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To: David Clugston (USACE)

From: Matt Keefer and Chris Peery (University of Idaho)

Re: Summary of the use of orifice gates at Bonneville Dam by adult Chinook salmon, sockeye salmon, and steelhead: 1997-1998; Letter Report

Introduction: This summary was prompted by ongoing interest in closing—or otherwise excluding pinnipeds from—floating orifice gate (FOGs) fishway entrances at Powerhouse II at Bonneville Dam. These fishway openings were monitored using radiotelemetry in 1997 (a high flow year) and 1998 (a near-average flow year). Powerhouse priority in both years was through Powerhouse I. Here, we address the relative use of FOGs compared to other fishway entrances at the dam and evaluate FOG entrance effectiveness using entrance:exit ratios.

Methods: Although all Bonneville fishway entrances were monitored in 1997-1998 (FOGs have not been monitored since), there was some ambiguity regarding specific entry sites, particularly when two sites were close together as with some FOGs. As a result, some FOG entrances and exits by radio-tagged fish were coded as unknown with respect to exact location and time. Coded records did, however, indicate the likely site used, and the reliability of these estimates was considered quite high. For this summary, fish entries and exits coded 'unknown' were assigned to the most likely fishway entrance site. This differs slightly from the Bonneville fishway use summaries presented in Keefer et al. *in review*, where unknown records were treated more conservatively. However, we believe the difference in methods has little effect on interpretation. See tables 9, 12, 22, and 25 in Keefer et al. *in review* for data used for the more conservative summaries.

Distributions of fishway entries and exits by radio-tagged fish were tabulated for FOGs (all sites combined) as well as for all fishway entrance sites at Powerhouse II (including FOGs), Powerhouse I, and in the spillways. Ratios of total entries:total exits were summarized for each month of each run, and for each run-year across months. These ratios show the relative 'effectiveness' of each group of fishway entrances. Fishway entrances were more effective as ratios increased (more entries than exits). Individual FOG use was also examined.

A more detailed summary of specific FOG entry use is also included, with estimates for the locations of unknown entries and exits. Estimates for the 'unknowns' were calculate using the proportions of known actions at each site. Sample sizes were quite small for some FOGs, especially when individual months were examined, and therefore summaries across entire run-years should be considered more reliable than monthly summaries.

Results and Discussion: From 6% to 16% of all fishway entries by radio-tagged spring-summer Chinook salmon and sockeye salmon were estimated to have been through FOGs (Table 1). Monthly estimates increased to 9% to 46% when only entries at Powerhouse II were considered. Estimates for steelhead in June and July were similar to those for the salmon, then dropped considerably from August-October. Relatively fewer fishway exits by Chinook and sockeye salmon were via FOGS (2-7% of all exits at the dam; 4-12% of all exits at Powerhouse II) (Table 2). In contrast, proportionately more fishway exits by steelhead were via FOGs.

In 1997, FOG effectiveness was relatively high compared to other sites for spring–summer Chinook salmon, except in April when it was lower than at some sites (Figure 1). Among the major fishway entrance groups, the entrances at Powerhouse II (including FOGs) were least effective for Chinook salmon in 1997. FOG effectiveness ratios were even higher for spring–summer Chinook salmon in 1998, though ratios were higher at all sites in this year, probably reflecting the lower flow in 1998 and a generally more benign passage environment.

Patterns for sockeye salmon in 1997 (Figure 3) showed less variability in effectiveness across sites, though FOGs were more effective than other sites at Powerhouse II. Results for steelhead in 1997 (Figure 4) differed from the salmon runs, with FOGs being less effective than other sites, except in June.

In all run-years, the conservative method of identifying entry use sites produced higher FOG ratios than the more inclusive method (black versus red bars in Figures 1-4). This pattern can be attributed to greater proportions of 'unknown' entrances than 'unknown' exits at FOGs. Estimates using the two methods were very consistent for the other sites, reflecting an overall greater level of uncertainty regarding fish movements into and out of FOGs. Nonetheless, results using both methods consistently indicated that FOGs were effective entrances for all runs (except steelhead in some months).

When use of individual FOGs was examined by run-year, the two FOGs near the north end of the collection channel were the most used by Chinook salmon and steelhead, followed by those near the south end of the channel; use was somewhat more evenly distributed across FOGs for sockeye salmon (Figures 5-8). Mid-channel FOGs were relatively lightly used. Most FOGs produced more entries than exits, especially for Chinook salmon. Monthly summaries (Figures 9-12) did not clearly indicate that patterns changed within individual runs, but again, sample sizes were quite small at this scale. Although entry:exit effectiveness can be calculated for individual FOGs, we believe the small samples make these estimates somewhat unreliable. In general effectiveness was > 1.0 for spring–summer Chinook salmon at most FOGs and was more variable for sockeye salmon and steelhead (e.g., effectiveness < 1.0 at some sites).

Overall, use of FOGs by the radio-tagged fish was fairly limited in relation to all fishway entrance sites at the dam but they were regularly used among the sites at Powerhouse II. FOGs were relatively more effective than many of the other entrance groups at the dam,

and appear to be among the most effective sites at Powerhouse II using the entries:exits ratio as a metric. The most used FOGs were near the ends of the collection channel, and these should be the priority if some subset of FOGs are to remain open. Closure of those in the center of the channel could likely have very limited impact.

Closure of all FOGs, however, may reduce overall entry:exit ratios, or increase the total number of fishway exits at the dam. We would expect this to result in passage delay for some fish, particularly as other fishway entrances at Powerhouse II appear to have relatively higher exit rates. It seems very unlikely that closing FOGs would reduce total passage conversion at the dam, as we would expect fish to easily locate other, larger fishway entrances.

The majority of the data used in this summary came from 1997. This was an unusually high flow year, and the distributions of fishway entrance use and fishway exit rates may not have been typical. Greater use of FOGs may occur in years with Powerhouse II priority, as this attracts fish to both the spillway and the north-shore fishways. FOGs may be more important under these conditions, especially given the relatively high exit rates from the Powerhouse II fishway generally (Keefer et al. *in review*).

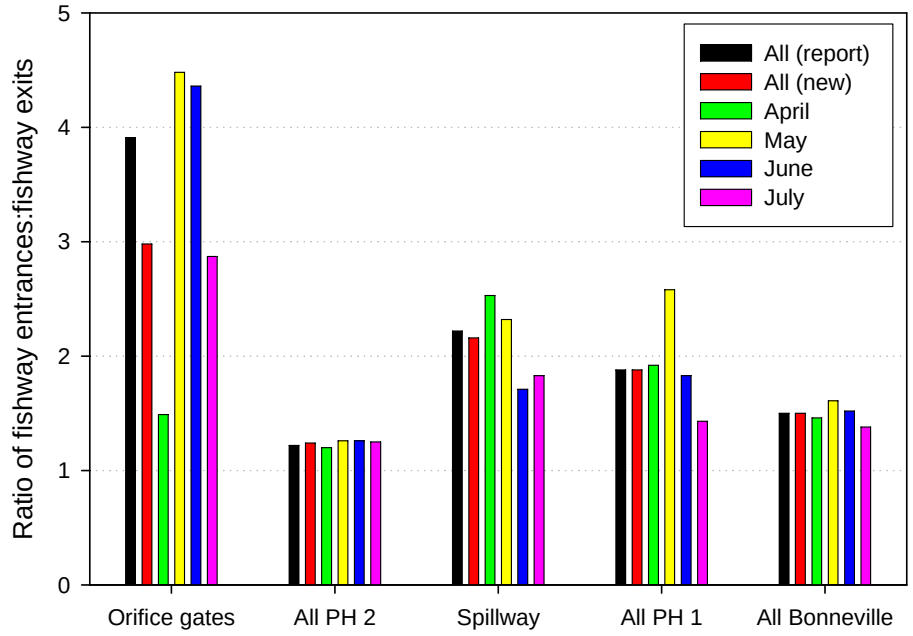

Figure 1. Fishway entrance effectiveness (ratio of total entries:total exits) for spring–summer Chinook salmon in 1997. Black bars generated from the more conservative method used to assign entry and exit locations in Keefer et al. *in review*. All other bars use the more inclusive method.

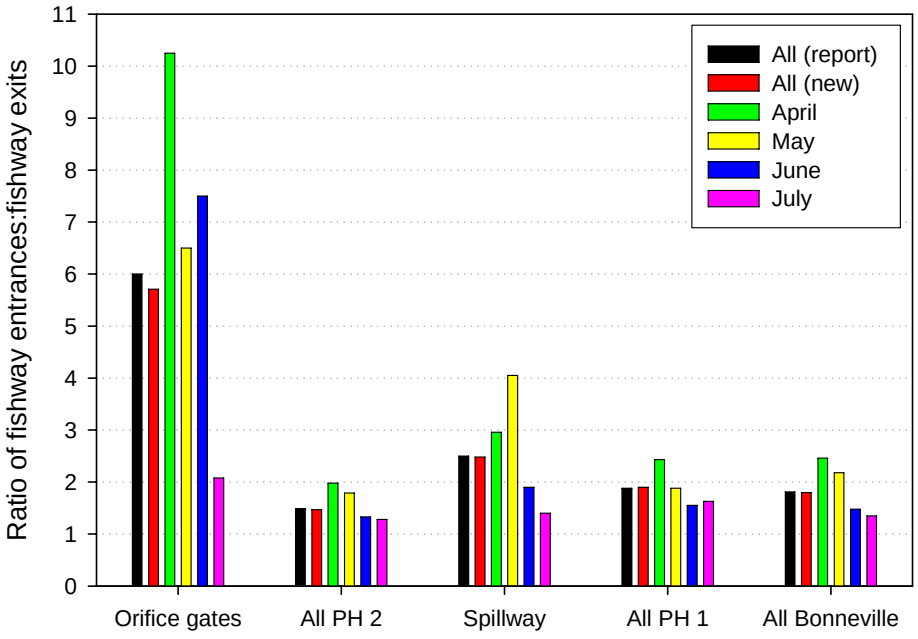

Figure 2. Fishway entrance effectiveness (ratio of total entries:total exits) for spring–summer Chinook salmon in 1998.

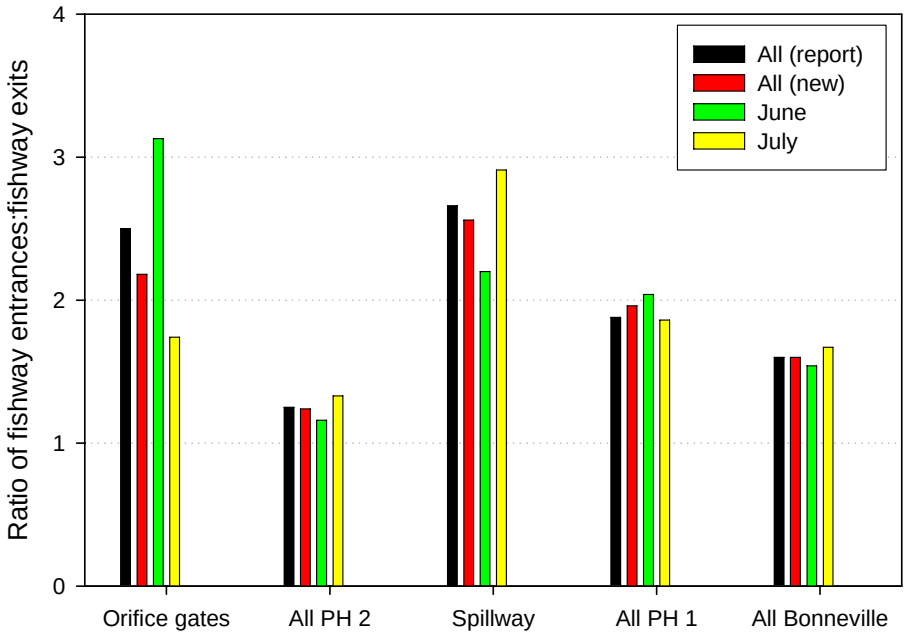

Figure 3. Fishway entrance effectiveness (ratio of total entries:total exits) for spring–summer sockeye salmon in 1997.

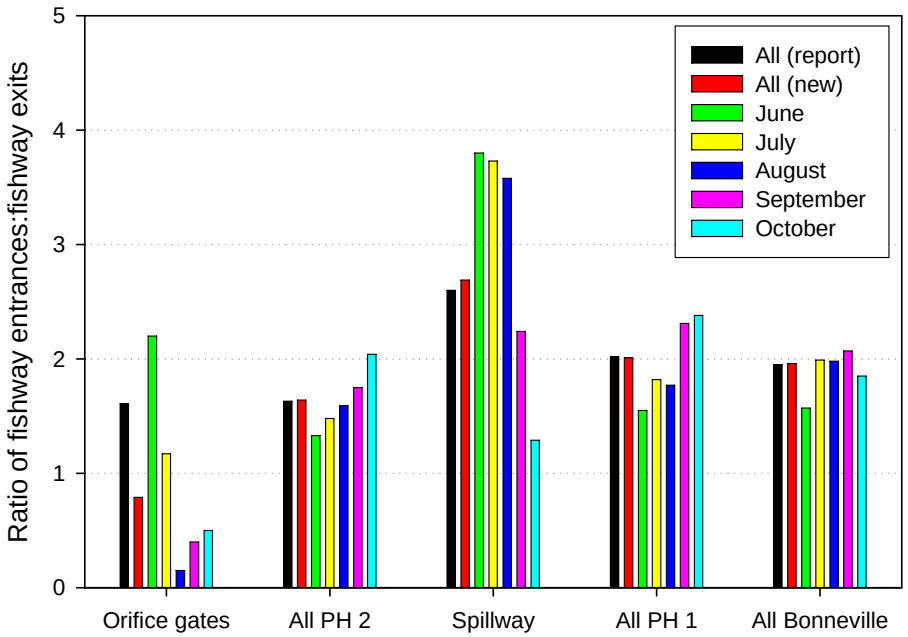

Figure 4. Fishway entrance effectiveness (ratio of total entries:total exits) for spring–summer steelhead in 1997.

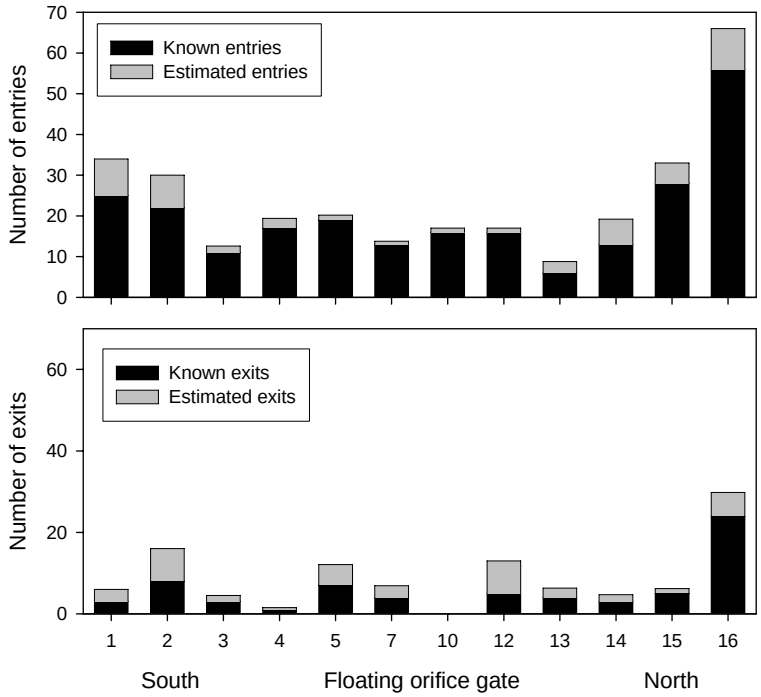

Figure 5. Known and estimated entries and exits through floating orifice gates by spring–summer Chinook salmon in 1997.

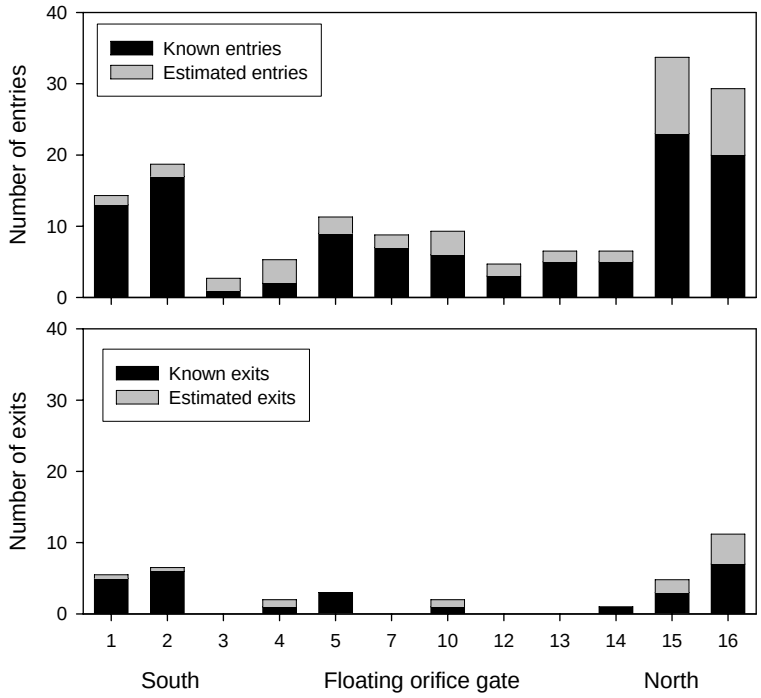

Figure 6. Known and estimated entries and exits through floating orifice gates by spring–summer Chinook salmon in 1998.

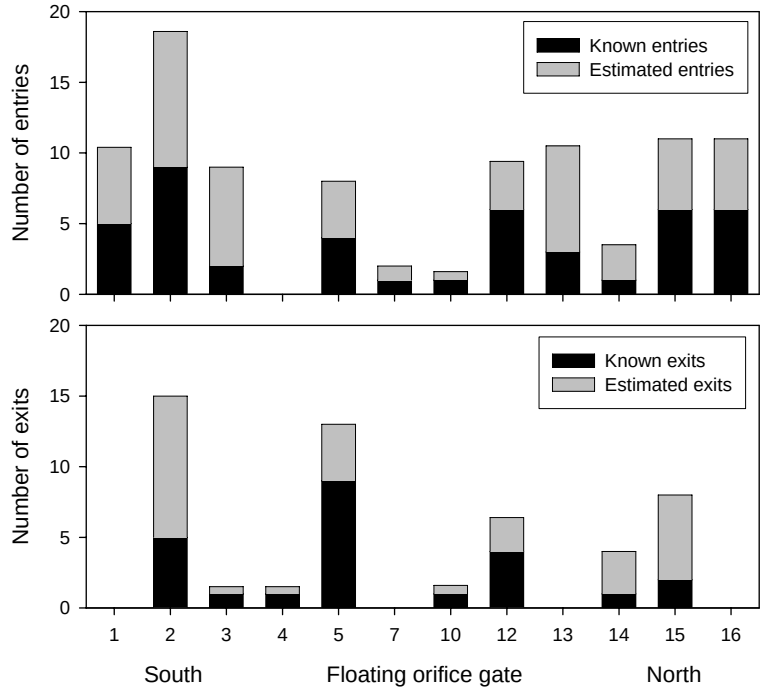

Figure 7. Known and estimated entries and exits through floating orifice gates by sockeye salmon in 1997.

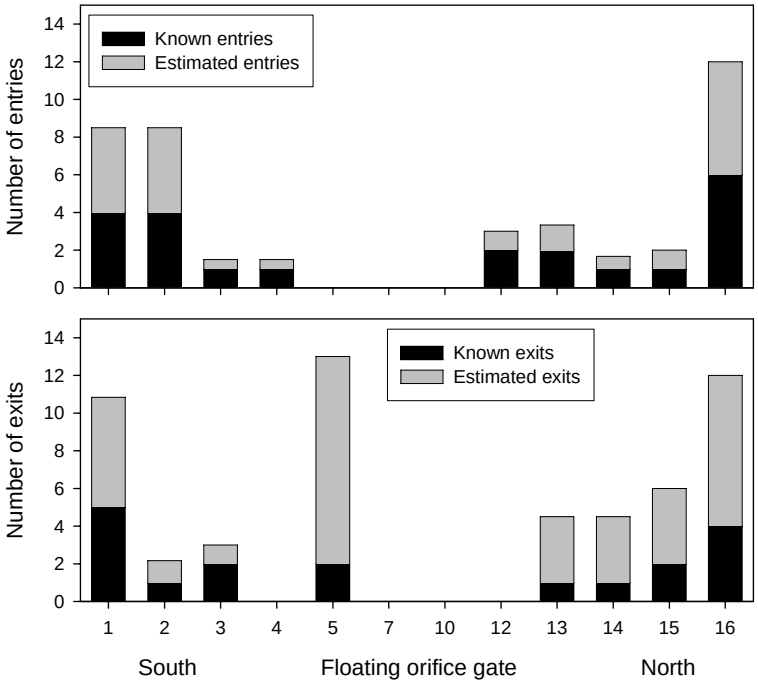

Figure 8. Known and estimated entries and exits through floating orifice gates by steelhead in 1997.

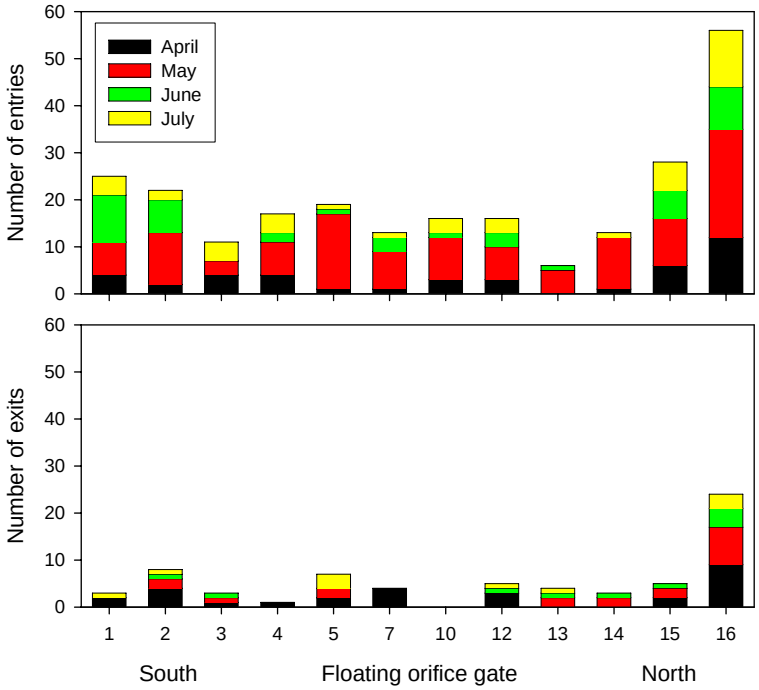

Figure 9. Known entries and exits through floating orifice gates by spring–summer Chinook salmon in 1997, by month.

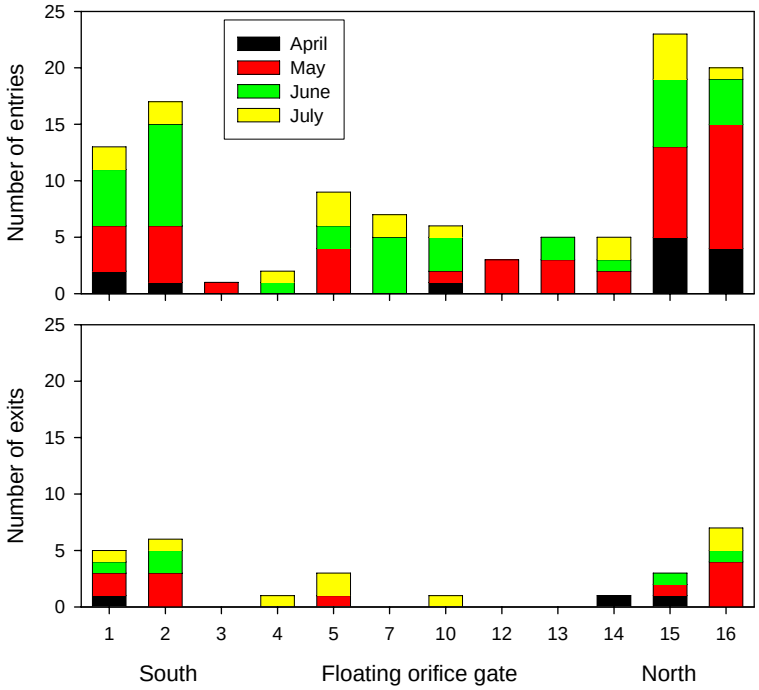

Figure 10. Known entries and exits through floating orifice gates by spring–summer Chinook salmon in 1998, by month.

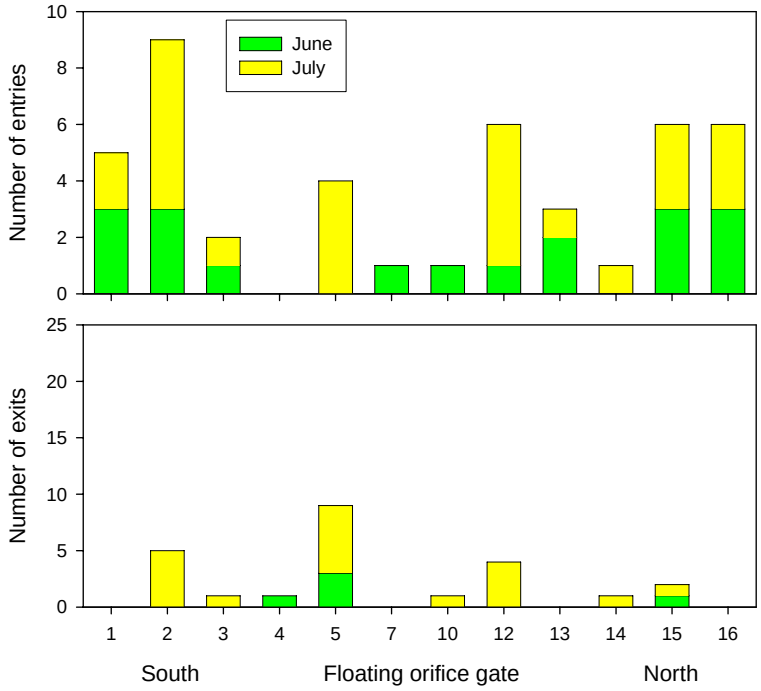

Figure 11. Known entries and exits through floating orifice gates by sockeye salmon in 1997, by month.

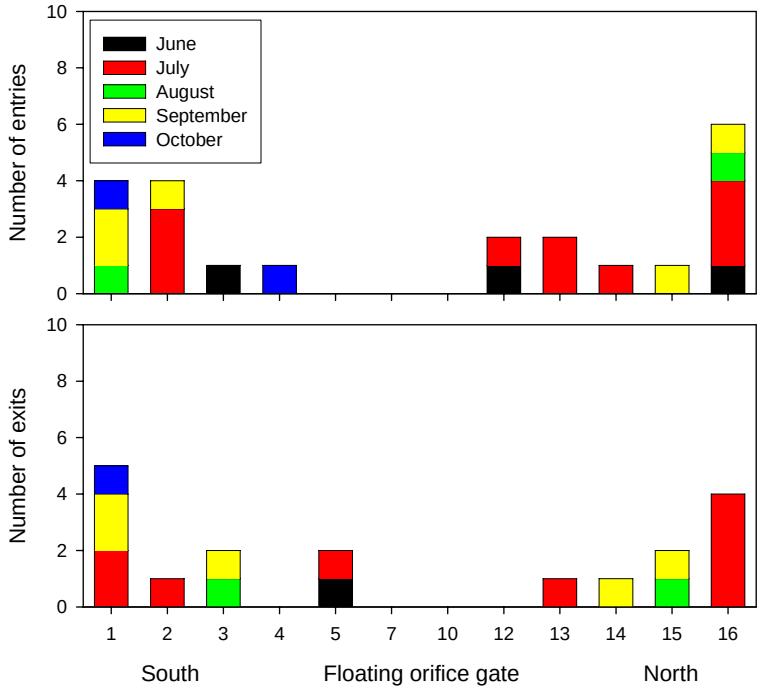

Figure 12. Known entries and exits through floating orifice gates by steelhead in 1997, by month.

Table 1. Numbers of fishway entries, by run-year and month, recorded at Bonneville Dam in 1997 and 1998. Bottom of table shows orifice gate entrances as percentages of all entrances at the dam and of all entrances at Powerhouse II sites.

	April	May	June	July	Aug	Sept	Oct
Total number of fishway entrances at dam							
1997 CK	830	1027	396	587			
1998 CK	554	584	494	428			
1997 SK			667	675	9		
1997 SH			121	341	480	663	191
Total number of fishway entrances at PH II							
1997 CK	507	566	168	316			
1998 CK	129	200	251	265			
1997 SK			293	317	1		
1997 SH			57	118	165	236	96
Total number of fishway entrances at floating orifice gates							
1997 CK	55	130	48	86			
1998 CK	41	91	60	25			
1997 SK			50	61			
1997 SH			11	28	2	6	3
Orifice gate entrances as a percentage of all entrances at dam							
1997 CK	6.6%	12.7%	12.1%	14.7%			
1998 CK	7.4%	15.6%	12.1%	5.8%			
1997 SK			7.5%	9.0%			
1997 SH			9.1%	8.2%	0.4%	0.9%	1.6%
Orifice gate entrances as a percentage of all entrances at PH II							
1997 CK	10.8%	23.0%	28.6%	27.2%			
1998 CK	31.8%	45.5%	23.9%	9.4%			
1997 SK			17.1%	19.2%			
1997 SH			19.3%	23.7%	1.2%	2.5%	3.1%

Table 2. Numbers of fishway exits, by run-year and month, recorded at Bonneville Dam in 1997 and 1998. Bottom of table shows floating orifice gate exits as percentages of all exits at the dam and of all exits at Powerhouse II sites.

	April	May	June	July	Aug	Sept	Oct
Total number of fishway exits at dam							
1997 CK	567	639	261	424			
1998 CK	225	268	334	316			
1997 SK			433	405	4		
1997 SH			77	171	243	321	103
Total number of fishway exits at PH II							
1997 CK	421	448	133	253			
1998 CK	65	112	189	207			
1997 SK			253	238	1		
1997 SH			43	80	104	135	47
Total number of fishway exits at floating orifice gates							
1997 CK	37	29	11	30			
1998 CK	4	14	8	12			
1997 SK			16	35			
1997 SH			5	24	13	15	6
Orifice gate exits as a percentage of all exits at dam							
1997 CK	6.5%	4.5%	4.2%	7.1%			
1998 CK	1.8%	5.2%	2.4%	3.8%			
1997 SK			3.7%	8.6%			
1997 SH			6.5%	14.0%	5.3%	4.7%	5.8%
Orifice gate entrances as a percentage of all entrances at PH II							
1997 CK	8.8%	6.5%	8.3%	11.9%			
1998 CK	6.2%	12.5%	4.2%	5.8%			
1997 SK			6.3%	14.7%			
1997 SH			11.6%	30.0%	12.5%	11.1%	12.8%

References:

Keefer, M. L., D. C. Joosten, C. L. Williams, C. M. Nauman, M. A. Jepson, C. A. Peery, T. C. Bjornn, R. R. Ringe, K. R. Tolotti, S. R. Lee, L. C. Stuehrenberg, M. M . Moser, and B. J. Burke. *In review*. Adult salmon and steelhead passage through fishways and transition pools at Bonneville Dam, 1997-2002. Draft Technical Report.