Evaluation of the Juvenile Collection and Bypass Systems at Bonneville Dam – 1984

by
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Annual Report

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INTRODUCTION

Initial studies to evaluate the efficiency of the fingerling collection and bypass system at the Bonneville Dam Second Powerhouse began in 1983. These studies showed a very low fish guiding efficiency (FGE) of less than 30% for the submersible traveling screens (STS) (Krcma et al. 1984). Vertical distribution tests, conducted during the same period, indicated two problem areas in developing acceptable (>70%) FGE. First, a large percentage of the smolts were passing through the intakes at a depth below the STS. Second, significant avoidance and/or rejection of guidance was occurring because FGE was approximately half of the potential indicated by vertical distribution studies. An extensive model study program was initiated to investigate ways of improving the distribution of fish entering the turbine intakes and reducing or eliminating the avoidance/rejection problem, thereby improving the guiding capabilities of the STS. A series of methods for improving FGE was developed.

During the 1984 smolt migration, the National Marine Fisheries Service (NMFS) under contract to the U.S. Army Corps of Engineers (CofE) evaluated various methods that were intended to improve the fingerling collection and bypass efficiency at the Bonneville Dam Second Powerhouse (Figs. 1 and 2). Studies were also conducted to evaluate the operation of the newly completed fingerling bypass and indexing facility at the First Powerhouse and identify problem areas and make recommendations if necessary for improved operation.

The 1984 research had the following primary objectives:

1. Evaluate the various modifications/additions developed during model studies to improve FGE at the Second Powerhouse.
Figure 1.—General overview of Bonneville Dam First and Second Powerhouses.
Figure 2.—Cross-section of turbine intake at Bonneville Dam Second Powerhouse showing the items tested in 1984.
2. Continue monitoring the downstream migrant system (DSM) and smolt indexing facilities at the Second Powerhouse.

3. Evaluate the operation of the smolt indexing system facilities at the First Powerhouse.

4. Determine fish quality and stress through the juvenile bypass and indexing system at the First Powerhouse.

5. Measure orifice passage efficiency (OPE) of the fingerling bypass orifices at both powerhouses.

OBJECTIVE I - EVALUATION OF MODIFICATIONS/ADDITIONS TO THE STS AND TRASHRACKS AT THE SECOND POWERHOUSE

Task 1 - STS FGE Tests

The following is a list and brief description and/or purpose of the various modifications/additions that were tested at the Second Powerhouse during 1984 to improve STS FGE:

1. Blocked Trashrack Sections - Existing sections of the trashrack were blocked by attaching steel panels. A total of six racks were modified to provide the capability of blocking the bottom one-third of an entire unit (two racks in each section of the penstock). This forced all the water and fish through the upper portion of the trashrack. This condition could only be tested at minimum turbine load (approximately 35 MW; 10,000 cfs).

2. Louvered Trashrack Sections - Four new trashrack sections were constructed with sloping plates attached at a 30° angle to the normal horizontal support members. This created a louver effect that directed approaching flows upward. Model studies indicated that velocities along the intake ceiling and the volume of flow into the gatewell increased when these racks were positioned in the upper portion of the trashrack array.
3. Lowering the STS - The STS was positioned 1 foot lower in the intake enlarging the throat opening and extending the STS deeper into the intake (Fig. 3).

4. Turning Vane - A curved plate attached to the underside of the support beam at the top of the STS to smooth out flows in the throat area and increase flow up the gatewell [used in conjunction with (3)].

5. Trashrack Deflector - A frame with wedge wire screen of equal porosity (32%) as the STS. It attached to a special trashrack section and was designed to simulate a lengthened STS by screening off the area from the trashrack to the STS. When not in use it could be lowered into a non-fishing stream-flow position. A short deflector was used with the 60° angle STS and a longer deflector with the 48° angle STS.

6. Side Wings on the STS - A modification that closed off an area of potential escapement created by a gap along the side of the STS and the wall (due to the side taper of the intakes). One STS was modified with a frame for attaching nets for evaluation, others were modified with solid plates.

7. Raised Operating Gate - Increased flow up the gatewell.

8. Removed Perforated Plate From Inside STS - Allowed more flow to pass through the STS by increasing its overall porosity from 32 to 40%. This was done to minimize flow deflection that might cause smolt avoidance or rejection.

9. Reduced Turbine Load - Lowered intake approach velocities.

10. Lighting the Forebay - Seven portable light towers were used to illuminate the forebay immediately upstream from the powerhouse during some of the tests to attract fingerlings to the surface. Two towers were placed on the powerhouse deck (near Gatewell 11-B) and directed at the forebay upstream
Figure 3.--Approximate position of the STS in the gateslot at Bonneville Dam Second Powerhouse in the normal (upper figure) and lowered positions, 1984.
from Turbine Unit 12. The remaining five towers were placed along Cascade Island from the powerhouse towards the upstream tip of the island at approximately 200-foot intervals (Fig. 1). Each light tower had four 1,000 watt metal halide lights.

Methods and Procedures

To obtain a substantial increase in FGE, several of the changes were incorporated into single tests. Also, since a large number of conditions were possible, different test combinations were conducted in the A and B Gatewells of Unit 12 simultaneously.

FGE tests were conducted using the same procedures developed in previous years. A net frame attached to the traveling screen supported nets that were used to collect unguided fish (Fig. 4). A standard replicate began by closing the orifice, lowering the STS and net frame into the intake, setting the STS at the required operating angle, dipnetting the gatewell to remove all residual fish, and starting the turbine. As an added precaution against biasing the tests, the turbine was operated only during the hours of actual testing. The gatewell was then dipnetted periodically until sufficient numbers of fish had entered the unit. Each test was ended by lowering the dipnet and leaving it open, shutting the unit off, closing the dipnet and making a final clean-out dip, raising the STS and net frame, and emptying the catch from each net into marked containers. Species identification and number were determined for all fish. Testing occurred from 2000 to 2400 h each test day. During the FGE tests, groups of marked (partial caudal clip) subyearling chinook salmon were used to determine dipnet efficiency. On four successive days, groups of approximately 100 marked fish were released into the gatewell after the turbine reached full load. The releases were made from a weighted
Figure 4.—Cross-section of the turbine intake with a traveling screen, net frame, and attached nets at Bonneville Dam Second Powerhouse and the net layout is also shown - 1984.
container approximately 10-15 feet below the surface. Recapture rates between 98 and 99% indicated dipnetting was very efficient.

Fish quality was monitored by examining fish captured in the gatewell for descaling. Descaling was determined by dividing the fish into five equal areas per side; if any two areas on a side were 50% or more descaled, the fish was classified as descaled. Target species for the FGE tests were yearling and subyearling chinook salmon; information on other species was collected as available.

FGE is the percentage of fish (by species) entering the turbine intake that are guided by the STS out of the intake and into the gatewell for a specific test condition. This is represented by the following formula:

\[
\text{FGE} = \frac{GW}{GW + GN + FN + CN} \times 100
\]

- **GW** = gatewell catch
- **GN** = gap net catch
- **FN** = fyke net catch\(^1\)
- **CN** = closure net catch

For statistical evaluation, tests usually require three to five replicates (about 200 STS guided fish per replicate). However, due to the large number of test conditions and the relatively short time available for testing of individual species, many of the test conditions were not replicated. If the initial test results did not approach 70% FGE or the condition of the fish resulted in unacceptably high descaling or mortality, only one or two replicates were usually conducted. If statistical significance was desired, the following properties were used: (1) the specified statistical significance level, (2) the discrimination of the test, (3) the magnitude of the variability, and (4) the number of treatment or factor levels.

\(^1\) Fyke net catches at levels with only a center net are expanded (x3).
The following formula for calculating confidence intervals for multinomial proportions was used to determine sample size per treatment:

\[ C.I. = P + (B \times P \times (1-P /N)^{1/2} \]

where \( P \) is the estimated probability for one of the treatment categories, \( B \) is the tabular value for the upper percentile of the chi-square distribution with one degree of freedom at the specified significance level for discrimination, and \( N \) is the total sample size.

The variables used to determine the number of replicates are related by the formula:

\[ (H \times S) / (N^{1/2}) \]

where \( H \) is an analysis of means factor and \( S \) is the estimated pooled standard deviation. The means factor is determined as a product of tabular values of the \( t \)-distribution at the specified statistical significance level and the number of replicates and sample size per replicate.

Results

A total of 21 test conditions consisting of 36 individual tests were conducted between 2 May and 6 August. Table 1 lists the test conditions and the corresponding FGE and descaling percentages (a numerical listing of the target species in these tests is shown in Appendix Table 1). Figures 5-8 are cross-sectional views of the intake showing the modifications/additions tested, corresponding FGE, and percentage of fish captured at the different net levels.

Prior to a discussion of these data, it is necessary to reiterate that primarily because FGE was poor in nearly every condition tested, very little replication occurred. With low FGE and the constraints of a relatively short field season, it was more important to test as many configurations as possible.
Table 1.—Traveling screen fish guiding efficiency (FGE) tests on yearling and subyearling chinook salmon conducted in Unit 12 at Bonneville Second Powerhouse during the FY84 field season.

<table>
<thead>
<tr>
<th>Test no.</th>
<th>STS angle of test(s)</th>
<th>Date(s)</th>
<th>Avg. unit disch. (kcfps)</th>
<th>Louvered(^{b}) / Blocked(^{b})</th>
<th>STS lowered (1 foot)</th>
<th>Turning vane</th>
<th>Forebay lights</th>
<th>Perforated plate in STS</th>
<th>Operating gate position</th>
<th>FGE (%)</th>
<th>Categorical mortality (%)</th>
<th>Descaled FGE (%)</th>
<th>Categorical mortality (%)</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>48</td>
<td>2 &amp; 4 May(^{d})/</td>
<td>Yes 48 18;14</td>
<td>2nd</td>
<td>6th</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>In</td>
<td>Normal</td>
<td>46</td>
<td>48 (10)</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>3 May</td>
<td>Yes 48 20</td>
<td>2nd</td>
<td>6th</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>In</td>
<td>Normal</td>
<td>27</td>
<td>46 (14)</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
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<td>2nd</td>
<td>6th</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>In</td>
<td>Normal</td>
<td>36</td>
<td>17</td>
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<tr>
<td>4</td>
<td>48</td>
<td>19 May</td>
<td>Yes 48 14</td>
<td>None</td>
<td>6th</td>
<td>No</td>
<td>No</td>
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<td>No</td>
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<td>6th</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>In</td>
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<td>53</td>
</tr>
<tr>
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<td>Yes 48 10</td>
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<td>5 &amp; 6</td>
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<td>No</td>
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<td>No</td>
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<td>7</td>
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<td>Yes 48 20;19</td>
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<td>No</td>
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<td>No</td>
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<td>-</td>
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<td>No</td>
<td>No</td>
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<td>-</td>
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<td>None</td>
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<td>No</td>
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<td>No</td>
<td>Out</td>
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<td>2 May</td>
<td>Yes 60 18</td>
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<td>6th</td>
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<td>Yes</td>
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<td>6th</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>In</td>
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<td>6th</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
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<td>20 May</td>
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<td>6th</td>
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<td>No</td>
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<td>No</td>
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<td>Up-23</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>In</td>
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<tr>
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<td>60</td>
<td>23, 24 &amp; 25 Jul</td>
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<td>No</td>
<td>No</td>
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<td>Up-23</td>
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<td>21(^{e})/</td>
<td>60</td>
<td>26 &amp; 27 Jul</td>
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<td>No</td>
<td>No</td>
<td>Out</td>
<td>Normal</td>
<td>-</td>
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</table>

\(^{a}/\) KCFS = thousand cubic feet/sec.

\(^{b}/\) This powerhouse has six (6) trashrack sections stacked on top of each other that cover each turbine intake bay; louvered trashrack in the second means the second section from the top. Blocked trashrack in the sixth means the bottom section was blocked.

\(^{c}/\) Indicates the percentage mortality of the various test conditions; descaling percentage include these data.

\(^{d}/\) Each date represents one replicate (one date equals one replicate, two dates equals two replicates, etc.).

\(^{e}/\) These tests are not compatible with any of the other tests because the STS angle was incorrect in relation to the deflector.
Figure 5.--Results of STS tests (48° angle) for yearling chinook salmon showing FGE and percentage fish captured at the various net levels, Bonneville Dam Second Powerhouse, 1984. Test numbers correspond to tests as listed in Table 1 (refer to this table for complete test details).
Figure 6.--Results of STS tests (48° angle) for subyearling chinook salmon showing FGE and percentage fish captured at the various net levels, Bonneville Dam Second Powerhouse, 1984. Test numbers correspond to tests as listed in Table 1 (refer to this table for complete test details).
Figure 7.—Results of STS tests (60° angle) for yearling chinook salmon showing FGE and percentage fish captured at the various net levels, Bonneville Dam Second Powerhouse, 1984. Test numbers correspond to tests as listed in Table 1 (refer to this table for complete test details).

[Diagram showing results for different test dates with FGE values and percentage fish captured at various net levels]
Figure 8.—Results of STS tests (60° angle) for subyearling chinook salmon showing FGE and percentage fish captured at the various net levels, Bonneville Dam Second Powerhouse, 1984. Test numbers correspond to tests as listed in Table 1 (refer to this table for complete test details).
to try and improve FGE rather than replicate conditions yielding poor FGE just to obtain sufficient data for statistical evaluation. With this perspective, the following is a discussion of the possible effects of the different modifications/additions on FGE and descaling:

**Blocked Trashrack Sections** - This condition was tested in conjunction with other modifications (deflector and/or louvered trashrack). In 11 of 12 tests, FGE did not exceed 50%. In Test 6, FGE was 86%. During this test, the two trashracks below the 48° deflector were blocked, thus forcing almost all the flow (and fish) into the area intercepted by the deflector and STS. Only a small area below the deflector remained unblocked; it consisted of a short section of trashrack (approximately 3 feet high) that supported the deflector. For this test, it was also necessary to operate the unit at a minimum load of approximately 35MW (about 10,000 cfs) for structural reasons and also to reduce velocity through the screen area as much as possible. Even with reduced velocity, descaling was extremely high—exceeding 50%.

**Louvered Trashrack Section** - Tests 11 and 13 indicate use of this modification may have actually decreased FGE (34% w/louver vs 41% w/o louver).

**Lowering STS and Turning Vane** - No independent comparison could be made of this modification. However, it would appear there was no benefit from a lowered STS. In tests where they were used, FGE still remained low and descaling high in addition to higher levels of mortality (Tests 1-3 and 9-15).

**Trashrack Deflectors** - This addition simulates an extension of the STS and should theoretically intercept significantly more fish. FGE test results indicated a slight increase for yearling chinook salmon (Test 17 - FGE 32%) when compared to 1983 data (FGE 19.3% ± 7.0). However, this is still only about one-half of what it should be based on vertical distribution data (see section on vertical distribution results). This condition also appeared to be more detrimental to fish as indicated by an increase in descaling.

16
Side Wings - A very small percentage \((12/714 = 1.7\%)\) of the total (guided plus unguided) fingerlings were captured in this area.

Raised Operating Gate - No major increase in FGE was noted when tested with subyearling chinook salmon. Two raised gate conditions were tested; one with and without perforated plate in the STS and the other with and without the deflector. For Tests 9 and 10 (no perforated plate), FGE for the normal gate vs raised gate was 29 vs 30\%, and in Tests 18 and 19 (without deflector), it was 27 and 29\%, respectively.

Removing Perforated Plate from Inside the STS - No appreciable benefit could be related to removal of the perforated plates (Tests 7, 9, and 10).

Reduced Turbine Load - Descaling appeared to be significantly decreased, but FGE was not enhanced (Tests 3 and 14). The reduced descaling rates, though, were still unacceptably high—17 and 19\%, respectively.

Lighting of Forebay - No consistent pattern of improvement occurred with forebay lights. In Tests 1 and 2, forebay lights appeared to improve FGE (46 vs 27\%), but in Tests 11 and 12, no benefit was noted (34 vs 35\%). The highest FGE for any lighted forebay condition was 46\%, well below an acceptable level of FGE.

In summary, in all but one test (everything completely blocked), FGE was not appreciably improved by the various modifications over that measured in 1983. In some instances, it appeared that some of the items tested were actually counter-productive, e.g., the tests with partially blocked trashracks and deflectors. Both of these additions theoretically should have increased FGE simply because they both reduced the unscreened area of the intake, thereby forcing more fish into the area that should be intercepted by the STS. However, both were counter-productive based on vertical distribution...
information which showed that the STS guided only 30 to 50% of the fish available for interception. Apparently, fish are avoiding or rejecting the STS (Krcma et al. 1984). Possible reasons for this rejection include: (1) there is a flow restriction that subsequently produces a "zone of resistance" that fish detect and avoid, (2) an increasing velocity beneath the STS that is attractive to smolts, (3) a flow deflection that diverts a percentage of the intercepted fish below the STS, or (4) a combination of all three. If this is true, then reducing the open area of the intake (by adding blocked trashracks and/or a deflector) quite possibly compounds these guidance problems and may even transfer the "zone of resistance" further upstream while simultaneously flows are increasing beneath the guiding device. Methods for testing these theories have been developed and will be conducted during the 1985 field season.

Task 2 - Vertical Distribution Tests

Methods and Procedures

Vertical distribution data were obtained by using a single column of fyke nets attached to a frame installed in the turbine intake. Figure 9 illustrates this frame with the number and position of each net. The lower nets (4-7) were about 6.0 x 6.5 ft at the mouth and approximately 15 ft long. The upper nets (1-3) were the same size but were divided in half in an attempt to more accurately define the distribution of the fish in the area intercepted by the STS or deflectors. The nets tapered to an 8-inch diameter metal ring to which a 3-ft long cod-end bag was attached. A standard replicate was conducted in the same manner as the FGE tests, i.e., closing the orifice, lowering the net frame, dipnetting the gatewell, etc. As in the FGE tests, the turbine was run only during the hours when tests were conducted.
Figure 9.—Cross-section of the turbine intake at Bonneville Dam Second Powerhouse with vertical distribution frame and fyke nets, including a view showing the net layout, 1984.
Testing occurred from 2000 to 2400 h under full turbine load, 70 ± 5 MW (approximately 20,000 cfs). At the end of each test, individual net catches were identified and enumerated by species. Vertical distribution was based on an estimate of the total number of fish entering the intake. Since the single column of fyke nets fished the middle third of the intake, each net catch was multiplied by a factor of three to estimate the number of fish in that net level. The sum of these estimates plus the gatewell catch provided an estimate of the total number of fish entering the intakes during the test. The percentage of fish for each net level (vertical distribution) was determined by dividing the computed figure for each net level by the total intake estimate. Half net data from the top rows were combined for comparison to 1983 data. Vertical distribution testing was done with various combinations of intake conditions. All but two of the conditions tested in 1984 were replicated a minimum of three times.

Results

Twenty-one vertical distribution tests were conducted from 5 May through 20 June. Tests were conducted in Units 12A, 12B, and 15B. Vertical distribution was measured for five different intake conditions: (1) one louvered and one blocked trashrack, (2) 48° deflector with one louvered and one blocked trashrack, (3) 48° deflector only, and (4) 60° deflector only, and (5) intake with no modifications (net frame only). Tables 2 and 3 summarize the results of these tests for yearling chinook and coho salmon and subyearling chinook salmon. Additional details including date, number of fish per net, etc., for each test are contained in Appendix Tables 2 and 3.

These tests indicate that the deflectors and partially blocked trashracks, in conjunction with the STS should be capable of intercepting and
Table 2.--Percentage of yearling chinook salmon and coho salmon in gatewells and fyke nets during vertical distribution tests conducted at Bonneville Dam Second Powerhouse in 1983 and 1984.

<table>
<thead>
<tr>
<th>Location</th>
<th>Test 1 (12B), yearling chinook, louvered rack (2nd), blocked rack (6th) (3)</th>
<th>Test 2 (12B), yearling chinook, 48° deflector, louvered rack (2nd), blocked rack (6th) (2)</th>
<th>Test 3 (12B), yearling coho, 48° deflector (3)</th>
<th>Test 4 (12A), yearling chinook, 60° deflector, blocked rack (6th) (2)</th>
<th>1983 Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatewell</td>
<td>Approximate distance from intake ceiling (feet)</td>
<td>Individual (%)</td>
<td>Cumulative (%)</td>
<td>Individual (%)</td>
<td>Cumulative (%)</td>
</tr>
<tr>
<td>Gatewell</td>
<td>8.8</td>
<td>17.6</td>
<td>17.9</td>
<td>23.6</td>
<td>12.1</td>
</tr>
<tr>
<td>Net 1</td>
<td>6.5</td>
<td>32.1</td>
<td>40.9</td>
<td>48.3</td>
<td>65.9</td>
</tr>
<tr>
<td>Net 2c</td>
<td>13.0</td>
<td>23.9</td>
<td>64.8</td>
<td>14.8</td>
<td>80.7</td>
</tr>
<tr>
<td>Net 3d</td>
<td>19.5</td>
<td>12.2</td>
<td>77.0</td>
<td>5.1</td>
<td>85.8</td>
</tr>
<tr>
<td>Net 4e</td>
<td>26.0</td>
<td>9.1</td>
<td>86.1</td>
<td>4.0</td>
<td>89.8</td>
</tr>
<tr>
<td>Net 5</td>
<td>32.5</td>
<td>3.5</td>
<td>89.6</td>
<td>5.7</td>
<td>95.5</td>
</tr>
<tr>
<td>Net 6</td>
<td>39.0</td>
<td>4.3</td>
<td>93.9</td>
<td>4.0</td>
<td>99.5</td>
</tr>
<tr>
<td>Net 7</td>
<td>45.5</td>
<td>6.0</td>
<td>100.0</td>
<td>0.6</td>
<td>100.0</td>
</tr>
</tbody>
</table>

a/ ( ) gatewell.
b/ Number of replicates.
c/ Level that could theoretically be intercepted by the STS at the 48° angle.
d/ Level that could theoretically be intercepted by the STS at the 60° angle and a trashrack deflector.
e/ Level that could theoretically be intercepted by the STS at the 48° angle and a trashrack deflector.
Table 3.—Percentage of sub-yearling chinook salmon in gatewells and fyke nets during vertical distribution test conducted at Bonneville Dam Second Powerhouse in 1983 and 1984.

<table>
<thead>
<tr>
<th>Location</th>
<th>Approximate distance from intake ceiling (feet)</th>
<th>1984 Tests</th>
<th>1983 Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test 1 (12B), 48° deflector</td>
<td>Test 2 (12B), net frame only</td>
<td>Test 3 (15B), net frame only</td>
</tr>
<tr>
<td></td>
<td>Individual (%)</td>
<td>Cumulative (%)</td>
<td>Individual (%)</td>
</tr>
<tr>
<td>Gatewell</td>
<td>10.1</td>
<td>9.6</td>
<td>13.7</td>
</tr>
<tr>
<td>Net 1</td>
<td>6.5</td>
<td>29.0</td>
<td>39.2</td>
</tr>
<tr>
<td>Net 2</td>
<td>13.0</td>
<td>17.6</td>
<td>56.8</td>
</tr>
<tr>
<td>Net 3</td>
<td>19.5</td>
<td>11.8</td>
<td>68.6</td>
</tr>
<tr>
<td>Net 4</td>
<td>26.0</td>
<td>7.6</td>
<td>76.2</td>
</tr>
<tr>
<td>Net 5</td>
<td>32.5</td>
<td>8.2</td>
<td>84.4</td>
</tr>
<tr>
<td>Net 6</td>
<td>39.0</td>
<td>11.6</td>
<td>96.0</td>
</tr>
<tr>
<td>Net 7</td>
<td>45.5</td>
<td>4.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

a/ () gatewell.
b/ Number of replicates.
c/ Level that could theoretically be intercepted by the STS at the 48° angle.
d/ Level that could theoretically be intercepted by the STS at the 60° angle and a trashrack deflector.
e/ Level that could theoretically be intercepted by the STS at the 48° angle and a trashrack deflector.
guiding over 70% of the subyearling chinook salmon and 80% of the yearling fish. However, FGE for similar test configurations ranged between 20 and 30% for subyearlings and 26 to 41% for yearling fish.

It was difficult to say if vertical distribution for fingerling salmonids was significantly different between gatewells because intake conditions were not the same for many of the tests in 1984. However, the differences were relatively minor and in no circumstances could they be construed as being capable for significantly improving FGE.

OBJECTIVE II - CONTINUED MONITORING OF THE SECOND POWERHOUSE DSM AND SMOLT INDEXING FACILITIES

The random sampler in the Second Powerhouse provides the means to examine the condition of salmonids passing through the downstream migrant bypass system (DSM) and to index smolt migrations passing Bonneville Dam. The DSM consists of a smolt sampler designed to randomly collect a portion of the juvenile migrants passing through the DSM, a dry separator for removing adult fish and debris, a wet separator in the migrant observation room for separating juvenile migrants by size, and four raceways to hold fish graded by the wet separator.

The 1984 evaluation of the DSM and indexing system had the following primary research objectives: (1) enumerate fish collected by species, measure descaling, and record marks daily throughout the 1984 juvenile salmonid outmigration; (2) improve the size grading capability of the wet separator; (3) evaluate a modified sampling system for taking sample sizes of less than 10%; and (4) monitor DSM operation to determine if recommended improvements to correct deficiencies identified during the past 2 years are satisfactory.
Task 1 - Smolt Indexing

Methods and Procedures

Fish passing through the Second Powerhouse bypass system that were collected by the random sampler were used as an index of the smolt migration and examined to monitor their quality. At least twice a day fish were crowded to the downstream end of the raceways and dipnetted into an anesthetic bath (MS 222). The anesthetized fish were enumerated by species or race and examined for descaling and marks. Descaling was determined by dividing the fish into five equal areas per side; if any two areas on a side were 50% or more descaled, the fish was classified as descaled. Using this criteria, fish classified as descaled are considered to have a poor chance of survival. When large numbers of fish were captured, subsamples of 200 fish per species or race were examined and the remainder enumerated and released. During most weeks, the random sampler was operated Monday through Friday, 24 h a day. Estimates of total weekly passage (by species) were determined by expanding the catch per unit effort from Appendix Table 4 x 10 (random sampler efficiency is 10%).

Results

Between 23 April and 4 October, the random sampler operated for 2,153 h for an average of about 90 h per week. During this time, a total of 80,379 juvenile salmonids were captured, of which 36,099 were examined for descaling and injury (Appendix Table 4). These numbers represent a passage rate for a restricted powerhouse operating level. Usually only three or four of the existing eight turbines at the Second Powerhouse were running during peak periods of fish movement. This limitation was implemented by the CofE to provide added protection for salmonid smolts at this powerhouse until better passage conditions are developed. Figure 10 illustrates a weekly estimate of
Figure 10.--Weekly estimated passage of salmonids at Bonneville Dam Second Powerhouse, 23 April to 6 October 1984.
the number of fish by species that were bypassed at the Second Powerhouse during the period 23 April to 4 October. Periods of peak migration and the total estimated Second Powerhouse DSM passage by species were: (1) yearling chinook salmon 7 May - 312,750; (2) subyearling chinook salmon 14 May - 853,520; (3) steelhead 14 May - 46,580; (4) coho salmon 21 May - 209,460; and (5) sockeye salmon 14 May - 34,990.

The amount of descaling varied among species. Sockeye salmon had the highest descaling rate (28.3%) and coho salmon the lowest (1.9%). Yearling chinook salmon, subyearling chinook salmon, and steelhead had descaling rates of 9.6, 3.2, and 5.9%, respectively. Compared to 1983 data (Krcma et al. 1984), these descaling rates are higher for yearling chinook salmon, subyearling chinook salmon, and sockeye salmon, but lower for coho salmon and steelhead.

Mortality rates during 1984 were highest for sockeye salmon (23.5%) followed by subyearling chinook salmon (4.5%). Mortality rates for other species were low. Of particular concern was the increased mortality and descaling rates for subyearling chinook salmon at both the First and Second Powerhouses in 1984. At the Second Powerhouse, the subyearling chinook salmon mortality rate was nearly four times greater and the descaling rate three times greater than in 1983 (Krcma et al. 1984). To determine where this injury and descaling was occurring, releases of marked subyearling chinook salmon (three replicates, approximately 600 fish per replicate) were made on 3 June into Gatewell 17A at the Second Powerhouse. The resulting combined mortality and descaling rate was less than 0.2%. These data indicated that the injury and descaling were occurring before the fish entered the gatewell. A possible explanation of this mortality is the quality of fish
passing through the dam. Bonneville Dam is the first hydroelectric project encountered by subyearling chinook salmon released from several local hatcheries. The majority of the subyearling chinook salmon examined at the Second Powerhouse were from these releases. Of 16,833 subyearling chinook salmon captured at the Second Powerhouse from a Spring Creek National Fish Hatchery (NFH) release of subyearling chinook salmon in May, 6.1% suffered mortalities and 5.2% were descaled. Mortality and descaling rates in the DSM returned to a more acceptable level after these hatchery releases passed Bonneville Dam.

A total of 4,248 adipose fin clipped and/or branded salmonids were captured at the Second Powerhouse in 1984—4,036 adipose clips and 212 nitrogen freeze brands (Table 4). Individual brand information is available to interested agencies (c/o William Muir, P.O. Box 67, North Bonneville, WA 98639).

Sampling at the Second Powerhouse indexing facilities was discontinued on 4 October because of problems with the mesh on the inclined screen in the DSM. Because of the small numbers of salmonids passing through the Second Powerhouse at this time of year, repair of the inclined screen was postponed and fish were bypassed through the emergency relief conduit. Monitoring of the smolt migration was continued by dipnetting gatewells until 1 December when the STS were removed for annual maintenance requirements (Appendix Table 5).

Task 2 - Wet Separator Evaluation

Methods and Procedures

The wet separator in the Second Powerhouse consists of three grading compartments and an overflow area. In the first, second, and third
Table 4.—Numbers of marked salmonids captured at the Second Powerhouse indexing facility at Bonneville Dam in 1984.

<table>
<thead>
<tr>
<th>Mark</th>
<th>Yearling chinook</th>
<th>Subyearling chinook</th>
<th>Steelhead</th>
<th>Coho</th>
<th>Sockeye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adipose clips</td>
<td>1,372</td>
<td>431</td>
<td>823</td>
<td>1,409</td>
<td>1</td>
</tr>
<tr>
<td>Brands</td>
<td>178</td>
<td>1</td>
<td>22</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>
compartments there are 3/8-, 3/4-, and 1 1/2-inch spacing between the grading bars, respectively. Each compartment empties into a separate raceway with the overflow diverted into a fourth raceway.

In 1983, the separator only successfully graded 54% of the fish. We felt that fluctuating water levels, mostly at night, caused the poor separation. During 1984, 4 weeks of data were recorded for both day and night operation to determine the impact of fluctuations in water levels in the DSM. During the day when NMFS personnel were in the vicinity of the wet separator, water levels were kept at or near the optimum level for separation. During the night, water levels in the wet separator were raised to reduce the threat of stranding caused by fluctuating water levels in the DSM. Species composition and length frequencies were recorded for each raceway and combined weekly for analysis.

Results

For the 4-week test in 1984, an average of 71.6% of the subyearling chinook salmon were separated by the 3/8-inch grader during the day, 41.3% during the night, and 58.0% combined (Table 5). The range was 67.8-77.6% for daytime separation and 32.9-47.5% for nighttime separation. Separation of other species was also improved with the better water level controls in daytime hours. If accurate separation is required, the data strongly support the need for accurate water level control.

Several factors affected the separation data collected during 1984. First, although water levels in the separator were lowered and monitored during the day, there was still some fluctuation. In general, water level control was much improved over 1983, but could still be improved. Second, to avoid a buildup of fish in the dry separator in the DSM, it was drained each
<table>
<thead>
<tr>
<th>Grader size</th>
<th>Yearling chinook</th>
<th>Subyearling chinook</th>
<th>Steelhead</th>
<th>Coho</th>
<th>Sockeye</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent capture</td>
<td>Mean fork length (mm)</td>
<td>SE</td>
<td>Percent capture</td>
<td>Mean fork length (mm)</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>26.1</td>
<td>131.5</td>
<td>0.8*</td>
<td>71.6</td>
<td>90.8</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>37.2</td>
<td>142.9</td>
<td>0.9*</td>
<td>13.9</td>
<td>90.2</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>36.7</td>
<td>145.0</td>
<td>1.1*</td>
<td>14.5</td>
<td>89.3</td>
</tr>
<tr>
<td></td>
<td>daytime operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>14.5</td>
<td>132.1</td>
<td>0.9*</td>
<td>41.3</td>
<td>90.1</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>27.4</td>
<td>143.7</td>
<td>0.8*</td>
<td>11.3</td>
<td>90.9</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>51.2</td>
<td>145.6</td>
<td>0.8*</td>
<td>36.1</td>
<td>91.1</td>
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<tr>
<td>+Overflow</td>
<td>6.9</td>
<td>137.6</td>
<td>1.5</td>
<td>11.3</td>
<td>78.6</td>
</tr>
<tr>
<td></td>
<td>nighttime operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = P < 0.05.
+ = No statistical comparison.
morning. Wet separator water levels were adjusted during this operation to keep from stranding fish. Third, although data were recorded separately for day and night, fish still held up in the wet separator from one time period to another. If hold up in the dry and wet separators were reduced or eliminated and water level fluctuations controlled in the DSM, species separation could be improved.

Task 3 - Modified Sampling System
Because of mechanical problems associated with raising and lowering the random sampler, tests for taking samples of less than 10% were cancelled.

Task 4 - DSM Improvements Evaluation
None of the improvements recommended were completed, thus no evaluation was conducted.

Task 5 - Sampling During Releases of Lower River Hatchery Fish
Large numbers of salmonids can often be expected to enter the bypass system soon after local hatchery releases. To avoid handling large numbers of these production releases, while retaining the ability to sample other salmonids, a compartment bypass method was tested. To use this method, the outlet pipe from the desired compartment of the wet separator was connected directly to the raceway overflow. Fish then bypass the raceway and go directly from the wet separator into the downwell and return to the river. Wet separator evaluation data from Table 5 were then used to estimate numbers of fish utilizing the bypassed compartment (i.e., if the 3/8-inch grader compartment was bypassed, then numbers of subyearling chinook salmon collected in the other three compartments divided by 0.299 would provide the estimate of numbers of bypassed subyearlings, etc.).
A 5 June release of 6.9 million subyearling chinook salmon from Little White Salmon NFH was chosen to test the compartment bypass method. On 5 June, this compartment was connected to the raceway overflow, and water levels were monitored continually for the next 3 days. During this period, a total of 3,633 salmonids (all species) were sampled. Had fish not been bypassed, we estimated a total of 9,957 would have been sampled. Thus, we were able to significantly reduce the numbers of sampled fish while still providing accurate estimates of passage.

OBJECTIVE III - EVALUATION OF THE FIRST POWERHOUSE SMOLT INDEXING FACILITIES

The juvenile bypass system at the First Powerhouse was completed during 1984, and began operating on 17 April. The basic design includes features in common with other bypass systems. Submersible traveling screens guide fish into the upstream gatewells. Vertical barrier screens prevent guided fish from re-entering the turbine intake via the downstream gatewell. Fish exit the gatewells through orifices and enter a transportation channel that terminates in an outfall conduit with a submerged discharge in the tailrace.

Features of the system unique to the First Powerhouse include: (1) 14-inch diameter orifices (equipped for timed, automatic back-flushing for debris removal) that operate at a minimum head of about 2.5 feet and with a submerged discharge; (2) a non-sloping transportation channel confined to the existing ice and trash sluiceway, so that flow may run either north to the 24-inch diameter outfall conduit (normal operation) or south into the ice and trash sluiceway; (3) the manual installation of a fish collection tank and flume for sampling of fish (Fig. 11); (4) the ability to either discharge excess water, dissipated through the adjustable inclined screen, to the tailrace through a
Figure 11.—Cross-section of the juvenile bypass (downstream end) system at Bonneville Dam First Powerhouse, 1984.
48-inch diameter emergency relief conduit or pump excess water back into the forebay (as a water/energy conservation method); and (5) an add-in gate designed to automatically adjust as the forebay fluctuates to maintain a constant water level in the transportation channel, on the inclined screen, and in the emergency relief conduit.

The primary objectives of the evaluation of the smolt indexing facilities were to determine the utility and efficiency of the sampling equipment.

Accomplishment of the objectives was hindered by repeated mechanical failures of the inclined screen trash sweep and by malfunction of the automatic water level controls. These problems usually required reversal of the transportation channel flow to the south (away from the sampling facilities). Downtime for sampling purposes totaled 49 days from 17 April to 10 June (Appendix Table 6). More reliable operation was achieved from 10 June until 21 October when the inclined screen trash sweep failed again, and bypass flow was directed to the south where it remained until the end of the season. Appendix Table 7 is a summary of the smolts captured with the sampling equipment from 30 April to 20 September. From 26 September until 1 December monitoring of the smolt migration was done by dipnetting gatewells (Appendix Table 8). When monitoring was discontinued, fewer than 10 fish per day were estimated entering Gatewell 10A with an STS.

Task 1 - Utility of Sampling Equipment

Methods and Procedures

Sampling equipment included a sample tank, sample flume, dump chute, holding tank, anesthetic trough, and recovery tanks. The sampling procedure began by lowering the sample tank and flume onto a support arm over the downwell (Fig. 11). The sample flume was then tipped to bridge the gap
between the sample tank and crest of the inclined screen. After fishing for the desired time, the sample flume was removed from the flow and the sample tank raised. Fish were transferred to the holding tank (through the dump chute), anesthetized, examined, allowed to recover, and released.

Results

Considerable difficulty was experienced handling the sample tank and flume, specifically during placement into the fishing position and transferring the catch to the holding tank. These and other deficiencies were addressed and are listed under General Recommendations. Modifications are underway and should be implemented before the 1985 field season.

Task 2 - Efficiency of Sampling Equipment

Methods and Procedures

The sample flume intercepts approximately 25% of the flow width at the inclined screen crest. If the smolts are randomly distributed across the channel, then fishing for 20 minutes each hour should result in a sampling efficiency of approximately 8%. To measure this and provide information on descaling (see Objective IV), groups of marked subyearling chinook salmon were released at several points within the bypass system.

Results

The marked fish releases provided some information concerning sampler efficiency, but were inadequate for complete evaluation. An average of 10% of the marked fish released into Gatewell 1A were recovered by the sampler (244/2451, range 6.2 - 12.7%) for three replicates (Table 6). The major problem was that the sampler could not be fished on a continuous basis. This problem was addressed, and an improved technique will be tried during the 1985 field season.
Table 6.—Summary of recaptures and descaling for various groups of marked subyearling chinook salmon released in the Bonneville Dam First Powerhouse DSM, 1984.

<table>
<thead>
<tr>
<th>Release location</th>
<th>Replicate number</th>
<th>Total</th>
<th>Percent descaled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
</tr>
<tr>
<td>Gate slot 1A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number released</td>
<td>863</td>
<td>896</td>
<td>692</td>
</tr>
<tr>
<td>Number recaptured</td>
<td>87</td>
<td>114</td>
<td>43</td>
</tr>
<tr>
<td>Percent recaptured</td>
<td>10.1</td>
<td>12.7</td>
<td>6.2</td>
</tr>
<tr>
<td>Upper transportation channel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number released</td>
<td>856</td>
<td>843</td>
<td>898</td>
</tr>
<tr>
<td>Number recaptured</td>
<td>64</td>
<td>274</td>
<td>181</td>
</tr>
<tr>
<td>Percent recaptured</td>
<td>7.5</td>
<td>32.5</td>
<td>20.6</td>
</tr>
<tr>
<td>Lower transportation channel a/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number released</td>
<td>844</td>
<td>840</td>
<td>856</td>
</tr>
<tr>
<td>Number recaptured</td>
<td>351</td>
<td>401</td>
<td>483</td>
</tr>
<tr>
<td>Percent recaptured</td>
<td>41.6</td>
<td>47.7</td>
<td>56.4</td>
</tr>
<tr>
<td>Lower transportation channel b/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number released</td>
<td>887</td>
<td>916</td>
<td>894</td>
</tr>
<tr>
<td>Number recaptured</td>
<td>360</td>
<td>452</td>
<td>465</td>
</tr>
<tr>
<td>Percent recaptured</td>
<td>40.6</td>
<td>49.3</td>
<td>52.0</td>
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</tbody>
</table>

a/ Upstream of concrete support member.

b/ Downstream of concrete support member.
OBJECTIVE IV - MONITOR FISH QUALITY AND STRESS ON FINGERLINGS IN THE BYPASS AND INDEXING FACILITIES AT THE FIRST POWERHOUSE

Task 1 - Fish Quality

Methods and Procedures

Groups of freeze branded and partial caudal clipped subyearling chinook salmon (tule stock, Spring Creek NFH) were used to determine if fish quality was adversely impacted by the First Powerhouse bypass system. Fish were transported to Bonneville Dam, held for 2 days, marked, and allowed to recover for 4 days before release. Release locations included: (1) Gatewell 1A, (2) upper transportation channel, and (3) two places in the lower transportation channel; one upstream and one downstream from the concrete support member that obstructs a portion of the lower channel (Fig. 11). Releases began on 25 June, and each was replicated three times on successive days. Sampling was done for 20 minutes each hour from first release until catches indicated the marked fish were clear of the system. All marked fish recovered during the tests were examined for descaling. Standard descaling criteria were used to determine fish quality (see Objective II).

Results

Table 6 is a summary of the recapture and descaling data from the marked fish releases. Only four subyearlings (0.1%) out of a total recapture of 3,275 were classified as descaled. It should be noted that these marked fish were not in a smolting condition, consequently, they may have been less susceptible to descaling than natural migrants. During a period when a direct comparison between DSM descaling and gatewell descaling (fish that had not passed through the system) could be made on subyearling chinook salmon,
descaling was 3.5 and 1.0%, respectively, indicating a slight amount of
descaling might be attributable to the DSM. Further evaluation will be
conducted during the 1985 field season.

Task 2 - Stress Tests

Methods and Procedures

Seawater challenge was used to measure stress on yearling chinook salmon
at the First Powerhouse. These tests were to be conducted for two purposes:
(1) to measure stress at various points within the DSM (continual mechanical
breakdowns precluded these tests) and (2) to measure stress in gatewells
equipped with either a standard or a balanced flow vertical barrier screen
(SVBS or BFVBS). The BFVBS is designed to evenly distribute the flows through
the barrier screens, thereby alleviating any turbulent (potentially stressful)
areas that may be present when using the SVBS.

Samples of yearling chinook salmon were collected during three periods of
the smolt migration (early season - 15 and 16 May; mid-season - 22, 23, and 24
May; and late season - 30 and 31 May and 1 June). Smolts were collected from
the gatewells with a standard dipnet. Samples were then taken with a small
dipnet equipped with a sanctuary bag. Fish were transferred using water to
water techniques into 10-gallon aquariums. Fish were held in the dark, in an
artificial seawater environment during testing. Water temperature was
maintained at ambient river temperature by using an external water bath
circulating system.

Mortality in seawater challenge tests was used as an indicator of
stress. At the termination of each test, counts of live and dead fish were
used to form contingency tables. The G-statistic as described by Sokal and
Rohlf (1981) was used to test for significance at the df = 0.05 levels. Data
were also collected on individual length, descaling, injuries, and disease symptoms.

Results

No significant difference in stress was determined between fish collected from gatewells equipped with either the SVBS or BFVBS ($P = 0.55$, df = 1) (Fig. 12). Data for the individual replicates are given in Appendix Tables 9-11.

OBJECTIVE V - MONITOR ORIFICE PASSAGE EFFICIENCY AT BOTH POWERHOUSES

Orifice passage efficiency (OPE) tests were to be conducted at both powerhouses during the 1984 field season. Tests were not conducted at the Second Powerhouse because the orifice trap is located in Unit 12B, and FGE tests took priority. Tests were, however, conducted at the First Powerhouse to compare OPE for 12- and 14-inch diameter orifices, SVBS and BFVBS, and for three different types of lights; standard quartz, high pressure sodium, and metal halide.

Methods and Procedures

OPE tests were conducted from 14 May to 25 August. Fish passing through the orifice of Gatewell 9C were captured by means of an inclined plane trap installed in the ice and trash sluiceway. Because there was room for only one trap, tests had to be run consecutively rather than as the more desirable paired replicate. Target species were yearling and subyearling chinook salmon. Tests comparing 12- and 14-inch diameter orifices were conducted in May when yearling fish dominated the catch. The remaining tests were conducted in June and July when mostly subyearling chinook salmon were present. All tests were 24 h in duration, beginning and ending during periods
Figure 12.—Seawater challenge stress tests conducted with yearling chinook salmon collected from gate slots equipped with balance flow (BFVBS) or standard (SVBS) vertical barrier screens, Bonneville Dam First Powerhouse, 1984. The bars show the 90% confidence intervals for each test condition.
of low fish movement (typically 1000-1400 h). OPE was determined by direct
comparison of the number of fish in the trap to the number that were collected
from the gatewell by dipnetting at the end of each test. A minimum of three
replicates with at least 200 fish of the target species was required for
statistical analysis utilizing the G-statistic (Sokal and Rohlf 1981). An OPE
approaching 75% in a 24-h period was considered acceptable.

Results

Table 7 summarizes the data for the OPE tests. Data for individual
replicates that meet the minimum number requirement were lumped for
analysis. Appendix Table 12 gives the collection data for the individual
replicates. No significant difference (G = 2.89, df-1, P = 0.09) was found in
OPE for yearling chinook salmon when comparing the 14- and 12-inch diameter
orifices (70.0 and 73.1%).

Periodical bypass channel reversals occurred due to breakdowns in the DSM
which limited the amount of OPE testing that could be accomplished.
Therefore, only the 12-inch + diameter orifice was used for tests comparing
BFVBS and SVBS. These tests were conducted later in the season when only
subyearling chinook salmon were available. The results indicated the OPE
appeared to be slightly better with a BFVBS than with a SVBS. Average OPE for
16 tests was 85 vs 79%. These differences, however, were not statistically
significant because of variability in OPE among replicates for both barrier
screen conditions. These variabilities may have resulted from changes in the
behavioral response of different races of fish collected during the 2 months
of testing; time lapses between replicates were as much as 7 days (Table 7).
In addition, tests with a SVBS were run 1 month earlier (4 June to 10 July)
than those with a BFVBS (17 July to 1 August). Tests in 1985 have been
Table 7.—Summary of the OPE data collected at Bonneville Dam First Powerhouse, 1984.

### Yearling Chinook Salmon

<table>
<thead>
<tr>
<th>Date</th>
<th>14-inch orifice</th>
<th>12-inch orifice</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Trap catch (no.)</td>
<td>Total catch (no.)</td>
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<td>14 May</td>
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<td>564</td>
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<td>613</td>
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### Subyearling Chinook Salmon

<table>
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<th>BFVBS</th>
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</thead>
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<td>Total catch (no.)</td>
</tr>
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<td>337</td>
</tr>
<tr>
<td>11 Jun</td>
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<td>291</td>
<td>374</td>
</tr>
<tr>
<td>1 Jul</td>
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<td>734</td>
</tr>
<tr>
<td>2 Jul</td>
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<td>615</td>
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<tr>
<td>5 Jul</td>
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<td>989</td>
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<td>419</td>
<td>466</td>
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<td>10 Jul</td>
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<td>345</td>
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designed to obtain more accurate comparisons of OPE by having to minimize potential bias in results from extended testing.

GENERAL CONCLUSIONS

1. Modifications of the trashrack and STS improved FGE over 1983, but not enough to be acceptable (only 20-40% for most tests). Descaling was higher than desired.

2. The low FGE measured indicates a major problem of deflection or rejection because vertical distribution tests indicated the STS in conjunction with a trashrack deflector should be capable of intercepting and guiding at least 70% of the fish.

3. Descaling of sockeye, yearling chinook, and subyearling chinook salmon in the DSM of the Second Powerhouse in 1984 was higher than in 1983; descaling of coho salmon and steelhead was lower. Sockeye salmon had the highest descaling and mortality.

4. Separating juvenile salmonids by size with the wet separator in the DSM at the Second Powerhouse can be accomplished if water levels can be controlled.

5. The wet separator compartment bypass method tested allows sampling during local hatchery releases without handling an excessive number of fish.

6. Mechanical breakdowns prevented a complete evaluation of the First Powerhouse smolt bypass and indexing facilities.

7. No significant difference in stress was found between groups of yearling chinook salmon collected from gatewells equipped with either a SVBS or a BFVBS.
8. No significant difference in OPE was found between 12- and 14-inch diameter orifices for yearling chinook salmon. OPE for subyearling chinook salmon was not significantly higher in gatewells equipped with a BFVBS.

GENERAL RECOMMENDATIONS

The following list of recommendations were developed at the end of the 1984 operating season. Since then, some of the modifications have been completed and others are in the process and should be finished in time for the 1985 season.

Second Powerhouse

1. Continue FGE testing to determine the cause of the deflection, rejection, or avoidance and determine where it is occurring.

2. Defer OPE testing until satisfactory FGE is achieved.

3. Repair or modify the automatic water level controls to eliminate fluctuations in the water level of the wet and dry separators in the DSM.

4. Modify random sampler in the DSM to allow it to be inserted or removed from the flow automatically. This would allow sampling of less than 10% of the fish from the DSM when desired.

5. Brace tracks of the random sampler to keep them from separating.

6. Complete installation of the spray bar system located between the random sampler and the dry separator.

7. Provide additional auxilliary water to supply both the dry separator hopper and the adult/trash bypass channel. Volume through the present auxilliary supply varies with forebay level resulting in fluctuations at the and dry separators. Additional auxilliary water should be provided from the
nearby upstream migrant transportation channel—a source not subject to forebay fluctuations.

8. Modify the dry separator hopper to allow operation at variable, stable water levels. The modified hopper must have overflow capacity to handle inflow from a plugged random sampler to eliminate flooding beneath the dry separator.

9. Weld or caulk the leaks in the dry separator hopper to reduce flooding problems.

10. Modify trash sweep on the dry separator for automatic, timed operation.

11. Install an 8-inch long clear section of pipe directly below the dry separator that can be lighted. This may help reduce fish hold up in the dry separator hopper.

12. Install a removable "hatch" in the dry separator to provide an access for releasing water balloons into the pipe connecting the two separators. This is done whenever the sampler is shut down to force fish out of the pipeline.

13. Cut down the weir between the energy dissipator and the downwell to elevation 44.0 so the water surface in the downwell can be maintained at this elevation. This will improve the drainage from the raceways for fish removal and reduce turbulence in the downwell. Also, lowering the weir would provide a greater range in which the automatic control system could operate and subsequently aid in maintaining the proper water levels.

First Powerhouse

1. Automatic water level controls in the DSM need to be operational for the 1985 field season in both pump-back and free-flowing modes.
2. Repair the inclined screen mesh and the trash sweep for 1985 testing.

3. Modify the sample tank, dump chute, sample flume, and hoist mechanisms of the indexing facilities so complete evaluation of the utility and efficiency of the sampling equipment can be accomplished.

4. Measure fish quality and stress on smolts collected at the indexing facilities.

5. Repeat OPE tests for yearling and subyearling chinook salmon comparing the 12- and 14-inch diameter orifices, BFVBS vs SVBS, and different types of lights. Reduce test duration and days between replicates to minimize potential bias in results from extended testing.
ACKNOWLEDGMENTS

Individual responsibilities for conducting research and writing reports were divided among the junior authors as follows:

OBJECTIVE I - Evaluation of modifications/additions to STS and trashracks at the Second Powerhouse -- Michael H. Gessel and Bruce H. Monk.

OBJECTIVE II - Continued monitoring of the Second Powerhouse DSM and smolt indexing facilities - William D. Muir.


OBJECTIVE IV - Monitor fish quality and stress on fingerlings in the bypass and indexing facilities at the First Powerhouse - C. Scott McCutcheon and Lyle G. Gilbreath.

OBJECTIVE V - Monitor orifice passage efficiency at both powerhouses - Lyle G. Gilbreath.

We would all like to express our appreciation to Bonneville Dam Project Engineer Mr. Gail Gardner and his Superintendent of Maintenance Mr. Quinn O'Brien for their grateful cooperation. We would also like to thank the members of their staffs, without whose assistance this study would not have been possible.

Sokal, R. R., and F. J. Rohlf.  
Appendix Table 1.—Numbers of fish collected in the individual replicates of STS FGE tests at Bonneville Dam Second Powerhouse, 1984 (tests conducted in July and August captured only subyearling chinook salmon).

<table>
<thead>
<tr>
<th>Location</th>
<th>Date and (test number)/</th>
<th>Date and (test number)/</th>
<th>Date and (test number)/</th>
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</thead>
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<td>2 May (11)</td>
<td>3 May (2)</td>
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<tr>
<td></td>
<td>SC  YC  ST  CO  SO</td>
<td>SC  YC  ST  CO  SO</td>
<td>SC  YC  ST  CO  SO</td>
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<tr>
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<tr>
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<td>2  7</td>
<td>1  5</td>
<td>4</td>
</tr>
<tr>
<td>Closure Net</td>
<td>1  2  2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
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<td>2  35  4</td>
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<td>10  29  5</td>
<td>8  43  7  1</td>
</tr>
<tr>
<td>4th Level &lt;b/&gt;</td>
<td>6  12  3</td>
<td>15</td>
<td>12  18</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Totals</td>
<td>8  116  13  3  4</td>
<td>14  146  21</td>
<td>23  156  33  10</td>
</tr>
</tbody>
</table>

|                | 3 May (12)              | 4 May (1)               | 4 May (13)              |
|                | SC  YC  ST  CO  SO      | SC  YC  ST  CO  SO      | SC  YC  ST  CO  SO      |
| Gatewell       | 66  24                  | 95  49                  | 126  66                 |
| Gap Net        |                         | 6  1                    | 1                       |
| Closure Net    | 8  10                   | 5                       | 28  22                  |
| 1st Level      | 2  15  2                | 6  2                    | 1  18  8  3             |
| 2nd Level      | 4  46  10               | 4  48  13               | 2  6  59  26  3         |
| 3rd Level      | 7  46  4  2             | 4  27  6                | 6  41  15               |
| 4th Level <b/> | 9  3  12  3             | 3  6  33  3             |
| 5th Level      |                         |                         | 3                       |
| Totals         | 13  190  50  7          | 11  199  74  5          | 19  309  140  6         |

<p>|                | 5 May (3)               | 5 May (14)              | 6 May (3)               |
|                | SC  YC  ST  CO  SO      | SC  YC  ST  CO  SO      | SC  YC  ST  CO  SO      |
| Gatewell       | 33  19                  | 44  19                  | 51  17  7              |
| Gap Net        | 1                       |                         |                         |
| Closure Net    | 3  28  4  2             | 1  3  3                 |                         |
| 1st Level      | 1  2  13  2             |                         | 1  3  3                 |
| 2nd Level      | 13  10  5               | 3  49  9  5             | 2  35  3  4             |
| 3rd Level      | 3  28  7  3             | 3  18  10               | 4  44  9  2             |
| 4th Level &lt;b/&gt; | 3  9  3                 |                         | 3  15                  |
| 5th Level      |                         |                         |                         |
| Totals         | 4  80  37  8            | 8  161  47  7           | 11  151  32  13         |</p>
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<td>1 1</td>
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<td>9 12 1 1</td>
<td>8 17 2 4</td>
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<td>25 17</td>
<td>1 1 11 5 1</td>
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<td>18 9</td>
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Appendix Table 1.—cont.

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\(a/\) Test numbers correspond to the numbers in Tables 5-8 in the text.

\(b/\) Numbers of fish captured at these levels have been expanded \((x3)\).

\(c/\) Due to severe net miltation, positive coho salmon identification was not possible, therefore, the net catches of coho salmon in these tests are estimates based on gatewell catch ratios.

SC-Subyearling chinook; YC-Yearling chinook; ST-Steelhead; CO-Coho; SO-Sockeye

53
Appendix Table 2.—Collection data for yearling chinook and coho salmon for the individual replicates of vertical distribution tests at Bonneville Dam

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Appendix Table 3.—Collection data of subyearling chinook salmon for the individual replicates of vertical distribution tests at Bonneville Dam Second Powerhouse, 1984.

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Test number and gatewell ( ), species, and condition tested

Test 1 (128), Subyearling chinook salmon, 48° deflector
Test 2 (128), Subyearling chinook salmon, net-frame only
Test 3 (158), Subyearling chinook salmon, net-frame only
Appendix Table 4.--Weekly and cumulative totals of fish captured by the random sampler in the
Second Powerhouse at Bonneville Dam in 1984.

<table>
<thead>
<tr>
<th>Yearling chinook</th>
<th>Subyearling chinook</th>
<th>Sthd. Coho Sock. Total</th>
<th>Hours fished</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. captured</td>
<td>1,839</td>
<td>589 189 186 11 2,614</td>
<td>April 99.0</td>
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<tr>
<td>No. examined</td>
<td>1,313</td>
<td>358 180 166 11 2,028</td>
<td>23</td>
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<tr>
<td>No. descaled</td>
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<tr>
<td>No. mortalities</td>
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<tr>
<td>% descaled</td>
<td>6.4</td>
<td>0.8 3.9 2.4 9.1 4.9</td>
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<tr>
<td>% mortality</td>
<td>1.9</td>
<td>2.3 0.0 0.5 0.0 1.7</td>
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<table>
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<tr>
<th>Yearling chinook</th>
<th>Subyearling chinook</th>
<th>Sthd. Coho Sock. Total</th>
<th>Hours fished</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. captured</td>
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<td>April 91.0</td>
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<tr>
<td>No. examined</td>
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<td>91 250 520 34 3,011</td>
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<tr>
<td>No. descaled</td>
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<td>0 10 5 4 136</td>
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<tr>
<td>No. mortalities</td>
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<tr>
<td>% descaled</td>
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<td>% mortality</td>
<td>1.9</td>
<td>4.2 0.0 1.0 2.9 1.7</td>
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<th>Sthd. Coho Sock. Total</th>
<th>Hours fished</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. captured</td>
<td>4,037</td>
<td>96 393 470 167 5,163</td>
<td>May 96.0</td>
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<tr>
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<td>77 371 431 148 2,694</td>
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<tr>
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<td>1 17 6 41 196</td>
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<tr>
<td>No. mortalities</td>
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<tr>
<td>% descaled</td>
<td>7.9</td>
<td>1.3 4.6 1.4 27.7 7.3</td>
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<td>% mortality</td>
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<td>4.2 0.5 0.4 7.8 2.3</td>
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<th>Sthd. Coho Sock. Total</th>
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<tbody>
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<td>82 32 9 106 415 May</td>
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<tr>
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<th>Sthd. Coho Sock. Total</th>
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<tr>
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<tr>
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### Appendix Table 4.—Continued

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<th>Sstd. Coho</th>
<th>Sock. Total</th>
<th>Date</th>
<th>Hours fished</th>
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<th>Sock. Total</th>
<th>Date</th>
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<th>Sock. Total</th>
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<th>Sstd. Coho</th>
<th>Sock. Total</th>
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<td>1.5</td>
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**/ Totals for this week are estimated because the compartment bypass test occurred at this time.**
### Weekly Totals

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<th>Coho</th>
<th>Sock.</th>
<th>Total</th>
<th>Date</th>
<th>Hours fished</th>
</tr>
</thead>
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<td>48</td>
<td>1,936</td>
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<tr>
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<td>382</td>
<td>39</td>
<td>1,762</td>
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### Cumulative Totals

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<th>Std.</th>
<th>Coho</th>
<th>Sock.</th>
<th>Total</th>
<th>Date</th>
<th>Hours fished</th>
</tr>
</thead>
<tbody>
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<td>1,431</td>
<td>32</td>
<td>383</td>
<td>48</td>
<td>1,936</td>
<td>June</td>
<td>94.0</td>
</tr>
<tr>
<td>No. examined</td>
<td>41</td>
<td>1,268</td>
<td>32</td>
<td>382</td>
<td>39</td>
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### Hours fished

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Appendix Table 4.—Continued.

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<th>Sock.</th>
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<th>Sock.</th>
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## Appendix Table 4.—Continued.

### WEEKLY TOTALS

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### CUMULATIVE TOTALS

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### Date

| Sep 5 | 81.0 |
| 1,803.0 |

### Hours fished

| 79,261 |
| 79,442 |
| 79,568 |
| 79,670 |

### Subyearling chinook

| 1,852 |
| 1,373 |
| 2,436 |

### Sthd.

| 1,854 |
| 1,375 |
| 2,436 |

### Coho

| 1,855 |
| 1,375 |
| 2,436 |

### Sock.

| 1,856 |
| 1,375 |
| 2,436 |

### Total

| 1,857 |
| 1,375 |
| 2,436 |

### Hours fished

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<th>Coho</th>
<th>Sock.</th>
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<th>Coho</th>
<th>Sock.</th>
<th>Total</th>
<th>Date</th>
<th>Hours fished</th>
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Appendix Table 5.--Gatewell catches by dipnetting of juvenile salmonids at the Bonneville Dam Second Powerhouse during October-December 1984. (A continuation of the temporal studies when failure of the inclined screen prevented routine sampling.)

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<th>Week</th>
<th>Sample dates</th>
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<td>28 Oct-</td>
<td>1 Nov</td>
<td>58</td>
</tr>
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<td>3 Jan</td>
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<td>84</td>
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\(^a/\) Sampling in gatewell 11c was terminated with the removal of the screen during the week of 2-8 December.
Appendix Table 6.--Operation of the Bonneville Dam First Powerhouse bypass system during 1984.

<table>
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<tr>
<th>Dates</th>
<th>Bypass direction(^a/)</th>
<th>Comment</th>
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<tbody>
<tr>
<td>17-19 Apr</td>
<td>X</td>
<td>Initial operation with bypass north.</td>
</tr>
<tr>
<td>20 Apr–8 May</td>
<td>X</td>
<td>Flow was reversed on 4/20 to investigate impingement of fish on the inclined screen. North bypass was attempted during this time but could not be sustained due to four instances of trash sweep failure.</td>
</tr>
<tr>
<td>9 May-10 Jun</td>
<td>X</td>
<td>Trash sweep modified. Air jet debris removal system installed.</td>
</tr>
<tr>
<td>11-14 Jun</td>
<td>X</td>
<td>Air system tested. Modified trash sweep functions without breakage.</td>
</tr>
<tr>
<td>15-20 Jun</td>
<td>X</td>
<td>Flow reversed to south to dewater screen for completion of contract work.</td>
</tr>
<tr>
<td>21 Jun-24 Jul</td>
<td>X</td>
<td>CoFe testing pumps and working to resolve automatic control problems.</td>
</tr>
<tr>
<td>25-27 Jul</td>
<td>X</td>
<td>Flow reversed to south to dewater screen. Seal plate had loosened, allowing debris to enter beneath the screen and plug add-in water gratings.</td>
</tr>
<tr>
<td>28 Jul-10 Aug</td>
<td>X</td>
<td>Trash sweep breaks, but is repaired without flow reversal.</td>
</tr>
<tr>
<td>11 Aug</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12 Aug-20 Sep</td>
<td>X</td>
<td>Trash sweep breaks. Both carrier bars and one chain are lost down outfall conduit. Bypass will be to the south for the balance of the 1984 outmigration.</td>
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</tbody>
</table>

\(^a/\) North bypass via the 24-inch outfall conduit terminating in the powerhouse tailrace. South bypass via the ice and trash sluiceway.
### Appendix Table 7.--Daily catches and descaling data for juvenile salmonids captured at Bonneville Dam First Powerhouse indexing facilities, 1984.

| Date  | Sample Time  | Subyearling chinook | | Yearling chinook | | Steelhead | | Coho | | Sockeye |
|-------|--------------|---------------------|----------------|-----------------|----------------|----------------|----------------|----------------|----------------|
|       |              | Catch | % Descaled | Catch | % Descaled | Catch | % Descaled | Catch | % Descaled | Catch | % Descaled |
| 4/30  |              | 1330-1350 | 6 | 0 | 113 | 19 | 14 | 14 | 0 | - | 0 | - |
| 5/1   |              | 1542-1554 | 2 | 0 | 156 | 9 | 41 | 15 | 2 | 0 | 0 | - |
| 5/8   |              | 1018-1048 | 3 | 121 | 17 | 2 | 2 | 51 |
|       |              | 1300-1314 | 1 | 116 | 21 | 0 | 0 | 32 |
|       |              | 4 | 0 | 237 | 14 | 38 | 8 | 2 | 0 | 83 | 4 |
| 6/13  | 0835-0905 | 203 | 31 | 15 | 2 | 62 |
|       | 1325-1350 | 52 | 15 | 11 | 1 | 18 |
|       |              | 255 | 46 | 7 | 26 | 8 | 3 | 33 | 80 | 1 |
| 6/14  | 0837-0914 | 263 | 12 | 13 | 1 | 41 |
|       | 1328-1358 | 151 | 15 | 13 | 1 | 53 |
|       |              | 414 | 4 | 27 | 4 | 26 | 0 | 2 | 50 | 94 | 0 |
| 6/15  | 0838-0908 | 85 | 6 | 1 | 0 | 27 |
|       | 0945-1000 | 38 | 3 | 0 | 0 | 8 |
|       |              | 123 | 2 | 9 | 0 | 1 | 0 | - | 35 | 0 |
| 7/2   | 1352-1422 | 495 | 26 | 27 | 7 | 3 | 1/ | 3 | 1/ | 1 | 1/ |
| 7/3   | 1242-1302 | 28 | 3 | 0 | 0 | 0 |
|       | 1318-1338 | 75 | 8 | 0 | 0 | 1 | 1/ |
|       |              | 103 | 34 | 11 | 9 | 0 | - | 0 | - | 1 |

1/ No descaling sample.

2/ Total catch not enumerated-descaling sample only.
Appendix Table 7.--(Continued)

<table>
<thead>
<tr>
<th>Date</th>
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<th>Yearling chinook</th>
<th>Steelhead</th>
<th>Coho</th>
<th>Sockeye</th>
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<td>Catch</td>
<td>Catch</td>
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<td># Descaled</td>
<td># Descaled</td>
<td># Descaled</td>
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1/ No descaling sample.
2/ Total catch not enumerated—descaling sample only.
### Appendix Table 7.--(Continued)

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1/ No descaling sample.
2/ Total catch not enumerated-descaling sample only.
### Appendix Table 7.--(Continued)

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|      | 0930-0950   | 7.0     | 39    | 3.51      | 39    | 3.51    | 11    | 0.98    | 11    | 0.98    |
|      | 1030-1050   | 18.0    | 62    | 5.55      | 62    | 5.55    | 26    | 2.28    | 26    | 2.28    |
|      | 1100-1120   | 34.3    | 62    | 5.55      | 62    | 5.55    | 26    | 2.28    | 26    | 2.28    |
|      | 1130-1150   | 14.3    | 25    | 2.28      | 25    | 2.28    | 10    | 0.85    | 10    | 0.85    |
|      | 1230-1250   | 3.7     | 10    | 0.85      | 10    | 0.85    | 6     | 0.53    | 6     | 0.53    |
|      | 1300-1320   | 21.8    | 45    | 3.85      | 45    | 3.85    | 8     | 0.71    | 8     | 0.71    |
|      | 1330-1350   | 28.6    | 89    | 7.92      | 89    | 7.92    | 8     | 0.71    | 8     | 0.71    |
|      | 1430-1450   | 21.8    | 82    | 7.45      | 82    | 7.45    | 8     | 0.71    | 8     | 0.71    |
|      | 1455-1515   | 8.7     | 60    | 5.36      | 60    | 5.36    | 6     | 0.53    | 6     | 0.53    |
|      | 1530-1550   | 3.7     | 9     | 0.79      | 9     | 0.79    | 4     | 0.34    | 4     | 0.34    |

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1/ No descaling sample.
2/ Total catch not enumerated—descaling sample only.
Appendix Table 7.--(Continued)

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1/ No descaling sample.
2/ Total catch not enumerated—descaling sample only.
Appendix Table 7.--(Continued)

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1/ No descaling sample.
2/ Total catch not enumerated-descaling sample only.
Appendix Table 8.—Gatewell catches by dipnetting of juvenile salmonids at the Bonneville Dam First Powerhouse during the period 26 August through 1 December 1984. (A continuation of the temporal studies after failure of the inclined screen trash sweep prevented routine sampling).

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<td></td>
<td>8 Nov</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>9 Nov</td>
<td>8</td>
</tr>
<tr>
<td>Week total</td>
<td></td>
<td>44</td>
</tr>
<tr>
<td>11-17 Nov</td>
<td>15 Nov</td>
<td>No sample&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Week total</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>18-24 Nov</td>
<td>21 Nov</td>
<td>No sample&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Week total</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>25 Nov-</td>
<td>1 Dec</td>
<td>No sample&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>30 Nov</td>
<td>No sample&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Week total</td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

<sup>a</sup> Screen was removed from 9C the week of 14-20 October. Sampling in 9C after 20 October was with no screen in place.

<sup>b</sup> Screen was removed for the year during the week of 2-8 December.

<sup>c</sup> Gatewell 9C was used exclusively for debris detector testing from the week of 11-17 November on.
Appendix Table 9.—Early Season seawater challenge test data for yearling chinook salmon collected from gatewells with standard (SVBS) or balanced flow vertical barrier screens (BFVBS) at Bonneville Dam First Powerhouse, 1984. Data includes test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 30 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were unintentionally sampled with chinook salmon in some tests).

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Number nondesceled</th>
<th>Number descelaled</th>
<th>Average fork length mm</th>
<th>Number nondesceled</th>
<th>Number descelaled</th>
<th>Average fork length mm</th>
<th>% Total biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td></td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/1 15 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>129.0</td>
<td>-</td>
<td>-</td>
<td>137.9</td>
</tr>
<tr>
<td>1/2 15 May</td>
<td>0 0 0 0 1</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>80.0</td>
<td>-</td>
<td>-</td>
<td>154.5</td>
</tr>
<tr>
<td>1/3 15 May</td>
<td>1 - 0 0 -</td>
<td>1 - 0 0 -</td>
<td>112.0</td>
<td>93.0</td>
<td>3 - 0 0 0</td>
<td>5 - 0 0 0</td>
<td>136.6</td>
</tr>
<tr>
<td>1/4 16 May</td>
<td>0 - 0 0 -</td>
<td>0 - 0 0 -</td>
<td>-</td>
<td>87.0</td>
<td>16 - 0 2 - 2</td>
<td>5 - 0 0 0</td>
<td>133.9</td>
</tr>
<tr>
<td>2/1 16 May</td>
<td>0 1 0 0 0</td>
<td>1 0 0 0 0</td>
<td>124.0</td>
<td>112.0</td>
<td>20 - 7 - 4</td>
<td>2 - 0 0 0</td>
<td>129.6</td>
</tr>
<tr>
<td>2/2 16 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>201.0</td>
<td>20 - 7 - 4</td>
<td>2 - 0 0 0</td>
<td>130.5</td>
</tr>
<tr>
<td>2/3 16 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>87.0</td>
<td>201.0</td>
<td>2 - 0 0 0</td>
<td>133.9</td>
</tr>
<tr>
<td>3/1 16 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>87.0</td>
<td>201.0</td>
<td>2 - 0 0 0</td>
<td>133.9</td>
</tr>
<tr>
<td>3/2 16 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>87.0</td>
<td>201.0</td>
<td>2 - 0 0 0</td>
<td>133.9</td>
</tr>
<tr>
<td>3/3 16 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>-</td>
<td>87.0</td>
<td>201.0</td>
<td>2 - 0 0 0</td>
<td>133.9</td>
</tr>
</tbody>
</table>

Note: Biomass includes incidental catches of other species.

YC = Yearling chinook, SC = Subyearling chinook, ST = Steelhead, CO = Coho, SO = Sockeye.
Appendix Table 10.—Mid-season seawater challenge test data for yearling chinook salmon collected from gatewells with standard (SVBS) or balanced flow vertical barrier screens (BFVBS) at Bonneville Dam First powerhouse, 1984. Data includes test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 32 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were unintentionally sampled with chinook salmon in some tests).

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Test Date</th>
<th>Number nondesceled</th>
<th>Number descelled</th>
<th>Average fork length mm</th>
<th>Number nondesceled</th>
<th>Number descelled</th>
<th>Average fork length mm</th>
<th>Total biomass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Date</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td></td>
</tr>
<tr>
<td>1/1 22 May</td>
<td>4 3 0 0 - 1 0 0 0 -</td>
<td>134.4 83.3 - -</td>
<td>17 0 3 2 - 4 0 1 0 -</td>
<td>137.7 - 156.3 134.0 -</td>
<td>899.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 22 May</td>
<td>3 3 1 0 1 0 0 0 0 0</td>
<td>123.7 78.3 173.0</td>
<td>88.0 7 0 1 6 0 4 0 3 1 0</td>
<td>137.6 - 159.3 142.9 -</td>
<td>865.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/3 22 May</td>
<td>2 3 1 1 2 1 0 0 0 0</td>
<td>124.7 84.3 191.0 120.0 91.5</td>
<td>12 0 1 7 0 2 0 0 0 0</td>
<td>141.9 - 163.0 143.9 -</td>
<td>876.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4 23 May</td>
<td>2 - 0 0 0 - 0 - 0 0 -</td>
<td>144.0 - - - -</td>
<td>9 2 8 0 2 0 0 0 0</td>
<td>138.5 - 194.8 139.5 -</td>
<td>856.0</td>
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<td></td>
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</tr>
<tr>
<td>2/2 23 May</td>
<td>0 1 0 0 0 1 0 0 0 0 0 0</td>
<td>132.0 104.0 - -</td>
<td>13 2 5 4 1 0 0 0 1 0</td>
<td>140.7 87.5 180.2 139.6 100.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3/2 23 May</td>
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<td>120.0 - - - -</td>
<td>13 1 4 3 2 0 0 0 0</td>
<td>139.3 80.0 186.0 145.7 -</td>
<td>696.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3/4 24 May</td>
<td>1 2 0 0 1 0 0 0 0 0 0 0 0</td>
<td>114.0 92.0 - -</td>
<td>12 3 1 2 1 2 0 0 0 0</td>
<td>139.7 94.7 195.0 138.7 100.0</td>
<td>911.5</td>
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<tr>
<td>3/5 24 May</td>
<td>3 1 0 0 1 1 1 0 0 0 0</td>
<td>122.5 100.0 - -</td>
<td>9 2 8 2 6 2 0 0 1 1</td>
<td>142.5 95.5 177.5 144.4 -</td>
<td>1651.0</td>
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<td>Totals or averages</td>
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<td>127.5 90.0 182.0 120.0 86.9</td>
<td>99 8 32 79 7 3 2 0 7 3 1</td>
<td>138.4 89.4 176.4 141.2 98.2</td>
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</table>

**Test Condition — 9C Mid-Season (SVBS)**

<table>
<thead>
<tr>
<th>Test</th>
<th>Date</th>
<th>Number nondesceled</th>
<th>Number descelled</th>
<th>Average fork length mm</th>
<th>Number nondesceled</th>
<th>Number descelled</th>
<th>Average fork length mm</th>
<th>Total biomass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Date</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
<td>YC SC ST CO SO</td>
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</tr>
<tr>
<td>1/1 22 May</td>
<td>4 7 0 0 1 0 0 1 0 0</td>
<td>131.0 91.9 178.0</td>
<td>102.0 10 0 1 8 1 2 0 1 0 0</td>
<td>137.7 - 167.0 145.5 73.0</td>
<td>909.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1/2 22 May</td>
<td>4 1 0 2 - 0 0 0 0 0 0 0</td>
<td>129.0 80.0 - 145.7</td>
<td>10 0 2 7 - 2 0 1 0 -</td>
<td>138.5 - 164.7 145.6 -</td>
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<td>149.0 84.5 187.0</td>
<td>- -</td>
<td>16 0 4 3 - 2 0 0 0 0</td>
<td>136.4 - 198.5 132.0 -</td>
<td>896.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4 23 May</td>
<td>2 4 1 0 - 1 0 0 0 0 0 0</td>
<td>149.0 84.5 187.0</td>
<td>- -</td>
<td>16 0 4 3 - 2 0 0 0 0</td>
<td>136.4 - 198.5 132.0 -</td>
<td>896.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/5 23 May</td>
<td>1 0 0 0 3 1 0 0 0 0</td>
<td>135.0 91.0 - -</td>
<td>16 3 2 2 1 3 0 1 1 0</td>
<td>144.3 99.0 176.3 136.3 97.0</td>
<td>915.0</td>
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</tr>
<tr>
<td>1/6 23 May</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>- - - - - -</td>
<td>8 2 6 3 1 6 0 0 0 0</td>
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<td></td>
</tr>
<tr>
<td>1/7 24 May</td>
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<td>117.0 - - 84.0</td>
<td>15 4 2 8 2 2 0 0 0 0</td>
<td>139.0 92.5 174.0 143.9 96.0</td>
<td>874.5</td>
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<tr>
<td>1/8 24 May</td>
<td>2 2 1 2 1 0 0 0 0 1 1</td>
<td>131.5 89.0 171.0 130.0 103.5</td>
<td>16 0 5 1 9 1 3 0 0 1 0</td>
<td>135.6 - 186.2 159.7 95.0</td>
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</tr>
<tr>
<td>1/9 24 May</td>
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<td>111.3 85.5 - -</td>
<td>9 4 3 13 2 1 0 0 0 0</td>
<td>131.8 95.3 168.7 136.1 95.5</td>
<td>846.0</td>
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<td></td>
</tr>
<tr>
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<td>141.5 82.0 - -</td>
<td>9 1 4 5 4 2 1 0 0 2 1</td>
<td>135.7 89.0 186.0 138.3 96.0</td>
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</tr>
<tr>
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<td>114 18 29 89 9 2 0 3 4 1</td>
<td>137.5 94.3 171.5 140.2 75.5</td>
<td>1009.1</td>
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<td></td>
</tr>
</tbody>
</table>

* Biomass includes incidental catches of other species.

YC = Yearling chinook, SC = Subyearling chinook, ST = Steelhead, CO = Coho, SO = Sockeye
Appendix Table II.--Late season seawater challenge test data for yearling chinook salmon collected from gatewell with standard (SVBS) or balanced flow vertical barrier screens (BFVBS) at Bonneville Dam First Powerhouse, 1984. Data includes test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 32 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were unintentionally sampled with chinook salmon in some tests).

<table>
<thead>
<tr>
<th>Test Condition - 10A Late Season (BFVBS)</th>
<th>DEAD FISH</th>
<th>LIVE FISH</th>
<th>Average fork length mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non-descaled</td>
<td>descaled</td>
<td>YC SC ST CO SO</td>
</tr>
<tr>
<td>1/1 30 May</td>
<td>1 0 0 0 0</td>
<td>1 0 0 0 0</td>
<td>123.0 - - - 96.0</td>
</tr>
<tr>
<td>1/2 30 May</td>
<td>1 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>123.0 - - - 96.0</td>
</tr>
<tr>
<td>1/3 30 May</td>
<td>1 - 0 0 1</td>
<td>0 - 0 0 0</td>
<td>151.0 - - - 88.0</td>
</tr>
<tr>
<td>2/1 31 May</td>
<td>3 2 0 0 0</td>
<td>1 0 0 0 0</td>
<td>117.3 80.5 - -</td>
</tr>
<tr>
<td>2/2 31 May</td>
<td>1 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>142.0 - - - 96.0</td>
</tr>
<tr>
<td>2/3 31 May</td>
<td>2 0 0 0 2</td>
<td>1 1 0 0 0</td>
<td>123.7 100.0 - 89.5</td>
</tr>
<tr>
<td>3/1 1 Jun</td>
<td>1 1 1 0 0</td>
<td>0 1 0 0 0</td>
<td>136.0 104.5 158.0 -</td>
</tr>
<tr>
<td>3/2 1 Jun</td>
<td>1 1 0 0 1</td>
<td>2 0 0 0 0</td>
<td>140.0 67.0 - 89.0</td>
</tr>
<tr>
<td>3/3 1 Jun</td>
<td>0 1 0 0 0</td>
<td>0 1 0 0 0</td>
<td>94.0 - - - 89.0</td>
</tr>
<tr>
<td>Totals or averages</td>
<td>11 5 1 0 5</td>
<td>5 3 0 0 0</td>
<td>129.5 89.2 158.0 -</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Condition - 9C Late Season (SVBS)</th>
<th>DEAD FISH</th>
<th>LIVE FISH</th>
<th>Average fork length mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non-descaled</td>
<td>descaled</td>
<td>YC SC ST CO SO</td>
</tr>
<tr>
<td>1/1 30 May</td>
<td>1 0 0 0 0</td>
<td>0 0 0 0 1</td>
<td>115.0 - - - 106.0</td>
</tr>
<tr>
<td>1/2 30 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>- - - 106.0</td>
</tr>
<tr>
<td>1/3 30 May</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
<td>- - - 106.0</td>
</tr>
<tr>
<td>1/4</td>
<td>1/5</td>
<td>1/6</td>
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</tr>
<tr>
<td>2/1 31 May</td>
<td>0 0 0 0 1</td>
<td>0 0 0 0 0</td>
<td>- - - 80.0</td>
</tr>
<tr>
<td>2/2 31 May</td>
<td>3 1 0 0 1</td>
<td>1 0 0 0 0</td>
<td>127.0 94.0 - 112.0</td>
</tr>
<tr>
<td>2/3 31 May</td>
<td>0 3 0 0 1</td>
<td>0 0 0 0 0</td>
<td>- 88.3 - 90.0</td>
</tr>
<tr>
<td>3/1 1 Jun</td>
<td>0 1 0 0 0</td>
<td>1 1 0 0 0</td>
<td>129.0 90.0 - -</td>
</tr>
<tr>
<td>3/2 1 Jun</td>
<td>0 1 0 0 0</td>
<td>0 1 0 0 1</td>
<td>127.0 95.0 - 131.0</td>
</tr>
<tr>
<td>3/3 1 Jun</td>
<td>1 1 0 0 1</td>
<td>0 2 0 0 0</td>
<td>113.0 93.7 - 85.0</td>
</tr>
<tr>
<td>Totals or averages</td>
<td>6 6 0 0 4</td>
<td>2 4 0 1 1</td>
<td>122.2 92.0 - 131.0 94.6</td>
</tr>
</tbody>
</table>

* Biomass includes incidental catches of other species.

YC - Yearling chinook, SC - Subyearling chinook, ST - Steelhead, CO - Coho, SO - Sockeye.
Appendix Table 12.—Orifice passage efficiency (OPE) tests conducted at Bonneville Dam First Powerhouse, 1984. All tests were 24 h in duration with approximately 2.5 feet of head on the orifice. Individual replicates <200 fish of a given species or race were not used for statistical evaluation.

<table>
<thead>
<tr>
<th>Date</th>
<th>Yearling Chinook</th>
<th>Subyearling Chinook</th>
<th>Steelhead</th>
<th>Obo</th>
<th>Sockeye</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trap Total $</td>
<td>Catch</td>
<td>Total OPE</td>
<td>Trap Total $</td>
<td>Catch</td>
</tr>
<tr>
<td>14-15 May</td>
<td>175</td>
<td>282</td>
<td>62.1</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>15-16 May</td>
<td>370</td>
<td>564</td>
<td>65.6</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>21-22 May</td>
<td>441</td>
<td>613</td>
<td>71.9</td>
<td>44</td>
<td>75</td>
</tr>
<tr>
<td>23-24 May</td>
<td>594</td>
<td>551</td>
<td>71.5</td>
<td>72</td>
<td>100</td>
</tr>
</tbody>
</table>

Totals 1,882 2,689 70.0 296 373 68.6 1,531 2,155 71.0 374 511 73.2 1,676 1,952 85.9

TEST 11.—12" Diameter Orifice, SVBS, Quartz Light

<table>
<thead>
<tr>
<th>Date</th>
<th>Yearling Chinook</th>
<th>Subyearling Chinook</th>
<th>Steelhead</th>
<th>Obo</th>
<th>Sockeye</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trap Total $</td>
<td>Catch</td>
<td>Total OPE</td>
<td>Trap Total $</td>
<td>Catch</td>
</tr>
<tr>
<td>29-30 May</td>
<td>181</td>
<td>253</td>
<td>71.5</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>30-31 May</td>
<td>214</td>
<td>298</td>
<td>71.8</td>
<td>24</td>
<td>55</td>
</tr>
<tr>
<td>31 May-1 Jun</td>
<td>171</td>
<td>223</td>
<td>76.7</td>
<td>65</td>
<td>90</td>
</tr>
<tr>
<td>4-5 Jun</td>
<td>41</td>
<td>51</td>
<td>80.4</td>
<td>200</td>
<td>337</td>
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<tr>
<td>11-12 Jun</td>
<td>33</td>
<td>48</td>
<td>68.7</td>
<td>270</td>
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<td>12-13 Jun</td>
<td>15</td>
<td>19</td>
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<td>253</td>
<td>306</td>
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<tr>
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<td>39</td>
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<td>224</td>
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<tr>
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<td>32</td>
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<td>13</td>
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<td>10-11 Jul</td>
<td>8</td>
<td>9</td>
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Totals 786 1,061 74.1 3,986 5,098 78.2 421 599 70.3 107 154 69.5 1,115 1,290 86.4
Appendix Table 12.—Continued

<table>
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<tr>
<th>Date</th>
<th>Yearling Chinook</th>
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<th>Steelhead</th>
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<th>Sockeye</th>
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<tr>
<td></td>
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<td>Trap catch</td>
<td>Total % OPE</td>
<td>Trap catch</td>
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<td>208 304 68.4</td>
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TEST III.—12" Diameter Orifice, BFVBS, Quartz Light

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<td>20-21 Aug</td>
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TEST IV.—12" Diameter Orifice, BFVBS, High Pressure Sodium Light

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<td>24-25 Aug</td>
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