Studies to evaluate the effectiveness of extended-length screens at Little Goose Dam, 1994

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CZES

Coastal Zone and Estuarine Studies Division

Northwest Fisheries Science Center

National Marine Fisheries Service

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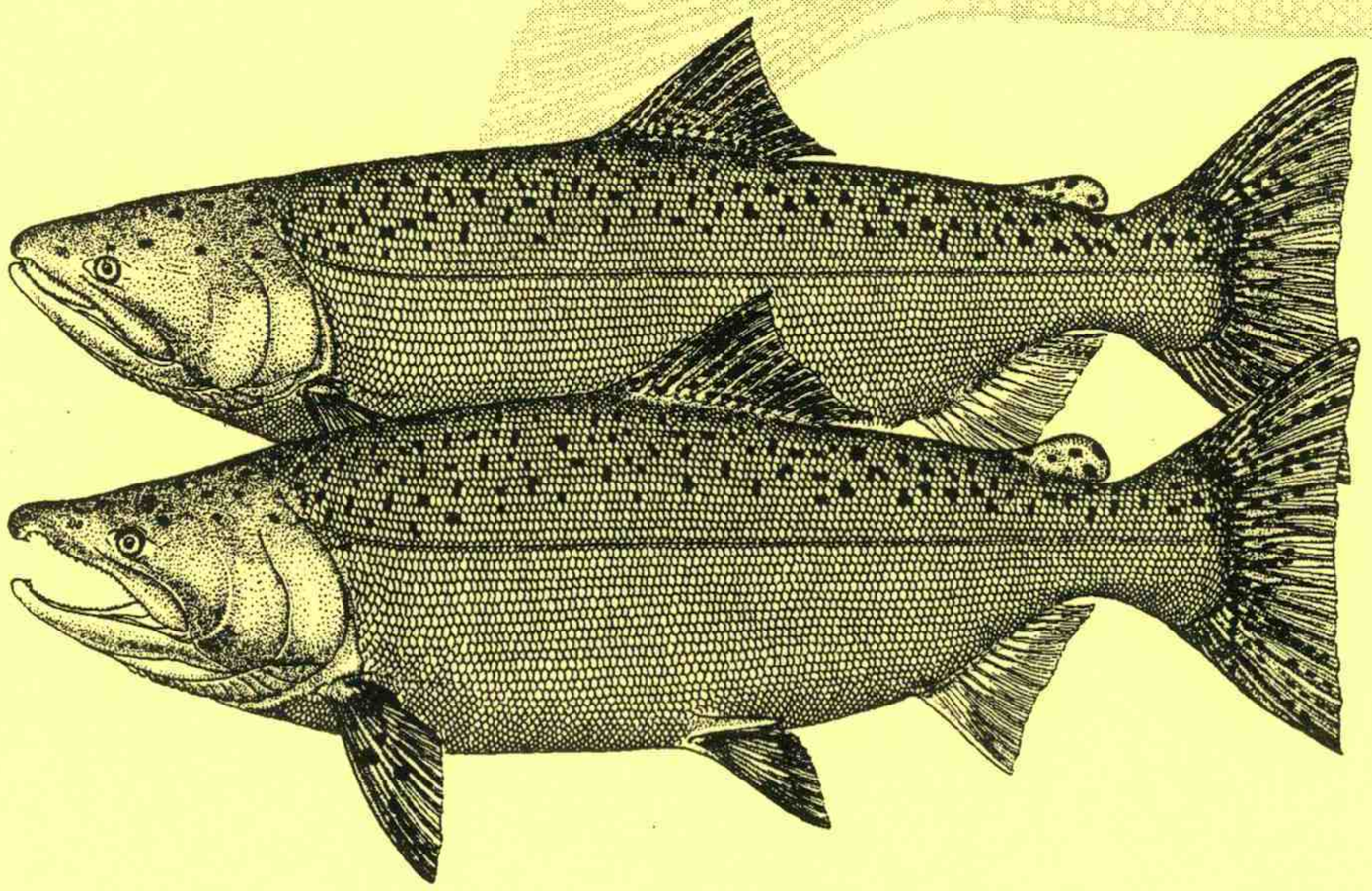
April 1995



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INTRODUCTION

Submersible traveling screens (STSs) have become an integral part of the bypass systems for juvenile salmonids (*Oncorhynchus* spp.) at hydroelectric dams on the Snake and Columbia Rivers. Studies to evaluate these screens began at Little Goose and Lower Granite Dams during the 1970s and continued through the 1980s. Fish guidance efficiency (FGE) for yearling chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*) generally has ranged between 50 and 80%.

In 1987, in an effort to provide more consistently high guidance levels, the National Marine Fisheries Service (NMFS) and the U.S. Army Corps of Engineers (COE) conducted research at Lower Granite Dam to test the concept of a longer STS. This new guidance concept resulted from engineering studies and hydraulic model tests conducted by the COE and was tested by placing one fixed bar screen (FBS) in one fish screen slot (located upstream of the bulkhead slot where the STS is placed). The FBS provided an additional guidance surface, which, in conjunction with the STS was designed to simulate a one-piece extended-length guidance device. The STS/FBS combination approximately doubled the length (to 12.2 m [40 feet]) of the guiding surface. Results of these tests indicated that the STS/FBS combination could improve guidance from 51 to 66% for yearling chinook salmon and from 74 to 82% for steelhead. In 1989, the STS/FBS combination was installed in all three slots of a turbine intake with 18.8-m (62-ft) raised operating gates. Significant increases in FGE were measured for both yearling chinook salmon and steelhead, with

weighted mean FGEs of 66 and 83%, respectively, compared to 57 and 77% with only an STS and raised operating gate.

Descaling of fish recovered from gatewells in slots without guidance devices was 3% or less. Descaling of guided yearling chinook salmon during FGE tests was 2.5 and 4.7% for control and treatment conditions, respectively.

Results from the Lower Granite Dam studies and continued efforts in hydraulic modeling led to the design of two types of extended-length screens. During the 1991 juvenile salmonid outmigration, NMFS tested extended-length submersible traveling screens (ESTSs) and extended-length submersible bar screens (ESBSs) at McNary Dam on the Columbia River. Each of these extended-length screens, which are approximately twice as long as an STS, guided nearly 80% of the yearling chinook salmon and over 50% of the subyearling chinook salmon, with no significant difference between devices (Brege et al. 1992). Extended-length screen tests continued from 1992 to 1994 at McNary Dam and were initiated at The Dalles and Little Goose Dams in 1993.

At Little Goose Dam in 1993, the results of prototype tests of ESTSs and ESBSs with different overall porosities (22, 25, and 28%), although somewhat limited by the number of tests (10 replicates), indicated that FGE was more than 80% for both the ESTS and ESBS with yearling chinook salmon (Gessel et al. 1994). Descaling of yearling chinook salmon was 7, 9, and 12% for the STS, ESBS, and ESTS, respectively. Also, no obvious differences in descaling were found among the different porosity ESBSs.

This report covers the continued evaluation of extended-length devices during the 1994 smolt outmigration at Little Goose Dam. Specific research objectives for 1994 were

1) Determine the FGE of different porosity ESBSs (25 and 28%) during the juvenile salmonid outmigration.
2) Determine the effect of these extended-length screens on descaling of juvenile salmonids.

OBJECTIVE 1: FISH GUIDANCE EFFICIENCY OF THE EXTENDED-LENGTH SUBMERSIBLE BAR SCREEN

Approach

Methods for determining FGE were similar to those used in previous extended-length screen studies at McNary and Little Goose Dams (Brege et al. 1992, McComas et al. 1993, Gessel et al. 1994). To evaluate their performance under different flow conditions, ESBSs (Fig. 1) were tested in Slots 4B and 5A. An STS was used in Slot 3B as a descaling control. Extended-length screens were also placed in the remaining slots of Turbine Units 4 and 5 to maintain uniform flows within each test unit. Initial placement of screens for 1994 FGE testing was as follows:

Turbine unit/slot	Screen type	Porosity
3B	STS	48%
4A	ESTS	28%
4B	ESBS	25%
4C	ESTS	25%
5A	ESBS	28%
5B	ESTS	25%
5C	ESBS	25%

The support structure for the extended-length screens extended to the floor of the turbine intake; therefore, the fyke-net frame was placed in the downstream or operating-gate slot (Fig. 1). A full complement of fyke nets (three columns of eight rows) with cod ends was used in the two extended-length screen test slots to collect unguided fish. Because only a few fish were caught in the smaller nets of Level 8, the catch totals reported for Level 7 include fish caught in Levels 7 and 8. Fyke-net catch by net column with extended-length screens was analyzed by McComas et al. (1994).

All test and control slots (see page 3) contained modified balanced-flow vertical barrier screens that separated the gatewell (bulkhead slot) from the operating-gate slot and confined guided fish to the gatewell (Fig. 1). A solid plate (1.3-m wide) was added to the bottom panel of the vertical barrier screens to distribute flow entering the gatewell more evenly.

All FGE test screens were operated at the standard elevation and screen angle was 55° throughout the tests. Operating gates were either fully raised or removed (Fig. 1).

Water flows into test turbine units were maintained at approximately 19,700 cfs[1] for FGE tests. This corresponded to a screen-approach velocity of around 2.5 fps with turbine power

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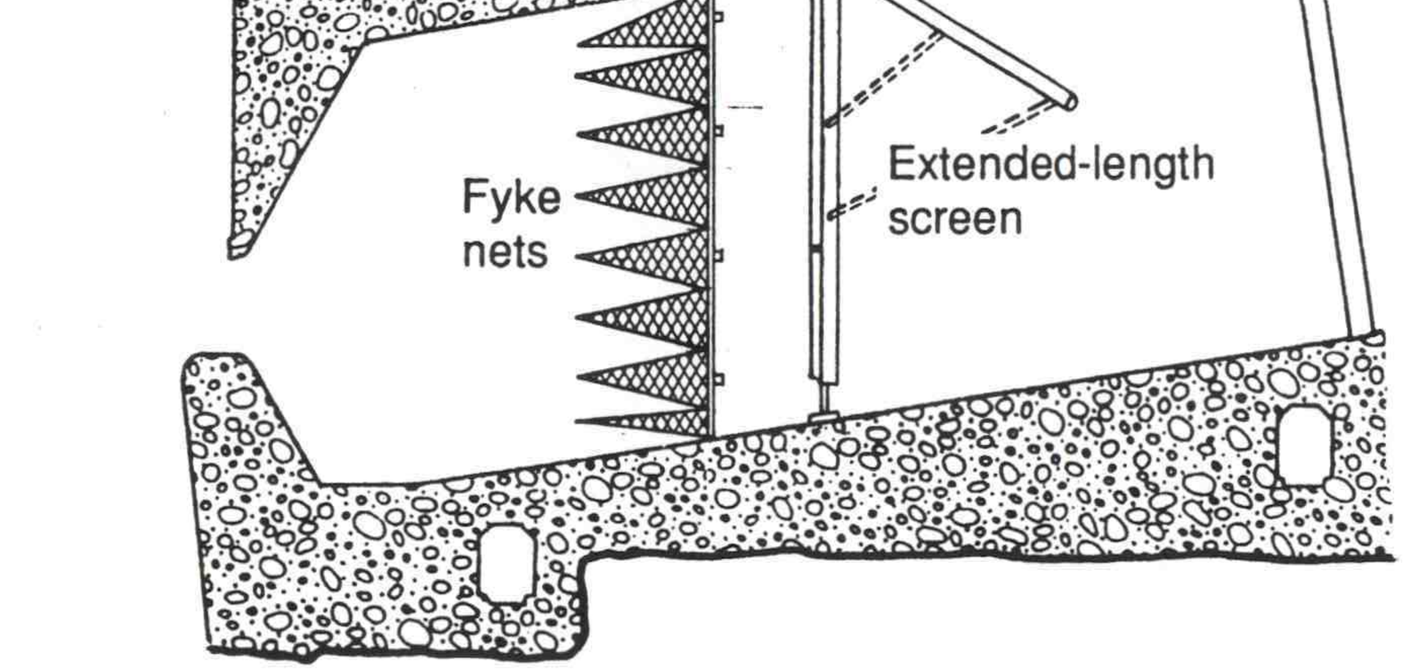
[1] To approximate the flow conditions near the guidance device under normal operating conditions (no net frame in place), it was necessary to increase the total flow into the turbine unit during FGE testing. This compensated for the flow reduction caused by the fyke-net frame and the full complement of fyke nets, and the head loss associated with extended-length screens.

Little Goose Dam cross section



1994 Fyke-net layout

Figure 1. Cross section of turbine intake with extended-length screen and fyke nets at Little Goose Dam, 1994.

loads of about 135 MW. For descaling tests conducted without fyke nets in the turbine intake, unit loading was 18,300 cfs.

Gatewell dipbasket catches provided the number of guided fish while the fyke-net catch gave the number of unguided fish. Fish guidance efficiency for each species was calculated as the gatewell catch divided by the total number of fish (by species) entering the turbine intake.

$$FGE = \frac{GW}{(GW + FN)} \times 100\%$$

GW = gatewell catch
FN = fyke-net catch

Tests began about 2000 h and generally lasted from 1 to 3 hours. At the end of each test, the turbine unit was shut down, the fyke-net frame was raised, and the catch was removed from each net and placed in a separate container. Both guided and unguided fish were counted, by species, and the gatewell catch was examined for descaling.

Mean FGE percentages for yearling chinook salmon and steelhead were statistically analyzed with paired t-tests. Significance was established at $\alpha = 0.05$.

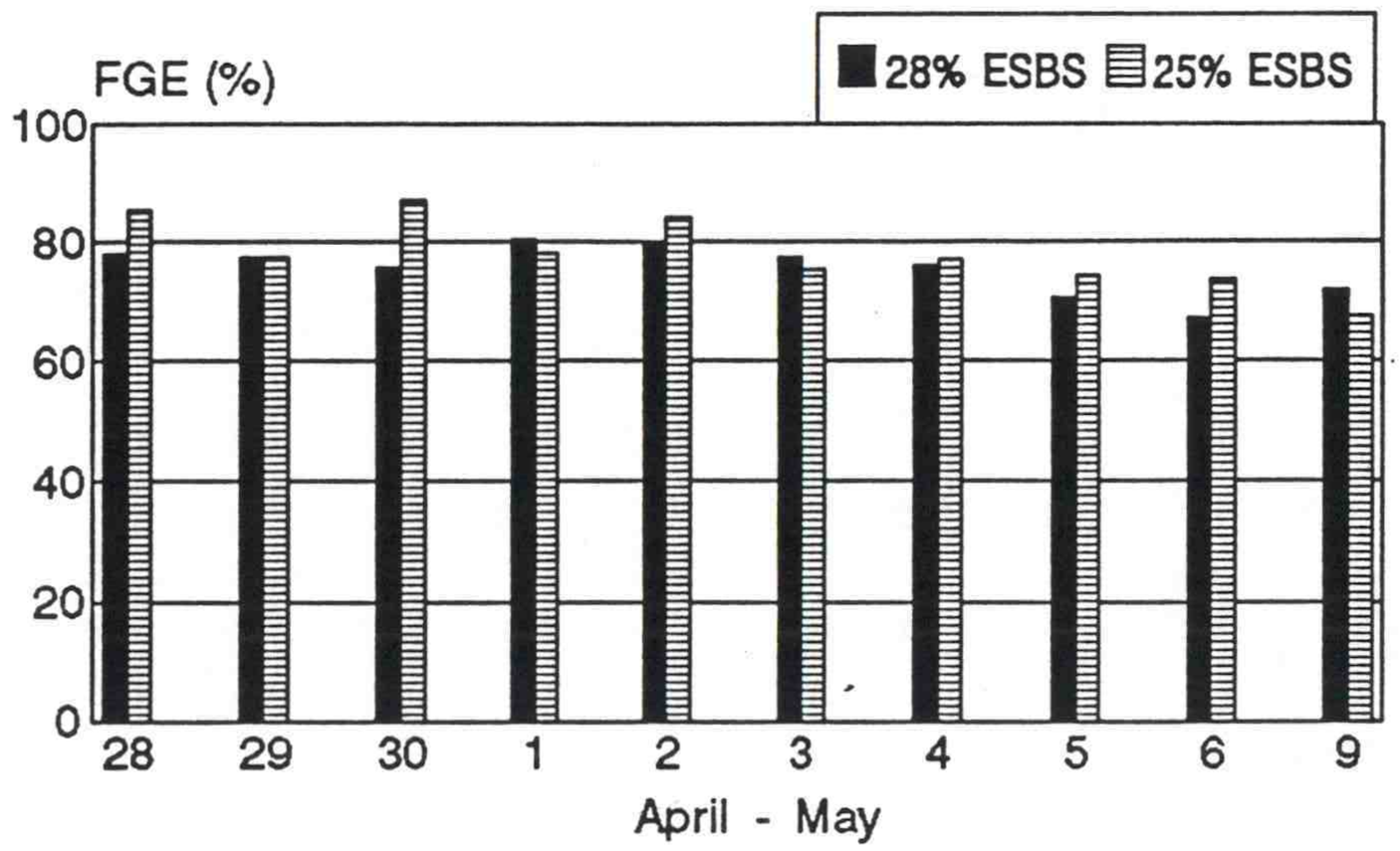
Results and Discussion

Fish Guidance Efficiency

Constraints resulting from the listing of Snake River sockeye (*O. nerka*) and spring/summer chinook salmon influenced the FGE evaluation since we were limited by the number of these fish we could handle. As in 1993, we were unable to conduct the

desired 20 FGE tests during the spring outmigration. Fish guidance efficiency tests to compare a 25% porosity ESBS in Slot 4B and a 28% porosity ESBS in Slot 5A were conducted from 28 April to 9 May (10 tests). Daily fish collections for the FGE tests are listed in Appendix Table A1 and the statistical analyses for yearling chinook salmon and steelhead are summarized in Appendix Table B1. Mean FGEs for the 25 and 28% ESBSs (77 and 75%, respectively, for yearling chinook salmon) were not significantly different (Fig. 2). For steelhead, mean FGE was significantly higher for the ESBS in Slot 4B with 25% porosity than for the ESBS in Slot 5A with 28% porosity (90 and 86%, respectively).

In addition to the comparison between screen types, we also attempted to determine if there was a difference in FGE between wild and hatchery smolts. Unfortunately, because of their physical similarities, the presence of some hatchery fish that were not fin clipped, and confusion over how hatchery fish were to be clipped, it was not possible to consistently separate wild and hatchery yearling chinook salmon during either the 1993 or 1994 outmigration. It was possible, however, to separate wild and hatchery steelhead, but since steelhead were not our target species, we often ended our nightly FGE tests with relatively low numbers of these fish. During the 1993 outmigration, FGE was 90 and 89% for wild and hatchery steelhead, respectively. In 1994, we were unable to combine FGE data because there was a statistically significant difference between the two ESBSs. Fish



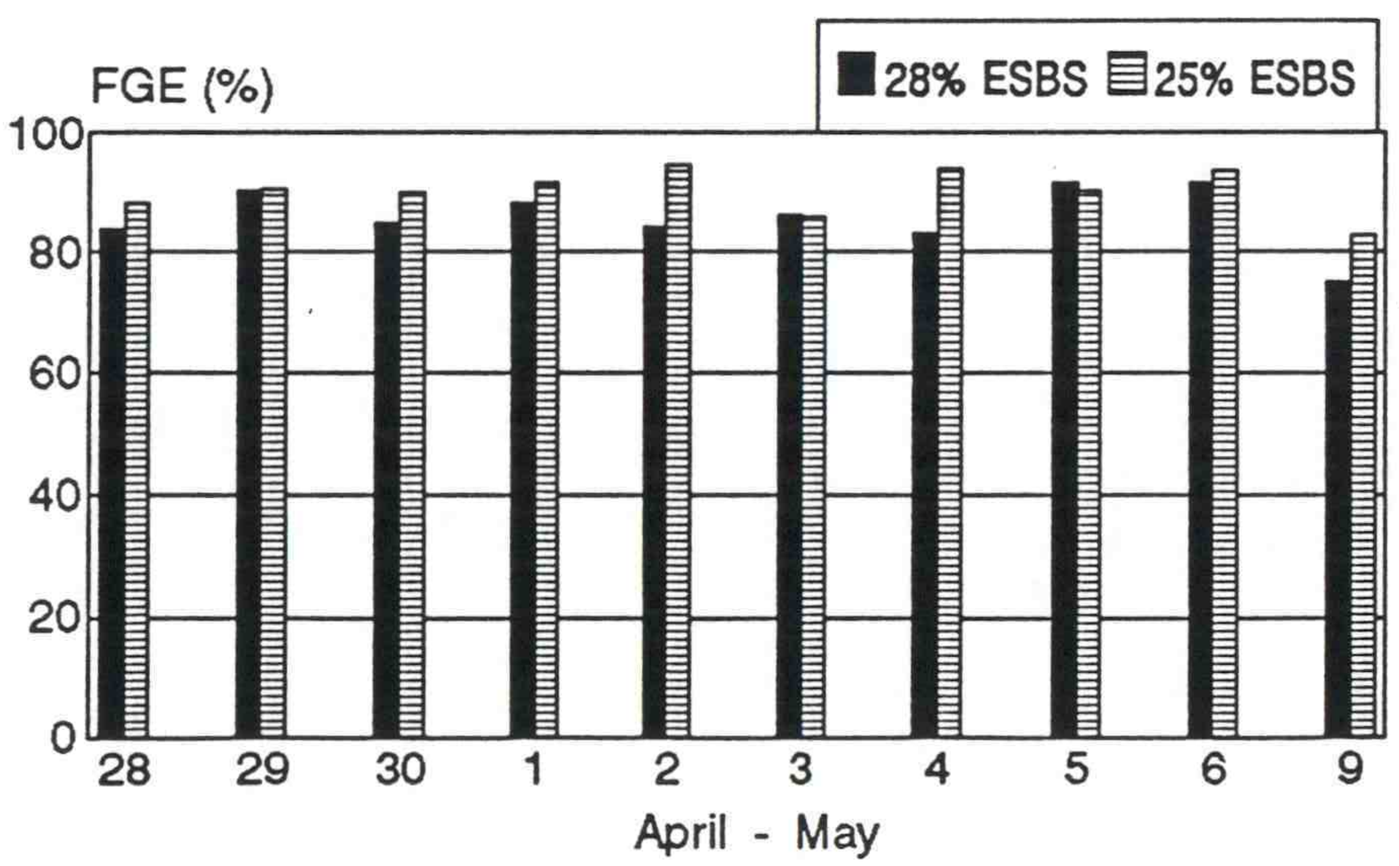


Figure 2. Fish guidance efficiency (FGE) for yearling chinook salmon and steelhead at Little Goose Dam, 1994 (ESBS = extended-length submersible bar screen).

guidance efficiency was 92 and 90% with the 25% porosity ESBS in Slot 4B for wild and hatchery steelhead,respectively. In Slot 5A with the 28% porosity ESBS, FGE was 82 and 87% for wild and hatchery steelhead, respectively. Only tests from either year with a minimum of 60 fish (30 wild and 30 hatchery) were used to determine these percentages. The low numbers of both test fish and replicates precluded meaningful statistical comparisons, but these results suggested that any difference in guidance between hatchery and wild fish was probably small. Appendix Table A2 summarizes daily collection totals for hatchery and wild yearling chinook salmon and steelhead at Little Goose Dam in 1994.

OBJECTIVE 2: JUVENILE SALMONID DESCALING

Approach

The external condition of all juvenile salmonids collected in the gatewells was evaluated using standard Fish Transportation Oversight Team descaling criteria (Ceballos et al. 1992). Descaling data were collected from 24 April to 27 May. Test conditions monitored for descaling are detailed below.

Test condition	Slot	Screen	Porosity (%)	Test days	Number of tests
1	3B	STS	48	25 Apr-27 May	31
2	4A	ESTS	28	25 Apr-12 May	12
3	4A	ESBS	25	13-27 May	15
4	4B	ESBS	25	28 Apr-27 May	20
5	5A	ESBS	28	24 Apr-27 May	32
6	5B	ESBS	25	24 Apr	1

Statistical analyses used for the various combinations of test conditions (designated above) were as follows.

Analysis	Conditions tested	Statistical test
1	1 and 5 (no steelhead)	Paired t-test
2	1, 2, and 5 (test dates 25 Apr-12 May)	Block ANOVA (steelhead) ANOVA
3	1, 3, and 5 (test dates 13-27 May)	Block ANOVA
4	1, (3 + 4), and 5	ANOVA

Note that Conditions 1 and 5 were tested together in all analyses and that Conditions 1, 3, and 5 were tested in two analyses. This was due to the time constraints on Conditions 2, 3, and 4. The analyses attempted to compare conditions only over appropriate date ranges to maximize use of blocking by day, ensure balanced sample sizes between conditions, and remove possible seasonal confounding. Also, Conditions 3 and 4 were identical except for the slot used, so Analysis 3 tested a 25% ESBS in Slot 4A, while Analysis 4 tested a 25% ESBS in Slots 4A and 4B. Conclusions for any comparison were based on the analysis which was most appropriate and precise. Note also that Analysis 1 was not repeated for steelhead. This was due to missing dates (small daily sample sizes) for some steelhead descaling data. Pairing would not have been appropriate and Analysis 1 would have been inferior to (i.e., a subset of) Analysis 5. Daily samples of less than 30 total fish were pooled with the subsequent day (3 days were pooled once).

Results and Discussion

There were no significant differences among mean descaling percentages for either yearling chinook salmon or steelhead in any of the analyses (Appendix Tables A3 and B2-B6). This was due to small actual differences rather than high variability or insufficient sample sizes. Yearling chinook salmon average descaling was 7.1, 8.2, and 7.0%, respectively, for the FGE tests (Slot 4B with a 25% porosity ESBS and Slot 5A with a 28% porosity ESBS) and the control (Slot 3B with an STS). Steelhead descaling for the FGE tests was 4.8, 5.8, and 4.7%, respectively. Mean descaling with the 28% porosity ESTS tested in Slot 4A was 9.4% for yearling chinook salmon and 2.9% for steelhead (small sample sizes).

CONCLUSIONS

1) For yearling chinook salmon, FGE averaged 77% for the 25% porosity extended-length bar screen and 75% for the 28% porosity extended-length bar screen. The difference was not statistically significant.

2) During FGE tests, yearling chinook salmon descaling averaged 7.1, 8.2, and 7.0% for the 25% porosity extended-length bar screen, the 28% porosity extended-length bar screen, and a standard-length traveling screen, respectively. The differences were not statistically significant.

3) For steelhead, FGE averaged 90% for the 25% porosity extended-length bar screen and 86% for the 28% porosity extended-length bar screen. The statistical evidence for a significant difference was present but not strong (P = 0.035).

4) During FGE tests, steelhead descaling averaged 4.8, 5.8, and 4.7% for the 25% porosity extended-length bar screen, the 28% porosity extended-length bar screen, and a standard-length traveling screen, respectively. The differences were not statistically significant.

ACKNOWLEDGMENTS

We express our appreciation to all of the Corps of Engineers personnel at Little Goose Dam for their assistance and cooperation in this study. The fish screen maintenance crew, supervised by Ken Weeks, and the Control Room Operators were particularly supportive.

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McComas, R. L., B. P. Sandford, and D. B. Dey. 1994. Studies to evaluate the effectiveness of extended-length screens at McNary Dam, 1993. Report to U.S. Army Corps of Engineers, Contract E86-91-0060, 85 p. plus Appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

APPENDIX A

Data Tables

Appendix Table A1.--Numbers of fish caught in individual replicates of fish guidance efficiency tests at Little Goose Dam, 1994.

28 April (4B, 25% ESBS)[a]

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot[b]	L	C	R	Tot	L	C	R	Tot
Level 1			1	1		1	2	3				
Level 2	1		8	9		3	6	9				
Level 3	4		9	13		1	4	5				
Level 4	3	3	9	15			2	2				
Level 5	3	3	2	8	1	1	1	3				
Level 6	5			5	1	1	1	3				
Level 7[c]	1			1	1		1	2				
Net total	17	6	29	52	3	7	17	27				
Gatewell				295				200				
Total				347				227				
FGE (%)				85				88				

28 April (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	1			1								
Level 2	4	1	4	9	2		3	5				
Level 3	7	1		8	1	1		2				
Level 4	6	2	6	14	3	5	3	11			1	1
Level 5	7	7	9	23	3	1	4	8				
Level 6		2	2	4		2	1	3				
Level 7												
Net total	25	13	21	59	9	9	11	29			1	1
Gatewell				210				151				0
Total				269				180				1
FGE (%)				78				84				

[a] Test date (Test slot, perforated plate porosity, and guidance device type: ESBS = extended-length bar screen).
[b] Refers to fyke-net column: L = left, C = center, R = right, Tot = total catch for net level.
[c] Includes data for Levels 7 and 8.

Appendix Table A1.--Continued.

29 April (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			4	4			2	2				
Level 2	3	1	4	8		1	3	4				
Level 3	1		11	12		1		1				
Level 4	3	5	7	15		1	1	2				
Level 5	3	3	5	11								
Level 6	2	1	2	5								
Level 7	1			1	1			1				
Net total	13	10	33	56	1	3	6	10				
Gatewell				193				95				
Total				249				105				
FGE (%)				78				91				

29 April (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	1		1	2								
Level 2	4	3	4	11	2	3	1	6				
Level 3	7	1	2	10			1	1				
Level 4	5	4	5	14	1			1				
Level 5	5	3	5	13		1	1	2				
Level 6	1	3	4	8		1	2	3				
Level 7			1	1		1		1				
Net total	23	14	22	59	3	6	5	14				
Gatewell				200				131				
Total				259				145				
FGE (%)				77				90				

Appendix Table A1.--Continued.

30 April (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			1	1								
Level 2	1		2	3		1		1				
Level 3			2	2		1		1				
Level 4	5	1	3	9		3	3	6				
Level 5		6	5	11	1			1				
Level 6	1	3		4	1		1	2				
Level 7												
Net total	7	10	13	30	2	5	4	11				
Gatewell				203				97				
Total				233				108				
FGE (%)				87				90				

30 April (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			2	2								
Level 2	1		2	3			1	1				
Level 3	2	2	2	6		2	3	5				
Level 4	2	1	2	5			1	1				
Level 5	3	2	7	12	1		3	4				
Level 6		3	3	6	1	2		3				
Level 7	1		4	5								
Net total	9	8	22	39	2	4	8	14				
Gatewell				121				77				
Total				160				91				
FGE (%)				76				85				

Appendix Table A1.--Continued.

1 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	1		3	4								
Level 2	2	2	1	5	1	2		3				
Level 3	2		1	3		1		1				
Level 4	3	1	5	9	2		1	3				
Level 5	6	6	6	18			4	4				
Level 6	2	1	2	5		1	1	2				
Level 7					1			1				
Net total	16	10	18	44	4	4	6	14				
Gatewell				155				153				
Total				199				167				
FGE (%)				78				92				

1 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			1	1								
Level 2	2		2	4	1	2	1	4				
Level 3	2	1	2	5		2	1	3				
Level 4	2	3	3	8	2	3		5				
Level 5	6	2	4	12	3		2	5				
Level 6	1		2	3	2	2		4				
Level 7	1			1			1	1				
Net total	14	6	14	34	8	9	5	22				
Gatewell				140				164				
Total				174				186				
FGE (%)				81				88				

Appendix Table A1.--Continued.

2 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	1		2	3								
Level 2	2	2	7	11		1	1	2				
Level 3			5	5			2	2				
Level 4	2	6	5	13								
Level 5	2	1	10	13			2	2				
Level 6	1	1	2	4			2	2				
Level 7												
Net total	8	10	31	49		1	7	8				
Gatewell				257				144				
Total				306				152				
FGE (%)				84				95				

2 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			1	1								
Level 2	3	1	1	5	1			1				
Level 3	1	1	3	5		1		1				
Level 4	3	5	3	11	6	1		7				
Level 5	1	9	3	13	6	2	2	10				
Level 6	2	1	7	10	2	3	1	6				
Level 7			1	1								
Net total	10	17	19	46	15	7	3	25				
Gatewell				179				131				
Total				225				156				
FGE (%)				80				84				

Appendix Table A1.--Continued.

3 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			1	1	1		2	3				
Level 2	5		5	10		1	1	2				
Level 3	4	3	8	15	1	1	1	3				
Level 4	5	5	6	16	2	1	1	4				
Level 5	8	7	11	26			3	3				
Level 6	2	1	7	10	1	2	2	5				
Level 7	1			1								
Net total	25	16	38	79	5	5	10	20				
Gatewell				241				120				
Total				320				140				
FGE (%)				75				86				

3 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			1	1								
Level 2	1		6	7	1		1	2				
Level 3	2	1	6	9	1		3	4				
Level 4	4	3	4	11	3		2	5				
Level 5	4	5	13	22	1		1	2				
Level 6	2		4	6	1	1	4	6				
Level 7			2	2			1	1				
Net total	13	9	36	58	7	1	12	20				
Gatewell				198				123				
Total				256				143				
FGE (%)				77				86				

Appendix Table A1.--Continued.

4 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			7	7								
Level 2	3	1	2	6	1	1	1	3				
Level 3	8	4	8	20			1	1				
Level 4	9	1	4	14		1	1	2				
Level 5	7	11	9	27		3	1	4				
Level 6	3	4	4	11	1			1				
Level 7		1	1	2								
Net total	30	22	35	87	2	5	4	11				0
Gatewell				290				166				1
Total				377				177				1
FGE (%)				77				94				

4 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	2	1	1	4	1		1	2				
Level 2	4	3	2	9	2	1	2	5				
Level 3	4	3	10	17			7	7				
Level 4	4	9	9	22	1	1	2	4				
Level 5	7	6	16	29	3	2	2	7				
Level 6	1	2	7	10			1	1				
Level 7		1	4	5	1	1		2				
Net total	22	25	49	96	8	5	15	28				
Gatewell				305				139				
Total				411				167				
FGE (%)				74				83				

Appendix Table A1.--Continued.

5 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			2	2								
Level 2	2	1	5	8								
Level 3	1	1	4	6	1	1	3	5				
Level 4	5	9	8	22	1	2	1	4				
Level 5	8	20	8	36	1	4	1	6				
Level 6	4	8	5	17			2	2				
Level 7	1	3	1	5	1			1				
Net total	21	42	33	96	4	7	7	18				0
Gatewell				278				164				4
Total				374				182				4
FGE (%)				74				90				

5 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1												
Level 2	8	4	6	18		1	1	2				
Level 3	2	7	6	15	1	1	2	4				
Level 4	7	8	8	23	1	2	1	4				
Level 5	12	12	10	34	2			2				
Level 6	2	8	6	16	1			1		2		2
Level 7			2	2			1	1				
Net total	31	39	38	108	5	4	5	14		2		2
Gatewell				260				152				3
Total				368				166				5
FGE (%)				71				92				60

Appendix Table A1.--Continued.

6 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	3		1	4	1			1				
Level 2	2		5	7		1		1				
Level 3	3	1	5	9	1			1				
Level 4	8	7	9	24	1	2	1	4				
Level 5	10	16	16	42	1	1	1	3				
Level 6		4	6	10			2	2				
Level 7			3	3								
Net total	26	28	45	99	4	4	4	12				0
Gatewell				274				172				3
Total				373				184				3
FGE (%)				74				94				

6 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1			3	3	1		1	2				
Level 2	7	1	5	13	1	1	4	6				
Level 3	14	1	8	23	1		1	2			2	2
Level 4	13	21	6	40	1	2	1	4				
Level 5	9	20	14	43	1	1	1	3				
Level 6	6	7	8	21	1	2	1	4			1	1
Level 7		1	7	8			1	1				
Net total	49	51	51	151	6	6	10	22			3	3
Gatewell				310				237				1
Total				461				259				4
FGE (%)				67				92				

Appendix Table A1.--Continued.

9 May (4B, 25% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1	1			1			2	2	1			1
Level 2	3	1		4						1		1
Level 3		1	2	3	1		1	2				
Level 4		1	3	4	1	1		2				
Level 5	2	3	4	9			1	1				
Level 6	2	3	2	7		2	2	4				
Level 7												
Net total	8	9	11	28	2	3	6	11	1	1		2
Gatewell				58				53				1
Total				86				64				3
FGE (%)				67				83				

9 May (5A, 28% ESBS)

Location	Yearling chinook				Steelhead				Sockeye			
	L	C	R	Tot	L	C	R	Tot	L	C	R	Tot
Level 1					2	1		3				
Level 2	3	1	1	5	1		2	3				
Level 3	1		2	3	4		1	5				
Level 4	4	1	3	8		2	2	4				
Level 5	3		2	5	2	4	4	10				
Level 6	2		2	4		2		2				
Level 7			1	1	1	2		3				
Net total	13	2	11	26	10	11	9	30				
Gatewell				67				90				
Total				93				120				
FGE (%)				72				75				

Appendix Table A2.--Hatchery and wild yearling chinook salmon and steelhead collected during fish guidance efficiency and descaling tests at Little Goose Dam, 1994.

	Yearling chinook				Steelhead			
Date	Hatchery	Wild[a]	Total	Percent wild	Hatchery	Wild	Total	Percent wild
24 April	85	78	163	47.9	25	26	51	51.0
25 April	147	165	312	52.9	70	145	215	67.4
26 April	238	136	374	36.4	69	33	102	32.4
27 April	227	137	364	37.6	33	46	79	58.2
28 April	608	227	835	27.2	187	237	424	55.9
29 April	612	97	709	13.7	208	71	279	25.4
30 April	522	118	640	18.4	122	90	212	42.5
1 May	482	91	573	15.9	314	59	373	15.8
2 May	533	91	624	14.6	277	58	335	17.3
3 May	663	137	800	17.1	265	81	346	23.4
4 May	744	155	899	17.2	288	75	363	20.7
5 May	791	139	930	14.9	322	56	378	14.8
6 May	764	158	922	17.1	407	44	451	9.8
9 May	239	17	256	6.6	268	19	287	6.6
10 May	237	41	278	14.7	501	45	546	8.2
11 May	345	58	403	14.4	123	9	132	6.8
12 May	323	31	354	8.8	217	27	244	11.1
13 May	391	42	433	9.7	287	8	295	2.7
14 May	362	32	394	8.1	664	55	719	7.6
15 May	126	25	151	16.6	358	45	403	11.2
16 May	297	50	347	14.4	683	53	736	7.2
17 May	362	28	390	7.2	83	10	93	10.8
18 May	508	75	583	12.9	316	45	361	12.5
19 May	533	72	605	11.9	418	74	492	15.0
20 May	664	105	769	13.7	368	30	398	7.5
21 May	622	140	762	18.4	689	47	736	6.4
22 May	475	62	537	11.5	517	19	536	3.5
23 May	271	53	324	16.4	750	57	807	7.1
24 May	363	98	461	21.3	859	49	908	5.4
25 May	231	35	266	13.2	652	67	719	9.3
26 May	515	50	565	8.8	441	21	462	4.5
27 May	565	108	673	16.0	392	51	443	11.5

[a] The estimated number of wild yearling chinook salmon is based on the assumption that all hatchery fish had either the adipose fin clipped or a ventral fin clipped.

Appendix Table A3.--Descaling data from fish guidance efficiency tests conducted at Little Goose Dam, 1994.

Test date	Yearling chinook			Steelhead		
	Total catch	Number descaled	Percent descaled	Total catch	Number descaled	Percent descaled
Unit 3, Slot B (48% STS)						
25 April	155	11	7.1	13	0	0.0
26 April	113	7	6.2	16	1	6.3
27 April	67	2	3.0	5	0	0.0
28 April	121	11	9.1	10	0	0.0
29 April	117	8	6.8	12	1	8.3
30 April	127	4	3.2	4	0	0.0
1 May	99	3	3.0	15	1	6.7
2 May	93	7	7.5	27	1	3.7
3 May	109	13	11.9	47	1	2.1
4 May	117	15	12.8	19	0	0.0
5 May	111	6	5.4	11	2	18.2
6 May	89	5	5.6	8	0	0.0
9 May	77	5	6.5	103	4	3.9
10 May	59	3	5.1	142	2	1.4
11 May	119	8	6.7	81	4	4.9
12 May	100	13	13.0	82	3	3.7
13 May	118	9	7.6	89	5	5.6
14 May	69	13	18.8	231	21	9.1
15 May	67	5	7.5	123	3	2.4
16 May	68	3	4.4	125	9	7.2
17 May	96	9	9.4	20	1	5.0
18 May	106	10	9.4	187	13	7.0
19 May	137	6	4.4	157	9	5.7
20 May	140	9	6.4	65	5	7.7
21 May	142	7	4.9	185	7	3.8
22 May	95	4	4.2	222	13	5.9
23 May	25	1	4.0	231	15	6.5
24 May	53	1	1.9	250	23	9.2
25 May	35	5	14.3	126	3	2.4
26 May	76	1	1.3	69	2	2.9
27 May	56	3	5.4	129	7	5.4
Unit 4, Slot A (28% extended-length traveling screen)						
25 April	105	11	10.5	52	0	0.0
26 April	199	13	6.5	34	0	0.0
27 April	227	15	6.6	18	0	0.0
28 April	98	11	11.2	7	0	0.0
29 April	84	4	4.8	17	0	0.0
30 April	120	5	4.2	4	0	0.0
1 May	101	8	7.9	5	0	0.0
3 May	115	10	8.7	16	0	0.0
5 May	77	8	10.4	19	2	10.5
10 May	79	12	15.2	117	3	2.6
11 May	113	19	16.8	43	1	2.3
12 May	96	9	9.4	126	19	15.1

Appendix Table A3.--Continued.

Test date	Yearling chinook Total catch	Yearling chinook Number descaled	Yearling chinook Percent descaled	Steelhead Total catch	Steelhead Number descaled	Steelhead Percent descaled
Unit 4, Slot A (25% extended-length bar screen)						
13 May	118	18	15.3	129	9	7.0
14 May	108	12	11.1	238	25	10.5
15 May	73	10	13.7	169	18	10.7
16 May	76	7	9.2	203	12	5.9
17 May	138	12	8.7	47	5	10.6
18 May	146	13	8.9	88	8	9.1
19 May	142	9	6.3	116	4	3.4
20 May	147	7	4.8	98	4	4.1
21 May	89	8	9.0	170	3	1.8
22 May	115	15	13.0	165	11	6.7
23 May	39	1	2.6	158	13	8.2
24 May	92	7	7.6	226	15	6.6
25 May	75	8	10.7	282	15	5.3
26 May	103	2	1.9	149	15	10.1
27 May	121	4	3.3	93	7	7.5
Unit 4, Slot B (25% extended-length bar screen)						
28 April	295	25	8.5	200	8	4.0
29 April	193	6	3.1	95	3	3.2
30 April	203	14	6.9	97	2	2.1
1 May	155	14	9.0	153	7	4.6
2 May	257	18	7.0	144	7	4.9
3 May	241	26	10.8	120	3	2.5
4 May	290	21	7.2	166	8	4.8
5 May	278	25	9.0	164	7	4.3
6 May	274	28	10.2	172	17	9.9
9 May	58	6	10.3	53	2	3.8
10 May	70	8	11.4	118	10	8.5
16 May	107	9	8.4	201	10	5.0
20 May	137	9	6.6	100	4	4.0
21 May	164	9	5.5	152	10	6.6
22 May	112	4	3.6	136	5	3.7
23 May	63	1	1.6	213	12	5.6
24 May	136	6	4.4	191	9	4.7
25 May	50	3	6.0	119	2	1.7
26 May	76	4	5.3	78	4	5.1
27 May	104	8	7.7	118	8	6.8

Appendix Table A3.--Continued.

Test date	Yearling chinook Total catch	Yearling chinook Number descaled	Yearling chinook Percent descaled	Steelhead Total catch	Steelhead Number descaled	Steelhead Percent descaled
Unit 5, Slot A (28% extended-length bar screen)						
24 April	56	2	3.6	35	1	2.9
25 April	52	5	9.6	150	2	1.3
26 April	71	3	4.2	52	5	9.6
27 April	70	4	5.7	56	1	1.8
28 April	210	9	4.3	151	4	2.6
29 April	200	10	5.0	131	5	3.8
30 April	121	9	7.4	77	2	2.6
1 May	140	7	5.0	164	5	3.0
2 May	179	10	5.6	131	6	4.6
3 May	198	21	10.6	123	8	6.5
4 May	305	20	6.6	139	1	0.7
5 May	260	22	8.5	152	7	4.6
6 May	310	28	9.0	237	10	4.2
9 May	67	7	10.4	90	4	4.4
10 May	70	12	17.1	169	9	5.3
11 May	171	11	6.4	8	1	12.5
12 May	158	15	9.5	36	6	16.7
13 May	197	35	17.8	77	2	2.6
14 May	123	19	15.4	75	8	10.7
15 May	146	12	8.2	111	10	9.0
16 May	96	12	12.5	207	12	5.8
17 May	146	20	13.7	26	3	11.5
18 May	149	15	10.1	61	1	1.6
19 May	139	9	6.5	117	5	4.3
20 May	240	18	7.5	44	2	4.5
21 May	184	9	4.9	184	5	2.7
22 May	123	10	8.1	130	6	4.6
23 May	62	4	6.5	106	8	7.5
24 May	106	3	2.8	172	14	8.1
25 May	43	3	7.0	115	8	7.0
26 May	138	3	2.2	73	9	12.3
27 May	100	9	9.0	86	6	7.0

APPENDIX B

Statistical Tables

Appendix Table B1.--Yearling chinook salmon and steelhead FGE comparison between a 28% porosity ESBS in Slot 5A and a 25% porosity ESBS in Slot 4B; paired t-test, means, and standard error (SE).

Slot	Porosity (%)	FGE (%)	SE
		Yearling Chinook	
5A	28	75.0	1.2
4B	25	77.3	
t-test			
t = 1.30	df = 8		p-value = 0.2300
		Steelhead	
5A	28	86.3	0.9
4B	25	89.6	
t-test			
t = 2.54	df = 8		p-value = 0.0347

Appendix Table B2.--Yearling chinook salmon descaling comparison between a 28% porosity ESBS in Slot 5A and an STS in Slot 3B; paired t-test, means, and standard error (SE).

Slot	Porosity (%)	Descaling (%)	SE
5A	28	8.3	0.5
3B	48	7.0	
t-test			
t = 1.69	df = 30		p-value = 0.1012

Appendix Table B3.--Yearling chinook salmon descaling comparison between a 28% porosity ESBS in Slot 5A, a 28% porosity ESTS in Slot 4A, and an STS in Slot 3B; Block ANOVA, means, and standard error (SE).

Slot	Screen	Porosity (%)	Descaling (%)	SE
5A	ESBS	28	7.8	0.9
4A	ESTS	28	9.4	
3B	STS	48	6.7	

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Day	223.5	11	20.3		
Treatment	42.2	2	21.1	2.27	0.1270
Error	204.3	22	9.3		
Total	469.9	35			

Appendix Table B4.--Steelhead descaling comparison between a 28% porosity ESBS in Slot 5A, a 28% porosity ESTS in Slot 4A, and an STS in Slot 3B; ANOVA, means, and standard errors (SE).

Slot	Screen	Porosity (%)	Descaling (%)	SE
5A	ESBS	28	4.7	1.0
4A	ESTS	28	2.9	1.2
3B	STS	48	3.8	1.2

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Treatment	20.6	2	10.3	0.74	0.4873
Error	418.8	30	14.0		
Total	439.4	32			

Appendix Table B5.--Yearling chinook salmon and steelhead descaling comparison between a 28% porosity ESBS in Slot 5A, a 25% porosity ESBS in Slot 4A, and an STS in Slot 3B; Block ANOVA, means, and standard error (SE).

Slot	Screen	Porosity (%)	Descaling (%)	SE
		Yearling Chinook		
5A	ESBS	28	8.8	0.8
4A	ESBS	25	8.4	
3B	STS	48	6.4	

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Day	552.0	14	39.4		
Treatment	29.4	2	14.7	1.61	0.2177
Error	255.2	28	9.1		
Total	836.6	44			

Slot	Screen	Porosity (%)	Descaling (%)	SE
		Steelhead		
5A	ESBS	28	6.6	0.6
4A	ESBS	25	7.1	
3B	STS	48	5.7	

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Day	155.8	14	11.1		
Treatment	16.1	2	8.0	1.32	0.2828
Error	170.0	28	6.1		
Total	341.8	44			

Appendix Table B6.--Yearling chinook salmon and steelhead descaling comparison between a 28% porosity ESBS in Slot 5A, a 25% porosity ESBS in Slot 4A and 4B, and an STS in Slot 3B; ANOVA, means, and standard errors (SE).

Slot	Screen	Porosity (%)	Descaling (%)	SE
		Yearling Chinook		
5A	ESBS	28	8.3	0.7
4	ESBS	25	7.7	0.7
3B	STS	48	7.0	0.6

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Treatment	26.1	2	13.1	0.96	0.3882
Error	1284.9	94	13.7		
Total	1311.1	96			

		Steelhead		
5A	ESBS	28	5.7	0.5
4	ESBS	25	5.8	0.5
3B	STS	48	5.0	0.6

ANOVA

Source	Sum of squares	df	Mean square	F	p-value
Treatment	10.3	2	5.2	0.62	0.5412
Error	719.1	86	8.4		
Total	729.5	88			