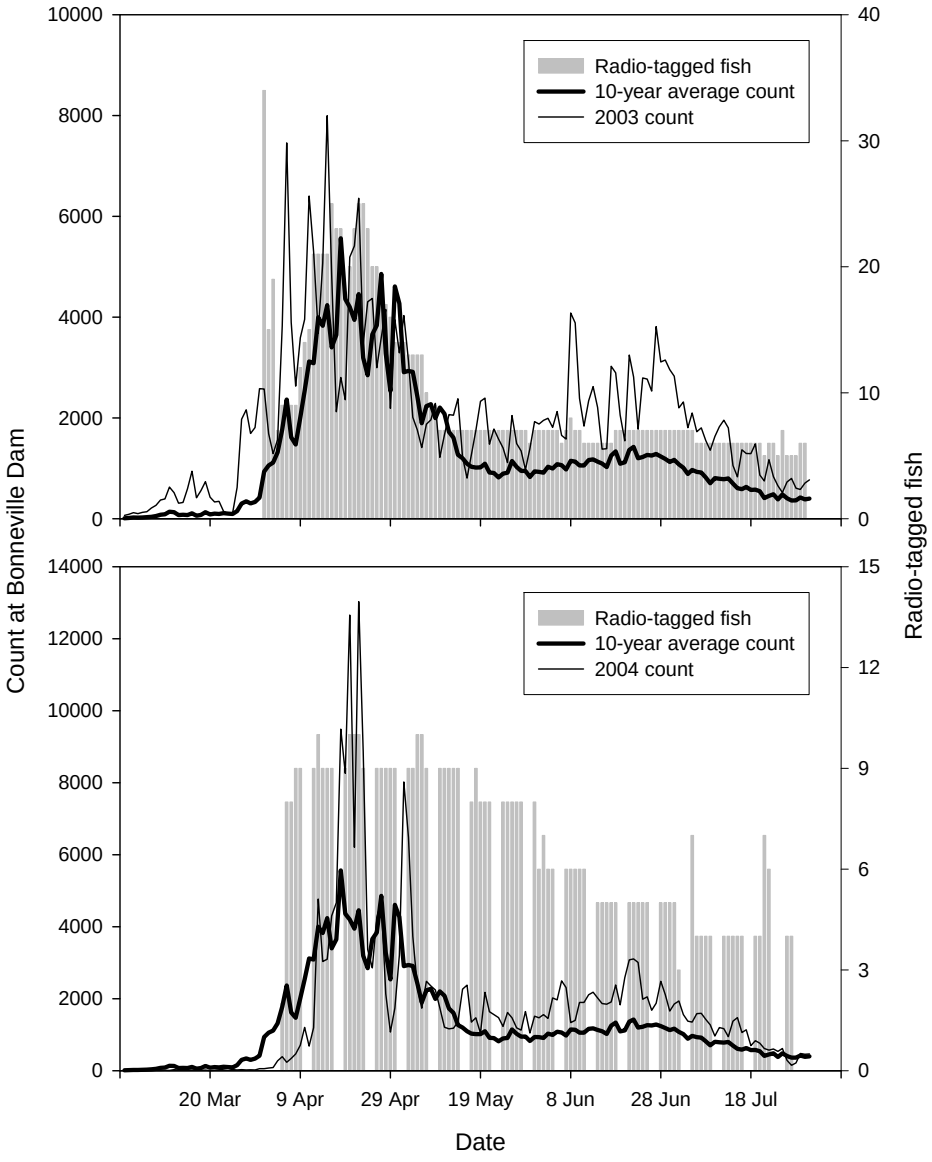
Keefer, M.L. and C.A. Peery. 2004. Revision of Hydrosystem escapement estimates to reflect Bonneville impact. Letter Report to Chris Ross and David Clugston, 11-August-2004.

Keefer, M.L., C.A. Peery, W.R. Daigle, M.A. Jepson, S.R. Lee, C.T. Boggs, K.R. Tolotti, T.C. Bjornn, B.J. Burke, M.L. Moser, and L.C. Stuehrenberg. 2005a. Escapement, harvest and unaccounted-for loss of radio-tagged adult Chinook salmon and steelhead in the Columbia-Snake River Hydrosystem. Technical Report 2005-2 of Idaho Cooperative Fish and Wildlife Research Unit, Moscow, ID for U.S. Army Corps of Engineers, Portland and Walla Walla Districts, and Bonneville Power Administration. (http://www.uidaho.edu/cnr/ferl/publications)

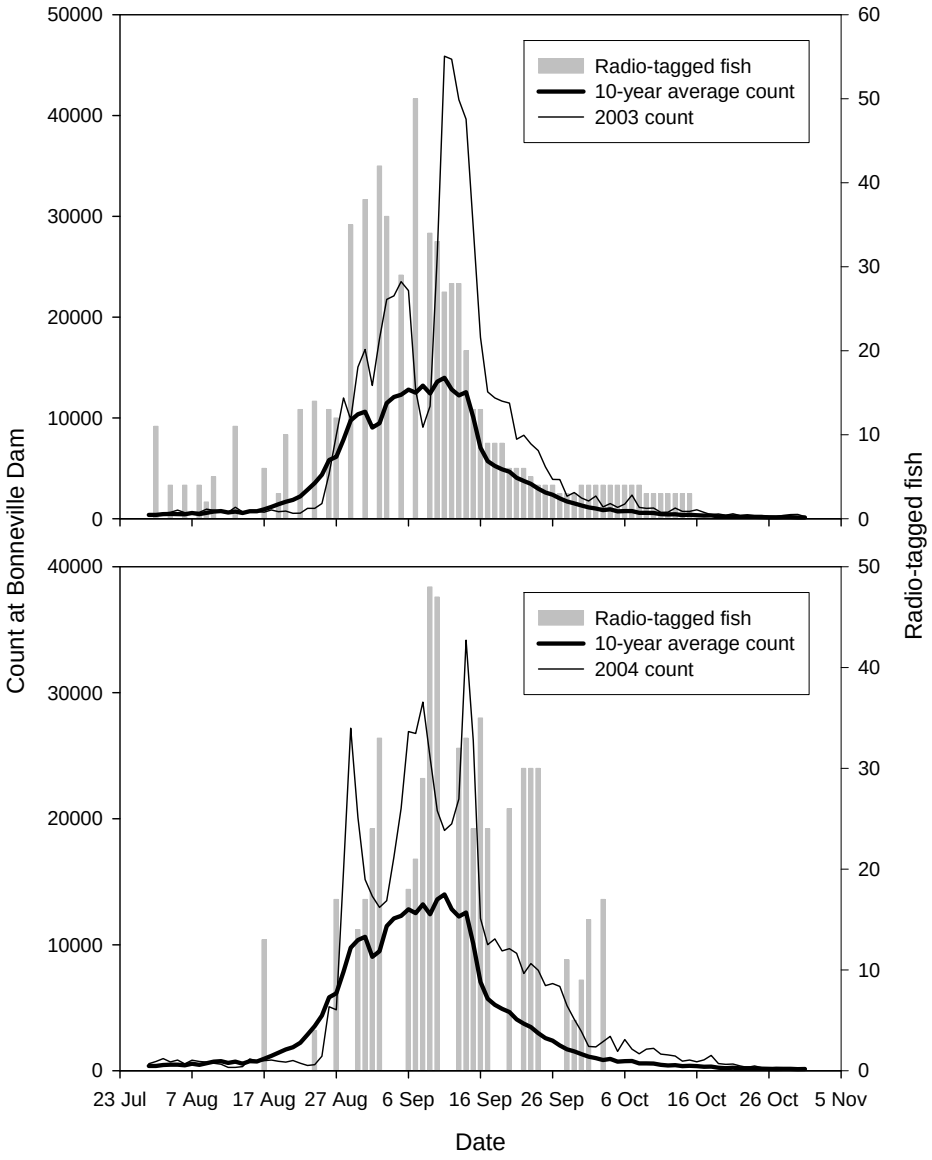
Keefer, M.L., C.A. Peery, J. Firehammer, and M.L. Moser. 2005b. Straying rates of known-origin adult Chinook salmon and steelhead within the Columbia River basin, 2000-2003. Technical Report 2005-5 of Idaho Cooperative Fish and Wildlife Research Unit, Moscow, ID for U.S. Army Corps of Engineers, Portland and Walla Walla Districts, and Bonneville Power Administration. (http://www.uidaho.edu/cnr/ferl/publications)

Keefer, M.L. and C.A. Peery. 2006. Summary of 2004 straying rates for known-origin adult Chinook salmon and steelhead in the Columbia/Snake Hydrosystem. Letter Report to David Clugston and Marvin Shutters, January 2006.

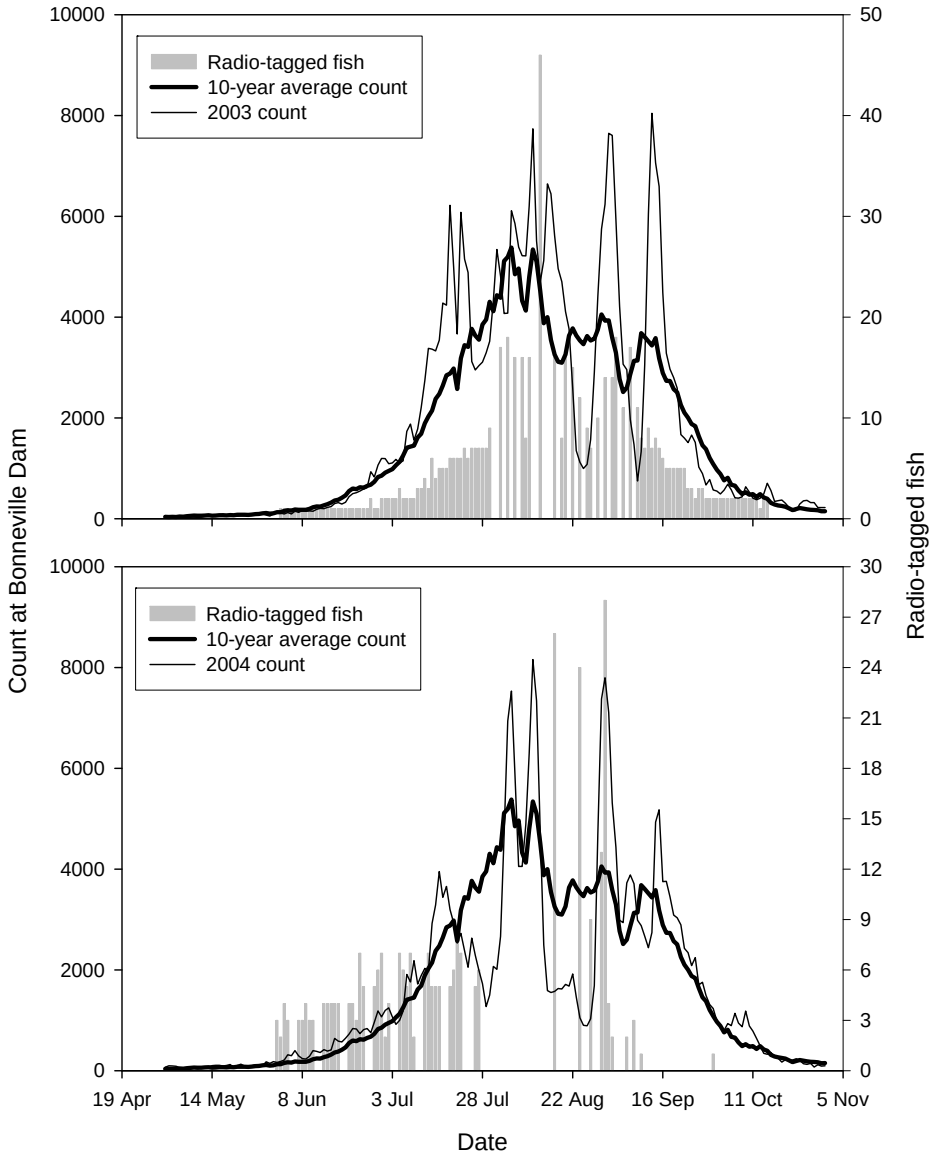
Naughton, G.P., C.C. Caudill, M.L. Keefer, T.C. Bjornn, L.C. Stuehrenberg, and C.A. Peery. 2005. Late-season mortality during migration of radio-tagged adult sockeye salmon (*Oncorhynchus nerka*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 62:30-47.



Appendix Figure 1. Number of spring-summer Chinook salmon counted at Bonneville Dam in 2003 and 2004, with the 1995-2004 ten-year average and the numbers of fish collected and radio-tagged in each year.



Appendix Figure 2. Number of fall Chinook salmon counted at Bonneville Dam in 2003 and 2004, with the 1995-2004 ten-year average and the numbers of fish collected and radio-tagged in each year.



Appendix Figure 3. Number of steelhead counted at Bonneville Dam in 2003 and 2004, with the 1995-2004 ten-year average and the numbers of fish collected and radio-tagged in each year.