To: David Clugston, USACE Portland District

From: Michael Jepson, Ken Tolotti, Christopher Peery, and Brian Burke – University of Idaho and NOAA Fisheries

RE: Radio-telemetry data for Chinook salmon at Bonneville Dam - 2007

Date: 18 October 2007

Introduction

Adult salmon are vulnerable to pinniped predation during the spawning migration through estuaries and river mouths, especially where salmon concentrate or passage may be constricted (NMFS 1997). Because most salmonids must pass through relatively narrow fishways to pass Bonneville Dam, the most downstream dam on the Columbia River, fish managers are concerned that unrestricted pinniped access to Bonneville's fishways may make salmonids particularly vulnerable to predation or may cause inordinately high dam passage times for adults migrating to upstream spawning sites.

For most years between 1980 and 2000, one to two sea lions (both *Zalophus californianus* and *Eumetopias jubatus*) were observed in the tailrace of Bonneville Dam. Since 2001, increasing numbers of sea lions and harbor seals (*Phoca vitulina richardii*) have been observed there. Surveys conducted from 2002 through 2006 suggest there has been a general increase in the proportion of the spring Chinook salmon (*Oncorhynchus tshawytscha*) run being preyed upon by pinnipeds (Stansell 2004; R. Stansell, personal communication). During these years, predations rates have averaged 1.5% annually; years with relatively high proportionate predation have been years with low salmon abundance. In absolute terms, a range of 1,010 – 3,533 adult salmon were estimated to have been preyed upon by pinnipeds each year from 2002 through 2006, with an average of 2,563 salmon annually.

During 2005, barred gates (or sea lion exclusion devices [SLEDs]) were intermittently placed at four main fishway openings of Powerhouse 2 to block pinniped access (Jepson et al. *in review*). Barred gates were similarly placed at all main fishway openings at the dam and continuously deployed during 2006. Active hazing (e.g., rubber bullets and firecrackers) and the use of acoustic deterrent devices (ADDs) were also employed in a blocked design as means of coercing pinnipeds to leave or avoid the Bonneville fishways and evaluating any effects of the hazing and ADDs on salmon passage in 2006. During 2007, SLEDs and ADDs were continuously deployed at and near all main fishway openings and the Corps contracted with USDA to conduct hazing of pinnipeds from the decks and shorelines of Bonneville Dam from dawn to dusk, seven days per week, beginning 1 March and ending 31 May. State and tribal agencies, along with NOAA Fisheries personnel, participated in hazing pinnipeds from boats using the same schedule. This report summarizes the passage times and behaviors of

radio-tagged Chinook salmon released during 2007 and based on comparisons to radio-telemetry data collected during years when no SLEDs, ADDs, or hazing were present, evaluates whether the combined effects of SLEDs, ADDs, and hazing activities impeded the passage of tagged salmon during 2007. We included passage times from 2006 in our comparisons after finding no difference in passage times between radio-tagged Chinook salmon that experienced or did not experience ADDs and hazing (Jepson et al. *in review*).

Methods

We collected and intra-gastrically radio-tagged 286 Chinook salmon at the Adult Fish Facility of Bonneville Dam and released them approximately nine kilometers downstream from the dam from 16 April through 29 May 07. A description of the tagging methods used is presented in Keefer et al. (2004). A total of 63,081 adult Chinook salmon were counted passing the dam during the same interval (Figure 1). One hundred and thirty-five tagged salmon (47%) were released on the Oregon shore at Dodson and the remainder was released on the Washington shore at Skamania Landing. Radio-tagged salmon represented ~0.5% of the salmon counted at the dam during the tagging period.

Hazing of pinnipeds by federal, tribal, and state personnel began 1 March 2007 and consisted of the use of crackershells and rubber bullets from the powerhouse decks and from boats in the tailrace. Seal bombs were used by hazers from the boats only. Working as a team, the intent was to chase pinnipeds away from the faces of the powerhouses and fishway openings and have hazers in boats chase them out of the tailrace area (Stansell et al. 2007). SLEDs were deployed at all main fishway openings during the week of 18-24 March 2007 (Mahar 2007a). The last SLEDS were removed from Powerhouse 2 on 30 May and hazing sea lions from the powerhouses and boats concluded on 26 May (Mahar 2007b). We included all tagged salmon released through 29 May 2007 in our analysis because of their potential for experiencing at least one of the components of the pinniped deterrent treatment applied through the end of May.

We compared monthly and grand median passage times from April – May 2007 to corresponding values from 1997-1998 and 2000-2004, years with no SLEDs, ADDs, or hazing present. We found no significant difference in passage times between radio-tagged Chinook salmon that experienced or did not experience ADDs and hazing during 2006 (Jepson et al. *in review*) so we pooled passage times from that year and included them in our comparisons. Flow, spillway discharge, and river temperatures in the Bonneville Dam tailrace varied considerably during the nine study years (Figure 2), which likely compromised our comparisons in a strict statistical sense. Nevertheless, we used data from previous years as reasonable gauges for evaluating whether there were any extraordinary deviations in the behaviors and passage times of radio-tagged Chinook salmon in response to the SLEDs, ADDs, and hazing treatment applied during 2007.

We additionally compiled a multi-year summary of fallback percentages and re-ascension rates of radio-tagged Chinook salmon that fell back at Bonneville Dam prior to 10 June, the last date pinnipeds have been observed in the tailrace there since 2002 (R. Stansell, personal communication). We included only tagged salmon that were released downstream from the

dam within years. Salmon that fall back may be injured or temporarily disoriented by the event, which may put them at a comparably high risk of being preyed upon by pinnipeds. Evidence to support this theory may be reflected in decreased re-ascension rates of radio-tagged salmon during years with high pinniped abundance. In addition to the 286 adult Chinook salmon radio-tagged and released through 29 May 2007, 21 were tagged and released downstream from the dam from 30 May through 1 June 2007. These tagged fish are included in this fallback and re-ascension rate summary.

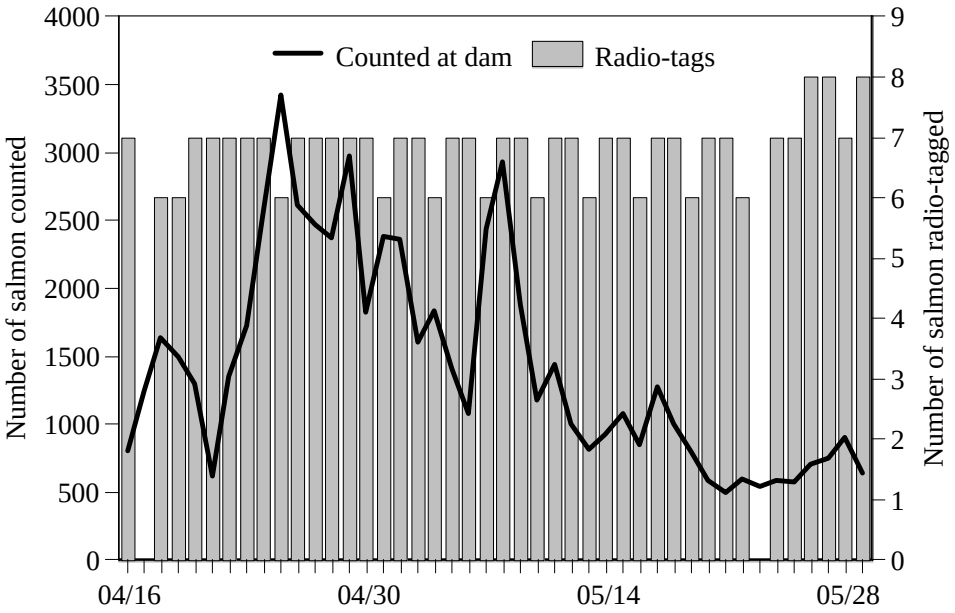

Figure 1. The number of Chinook salmon radiotagged and released downstream from Bonneville Dam and the count of adult Chinook salmon passing the dam from 16 April through 29 May 2007.

Results

Of the 286 salmon outfitted with transmitters and released downstream from the dam, 273 (95%) resumed upstream movements and were recorded on receiver sites at the dam, one (0.3%) regurgitated its transmitters prior to release, and 12 (4%) had no valid telemetry records. Of the 273 tagged salmon recorded at or upstream from the tailrace sites, 246 (90%) passed the dam (Table 1). One hundred and nine passage events (43%) were recorded via the Bradford Island ladder and 137 (57%) were recorded via the Washington-shore ladder. Among the 286 Chinook salmon tagged and released, an additional nine salmon passed the dam based on PIT-tag detections, making the percentage of released fish that passed the dam equal 89% (255/286). Among tagged salmon released through 29 May 2007, we observed 16 fallback events by 16 unique salmon (fallback percentage = 16 salmon that fell back /246 unique salmon passed = 6.5%); eight by salmon that passed via the Bradford Island ladder and eight by salmon that passed via the Washington-shore ladder. Nine of the 16 tagged salmon (56%) that fell back re-ascended the dam. With the exception of our presentation of

re-ascension rates of tagged salmon that fell back, no post-fallback data were evaluated as part of this report.

Table 1. Number (%) of adult radio-tagged fish released downstream from Bonneville Dam, recorded at the dam, that passed the dam, that were recorded on their first passage of the tailrace, first approach at a fishway opening, first fishway entry, and exit from the top of a ladder during 2007.

	2007
Released downstream	*286*
Recorded at dam	*273 (95%)*
Known to pass dam	*246 (86%)*
Recorded first tailrace passage	*230 (80%)*
Recorded first fishway approach	*259 (89%)*
Recorded first fishway entrance	*246 (86%)*
Recorded ladder exit	*246 (86%)*

Passage Times

The median time from release to first record in the tailrace was 25.8 h (n=70) for fish tagged and released in April 2007 and decreased to 6.0 h (n=158) for fish tagged and released in May 2007 (Table 2). The median time for all radio-tagged salmon to swim from the release site to being detected on the tailrace sites was 6.8 h during April-May 2007. Overall, the median time for all radio-tagged salmon to swim from the release site to the tailrace during 2007 ranked as the fastest among the nine study years.

The median time from first tailrace record to first fishway approach during April 2007 (19.6 h, n = 66) was the fourth slowest time observed during April of the nine study years. The median tailrace to first approach time for May 2007 tied with May 1997 as the third fastest among the nine study years. The median time to first approach a fishway after being detected in the tailrace during April-May 2007 was the fourth fastest among the nine study years.

The median time from first tailrace record to first fishway entry during April 2007 was third slowest among years whereas the median time for May 2007 ranked as the fifth slowest (or fastest). The grand median for April-May 2007 was in the middle of the range of medians among the nine study years.

The median time for radio-tagged Chinook salmon to pass Bonneville Dam (tailrace to ladder top) during April, May, and April-May 2007 ranked as the fourth slowest among corresponding values from all other study years.

The median time from first approach to first entry during April 2007 was the third slowest among April values and the median time for May 2007 was the slowest among all May values. The grand median time from first approach to first entry during 2007 ranked as the second slowest among all study years.

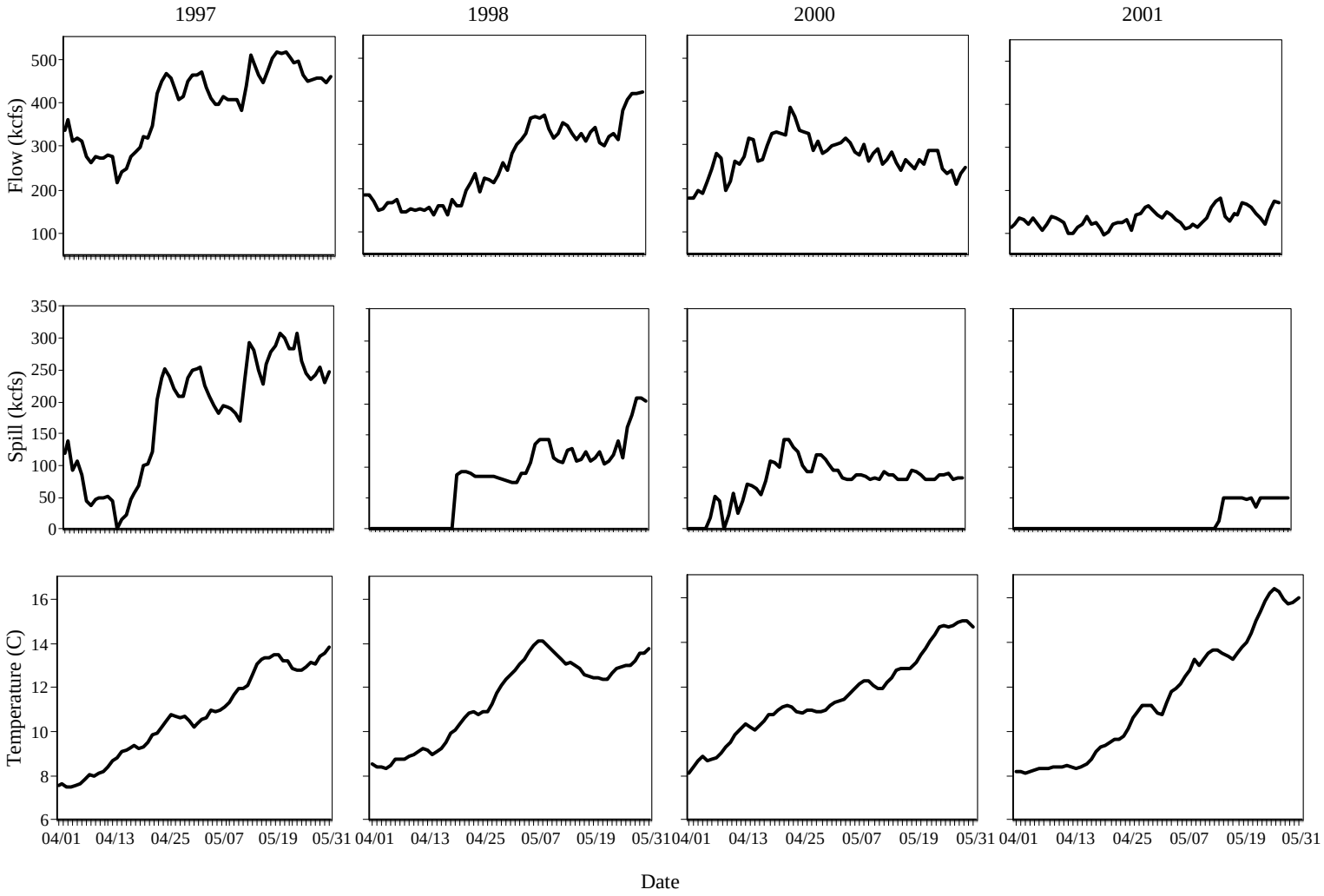

Figure 2. Mean daily flow, spillway discharge, and tailrace water temperature at Bonneville Dam during April – May, 1997-1998, 2000-2004, and 2006-2007.

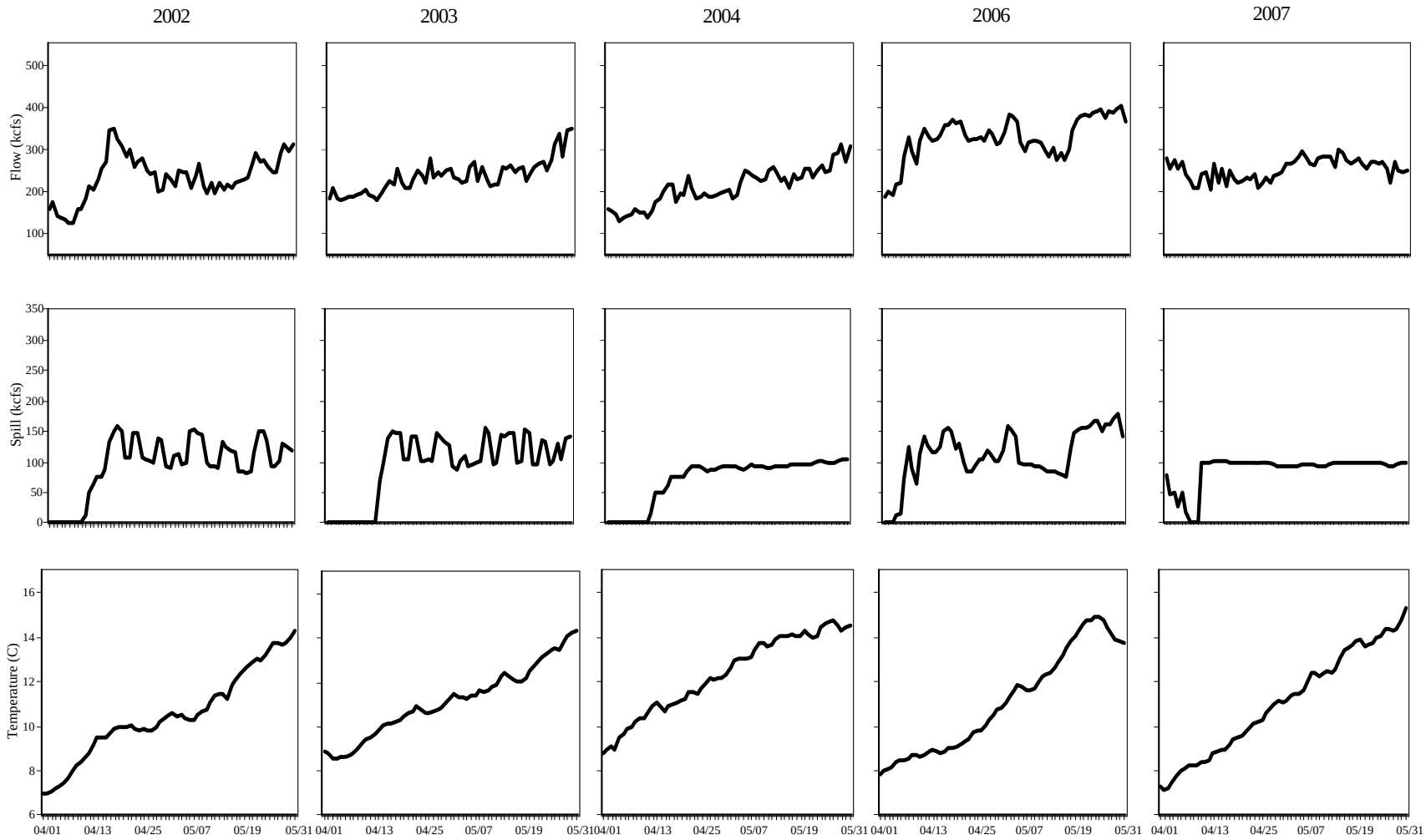

Figure 2 (continued). Mean daily flow, spillway discharge, and tailrace water temperature at Bonneville Dam during April – May, 1997-1998, 2000-2004, and 2006-2007.

Table 2. Number of adult radio-tagged spring Chinook salmon and median times to pass (h) from release to first tailrace record, and from first tailrace record to first fishway approach, to first fishway entrance, and to pass Bonneville Dam based on month fish were first detected in the tailrace, 1997-1998, 2000-2004, and 2006-2007. Rankings for 2007 values (1 = slowest time and 9 = fastest time) are listed to the right.

	1997		1998		2000		2001		2002		2003		2004		2006		2007		2007
Release to tailrace	N	Med.	n	Med.	n	Med.	n	Med.	n	Med	n	Med.	n	Med.	n	Med.	n	Med.	Rank
April	314	**22.6**	341	**7.0**	461	**15.2**	253	**17.1**	255	**29.5**	434	**25.9**	124	**23.6**	46	**47.8**	70	**25.8**	**4**
May	311	**23.9**	275	**7.0**	222	**6.7**	258	**13.0**	272	**16.1**	225	**20.1**	173	**17.2**	253	**21.0**	158	**6.0**	**9**
All	625	**23.2**	616	**7.0**	683	**12.8**	511	**14.1**	527	**20.2**	659	**24.0**	297	**18.2**	299	**23.6**	228	**6.8**	**9**
Tailrace to 1st approach																			
April	296	**3.4**	337	**3.9**	454	**6.9**	247	**20.3**	241	**17.5**	366	**23.5**	117	**46.7**	39	**15.7**	66	**19.6**	**4**
May	300	**2.6**	271	**2.0**	218	**2.5**	251	**9.0**	268	**12.1**	213	**9.2**	163	**29.7**	230	**5.2**	148	**2.6**	**6.5**
All	596	**3.0**	608	**2.7**	672	**3.8**	498	**13.2**	509	**14.1**	579	**17.6**	280	**33.4**	269	**6.5**	214	**4.0**	**6**
Tailrace to 1st entry																			
April	226	**17.0**	294	**14.3**	373	**25.3**	228	**37.6**	214	**34.6**	313	**47.0**	101	**78.6**	27	**68.3**	63	**49.6**	**3**
May	249	**9.7**	250	**10.2**	185	**13.2**	231	**11.5**	228	**23.8**	195	**23.2**	148	**37.2**	182	**21.8**	140	**18.4**	**5**
All	475	**12.9**	554	**12.5**	558	**20.7**	459	**19.7**	442	**29.7**	508	**34.2**	249	**42.6**	209	**24.1**	203	**23.6**	**5**
Tailrace to pass dam																			
April	306	**47.4**	330	**23.8**	449	**44.8**	237	**58.7**	248	**52.4**	400	**53.4**	110	**87.2**	33	**98.9**	63	**53.5**	**4**
May	304	**22.7**	267	**19.6**	219	**22.7**	254	**22.2**	267	**50.6**	206	**33.7**	158	**54.1**	193	**25.7**	140	**27.5**	**4**
All	610	**33.2**	597	**21.6**	668	**32.6**	491	**32.8**	515	**51.4**	606	**49.1**	268	**62.4**	226	**30.3**	203	**37.7**	**4**
First approach to first entry																			
April	237	**4.8**	312	**4.2**	390	**16.2**	266	**3.0**	290	**4.3**	351	**1.6**	123	**1.5**	31	**8.0**	72	**6.5**	**3**
May	266	**2.3**	273	**2.9**	193	**4.6**	267	**1.2**	250	**4.8**	225	**1.4**	158	**1.8**	208	**3.2**	170	**6.5**	**1**
All	503	**2.7**	585	**3.5**	583	**10.2**	533	**1.8**	540	**4.6**	576	**1.6**	281	**1.8**	239	**3.3**	242	**6.5**	**2**

Dam passage times and exit percentages

Forty-seven of the 246 radio-tagged Chinook salmon that entered a fishway during 2007 (19.1%) exited a fishway at least once (Table 3). Exit percentages (unique fish exited/unique fish entered) for radio-tagged Chinook salmon in April-May of eight previous years ranged from 8 to 61% for fishway entrants, with 2006 having the minimum percentage and 2007 having the second lowest percentage. The median time to pass the dam for radio-tagged salmon that made at least one exit during 2007 was 44.6 h (n = 38) compared to 30.5 h (n = 167) for radio-tagged salmon that made no exit.

Table 3. Number of radio-tagged Chinook salmon that entered a Bonneville Dam fishway prior to 1 June and the frequency and percentage of those salmon that exited a fishway at least once.

Year	No. tagged salmon that entered dam	No. tagged salmon that exited dam	Percent
1997	654	398	60.8
1998	651	256	39.3
2000	700	273	39.0
2001	594	166	27.9
2002	630	198	31.4
2003	700	176	25.1
2004	298	99	33.2
2006	296	24	8.2
2007	246	47	19.1

Re-ascension rates of radio-tagged salmon that fell back

Prior to 2001, the first year when pinniped abundance began increasing noticeably, re-ascension rates of unique radio-tagged salmon that fell back at Bonneville Dam before 10 June ranged from 84 to 96% (Table 4). These were also years when fallback percentages were relatively high (12-17%). Fallback percentages were relatively low (*range* = 3 to 7%) from 2001 through 2004 while re-ascension rates of unique salmon generally decreased during these years, reaching a minimum of 70% in 2004. During 2005, few Chinook salmon were radio-tagged and released downstream from the dam prior to 10 June (25 total) so the 100% re-ascension rate by unique salmon that year should likely be viewed with some wariness. Re-ascension rates of unique salmon during 2006 and 2007 decreased each year and reached a minimum of 56% during 2007.

Table 4. Fallback percentage (unique salmon that fell back / unique salmon that passed dam), number of fallback and re-ascension events by radio-tagged spring-summer Chinook salmon (prior to 10 June) and the number of unique radio-tagged Chinook salmon that fell back and re-ascended Bonneville Dam, 1996-1998, and 2000-2007.

Year	Fallback percentage	Fallback events	Re-ascension events	Percent re-ascended (events)	Unique salmon that fell back	Unique salmon that re-ascended	Percent re-ascended (unique salmon)
1996	14.6	122	111	91	103	93	90
1997	17.0	151	144	95	114	109	96
1998	12.2	113	96	85	84	71	84
2000	15.4	149	142	95	116	109	94
2001	5.0	51	44	86	33	29	88
2002	6.8	50	41	82	45	37	82
2003	5.3	56	48	86	41	39	95
2004	2.9	11	8	73	10	7	70
2005	12.5	2	2	100	2	2	100
2006	13.2	50	32	64	43	28	65
2007	6.1	16	9	56	16	9	56

Discussion

There are several things which might account for inter-annual variability in dam passage times by radio-tagged Chinook salmon at Bonneville Dam. Multivariate analyses of total dam passage time (tailrace entry to top of ladder) by Keefer et al. (*in review*) indicated that an exit from a fishway and water temperature were the most influential predictors. Times were consistently longest for fish that exited fishways, while passage times decreased as water temperatures rose within each year, especially for spring–summer Chinook salmon.

Compared to previous years, the percentage of radio-tagged salmon that exited Bonneville Dam fishways during 2007 was the second lowest. It is not clear to what extent the SLEDs, hazing, ADDs, or the presence of predators in the tailrace were responsible for the relatively low percentages of salmon exiting the fishways during 2007. It is possible that some salmon that may have otherwise exited the fishway remained inside as a predator avoidance strategy.

With the exception of the median time from first approach to first entry, monthly and grand medians from 2007 were within the range of corresponding values observed during previous study years. Based on these data and our somewhat rough inter-annual comparisons, we conclude that the passage of adult Chinook salmon at Bonneville Dam through late May of 2007 was not extraordinarily impeded because of the summed effects of SLEDs, ADDs, and hazing activities.

Finally, there appears to be a general decrease in re-ascension rates during years when pinnipeds have been observed in the tailrace of Bonneville Dam. Differences before and after 2001 may be partially due to the overall decline in fallback associated with shifting priorities at the project. Fewer fish falling back may indicate that those that do fall back are more likely to be

seeking downstream locations. However, this may not account for all fish that do not re-ascend the dam. Because we do not know if individual, radio-tagged salmon that failed to re-ascend the dam were preyed upon, it is not clear if pinnipeds are directly responsible for the general decrease in re-ascension rates in the last four year. Still, concerns appear circumstantially justified, particularly when high fall back percentages are coupled with the presence of pinnipeds and low re-ascension rates, as they were during 2006.

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