IDAHO COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT
COLLEGE OF NATURAL RESOURCES
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From: Matt Keefer & Chris Peery

Re: Adult salmonid fallback and escapement during summer (July-August) spill/no spill periods at Bonneville, The Dalles, John Day and Ice Harbor dams

Date: 22-March-2004

Introduction: We evaluated the effects of spill on fallback behavior and escapement of radio-tagged adult spring–summer and fall Chinook salmon and steelhead during July and August from 1996-2002. No-spill conditions occurred at these dams only in 2001, a near-record low discharge year. At Bonneville and The Dalles dams, 23 days of no-spill were recorded in July of 2001 (DART database), representing 6% of study dates at those dams. All no-spill dates were before the fall Chinook runs at Bonneville and The Dalles dams. No-spill conditions occurred for all of July and August at John Day and Ice Harbor dams in 2001, representing 17% of all study dates there. Excepting 2001, daily July and August spill levels at Bonneville and The Dalles dams averaged more than 80 kcfs, means at John Day Dam were more than 40 kcfs, and means at Ice Harbor Dam were about 30 kcfs (Table 1).

Table 1. Mean daily spill (kcfs) in July and August at Bonneville (BO), The Dalles (TD), John Day (JD) and Ice Harbor (IH) dams from 1996 to 2002.

	Mean daily July spill				Mean daily August spill			
	BO	TD	JD	IH	BO	TD	JD	IH
1996	86	135	34	24	91	100	39	24
1997	94	170	51	38	107	124	41	36
1998	90	90	51	50	86	67	43	27
2000	94	64	57	34	89	54	50	23
2001	2	5	0	0	39	33	0	0
2002	114	88	69	33	103	58	42	24

Fallback: During the summer of 2001, proportionately more spring–summer Chinook salmon fell back during spill than during no-spill at Bonneville (4.5% versus 1.3%) and The Dalles (6.5% versus 2.8%) dams, but differences were not statistically significant ($P > 0.05$, χ^2 tests) (Table 2). When spring–summer Chinook salmon from all years were pooled together, significantly more fell back during spill than during no-spill at The Dalles Dam (8.4% versus 2.8%) ($P = 0.042$). Steelhead fallback proportions in 2001 did not differ ($P > 0.05$) during treatments at Bonneville or The Dalles dams (Table 3). With all years pooled, steelhead fallback was significantly higher during spill only at Bonneville Dam (6.1% versus 0.0%) ($P = 0.015$). Only one fall chinook was recorded falling back at John Day Dam during the study (Table 4).

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Table 2. Number of radio-tagged spring–summer Chinook salmon (CK) recorded passing Bonneville, The Dalles, John Day and Ice Harbor dams during July-August periods of spill and no spill, with proportions recorded falling back and overall escapement[1] (Esc). Fish had to both pass and fall back during July-August to be included in fallback estimates.

			During Spill			During No Spill		
Run	Dam	Year	*n*	%FB	Esc	*n*	%FB	Esc
CK	Bonneville	1996	8	37.5	0.625			
		1997	173	5.2	0.902			
		1998	122	6.6	0.820			
		2000	130	3.8	0.925			
		2001	22	4.5	1.000	79	1.3	0.911
		2002	90	3.3	0.856			
		Total	**545**	**5.3**	**0.881**	**79**	**1.3**	**0.911**
CK	The Dalles	1996	10	20.0	0.900			
		1997	180	12.8	0.906			
		1998	134	11.2	0.813			
		2000	168	4.8	0.940			
		2001	31	6.5	0.903	107	2.8	0.935
		2002	129	3.9	0.891			
		Total	**652**	**8.4***	**0.893**	**107**	**2.8***	**0.935**
CK	John Day	1996	28	0.0	0.857			
		1997	183	4.9	0.913			
		1998	128	4.7	0.852			
		2000	154	1.3	0.974			
		2001	0			144	0.7	0.924
		2002	142	3.5	0.930			
		Total	**613**	**3.5**	**0.917**	**144**	**0.7**	**0.924**
CK	Ice Harbor	1996	8	0.0	0.875			
		1997	38	15.8	0.895			
		1998	18	16.7	0.889			
		2000	6	16.7	0.833			
		2001	0			19	5.3	0.947
		2002	10	0.0	1.000			
		Total	**80**	**12.5**	**0.900**	**19**	**5.3**	**0.947**

[1] Escapement = fish last recorded upstream from Priest Rapids or Lower Granite Dam or last recorded in a tributary, hatchery or fishery

* $P < 0.05$ ** $P < 0.005$ (χ^2 tests)

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Table 3. Number of radio-tagged steelhead (SH) recorded passing Bonneville, The Dalles, John Day and Ice Harbor dams during July-August periods of spill and no spill, with proportions recorded falling back and overall escapement[1]. Fish had to both pass and fall back during July-August to be included in fallback estimates.

			During Spill			During No Spill		
Run	Dam	Year	*n*	%FB	Esc	*n*	%FB	Esc
SH	Bonneville	1996	372	5.4	0.785			
		1997	428	13.6	0.820			
		2000	445	8.3	0.876			
		2001	336	2.1	0.869	93	0.0	0.925
		2002	518	1.0	0.902			
		Total	**2099**	**6.1***	**0.854**	**93**	**0.0***	**0.925**
SH	The Dalles	1996	199	4.5	0.794			
		1997	132	5.3	0.773			
		2000	203	3.4	0.847			
		2001	176	0.6	0.926	84	1.2	0.893
		2002	329	2.1	0.878			
		Total	**1039**	**3.0**	**0.851**	**84**	**1.2**	**0.893**
SH	John Day	1996	112	8.9	0.750			
		1997	74	10.8	0.716			
		2000	112	2.7	0.821			
		2001	0			134	5.2	0.925
		2002	191	4.2	0.890			
		Total	**489**	**5.9**	**0.816****	**134**	**5.2**	**0.925****
SH	Ice Harbor	1996	34	8.8	0.794			
		1997	34	17.6	0.824			
		2000	27	7.4	0.815			
		2001	0			28	10.7	0.857
		2002	81	8.6	0.852			
		Total	**176**	**10.2**	**0.830**	**28**	**10.7**	**0.857**

[1] Escapement = fish last recorded upstream from Priest Rapids or Lower Granite Dam or last recorded in a tributary, hatchery or fishery

* $P < 0.05$ ** $P < 0.005$ (χ^2 tests)

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Table 4. Number of radio-tagged fall Chinook salmon (FCK) recorded passing John Day Dam during July-August periods of spill and no spill, with proportions recorded falling back and overall escapement[1]. Fish had to both pass and fall back during July-August to be included in fallback estimates.

			During Spill			During No Spill		
Run	Dam	Year	*n*	%FB	Esc	*n*	%FB	Esc
FCK	John Day	2000	81	1.2	0.889			
		2001				57	0.0	0.877
		2002	88	0.0	0.932			
		Total	**169**	**0.6**	**0.911**	**57**	**0.0**	**0.877**

[1] Escapement = fish last recorded upstream from Priest Rapids or Lower Granite Dam or last recorded in a tributary, hatchery or fishery
* $P < 0.05$ ** $P < 0.005$ (χ^2 tests)

Escapement: No differences in escapement to tributaries, hatcheries or the top of Lower Granite or Priest Rapids dams were detected in comparisons of 2001 spill and no-spill periods for either spring–summer Chinook salmon or steelhead ($P > 0.05$) (Tables 2 and 3). With all years combined, steelhead escapement was significantly higher ($P = 0.002$) during no-spill at John Day Dam (0.925 versus 0.816), and marginally higher ($P = 0.056$) during no-spill at Bonneville Dam (0.925 versus 0.854) (Table 3). No escapement differences ($P > 0.05$) were found with all years pooled for spring–summer or fall Chinook salmon (Tables 2 and 4).

Effects of fallback on escapement: No samples were large enough to evaluate the effects of fallback on escapement during no-spill conditions. Spring–summer Chinook salmon and steelhead that fell back during spill tended to escape at lower rates than fish that did not fall back during spill. With all years combined, fallback spring–summer Chinook salmon escaped at significantly ($P < 0.05$) lower rates than non-fallback fish at Bonneville, The Dalles, John Day and Ice Harbor dams (Table 5). Similarly, fallback steelhead escaped at significantly lower rates than non-fallback steelhead at Bonneville and Ice Harbor dams (Table 6). Among individual years, negative consequences of fallback were greatest in 1997 (high-discharge) and 2002 (near-average discharge).

Conclusions:

1) This analysis of the effects of no-spill on adult fallback and escapement was strongly limited by the number and timing of no-spill days. No-spill conditions only occurred in 2001, an anomalous migration year. At both John Day and Ice Harbor dams, no-spill conditions existed throughout July and August, and no within-year comparisons were possible at those projects. Results from 2001—and comparisons between 2001 and other years—should be interpreted with caution.

2) As we have reported previously, fallback proportions tend to be lower during no-spill conditions at most dams for both spring–summer Chinook salmon and steelhead. Operating dams for no-spill during July and August may reduce overall adult fallback, but fish that do fall back must do so via routes (turbines, trash sluiceways, etc.) that may

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have greater negative escapement consequences than fallback via spillways. The low number of no-spill days prevented us from drawing conclusions of survival costs associated with fish that fall back during no-spill conditions.

3) Fallback during spill was associated with lower escapement for both spring–summer Chinook salmon and steelhead. This suggests that eliminating fallback via spillways in July and August may increase overall adult escapement. However, we are uncertain as to whether eliminating the spillway as a fallback route would result in greater fallback via other, potentially more-costly, routes. Greater understanding of this tradeoff would require a test of spill/no-spill operations during average or high discharge.

4) From our previous studies, up to about 30% of adult salmon and steelhead that fall back at lower Columbia and Snake river dams eventually enter tributaries downstream from the fallback location. These 'overshoot' fallbacks may be related to searching for natal tributaries. Eliminating summer spill as a fallback route may negatively impact escapement for fish with this behavior.

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Table 5. Escapement[1] of radio-tagged spring–summer Chinook salmon (CK) that did or did not fall back at Bonneville, The Dalles, John Day and Ice Harbor dams during July-August periods of spill and no spill. Fish had to both pass and fall back during July-August to be included in fallback estimates.

			During Spill				During No Spill			
			No fallback		Fallback		No fallback		Fallback	
Run	Dam	Year	*n*	Esc	*n*	Esc	*n*	Esc	*n*	Esc
CK	Bonneville	1996	5	0.600	3	0.667				
		1997	164	0.915*	9	0.667*				
		1998	114	0.825	8	0.750				
		2000	125	0.928	5	0.800	78	0.923	0	
		2001	21	1.000	1	1.000				
		2002	87	0.862	3	0.667				
		Total	**516**	**0.890****	**29**	**0.724****	**78**	**0.923**	**0**	
CK	The Dalles	1996	8	0.875	2	1.000				
		1997	157	0.930**	23	0.739**				
		1998	119	0.807	15	0.867				
		2000	160	0.944	8	0.875				
		2001	29	0.931	2	0.500	104	0.942	3	0.667
		2002	124	0.903*	5	0.600*				
		Total	**597**	**0.903***	**55**	**0.782***	**104**	**0.942**	**3**	**0.667**
CK	John Day	1996	28	0.857	0					
		1997	174	0.920	9	0.778				
		1998	122	0.852	6	0.833				
		2000	152	0.974	2	1.000				
		2001	0		0		143	0.930	1	0.000
		2002	137	0.934	5	0.800				
		Total	**613**	**0.920**	**22**	**0.818**	**143**	**0.930**	**1**	**0.000**
CK	Ice Harbor	1996	8	0.875	0					
		1997	32	0.938*	6	0.667*				
		1998	15	0.867	3	1.000				
		2000	5	1.000	1	0.000				
		2001	0		0		19	0.947	0	
		2002	10	1.000	0					
		Total	**70**	**0.929***	**10**	**0.700***	**19**	**0.947**	**0**	

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Table 6. Escapement[1] of radio-tagged steelhead (SH) that did or did not fall back at Bonneville, The Dalles, John Day and Ice Harbor dams during July-August periods of spill and no spill. Fish had to both pass and fall back during July-August to be included in fallback estimates.

			During Spill				During No Spill			
			No fallback		Fallback		No fallback		Fallback	
Run	Dam	Year	*n*	Esc	*n*	Esc	*n*	Esc	*n*	Esc
SH	Bonneville	1996	352	0.793	20	0.650				
		1997	370	0.843**	58	0.672**				
		2000	408	0.870	37	0.946				
		2001	329	0.869	7	0.857	93	0.925	0	
		2002	513	0.903	5	0.800				
		Total	**1972**	**0.860****	**127**	**0.764****	**93**	**0.925**	**0**	
SH	The Dalles	1996	190	0.800	9	0.667				
		1997	125	0.784	7	0.571				
		2000	196	0.847	7	0.857				
		2001	175	0.926	1	1.000	83	0.892	1	1.000
		2002	322	0.882	7	0.714				
		Total	**862**	**0.855***	**31**	**0.710***	**83**	**0.892**	**1**	**1.000**
SH	John Day	1996	102	0.755	10	0.700				
		1997	66	0.727	8	0.625				
		2000	109	0.817	3	1.000				
		2001	0		0		117	0.921	7	1.000
		2002	183	0.896	8	0.750				
		Total	**378**	**0.822**	**21**	**0.724**	**117**	**0.921**	**7**	**1.000**
SH	Ice Harbor	1996	31	0.806	3	0.667				
		1997	28	0.857	6	0.667				
		2000	25	0.840	2	0.500				
		2001	0				25	0.840	3	1.000
		2002	74	0.878*	7	0.571*				
		Total	**158**	**0.854***	**18**	**0.611***	**25**	**0.840**	**3**	**1.000**

[1] Escapement = fish last recorded upstream from Priest Rapids or Lower Granite Dam or last recorded in a tributary, hatchery or fishery

* $P < 0.05$ ** $P < 0.005$ (χ^2 tests)