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EVALUATION OF RUNNING TURBINE 1 AT MAXIMUM CAPACITY ON PASSAGE OF ADULT SALMON AND STEELHEAD AT JOHN DAY DAM - 1997

A report for Project MPE-P-95-1

by

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Abstract

Passage rates and routes of adult chinook and sockeye salmon and steelhead with radio transmitters were monitored at John Day Dam in 1997 with turbine 1 (south end of powerhouse) operated at two levels (100 and 150 MW). A split-block experimental design was used to compare where fish approached and entered fishways, and mean and median times for fish to first approach and enter fishways when turbine 1 was operated at either of the two generation levels. Proportions of salmon and steelhead that approached and entered the south-shore fishway entrance and mean and median times for all three species to first approach and first enter fishways did not vary significantly in relation to turbine 1 operation. We conclude that operating turbine 1 at maximum capacity did not significantly affect passage for salmon and steelhead at John Day Dam in 1997.

Introduction

At John Day Dam on the Columbia River (Figure 1), discharge from turbine 1 creates visibly turbulent flow conditions in the tailrace adjacent to the south-shore fishway entrance (SSE). In 1973, the U.S. Army Corps of Engineers (COE) conducted a study to determine if discharge from turbine 1 affected use of SSE at John Day Dam by adult salmon and steelhead (Duncan et al. 1974). Electronic counting tunnels were used to enumerate the number of fish that entered the SSE during a 7-day test in which turbine 1 was operated at high (125 MW), low (80-90 MW) and off settings. Duncan et al. (1974) concluded that fewer fish entered SSE when turbine 1 was operated at the high setting. Accordingly, the COE adopted the procedure of operating turbine 1 at a low setting (100 MW or less) at all times to aid passage of adult salmon and steelhead. During high flow years, as occurred in 1996 and 1997 (Figure 2), operating powerhouse turbines at less than maximum capacity results in more spill and higher dissolved gas saturation levels in the tailrace of the dam. As a consequence it was decided to conduct a second study using modern radio telemetry techniques to evaluate the effects of turbine-1 operation on passage conditions at John Day Dam. In 1997, chinook and sockeye salmon and steelhead outfitted with radio transmitters at Bonneville Dam were monitored as they passed John Day Dam during periods of time when turbine 1 was operated at a high (150 MW) and low (100 MW) setting (Figure 2). The goal of the study was to determine if running turbine 1 at full operating capacity would interfere with passage of salmon and steelhead at John Day Dam. Specifically, would discharge from turbine 1 make it difficult for salmon and steelhead to locate and enter the south-shore fishway entrance and increase the time to enter the fishway and pass the dam.

Methods

Effects of operating turbine 1 at full capacity at the John Day Dam powerhouse were evaluated by monitoring the passage of radio-tagged chinook and sockeye salmon and steelhead at two generating levels (100 MW and 150 MW). All fish used for this study were collected and outfitted with radio transmitters at Bonneville Dam

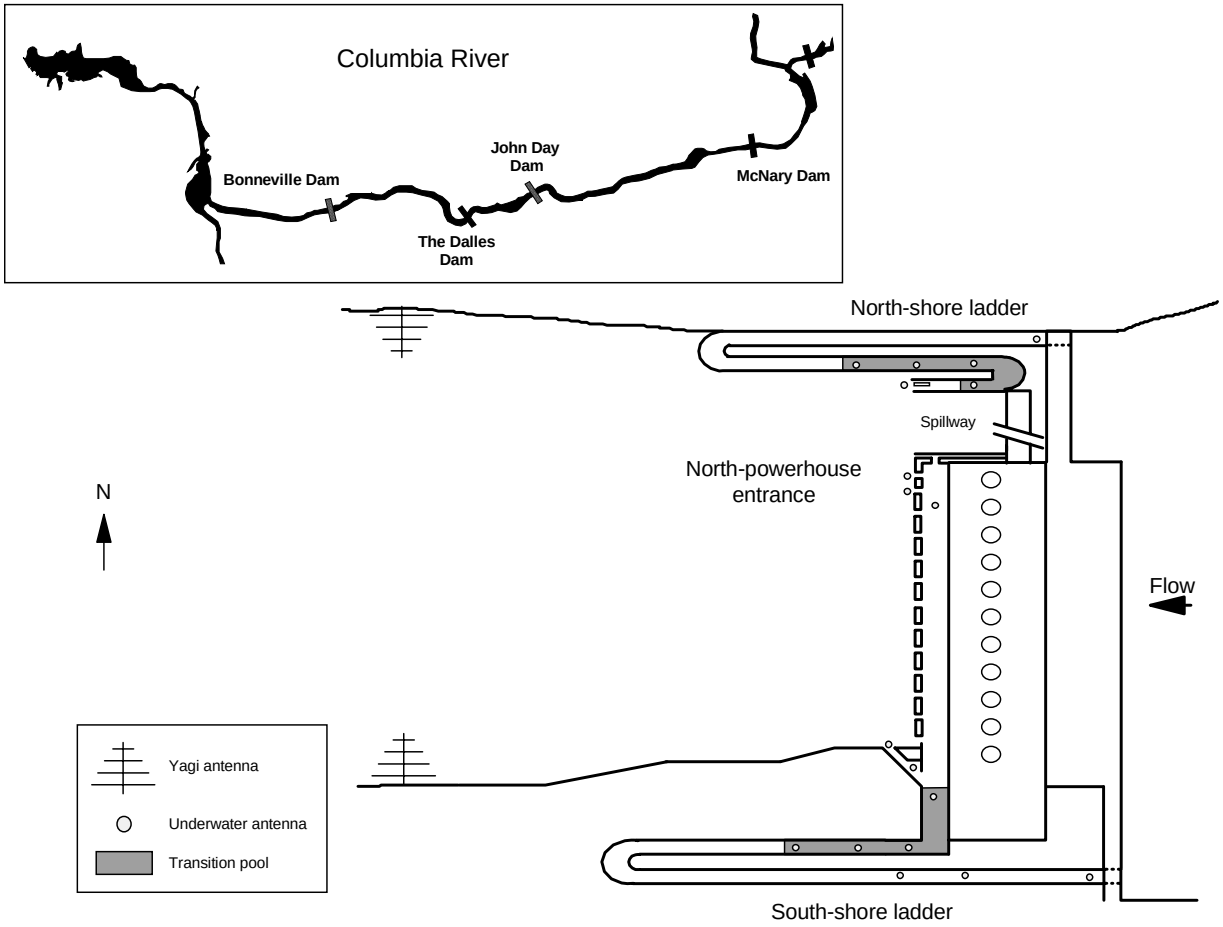

Figure 1. Placement of aerial and underwater antenna for radio receivers used at John Day Dam during 1997 and location of John Day and Bonneville dams on Columbia River (inset).

(Figure 1) and released 8 km downstream from Bonneville Dam as part of the lower Columbia River Adult Passage Study funded by the COE and Bonneville Power Administration (BPA). Radio transmitters and receivers used in this study were manufactured by Lotek Engineering Inc[1]., of New Market, Ontario, Canada. Transmitters used were 83 mm long x 16 mm diameter, or 43 mm x 14 mm, depending on size of fish tagged, with a 43 cm wire antenna. Transmitters emitted a digitally coded signal every 5 seconds. Transmitter signals were interpreted by radio receivers as a unique numerical code on the transmitted channel (frequency). Transmitter

[1] Provided for information only, does not signify endorsement.

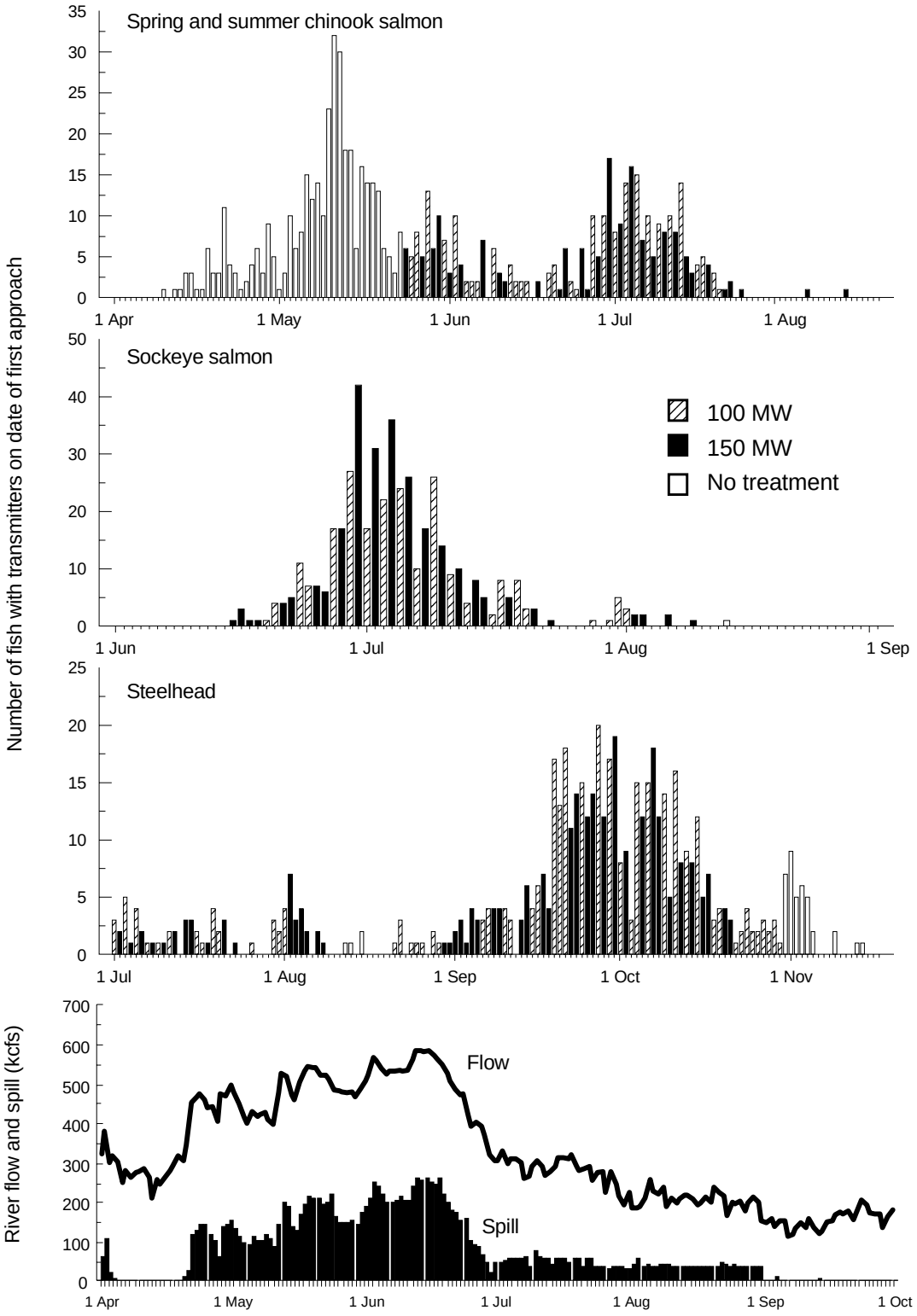

Figure 2. Number of chinook salmon, sockeye salmon and steelhead with radio transmitters on date of first approach to John Day Dam, and flow and spill (kcfs) at John Day Dam during 1997.

frequencies ranged from 149.480 (channel 9) to 149.740 MHz (channel 22) in 0.02 MHz increments. SRX-400 sequentially scanning receivers, set to scan for 6 seconds on each channel, were connected to 9-element Yagi antennas placed on each shore 1.9 km downstream from the dam to record when fish entered the tailrace. Seven SRX receivers linked with digital-spectrum processors (DSP/SRX), that scanned all channels simultaneously, were connected to underwater antenna to determine when fish approached and entered the north-shore entrance (NSE), north-powerhouse entrance (NPE), and the south-shore entrance (SSE), and when fish exited from the top of the north-shore and south-shore ladders (Figure 1). Orifice gates were not monitored at John Day Dam in 1997.

Evaluations of turbine 1 operation at John Day Dam in 1997 focused on where fish approached and entered fishways, and on time for fish to first approach and first enter fishways, during periods of time when turbine 1 was operating at the high (150 MW) and low (100 MW) settings. The receiver used to monitor the south-shore entrance and transition pool (shaded area, Figure 2) was downloaded nightly via modem to determine the number of fish entering the fishway. When at least five new fish were recorded at the base of the south-shore ladder, operators at the dam were contacted by phone and requested to switch the turbine-1 setting at midnight. A period of time during which turbine 1 was operated at the high and then at the low setting, and during which at least four fish were recorded with first approach or first entrance passage times for each setting, constituted one replicate block for analysis (Table 1). Fish that had been exposed to more than one turbine-1 treatment before approaching or entering a fishway were eliminated from analysis of passage times. Treatment blocks that contained fewer than four fish with usable passage times were also eliminated from analysis. This resulted in 11 to 17 replicate blocks of treatments, depending on the species and variable being analyzed. Passage times were analyzed using a split-block analysis of variance (ANOVA) (Proc GLM, SAS Institutes Inc. 1990). The block term was removed from the overall model if it was found to be insignificant and the analysis was rerun, testing for effect of turbine-1 treatment on passage times in a one-way ANOVA model.

Table 1. Replicate blocks used during analysis, turbine-1 settings and dates of turbine-1 settings completed during 1997, number of fish used for analysis, mean and median time to first approach for fish during replicate blocks used in analysis, and number of fish excluded from analysis.

Block	Turbine-1 treatment	Dates	Fish used	Times to first approach Mean (h)	Median (h)	Fish not used
			Chinook salmon			
	150 MW	24 May	0	-	-	6
1	100 MW	25-26 May	11	12.1	3.1	2
1	150 MW	27 May	5	7.5	4.9	0
2	100 MW	28 May	8	20.6	4.1	5
2	150 MW	29-30 May	11	4.7	3.1	5
3	100 MW	31 May	5	5.8	2.6	2
	150 MW	1 Jun	0	-	-	3
4	100 MW	2 Jun	8	36.4	2.4	2
3	150 MW	3 Jun	4	30.6	5.2	0
	100 MW	4-6 Jun	0	-	-	6
4	150 MW	7 Jun	6	9.5	2.6	1
5	100 MW	8-9 Jun	5	60.8	2.3	1
5	150 MW	10-11 Jun	5	174.1	167.7	0
6	100 MW	12-15 Jun	9	64.1	2.0	1
	150 MW	16-18 Jun	0	-	-	2
7	100 MW	19-20 Jun	6	2.6	2.0	1
6	150 MW	21-22 Jun	7	3.6	2.1	0
	100 MW	23-24 Jun	0	-	-	3
7	150 MW	25-26 Jun	6	105.0	116.4	1
8	100 MW	27 Jun	6	5.1	5.2	4
	150 MW	28 Jun	0	-	-	5
9	100 MW	29 Jun	6	42.7	3.9	4
8	150 MW	30 Jun	9	19.1	2.9	8
10	100 MW	1 Jul	5	7.2	6.4	3
9	150 MW	2 Jul	8	14.6	3.2	1
11	100 MW	3 Jul	9	4.0	3.9	5
10	150 MW	4 Jul	12	8.8	5.5	4
12	100 MW	5 Jul	7	4.1	3.2	8
11	150 MW	6 Jul	5	2.4	1.9	2
13	100 MW	7 Jul	8	2.9	1.8	2
12	150 MW	8 Jul	4	2.0	1.9	1
14	100 MW	9 Jul	9	2.6	2.0	0
13	150 MW	10 Jul	8	3.1	1.9	0
	100 MW	11 Jul	0	-	-	0
14	150 MW	12 Jul	4	2.1	2.1	4

Table 1. Continued.

Block	Turbine-1 treatment	Dates	Fish used	Times to first approach Mean (h)	Median (h)	Fish not used
15	100 MW	13 Jul	13	5.0	2.2	1
15	150 MW	14-15 Jul	7	3.7	1.5	1
16	100 MW	16-17 Jul	8	3.1	1.5	1
16	150 MW	18 Jul	4	1.5	1.6	0
17	100 MW	19-20 Jul	4	5.0	3.9	0
17	150 MW	21-22 Jul	4	2.0	1.2	0
			Sockeye salmon			
1	150 MW	16-18 Jun	5	2.3	2.2	0
	100 MW	19-20 Jun	0	-	-	1
2	150 MW	21-22 Jun	9	6.3	2.5	0
1	100 MW	23-24 Jun	5	1.8	1.7	0
3	150 MW	25-26 Jun	11	4.5	2.4	2
2	100 MW	27 Jun	15	8.4	8.4	3
4	150 MW	28 Jun	13	3.0	1.5	4
3	100 MW	29 Jun	11	2.8	2.8	6
5	150 MW	30 Jun	27	4.8	1.7	15
4	100 MW	1 Jul	15	3.3	3.3	12
6	150 MW	2 Jul	22	8.1	1.9	9
5	100 MW	3 Jul	12	4.4	4.4	5
7	150 MW	4 Jul	26	2.6	1.8	10
6	100 MW	5 Jul	18	5.8	5.8	4
8	150 MW	6 Jul	22	8.0	2.0	4
7	100 MW	7 Jul	13	2.9	2.9	11
9	150 MW	8 Jul	16	1.7	1.4	1
8	100 MW	9 Jul	9	3.8	3.8	1
10	150 MW	10 Jul	12	1.6	1.2	2
9	100 MW	11 Jul	26	3.2	3.2	0
11	150 MW	12 Jul	9	5.9	3.6	1
10	100 MW	13 Jul	9	1.7	1.7	0
12	150 MW	14-15 Jul	13	5.3	1.3	0
	100 MW	16-17 Jul	0	-	-	4
	150 MW	18 Jul	0	-	-	5
11	100 MW	19-20 Jul	7	1.3	1.3	3
	150 MW	21-25 Jul	0	-	-	4
12	100 MW	26 Jul-1 Aug	11	1.3	1.3	0
13	150 MW	2-10 Aug	7	73.6	1.5	0
13	100 MW	16 -29 Aug	8	1.7	1.7	2

Table 1. Continued.

Block	Turbine-1 treatment	Dates	Fish used	Times to first approach Mean (h)	Median (h)	Fish not used
			Steelhead			
	100 MW	23-24 Jun	0	-	-	3
	150 MW	25-26 Jun	0	-	-	2
	100 MW	27 Jun	0	-	-	0
	150 MW	28 Jun	0	-	-	0
	100 MW	29 Jun	0	-	-	2
	150 MW	30 Jun	0	-	-	0
	100 MW	1 Jul	0	-	-	2
	150 MW	2 Jul	0	-	-	2
	100 MW	3 Jul	0	-	-	5
	150 MW	4 Jul	0	-	-	1
	100 MW	5 Jul	0	-	-	4
	150 MW	6 Jul	0	-	-	2
	100 MW	7 Jul	0	-	-	1
	150 MW	8 Jul	0	-	-	1
	100 MW	9 Jul	0	-	-	1
	150 MW	10 Jul	0	-	-	0
	100 MW	11 Jul	0	-	-	2
	150 MW	12 Jul	0	-	-	2
	100 MW	13 Jul	0	-	-	0
	150 MW	14-15 Jul	0	-	-	4
	100 MW	16-17 Jul	0	-	-	3
	150 MW	18 Jul	0	-	-	0
1	100 MW	19-20 Jul	5	2.3	2.7	1
	150 MW	21-25 Jul	0	4.1	2.1	4
2	100 MW	26 Jul-1 Aug	9	21.8	6.0	0
1	150 MW	2-10 Aug	13	4.2	2.3	5
	100 MW	16-29 Aug	0	-	-	5
2	150 MW	30 Aug-5 Sep	11	3.7	2.8	1
3	100 MW	6-7 Sep	5	2.2	2.7	0
3	150 MW	8-9 Sep	8	2.0	2.2	0
	100 MW	10-11 Sep	0	-	-	5
4	150 MW	12-14 Sep	5	3.0	2.3	3
4	100 MW	15-16 Sep	8	1.9	1.4	1
5	150 MW	17-18 Sep	10	3.9	3.1	0
5	100 MW	19-21 Sep	36	3.1	1.9	9
6	150 MW	22-23 Sep	22	2.5	1.5	1
6	100 MW	24 Sep	12	3.1	1.8	1
7	150 MW	25-26 Sep	23	2.5	1.7	1
7	100 MW	27 Sep	14	2.6	1.9	3

Table 1. Continued.

Block	Turbine-1 treatment	Dates	Fish used	Times to first approach Mean (h)	Median (h)	Fish not used
8	150 MW	28 Sep	10	8.3	3.6	1
8	100 MW	29 Sep	16	1.8	1.5	0
9	150 MW	30 Sep	14	3.1	1.9	3
9	100 MW	1 Oct	6	4.4	3.0	1
10	150 MW	2 Oct	9	2.9	2.1	0
10	100 MW	3-4 Oct	15	2.5	1.6	2
11	150 MW	5 Oct	7	8.8	12.5	0
11	100 MW	6 Oct	11	4.5	2.6	1
12	150 MW	7-8 Oct	24	4.2	2.3	1
12	100 MW	9 Oct	11	5.0	3.4	0
13	150 MW	10 Oct	4	5.2	3.5	1
13	100 MW	11 Oct	16	2.4	2.0	0
14	150 MW	12 Oct	6	5.4	2.7	1
14	100 MW	13 Oct	6	3.0	2.1	2
15	150 MW	14 Oct	6	4.5	4.5	0
15	100 MW	15 Oct	9	11.9	3.0	2
16	150 MW	16-17 Oct	7	10.7	3.7	2
16	100 MW	18-19 Oct	6	10.2	2.8	0
17	150 MW	20-21 Oct	6	5.4	2.9	0
17	100 MW	22-30 Oct	17	18.8	5.8	2

Median passage times for each block were compared with respect to turbine-1 treatment using the 2-sample test of medians (Proc NPAR1WAY, SAS Institutes Inc. 1990). This procedure determined the overall median for the data set, then scored individual data points as a 1 if it was above the overall median, or 0 if it was below the overall median. Scores were then totaled for each treatment and compared using a normalized Z score. The proportion of approaches and entrances that occurred at SSE during each block at the high and low turbine-1 settings were compared using chi-square contingency tables. Only blocks during which five or more approaches or entries occurred were used for this analysis. The proportion of fish that used the south-shore ladder during the high and low turbine-1 settings was pooled over all blocks, because of the low frequency of fish that passed during each block, and compared using chi-square analysis,

Chinook Salmon

Locations of first approaches and entries into fishways, and passage times of chinook salmon at the dam were similar when turbine 1 was operated at the high and low settings at John Day Dam in 1997. During 24 May to 14 August, turbine 1 at John Day Dam was alternately operated at the low (100 MW) and high (150 MW) settings a total of 20 times, during which 658 chinook salmon with transmitters were recorded at John Day Dam. However, about half of the chinook salmon were not used in analysis because passage occurred when turbine 1 was not operating or was operating at a level other than at the high or low treatment settings.

Times from first record in the tailrace to first approach at the three main fishway entrances (NSE, NPE and SSE) were analyzed for 236 chinook salmon during 17 replicate blocks (Table 1). Mean times to first approach at the high and low turbine-1 settings were 23.2 h (95% CI = $\pm$ 23.7 h) and 16.7 h ($\pm$ 10.8 h), and these values were not significantly different (ANOVA P = 0.6267). When one fish that took 17 d to first approach the dam was removed from analysis, mean time to first approach the dam dropped to 19.6 h ($\pm$ 10.8 h) during the high setting, and there was no change in the conclusions of the analysis (P = 0.7110). Median times to first approach the dam at the high and low turbine-1 settings were 2.8 h and 2.7 h, and these values did not differ significantly based on the outcome of the test of medians (P = 0.6959) (Figure 3).

There were 668 first approaches of salmon at the dam, 157 when turbine 1 was at the high setting, 179 when turbine 1 was at the low setting, and 332 first approaches occurred when turbine 1 was not operating at either the high or low setting. When at the high setting 54% of the salmon first approached the dam at the south-shore entrance (SSE), versus 56% during the low setting (Figure 3). Chi-square analysis was conducted using 16 blocks (315 approaches) during which first approaches to SSE averaged 55% ($\pm$ 11%) during the high setting and 55% ($\pm$ 9%) during the low setting (P = 0.699). For all approaches to the dam (6,880 during treatment periods), the occurrence at SSE was 27% during the high setting and 30% during the low setting. Chi-square analysis was conducted using all 20 blocks (6,880 approaches) during which approaches to SSE averaged 30% ($\pm$ 4%) during the high setting and 34% ($\pm$ 3%) during the low setting (P = 0.863).

Times from first record in the tailrace to first entrance at the three main fishway entrances were analyzed for 147 chinook salmon during 12 replicate blocks. Mean times to first entrance at the high and low turbine-1 settings were 34.7 h (± 36.6 h) and 18.4 h (± 14.9 h), and these values were not significantly different (ANOVA P = 0.2416). When one fish that took 17 d to first enter the fishway was removed from analysis, mean time to first entry dropped to 28.6 h (± 11.8 h) during the high setting, and there was no change in the conclusions of the analysis (P = 0.2935). Median times to first entrance at the dam at the high and low turbine-1 settings were 5.6 h and 6.1 h, and these values did not differ significantly (P = 0.9264) (Figure 3).

There were 683 first entries by salmon to the fishway, 162 when turbine 1 was at the high setting and 199 when turbine 1 was at the low setting, and 322 first entries when turbine 1 was not operating at either the high or low setting. When at the high setting, 31% of the salmon first entered at SSE, as compared to 29% that first entered at SSE during the low setting (Figure 3). Chi-square analysis was conducted using 16 blocks (339 entries) during which first entries at SSE averaged 31% (± 12%) during the high setting and 30% (± 8%) during the low setting (P = 0.762). For all entrances to the dam (1,911 during treatment periods), the occurrence at SSE was 27% during the high setting and 26% during the low setting . Chi-square analysis was conducted using all 20 blocks (1,911 entries) during which entries at SSE averaged 28% (± 7%) during the high setting and 29% (± 7%) during the low setting (P = 0.959).

There were 47 chinook salmon from four replicate blocks that could be analyzed for passage from first record in the tailrace until exit from top of ladders, which was too few to produce reliable ANOVA results. Mean times to pass the dam for the 47 fish were 40.3 h (± 26.6 h) at the high setting and 28.3 h (± 11.8 h) at the low setting. Median times to pass the dam at the high and low turbine-1 settings were 13.3 h and 22.2 h (Figure 3). Mean and median times for all fish to pass the dam in 1997 (n = 565) were 95.9 h and 40.0 h.

There were 139 chinook salmon that moved between their first approach at the dam and exit from top of ladders during a single turbine-1 treatment, 67 when turbine 1 was at the high setting and 72 at the low setting. When at the high setting, 70% of those salmon passed the dam using the south-shore ladder, as compared to 71% that used

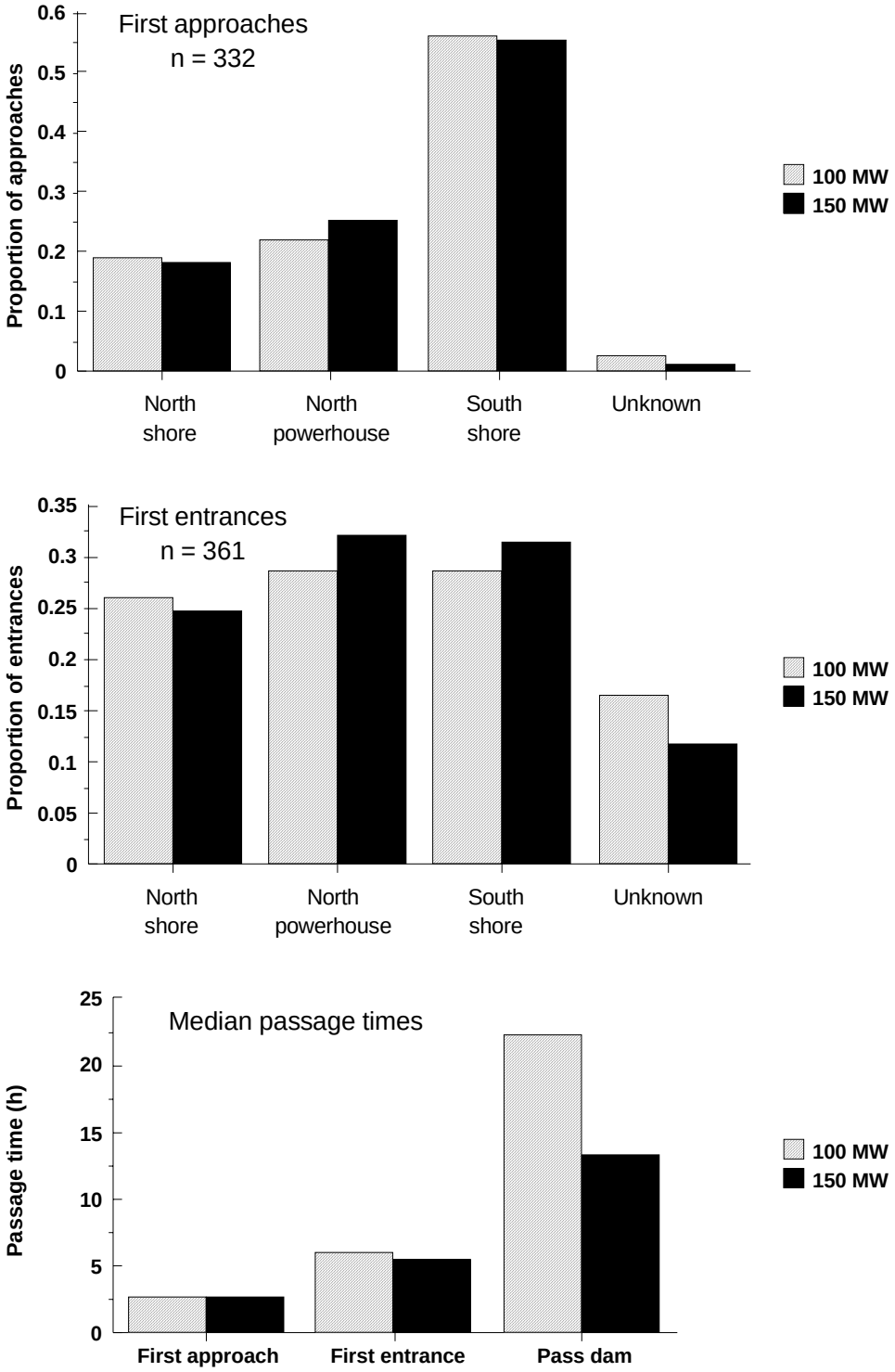

Figure 3. Proportion of first approaches and first entrances made by chinook salmon at the north-shore, north-powerhouse, and south-shore entrances to fishways and their median passage times (h) to first approach, first enter, and to pass over John Day Dam with turbine 1 operating at low (100 MW) and high (150 MW) settings.

the south-shore ladder during the low setting (Chi-square P = 0.930). Median times for chinook salmon to pass up the two ladders (from the transition pool until last record at top of ladders) were 3.0 h for the north-shore ladder and 2.7 h for the south-shore ladder.

Sockeye Salmon

Locations of first approaches and entries into fishways, and passage times of sockeye salmon at the dam were similar at the high and low turbine-1 settings at John Day Dam in 1997. During 16 June to 13 August, turbine 1 at John Day Dam was alternately operated at the low and high settings a total of 15 times, during which 458 sockeye salmon with transmitters were recorded at John Day Dam.

Times from first record in the tailrace to first approach at the three main fishway entrances were analyzed for 351 sockeye salmon during 13 replicate blocks (Table 1). Mean times to first approach at the high and low turbine-1 settings were 9.8 h ($\pm$ 11.7 h) and 3.3 h ($\pm$ 1.3 h), and these values were not significantly different (ANOVA P = 0.2185). When one fish that took 21 d to first approach the dam was removed from analysis, mean time to first approach the dam dropped to 4.3 h ($\pm$ 2.6 h) during the high setting, and there was no change in the conclusions of the analysis (P = 0.3899). Median times to first approach the dam at the high and low turbine-1 settings were 1.8 h and 1.5 h, and these values did not differ significantly based on the outcome of the test of medians (P = 0.0912) (Figure 4).

There were 471 first approaches of salmon at the dam, 258 when turbine 1 was at the high setting and 213 when turbine 1 was at the low setting. When at the high setting, 44% of the salmon first approached the dam at SSE, versus 42% during the low setting (Figure 4). Chi-square analysis was conducted using 14 blocks (466 approaches) during which first approaches at SSE averaged 44% ($\pm$ 9%) during the high setting and 42% ($\pm$ 12%) during the low setting (P = 0.7). For all approaches to the dam (2,456), the occurrence at SSE was 39% during the high setting and 42% during the low setting. Chi-square analysis was conducted using 14 blocks (2,455 approaches) during which approaches at SSE averaged 40% ($\pm$ 6%) during the high setting and 42% ($\pm$ 4%) during the low setting (P = 0.956).

Times from first record in the tailrace to first entrance at the three main fishway entrances were analyzed for 335 sockeye salmon during 13 replicate blocks. Mean times to first entrance at the high and low turbine-1 settings were 11.3 h (± 13.5 h) and 3.9 h (± 0.2 h), and these values were not significantly different (ANOVA P = 0.2607). When one fish that took 21 d to first enter the fishway was removed from analysis, mean time to first entry dropped to 4.8 h (± 2.5 h) during the high setting, and there was no change in the conclusions of the analysis (P = 0.4788). Median times to first entrance at the dam at the high and low turbine-1 settings were 2.1 h and 2.0 h, and these values did not differ significantly (P = 0.8666) (Figure 4).

There were 463 first entries by salmon to the fishway, 249 when turbine 1 was at the high setting and 214 when turbine 1 was at the low setting. When at the high setting, 28% of the salmon first entered at SSE, as compared to 26% that first entered at SSE during the low setting (Figure 4). Chi-square analysis was conducted using 14 blocks (459 entries) during which first entries at SSE averaged 30% (± 11%) during the high setting and 27% (± 11%) during the low setting (P = 0.706). For all entrances to the dam (1,439), the occurrence at SSE was 38% during the high setting and 40% during the low setting. Chi-square analysis was conducted using all 15 blocks (1,439 entries) during which entries at SSE averaged 41% (± 7%) during the high setting and 40% (± 7%) during the low setting (P = 0.879.

Times from first record in the tailrace until exit from top of ladders were analyzed for 191 sockeye salmon during 11 replicate blocks. Mean times to pass the dam at the high and low turbine-1 settings were 11.2 h (± 1.7 h) and 12.2 h (± 2.1 h), and these values were not significantly different (ANOVA P = 0.4280). Median times to pass the dam at the high and low turbine-1 settings were 10.3 h and 10.1 h, and these values did not differ significantly (P = 0.8277) (Figure 4). Mean and median times for all fish to pass the dam in 1997 (n = 333) were 26.8 h (± 4.0 h) and 14.1 h.

There were 230 fish that moved between their first approach at the dam and exit from top of ladders during a single turbine-1 treatment, 115 when turbine 1 was at the high setting and 115 when turbine 1 was at the low setting. When at the high setting, 55% of those salmon passed the dam using the south-shore ladder, as compared to 64% that used the south-shore ladder during the low setting (Chi-square P = 0.139).

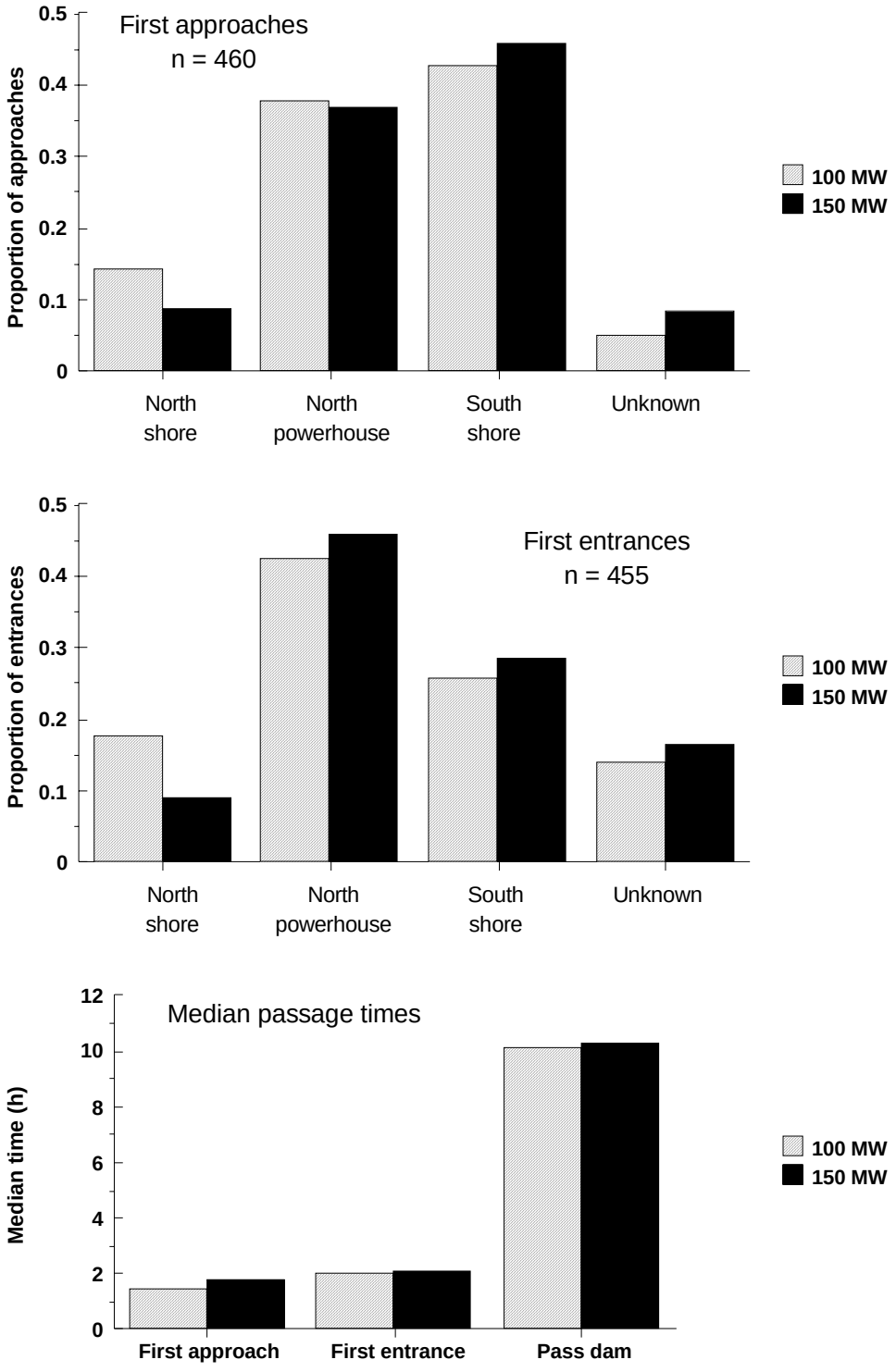

Figure 4. Proportion of first approaches and first entrances made by sockeye salmon at the north-shore, north-powerhouse, and south-shore entrances to fishways and their median passage times (h) to first approach, first enter, and to pass over John Day Dam with turbine 1 operating at low (100 MW) and high (150 MW) settings.

Median times for sockeye salmon to pass up the two ladders (from the transition pool until last record at top of ladders) were 3.1 h for the north-shore ladder and 2.8 h for the south-shore ladder.

Steelhead

Locations of first approaches and entries into fishways, and passage times of steelhead at the dam were similar at the high and low turbine-1 settings at John Day Dam in 1997. A total of 584 steelhead with transmitters were recorded at John Day Dam during 1997. During 19 July to 30 October, turbine 1 at John Day Dam was alternately operated at the low and high settings a total of 19 times, during which 499 steelhead were recorded at John Day Dam.

Times from first record in the tailrace to first approach at the three main fishway entrances were analyzed for 387 steelhead during 17 replicate blocks (Table 1). Mean times to first approach at the high and low turbine-1 settings were 4.7 h ($\pm$ 1.2 h) and 6.0 h ($\pm$ 3.1 h), and these values were not significantly different (ANOVA P = 0.8638). Median times to first approach the dam at the high and low turbine-1 settings were 2.3 h and 2.2 h, and these values did not differ significantly based on the outcome of the test of medians (P = 0.3354) (Figure 5).

There were 575 first approaches of steelhead at the dam, 269 when turbine 1 was at the high setting and 306 when turbine 1 was at the low setting. When at the high setting, 55% of the steelhead first approached the dam at SSE, versus 60% during the low setting (Figure 5). Chi-square analysis was conducted using 18 blocks (534 approaches) during which first approaches at SSE averaged 59% ($\pm$ 12%) during the high setting and 57% ($\pm$ 8%) during the low setting (P = 0.884). For all approaches to the dam (4,398 during treatments), the occurrence at SSE was 38% during the high setting and 44% during the low setting. Chi-square analysis was conducted using all 19 blocks (4,398 approaches) during which approaches at SSE averaged 36% ($\pm$ 5%) during the high setting and 38% ($\pm$ 7%) during the low setting (P = 0.697) .

Times from first record in the tailrace to first entrance at the three main fishway entrances were analyzed for 251 steelhead during 13 replicate blocks. Mean times to first entrance at the high and low turbine-1 settings were 5.6 h ($\pm$ 1.9 h) and 7.4 h ($\pm$

4.0 h), and these values were not significantly different (ANOVA P = 0.5907). Median times to first entrance at the dam at the high and low turbine-1 settings were 3.4 h and 2.9 h, and these values did not differ significantly (P = 0.1861) (Figure 5).

There were 549 first entries by steelhead to the fishway, 260 when turbine 1 was at the high setting and 289 when turbine 1 was at the low setting. When at the high setting, 38% of the steelhead first entered at SSE, as compared to 45% that first entered at SSE during the low setting (Figure 5). Chi-square analysis was conducted using 18 blocks (511 entries) during which first entries at SSE averaged 39% (± 18%) during the high setting and 42% (± 8%) during the low setting (P = 0.834). For all entrances to the dam (2,458 during treatments), the occurrence at SSE was 37% during the high setting and 44% during the low setting. Chi-square analysis was conducted using all 19 blocks (2,458 entries) during which entries at SSE averaged 35% (± 6%) during the high setting and 35% (± 8%) during the low setting (P = 0.624).

Times from first record in the tailrace until exit from top of ladders were analyzed for 209 steelhead during 12 replicate blocks. Mean times to pass the dam at the high and low turbine-1 settings were 12.4 h (± 2.0 h) and 15.8 h (± 8.4 h), and these values were not significantly different (ANOVA P = 0.1495). Median times to pass the dam at the high and low turbine-1 settings were 10.4 h and 10.2 h, and these values did not differ significantly (P = 0.3923) (Figure 5). Mean and median times for all fish to pass the dam in 1997 (n = 489) were 54.8 h (± 13.2 h) and 17.1 h, including 31 fish that took from 7 to 65 d to pass the dam.

There were 256 fish that moved between their first approach at the dam and exit from top of ladders during a single turbine-1 treatment, 135 when turbine 1 was at the high setting and 121 when turbine 1 was at the low setting. When at the high setting, 73% of those steelhead passed the dam using the south-shore ladder, as compared to 77% that used the south-shore ladder during the low setting (Chi-square P = 0.434). Median times for steelhead to pass up the two ladders (from the transition pool until last record at top of ladders) were 3.0 h for the north-shore ladder and 2.9 h for the south-shore ladder.

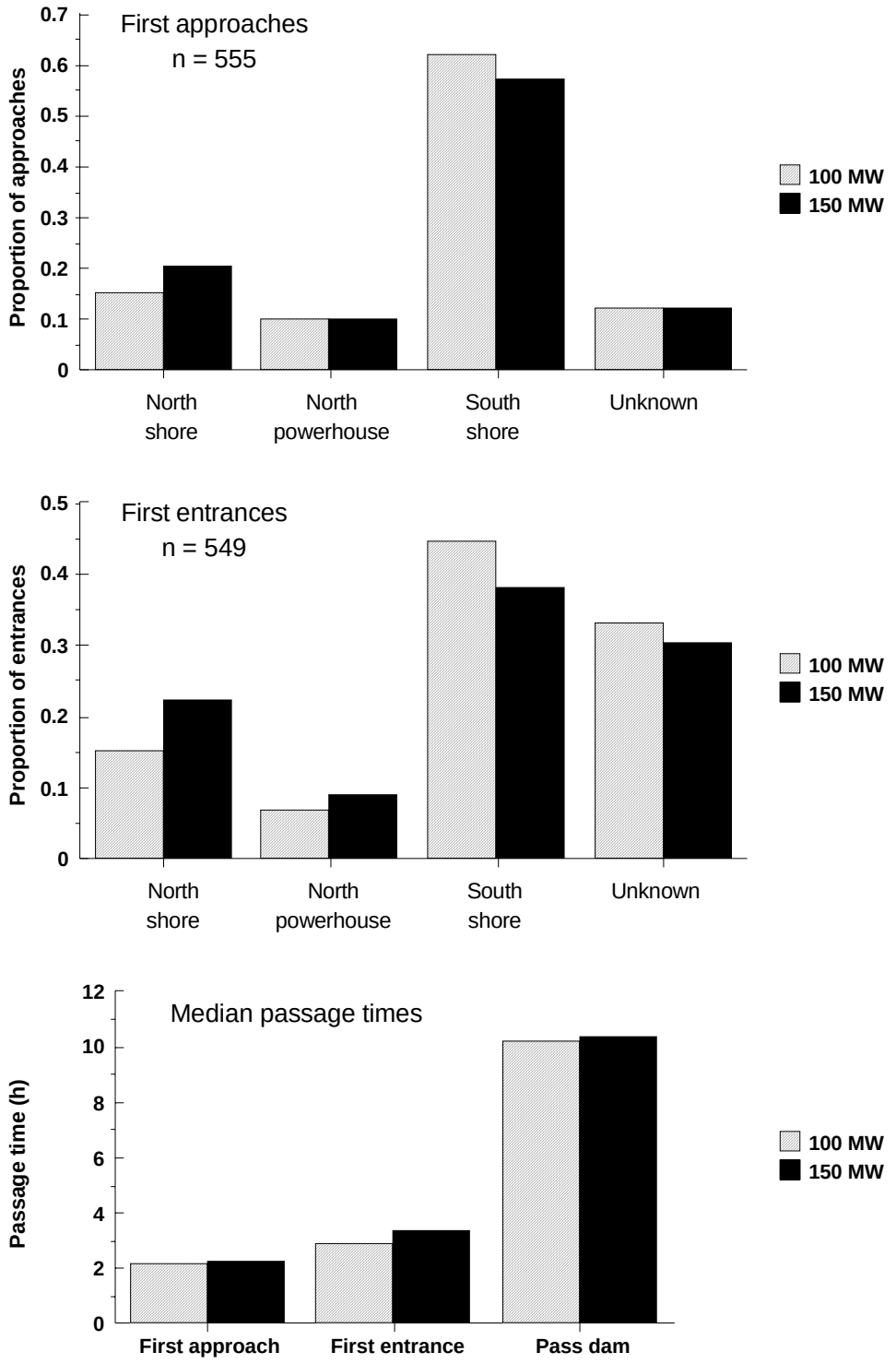

Figure 5. Proportion of first approaches and first entrances made by steelhead at the north-shore, north-powerhouse, and south-shore entrances to fishways, and their median passage times (h) to first approach, first enter, and to pass over John Day Dam with turbine 1 operating at low (100 MW) and high (150 MW) settings.

Conclusions

We found no evidence that operating turbine 1 at maximum capacity at John Day Dam interfered with the passage of salmon and steelhead in 1997. There were no significant differences in use of the SSE nor were there significant differences in mean and median passage times for all three species at the low and high turbine-1 settings. Columbia River flows were above average in 1997. Effects of turbine-1 operation on passage of salmon and steelhead at John Day Dam during low flow years may vary from that observed during this study. By remotely downloading the receiver monitoring the transition pool at John Day Dam we were able to obtain 13 to 17 replicates of turbine-1 treatments for analysis of times and locations of first approaches and first entries to fishway entrances. Sample size was insufficient to allow analysis of time to pass the dam for chinook salmon, but that variable was considered secondary in importance for the evaluation of effects of turbine-1 setting on passage conditions.

Results from this study differ from those from the 1973 John Day Dam study reported by Duncan et al. (1974). Differences in how the two studies were conducted make comparisons of their results difficult. Our analysis focused on times for the salmon and steelhead to approach and enter fishway entrances as well as which entrances were used at the high and low turbine settings, while only total counts of fish passing through SSE were analyzed during the 1973 study. Our study was conducted from May to October in 1997, using three separate salmonid species. The 1973 study lasted 7 days in the fall during which time turbine-1 treatments (off, low, and high) were operated for 9 h a day, three hours per treatment. All fish counted by the electronic tunnels, including non-salmonid species (shad, carp, suckers, etc.) were used for analysis in 1973.

Literature Cited

Duncan, R.N., D.P. Arndt, J.R. Kuskie Jr., G.A. Johnson, and D.D. Sunday. 1974. John Day Lock and Dam powerhouse fish collection studies. U.S. Army Corps of Engineers, Portland, Oregon.