Technical Report 2003-6

An Evaluation of the Effects of Spill Basin Drilling on Salmon and Steelhead Passage at Lower Monumental Dam in 2002 using Radio-telemetry

by

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Preface

Studies of adult salmon *Oncorhynchus* spp. and steelhead *O. mykiss* migrations past dams, through reservoirs, and into tributaries began in 1990 with planning, purchase, and installation of radio telemetry equipment for studies at the Snake River dams. Adult spring and summer chinook salmon *O. tshawytscha* and steelhead *O. mykiss* were outfitted with transmitters at Ice Harbor and John Day dams in the early 1990's. The focus of adult salmon passage studies expanded to the lower Columbia River dams in 1995, when telemetry equipment was set up at the dams and tributaries, and spring/summer chinook salmon and steelhead were outfitted with transmitters at Bonneville Dam starting in 1996. In this report we present information on the passage behavior of adult fall chinook salmon and steelhead at Lower Monumental Dam between 19 August and 18 October 2002, when construction associated with a new spill basin bottom occurred.

Acknowledgements

Many people assisted in the field work and data compilation for this project and the successful completion was made possible through their efforts. They include: Kevin Traylor and Mark Morasch for downloading and maintaining radio receivers, Cody Williams and Christine Nauman for interpretting and summarizing the telemetry data, Matt Keefer and Brian Burke for their critical review of this report, and Ted Bohn for administering the database in Seattle. This study was funded by the U.S. Army Corps of Engineers, Walla Walla District, with assistance provided by Marvin Shutters and Mark Smith.

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Abstract

Construction work associated with a new spill basin bottom occurred during the evening hours (1600-0230 hrs) on 46 of the 61 days between 19 August and 18 October 2002 at Lower Monumental Dam. We monitored the movements of adult fall chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* outfitted with radio transmitters and determined the time they used to make their first approach and first entrance at a monitored fishway opening, and their total time to pass the dam. We compared values from 2002, when construction occurred, with those from the preceding two years, prior to construction. We additionally compared the proportionate use by salmon and steelhead of the three available openings (orifice gates were closed in 2000-2002) to first approach and first enter the dam. We also examined proportionate use of the two fish ladders to pass the dam. All of these comparisons were made across the three years to evaluate any changes in adult fish behavior that may have been associated with construction activity.

We found no significant difference among years in the median times fall chinook salmon required to first approach, first enter, or pass Lower Monumental Dam. We did find significant differences among years in the proportionate use of the three openings to first approach the fishways at the dam and in proportionate use of the two ladders to pass the dam, but found no significant difference among years in the proportionate use of the openings to first enter fishways at the dam. While there were no significant differences among years in the median times to first approach, first enter, or pass the dam, the highest proportionate use of the north shore entrance (NSE) to first approach, and the north shore ladder (NSL) to pass the dam, occurred in 2002. This may have been associated with salmon avoiding the construction area, which was closer to the south powerhouse entrance (SPE) and south spillway entrance (SSE).

We found significant differences among years in the median times steelhead used to first approach, first enter, and pass Lower Monumental Dam but the highest median times to first approach and first enter a fishway did not occur during 2002. The median time for steelhead to pass Lower Monumental Dam was highest in the year with construction (2002) but it was not significantly different from the median time observed in 2000. We also found significant differences among years in the proportionate use of the three fishway openings by steelhead to first approach and first enter the fishways, and in use of the two ladders to pass the dam. As with fall chinook salmon, we believe this may have been associated with steelhead avoiding the construction area.

We concluded that construction activity at Lower Monumental Dam in 2002 did not significantly retard fall chinook salmon passage, may have mildly impeded steelhead passage, and may have caused an increased proportion of fish to use the opening and ladder on the north shore to preferentially approach, enter, and pass the dam.

Introduction

Erosion in the spillway stilling basin at Lower Monumental Dam (rkm 588.6) over the past 32 years made repairs necessary to maintain the structural integrity of the project. Repairs proposed for 2002 involved adding concrete fill material to eroded areas. Anchor points for the blocks of fill material were to be drilled into river bottom bedrock. Repairs began in August 2002 and coincided with the migration of adult fall chinook salmon and steelhead. There were concerns that activity, especially sounds and vibrations, associated with construction/repair activities in the tailrace would hinder passage of adult migrants at Lower Monumental Dam. We evaluated effects of the repair activities at Lower Monumental Dam by monitoring movements of radio-tagged salmon and steelhead in the tailrace area during the initial construction period, and by continuous monitoring of the project via fixed receiver sites.

Methods

Adult chinook salmon and steelhead were outfitted with radio transmitters at Bonneville Dam in 2000-2002, and released both downstream and upstream from the dam. Data were collected as the radio-tagged salmonids passed within the range of antennas that were connected to sequentially scanning SRX (tailrace sites) and continuously scanning SRX/DSP (fishway sites) receivers deployed at Lower Monumental Dam (Figure 1). Records were compiled for each fish passing the dam to determine: 1) the date and time it entered the tailrace, 2) the date, time, and location it first approached and first entered a fishway, and 3) the date, time, and location of exit at the top of a ladder.

Construction work associated with a new spill basin bottom occurred during the evening hours (1600-0230 hrs) during 46 of the 61 days between 19 August and 18 October 2002 at Lower Monumental Dam. Of the 61 radio-tagged fall chinook salmon that were recorded passing Lower Monumental Dam between 19 August and 18 October 2002, none completed their entire passage during the course of an evening's drilling. Similarly, only 2 of 380 (0.6%) radio-tagged steelhead recorded at Lower Monumental Dam during the construction period completed their entire passage during an evening's drilling. As such, we could not compare passage times of fish that passed while drilling occurred with those of fish that passed while no drilling occurred. Instead, we compared median passage times from the 2002 construction period (19 August -18 October) with those from 19 August – 18 October in 2000 and 2001, years in which no drilling occurred. We used the Kruskal-Wallis Test to test for differences in passage times among all three years and, if significant differences were detected, we made pairwise comparisons of all years. Similarly, we used Chi-square analyses to compare the proportionate use by salmon and steelhead of the three available openings (NSE, SPE, and SSE - orifice gates were closed in 2000-2002) and of the two fish ladders at to first approach, first enter, and pass Lower Monumental Dam across the three years. We used Fisher's Exact Test in comparisons of proportionate use when a cell count was less than five in any contingency table.

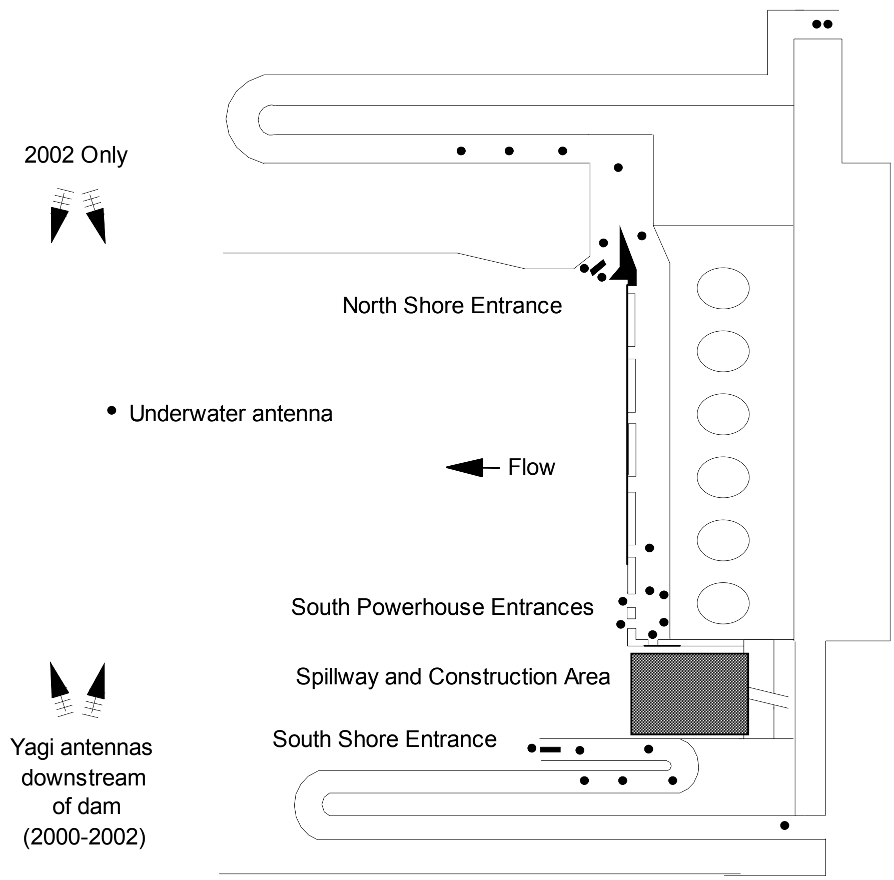

Figure 1. Fishway entrances and location of antennas used at Lower Monumental Dam during 2000-2002 fall chinook salmon and steelhead migration seasons.

We obtained adult fish passage counts at Lower Monumental Dam in 2002 from the JavaDART electronic database (USACE, 2003) and examined the percentage change (from the previous day) in window count data on days when construction activity started (after at least one day of no drilling) and on days when construction activity stopped (after at least one day of drilling) to evaluate any trends in passage estimates that may have been associated with construction. Daily mean flow and spill data for the Snake River at Lower Monumental Dam were also obtained from the JavaDART electronic database.

The telemetry monitoring was not designed to experimentally test hypotheses related to construction activity at Lower Monumental Dam. Our analyses related to the construction were retrospective and strict statistical criteria (i.e. randomized and independent sampling) were not met for most comparisons. Our objectives with these 'ad hoc' statistical analyses were to identify general relationships between adult fish passage and the construction activity.

Results

Flow and Spill

Between 1 June and 31 July, Snake River discharge at Lower Monumental Dam was highest in 2002, intermediate in 2000, and lowest in 2001 (Figure 2). During the majority of fall chinook and steelhead passage events (1 August -1 November), flows were roughly similar in 2000 and 2002, and approximately 80% of those years' values in 2001 (USACE, 2003). With the exception of three days when spillway discharge occurred in 2001, zero-spill conditions existed at Lower Monumental Dam after 20 June in all study years. To this extent, we believe our comparisons of passage times and behaviors among years were not confounded by large variations in flow and spill conditions.

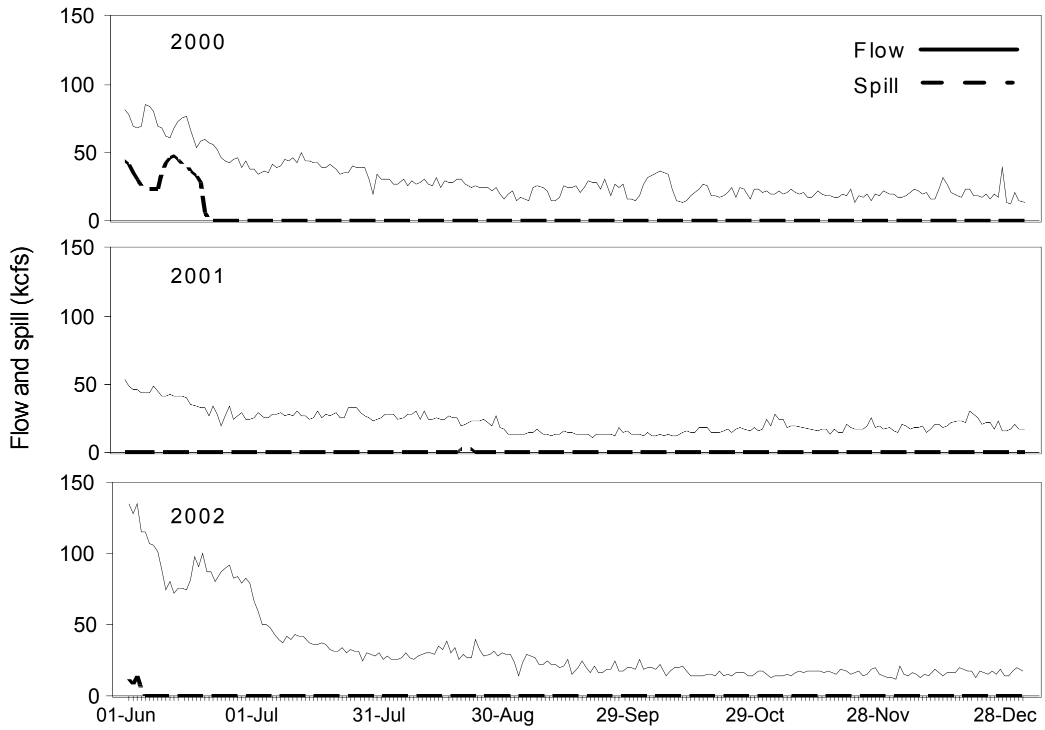

Figure 2. Mean daily flow and spillway discharge at Lower Monumental Dam from 1 June to 31 December 2000, 2001, and 2002.

Fall Chinook Salmon

<u>First Approach to Fishway</u>

The majority (range = 64.3 - 72.1%) of fall chinook salmon took less than 2 h to approach Lower Monumental Dam after being recorded in the tailrace in all three study years (Figure 3). The median time for radio-tagged fall chinook salmon to first approach a fishway opening after being recorded in the tailrace of Lower Monumental Dam in

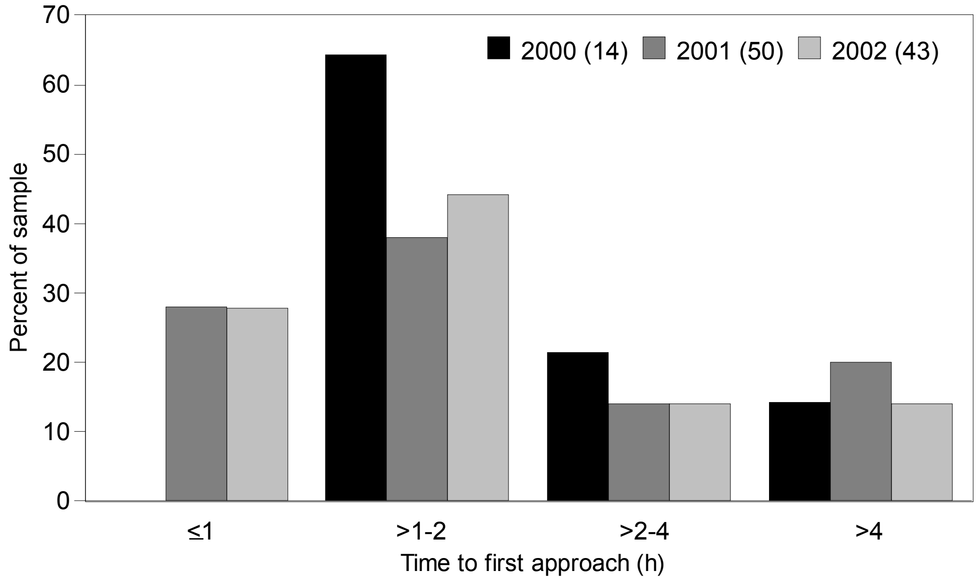

Figure 3. Frequency distribution of fall chinook salmon passage times from the tailrace to first approach at Lower Monumental Dam 2000-2002.

2002 was 1.2 h (n=43) while the median times in 2000 and 2001 were 1.6 h (n=14) and 1.3 h (n=50), respectively. There was no significant difference among years in the median times for fall chinook salmon to first approach the dam (*P* = 0.33, Kruskal-Wallis Test).

The percentage of fall chinook salmon recorded first approaching Lower Monumental Dam at the south shore entrance (SSE) ranged between 3.8 and 13.3% during 2000-2002 (Figure 4). The percentage of fall chinook salmon first approaching Lower Monumental Dam at the south powerhouse entrance (SPE) was highest in 2000 at 46.7% and decreased to 27.5% in 2001 and 16.4% in 2002. Conversely, the percentage of fall chinook salmon that first approached the north shore entrance (NSE) at Lower Monumental Dam increased steadily between 2000 and 2002 with the highest percentage observed in 2002 (74.6%). We found significant differences among years in the proportions of salmon using the three sites to first approach the dam (*P*=0.005, Fisher's Exact Test). The highest use of the NSE as a first approach site was in 2002, coincident with construction activities. While there was no difference among years in the median times to first approach the dam, the greatest proportionate use of the NSE by fall chinook salmon as a first approach site in 2002 may have been associated with salmon avoiding the construction area, which was closer to the SPE and SSE.

<u>First Entrance to Fishway</u>

Exactly half of the fall chinook salmon took less than 2 h to enter a fishway at Lower Monumental Dam after being recorded in the tailrace in 2001 and 2002 while only 35.7% did so in 2000 (Figure 5). The median times for radio-tagged fall chinook salmon to first enter Lower Monumental Dam were 2.3 h (n=14) in 2000, 1.9 h (n=48) in 2001

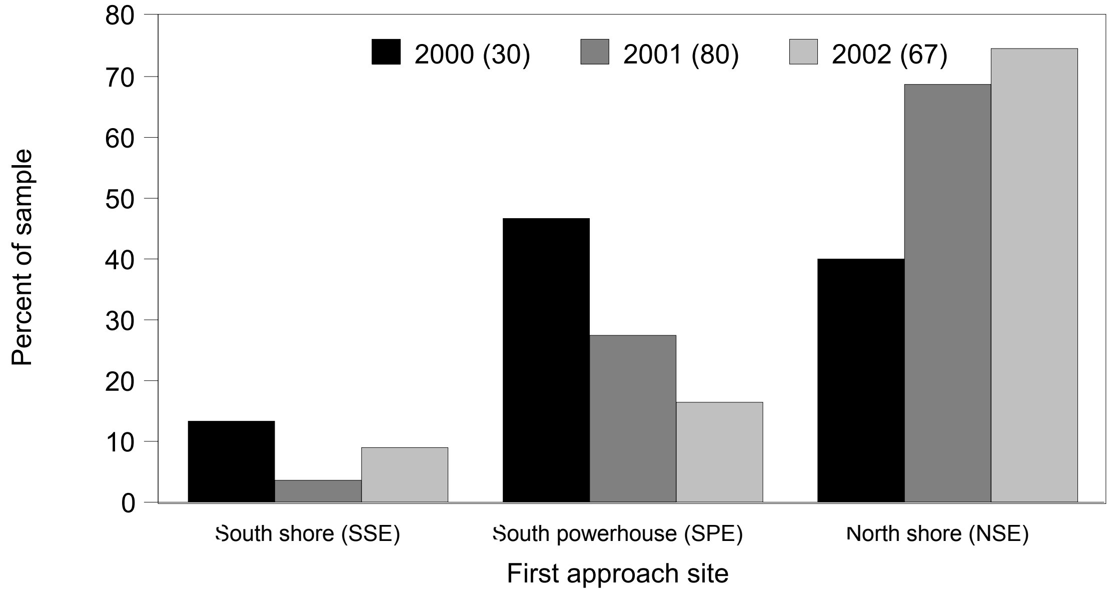

Figure 4. Frequency distribution of first approach sites for fall chinook salmon at Lower Monumental Dam 2000-2002.

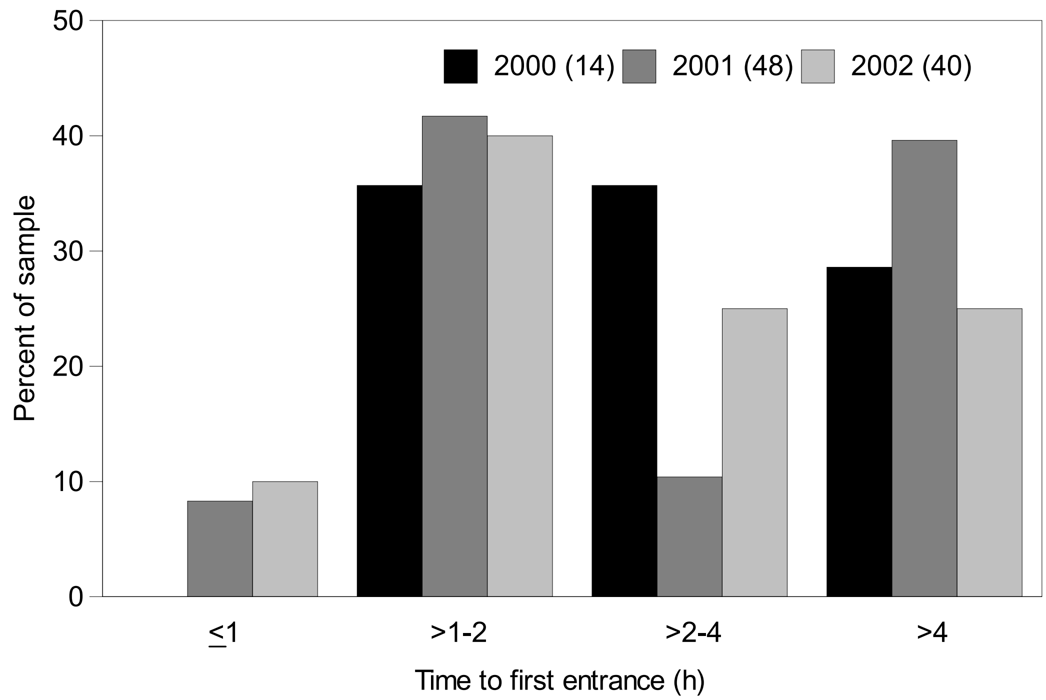

Figure 5. Frequency distribution of fall chinook salmon passage times from tailrace to first entrance at Lower Monumental Dam 2000-2002.

and 1.9 h (n=40) in 2002. There was no significant difference among years in the median times for fall chinook salmon to first enter Lower Monumental Dam (*P*=0.58, Kruskal-Wallis Test).

The percentage of radio-tagged fall chinook salmon first entering Lower Monumental Dam at the SPE was relatively constant in the three study years (range = 42.3 – 44.8%) (Figure 6). Roughly equal percentages of salmon first entered Lower Monumental Dam at the NSE and SSE in 2000, while greater percentages of salmon first entered the NSE in 2001 and 2002 relative to SSE entries. We found no significant difference among years in the proportions of salmon using the three sites to first enter the dam (*P*=0.22, Fisher's Exact Test).

Dam passage

Forty-five percent or more of all radio-tagged fall chinook salmon passed Lower Monumental Dam in 12 hours or less in all three study years (Figure 7). Forty fall chinook salmon with transmitters were recorded at the tailrace and at a ladder exit in 2002 and the median time for them to pass the dam was 11.0 h. In comparison, the median time to pass Lower Monumental Dam by radio-tagged fall chinook salmon was 24.4 h (n=13) in 2000 and 12.9 h (n=48) in 2001. There was no significant difference among years in the median times for fall chinook salmon to pass Lower Monumental Dam (*P*=0.42, Kruskal-Wallis Test).

The majority of radio-tagged fall chinook salmon passing Lower Monumental Dam during 2000-2002 did so via the north shore ladder (NSL) and the percentage of salmon using the NSL to pass increased each year after 2000 to a maximum of 95.2% in 2002 (Figure 8). We found significant differences among years in the proportions of salmon using the two ladders to pass Lower Monumental Dam (*P*<0.001, Fisher's Exact Test). The greatest use of the NSL to pass the dam was in 2002, coincident with construction. There was no significant difference among years in the median times to pass the dam but the increased use of the NSL by fall chinook salmon to pass the dam in 2002 may have been associated with salmon avoiding the construction area, which was closer to the SPE and SSE.

Steelhead

First Approach to Fishway

At least 56% of radio-tagged steelhead recorded in the tailrace of Lower Monumental Dam in 2000-2002 were recorded approaching the dam less than 2 h later (Figure 9). Median times for steelhead to first approach Lower Monumental Dam were 1.9 h (n=181) in 2000, 1.6 h (n=173) in 2001 and 1.8 h (n=339) in 2002. We found significant differences among years in the median time for steelhead to first approach Lower Monumental Dam (*P*<0.001, Kruskal-Wallis Test). While significant differences were found, the median time for steelhead to first approach Lower Monumental Dam in 2002 fell within the range of medians from the 2 years during which there was no construction. Specifically, the median time to first approach the dam in 2002 was not significantly different from the median time observed in 2000 (*P*= 0.624, Kruskal-Wallis Test) and the median time to first approach the dam in 2001 was significantly different

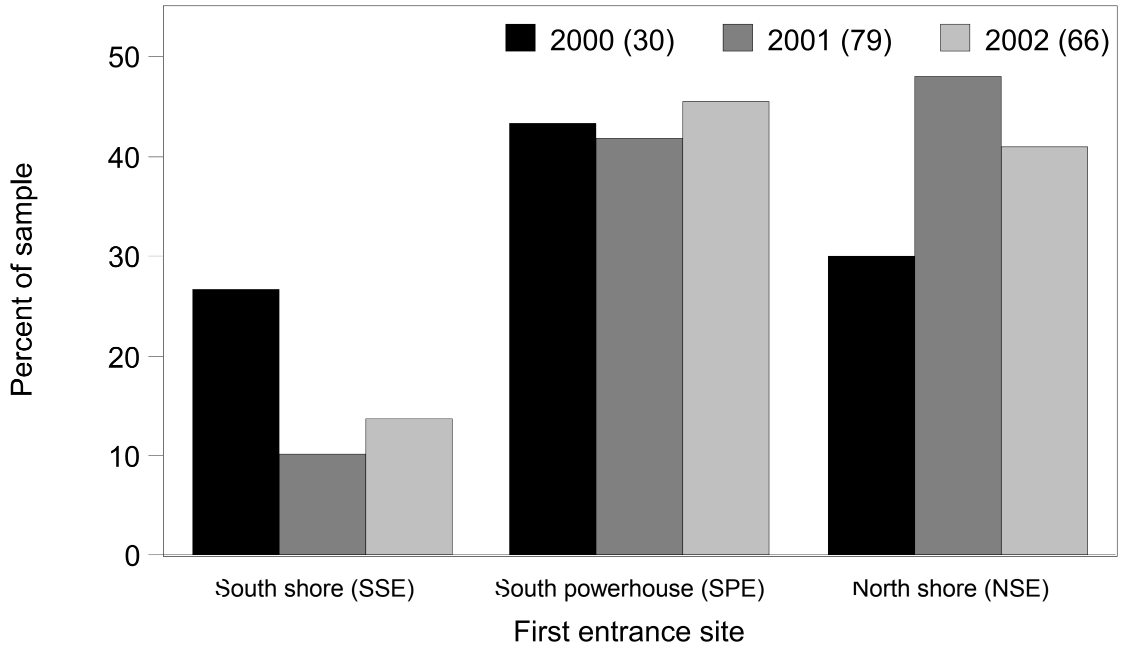

Figure 6. Frequency distribution of first entrance sites for fall chinook salmon at Lower Monumental Dam 2000-2002.

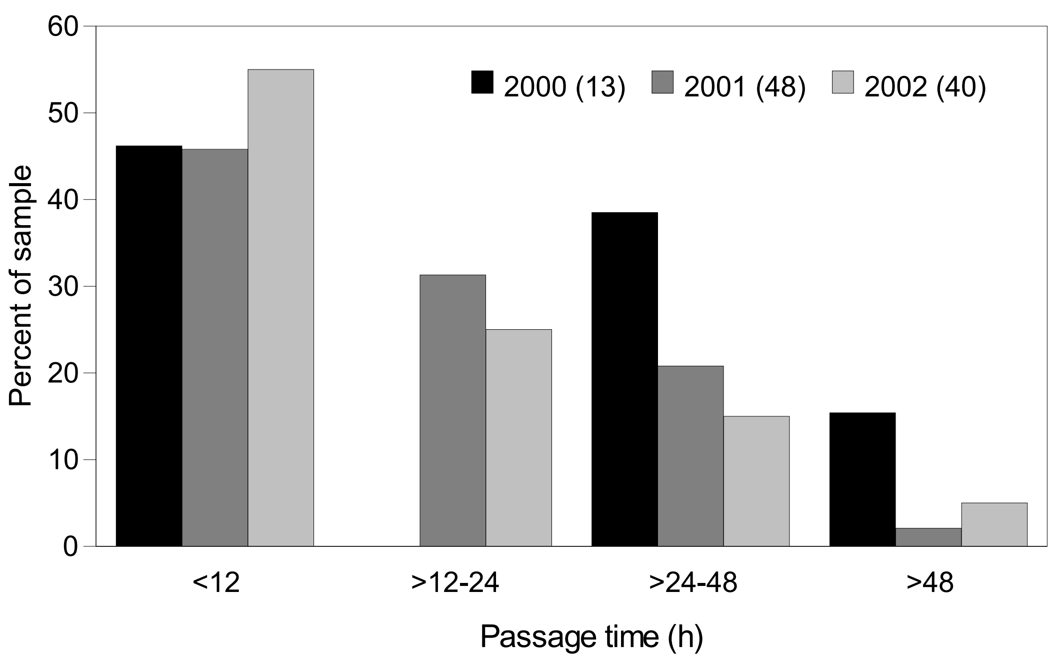

Figure 7. Frequency distribution of fall chinook salmon passage times from tailrace to ladder exit at Lower Monumental Dam 2000-2002.

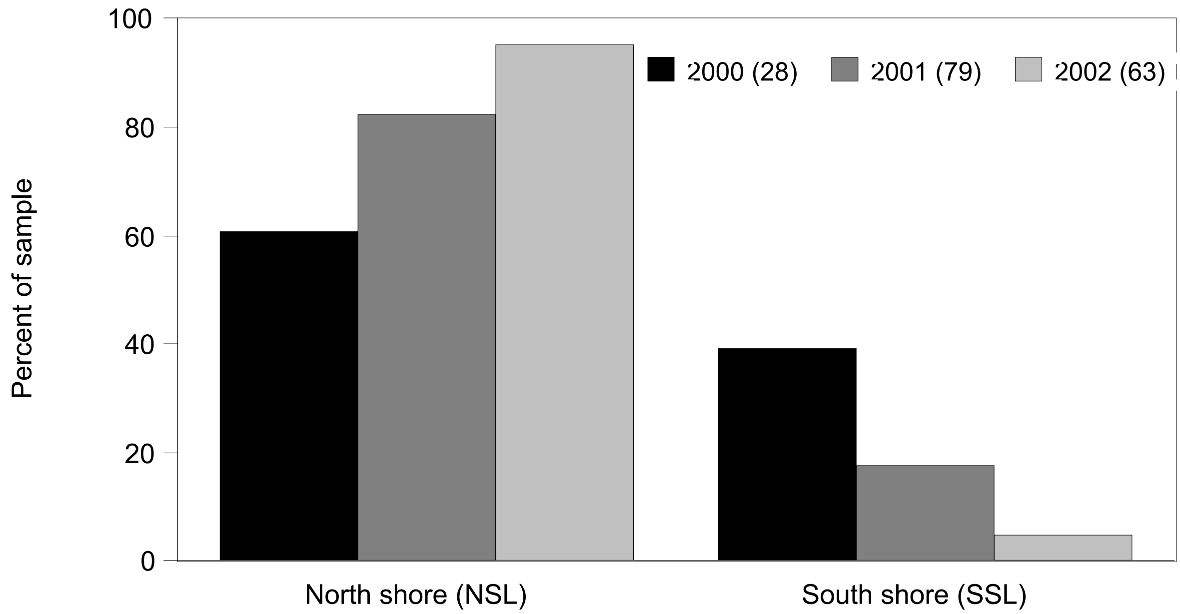

Figure 8. Frequency distribution of ladders used by fall chinook salmon to pass Lower Monumental Dam 2000-2002.

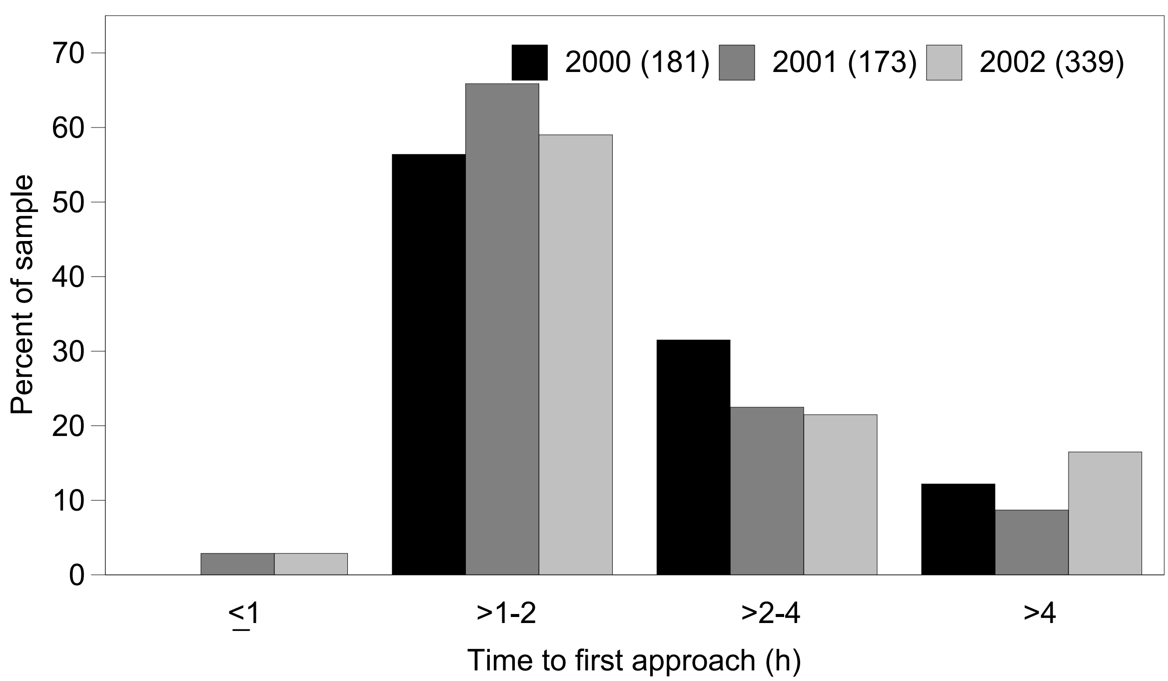

Figure 9. Frequency distribution of first approach sites for steelhead at Lower Monumental Dam 2000-2002.

from the median times observed in both 2000 (*P* = 0.0231, Kruskal-Wallis Test) and 2002 (*P* <0.0001, Kruskal-Wallis Test).

The percentage of steelhead recorded first approaching Lower Monumental Dam at the SSE was relatively consistent over the three study years and ranged between 5.4 and 9.4% (Figure 10). The percentage of steelhead first approaching Lower Monumental Dam at the SPE was highest in 2000 at 43.3% and decreased to 25.4% in 2001 and 18.5% in 2002. Conversely, the percentage of steelhead using the NSE to first approach Lower Monumental Dam increased steadily from 2000 to 2002 with a maximum percentage of 74.4% in 2002. We found significant differences among years in the proportions of steelhead using the three sites to first approach the dam (*P*<0.0001, Chi-square Test); the greatest proportionate use of the NSE as a first approach site coincided with construction in 2002.

First Entrance to Fishway

The percentage of radio-tagged steelhead that took less than 4 h to first enter Lower Monumental Dam fishways after being recorded in the tailrace was highest in 2001 (78.2%), and lower in 2000 (64.1%) and 2002 (64.7%) (Figure 11). The median times for steelhead to first enter fishways were 2.9 h (n=162) in 2000, 2.2 h (n=160) in 2001, and 2.8 h (n=325) in 2002. There were significant differences among years in median first entry times (*P*=0.0002, Kruskal-Wallis Test). As with the median first approach time of radio-tagged steelhead, the median time for steelhead to first enter a fishway in 2002 fell within the range of medians from the two non-construction years. Specifically, the median time to first enter the dam in 2002 was not significantly different from the median time observed in 2000 (*P*= 0.6135, Kruskal-Wallis Test) and the median time to first enter the dam in 2001 was significantly different from the median times observed in both 2000 (*P* = 0.0002, Kruskal-Wallis Test) and 2002 (*P* =0.0003, Kruskal-Wallis Test).

The highest proportionate use of the NSE (57.5%) and the lowest proportionate use of the SSE (9.9%) by radio-tagged steelhead to first enter fishways occurred in 2002 (Figure 12). Differences among years in the proportions of steelhead using the three sites to first enter fishways were significant (*P*=0.0104, Chi-square Test). Proportionately more steelhead used the NSE as a first entrance site in 2002, coincident with construction.

Dam passage

About 87% of all radio-tagged steelhead passed Lower Monumental Dam in less than 24 h during the three study years (Figure 13). Median times to pass Lower Monumental Dam were 9.1 h (n=186) in 2000, 7.4 h (n=174) in 2001 and 9.3 h (n=346) in 2002. Differences among years in the median dam passage times for steelhead were significant (*P*=0.001, Kruskal-Wallis Test) and the highest median passage time was observed in 2002, when construction occurred. However, the median dam passage time in 2002 was not significantly different from the median time observed in 2000 (*P*= 0.6849, Kruskal-Wallis Test) and the median time to pass the dam in 2001 was significantly different from the median times observed in both 2000 (*P* = 0.0239, Kruskal-Wallis Test) and 2002 (*P* =0.0030, Kruskal-Wallis Test). This suggests that the

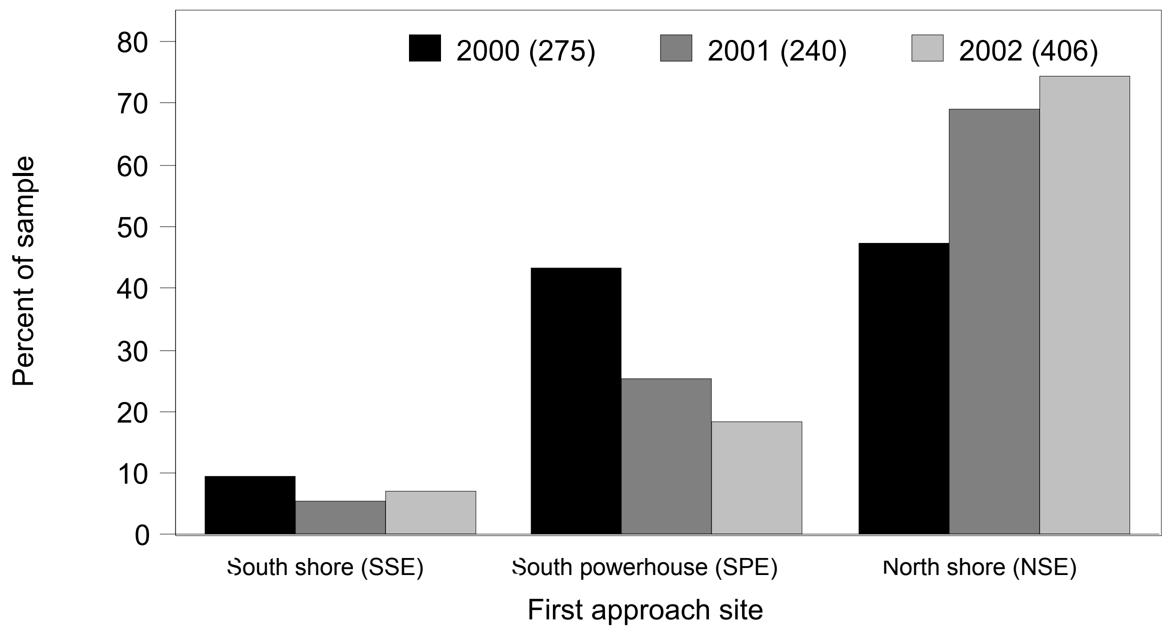

Figure 10. Frequency distribution of first approach sites for steelhead at Lower Monumental Dam 2000-2002.

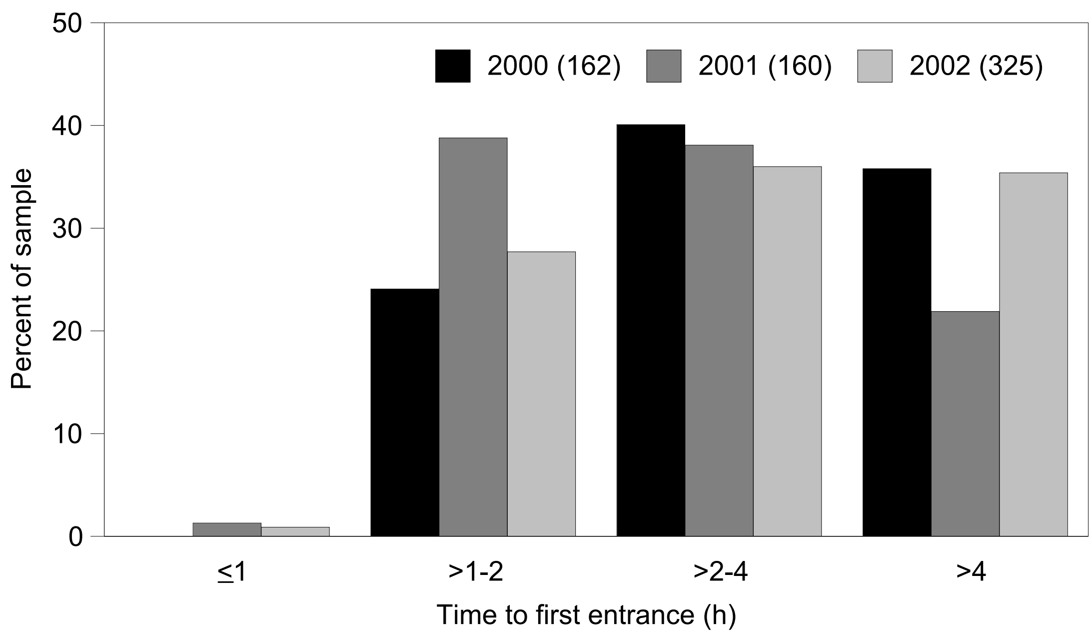

Figure 11. Frequency distribution of steelhead passage times from tailrace to first entrance at Lower Monumental Dam 2000-2002.

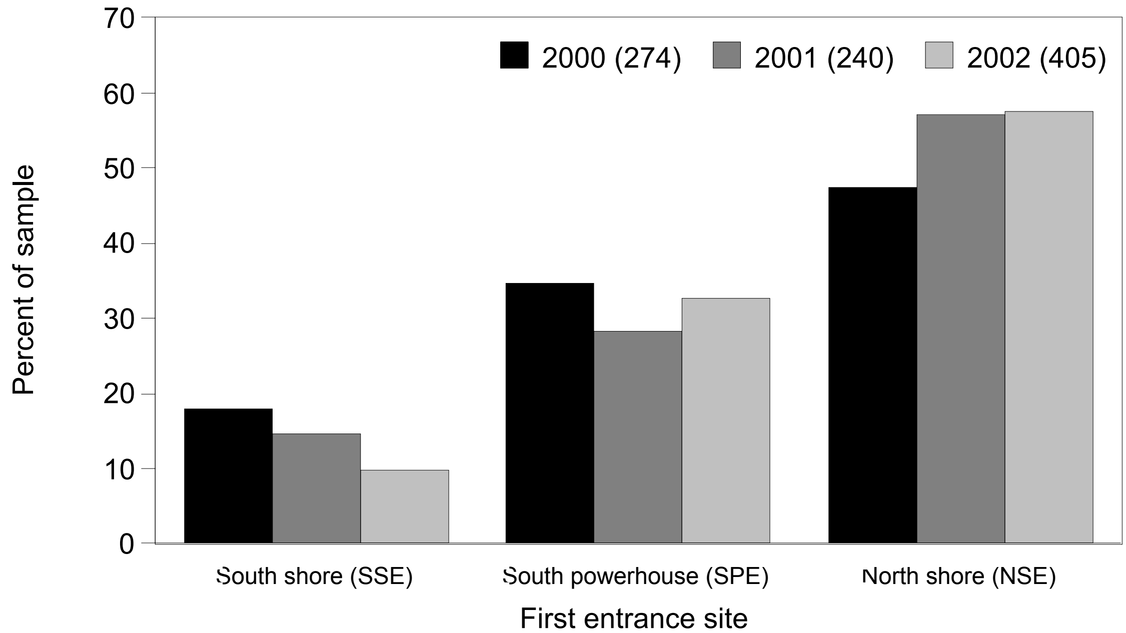

Figure 12. Frequency distribution of first entrance sites for steelhead at Lower Monumental Dam 2000-2002.

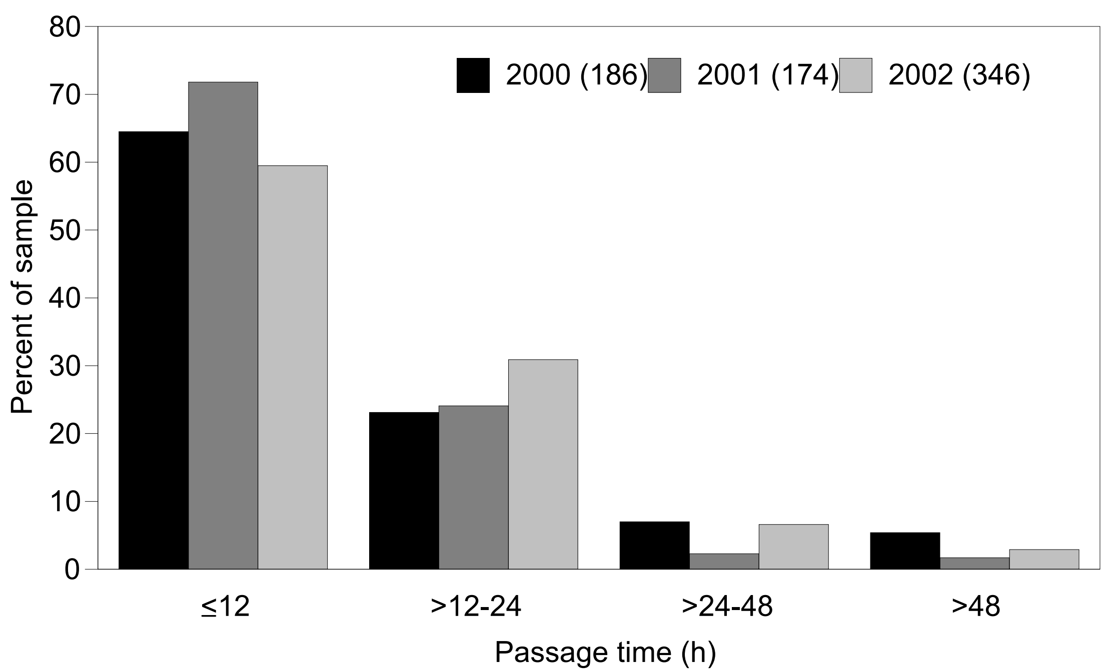

Figure 13. Frequency distribution of steelhead passage times from tailrace to ladder exit at Lower Monumental Dam 2000-2002.

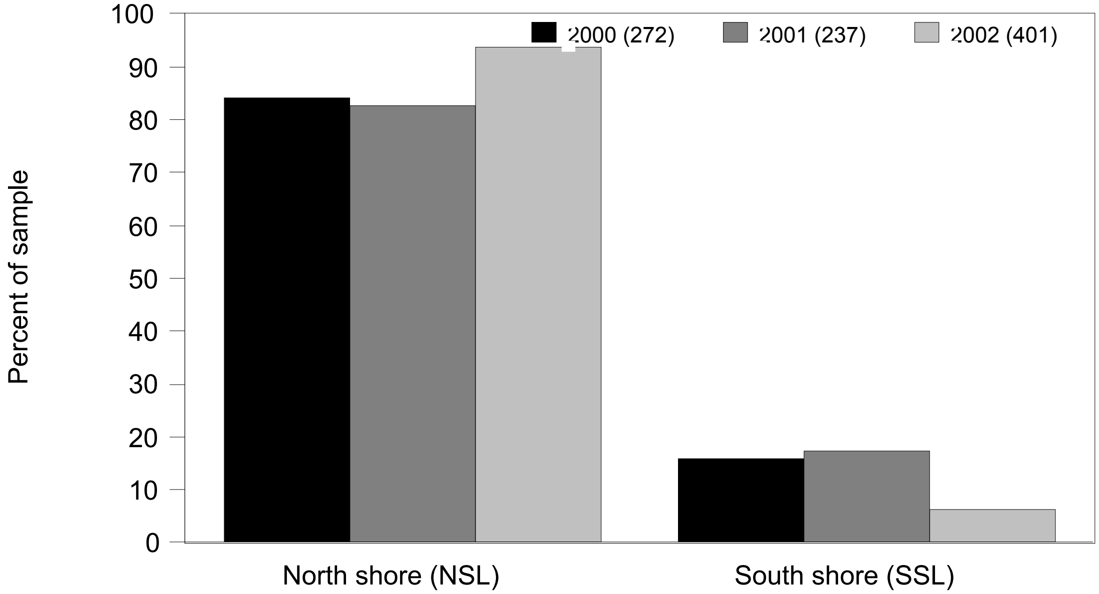

Figure 14. Frequency distribution of steelhead ladder use at Lower Monumental Dam 2000-2002.

longer median passage time in 2002 may not have been directly attributable to the construction activity or that in-river conditions during 2001 contributed to significantly lower passage times that year.

The majority of radio-tagged steelhead passing Lower Monumental Dam during 2000-2002 did so via the NSL (Figure 14). We found significant differences among years in the proportions of steelhead using the two ladders to pass the dam ($P<0.001$, Chi-square Test), with the highest use of the NSL in 2002. The increased use of the NSL by steelhead in 2002 may have been associated with steelhead avoiding the construction area, which was closer to the SPE and SSE.

Field Observations

A field technician outfitted with a receiver and hand-held yagi antenna scanned for fish with radio transmitters from the shoreline of the Lower Monumental Dam tailrace and the powerhouse deck during the afternoon and evening hours (range = 1429 - 0224 hrs) of 19-22 and 26-29 August 2002, the first two weeks of construction. A total of eight unique transmitters were recorded during the mobile tracking sessions. While the resolution of these techniques are admittedly poor, the technician noted no aberrant behaviors by the fish (avoidance/or flight response consistent with swimming downstream) during the course of the observations and to this degree, had no compelling evidence to suggest the construction activity was impeding fish passage.

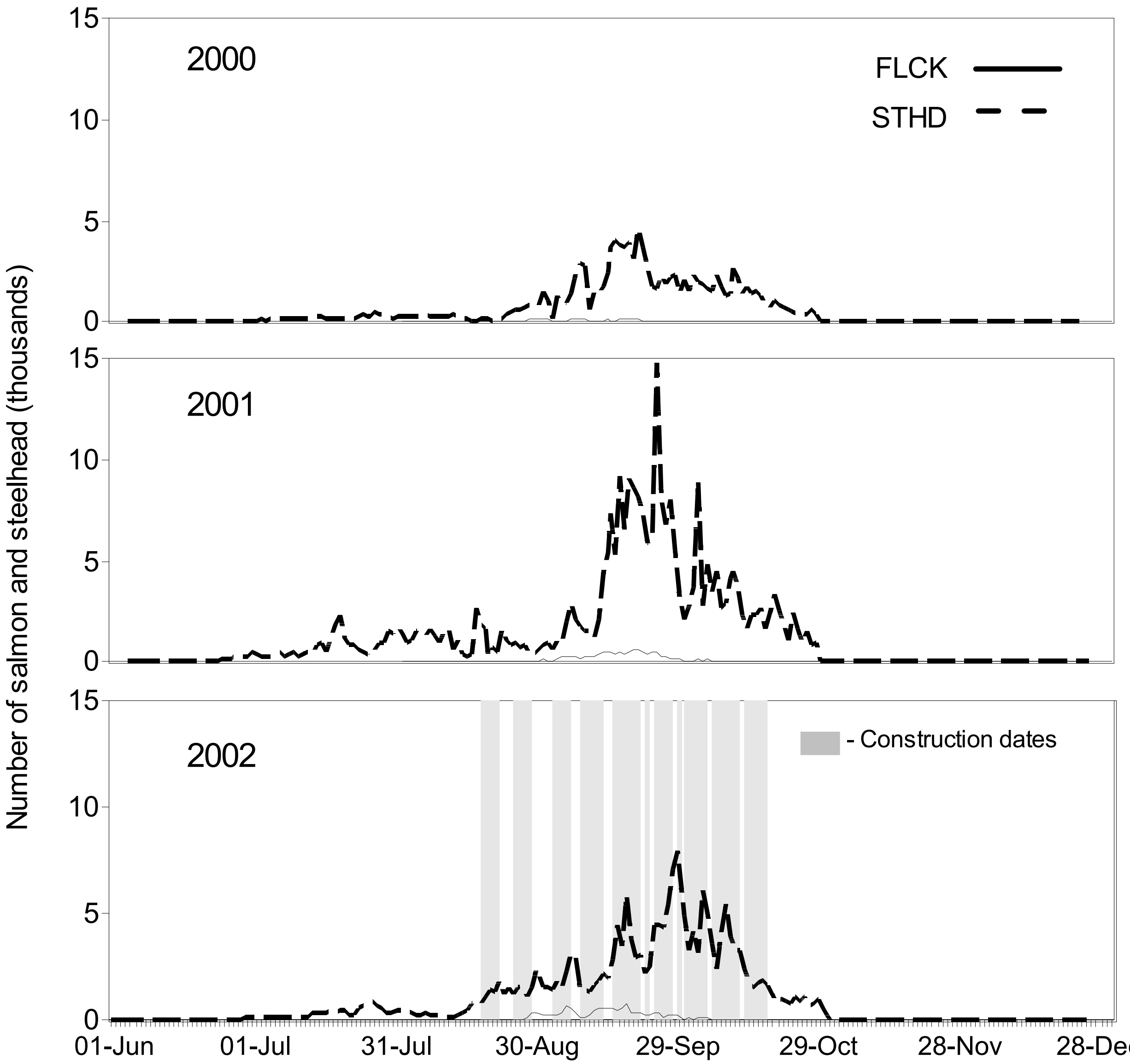

Figure 15. Number of adult salmon and steelhead recorded passing ladders at Lower Monumental Dam in 2000-2002 and dates of construction activity in 2002.

Counting Window Estimates of Fish Passage

We examined the percentage change in count data on days when construction activity started (after at least one day of no drilling) and on days when construction activity stopped (after at least one day of drilling) (Figure 15). The percent change in steelhead counts tended to decrease on days when construction activity started and increase on days when the construction activity stopped, although the relationship was not statistically significant at the α=0.05 level (P=0.06, Kruskal-Wallis Test). We observed no significant percent change in count data for the fall chinook salmon on days when construction activity started or stopped (P=0.37, Kruskal-Wallis Test).

Discussion

The construction work associated with a new spill basin bottom occurred during evening hours (1600-0230 hrs) on 46 of 61 days between 19 August and 18 October 2002 at Lower Monumental Dam. The time of day chosen to make the repairs was based on previous observations that adult salmon and steelhead are less active at night (Keefer et al., 2002, Bjornn et al., 2000). Nearly 60% of radio-tagged fish in all years approached, entered, and passed Lower Monumental Dam during daylight hours, and therefore did not encounter construction activities. Although some fish were exposed to construction in 2002, many were not, which may explain our finding no significant differences among years in the median times fall chinook salmon required to first approach, first enter or pass Lower Monumental Dam. While we did find significant differences among years in the median times steelhead used to first approach, first enter and pass Lower Monumental Dam, the median times to first approach and first enter the dam in 2002 were within the range of medians observed during the two years with no construction. Similarly, the median time for steelhead to pass Lower Monumental Dam was highest in the year with construction (2002), but that time was not significantly different from the median time observed in 2000. The low median dam passage time for steelhead in 2001 may have been related to the low-flow conditions that year.

Independent of differences in fall chinook salmon or steelhead passage times across years, there was a pattern of slightly increased proportionate use of the NSE and the NSL by fall chinook salmon to first approach and pass the dam, and for steelhead to first approach, first enter, and pass the dam in 2002. This behavior was likely a response by some fish to avoid the construction area, which was closer to the south shore. The near absence of spill at Lower Monumental Dam in all three years (there were three days of spill in 2001 during fall chinook salmon and steelhead migrations) suggests that differences in proportionate fishway use in 2002 were attributable to the construction.

Based on our comparisons of passage times across years, the absence of obvious flight responses by fish mobile-tracked at the onset of construction, and no sharp decrease in fall chinook salmon counts at counting windows during the construction period, we conclude that the construction activity at Lower Monumental Dam in 2002 did not significantly impede fall chinook salmon passage. We draw a similar conclusion for steelhead but note that significantly longer steelhead passage times in the year coincident with construction, and the tendency for steelhead window counts to decrease on days construction started, suggest that steelhead passage may have been mildly impeded by the construction activity. Finally, we conclude the construction may have caused an increased tendency for both species to use the fishway entrance and fish ladder on the north shore to approach, enter, and ultimately pass the dam.

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