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COASTAL ZONE AND ESTUARINE STUDIES

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INTRODUCTION

Lower Granite and Little Goose Dams are the first dams encountered by most juvenile salmon (Oncorhynchus spp.) and steelhead (Salmo gairdneri) migrating downstream in the Snake River Basin (Fig. 1). The U.S. Army Corps of Engineers (COE) built these hydroelectric projects in the 1970s and have operated them ever since. Submersible traveling screens (STS)(Farr 1974) were installed at Lower Granite and Little Goose Dams in the late 1970s to guide juvenile salmonids from the turbine intakes into gatewells to decrease the direct and indirect mortalities of up to 33% for juvenile salmonids passing through turbines (Raymond 1979) (Fig. 2). The guided fish pass from the gatewells to collection facilities, where the majority are subsequently loaded into barges for transport to a release site in the Columbia River downstream from Bonneville Dam (Park et al. 1984).

The turbine intakes at Lower Granite Dam are unique. They have a special fish screen slot (FSS) located upstream from the bulkhead slot (Fig. 3). Submersible traveling screens were initially operated in the FSS, but research by the National Marine Fisheries Service (NMFS) found that STSs operated in the FSS had low fish guiding efficiency (FGE) and created unacceptable descaling rates for fish. Therefore, the STSs were moved to the bulkhead slot (Park et al. 1978).

In 1983, FGE research at Lower Granite Dam with the STS in the bulkhead slot showed that an STS in conjunction with a raised operating gate (a condition which increases the flow of water into the gatewell) successfully guided over 70% of the juvenile salmonids into the gatewell (Swan et al. 1984). However in 1984 and 1985, FGE tests, with the same conditions as 1983, conducted early in the yearling chinook salmon migration resulted in considerably lower guidance

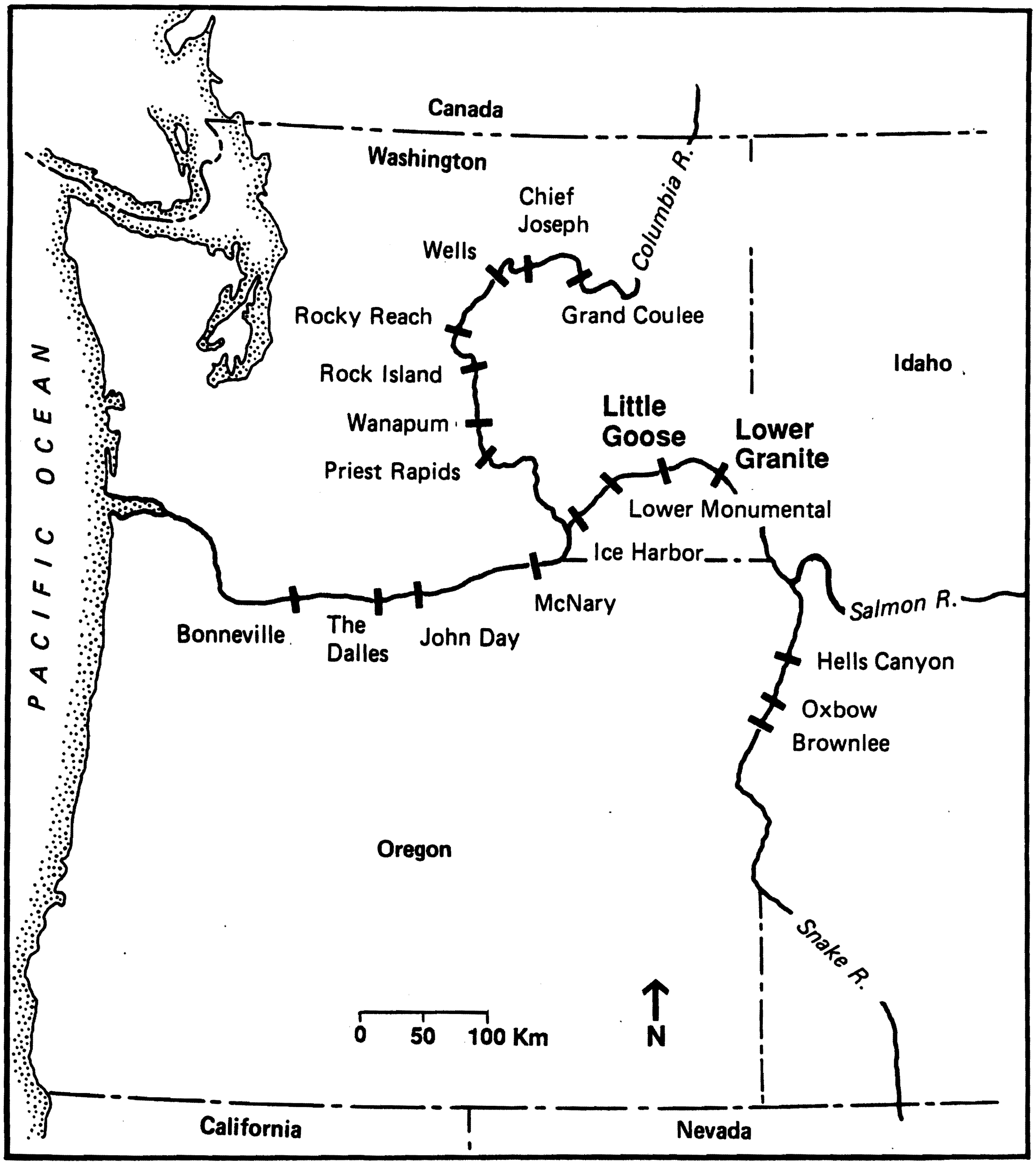

Figure 1.--Locations of Lower Granite and Little Goose Dams relative to other hydroelectric projects on the Snake and Columbia Rivers.

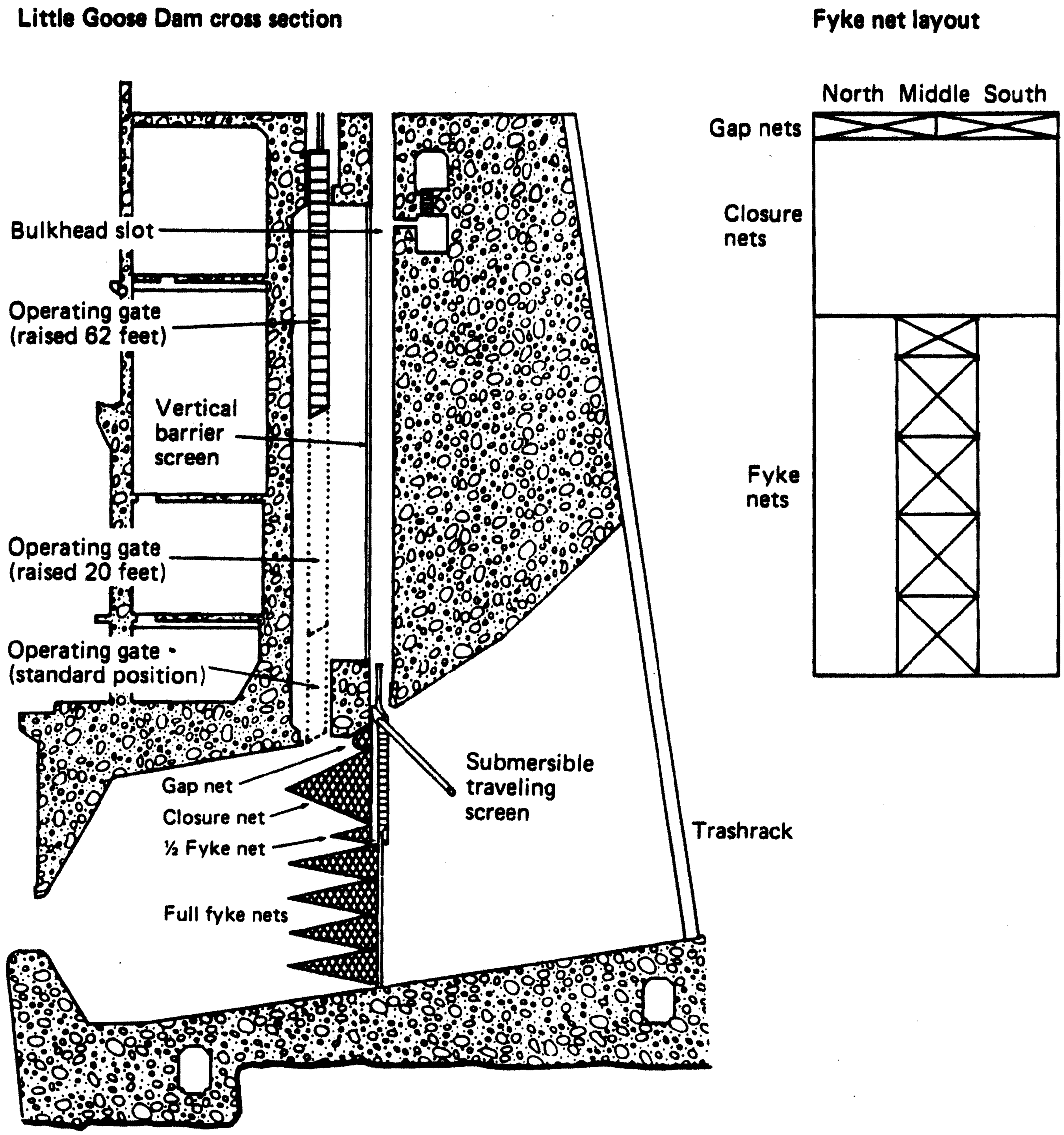

Figure 2.--Cross-section of a turbine intake at Little Goose Dam showing STS, fyke nets, and various positions of operating gates for FGE testing used at Little Goose and Lower Granite Dams, 1987.

levels (<40%); although FGE increased as the migration progressed (Swan et al. 1985, 1986). The increasing FGE through time suggested that a biological rather than a mechanical factor might be affecting FGE of yearling chinook salmon.

In 1986 at Little Goose Dam, FGE tests with a raised operating gate averaged about 70% without the extreme seasonal variations observed at Lower Granite Dam in earlier years (Swan et al. 1987).

In 1987, NMFS, in conjunction with the COE, conducted additional research to improve fish guidance at Lower Granite Dam. The researchers also provided samples of guided and non-guided yearling chinook salmon for smoltification studies reported by Muir et al. (1988). The primary objective of the Lower Granite Dam research was to determine if FGE was improved by increasing the turbine area screened with normal and lowered STSs. A non-traveling bar screen deflector (BSD) was used to test the concept of an extended STS, the primary objective was not to test a bar screen deflector per se. Secondary objectives were to:

1) compare FGE of an STS with a BSD and the operating gate in the stored position (0 foot) to FGE of an STS without a BSD and the operating gate raised 62 feet (control),
2) compare FGE of an STS lowered an additional 4 feet into the bulkhead slot (LSTS) and the operating gate raised 5 feet to FGE of the control condition,
3) compare FGE of an LSTS and the operating gate raised 62 feet to FGE of the control, and
4) determine the vertical distribution of salmonids entering the turbine intake every fourth test night.

At Little Goose Dam, the only objectives were to measure FGE and provide samples of guided and non-guided yearling chinook salmon for smoltification studies, [reported by Muir et al. (1988)].

METHODS AND MATERIALS

The FGE tests at both dams were scheduled to start during early April near the beginning of the migration. The timing of the sampling at Little Goose Dam was based on the arrival of yearling chinook salmon from Lower Granite Dam. By targeting early migrants sequentially at Lower Granite Dam and then Little Goose Dam, we attempted to measure FGE for the same general fish population. Additional FGE testing was scheduled for a period near the end of the migration at each dam if guidance of yearling chinook salmon was initially low.

At Lower Granite Dam, FGE tests were conducted in Slots 4A and 4B, slots which contained balanced flow vertical barrier screens. Vertical distribution measurements were conducted in Slot 4C which contained a standard vertical barrier screen. The vertical barrier screens were previously used for orifice passage efficiency research (Swan et al. 1985) and were not considered to have an effect on the guidance tests. The BSD was placed in the FSS upstream from either Slot 4A or 4B, dependent on the test condition, as an extension to the STS (Fig. 3). Also, during the middle and latter part of the migration season, the LSTS was used in Slot 4A (Fig. 4).

At Little Goose Dam, only Slot B was used for FGE tests; it contained a standard vertical barrier screen.

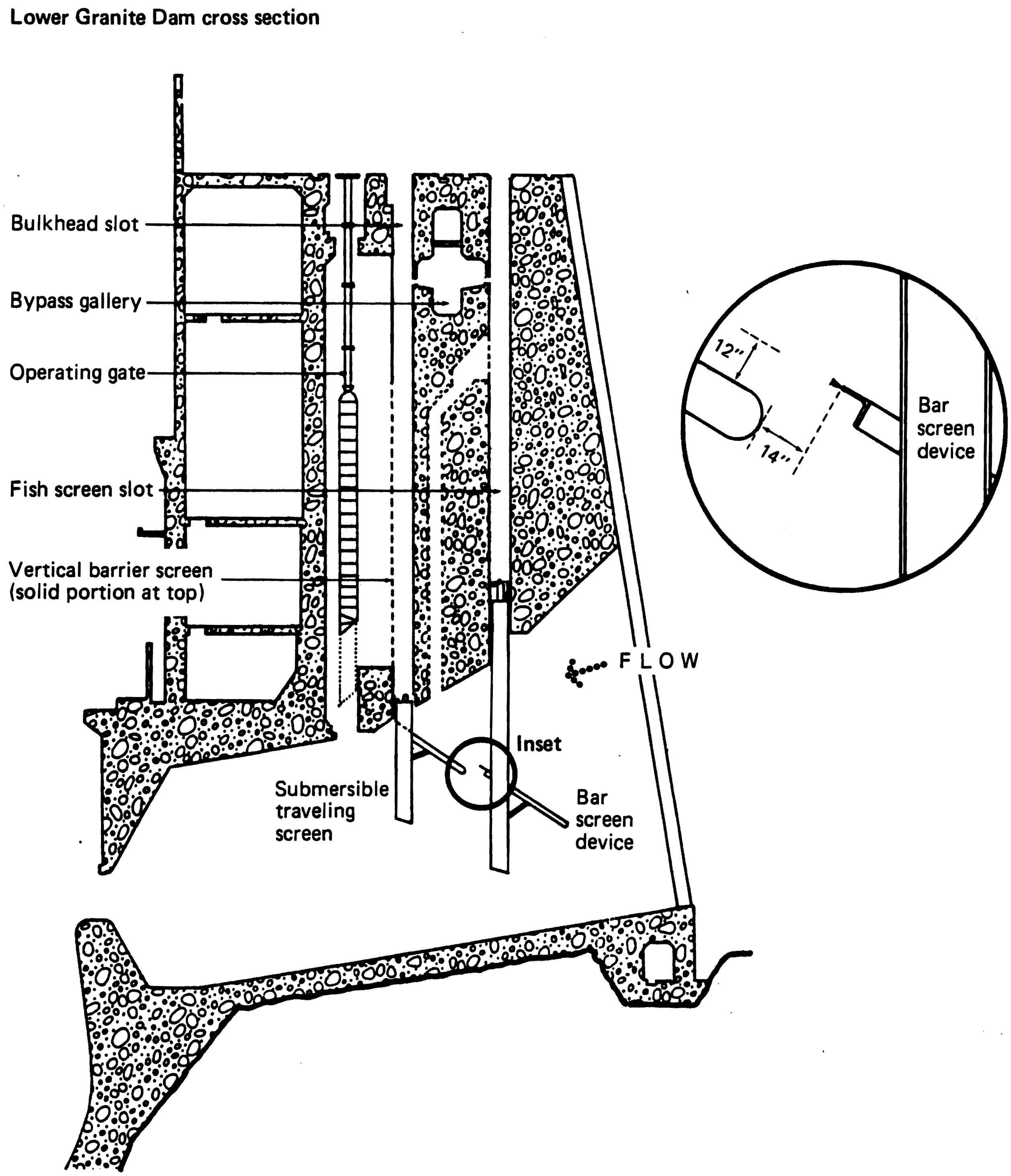

Figure 3.--Cross-section of a turbine intake at Lower Granite Dam showing an STS in the bulkhead slot aligned with a bar screen deflector (BSD) in the fish screen slot.

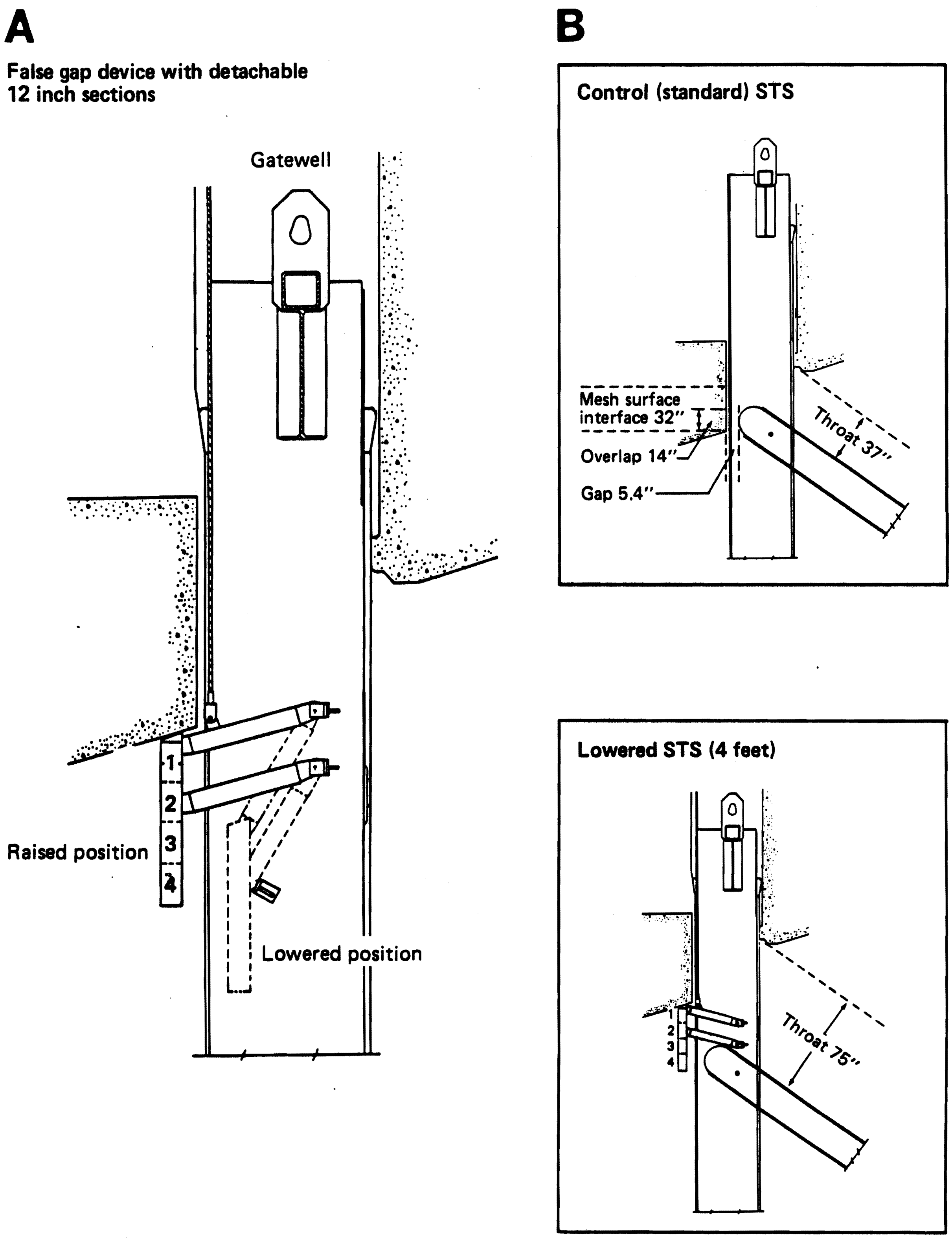

Figure 4.--Close-up view of a turbine intake at Lower Granite Dam comparing the control STS to the lowered STS with a false gap device.

At Lower Granite and Little Goose Dams all STSs are 30 cm (12 inches) lower in the gatewells than at other projects (Jacobs[1/]). At both dams, the control STS, from the center of the dogging shoe to the center pin on the traveling screen, was 206 cm (81 inches); the same dimension on the LSTS was 325 cm (128 inches).[2/]

Generally, tests began at dusk (about 1900 hours) and required about 2 hours of turbine operation to collect sufficient numbers of fish for a test (an estimated 250 yearling chinook salmon entering the test slot). Fish movement into the turbine unit, which increased rapidly just after dark, was monitored by periodically removing fish from the gatewell with a dipbasket (Swan et al. 1979) and then counting the fish. During the middle and latter parts of the testing season, the numbers of juvenile salmonids in the river increased, and 250 yearling chinook salmon could be collected in as few as 15 minutes after darkness. Therefore, during this period, the unit was started about 1 hour prior to darkness, even though few fish were collected during the first 45 minutes of testing. It was assumed the early turbine start would allow normal flow patterns to develop and to stabilize in the forebay before large numbers of fish entered the unit. The unit remained out of service between tests.

Fork length frequencies were determined from a sample of captured fish, and the effects of the STSs and BSD on fish were evaluated, as in previous years, by use of a descaling index for fish recovered from the gatewells.

1/ Larry Jacobs, COE, Hydroelectric Design Center, Portland, Oregon, pers. comm., December 1987

2/ At Lower Granite Dam the control STSs were numbered as follows: 7, Unit 4C; 13, Unit 4B; and 5, Unit 4A. Screen Number 15 was modified to make the lowered STS and STS Number 25 was used for testing at Little Goose Dam.

Fish Guiding Efficiency Tests

Fish guiding efficiency (FGE) tests were conducted to determine the proportion of the fish guided into the gatewell slot by the STS and to determine the change in FGE associated with various test conditions. The methods for determining FGE were similar to those used in previous years (Swan et al. 1983). To minimize mortality of fish in fyke nets, FGE calculations used estimates of non-guided fish derived from a one-third sample of fish caught in a single vertical column of fyke nets below the STS (Fig. 2).

The FGE was calculated as the number of guided fish (at Lower Granite Dam this included fish recovered in gatewells of the bulkhead slot and FSS) divided by the total number of fish estimated to have passed through the intake slot during the test period:

$$\text{FGE (\%)} = \frac{\text{gatewell catch}}{\text{gatewell catch + adjusted total net catch}} \text{ X 100}$$

where: adjusted total net catch = actual net catch adjusted for missing side nets or nets lost during testing.

Bar Screen Deflector

On 7 April (prior to the start of testing on 11 April), the BSD and a control STS were lowered to fishing position at Lower Granite Dam and commercial divers verified the angle of alignment and the spacing between the two screens. The inspection revealed that the BSD was correctly aligned with the STS but there was a 36-cm (14-inch) gap between the BSD and the STS. Hydraulic model tests subsequently conducted by the COE suggested that a strong downward flow of water would occur through the gap (original specifications called for a slight overlap of screens). Potentially a large number of fish could be carried downward through the gap and under the STS. Since there was insufficient time to modify the BSD, the dogging shoes of the BSD were adjusted to raise it 30 cm (12 inches) above the STS (Fig. 3). Hydraulic model tests indicated that when fished in this position, the flow of water from the downstream end of the BSD would be intercepted by the STS and not flow through the gap.

All manipulations and cleaning of the BSD were accomplished during daylight hours by private contractors to the COE. The top margin of the BSD frame was equipped with brushes designed to prevent fish from entering the FSS (Swan et al. 1986); a closure device designed for the same purpose was placed by private contractors in the alternate FSS. The brushes and the closure device were not expected to be totally effective, therefore, after each test, the FSSs were dipped and all fish present were counted as guided fish.

Lowered Submersible Traveling Screen

The LSTS used at Lower Granite Dam was constructed by the COE from an existing STS by welding a 122-cm (4-foot) long, non-adjustable section onto the upper frame of the STS. A false gap device attached to the LSTS (Gessel et al. 1987) was used to adjust the gap opening between the downstream guiding surface of the lowered screen and the concrete beam separating the operating and bulkhead gate slots (Fig. 4). After the LSTS was lowered into the gatewell, the false gap device was pulled up against the intake ceiling using pendant cables from the deck of the dam. Three, 30-cm (12-inch) sections could be attached to the false gap device to vary the gap opening; two sections were used during initial tests, and three were used during the final four tests. Gap nets attached to the bottom of the false gap device were deployed as the false gap device was raised into position. During initial tests, a single ceiling-net (no cod end) was used in the gap, but to avoid losing fish, this was replaced with two conventional gap nets with cod ends after the second night's test (25 April).

Vertical Distribution Measurements

Vertical distribution measurements were made only at Lower Granite Dam. They were obtained by replacing the STS in Slot 4C with a vertical distribution net frame (Fig. 5). The distribution of recovered fish was used to determine the proportion of fish that potentially could be guided into the gatewell by an STS--theoretical FGE (TFGE). The TFGE included all fish removed from the gatewell and those located in the upper 4.8 m of the intake--the depth of the third fyke net. To minimize mortality of fish in nets, only a center vertical row of nets was used. Each net was designed to sample 1/3 of the intake flow at a given depth between the ceiling and floor of the intake. Most nets were 2.0 m high and 2.1 m wide,except at Level 3, where they were divided into upper and lower halves (3U and 3L) so that TFGE could be estimated. The numbers of fish collected in the center nets at each level were multiplied by three to estimate the total fish passing at the various depths in the intake. The cumulative percentage of fish captured from the gatewell plus the estimated percentage down to Net Level 3U provided the estimate of TFGE.

Vertical distribution measurements and FGE tests were conducted simultaneously in the same unit. There was not support from fisheries agencies to use two separate units for testing. Termination of tests was determined from numbers of fish dipnetted from the gatewells containing STSs. Vertical distribution measurements were originally scheduled for every fourth test night; however, they were suspended after 27 April to minimize the impact on juvenile steelhead.

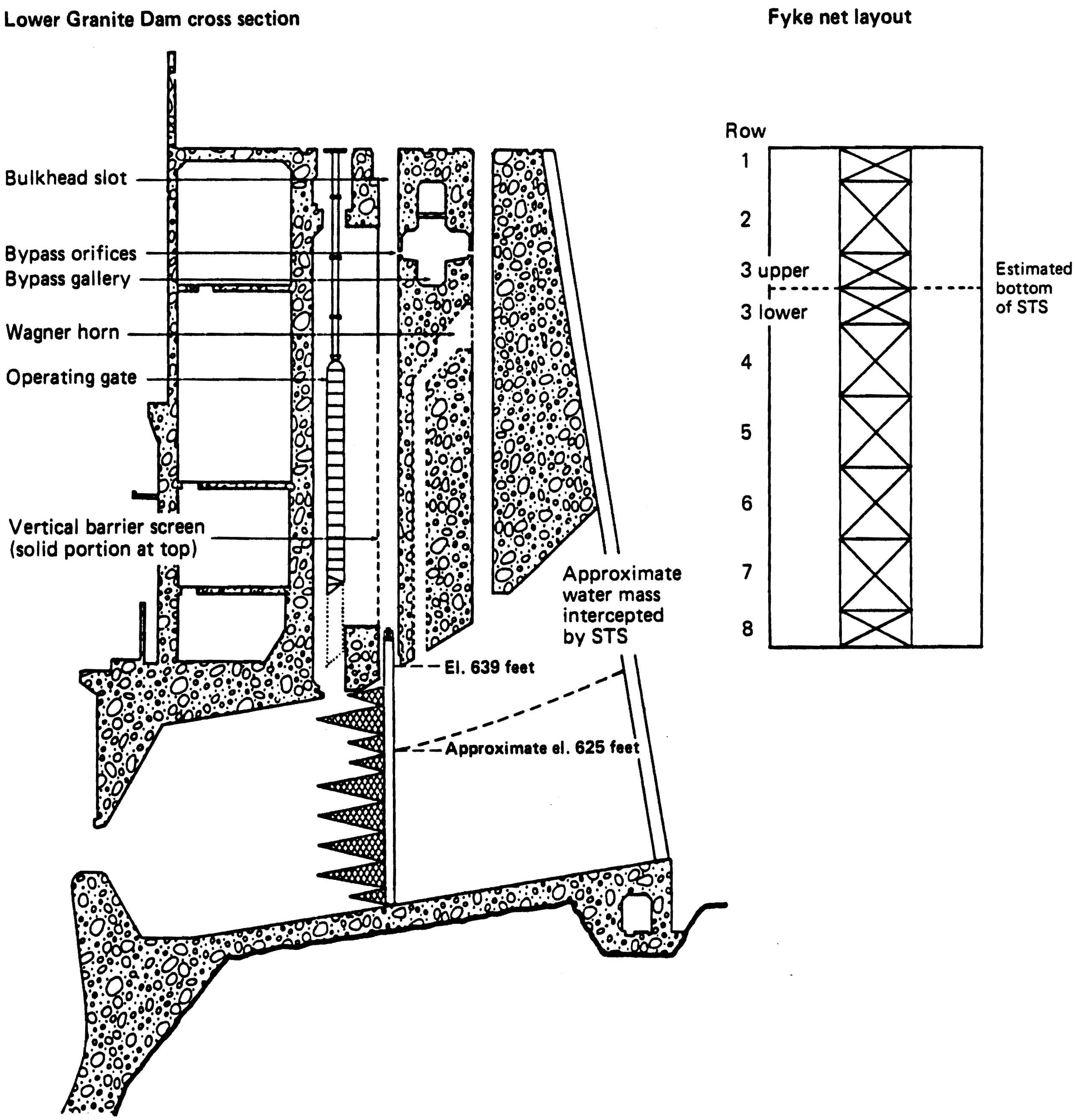

Figure 5.--Cross-section of a turbine intake at Lower Granite Dam with a vertical distribution net frame, 1987.

Data Analyses

To compare FGEs of the control condition (STS and 62-foot raised gate) to FGEs of the BSD condition, the BSD was alternated between Slots A and B for six consecutive tests. This cross-over method (Cochran and Cox 1957) provided a balanced design containing three trials from each intake for each condition. A detailed discussion and specific calculations for cross-over analysis of variance used to compare FGE test and control data at Lower Monumental Dam were presented by Ledgerwood et al. (1987).

To evaluate FGE of the BSD using a 0-foot raised (stored) operating gate (Slot 4B), the BSD was left in Slot 4B for three consecutive test nights; the control was maintained in Slot 4A. We tested the hypothesis that there was no significant difference in FGE ($P \geq 0.05$) between the two conditions using a paired t-test (Sokal and Rohlf 1981). Paired and ordinary t-tests were used to compare descaling rates of guided fish under various test conditions. Analysis of variance (F-test) was used to evaluate differences in fork length distributions for fish captured in the gatewells and various nets. Chi-square analysis was used to evaluate the extrinsic hypothesis that equal numbers of fish entered the two FGE test slots regardless of BSD placement.

Sample Size Requirements

For vertical distribution tests using a single vertical row of nets and assuming 10% volitional guidance into the gatewell, the desired sample size was 200 actual net-caught fish. If volitional guidance was higher, slightly fewer net-caught fish were needed. For FGE tests with side nets removed and FGE >60%, the desired total sample size was 200 fish, including gatewell fish; if FGE was

<60%, the desired sample size for validation increased to 250 fish.[3] A minimum of three replicates was required for each test condition to detect a difference of 10% or greater in FGE at an alpha = 0.05 level of significance with a power of the test 1-B = 0.80 (Swan et al. 1987).

RESULTS

Tests at Lower Granite Dam were conducted from 11 to 19 April and 24 April to 4 May (Appendix Tables A1 and A2). Tests at Little Goose Dam were conducted from 20 to 22 April and 5 to 7 May (Appendix Table A3). Yearling chinook salmon were the primary species present during the early testing. Juvenile steelhead were present in sufficient numbers for test purposes beginning 24 April at Lower Granite Dam and were the predominant species at both projects (>60% of the nightly catch) from 1 May to the end of testing at Lower Granite Dam.

Vertical Distribution Measurements

At Lower Granite Dam, vertical distribution measurements indicated that between 72 and 90% of yearling chinook salmon and about 92% of juvenile steelhead were located in the water mass that could potentially be intercepted by an STS (Table 1). Volitional guidance ranged from 1.6 to 10.6% for yearling chinook salmon and was 22.2% for steelhead. The timing of turbine shut down was keyed to gatewell catches in Slots A and B (FGE test slots) which typically had greater numbers of fish; consequently, slightly fewer than the desired 200 net-caught yearling chinook salmon were obtained in Slot 4C on two of four tests. Vertical distribution measurements in Slot 4C may have been

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3 The sample size requirements for vertical distribution and FGE tests were established at a meeting between COE and NMFS biologists and statisticians on 11 April 1986.

Table 1.--Vertical distribution catch data and descaling rates for yearling chinook salmon and juvenile steelhead at Lower Granite Dam, 1987.

Date	Species	Actual catch[a]		Adjusted total[b] catch	Descaled[c] (%)	TFGE[d] (%)
		Gatewell	Nets			
11 Apr	chinook salmon	29	145	464	0.0	72.2
14 Apr	chinook salmon	79	318	1,033	2.5	72.1
24 Apr	chinook salmon	29	90	299	3.4	80.9
27 Apr	chinook salmon	89	251	842	5.6	90.0
27 Apr	steelhead	254	296	1,142	2.7	92.1

[a]Data for species having at least 90 net-caught fish.

[b]Gatewell catch + adjusted net catch (= 3 X actual net catch).

[c]Gatewell catch only.

[d]TFGE = (Gatewell catch + adjusted net catch through Row 3U/Total adjusted catch) X 100.

influenced by STSs in Slots 4A and 4B, but to what degree was unknown. We do not expect it was higher than measured. If the true vertical distribution was lower than measured then the effectiveness of the guiding device would have been higher as the FGE would have been closer to the TFGE.

Fish Guiding Efficiency Tests

Temporal Patterns

At Lower Granite Dam, FGE for yearling chinook salmon (standard STS with 62-foot raised operating gate) ranged from 38.4 to 69.5% (Fig. 6). The patterns observed did not appear strongly related to any seasonal trend or to changes in the catch related to the contribution of various hatchery stocks (Fig. 7). The FGE for steelhead ranged from 64.3 to 82.5% (Appendix Table A1).

At Little Goose Dam, FGE for yearling chinook salmon ranged from 52.4 to 77.7% (Fig 6). There were insufficient numbers of steelhead for evaluation during the first sampling period; FGEs during the second sampling period ranged from 83.6 to 89.9% (Appendix Table A3).

Bar Screen Deflector

In 15 of 17 tests for yearling chinook salmon and 8 of 8 tests for steelhead at Lower Granite Dam, FGEs were higher in the slot containing the BSD (Appendix Table A1). During the early part of the yearling chinook salmon migration, FGEs increased rapidly (Fig. 8) and there was a significant increase in FGE ($P=0.0395$, cross-over method) in the test versus the control condition (11 to 16 April), means 66.4 and 51.2%, respectively. During this test series, there were insufficient steelhead captured for a comparable analysis. During the final test series, FGE using the BSD was only comparable to the control STS on consecutive nights (Table 2). Because of the low number of replicates and

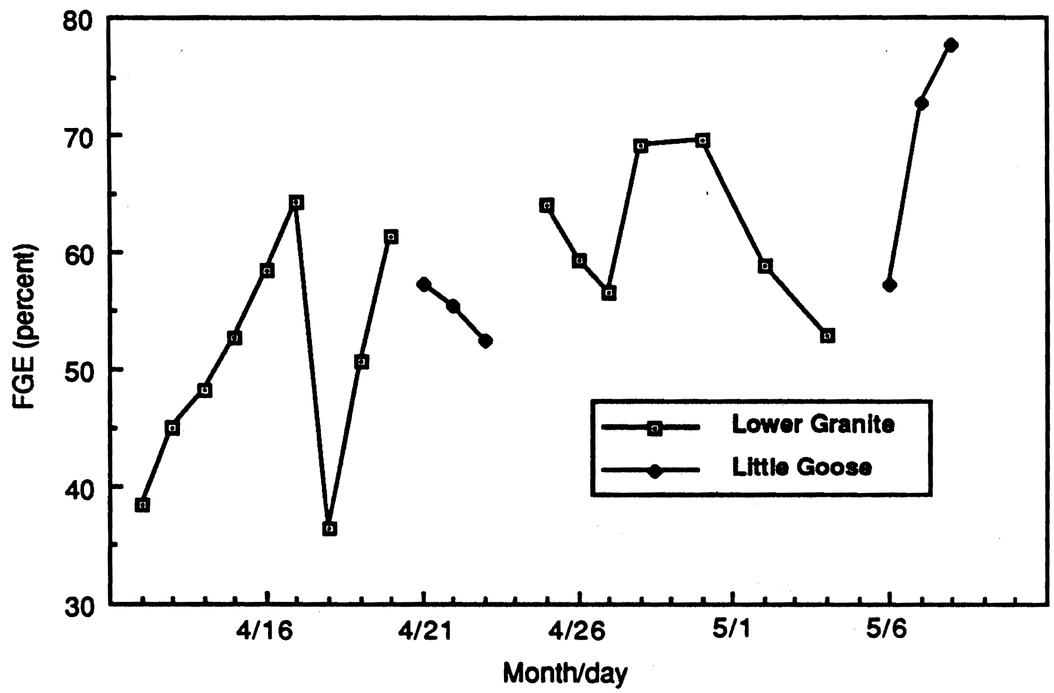

Figure 6.--Temporal patterns of fish guiding efficiency (FGE) for yearling chinook salmon (control STS) at Lower Granite and Little Goose Dams, 1987.

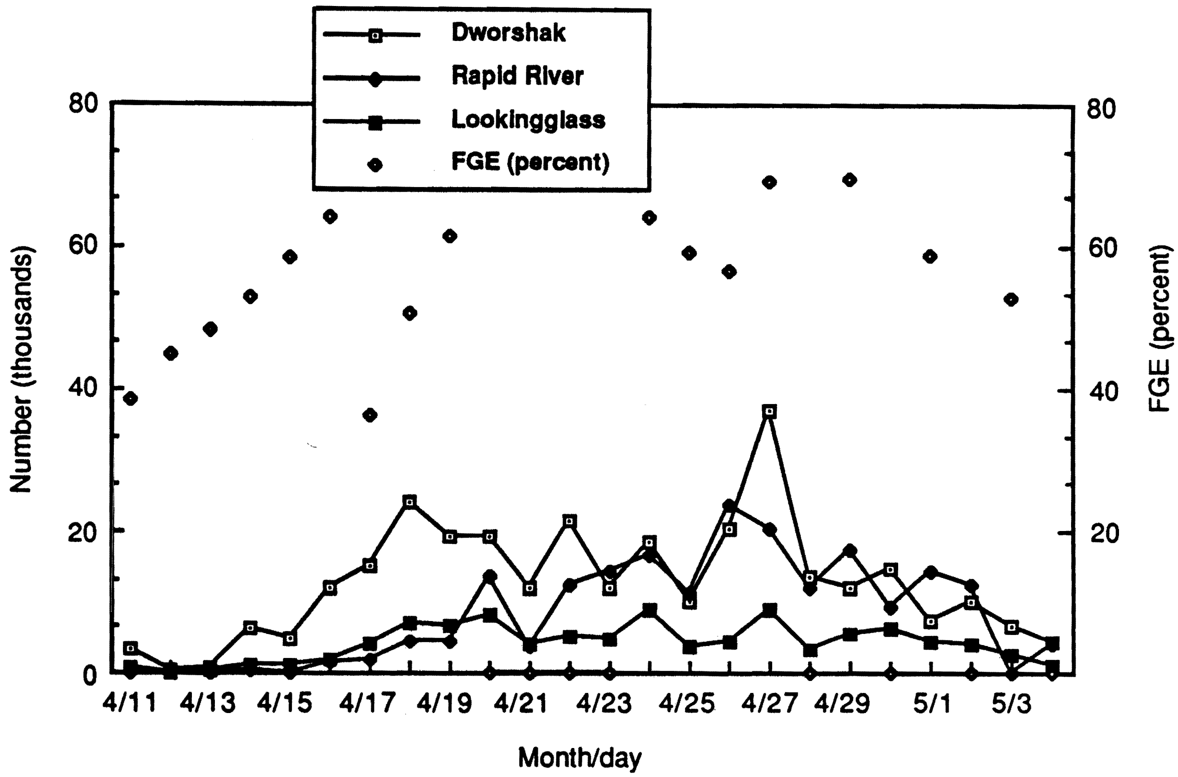

Figure 7.--Temporal patterns of fish guiding efficiency (FGE) compared to the estimated catch composition of hatchery stocks of yearling chinook salmon providing the major catch contribution during FGE studies at Lower Granite Dam, 1987.

Table 2.--Fish guiding efficiencies (FGEs) with a 62-foot raised operating gate comparing a lowered submersible traveling screen (LSTS) to a control STS, with and without a bar screen deflector (BSD), at Lower Granite Dam, 1987.

Date	Yearling chinook salmon				Steelhead			
	Control STS (%)	LSTS (%)	Control STS with BSD (%)	LSTS with BSD (%)	Control STS (%)	LSTS (%)	Control STS with BSD (%)	LSTS with BSD (%)
27 Apr[a]	69.1	----	----	63.5	77.9	----	----	81.0
28 Apr[a]	----	46.2	73.4	----	----	68.1	85.1	----
29 Apr[a]	69.5	----	----	67.3	64.3	----	----	92.2
30 Apr[a]	----	38.6	81.9	----	----	74.4	81.9	----
1 May[b]	58.9	----	----	71.9	82.5	----	----	90.1
2 May[b]	----	44.1	65.7	----	----	66.6	81.4	----
3 May[b]	53.0	----	----	70.6	71.9	----	----	93.1
4 May[b]	----	53.2	(91.5)[c]	----	----	70.5	80.4	----
Mean	62.6	45.5	73.7	68.3	74.2	69.9	82.2	89.1
number	4	4	3	4	4	4	4	4
SE[d]	4.04	3.02	4.68	1.88	3.93	1.70	1.01	2.77

[a]LSTS with a two-panel false gap device (for chinook salmon, 14% of adjusted catch was from the gap nets).

[b]LSTS with a three-panel false gap device (for chinook salmon, 7% of the total adjusted catch was from the gap nets).

[c]Insufficient fish (94) for statistical validity.

[d]Standard error of the mean.

the unbalanced number of comparisons, the statistical analyses for the final test series were not powerful and therefore are not presented. However, FGEs of the control STS with the BSD averaged 11.1% higher for yearling chinook salmon and 8.0% higher for steelhead than the control STS without the BSD.

When the BSD was tested with a stored operating gate, FGE for chinook salmon (mean 57.9%) was significantly different than FGE in the control slot (mean 49.5%) (P=0.0227, 2-tailed) (Figure 9). Numbers of steelhead were insufficient for a comparable analysis (Appendix Table A1).

Fish were effectively blocked from the FSS by the fish screen slot closure device and less effectively blocked by the BSD (Appendix Table A1). When the plug was used, an average of 0.1% of the guided chinook salmon and 0.4% of the guided steelhead were recovered in the FSS. When the BSD was used, the numbers of yearling chinook salmon and steelhead increased to 1.4 and 11.1%, respectively. The higher position of steelhead compared to chinook salmon in the water column was probably the cause of the higher percentages of steelhead in the FSS.

Lowered STS

Guidance of yearling chinook salmon at Lower Granite Dam with the LSTS was less than the control (Fig. 10) (Table 2), and the poor guidance was possibly related to hydraulic conditions with the modified screen. Only during the initial test series (24 to 26 April) were three replicates done with the LSTS. During the final test series, the false gap device attached to the LSTS was modified after two replicates. In addition, during the final test of the season, too few yearling chinook salmon were present in Slot B for statistical analysis. Because of the low number of replicates and the unbalanced number of

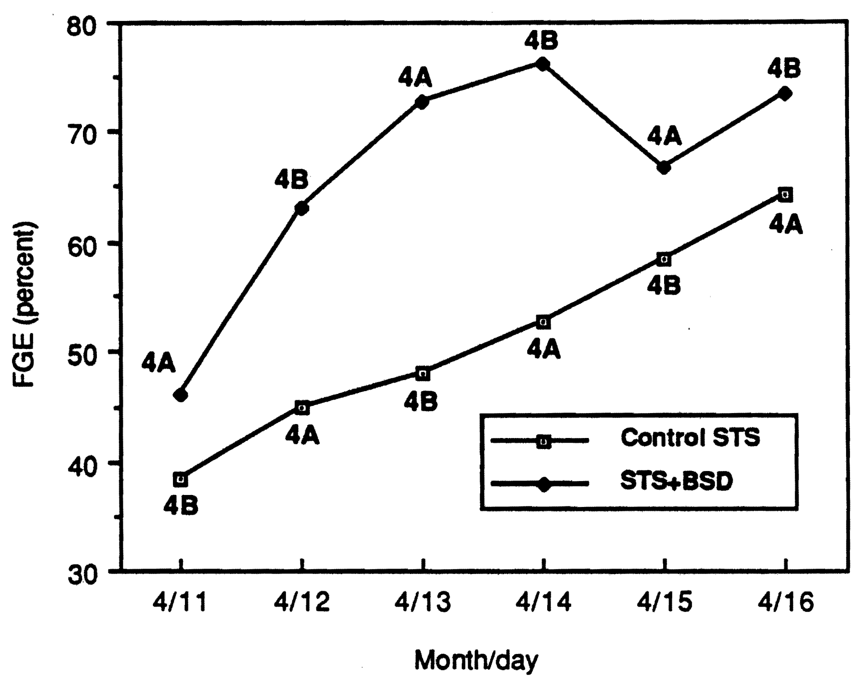

Figure 8.--Fish guiding efficiencies (FGEs) of yearing chinook salmon comparing a bar screen deflector (BSD) and control STS with a cross-over design during the early portion of the migration past Lower Granite Dam, 1987.

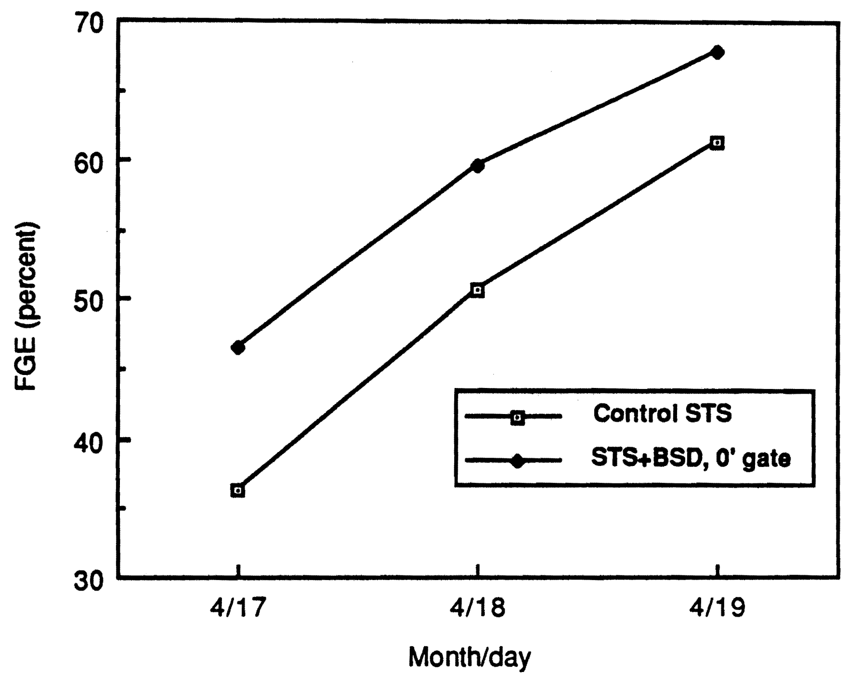

Figure 9.--Fish guiding efficiencies (FGEs) of yearling chinook salmon comparing a bar screen deflector (BSD) with a control STS and a stored (0-foot) operating gate to FGEs of a control STS with a 62-foot raised operating gate and no BSD, Lower Granite Dam, 1987.

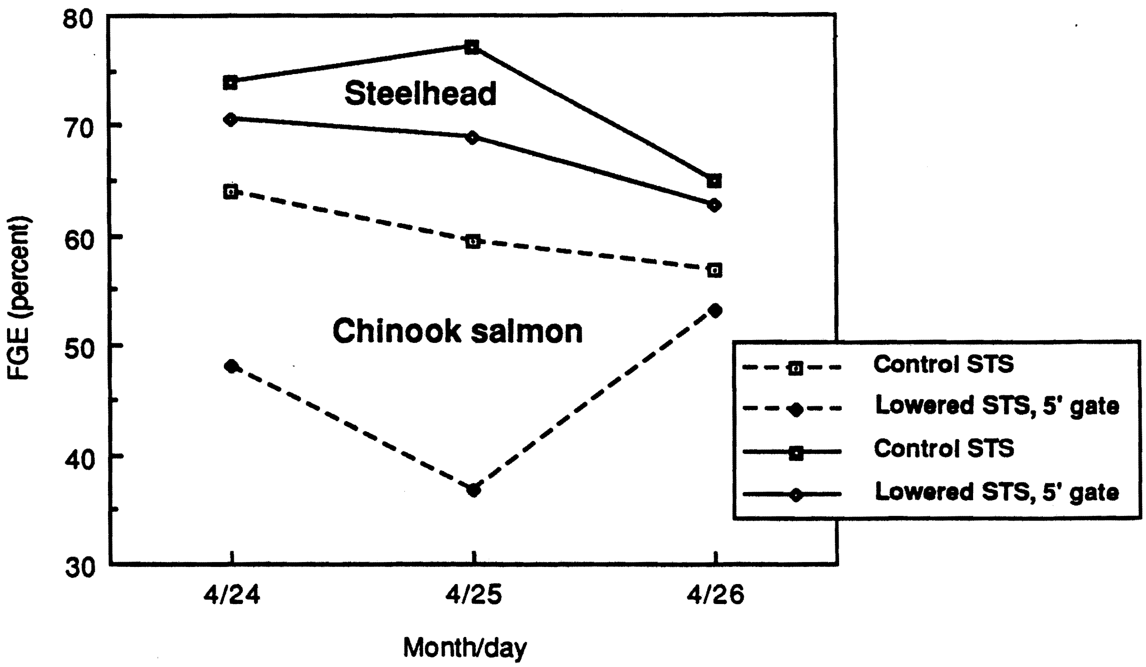

Figure 10.--Fish guiding efficiencies (FGEs) of yearling chinook salmon and juvenile steelhead comparing a lowered STS (LSTS) with a 5-foot raised operating gate to a control STS with a 62-foot raised operating gate, Lower Granite Dam, 1987.

comparisons, the statistical analyses for the final test series were not powerful and therefore are not presented.

Fish guiding efficiencies obtained using the LSTS with a 60-cm (2-foot) false gap device and a 1.5-m (5-foot) raised operating gate (24 to 26 April) were lower than the control condition in each of the three tests for yearling chinook salmon and steelhead, but the differences were not significant (P=0.1282 and P=0.1307) (Fig. 10). The lower guidance obtained with the LSTS during this initial series was attributed to the estimated 39% decrease in volume of water flowing into the gatewell caused by lowering the operating gate to 1.5 m (5 feet) (Table 3). During all subsequent tests, the operating gate was raised to 18.9 m (62 feet).

During the final test series, inspection of the data after Night 4 revealed that the gap nets of the LSTS had contributed about 14% of the total adjusted catch whereas gap nets of the control STSs contributed about 1% of the total gatewell catch (seasonal average)(Appendix Table A1). During the final four tests with the LSTS, when a third panel was added to the false gap device, gap net catches declined to 7% and the differences in FGEs between control and lowered STSs were less. If all fish captured in the gap nets of the LSTS were counted as guided fish the estimated FGEs would be similar to FGEs of the control STS (Fig. 11). Guidance of steelhead averaged 70% or greater regardless of test condition, probably due to their higher position in the water column.

Fish Descaling Rates

Descaling rates of volitionally guided fish (no STS) recovered from gatewells at Lower Granite Dam during vertical distribution tests were less than 6% for both species (Table 1). Generally, the BSD did not significantly increase descaling rates of guided fish--mean values, 4.6% with BSD and 3.8%

Table 3.--Estimated change of water volume flowing into the gatewell at Lower Granite Dam associated with different operating gate elevations, STS lengths, with and without a simulated bar screen deflector.

STS configuration	Height of operating gate raise (m)	(feet)	STS[a] length	Flow into gatewell slot[b] (m^3/s)	(cfs)
Standard[c]	0	0	normal	5.5	195
"	1.5	5	normal	10.2	360
"	6.1	20	normal	14.3	505
"	18.8	62	normal	14.3	505
"	0	0	extended	---[d]	---
"	1.5	5	extended	10.3[e]	365[e]
"	6.1	20	extended	13.6[e]	480[e]
"	18.8	62	extended	---	---
Lowered[f]	0	0	normal	---	---
"	1.5	5	normal	11.6	410
"	6.1	20	normal	19.0	670
"	18.8	62	normal	---	---
"	0	0	extended	---	---
"	1.5	5	extended	12.7	450
"	6.1	20	extended	20.4	720
"	18.8	62	extended	---	---

a An extended (double length) STS theoretically has similar flow patterns to a bar screen deflector mounted in the fish screen slot.

b Flow data from hydraulic model studies courtesy Mark Lingren, Walla Walla District, COE.

c Distance from the center of the dogging shoes to the center pin on the traveling screen was 206 cm (81 inches).

d --- Data not available for this test condition.

e During these tests, the extended screen was miss-aligned with the STS by plus 1 foot to simulate test conditions used with the bar screen deflector at Lower Granite Dam in 1987.

f Distance from the center of the dogging shoes to the center pin on the traveling screen was 325 cm (128 inches or "4-foot lowered").

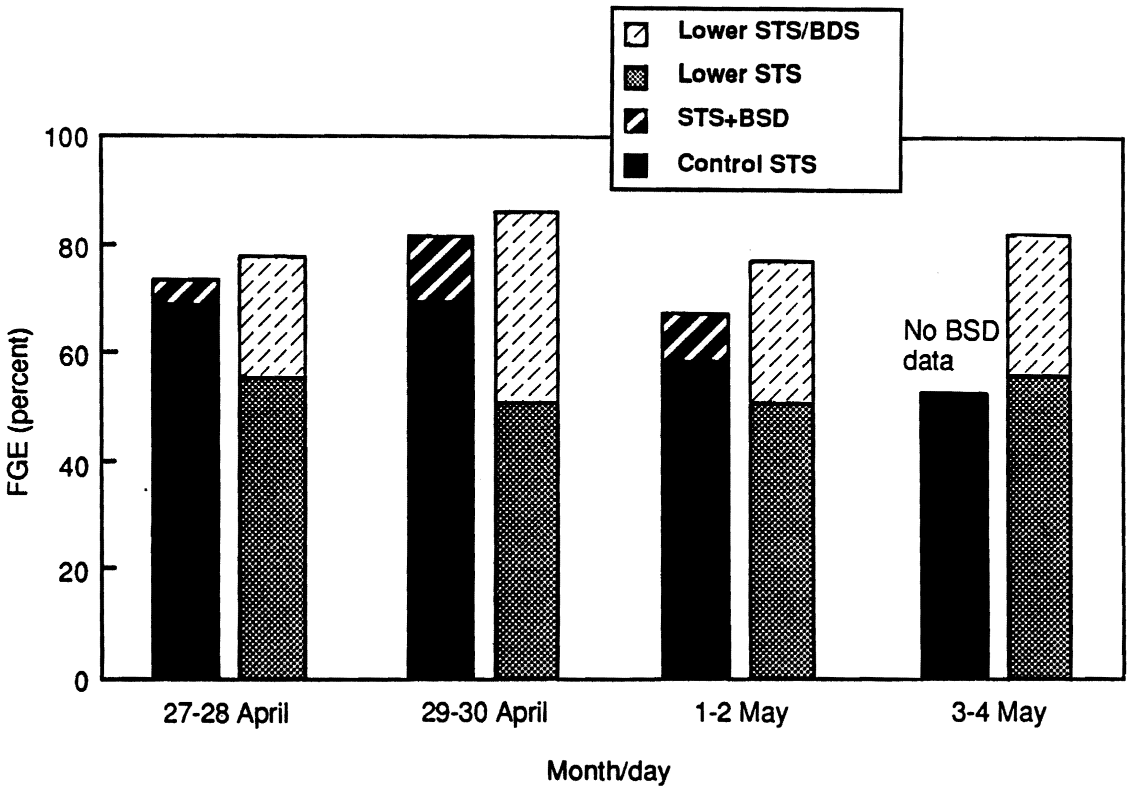

Figure 11.--Fish guiding efficiencies (FGEs) of yearling chinook salmon comparing a control STS to a lowered STS (LSTS) where the FGE of the LSTS included the gap net catch as guided fish. Comparisons are shown with and without a bar screen deflector (BSD), Lower Granite Dam, 1987.

with no BSD for yearling chinook salmon and 6.0 and 5.3%, respectively, for steelhead (Appendix Table A4). Descaling rates of guided fish using an STS were not significantly different than volitionally guided fish obtained during vertical distribution tests. During the stored operating gate test series (17 to 19 April), when the BSD was not cleaned for four consecutive days, the descaling rate for yearling chinook salmon was significantly different (higher)($P=0.0075$) than the descaling rate in the control slot. The increase in descaling may have been coincidental or related to unseen debris that fell from the BSD as it was raised to the surface.

Fish Length Distributions

Significant differences ($P \leq 0.05$) in length frequency distributions for yearling chinook salmon recovered in the gatewells and at various depths in the turbine intake at Lower Granite Dam occurred occasionally, but the differences were in both directions and no general trend was evident in either vertical distribution or FGE tests (Appendix Table A5). Length data from the other test conditions were similar and are available upon request.

DISCUSSION

Effects of the Drought on FGE

The regional drought in 1987 may have affected the depth distributions of juvenile salmonids in the Snake River and local weather phenomena did appear to affect FGE measurements. Rain and wind squalls struck the immediate area around Lower Granite Dam on the night prior to testing on 10 April and again a few minutes prior to the start of testing on 17 April; following these squalls, control FGEs hit seasonal lows (38.4% on 11 April and 36.3% on 17 April) then steadily increased during the next several nights to above 60%.

Lateral Diversion of Fish by the BSD

In 14 of 17 tests with yearling chinook salmon and 7 of 8 tests with steelhead, the slot containing the BSD had less than 50% of the total fish entering the FGE test slots; means were 36 and 38%, respectively (Tables 4 and 5). The data suggest that fish avoided the slot with the BSD as flows were only increased into the adjacent slots by approximately 5%. As a consequence, we feel additional testing to determine fish movement is required in a unit with a full complement of BSDs. It is important to determine if fish will only divert latterally or may divert below a slot with the extended screen configuration. The possibility exists that fish could divert below the BSD if flows were redirected there rather than to an adjacent slot.

CONCLUSIONS

Lower Granite Dam

1) The FGEs for yearling chinook salmon and steelhead in the control slot ranged from 38 to 70% and 64 to 83%, respectively.
2) The combination of a 62-foot raised operating gate, a BSD, and a normal or lowered STS increased FGEs approximately 15% in 15 of 17 tests compared to the condition without the BSD. However, significantly fewer fish entered the slot with the BSD than the slot without the BSD.
3) The average FGE with the LSTS was lower than the average FGE of the controls (no BSD).
4) The FGEs for the LSTs with BSD were higher than for the control STS with BSD.

Table 4.--Influence of the bar screen deflector (BSD) on the proportion of yearling chinook salmon captured in Turbine Intake Slots 4A and 4B during fish guiding efficiency studies at Lower Granite Dam, 1987.

Date	Total fish[a] Slot A + B	Test slot	Fish in test slot (%)[b]	Test condition	Statistical analysis[c]
11 Apr	2,159	4A	48.3	BSD with	Chi-square = 616.0
12 Apr	3,902	4B	31.0	control[d]	df=5, P<0.0001
13 Apr	3,535	4A	54.9	vs.	
14 Apr	1,896	4B	37.4	control	
15 Apr	4,168	4A	34.4		
16 Apr	1,363	4B	35.8		
17 Apr	2,889	4B	31.0	BSD with operating	
18 Apr	888	4B	24.5	gate stored	Chi-square = 832.8
19 Apr	3,560	4B	23.2	vs. control	df=2, P<0.0001
27 Apr	1,329	4A	34.0	BSD with LSTS[e]	
29 Apr	2,065	4A	29.4	vs.	Chi-square = 659.6
1 May	1,966	4A	27.7	control	df=3, P<0.0001
3 May	1,390	4A	21.8		
28 Apr	3,581	4B	56.1	BSD with	Chi-square = 56.9
30 Apr	2,328	4B	51.0	control	df=3, P<0.0001
2 May	880	4B	45.3	vs.	
4 May	316	4B	29.7	LSTS	
	Combined		36.2	BSD vs. no BSD	Chi-square = 2165.3 df=16, P<0.0001

[a]Total fish in Intake Slots 4A and 4B, adjusted for partial netting.

[b]Total fish in slot with BSD/total fish in Slots A + B.

[c]Ho: No difference in percentages of fish between the two slots.

[d]Control condition = Standard STS with the operating gate raised 18.8 m.

[e]LSTS = STS lowered 325 cm into the intake from the standard position.

Table 5.--Influence of the bar screen deflector (BSD) on the proportion of steelhead captured in Turbine Intake Slots 4A and 4B during fish guiding efficiency studies at Lower Granite Dam, 1987.

Date	Total fish[a] Slot A + B	Test slot	Fish in test slot (%)[b]	Test condition	Statistical analysis[c]
27 Apr	1,551	4A	36.3	BSD with LSTS[d]	Chi-square = 712.53
29 Apr	1,073	4A	28.5	vs.	df=3, P<0.0001
1 May	4,039	4A	28.9	Control[e]	
3 May	2,761	4A	31.1		
28 Apr	1,565	4B	52.3	BSD with	Chi-square = 283.014
30 Apr	1,476	4B	41.3	Control	df=3, P<0.0001
2 May	1,759	4B	44.3	vs.	
4 May	2,077	4B	41.5	LSTS	
	Combined		38.0	BSD vs. no BSD	Chi-square = 995.6 df=7, P<0.0001

[a]Total fish in intake slots 4A and 4B, adjusted for partial netting.

[b]Total fish in slot with BSD/total fish in slots A + B.

[c]Ho: No difference in percentages of fish between the two slots.

[d]LSTS = STS lowered 325cm into the intake from the standard position.

[e]Control condition = Standard STS with the operating gate raised 18.8 m.

5) The theoretical FGEs based upon vertical distribution measurements ranged from 72 to 90% for yearling chinook salmon. Lower values were obtained early in the migration.

Little Goose Dam

1) The FGEs of yearling chinook salmon averaged 55 and 71% for the early and late season tests, respectively. The average FGE for steelhead during the late season tests was 87%.

RECOMMENDATIONS

1) Eliminate the 14-inch gap between the STS and BSD and realign the BSD with the STS as originally designed.

2) For future tests of FGE, install three BSDs in one turbine unit to minimize the effects of diversion of fish to adjacent slots by the BSD. If two units were available for testing, a cross-over design, having the BSDs rotated between the units, would be preferred. If only a single unit were available, and BSDs were rotated in and out of the test unit daily, FGE comparisons between control (no BSD) and test (with BSD) conditions could be made on consecutive nights using a paired t-test.[4/]

3) Conduct additional research to define the optimum gap opening and distance to lower an STS. Test the best condition with BSDs.

4) Conduct simultaneous FGE/smoltification in a normal flow year to compare with results obtained during the regional drought in 1987.

4/ The consecutive day/same slot design would eliminate possible slot bias from the results, yet would require a longer test series than the cross-over design due to the non-blocked effects on FGE of different test dates for treatment and control.

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APPENDIX

Data tables

Appendix Table A1.--Physical data, catch data, descaling rates, and fish guiding efficiency (FGE) of submersible traveling screens at Lower Granite Dam, 1987.

Date[a]	Slot	Time Start	Time End	Test[b] Condition	Sps.[c]	Nets[d] LG	RG	LC	RC	M1	M2	M3	M4	M5	Adjusted[e] total	Guided fish Gatewell	Guided fish FSS[f]	Descale[g] (%)	FGE[h] (%)
4/11	4A	2008	2246	S2D	5	3	3	10	17	3	49	62	47	15	561	480	1	2.5	46.2
4/11	4A	2008	2246	S2D	6	0	1	0	1	1	1	1	2	0	17	50	11	9.6	78.2
4/11	4B	2008	2246	S62	5	4	3	39	51	19	82	50	38	8	688	429	0	1.6	38.4
4/11	4B	2008	2246	S62	6	0	0	1	2	1	2	0	0	0	12	50	0	16.7	80.6
4/12	4A	2000	2150	S62	5	13	8	106	111	75	196	96	41	7	1483	1208	0	2.0	44.9
4/12	4A	2000	2150	S62	6	1	0	4	3	7	11	2	0	0	68	195	2	0.0	74.3
4/12	4B	2000	2150	S2D	5	10	12	16	14	7	36	52	29	8	448	763	0	1.1	63.0
4/12	4B	2000	2150	S2D	6	0	0	1	0	0	0	1	1	0	7	69	0	0.0	90.8
4/13	4A	1934	2142	S2D	5	8	12	22	25	13	46	57	31	7	529	1398	12	1.2	72.7
4/13	4A	1934	2142	S2D	6	0	0	1	2	0	3	4	1	0	27	96	7	0.0	79.2
4/13	4B	1934	2142	S62	5	4	4	78	81	35	117	56	12	0	827	769	0	4.2	48.2
4/13	4B	1934	2142	S62	6	2	0	4	2	1	8	3	2	0	50	70	0	0.0	58.3
4/14	4A	1929	2131	S62	5	6	3	40	62	21	80	40	8	1	561	622	3	1.8	52.7
4/14	4A	1929	2131	S62	6	0	1	2	5	4	10	5	1	0	68	92	0	0.0	57.5
4/14	4B	1929	2131	S2D	5	4	5	9	5	4	8	24	10	3	170	538	2	3.7	76.1
4/14	4B	1929	2131	S2D	6	1	1	2	0	0	3	1	1	0	19	82	3	0.0	81.7
4/15	4A	1924	2059	S2D	5	5	10	20	9	5	57	50	22	10	476	936	22	5.0	66.8
4/15	4A	1924	2059	S2D	6	0	1	0	1	0	4	3	2	0	29	24	1	0.0	46.3
4/15	4B	1924	2059	S62	5	10	16	105	86	62	145	74	17	9	1138	1596	0	1.9	58.4
4/15	4B	1924	2059	S62	6	0	0	2	1	2	8	6	0	0	51	67	1	16.7	57.1
4/16	4A	1909	2027	S62	5	5	6	27	34	20	46	7	6	1	312	563	0	6.2	64.3
4/16	4A	1909	2027	S62	6	0	0	1	1	1	2	0	1	0	14	18	0	11.1	56.3
4/16	4B	1909	2027	S2D	5	5	5	1	5	0	10	17	10	1	130	355	3	1.5	73.4
4/16	4B	1909	2027	S2D	6	0	0	1	0	0	0	0	1	0	4	16	0	20.0	80.0
4/17	4A	1905	2016	S62	5	6	6	87	77	49	158	101	50[i]	6	1268	724	—[j]	2.0	36.3
4/17	4A	1905	2016	S62	6	0	0	5	0	0	1	1	0[i]	0	11	13	—	0.0	54.2
4/17	4B	1905	2016	S0D	5	9	9	15	19	9	41	44	37	11	478	412	7	4.3	46.7
4/17	4B	1905	2016	S0D	6	0	0	0	0	0	2	1	0	0	9	8	1	0.0	50.0
4/18	4A	1908	2032	S62	5	3	3	18	33	22	47	17	3	2	330	340	0	3.2	50.7
4/18	4A	1908	2032	S62	6	0	0	1	4	0	7	1	0	0	29	36	0	0.0	55.4
4/18	4B	1908	2032	S0D	5	3	3	8	5	0	3	8	9	3	88	126	4	6.3	59.6
4/18	4B	1908	2032	S0D	6	1	1	1	0	0	1	0	0	0	6	19	3	5.3	78.6
4/19	4A	1900	2100	S62	5	13	18	106	19	23	156	76	36	9	1056	1677	0	3.6	61.4
4/19	4A	1900	2100	S62	6	0	4	7	0	1	10	5	1	0	62	172	0	5.6	73.5
4/19	4B	1900	2100	S0D	5	7	23	31	17	3	25	24	6	6	270	553	4	6.5	67.4
4/19	4B	1900	2100	S0D	6	4	0	1	0	0	4	1	2	0	26	60	4	25.0	71.1
4/24	4B	1952	2122	S62	5	2	2	13	35	20	53	17	1	4	337	603	0	3.0	64.1
4/24	4B	1952	2122	S62	6	4	5	0	14	9	23	7	0	0	140	398	0	1.6	74.0
4/24	4A	1952	2122	L5	5	55	48	46	50	32	70	23	4	1	589	549	0	1.0	48.2
4/24	4A	1952	2122	L5	6	4	2	8	9	7	24	9	0	0	143	343	0	1.3	70.6
4/25	4A	1923	2100	L5	5	72[k]	39[k]	90	105	52	148	58	5	0	1095	634	0	3.2	36.7
4/25	4A	1923	2100	L5	6	3[k]	6[k]	13	19	11	25	6	0	0	167	370	0	3.7	68.9
4/25	4B	1923	2100	S62	5	6	5	64	71	38	103	44	14	4	755	1097	6	4.7	59.4
4/25	4B	1923	2100	S62	6	2	2	12	8	5	24	13	1	1	156	517	4	7.8	77.0
4/26	4A	1918	2027	L5	5	53	56	5	70	25	61	15	2	0	493	559	0	2.2	53.1
4/26	4A	1918	2027	L5	6	3	2	0	16	5	18	3	0	0	99	168	0	7.1	62.9
4/26	4B	1918	2027	S62	5	7	9	52	43	25	87	34	13	3	597	774	9	1.7	56.7
4/26	4B	1918	2027	S62	6	1	2	6	13	7	17	5	3	0	118	213	6	0.0	65.0
4/27	4A	1908	2044	L2D	5	33	33	3	6	1	18	5	6	0	165	279	8	2.6	63.5
4/27	4A	1908	2044	L2D	6	1	5	0	2	1	10	14	7	1	107	393	63	0.0	81.0
4/27	4B	1908	2044	S62	5	2	2	22	14	16	46	13	1	1	271	606	0	2.7	69.1
4/27	4B	1908	2044	S62	6	2	4	19	7	10	33	13	5	1	218	770	0	3.7	77.9
4/28	4A	1927	2027	L62	5	63	86	91	56	45	117	14	7	0	845	726	1	2.6	46.2
4/28	4A	1927	2027	L62	6	6	7	20	19	24	27	11	0	0	238	505	3	3.3	68.1
4/28	4B	1927	2027	S2D	5	12	13	27	27	5	54	60	30	3	535	1458	16	5.2	73.4
4/28	4B	1927	2027	S2D	6	6	5	4	5	1	7	18	7	1	122	625	72	0.0	85.1
4/29	4A	1910	2030	L2D	5	58	57	4	11	3	9	10	1	0	199	386	23	5.9	67.3
4/29	4A	1910	2030	L2D	6	0	3	0	3	1	4	1	0	0	24	239	43	5.3	92.2
4/29	4B	1910	2030	S62	5	2	7	38	46	26	67	22	2	0	444	1012	1	3.8	69.5
4/29	4B	1910	2030	S62	6	4	5	19	15	9	43	20	3	2	274	489	4	0.6	64.3
4/30	4A	1906	2045	L62	5	69	74	51[i]	51	40	88	19	5[i]	0[i]	701	440	—	9.8	38.6
4/30	4A	1906	2045	L62	6	7	9	10[i]	10	18	32	12	0[i]	0[i]	222	645	—	4.5	74.4
4/30	4B	1906	2045	S2D	5	5	10	14	12	3	23	19	12	1	215	963	9	8.1	81.9
4/30	4B	1906	2045	S2D	6	4	4	5	4	0	13	13	5	0	110	449	50	14.9	81.9

Appendix Table A1.--continued.

Date[a]	Slot	Time Start	Time End	Test[b] Condition	Sps.[c]	Nets[d] LG	RG	LC	RC	M1	M2	M3	M4	M5	Adjusted[e] total	Guided fish Gatewell	FSS[f]	Descale[g] (%)	FGE[h] (%)
5/01	4A	1906	2000	L2D	5	7	22	22	9	0	15	14	2	0	153	386	5	4.5	71.9
5/01	4A	1906	2000	L2D	6	5	5	7	6	1	19	10	1	0	116	901	151	3.9	90.1
5/01	4B	1906	2000	S62	5	13	8	25	79	31	91	29	1	1	584	838	0	8.6	58.9
5/01	4B	1906	2000	S62	6	14	12	29	39	41	67	21	5	2	502	2365	4	1.7	82.5
5/02	4A	1904	2035	L62	5	14	20	37	27	19	30	7	1	0	269	209	3	6.5	44.1
5/02	4A	1904	2035	L62	6	2	3	23	44	25	47	14	1	0	333	647	5	9.8	66.2
5/02	4B	1904	2035	S2D	5	0	2	5	1	1	17	10	15	0	137	255	7	6.8	65.7
5/02	4B	1904	2035	S2D	6	5	9	7	4	0	15	13	9	3	145	573	62	10.8	81.4
5/03	4A	1906	2029	L2D	5	21	15	0	5	1	9	5	1	0	89	204	10	9.4	70.6
5/03	4A	1906	2029	L2D	6	6	4	4	6	1	5	5	2	0	59	702	99	11.2	93.1
5/03	4B	1906	2029	S62	5	10	7	39	38	23	67	27	18	4	511	576	0	7.5	53.0
5/03	4B	1906	2029	S62	6	16	6	31	37	34	76	29	8	1	534	1359	8	19.4	71.9
5/04	4A	1905	2213	L62	5	5	3	12	15	5	15	2	1	0	104	118	0	2.5	53.2
5/04	4A	1905	2213	L62	6	6	10	38	32	18	54	16	2	1	359	852	5	9.4	70.5
5/04	4B	1905	2213	S2D	5	0	1	1	0	0	0	1	1	0	8	84	2	3.6	91.5
5/04	4B	1905	2213	S2D	6	3	7	4	5	0	13	17	18	2	169	642	50	1.6	80.4

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a/ Month/day.

b/ Abbreviations for test conditions were: 1. S62=control STS with 62-foot operating gate (OG), no bar screen deflector (BSD), 2. S2D=control STS, 62-foot OG, with BSD, 3. S0D=control STS, stored OG, with BSD, 4. L5=lowered STS (LSTS), 5-foot OG, no BSD, 5. L2D=LSTS, 62-foot OG, with BSD, and 6. L62=LSTS with 62 foot OG, no BSD.

c/ Species codes: 5=yearling chinook salmon, 6=steelhead.

d/ Net codes: 1st. character, L=left, M=middle, R=right; 2nd. character, G=gap, C=closure, 1-5=fyke net.

e/ Actual net catch adjusted for missing side nets or nets lost during testing.

f/ FSS=fish screen slot.

g/ A subsample of generally 100 or more guided fish were observed for descaling.

h/ FGE%=(Number of guided fish)/(Number of guided fish+adjusted total net fish)*100

i/ Net lost during the test; catch estimated.

j/ --=number of fish captured in the FSS inadvertently included in the gatewell catch.

k/ Gap net (with no cod-end) enverted during the test and it was estimated that about two thirds of the fish were lost; numbers of fish remaining in the nets were as follows: chinook, LG=24, RG=13, steelhead, LG=1, and RG =2. For subsequent tests, gap nets having cod-ends were used.

Appendix Table A2.--. Physical data, catch data, descaling rates, and theoretical fish guiding efficiencies (TFGEs) for vertical distribution studies at Lower Granite Dam, 1987.

Date[a]	Slot	Time Start	Time End	Sps.[b]	Nets[c] (no.) M1	M2	M3U	M3L	M4	M5	M6	M7	M8	Adjusted[d] total (no.)	Gatewell Catch (no.)	Gatewell Descale (%)	TFGE[e] (%)
4/11	4C	2008	2246	5	58	32	12	12	14	11	3	3	0	435	29	0.0	72.2
4/11	4C	2008	2246	6	10	3	0	0	4	0	1	0	0	54	7	0.0	75.4
4/14	4C	1929	2131	5	150	59	13	16	24	31	20	5	0	954	79	2.5	72.1
4/14	4C	1929	2131	6	21	11	1	4	8	5	4	1	0	165	43	0.0	68.3
4/24	4C	1952	2122	5	45	21	5	4	9	5	1	0	0	270	29	3.4	80.9
4/24	4C	1952	2122	6	44	13	7	6	6	3	0	0	0	237	65	1.5	85.0
4/27	4C	1908	2044	5	147	63	13	8	14	5	0	1	0	753	89	5.6	90.0
4/27	4C	1908	2044	6	191	63	12	15	9	5	1	0	0	888	254	2.7	92.1

a/ Month/day.

b/ Species codes: 5=yearling chinook salmon, 6=steelhead.

c/ Only middle nets used; net codes: 1st. character, M=middle; 2nd. character=net level; 3rd. character U=upper net, L=lower net.

d/ Actual net catch adjusted for missing nets.

e/ TFGE=(Adjusted net catch through net level 3U + Gatewell catch)/(Total adjusted net catch + Gatewell catch)*100.

Appendix Table A3.--Physical data, catch data, descaling rates, and fish guiding efficiencies (FGEs) of submersible traveling screens at Little Goose Dam, 1987.

Date[a]	Slot	Time Start	Time End	Test[b] Condition	Sps.[c]	Nets[d] LG (no.)	RG	LC	RC	M1	M2	M3	M4	M5	Adjusted[e] (no.)	Gatewell Catch (no.)	Gatewell Descale[f] (%)	Gatewell FGE[g] (%)
4/20	4B	2112	2257	S20	5	5	6	50	66	32	104	29	5	1	640	860	2.8	57.3
4/20	4B	2112	2257	S20	6	1	1	2	2	3	3	0	0	0	24	75	0.0	75.8
4/21	4B	2004	2400	S20	5	5	0	36	46	30	76	21	8	2	498	618	6.6	55.4
4/21	4B	2004	2400	S20	6	1	0	2	3	0	4	2	2	0	30	52	0.0	63.4
4/22	4B	1947	2300	S20	5	3	2	42	61	39	86	29	5	0	585	643	5.5	52.4
4/22	4B	1947	2300	S20	6	0	0	1	0	3	3	0	1	0	22	52	0.0	70.3
5/05	4B	1910	2217	S20	5	7	7	54	26	42	66	16	2	5	487	805	1.2	62.3
5/05	4B	1910	2217	S20	6	5	5	10	17	8	16	6	2	2	139	711	1.3	83.6
5/06	4B	2000	2135	S20	5	5	7	80	102	77	111	25	9	2	866	2320	3.9	72.8
5/06	4B	2000	2135	S20	6	0	0	7	5	5	12	2	0	0	69	612	1.2	89.9
5/07	4B	2000	2126	S20	5	1	1	13	13	9	17	3	0	0	115	401	2.4	77.7
5/07	4B	2000	2126	S20	6	1	0	2	4	4	8	2	2	0	55	361	3.0	86.8

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a/ Month/day.

b/ Abbreviation for test condition S20=control length STS with operating gate raised 20 feet.

c/ Species codes: 5=yearling chinook salmon, 6=steelhead.

d/ Net codes: 1st. character, L=left, M=middle, R=right; 2nd. character, G=gap, C=closure, 1-5=fyke net.

e/ Actual net catch adjusted for missing side nets.

f/ A subsample of generally 100 or more guided fish were observed for descaling.

g/ FGE%=(Number of guided fish)/(Number of guided fish + adjusted total net catch)*100

Appendix Table A4.--Differences in descaling percentages of guided juvenile salmonids collected during fish guiding efficiency studies at Lower Granite Dam, 1987.

	YEARLING CHINOOK SALMON				STEELHEAD			
Test condition[a]	Mean difference	Paired t-value	df	Probability (2-tailed)	Mean difference	Paired t-value	df	Probability (2-tailed)
STS vs BSD	-0.45	-0.30	5	0.7762	----[b]	----	--	----
STS vs BSD, 0-gate	-2.77	11.51	2	0.0075	----	----	--	----
STS vs LSTS, 5-gate	1.00	1.31	2	0.3207	1.17	0.77	2	0.5198
STS vs LSTS	0.30	0.12	3	0.9121	-0.40	-0.10	3	0.9243
STS vs BSD	-1.66	-0.90	2	0.4631	3.65	0.73	3	0.5209
STS vs LSTS+BSD	0.05	0.03	3	0.9780	1.25	0.43	3	0.6965
STS+BSD vs LSTS	0.40	0.30	2	0.7762	0.90	0.22	3	0.8377
STS+BSD vs LSTS+BSD	2.37	19.60	2	0.0026	1.70	0.40	3	0.7140
Combined data comparisons (ordinary t-test)								
No BSD vs BSD	0.91	1.153	37	0.2563	0.68	0.29	20	0.7762

a/ The following abbreviations were used: STS=control length STS with 62 foot raised operating gate; BSD= bar screen deflector; LSTS = STS lowered 4 feet; 0-gate= operating gate in stored position; 5-gate= operating gate raised 5 feet.

b/ ---- = insufficient fish present for analysis.

Appendix Table A5.--Mean fork lengths (mm) of yearling chinook salmon captured during vertical distribution and fish guiding efficiency tests at Lower Granite Dam, 1987.

A. Vertical distribution tests (Slot 4C).

Date	14 AP	24 AP	27 AP
Level		Lengths	
Gatewell	122.4	128.3	121.0
Fyke net 1	123.0	122.1	122.0
Fyke net 2	130.8	124.0	125.2
Fyke net 3U	122.3	-----[a]	126.2
Fyke net 3L	137.8	-----	140.6
Fyke net 4	128.5	-----	135.0
Fyke net 5	121.8	-----	-----
Fyke net 6	127.7	-----	-----
Fyke net 7	-----	-----	-----
Fyke net 8	-----	-----	-----
Mean	125.1	124.4	123.9

B. Fish guiding efficiency tests (Slots 4A and 4B--control condition [b]).

Date[c]	12 AP	13 AP	14 AP	15 AP	16 AP	17 AP[d]	18 AP[e]	19 AP	24 AP	25 AP	26 AP	27 AP	29 AP[f]	1 MY	3 MY
Level								Lengths							
Gatewell	133.4	132.7	130.0	128.8	127.2	129.3	118.8	124.6	126.3	127.7	129.9	123.3	127.7	125.4	126.7
Gap net	121.0	-----	-----	124.2	122.3	127.5	-----	118.1	-----	130.5	120.9	-----	-----	120.8	120.3
Closure net	132.3	134.0	133.9	129.4	128.0	127.0	126.7	126.8	126.4	128.5	127.6	124.0	133.9	125.9	122.3
Fyke net 1	131.3	134.4	131.9	127.6	131.2	125.8	119.8	125.2	119.7	125.9	131.6	122.5	134.0	125.3	126.3
Fyke net 2	133.6	134.8	128.9	128.7	123.4	127.2	128.7	124.3	128.4	128.7	128.3	125.1	130.1	125.8	122.5
Fyke net 3	138.5	132.6	130.1	128.0	-----	128.6	135.3	128.6	132.6	128.4	126.9	117.3	133.9	133.8	130.6
Fyke net 4	137.0	130.0	-----	134.4	-----	-----	-----	128.2	-----	131.8	128.5	-----	-----	-----	125.8
Fyke net 5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	133.4	133.5	130.4	128.7	126.9	128.0	122.1	125.4	126.6	128.2	128.6	123.4	130.0	126.1	125.0

a/ ----- = fewer than 10 fish measured.

b/ Length data for other test conditions at Lower Granite and Little Goose Dams are available upon request.

c/ Data for test on 11 April are not presented because both total and fork lengths were recorded.

d/ Gatewell fish significantly different (larger) than net fish ($P \leq 0.05$).

e/ Gatewell fish significantly different (smaller) than net fish and there were significant differences among net fish ($P \leq 0.05$).

f/ Gatewell fish significantly different (smaller) than net fish ($P \leq 0.05$).