Spring–summer Chinook salmon passage times at John Day Dam, with an emphasis on spill effects, 1996-2004

Presented below is a retrospective summary of spring–summer Chinook salmon passage times at John Day Dam. The primary objective is to qualitatively describe the effects of various spill 'treatments' on adult passage times. Because passage times are also strongly related to overall flow as well as water temperature and migration timing, we attempt to address spill treatment effects within this broader context.

During eight study years (1996-1998, 2000-2004), 4,204 radio-tagged Chinook salmon had tailrace and top-of-ladder records at the dam. The median passage time for these fish was 27.2 h (*mean* = 56.0 h, *SD* = 85.5 h).

Timing: Annual medians ranged from 20.3 to 35.8 h (Figure 1), with the longest median in 1997, the year with the highest total discharge. The monthly median passage time (all years combined) was lowest in August (19.4 h) and highest in June (39.2 h) (Figure 2).

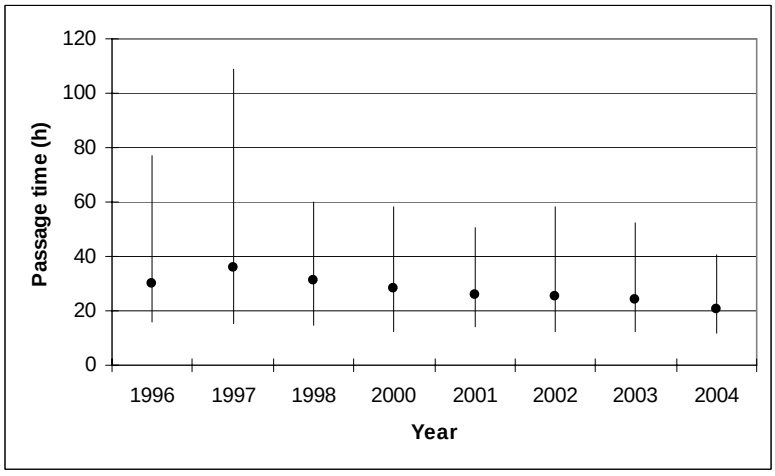

Figure 1. Median and quartile Chinook salmon passage times at John Day Dam, by year.

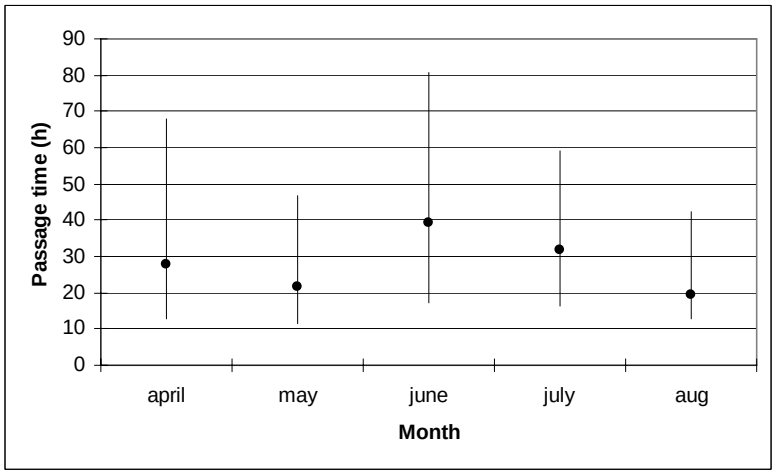

Figure 2. Median and quartile Chinook salmon passage times at John Day Dam, by month.

When all year×month combinations were considered (Figure 3) no within-year pattern was consistently observed across years. In 1997 and 1998, times decreased with each successive month. In 1996, 2000, 2001, 2002, and 2003, monthly medians were lowest in May. In 1996, 2003, and 2004 medians were highest in June.

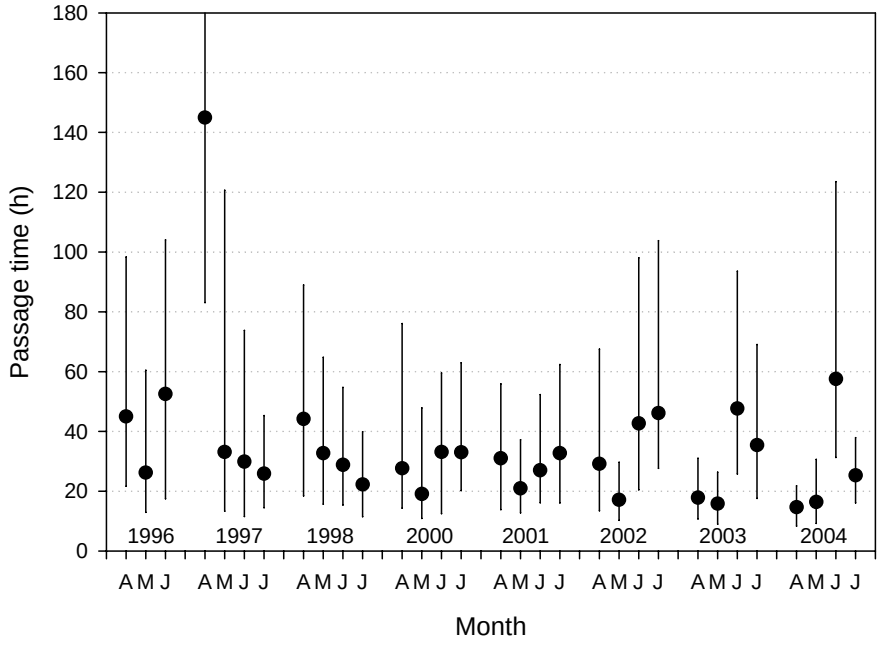

Figure 3. Median and quartile passage times (h) at John Day Dam by year and month. Only includes months with ≥ 20 salmon.

Columbia River Flow: For all months, mean Columbia River discharge was highest in 1997 and lowest in 2001 (Figure 4). 1996 was also a relatively high flow year. Peak flows within years occurred in either June or May. When salmon were categorized by total river discharge on the date they entered the John Day River tailrace, passage times were highest at the highest flow (median = 58.6 h at flow > 500 kcfs) and were lowest at low to intermediate flow (median = 24.4 h at flow between 200-300 kcfs) (Figure 5).

Median passage times for the five months with the slowest passage ranged from about 46 h in July 2002 to 145 h in April 1997 (Table 1). Median times in the fastest passage months were between 14 and 18 h; all were in April or May. Mean monthly Columbia River flow for these months tended to be higher in the months when salmon passage was slowest, but there was some overlap.

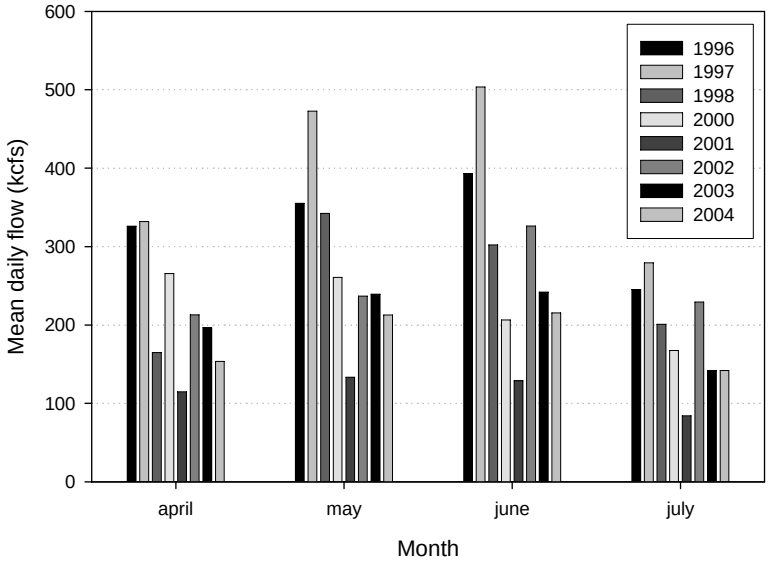

Figure 4. Mean daily flow at John Day Dam by month and year.

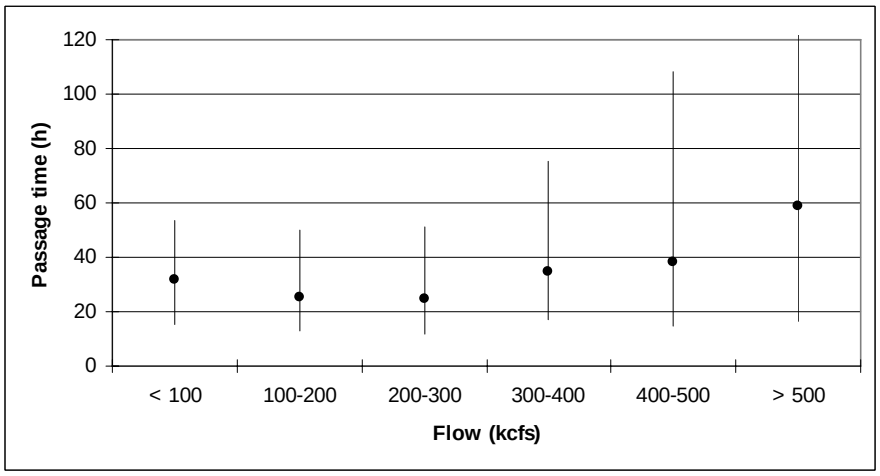

Figure 5. Median and quartile Chinook salmon passage times, by flow on tailrace entry date.

Table 1. Months with highest and lowest median Chinook salmon passage times (h) at John Day Dam

		Median passage	Flow			Median passage	Flow
Year	Month	time (*n*)	(kcfs)	Year	Month	time (*n*)	(kcfs)
Slowest passage				**Fastest passage**			
1997	April	144.9 (58)	332	2004	April	14.6 (68)	154
2004	June	57.5 (83)	215	2003	May	15.8 (161)	239
1996	June	52.5 (80)	393	2004	May	16.4 (129)	213
2003	June	47.6 (168)	242	2002	May	17.1 (314)	237
2002	July	46.1 (94)	229	2003	April	17.8 (169)	197

Columbia River Water Temperature: Water temperature was strongly correlated with date in all years ($r > 0.90$) and so migration date was not considered further. Salmon passage times showed a bimodal distribution with respect to temperature, with the highest median times at the lowest temperatures (37.2 h at 8º C) and at intermediate temperatures (40.5 h at 15º C) (Figure 6). The fastest passage occurred at 22º C (15.1 h). This pattern closely mirrors that for monthly medians shown in Figure 2.

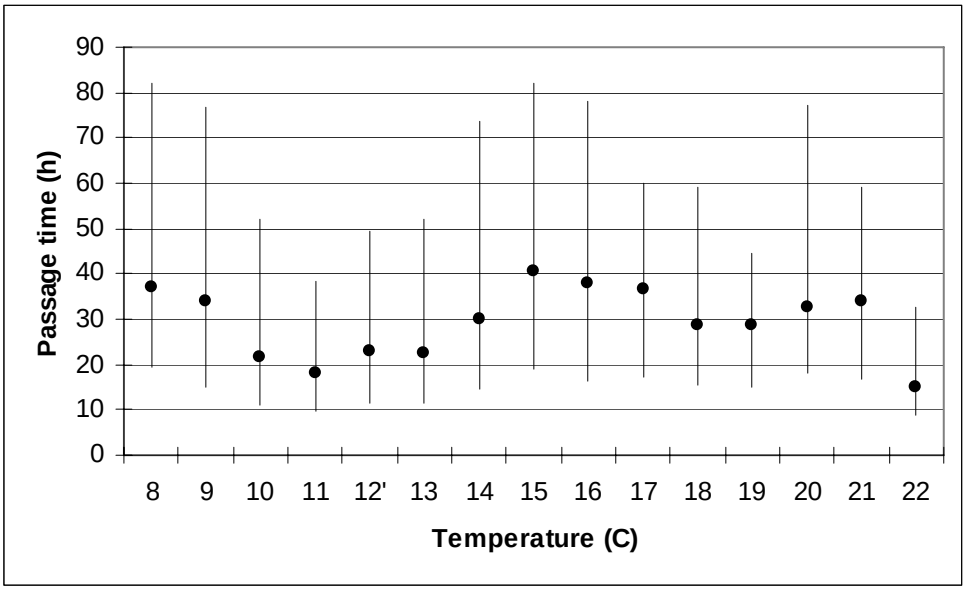

Figure 6. Median and quartile Chinook salmon passage times, by temperature (º C) on tailrace entry date. Only temperatures with ≥ 20 salmon included.

When flow and temperature combinations were considered (61 groups), the slowest passage times occurred at moderate to high discharge (300 to > 500 kcfs) with either low (9º C) or moderate (13-15º C) temperatures (Table 2). The fastest passage occurred at lower flows (100-300 kcfs) and either very high (22º C) or moderately low (11-13º C) temperatures. Medians for the highest combinations were 3-7 times higher than for the lowest combinations. Moderate temperatures tended to coincide with peak discharge.

Table 2. Flow-temperature combinations with highest and lowest median Chinook salmon passage times (h) at John Day Dam, including mean flow and dominant spill conditions.

		Median			Median
		passage			passage
Flow (kcfs)	Temp ©	time (*n*)	Flow (kcfs)	Temp ©	time (*n*)
Slowest passage			**Fastest passage**		
400-500	9	107.2 (40)	100-200	22	15.1 (33)
400-500	15	82.1 (25)	100-200	13	15.2 (52)
300-400	9	75.1 (22)	200-300	11	15.6 (133)
300-400	13	54.9 (61)	200-300	13	16.6 (129)
>500	14	54.1 (28)	100-200	11	17.8 (218)

Spill 'Treatment': Although spill was the primary variable of interest in this summary, day- and night-time spill patterns were inconsistent among years (Figure 7) and therefore difficult to assess.

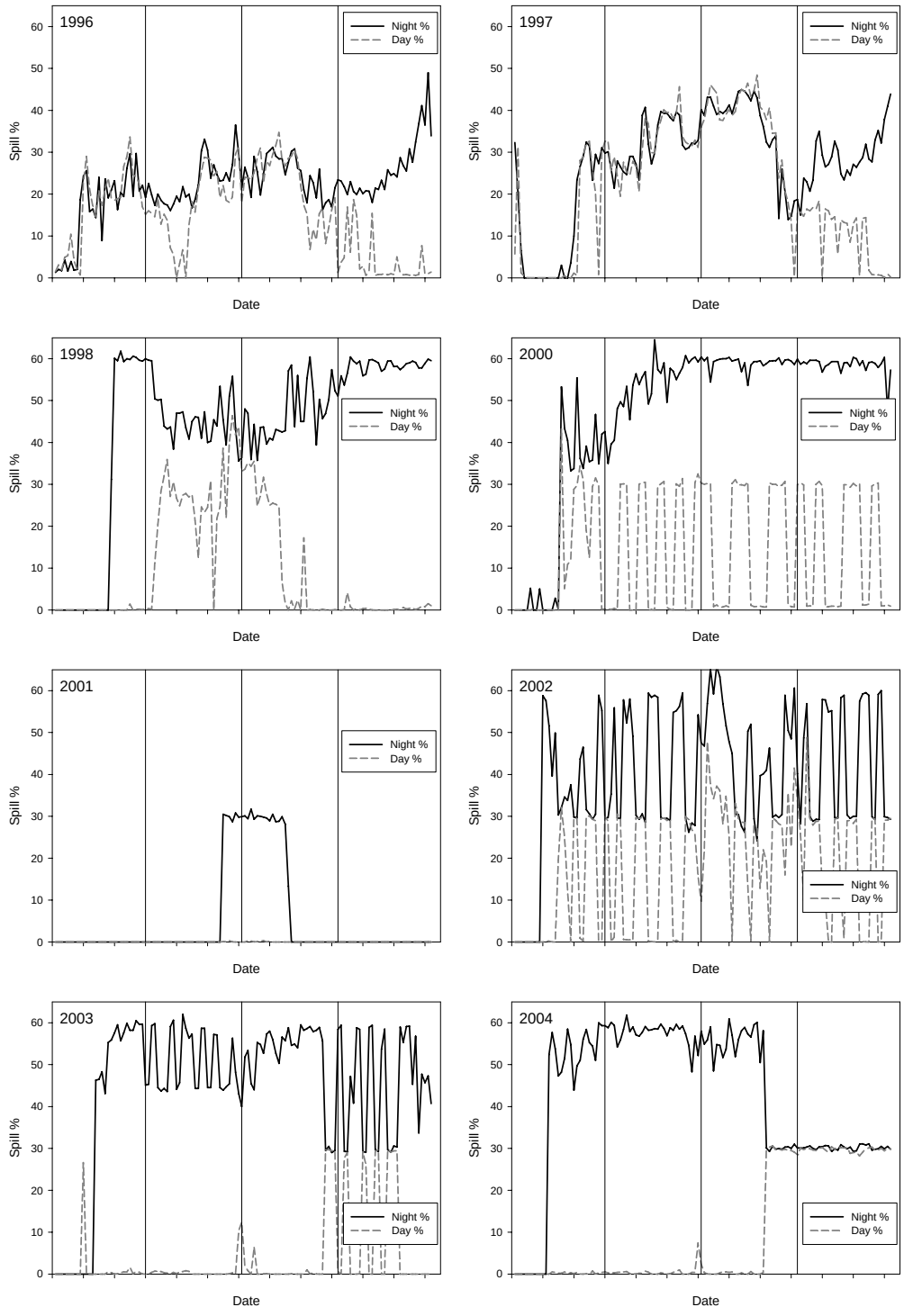

Figure 7. Percent day- and night-time spill at John Day Dam, April-July, 1996-2004.

One of the challenges of this type of retrospective analysis is that the spill 'treatments' at the dam were not designed for testing adult passage. Treatment intervals and changes in spill patterns were often rapid, particularly in 2000 and 2002, while in 1996 and 1997 patterns were almost continuously changing. Many adult fish therefore could encounter more than one spill treatment condition (median times were about 1 d and means were about 2 d). There is also some evidence that spill treatment switches, including between day and night patterns, can substantially affect adult passage behaviors as flow volumes and distributions in dam tailraces can be substantially altered. Given these potentially important complications, the following analyses should be considered general and qualitative rather than rigorous quantitative tests.

We initially grouped salmon based on the spill conditions they encountered on the date each fish entered the John Day tailrace. Subsequent spill changes during the time fish were passing the dam were ignored. In Figure 8, spill 'treatments' were split into 4 categories (4 each day and night). The highest median times occurred when day-time spill was 10-30% or 30-50% and night-time spill was 30-50%. The lowest median was for 0-10% day-time spill and 30-50% night-time spill.

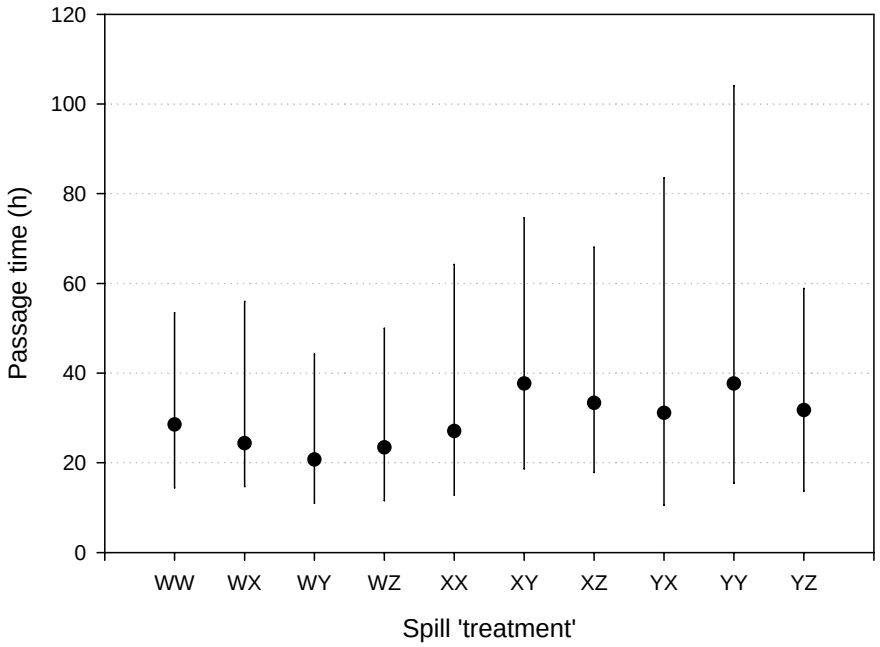

Figure 8. Median and quartile passage times by spill 'treatment'. First letter of treatment indicates day-time spill%, second letter indicates night-time spill%. W = 0-10%, X = 10-30%, Y = 30-50%, Z = > 50%. Only treatments with ≥ 20 salmon included.

Next, we divided the spill 'treatments' by 10% intervals (Figure 9). With this breakdown, most treatments with the highest medians (40-54 h) had day-time and night-time spill that was 30% or greater (Table 3). The lowest median times (18-21 h) all occurred during treatments where day-time spill was ≤ 10%, with variable night-time spill.

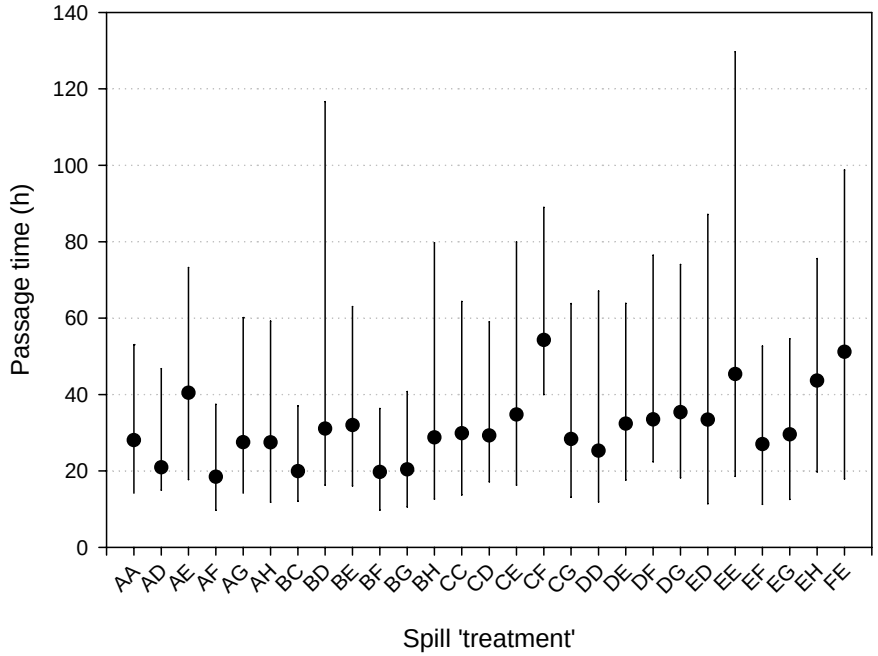

Figure 9. Median and quartile passage times by spill 'treatment'. First letter of treatment indicates day-time spill%, second letter indicates night-time spill%. A = 0%, B = 1-10%, C = 10-20%. D = 20-30%, E = 30-40%, F = 40-50%, G = 50-60%, H = > 60%. Only treatments with ≥ 20 salmon included.

Table 3. Spill treatments with highest and lowest median Chinook salmon passage times (h) at John Day Dam.

		Median			Median
Day-time	Night-time	passage	Day-time	Night-time	passage
Spill%	Spill%	time (*n*)	Spill%	Spill%	time (*n*)
Slowest passage			**Fastest passage**		
10-20%	40-50%	54.3 (39)	0%	40-50%	18.5 (161)
40-50%	30-40%	51.2 (23)	1-10%	40-50%	19.7 (147)
30-40%	30-40%	45.4 (225)	1-10%	10-20%	19.9 (34)
30-40%	> 60%	43.6 (30)	1-10%	50-60%	20.4 (658)
0%	30-40%	40.4 (22)	0%	20-30%	20.9 (33)

In the next set of analyses, both total flow and spill treatment were used to group fish. With the first spill treatment series (~20% intervals) the general trend was for increasing median passage times as total flow increased (Figure 10). Within flow categories, there was also a tendency for increased passage times as day-time spill percentages increased, though variability was quite high. One outlying data point was for salmon that entered the tailrace with 0-10% day- and night-time spill and moderate flow.

Similar general patterns emerged with 10% spill intervals (Figure 11)

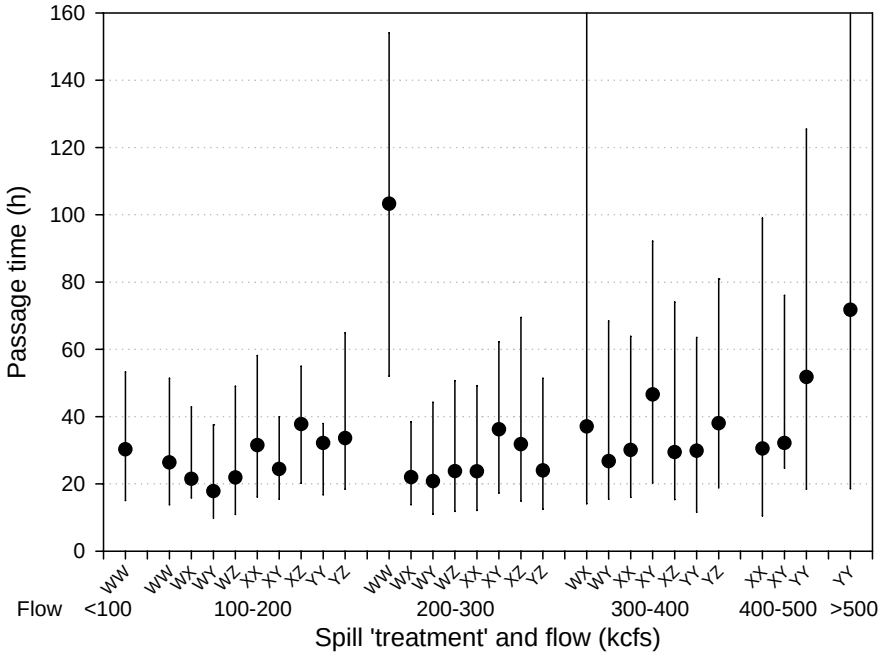

Figure 10. Median and quartile passage times by spill 'treatment' and flow. First letter of treatment indicates day-time spill%, second letter indicates night-time spill%. W = 0-10%, X = 10-30%, Y = 30-50%, Z = > 50%. Only treatments with ≥ 20 salmon included.

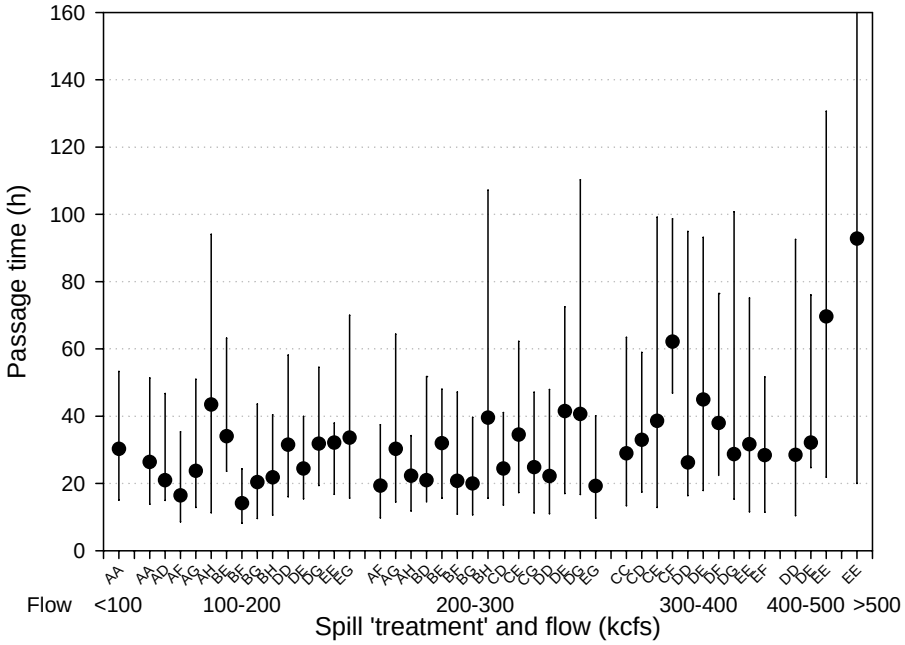

Figure 11. Median and quartile passage times by spill 'treatment' and flow. First letter of treatment indicates day-time spill%, second letter indicates night-time spill%. A = 0%, B = 1-10%, C = 10-20%. D = 20-30%, E = 30-40%, F = 40-50%, G = 50-60%, H = > 60%. Only treatments with ≥ 20 salmon included.

Two final summaries identified the flow-spill combinations with the highest and lowest median passage times (Table 4) and the individual months with the highest and lowest times (Table 5). Consistent with the previous summaries, the longest passage times by spring-summer Chinook salmon tended to occur when total flow was high and daytime spill was moderate to high. These conditions occurred during a range of months and years (Tables 4 and 5). Faster passage was almost always associated with lower flow and low day-time spill.

Table 4. Spill treatment-flow combinations with highest and lowest median Chinook salmon passage times (h) at John Day Dam. (Spill treatments by 10% intervals.)

	Day-time	Night-time	Median passage	
Flow (kcfs)	Spill%	Spill%	time (*n*)	Principal occurrence
Slowest passage				
> 500	30-40%	30-40%	92.7 (58)	may 1997; june 1997
400-500	30-40%	30-40%	69.6 (99)	june 1996; april 1997; may 1997;
300-400	10-20%	40-50%	62.1 (30)	may 1998; july 2002
300-400	20-30%	30-40%	44.9 (59)	april 2000; june 2002
100-200	0%	> 60%	43.4 (20)	april 1998
Fastest passage				
100-200	1-10%	40-50%	14.1 (46)	may 2003; august 2003; april 2004
100-200	0%	40-50%	16.4 (49)	june 1998; may 2000; april 2003; may 2003; june 2003
200-300	30-40%	50-60%	19.2 (67)	may 2000; june 2000
200-300	0%	40-50%	19.3 (102)	june 1998; may 2000; april 2003; may 2003; june 2003;
200-300	1-10%	50-60%	19.9 (432)	may 1998; june 1998; july 1998; june 2000; april 2002; may 2002; april 2003; june 2003; may 2004; june 2004

Table 5. Months with highest and lowest median Chinook salmon passage times (h) at John Day Dam, including mean flow and dominant spill conditions.

Year	Month	Median passage time (*n*)	Mean flow (kcfs)	Spill treatment(s)
Slowest passage				
1997	April	144.9 (58)	332	zero; 0-30% day & night
2004	June	57.5 (83)	215	60% night 0% day; 30% day & night
1996	June	52.5 (80)	393	10-30% day & night
2003	June	47.6 (168)	242	40-60% night 0% day
2002	July	46.1 (94)	229	60% night 0% day; 30% day & night
Fastest passage				
2004	April	14.6 (68)	154	zero; 45-60% night 0% day
2003	May	15.8 (161)	239	45-60% night 0% day
2004	May	16.4 (129)	213	50-60% night 0% day
2002	May	17.1 (314)	237	60% night 0% day; 30% day & night
2003	April	17.8 (169)	197	zero; 45-60% night 0% day