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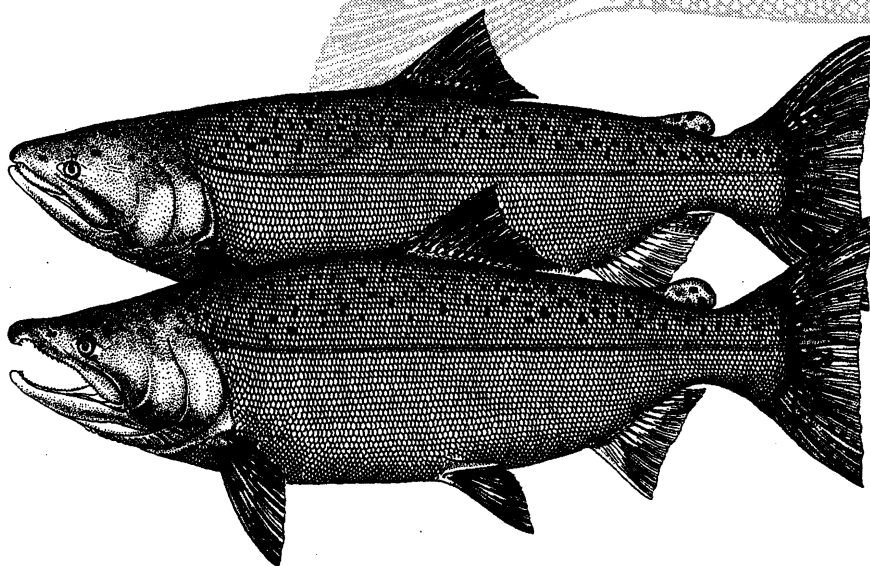
**National Marine  
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Seattle, Washington

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

by  
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and Douglas B. Dey

April 1995





STUDIES TO EVALUATE THE EFFECTIVENESS  
OF EXTENDED-LENGTH SCREENS AT LITTLE GOOSE DAM, 1994

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## CONTENTS

|  | Page |
|--|------|
| INTRODUCTION . . . . .   | 1    |
| OBJECTIVE 1: FISH GUIDANCE EFFICIENCY OF THE<br>EXTENDED-LENGTH SUBMERSIBLE BAR SCREEN . . . | 3    |
| Approach . . . . .   | 3    |
| Results and Discussion . . . . .   | 6    |
| Fish Guidance Efficiency . . . . .   | 6    |
| OBJECTIVE 2: JUVENILE SALMONID DESCALING . . . . .   | 9    |
| Approach . . . . .   | 9    |
| Results and Discussion . . . . .   | 11   |
| CONCLUSIONS . . . . .  | 11   |
| ACKNOWLEDGMENTS . . . . .  | 12   |
| REFERENCES . . . . .   | 13   |
| APPENDIX A . . . . .   | 14   |
| APPENDIX B . . . . .   | 29   |

## 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:

| <u>Turbine<br/>unit/slot</u> | <u>Screen<br/>type</u> | <u>Porosity</u> |
|------------------------------|------------------------|-----------------|
| 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).

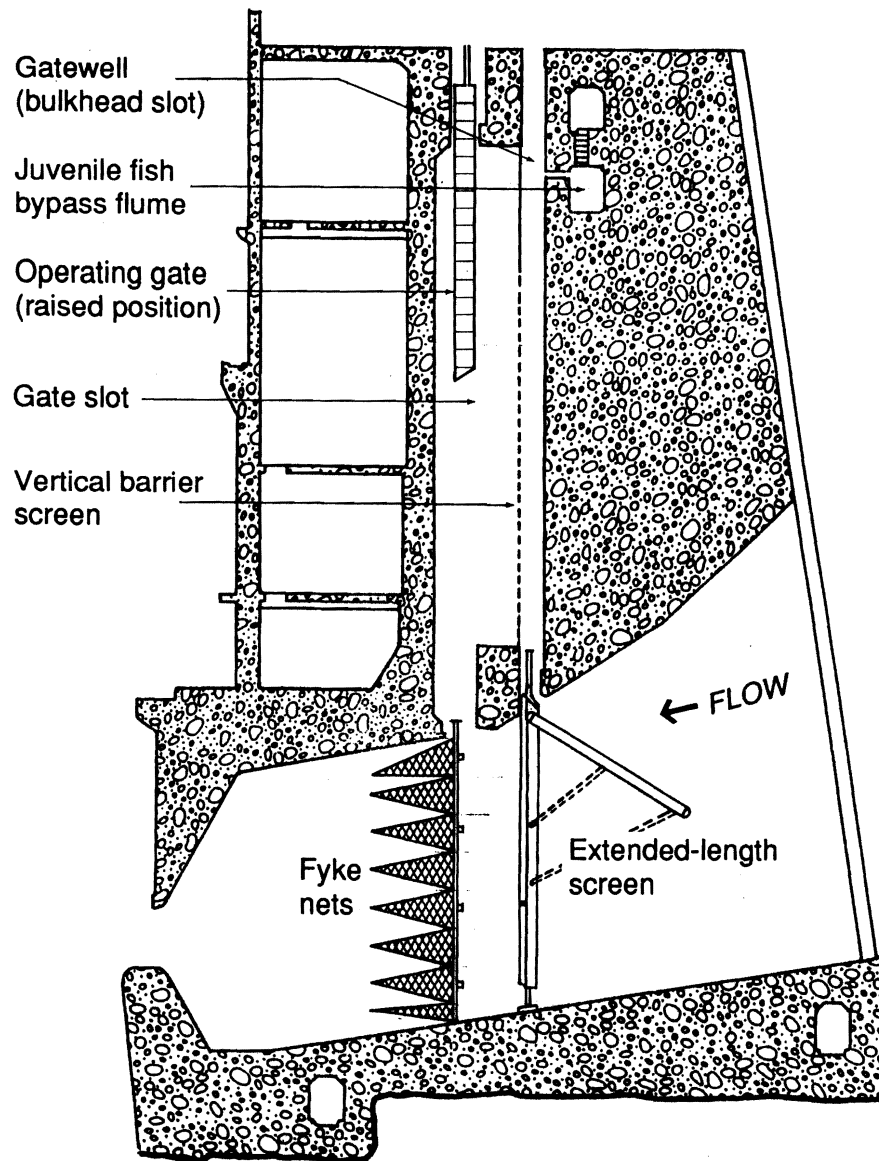
Water flows into test turbine units were maintained at approximately 19,700 cfs<sup>1</sup> for FGE tests. This corresponded to a screen-approach velocity of around 2.5 fps with turbine power

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<sup>1</sup> 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

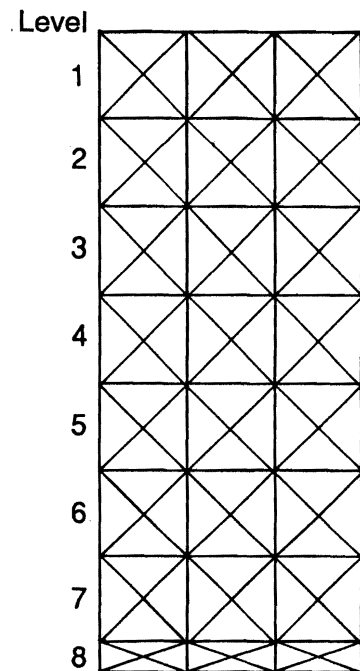


Figure 1. Cross section of turbine intake with extended-length screen and fyke nets at Little Goose Dam, 1994.

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

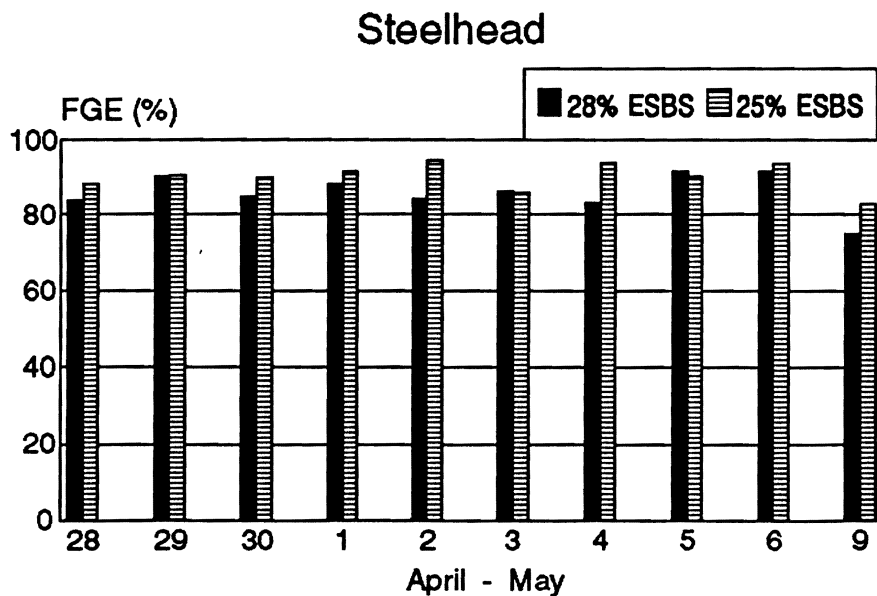
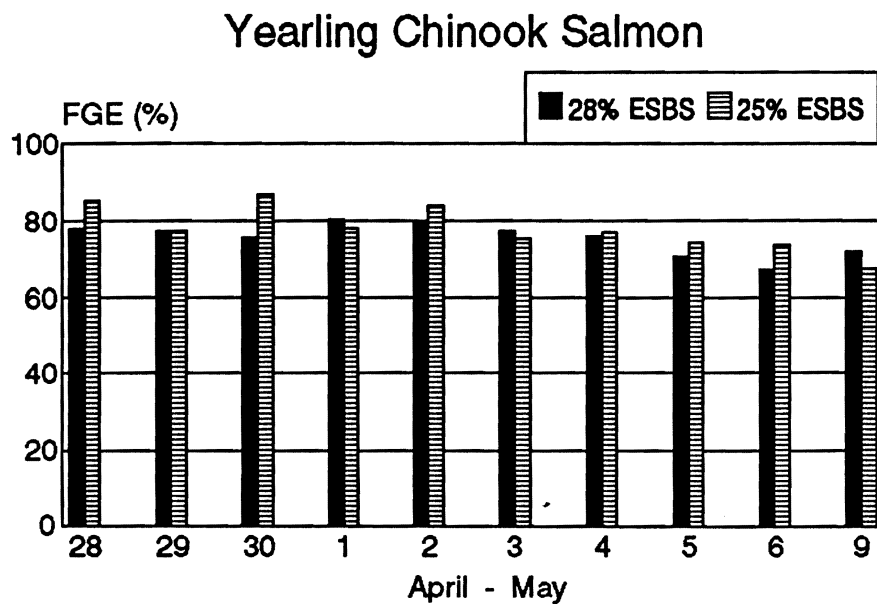


Figure 2. Fish guidance efficiency (FGE) for yearling chinook salmon and steelhead at Little Goose Dam, 1994 (ESBS = extended-length submersible bar screen).

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.

| <u>Test condition</u> | <u>Slot</u> | <u>Screen</u> | <u>Porosity (%)</u> | <u>Test days</u> | <u>Number of tests</u> |
|-----------------------|-------------|---------------|---------------------|------------------|------------------------|
| 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.

| <u>Analysis</u> | <u>Conditions tested</u>               | <u>Statistical test</u>          |
|-----------------|--|----------------------------------|
| 1               | 1 and 5 (no steelhead)                 | Paired t-test                    |
| 2               | 1, 2, and 5 (test dates 25 Apr-12 May) | Block ANOVA<br>(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**

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## REFERENCES

- Brege, D. A., S. J. Grabowski, W. D. Muir, S. R. Hirtzel, S. J. Mazur, and B. P. Sandford. 1992. Studies to determine the effectiveness of extended traveling screens and extended bar screens at McNary Dam, 1991. Report to U.S. Army Corps of Engineers, Contract E86-91-0060, 50 p. plus Appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)
- Ceballos, J. R., S. W. Pettit, and J. L. McKern. 1992. Fish Transportation Oversight Team. Annual Report FY - 1991. Transportation operations on the Snake and Columbia Rivers. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWR-29. 77 p. plus Appendix. (Available from Environmental and Technical Services Division, 525 N.E. Oregon St., Suite 500, Portland, OR 97232-2737.)
- Gessel, M. H., B. P. Sandford, and D. B. Dey. 1994. Studies to evaluate the effectiveness of extended-length screens at Little Goose Dam, 1993. Report to U.S. Army Corps of Engineers, Contract E86920164, 18 p. plus Appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)
- McComas, R. L., D. A. Brege, W. D. Muir, B. P. Sandford, and D. B. Dey. 1993. Studies to determine the effectiveness of extended-length submersible bar screens at McNary Dam, 1992. 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.)
- 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)<sup>a</sup>

| Location             | Yearling chinook |   |    |                  | Steelhead |   |    |     | Sockeye |   |   |     |
|----------------------|------------------|---|----|------------------|-----------|---|----|-----|---------|---|---|-----|
|                      | L                | C | R  | Tot <sup>b</sup> | 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 <sup>c</sup> | 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  |         |   |   |     |

<sup>a</sup> Test date (Test slot, perforated plate porosity, and guidance device type: ESBS = extended-length bar screen).

<sup>b</sup> Refers to fyke-net column: L = left, C = center, R = right, Tot = total catch for net level.

<sup>c</sup> 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.

| Date     | Yearling chinook |                   |       |              | Steelhead |      |       |              |
|----------|------------------|-------------------|-------|--------------|-----------|------|-------|--------------|
|          | Hatchery         | Wild <sup>a</sup> | 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         |

<sup>a</sup> 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 |                 |                  | Steelhead   |                 |                  |
|---|------------------|-----------------|------------------|-------------|-----------------|------------------|
|   | Total catch      | Number descaled | Percent descaled | Total catch | Number descaled | 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 |                 |                  | Steelhead   |                 |                  |
|---|------------------|-----------------|------------------|-------------|-----------------|------------------|
|   | Total catch      | Number descaled | Percent descaled | Total catch | Number descaled | 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              |     |
| <b>t-test</b> |              |                  |     |
| 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          | 2.27 | 0.1270  |
| Treatment | 42.2           | 2            | 21.1          |      |         |
| 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          | 1.61 | 0.2177  |
| Treatment        | 29.4           | 2            | 14.7          |      |         |
| Error            | 255.2          | 28           | 9.1           |      |         |
| Total            | 836.6          | 44           |               |      |         |
| 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          | 1.32 | 0.2828  |
| Treatment        | 16.1           | 2            | 8.0           |      |         |
| Error            | 170.0          | 28           | 6.1           |      |         |
| Total            | 341.8          | 44           |               |      |         |

Appendix Table B6.--Yearling chinook salmon and steelhead  
 descaling comparison between a 75% porosity  
 ESBS in Slot 5A, a 25% porosity  
 Slot 4A and 4B, and an STS in Slot 5A.  
 ANOVA, means, and standard error

33  
 FINAL PAGE!

| 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 |             |      |         |