EVALUATION OF A CHAMFERED PERFORATED PLATE FOR EXTENDED-LENGTH BAR SCREENS AT LITTLE GOOSE AND MCNARY DAMS, 1999

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EXECUTIVE SUMMARY

Extended-length bar screens (ESBS) have replaced submersible traveling screens (STS) at a number of dams on the Snake and Columbia Rivers. The ESBSs are approximately twice as long as the STSs. A perforated plate is attached to the downstream side of the ESBS to balance flow through the ESBS so that juvenile salmon are not impinged on the face of the guiding device. The perforated plate is bolted or welded to the framework that supports the ESBS. In some instances, vibration caused by flow through the perforated plate has caused the bolts or welds to break. Hydraulic model studies, conducted at the Iowa Institute of Hydraulic Research, have indicated that this vibration could be dampened by using a plate with 30º, full-chamfered perforations.

We evaluated this new perforated plate design during the 1999 juvenile salmonid migration. Studies were conducted at Little Goose Dam during the spring and at McNary Dam during the summer. Differences in fish condition (descaling and/or obvious external injury) after being guided by either a test ESBS (chamfered perforated plate) or control ESBS (standard perforated plate) were compared. Results from both locations indicated that the full-chamfered perforated plate did not increase descaling and/or injury to the fish compared to the standard perforated plate. At Little Goose Dam, long-term (19-hour) descaling for yearling chinook salmon was significantly lower with the chamfered plate, indicating that turbulence in the gatewell might be decreased with the new design.

CONTENTS

INTRODUCTION

At Lower Granite and Little Goose Dams on the Snake River and McNary Dam on the Columbia River, extended-length bar screens (ESBS) have replaced standard-length submersible traveling screens as the means of guiding outmigrant juvenile salmonids (*Oncorhynchus* spp.) past turbine intakes and into collection or bypass systems. At these dams, the ESBSs have produced levels of fish guidance efficiency (FGE) over 70% and orifice passage efficiency (OPE) over 80% along with low levels of descaling (Swan et al. 1990, McComas et al. 1994, Gessel et al. 1995).

The ESBSs are equipped with a perforated plate on the downstream side of the screen to balance flow through the screen so that juvenile salmonids are not impinged on the face of the screen. Perforated plate sections are either bolted or welded to the ESBS frames. These sections are steel panels (0.6 cm thick by 0.6 m by 1.2 m) that have 2.54-cm holes punched 3.5 cm apart on center to provide the necessary overall porosity (Fig. 1). However, in some cases, vibration caused by flow through the perforated plates breaks some of the welds or bolts. Studies in 1998 at the Iowa Institute of Hydraulic Research found that a full-depth, 30° chamfer on the holes in the perforated plate would reduce this vibration, reduce maintenance costs, and possibly extend the life of these plates.

To ensure that the chamfered perforated plate would not cause descaling or injury to migrating juvenile salmon, ESBSs were equipped with these plates for evaluations at both Little Goose and McNary Dams. Guided fish were then sampled and compared to fish collected with an ESBS using standard perforated plates during the 1999 juvenile salmon migration.

Because of the substantial difference in flow between turbines at Little Goose and McNary Dams (approximately 18,000 cfs compared to approximately 12,000 cfs, respectively), it was necessary to conduct tests at both projects. The initial tests were conducted at Little Goose Dam using yearling spring chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*) as the test fish. Later in the juvenile migration season, tests were conducted at McNary Dam with subyearling fall chinook salmon.

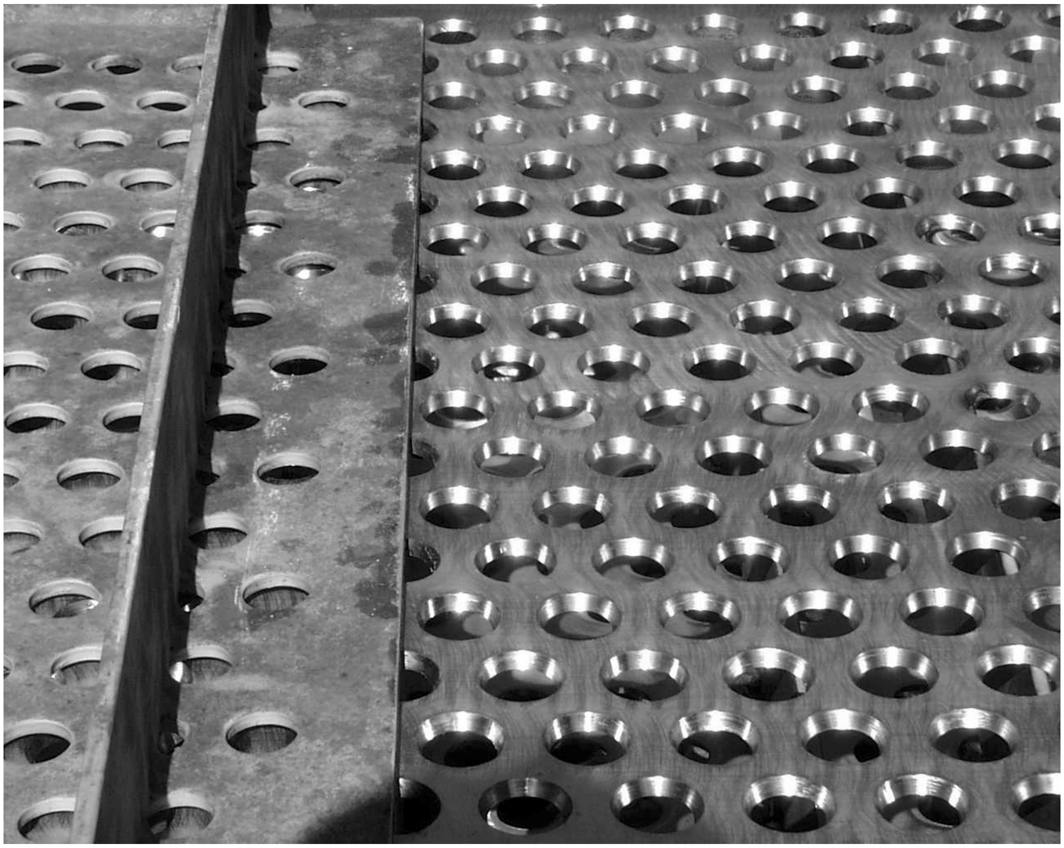

Figure 1. Standard porosity perforated plate (left) and modified perforated plate with 30º full-chamfered holes.

OBJECTIVE: EVALUATE FULL-DEPTH, 30° CHAMFERED PERFORATED PLATE ON AN EXTENDED-LENGTH BAR SCREEN BY MONITORING DESCALING/INJURY OF JUVENILE SALMONIDS

Approach

Little Goose Dam

We evaluated the amount of descaling on migrating juvenile yearling chinook salmon and steelhead caused by an ESBS fitted with a standard perforated plate compared to that caused by an ESBS fitted with a chamfered perforated plate. Tests were conducted at Little Goose Dam from 19 April to 7 May in Turbine Units 3 and 4 (Gatewells 3B and 4B). To avoid possible confounding effects from the different units, the two ESBSs were switched between units once a week, and an equal number of tests were conducted with each type of ESBS in each unit.

The two test units were operated at approximately equal flows, 24 hours a day, except on days when units were off for 3 to 4 hours to accommodate the ESBS change. On each test day, all fish were removed from both test gatewells between 1700 and 1800 h, and 100 to 150 yearling chinook salmon and steelhead (plus any incidental catch) were sampled from this catch and examined for descaling. Some of these fish could have remained in the gatewell since the previous night's test (approximately 19 hours). We classified these examinations as evaluations of long-term descaling, meaning the direct effect of the ESBS plus any additional descaling caused by residence in the gatewell.

Approximately 100 to 150 yearling chinook salmon and steelhead each were also sampled at 2000 and 2200 h. These fish could have been in the gatewell for a maximum of 3 to 4 hours. Since the peak movement of migrating juvenile salmonids occurs from dusk to early evening (Gessel et al. 1986, Brege et al. 1996), a high percentage of these fish had probably been in the gatewell for only 1 to 2 hours. The results of these two sampling times were combined and reported as short-term descaling, which was a more accurate measure of the direct effects of the ESBS than long-term descaling.

For all tests, fish were collected from the gatewells using a modified dip-basket similar to the one described by Swan et al. (1979). Percent descaling was estimated using standard Fish Transportation Oversight Team fish descaling criteria (Ceballos et al. 1992). Comparisons of the daily descaling rates (short-term, long-term, and combined) between the two plate types were done using analysis of variance (ANOVA) with adjusted sum of squares.

McNary Dam

We evaluated the chamfered perforated plate at McNary Dam during the summer subyearling chinook salmon migration season. These tests were conducted in conjunction with ongoing tests of the orifice shelter. The orifice shelter tests were being conducted in Turbine Units 3 and 4 (Gatewells 3A and 4A), and rather than use a different turbine unit, we placed the chamfered perforated plate on an ESBS in Gatewell 3B.

Generally, we would have preferred placing the chamfered perforated plate in another "A" gatewell, but since the descaling estimates at Little Goose Dam had been very low, we stayed in the same two turbine units to limit the handling of fish as much as possible. We began testing at McNary Dam on 30 June and continued through 16 July. Fish were dipped from the two control gatewells (3A and 4A) and the one test gatewell (3B) on each test day around 1800 hours.

Methods of capture and of estimating descaling were the same as those used at Little Goose Dam, and results were analyzed using *t*-tests, paired by day. Since we collected control fish during the 24-hour orifice shelter tests, and there were no ongoing FGE tests in which fish could be collected within 3 hours, we were unable to make short-term comparisons of descaling. Also, the test ESBS (chamfered porosity plate) was not switched between the two units as at Little Goose Dam.

Results and Discussion

Little Goose Dam

The total number of paired descaling tests which we were able to conduct was reduced from the original test design, because it was not always possible to run both units at equal discharges and within 1% of peak efficiency (COE 1999), and also maintain the required spill levels set by the NMFS 1995 biological opinion and 1998 supplement (NMFS 1995, 1998). From 20 April to 7 May, 13 long-term and 15 short-term paired tests were conducted with the two plate types. A total of 11,975 yearling chinook salmon, 10,489 steelhead, and 9 coho salmon (*O. kisutch*) were examined and released back into the gatewells. Results of the daily descaling tests for all yearling chinook salmon and steelhead at Little Goose Dam are given in Appendix Table 1. Results of the ANOVA comparing the standard perforated plate to the modified plate are given in Appendix Table 2.

For yearling chinook salmon, there was no difference in percent descaling between the standard perforated plate and the chamfered perforated plate during short-term tests, which produced descaling rates of 2.1% (SD = 0.24) and 1.9% (SD = 0.24), respectively (Fig. 2). However, during the long-term tests, descaling for yearling chinook salmon with the standard plate was 4.2% (SD = 0.40), which was significantly higher at P = 0.053 than the 2.9% (SD = 0.40) rate resulting from the chamfered plate. When the short- and long-term descaling rates were combined, there again was no significant difference in descaling between the two plate types.

The significant difference in descaling between the two plates during long-term tests indicated that flows into the gatewell, and through the vertical barrier screen, as well as turbulence in the gatewell, might have been decreased with the 30° chamfered perforated plate installed on the ESBS. With fish that had only been in the gatewell from 1 to 3 hours (the short-term tests), effects of the chamfered plate were not apparent.

For steelhead, there was no significant difference between the standard and chamfered perforated plates for either short-term descaling, 2.1% (SD = 0.3) and 1.9% (SD = 0.3), respectively, or long-term descaling, 2.3% (SD = 0.3) and 2.4% (SD = 0.3), respectively (Fig. 2). If the differences in flows and turbulence in the gatewell with the chamfered perforated plate were slight, one would not expect the larger, stronger steelhead to be affected as much as yearling chinook salmon.

The two plate types were interchanged three times between Gatewells 3B and 4B to avoid any effects of the different turbine units on descaling or injury. However, the ANOVAs for both short-term and long-term tests for both species showed no effect between the two units, with P values ranging from 0.22 to 1.0 (Appendix Table 2).

McNary Dam

During the test period we examined a total of 5,152 subyearling chinook salmon from Gatewell 3B and 7,506 from Gatewells 3A and 4A combined. Daily collection data are given in Appendix Table 3. Because there were no significant differences in mean descaling for subyearling chinook salmon between Gatewells 3A and 4A (both with a standard perforated plate), the descaling data for these two gatewells were combined (P = 0.068, Appendix Table 4). Comparisons of mean descaling rates between Gatewell 3B (5.3%) and the pooled results of Gatewells 3A and 4A (5.1%) indicated no significant differences in descaling between the two test conditions (P = 0.810, Fig. 3). All of these results were for long-term (24-hour) descaling. Because there was no concurrent FGE testing wherein fish could be collected within 3 hours, short-term descaling was not measured. Insufficient numbers of fish precluded analyses of descaling for fish species other than subyearling chinook salmon.

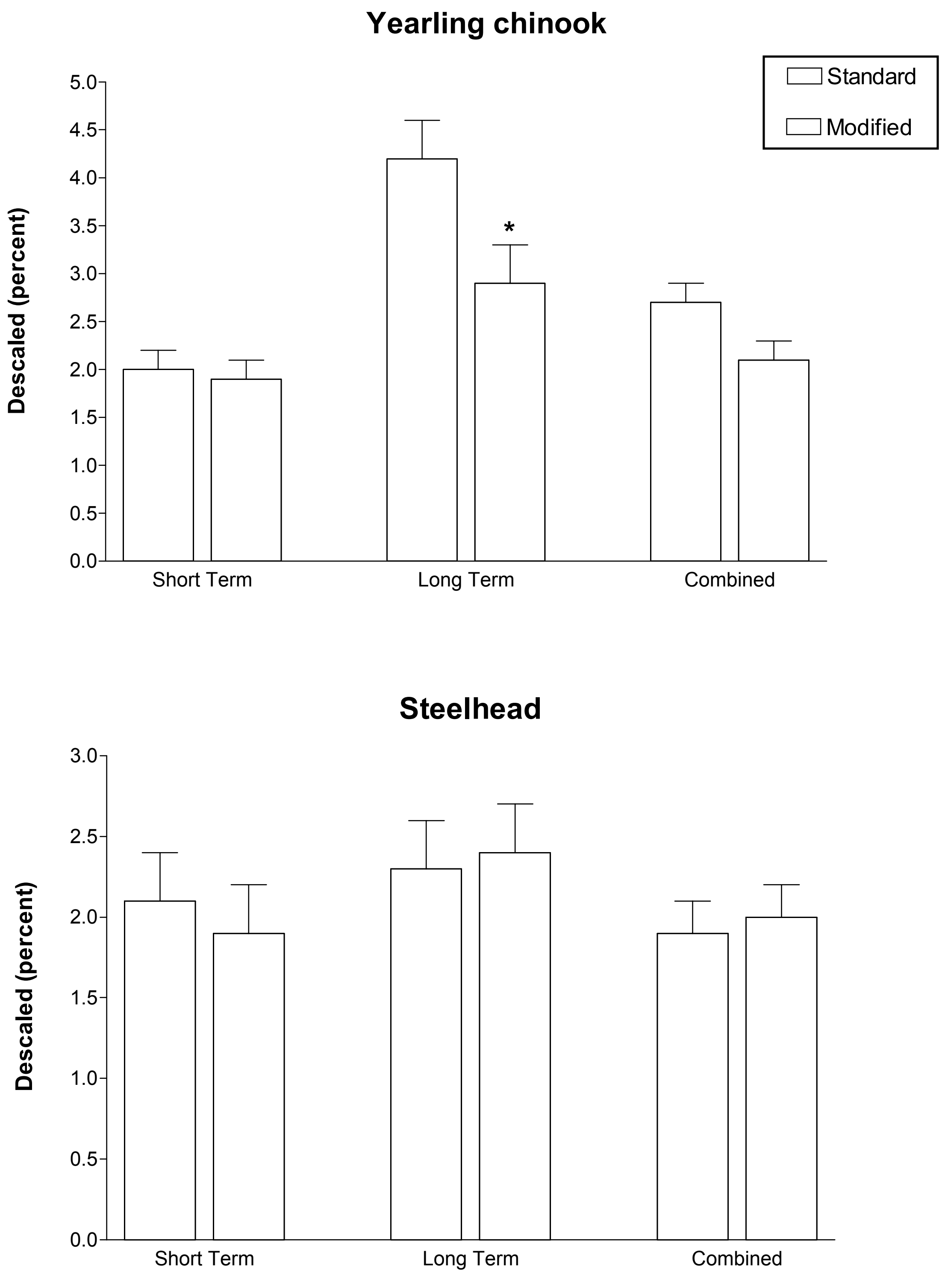

Figure 2. Percent descaling and standard error for yearling chinook salmon and steelhead at Little Goose Dam for short-term, long-term, and combined tests, comparing a standard to chamfered perforated plate (* denotes significant difference at $P \leq 0.5$).

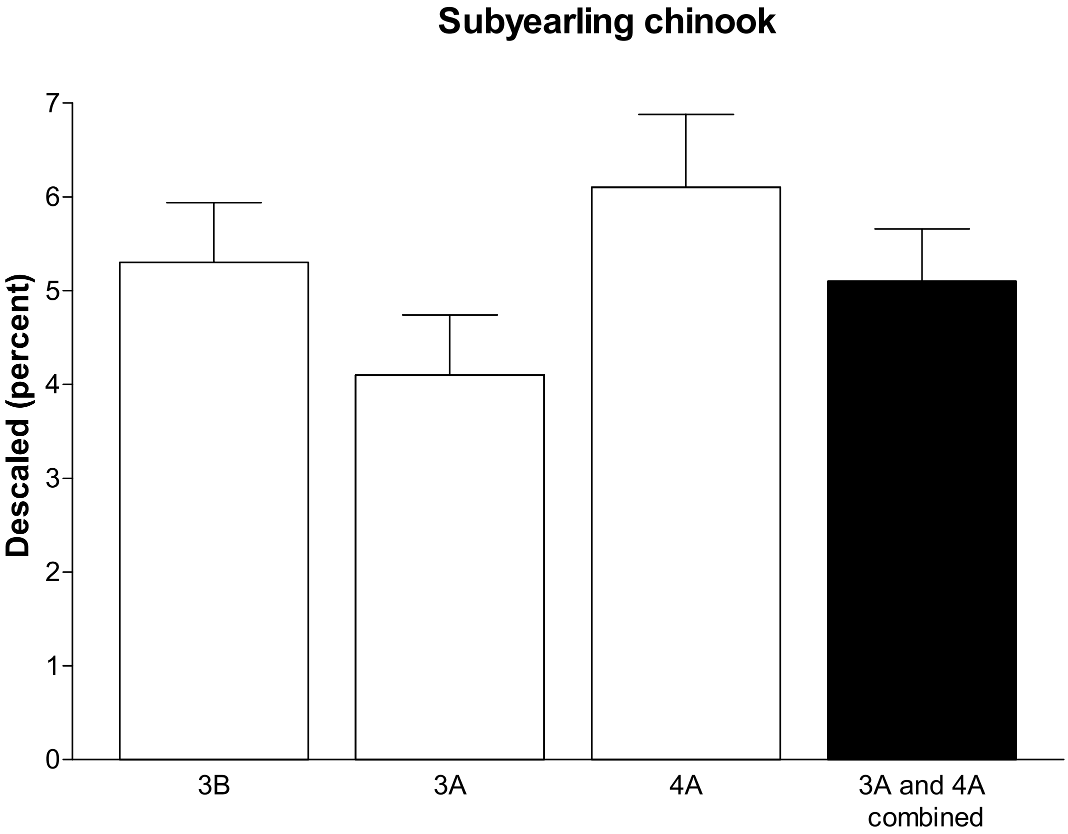

Figure 3. Percent descaling and standard error for subyearling chinook salmon at McNary Dam, comparing results of a 30º chamfered perforated plate (3B) to a standard perforated plate (3A and 4A).

ACKNOWLEDGMENTS

We express our appreciation to the seasonal personnel at both Little Goose and McNary Dams for their enthusiasm and efforts during these studies. We would also like to thank all COE personnel who gave support and assistance in these studies, especially Rebecca Kalamasz who helped initiate the study and coordinated daily with the project and reservoir control personnel. At Little Goose Dam, the structural crew interchanged the test screens as we required, and the operations staff was also very helpful in coordinating unit outages and discharge levels so that the two test units could be operated at required levels every night.

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APPENDIX TABLES

Appendix Table 1. Number examined and number and percent descaled for hatchery and wild spring chinook salmon and steelhead during daily tests, both short-term (ST) and long-term (LT), at Little Goose Dam, 1999. Chin = chinook, Sthd = steelhead, Desc = descaled.

Modified screen - plate with 30° chamfered perforations

			Chin - Hatchery			Chin - Wild			Combined			Sthd - Hatchery			Sthd - Wild			Combined		
Date	Unit	Time	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%
20 Apr	3B	LT	86	6	7.0	25	0	0.0	111	6	5.4	116	6	5.2	26	1	3.8	142	7	4.9
		ST	179	7	3.9	109	1	0.9	288	8	2.8	144	8	5.6	35	0	0.0	179	8	4.5
									399	14	3.5							321	15	4.7
21 Apr	4B	ST	222	6	2.7	65	0	0.0	287	6	2.1	70	2	2.9	22	0	0.0	92	2	2.2
22 Apr	4B	LT	234	3	1.3	68	3	4.4	302	6	2.0	44	1	2.3	23	0	0.0	67	1	1.5
		ST	236	2	0.8	58	0	0.0	294	2	0.7	89	0	0.0	31	0	0.0	120	0	0.0
									596	8	1.3							187	1	0.5
23 Apr	4B	LT	187	1	0.5	48	1	2.1	235	2	0.9	43	1	2.3	13	0	0.0	56	1	1.8
		ST	123	1	0.8	17	0	0.0	140	1	0.7	140	2	1.4	59	1	1.7	199	3	1.5
									375	3	0.8							255	4	1.6
24 Apr	4B	LT	130	4	3.1	37	1	2.7	167	5	3.0	76	4	5.3	28	0	0.0	104	4	3.8
		ST	33	1	3.0	8	0	0.0	41	1	2.4	105	3	2.9	38	1	2.6	143	4	2.8
									208	6	2.9							247	8	3.2
25 Apr	4B	LT	182	0	0.0	39	1	2.6	221	1	0.5	124	2	1.6	26	1	3.8	150	3	2.0
		ST	61	1	1.6	12	0	0.0	73	1	1.4	103	1	1.0	33	0	0.0	136	1	0.7
									294	2	0.7							286	4	1.4
29 Apr	3B	LT	185	5	2.7	49	3	6.1	234	8	3.4	41	2	4.9	5	0	0.0	46	2	4.3
		ST	396	5	1.3	144	0	0.0	540	5	0.9	106	2	1.9	10	1	10.0	116	3	2.6
									774	13	1.7							162	5	3.1

Appendix Table 1. Continued.

			Modified screen - plate with 30° chamfered perforations																	
			Chin - Hatchery			Chin - Wild			Combined			Sthd - Hatchery			Sthd - Wild			Combined		
Date	Unit	Time	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%
30 Apr	3B	LT	165	5	3.0	42	0	0.0	207	5	2.4	100	1	1.0	8	0	0.0	108	1	0.9
		ST	395	9	2.3	146	5	3.4	541	14	2.6	95	0	0.0	14	0	0.0	109	0	0.0
									748	19	2.5							217	1	0.5
1 May	3B	LT	118	5	4.2	43	0	0.0	161	5	3.1	35	1	2.9	3	0	0.0	38	1	2.6
		ST	237	3	1.3	39	0	0.0	276	3	1.1	395	4	1.0	18	0	0.0	413	4	1.0
									437	8	1.8							451	5	1.1
2 May	3B	LT	69	2	2.9	11	0	0.0	80	2	2.5	257	3	1.2	0			257	3	1.2
		ST	261	4	1.5	46	3	6.5	307	7	2.3	431	7	1.6	6	0	0.0	437	7	1.6
									387	9	2.3							694	10	1.4
3 May	3B	LT	34	1	2.9	8	0	0.0	42	1	2.4	244	5	2.0	7	0	0.0	251	5	2.0
		ST	125	3	2.4	17	0	0.0	142	3	2.1	541	9	1.7	6	0	0.0	547	9	1.6
									184	4	2.2							798	14	1.8
4 May	3B	LT	32	2	6.3	3	0	0.0	35	2	5.7	283	2	0.7	4	0	0.0	287	2	0.7
		ST	198	4	2.0	42	3	7.1	240	7	2.9	408	5	1.2	8	0	0.0	416	5	1.2
									275	9	3.3							703	7	1.0
6 May	3B	ST	247	3	1.2	33	0	0.0	280	3	1.1	176	4	1.2	16	0	0.0	192	4	2.1
7 May	4B	LT	179	6	3.4	22	1	4.5	201	7	3.5	34	1	2.9	6	0	0.0	40	1	2.5
		ST	230	7	3.0	27	0	0.0	257	7	2.7	115	4	3.5	9	1	11.1	124	5	4.0
									458	14	3.1							164	6	3.7

Appendix Table 1. Continued.

			Standard screen - standard perforated plate																	
			Chin - Hatchery			Chin - Wild			Combined			Sthd - Hatchery			Sthd - Wild			Combined		
Date	Unit	Time	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%
20 Apr	4B	LT	48	4	8.3	5	1	20.0	53	5	9.4	49	2	4.1	4	0	0.0	53	2	3.8
		ST	90	3	3.3	46	1	2.2	136	4	2.9	48	5	10.4	9	0	0.0	57	5	8.8
									189	9	4.8							110	7	6.4
21 Apr	3B	ST	292	4	1.4	94	2	2.1	386	6	1.6	156	7	4.5	48	0	0.0	204	7	3.4
22 Apr	3B	LT	200	10	5.0	109	2	1.8	309	12	3.9	69	2	2.9	16	0	0.0	85	2	2.4
		ST	234	0	0.0	174	0	0.0	408	0	0.0	98	1	1.0	45	0	0.0	143	1	0.7
									717	12	1.7							228	3	1.3
23 Apr	3B	LT	153	1	0.7	32	1	3.1	185	2	1.1	101	4	4.0	19	0	0.0	120	4	3.3
		ST	202	2	1.0	61	0	0.0	263	2	0.8	358	3	0.8	91	0	0.0	449	3	0.7
									448	4	0.9							569	7	1.2
24 Apr	3B	LT	142	2	1.4	42	2	4.8	184	4	2.2	238	7	2.9	49	0	0.0	287	7	2.4
		ST	217	6	2.8	61	1	1.6	278	7	2.5	398	9	2.3	90	4	4.4	488	13	2.7
									462	11	2.4							775	20	2.6
25 Apr	3B	LT	147	3	2.0	28	1	3.6	175	4	2.3	170	2	1.2	25	0	0.0	195	2	1.0
		ST	148	3	2.0	18	1	5.6	166	4	2.4	341	6	1.8	81	0	0.0	422	6	1.4
									341	8	2.3							617	8	1.3
29 Apr	4B	LT	206	6	2.9	62	0	0.0	268	6	2.2	63	2	3.2	9	0	0.0	72	2	2.8
		ST	360	0	0.0	104	0	0.0	464	0	0.0	122	0	0.0	24	0	0.0	146	0	0.0
									732	6	0.8							218	2	0.9
30 Apr	4B	LT	182	11	6.0	58	2	3.4	240	13	5.4	22	0	0.0	4	0	0.0	26	0	0.0
		ST	244	5	2.0	53	0	0.0	297	5	1.7	104	1	1.0	19	0	0.0	123	1	0.8
									537	18	3.4							149	1	0.7

Appendix Table 1. Continued

			Standard screen - standard perforated plate																	
			Chin - Hatchery			Chin - Wild			Combined			Sthd - Hatchery			Sthd - Wild			Combined		
Date	Unit	Time	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%	Exam	Desc	%
1 May	4B	LT	151	7	4.6	199	9	4.5	350	16	4.6	67	3	4.5	2	0	0.0	69	3	4.3
		ST	181	5	2.8	35	2	5.7	216	7	3.2	312	6	1.9	39	0	0.0	351	6	1.7
									566	23	4.1							420	9	2.1
2 May	4B	LT	182	7	3.8	24	3	12.5	206	10	4.9	119	1	0.8	6	0		125	1	0.8
		ST	147	2	1.4	39	0	0.0	186	2	1.1	492	6	1.2	24	0	0.0	516	6	1.2
									392	12	3.1							641	7	1.1
3 May	4B	LT	57	2	3.5	9	2	22.2	66	4	6.1	179	5	2.8	9	0	0.0	188	5	2.7
		ST	128	7	5.5	42	0	0.0	170	7	4.1	581	8	1.4	6	0	0.0	587	8	1.4
									236	11	4.7							775	13	1.7
4 May	4B	LT	56	3	5.4	5	0	0.0	61	3	4.9	164	3	1.8	0			164	3	1.8
		ST	247	8	3.2	46	2	4.3	293	10	3.4	274	1	0.4	8	0	0.0	282	1	0.4
									354	13	3.7							446	4	0.9
6 May	4B	ST	264	6	2.3	90	3	3.3	354	9	2.5	178	5	2.8	9	0	0.0	187	5	2.7
7 May	4B	LT	113	8	7.1	7	0	0.0	120	8	6.7	245	5	2.0	9	1	11.1	254	6	2.4
		ST	328	9	2.7	48	1	2.1	376	10	2.7	119	5	4.2	8	0	0.0	127	5	3.9
									496	18	3.6							381	11	2.9

Appendix Table 2. Means of percent descaling, standard errors, and ANOVAs for yearling chinook salmon and steelhead for combined short-term (3-5 hour) and long-term (24 hours) descaling tests at Little Goose Dam, 1999.

Yearling chinook salmon: short-term

Source	df	Sum of squares	Mean square	F	P
Date	11	20.40	1.85	2.81	0.057
Unit	1	0.10	0.10	0.15	0.704
Perforated plate	1	0.07	0.07	0.11	0.747
Error	10	6.60	6.60	0.66	
Total	23				

Least square means for short-term

Unit	Mean	s.e.
3B	1.8	0.24
4B	2.0	0.24
Perforated plate		
30° chamfered	1.9	0.24
Standard	2.1	0.24

Yearling chinook salmon: long-term

Source	df	Sum of squares	Mean square	F	P
Date	10	63.64	6.36	3.68	0.031
Unit	1	1.27	1.27	0.74	0.413
Perforated plate	1	8.60	8.60	4.98	0.053
Error	9	15.60	1.73		
Total	21	91.81			

Appendix Table 2. Continued.

Least squares means for long-term

Unit	Mean	s.e.
3B	3.3	0.40
3B	3.8	0.40
Perforated plate		
30° chamfered	2.9	0.40
Standard	4.2	0.40

Yearling chinook: combined (short-term and long-term)

Source	df	Sum of squares	Mean square	F	P
Date	11	22.95	2.09	4.06	0.018
Unit	1	0.89	0.89	1.73	0.218
Perforated plate	1	2.17	2.17	4.23	0.067
Error	10	5.13	0.51		
Total	23				

Least squares means for combined

Unit	Mean	s.e.
3B	2.2	0.21
4B	2.6	0.21
Perforated plate		
30° chamfered	2.1	0.21
Standard	2.7	0.21

Appendix Table 2. Continued.

Steelhead: short-term

Source	df	Sum of squares	Mean square	F	P
Date	13	73.89	5.68	4.61	0.006
Unit	1	0.00	0.00	0.00	0.960
Perforated plate	1	0.54	0.54	0.44	0.519
Error	12	14.80	1.23		
Total	27				

Least squares means for short-term

Unit	Mean	s.e.
3B	2.0	0.30
4B	2.0	0.30
Perforated plate		
30° chamfered	1.9	0.30
Standard	2.1	0.30

Steelhead: long-term

Source	df	Sum of squares	Mean square	F	P
Date	11	29.62	2.70	3.62	0.026
Unit	1	0.00	0.00	0.00	0.997
Perforated plate	1	0.02	0.02	0.03	0.873
Error	10	7.43	0.74		
Total	23				

Appendix Table 2. Continued.

Least squares means for long-term		
Unit	Mean	s.e.
3B	2.3	0.25
4B	2.3	0.25
Perforated plate		
30º chamfered	2.4	0.25
Standard	2.3	0.25

Steelhead: combined (short-term and long-term)

Source	df	Sum of squares	Mean square	F	P
Date	11	41.92	3.81	7.16	0.002
Unit	1	0.19	0.19	0.36	0.561
Perforated plate	1	0.01	0.01	0.02	0.901
Error	10	5.32	0.53		
Total	23				

Least squares means for combined		
Unit	Mean	s.e.
3B	1.9	0.21
4B	2.0	0.21
Perforated plate		
30º chamfered	2.0	0.21
Standard	1.9	0.21

Appendix Table 3. Descaling data for juvenile salmonids collected from gatewells with standard perforated plate (3A and 4A) and chamfered perforated plate (3B) at McNary Dam, 1999. Desc = number of descaled fish, Catch = total number of fish examined, % = percentage of descaled fish.

Unit 3, Slot A

Test	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
date	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%
June 30	11	308	3.6	0	2	0.0	0	0		0	0		0	1	0.0
July 1	11	218	5.0	0	6	0.0	0	1	0.0	0	0		0	0	
July 2	75	6	8.0	0	0		0	0		0	0		0	0	
July 7	20	389	5.1	1	10	10.0	0	0		0	1	0.0	1	2	50.0
July 8	1	32	3.1	0	1	0.0	0	0		0	0		0	0	
July 9	8	204	3.9	0	0		0	0		0	0		0	0	
July 10	4	136	2.9	0	1	0.0	0	0		0	0		0	1	0.0
July 11	4	123	3.3	0	1	0.0	0	0		0	0		0	0	
July 12	7	89	7.9	0	0		0	1	0.0	0	0		0	0	
July 13	14	215	6.5	0	0		0	0		0	0		0	0	
July 14	6	141	4.3	0	6	0.0	0	1	0.0	0	0		0	0	
July 15	1	84	1.2	0	2	0.0	0	0		0	0		0	0	
July 16	7	201	3.5	0	0		0	0		0	0		0	1	0.0
July 19	27	333	8.1	0	9	0.0	0	0		0	0		0	0	

Appendix Table 3. Continued.

Unit 4, Slot A

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%
June 30	73	863	8.5	0	1	0.0	0	0		0	1	0.0	0	0	
July 1	19	735	2.6	0	14	0.0	0	1	0.0	0	1	0.0	1	1	100
July 2	39	487	8.0	1	5	20.0	0	1	0.0	0	1	0.0	0	0	
July 7	151	3011	5.0	3	41	7.3	0	3	0.0	0	1	0.0	0	0	
July 8	8	208	3.8	0	4	0.0	0	0		0	1	0.0	0	0	
July 9	37	830	4.5	0	2	0.0	0	0		0	0		0	0	
July 10	52	648	8.0	1	8	12.5	0	0		0	0		0	0	
July 11	29	441	6.6	0	8	0.0	0	0		1	1	100	1	2	50
July 12	93	1713	5.4	0	9	0.0	0	1	0.0	0	0		0	0	
July 13	53	1526	3.5	0	7	0.0	0	0		0	0		0	0	
July 14	27	767	3.5	0	8	0.0	0	2	0.0	0	1	0.0	0	0	
July 15	16	413	3.9	0	13	0.0	0	1	0.0	0	0		0	0	
July 16	48	870	5.5	0	6	0.0	0	0		0	0		0	0	

Appendix Table 3. Continued.

Unit 3, Slot B

Test	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
Date	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%
June 30	33	471	7.0	0	7	0.0	0	0		0	1	0.0	0	0	
July 1	11	263	4.2	0	4	0.0	0	0		0	0		0	0	
July 2	2	170	1.2	0	0		0	0		0	0		0	0	
July 7	69	763	9.0	0	6	10.0	0	0		0	1	0.0	0	2	0.0
July 8	22	314	7.0	0	3	0.0	0	0		0	0		0	0	
July 9	57	716	8.0	0	2	0.0	0	0		0	0		0	0	
July 10	17	282	6.0	0	7	0.0	0	0		0	1	0.0	0	0	
July 11	5	72	6.9	0	1	0.0	0	0		0	0		0	0	
July 12	21	356	5.9	0	3	0.0	0	0		0	0		0	0	
July 13	16	359	4.5	0	0		0	0		0	0		0	0	
July 14	17	753	2.3	0	3	0.0	0	1	0.0	0	0		0	0	
July 15	8	255	3.1	0	2	0.0	0	0		0	0		0	0	
July 16	4	96	4.2	0	0		0	0		0	0		0	1	0.0

Appendix Table 4. Means of percent descaling and *t*-test evaluations of subyearling chinook salmon collected from Gatewells 3B (chamfered perforated plate) and 3A and 4A (both with standard perforated plate), at McNary Dam, 1999.

Date	3B Descaling (%)	3A Descaling (%)	4A Descaling (%)
6-30	7.0	3.6	8.5
7-01	4.2	5.0	
7-02	1.2		8.0
7-07	9.0	5.1	
7-08	7.0		3.8
7-09	8.0	3.9	
7-10	6.0		8.0
7-11	6.9	3.3	
7-12	5.9		5.4
7-13	4.5	6.5	
7-14	2.3		3.5
7-15	3.1	1.2	
7-16	4.2		5.5
Means	5.3	4.1	6.1
s.e.	0.64	0.64	0.78

***t*-test: two-sample comparing 3A with 4A**

	3A	4A
Mean	4.1	6.1
Variance	0.03	0.04
Observations	7	7
Pooled Variance	0.0003	
df	12	12
t-Stat	-2.01	
P	0.0678	

***t*-test: two-sample comparing 3B to pooled data from 3A and 4A**

	3B	3A and 4A
Mean	5.3	5.1
Variance	0.05	0.04
Observations	13	13
Pooled Variance	0.0005	
df	24	24
t-Stat	0.24	
P	0.8099	