Studies to Evaluate the Effectiveness of Extended-Length Screens at Little Goose Dam, 1993

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Coastal Zone and Estuarine Studies Division

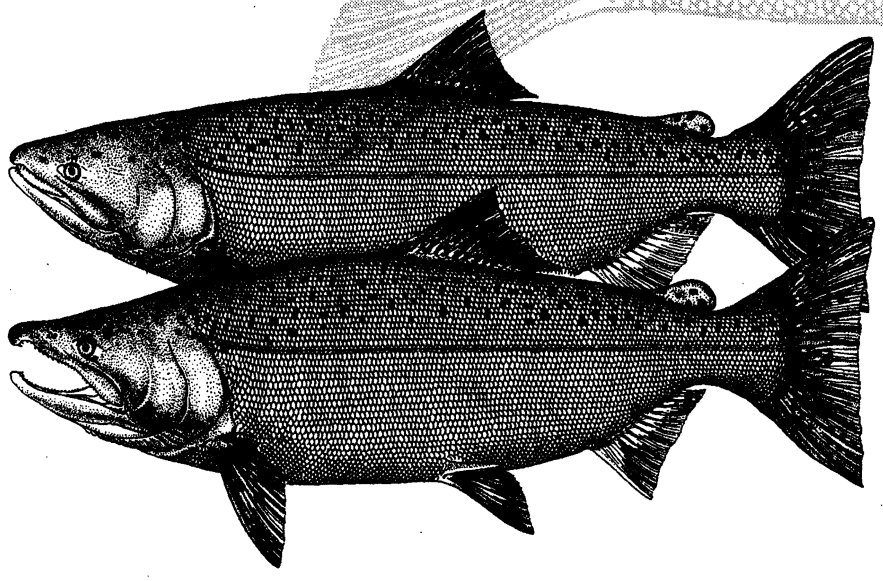
Northwest Fisheries Science Center

National Marine Fisheries Service

Seattle, Washington

by
Michael H. Gessel, Benjamin P. Sandford, and Douglas B. Dey

September 1994



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INTRODUCTION

At Little Goose and Lower Granite Dams on the Snake River, juvenile salmonids (*Oncorhynchus* spp.) are guided into the collection/bypass facilities by standard-length submersible traveling screens (STSs) installed in the 1970s. From 1982 to 1985, National Marine Fisheries Service (NMFS) researchers extensively evaluated the STSs at Lower Granite Dam and found that fish guidance efficiency (FGE) was approximately 50% for yearling chinook salmon (*O. tshawytscha*).

In 1987, in an effort to improve guidance levels, NMFS conducted research at Lower Granite Dam to test a simulated extended-length screen. This was done by placing a fixed bar screen (FBS) in the fish screen slot in conjunction with an STS in the bulkhead slot. The STS is about 6.1 m (20 ft) long, and the addition of the FBS approximately doubled the length of the guiding surface. Results of these tests indicated that the STS/FBS combination could improve guidance.

Research at Lower Granite Dam in 1989 was done with an entire turbine intake screened with the STS/FBS combination and 18.8-m (62-ft) raised operating gates. Significant increases in FGE for both yearling chinook salmon and steelhead (*O. mykiss*) were realized (weighted FGEs of 66 and 83%, respectively, compared to 57 and 77% with the STS and raised operating gate). The descaling rate for fish recovered from gatewells without an STS was 3% or less. Descaling rates for guided yearling chinook salmon during FGE tests were 2.5 and 4.7% for control and treatment conditions, respectively.

Studies at Little Goose Dam were conducted in 1986 and 1987. They provided baseline FGE data on yearling chinook salmon and steelhead with STSs at either standard elevation or in a lowered position, and operating gates in either the standard or raised position. Vertical distribution measurements were taken of fish entering the turbine intake to determine theoretical fish guidance efficiency (TFGE, defined as an estimate of the percentage of fish theoretically guidable based upon a measured vertical distribution of fish passing into the turbine intakes and flow distributions within the intake with an STS in place as determined from hydraulic model studies). Also, the effect of traveling screens on fish condition was assessed by comparing descaling levels of fish collected in the gatewell during FGE tests with those collected during vertical distribution measurements. Based upon the vertical distribution measurements, estimates of TFGE at Little Goose Dam were greater than 80% for both yearling chinook salmon and steelhead.

Guidance at Little Goose Dam for yearling chinook salmon and steelhead was in the 60-70% range and improved with the raised operating gate. Also, there was a general increase in FGE as the outmigration progressed. This trend may have been related to the increased smoltification level of fish passing the project during the later stages of the outmigration (Muir et al. 1988).

The respective seasonal descaling averages for yearling chinook salmon and steelhead were 2.1 and 0.7% in 1986 and 3.7 and 0.9% in 1987.

During spring and summer of 1991, NMFS tested an extended-length submersible traveling screen and an extended-length submersible bar screen at McNary Dam on the lower Columbia River. Each of these extended-length screens, which are approximately twice as long as an STS, increased FGE to about 80% for yearling chinook salmon and to well over 50% for subyearling chinook salmon, with no significant difference in FGE between devices (Brege et al. 1992). However, lower descaling of guided fish was observed with the extended-length bar screen.

Additional testing was done with the extended-length bar screen at McNary Dam during the 1992 outmigration, with similar FGE results (McComas et al. 1993). These studies led to the development and prototype testing of extended-length bar screens and extended-length traveling screens with various perforated plate porosities at Little Goose Dam in 1993. This report covers the first year of the evaluation of these devices.

Specific research objectives for 1993 were:

1) Evaluate the ability of extended-length traveling screens and extended-length bar screens to guide fish during the juvenile salmonid outmigration.
2) Determine the effect of extended-length screens on descaling of juvenile salmonids.

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

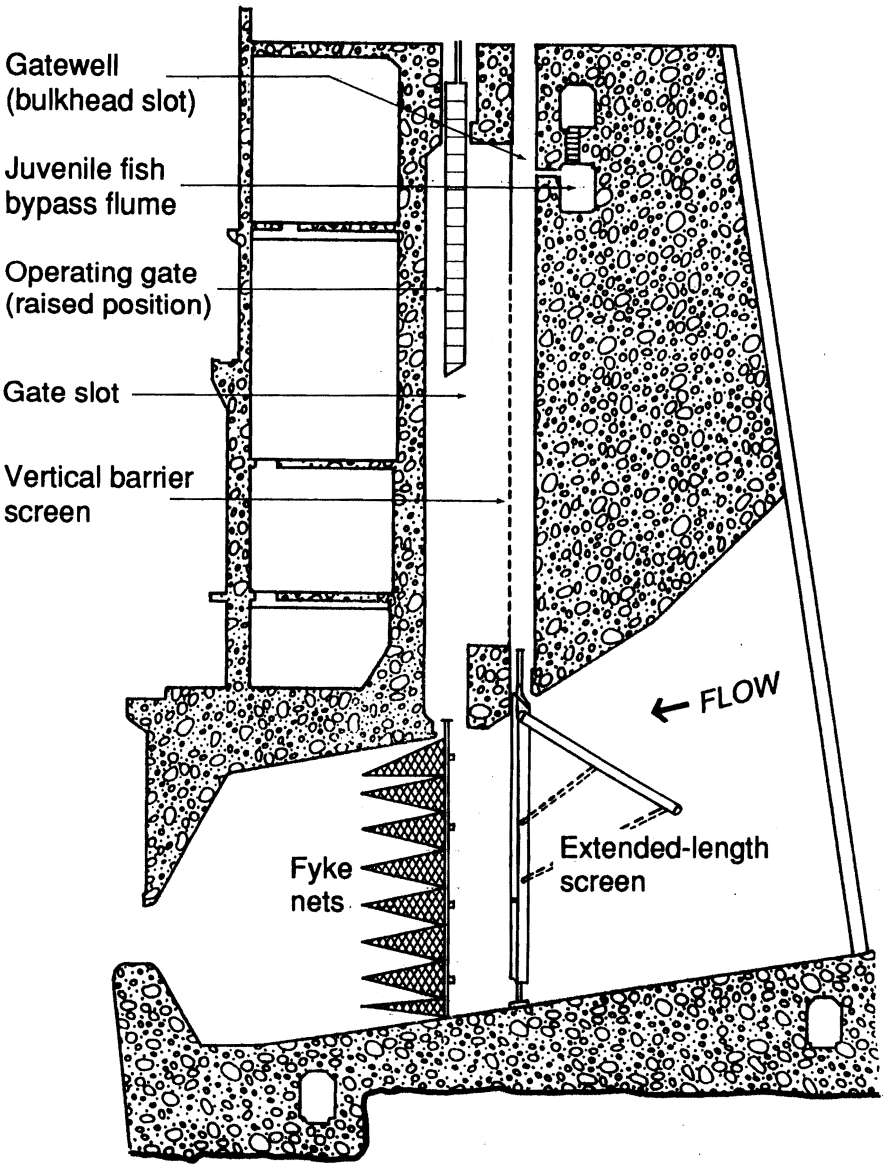
Approach

Fish guidance efficiency tests at McNary Dam in 1992 indicated that an extended-length bar screen with a 35% perforated plate porosity was the optimum configuration for fish condition (descaling) and guidance. Average water flow within McNary Dam turbine intakes is substantially less than at Little Goose Dam (about 15,000 vs. 18,000 cfs). The higher volume flow is produced by higher water velocity within the turbine intakes. To compensate for the higher velocity at Little Goose Dam, it was necessary to reduce the overall porosity of the screens by altering the perforated plate porosity.

To determine which porosity was most effective, three different perforated plate porosities were tested with both the extended-length traveling screen and extended-length bar screen: 22, 25, and 28%. Prior to FGE testing, we monitored descaling for each of the extended-length screens at the different porosities; this was done in Slots 4A, 4B, 4C, 5A, 5B, and 5C. Once we had determined that none of the porosities caused unacceptably high descaling, we selected the initial test porosity for each screen and began the FGE tests.

Methods for determining FGE at Little Goose Dam were similar to those used in previous STS studies at McNary Dam (Brege et al. 1992; McComas et al. 1993). Extended-length screens (Fig. 1) were tested in Slots 4B and 5B, and an STS was used in Slot 3B as a control. Extended-length screens were also placed in Slots 4A,

Little Goose Dam cross section



1993 Fyke-net layout

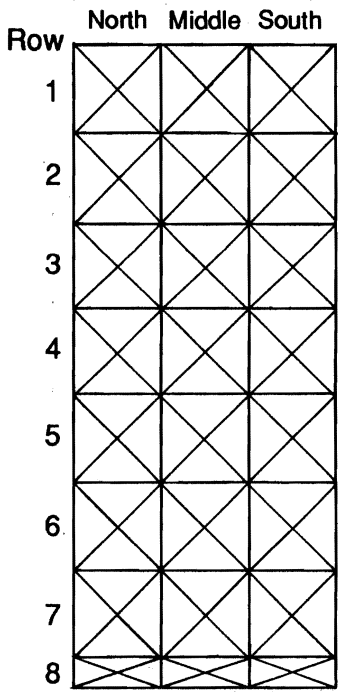


Figure 1.--Cross section of turbine intake with extended-length screen and fyke nets at Little Goose Dam.

4C, 5A, and 5C to maintain uniform flows within each test unit. Placement of test screens during FGE testing was as follows:

Turbine unit and slot	Screen type	Perforated plate porosity (%)
3B	Standard-length STS	48
4A	Extended-length bar screen	22
4B	Extended-length bar screen	25
4C	Extended-length bar screen	28
5A	Extended-length STS	22
5B	Extended-length STS	25
5C	Extended-length STS	28

The support structure for the extended-length screens extends to the floor of the turbine intake; therefore, it was necessary to place the fyke-net frame for collecting unguided fish in the downstream or operating gate slot (Fig. 1). A full complement of nets (three columns of eight rows) with cod ends was used in the two extended-length screen test slots. An analysis of fyke-net catch by net column with extended-length screens at McNary Dam is included in McComas et al. 1994.

The fyke-net frame used with the STS also had a full complement of nets, but to limit the number of mortalities, only the center column of nets had cod ends. Previous statistical analyses of a similar standard-length screen configuration indicated that multiplying the center-column catch by 3 would provide a reasonable approximation of the total fyke-net catch (Gessel et al. 1986).

All the extended-length screen slots in Turbine Units 4 and 5, as well as Slot 3B (control), 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.

All screens were operated at the standard elevation; 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 19,500 cfs[1] for FGE tests. This corresponded to a screen-approach velocity of around 2.5 fps with turbine power loads of about 135 MW.

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 at 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

[1] To approximate the flow conditions near the guiding device under normal operating conditions (no net frame in place), it was necessary to increase the 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 unguided fish were counted by species and the gatewell catch was examined for descaling.

Mean FGE differences between the extended-length bar screen in Slot 4B and the extended-length traveling screen in Slot 5B were examined using analysis of variance (ANOVA) with Fisher's Protected Least Significant Difference (FPLSD) used for multiple comparisons of significant F-tests (Petersen 1985). Blocking by day for statistical analysis was not possible because on some days the tests were only conducted in one unit or fish numbers were too low in one or both test units. Analyses were done for yearling chinook salmon (16 and 13 replicate test days for the extended-length bar screen and extended-length traveling screen, respectively) and steelhead (18 and 15 test days). Guidance estimates were not used where total sample size was less than 30 fish.

All fish were monitored for PIT-tags. Additionally, all yearling chinook salmon and steelhead were examined for brands, fin clips, or distinguishing marks that would indicate whether they were wild or of hatchery origin.

Dipbasket efficiency was estimated by recovering marked yearling chinook salmon from a gatewell during the FGE tests. Standard procedure was to release a known number of marked fish into the test gatewell after the unit had reached normal test loading (135 MW). The test gatewell was dipped 30-60 minutes later and dipbasket efficiency was estimated by the percentage of marked, released fish that were recovered.

Results and Discussion

Dipbasket Efficiency

Five gatewell releases of yearling chinook salmon were made to estimate dipbasket efficiency. A total of 124 out of 139 smolts were recaptured (89.2%). Fourteen of the missing fish were lost during two of the tests. The remaining tests showed a 99% collection efficiency.

Fish Guidance Efficiency

Constraints resulting from the listing of Snake River sockeye salmon (*O. nerka*) and Snake River wild spring/summer chinook salmon under the Endangered Species Act influenced the FGE evaluation since we were limited by the number of these fish we could handle. Because of the unusually high ratios of wild to hatchery yearling chinook salmon (Appendix Table 1), high river flows, and a delay in the outmigration of approximately 2 weeks, we were able to conduct only a portion of the desired number of FGE tests. It was also necessary to adjust downward the minimum number of fish acceptable for statistical analysis from approximately 200 per replicate to 30 per replicate. Estimates of FGE can be assumed to be binomially distributed. A sample size of 30 ensures that the data are approximately normally distributed, which satisfies one assumption in the use of analysis of variance procedures.

Daily fish collections for FGE tests are listed in Appendix Table 2. Overall mean FGE for the extended-length bar screen (84 and 92% for yearling chinook salmon and steelhead, respectively) was not significantly different from mean FGE for the extended-

length traveling screen (86 and 87%). Daily guidance estimates showed no apparent trend over time for either extended-length screen or species. Figure 2 shows FGE results for both yearling chinook salmon and steelhead for the three screen types on days when sufficient numbers of fish were captured in each test slot for statistical analysis. Guidance tests in the control slot (3B) with the STS were only conducted on three days (22-24 May); FGE averaged 74 and 95% for yearling chinook salmon and steelhead, respectively.

A total of 183 PIT-tagged yearling chinook salmon were identified during FGE tests. Of these, 16 were killed in the fyke nets and 167 were collected from gatewells and returned to the juvenile salmonid bypass system.

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).

Mean descaling differences among the 25% porosity extended-length bar screen in Slot 4B, the 25% extended-length traveling screen in Slot 5B, the STS in Slot 3B, and the 22% extended-length bar screen in Slot 4A were examined using ANOVA. Descaling estimates were not included in analyses if the sample size was less than 25 fish. Analyses were done for yearling chinook salmon with 21, 20, 16, and 8 test days, respectively, for the four screen conditions. Steelhead descaling estimates

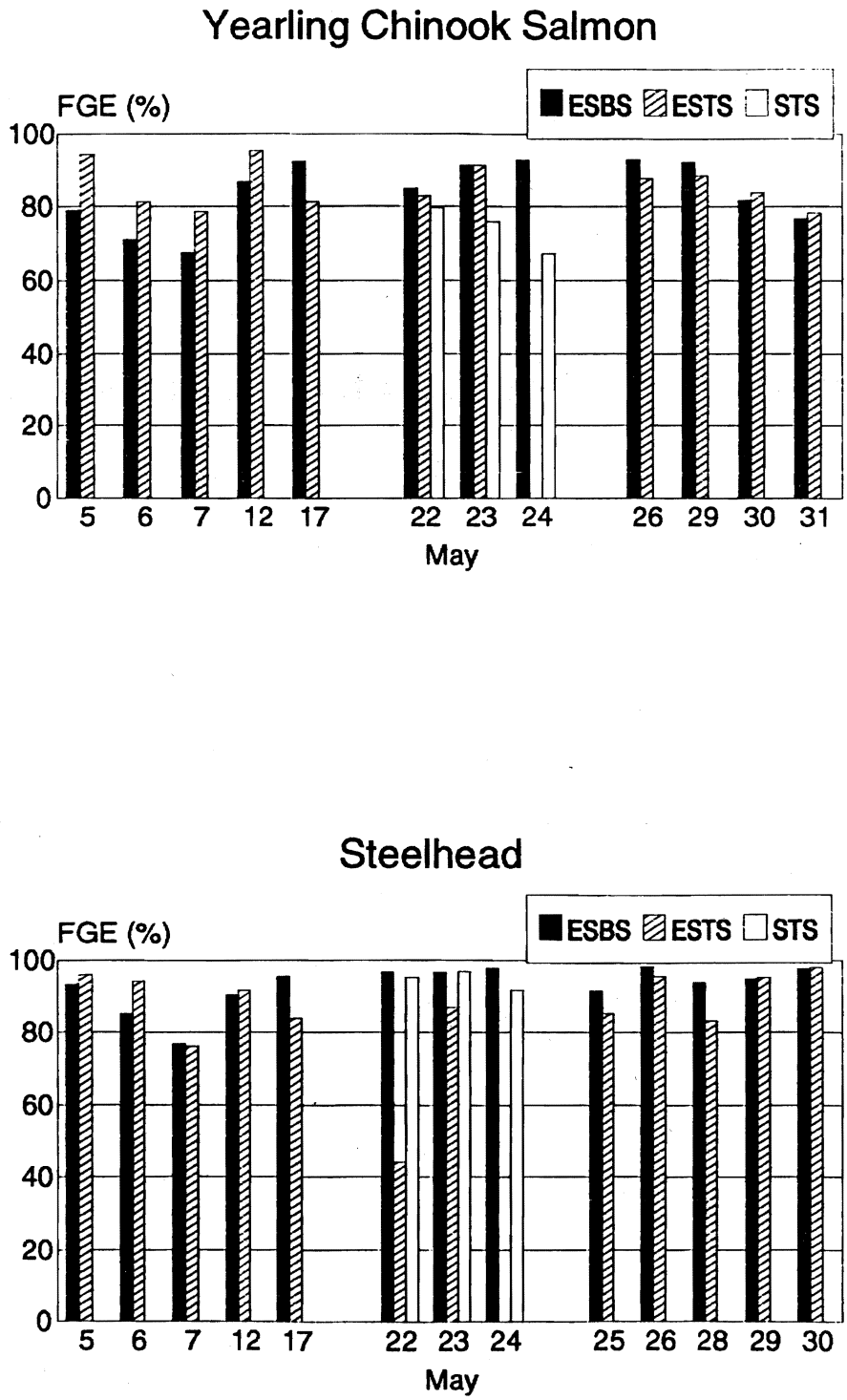


Figure 2.--Fish guidance efficiency (FGE) for yearling chinook salmon and steelhead at Little Goose Dam, 1993 (ESBS = extended-length bar screen, ESTS = extended-length traveling screen, STS = standard-length traveling screen).

for all screens increased noticeably after 12 May and again after 22 May, so data in these time periods were analyzed separately. Analyses for early season data (19 April-12 May) were done with 8, 8, 6, and 2 test days for the extended-length bar screen, extended-length traveling screen, STS, and the Slot 4A extended-length bar screen, respectively. Analyses for the middle season data (15 May-22 May) were done with 5, 3, and 6 test days (no Slot 4A extended-length bar screen). Analyses for late season data (23 May-3 June) were done with 9, 6, 11, and 7 test days.

Results and Discussion

Table 1 summarizes the results of the initial descaling tests conducted for three days prior to FGE testing. This monitoring was done to make sure test conditions and prototype equipment would not cause an inordinate amount of descaling or injury to juvenile salmonids. Constraints of available test days and low numbers of fish limited us to only a cursory examination of descaling. However, the information collected reaffirmed our selection of the 25% porosity extended-length screens for Slots 4B and 5B in the initial FGE test series. Because of concern about descaling problems occurring as the outmigration proceeded, the highest porosity screens (28%) were placed in Slots 4C and 5C (i.e., slots with lowest discharge).

Daily descaling data collected during FGE tests are provided in Appendix Table 3. Mean descaling for the extended-length traveling screen in Slot 5B (12%) was significantly higher than for the extended-length bar screen in Slot 4B and STS in Slot 3B (9 and 7%, respectively) for yearling chinook salmon. It was not

Table 1.--Descaling of yearling chinook salmon and steelhead during the initial testing of different porosity (%) extended-length screens at Little Goose Dam, 19-21 April 1993.

Yearling chinook salmon

	Slot 3B 48% STS		Slot 4A 25% ESTS		Slot 4B 22% ESBS		Slot 4C 22% ESTS		Slot 5A 25% ESBS		Slot 5B 28% ESBS		Slot 5C 28% ESTS	
	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%
	9	11.1	61	11.5	80	15.0	53	9.4	55	21.8	58	13.8	19	10.5
	24	4.6	85	10.6	106	2.8	45	8.9	82	14.6	88	9.1	23	13.0
	6	0.0			53	9.4					40	15.0		
Overall	39	5.1	146	11.0	239	8.4	98	9.2	137	17.5	186	11.8	42	11.9

Steelhead

	Slot 3B 48% STS		Slot 4A 25% ESTS		Slot 4B 22% ESBS		Slot 4C 22% ESTS		Slot 5A 25% ESBS		Slot 5B 28% ESBS		Slot 5C 28% ESTS	
	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%	Fish	Desc%
	42	2.3	83	6.0	79	3.8	40	2.5	68	5.9	57	5.3	15	0.0
	68	4.4	94	6.4	137	1.5	41	7.3	77	14.3	70	11.4	21	4.8
	26	0.0			92	5.4					59	5.1		
Overall	136	2.9	177	6.2	308	3.2	81	4.9	145	10.3	186	7.5	36	2.8

significantly higher than the 10% descaling for the extended-length bar screen in Slot 4A (22% porosity). There were no significant differences in mean descaling between extended-length bar screens in Slots 4A and 4B and the STS. Daily descaling estimates showed no apparent trends over time for any screen.

There were no significant differences among screens in mean descaling for steelhead. Overall season descaling averaged 16, 15, 17, and 20% for the extended-length bar screen, extended-length traveling screen, STS, and the extended-length bar screen in Slot 4A (mostly tested after 24 May), respectively. These descaling rates were higher than expected and we do not have a definitive explanation. It is noteworthy, however, that descaling for steelhead (under the various guidance conditions tested) averaged between 4 and 6% before 13 May, between 11 and 17% from 15 May to 22 May, and between 23 and 29% after 23 May. High river flows and spill at Snake River dams, as well as the influx of hatchery steelhead all occurred around 12 May, shortly before the increase in steelhead descaling.

CONCLUSIONS

1) Fish guidance efficiency of the extended-length traveling screen and the extended-length bar screen was high for both yearling chinook salmon and steelhead (nearly 85 and 90%, respectively) and was not significantly different between the two types of extended-length screens.

2) Mean descaling for yearling chinook salmon and was significantly higher with the extended-length traveling screen (12%) than with the extended-length bar screen (9%) or STS (7%). There was no significant difference in mean descaling between the extended-length bar screen and the STS.

3) Descaling for steelhead was about 5% prior to mid-May, 15% in late May, and 25% by early June, but was not significantly different for any screen type.

ACKNOWLEDGMENTS

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Appendix Table 1.--Hatchery and wild yearling chinook salmon and steelhead collected during descaling and fish guidance efficiency tests at Little Goose Dam, 1993.

	Yearling chinook				Steelhead			
Date	Hatchery	Wild[a]	Total	Percent wild	Hatchery	Wild	Total	Percent wild
19 April	290	47	337	13.9	88	322	410	78.5
20 April	381	75	456	16.4	177	331	508	65.2
21 April	90	9	99	9.1	111	66	177	37.3
28 April	104	76	180	42.2	175	25	200	12.5
4 May	399	64	463	13.8	151	25	176	14.2
5 May	751	102	853	12.0	457	146	603	24.2
6 May	195	27	222	12.2	162	72	234	30.8
7 May	171	30	201	14.9	408	157	565	27.8
12 May	663	81	744	10.9	555	111	666	16.7
15 May	57	17	74	23.0	332	69	401	17.2
16 May	66	22	88	25.0	466	66	532	12.4
17 May	129	82	211	38.9	651	68	719	9.5
18 May	246	94	340	27.6	272	37	309	12.0
19 May	131	53	184	28.8	167	38	205	18.5
21 May	34	18	52	34.6	101	11	112	9.8
22 May	117	33	150	22.0	293	30	323	9.3
23 May	266	108	374	28.9	183	29	212	13.7
24 May	394	226	620	36.5	562	56	618	9.1
25 May	69	19	88	21.6	215	32	247	13.0
26 May	342	103	445	23.1	308	45	353	12.7
27 May	86	20	106	18.9	145	18	163	11.0
28 May	103	14	117	12.0	273	34	307	11.1
29 May	276	93	369	25.2	314	38	352	10.8
30 May	171	69	240	28.8	276	31	307	10.1
31 May	292	69	361	19.1	155	18	173	10.4
2 June	113	58	171	33.9	60	12	72	16.7
3 June	173	41	214	19.2	114	20	134	14.9

[a]Prior to May 4, the estimated number of wild yearling chinook salmon was based on the assumption that all hatchery fish had their adipose fin clipped; after this date, the estimated number of wild yearling chinook salmon was based on the assumption that all hatchery fish had either the adipose fin clipped or a ventral fin clipped.

Appendix Table 2.--Numbers of fish caught in individual replicates of fish guidance efficiency tests at Little Goose Dam, 1993.

28 April (5B, ESTS)[a]

Location	Subyearling chinook[b]				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot[c]	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						3		3		1		1				
Level 3							1	1	1	3	1	5				
Level 4					1	2	4	7	3	3	8	14				
Level 5					4	4	3	11	2		1	3				
Level 6					2	1	3	6		2	2	4				
Level 7										1		1				
Net total					7	10	11	28	6	10	12	28				
Gatewell							152					172				
Total							180					200				
FGE (%)							84					86				

04 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1						4		4		2		2				
Level 2					2		6	8		1		1				
Level 3					1	2	4	7			2	2				
Level 4					3	7	6	16	1	1	4	6				
Level 5					4	5	6	15		1	2	3				
Level 6					5	5	5	15		1	1	2				
Level 7						1		1								
Net total					15	24	27	66	1	6	9	16				
Gatewell								302				132				
Total								368				148				
FGE (%)								82				89				

[a]Test date (Test slot, guidance device type: ESTS = extended-length traveling screen, ESBS = extended-length bar screen, STS = standard-length submersible traveling screen).
[b]Age 0+ fish, <30 mm in length.
[c]Refers to fyke-net column: L = left, M = middle, R = right, Tot = total catch for net level.

Appendix Table 2.--Continued.

05 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1							2	2	3	1		4				
Level 2					3	4	5	12			2	2				
Level 3					2		8	10		1		1				
Level 4					4	1	3	8		1	1	2				
Level 5					1	2	6	9	4	2		6				
Level 6					5	5	2	12	1	1	2	4				
Level 7					4	1	2	7		2		2				
Net total					19	13	28	60	8	8	5	21				
Gatewell								221				311				
Total								281				332				
FGE (%)								79				94				

05 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1											1	1				
Level 2											1	1				
Level 3					1		1	2								
Level 4					1	1	4	6	1	1	1	3				
Level 5					3	2	5	10	1		1	2				
Level 6					4			4		1	2	3				
Level 7																
Net total					9	3	10	22	2	2	6	10				
Gatewell								362				248				
Total								384				258				
FGE (%)								94				96				

Appendix Table 2.--Continued.

06 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1					1			1	2			2				
Level 2					2	1	2	5	5	4	1	10				
Level 3					4		1	5	1		2	3				
Level 4					2			2		1		1				
Level 5					2	3	1	6			1	1				
Level 6					2		1	3	1		1	2				
Level 7											1	1				
Net total					13	4	5	22	9	5	6	20				
Gatewell								54				115				
Total								76				135				
FGE (%)								71				85				

06 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2																
Level 3																
Level 4							1	1		1		1				
Level 5					1	1	1	3								
Level 6					2			2	1	1		2				
Level 7																
Net total					3	1	2	6	1	2		3				
Gatewell								28				50				
Total								34				53				
FGE (%)								82				94				

Appendix Table 2.--Continued.

07 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									1			1				
Level 2					1	2	1	4	3	6	6	15				
Level 3					3	3		6	5	4	9	18				
Level 4					1	2	3	6		6	2	8				
Level 5					1	4	1	6	5	7	4	16				
Level 6					2	3	4	9	4	9	2	15				
Level 7						2		2		3		3				
Net total					8	16	9	33	18	35	23	76				
Gatewell								69				252				
Total								102				328				
FGE (%)									68	77						

07 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2									2	1	1	4				
Level 3									1	2	7	10				
Level 4									4	5	3	12				
Level 5					1	2		3		4	5	9				
Level 6									2		3	5				
Level 7																
Net total					1	2		3	9	12	19	40				
Gatewell									11			127				
Total									14			167				
FGE (%)									79			76				

Appendix Table 2.--Continued.

12 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1					3	1		4	2			2				
Level 2	1			1	1	2	9	12	1	2	1	4				
Level 3		1		1	3	1	3	7	3	1	5	9				
Level 4					2	3	5	10	4	4	4	12				
Level 5	1			1	2	2	7	11	1	4	3	8				
Level 6						6	6	12		3		3				
Level 7							2	2								
Net total	2	1		3	11	15	32	58	11	14	13	38				
Gatewell				0				378				363				
Total				3				436				401				
FGE (%)				0				87				91				

12 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2									2			2				
Level 3					1		1	2	2	2	3	7				
Level 4						1	2	3	1	1	1	3				
Level 5					1			1			2	2				
Level 6						2		2	2	2	2	6				
Level 7																
Net total					2	3	3	8	7	5	8	20				
Gatewell								166				228				
Total								174				248				
FGE (%)								95				92				

Appendix Table 2.--Continued.

15 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1										1	1	2				
Level 2									1	1	3	5				
Level 3							1	1								
Level 4										1	2	3				
Level 5						2		2								
Level 6									1	1	2	4				
Level 7										1		1				
Net total				0		2	1	3	2	5	8	15				
Gatewell				5				23				207				
Total				5				26				222				
FGE (%)				100				89				93				

16 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									2			2				
Level 2	1			1					1	1	3	5				
Level 3					1			1	3	3		6				
Level 4									1	1	4	6				
Level 5						1	2	3	3	1	2	6				
Level 6						2	1	3	1	1	2	4				
Level 7					1			1								
Net total	1			1	2	3	3	8	11	7	11	29				
Gatewell				5				44				385				
Total				6				52				414				
FGE (%)				83				85				93				

Appendix Table 2.--Continued.

17 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									1			1				
Level 2							2	2	3		2	5				
Level 3	2			2			2	2	2	3	1	6				
Level 4									1	2	1	4				
Level 5					1		1	2			1	1				
Level 6					2	1	1	4		2		2				
Level 7										1		1				
Net total	2			2	3	1	6	10	7	8	5	20				
Gatewell				6				121				451				
Total				8				131				471				
FGE (%)				75				92				96				

17 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									2		1	3				
Level 2	1			1					2	1	3	6				
Level 3	1			1			1	1	1	2		3				
Level 4					1	1		2	2	2	5	9				
Level 5					1	2	5	8	1	3	5	9				
Level 6					1	2	1	4		1	5	6				
Level 7									2	1	1	4				
Net total	2			2	3	5	7	15	10	10	20	40				
Gatewell				0				65				209				
Total				2				80				249				
FGE (%)				0				81				84				

Appendix Table 2.--Continued.

18 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1											1	1				
Level 2	1			1		1	5	6	1	2	4	7				
Level 3						1	4	5		2	4	6				
Level 4					2	1	2	5			4	4				
Level 5	1			1	1	1	1	3		1	4	5				
Level 6						4	3	7	2	1	1	4				
Level 7					1	1		2	1		1	2				
Net total	2			2	4	9	15	28	4	6	19	29				
Gatewell				2				166				236				
Total				4				194				265				
FGE (%)				50				86				89				

19 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									1	1		2				
Level 2							2	2		1		1				
Level 3					1	1		2		2		2				
Level 4					1		1	2	1		2	3				
Level 5					1			1		1		1				
Level 6					1	1		2			2	2				
Level 7					1			1	1			1				
Net total					5	2	3	10	3	5	4	12				
Gatewell				1				99				155				
Total				1				109				167				
FGE (%)				100				91				93				

21 May (4B,ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2									1			1				
Level 3							1	1		1		1				
Level 4							1	1	1	1		2				
Level 5					1			1	1			1				
Level 6																
Level 7																
Net total					1		2	3	3	2		5				
Gatewell				1				18				52				
Total				1				21				57				
FGE (%)				100				86				91				

Appendix Table 2.--Continued.

22 May (3B,STS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						1		3								
Level 3																
Level 4						2		6		1		3				
Level 5						1		3								
Level 6																
Level 7																
Net total						4		12		1		3				0
Gatewell								47				63				1
Total								59				66				1
FGE (%)								80				95				100

22 May (4B ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2											1	1				
Level 3					1		1	2								
Level 4					1	2		3								
Level 5									1			1				
Level 6							1	1								
Level 7																
Net total					2	2	2	6	1		1	2				
Gatewell								34				58				
Total								40				60				
FGE (%)								85				97				

22 May (5B,ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1									1			1				
Level 2					1			1	1	5	4	10				
Level 3										3	1	4				
Level 4					1			1		1		1				
Level 5										1	1	2				
Level 6					1		1	2		1		1				
Level 7							1	1								
Net total					3		2	5	2	11	6	19				
Gatewell								24				15				
Total								29				34				
FGE (%)								83				44				

Appendix Table 2.--Continued.

23 May (3B, STS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						4		12								
Level 3						6		18								
Level 4						2		6		1		3				
Level 5						1		3								
Level 6																
Level 7																
Net total						13		39		1		3				0
Gatewell								123				96				1
Total								162				99				1
FGE (%)								76				97				100

23 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2							2	2								
Level 3						1	2	3								
Level 4	1			1		1	2	3								
Level 5					2		2	4								
Level 6										1	1	2				
Level 7																
Net total	1			1	2	2	8	12		1	1	2				
Gatewell				0				127				61				
Total				1				139				63				
FGE (%)				0				91				97				

23 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2							2	2			1	1				
Level 3									1		1	2				
Level 4					1			1								
Level 5					1	1		2								
Level 6						1		1								
Level 7							1	1			1	1				
Net total					2	2	3	7	1		3	4				
Gatewell								74				27				
Total								81				31				
FGE (%)								91				87				

Appendix Table 2.--Continued.

24 May (3B, STS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1						1		3								
Level 2										1		3				
Level 3						15		45								
Level 4						17		51		4		12				
Level 5						4		12		3		9				
Level 6																
Level 7						1		3								
Net total						38		114		8		24				0
Gatewell								235				274				1
Total								349				298				1
FGE (%)								67				92				100

24 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1					1			1			1	1				
Level 2					1		1	2	1			1				
Level 3					1			1			1	1				
Level 4					1		2	3								
Level 5					2	1	2	5								
Level 6							1	1								
Level 7																
Net total					6	1	6	13	1		2	3				0
Gatewell								168				138				1
Total								181				141				1
FGE (%)								93				98				100

Appendix Table 2.--Continued.

25 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						1		1		1		1				
Level 3						1	1	2								
Level 4							1	1								
Level 5							1	1	1			1				
Level 6										1		1				
Level 7																
Net total						2	3	5	1	2		3				
Gatewell								7				33				
Total								12				36				
FGE (%)								58				92				

25 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2																
Level 3							1	1								
Level 4					1		2	3		1		1				
Level 5					1	1	2	4	3			3				
Level 6							1	1			1	1				
Level 7					1			1		1		1				
Net total					3	1	6	10	3	2	1	6				
Gatewell								11				35				
Total								21				41				
FGE (%)								52				85				

Appendix Table 2.--Continued.

26 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						1	1	2								
Level 3										1		1				
Level 4					1	1	1	3								
Level 5																
Level 6																
Level 7																
Net total					1	2	2	5		1		1				
Gatewell								66				59				
Total								71				60				
FGE (%)								93				98				

26 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						2		2								
Level 3							1	1								
Level 4					3	2	2	7	1		1	2				
Level 5					1	5	2	8	1		1	2				
Level 6						1	1	2		1		1				
Level 7																
Net total					4	10	6	20	2	1	2	5				
Gatewell								143				108				
Total								163				113				
FGE (%)								88				96				

Appendix Table 2.--Continued.

27 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2																
Level 3																
Level 4																
Level 5							1	1								
Level 6						1		1								
Level 7																
Net total						1	1	2								0
Gatewell								11				19				1
Total								13				19				1
FGE (%)								85				100				100

27 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2					1		1	2								
Level 3						1	1	2								
Level 4					1			1		2		2				
Level 5					1	1		2			1	1				
Level 6																
Level 7			1	1												
Net total			1	1	3	2	2	7		2	1	3				
Gatewell				2				19				18				
Total				3				26				21				
FGE (%)				67				73				86				

Appendix Table 2.--Continued.

28 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2																
Level 3							1	1		1	1	2				
Level 4					2			2			1	1				
Level 5							2	2			1	1				
Level 6										1		1				
Level 7																
Net total					2		3	5		2	3	5				
Gatewell								30				77				
Total								35				82				
FGE (%)								86				94				

28 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2									1		1	2				
Level 3										2		2				
Level 4							2	2	1	2		3				
Level 5					1			1		2	1	3				
Level 6	1			1	1		1	2			1	1				
Level 7																
Net total	1			1	2		3	5	2	6	3	11				
Gatewell				2				17				55				
Total				3				22				66				
FGE (%)				67				77				83				

Appendix Table 2.--Continued.

29 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1											1	1				
Level 2	1			1		2		2			1	1				
Level 3										1	1	2				
Level 4					2	1	1	4	1			1				
Level 5					1	2		3		1		1				
Level 6														1		1
Level 7																
Net total	1			1	3	5	1	9	1	1	4	6		1		1
Gatewell				0				107				114				0
Total				1				116				120				1
FGE (%)				0				92				95				0

29 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2						1		1								
Level 3					1	1		2	2			2				
Level 4						1	1	2	1		2	3				
Level 5					1	2		3		1		1				
Level 6			1	1	2			2								
Level 7																
Net total			1	1	4	5	1	10	3	1	2	6				
Gatewell				0				77				122				
Total				1				87				128				
FGE (%)				0				89				95				

Appendix Table 2.--Continued.

30 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1					1		1	2								
Level 2					1	2	1	4								
Level 3						1		1			1	1				
Level 4					1		1	2		1		1				
Level 5					1		1	2								
Level 6							1	1								
Level 7			1	1		1		1								
Net total			1	1	4	4	5	13		1	1	2				
Gatewell				0				58				90				
Total				1				71				92				
FGE (%)				0	82	98										

30 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2					1			1								
Level 3							1	1			1	1				
Level 4					2	1	2	5								
Level 5					2	2		4								
Level 6																
Level 7																
Net total					5	3	3	11			1	1				
Gatewell								57				51				
Total								68				52				
FGE (%)								84				98				

Appendix Table 2.--Continued.

31 May (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1										1		1				
Level 2					2		2	4	1			1				
Level 3										1		1				
Level 4					3	1	2	6								
Level 5							6	6			1	1				
Level 6					1		1	2								
Level 7					1			1								
Net total				0	7	1	11	19	1	2	1	4				0
Gatewell				1				63				33				2
Total				1				82				37				2
FGE (%)				100				77				89				100

31 May (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2							1	1								
Level 3					1	2	2	5		1		1				
Level 4					2		5	7								
Level 5							1	1								
Level 6					1	1	2	4								
Level 7																
Net total					4	3	11	18		1		1				
Gatewell								65				14				
Total								83				15				
FGE (%)								78				93				

Appendix Table 2.--Continued.

02 June (4B, ESBS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2					1			1								
Level 3							1	1								
Level 4					1		1	2								
Level 5							1	1								
Level 6						1		1								
Level 7																
Net total					2	1	3	6				0				
Gatewell								27				18				
Total								33				18				
FGE (%)								82				100				

02 June (5B, ESTS)

Location	Subyearling chinook				Yearling chinook				Steelhead				Sockeye			
	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot	L	M	R	Tot
Level 1																
Level 2																
Level 3						3		3								
Level 4					1			1								
Level 5																
Level 6					1	2	1	4								
Level 7							1	1								
Net total					2	5	2	9				0				
Gatewell								42				11				
Total								51				11				
FGE (%)								82				100				

Appendix Table 3.--Descaling data from fish guidance efficiency tests conducted at Little Goose Dam, 1993.

Test date	Yearling chinook Total catch	Yearling chinook Number descaled	Yearling chinook Percent descaled	Steelhead Total catch	Steelhead Number descaled	Steelhead Percent descaled
Unit 3, Slot B (48% STS)						
4 May	95	7	7.4	28	4	14.3
5 May	188	14	7.4	12	1	8.3
6 May	114	10	8.8	46	4	8.7
7 May	85	6	7.1	70	3	4.3
12 May	134	11	8.2	7	1	14.3
15 May	48	2	4.2	179	23	12.8
16 May	36	3	8.3	98	12	12.2
18 May	146	9	6.2	44	2	4.5
19 May	75	1	1.3	38	2	5.3
21 May	31	5	16.1	55	9	16.4
22 May	47	0	0.0	63	11	17.5
23 May	123	7	5.7	96	29	30.2
24 May	139	16	11.5	146	35	24.0
25 May	10	1	10.0	83	32	38.6
26 May	87	4	4.6	36	8	22.2
27 May	45	3	6.7	97	24	24.7
28 May	36	3	8.3	110	25	22.7
29 May	81	10	12.3	71	17	23.9
30 May	37	3	8.1	102	28	27.5
31 May	96	9	9.4	79	18	22.8
2 June	48	4	8.3	26	7	26.9
3 June	58	3	5.2	62	14	22.6
Unit 4, Slot A (22% extended-length bar screen)						
24 May	108	6	5.6	76	15	19.7
25 May	10	2	20.0	30	9	30.0
26 May	78	4	5.1	38	9	23.7
27 May	19	3	15.8	23	1	4.3
28 May	27	4	14.8	54	3	5.6
29 May	89	9	10.1	34	7	20.6
30 May	68	3	4.4	59	18	30.5
31 May	88	13	14.8	40	11	27.5
Unit 4, Slot A (28% extended-length bar screen)						
2 June	39	4	10.3	17	3	17.6
3 June	82	12	14.6	39	10	25.6

Appendix Table 3.--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 B (25% extended-length bar screen)						
4 May	302	30	9.9	132	7	5.3
5 May	221	21	9.5	311	17	5.5
6 May	54	4	7.4	115	3	2.6
7 May	69	11	15.9	252	8	3.2
12 May	378	45	11.9	363	22	6.1
15 May	23	0	0.0	207	37	17.9
17 May	121	7	5.8	187	22	11.8
19 May	99	6	6.1	155	29	18.7
21 May	18	5	27.8	52	9	17.3
22 May	34	0	0.0	58	10	17.2
23 May	127	8	6.3	61	20	32.8
24 May	168	7	4.2	138	27	19.6
25 May	7	1	14.3	33	8	24.2
26 May	66	3	4.5	59	17	28.8
27 May	11	0	0.0	19	5	26.3
28 May	30	3	10.0	77	13	16.9
29 May	107	11	10.3	114	30	26.3
30 May	58	0	0.0	90	22	24.4
31 May	63	9	14.3	33	10	30.3
2 June	27	2	7.4	18	6	33.3
3 June	74	15	20.3	33	9	27.3
Unit 5, Slot B (25% extended-length traveling screen)						
28 April	152	14	9.2	172	15	8.7
5 May	362	33	9.1	248	10	4.0
6 May	26	4	15.4	50	3	6.0
7 May	11	2	18.2	127	2	1.6
12 May	166	21	12.7	228	7	3.1
16 May	44	5	11.4	385	49	12.7
17 May	65	4	6.2	96	13	13.5
18 May	147	14	9.5	179	24	13.4
22 May	24	4	16.7	15	2	13.3
23 May	74	9	12.2	27	8	29.6
25 May	11	1	9.1	35	12	34.3
26 May	143	26	18.2	108	31	28.7
27 May	19	2	10.5	18	9	50.0
28 May	17	0	0.0	55	11	20.0
29 May	77	4	5.2	122	36	29.5
30 May	57	6	10.5	51	17	33.3
31 May	65	11	16.9	14	6	42.9
2 June	42	4	9.5	11	5	45.5