Evaluation of Fish Guidance Efficiency of Submersible Traveling Screens and Other Modifications at Bonneville Dam Second Powerhouse, 1993

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Coastal Zone and Estuarine Studies Division

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Seattle, Washington

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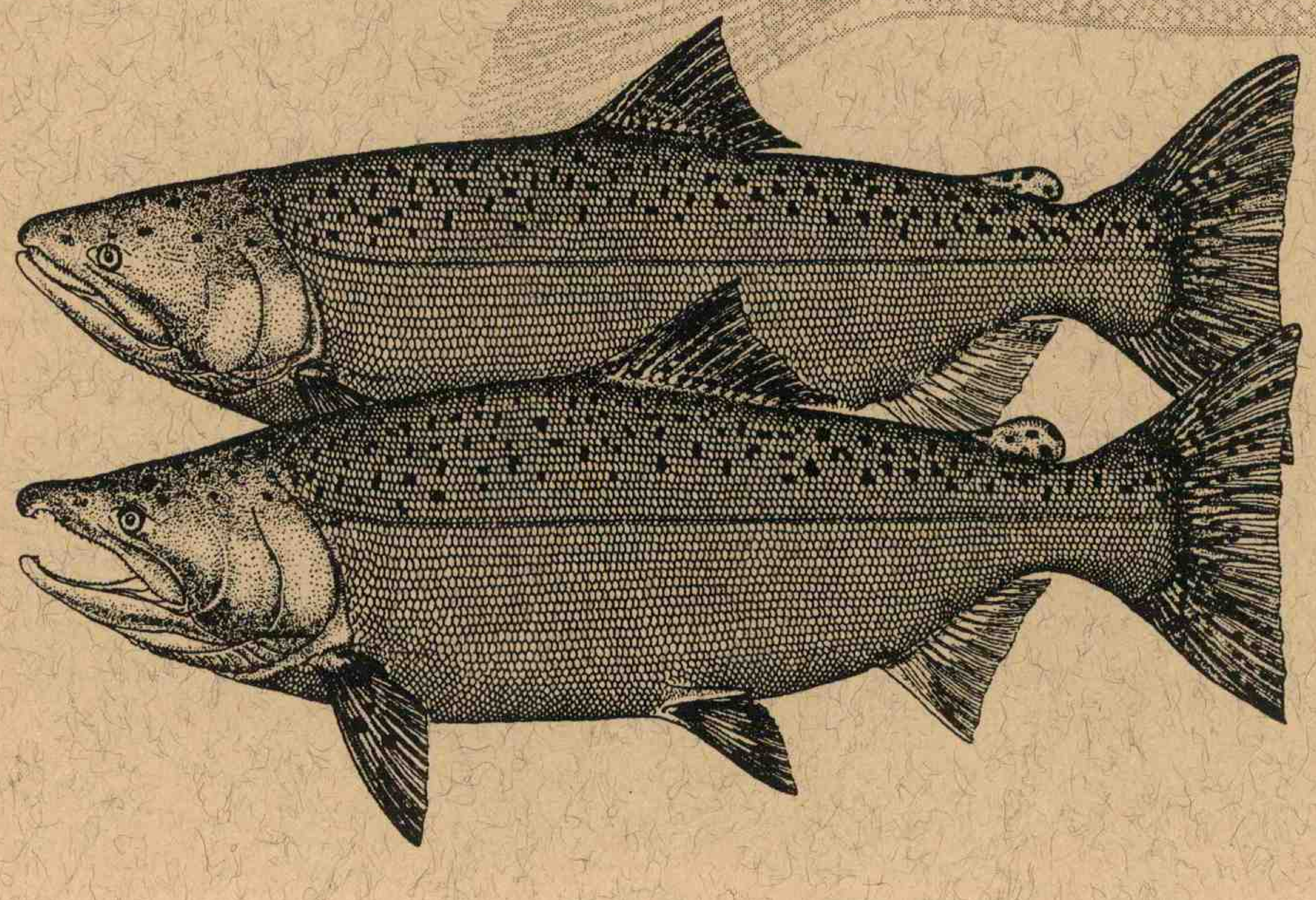

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by

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INTRODUCTION

Bonneville Dam Second Powerhouse was completed in 1982 and National Marine Fisheries Service (NMFS) researchers began evaluating fish guidance efficiency (FGE) at this facility in 1983. Initial measurements of FGE with standard-length submersible traveling screens (STSs) were less than 25% for yearling chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*), and approximately 33% for steelhead (*O. mykiss*). These results were lower than the expected design level of greater than 70% for all species (Krcma et al. 1984). As a result, the NMFS study objective changed from evaluating FGE to determining means to improve FGE.

In 1984, we tested various modifications designed to intercept more fish entering the turbine intake and/or to improve conditions which would lead to a greater diversion of fish into gatewells. We also illuminated the forebay immediately upstream from the powerhouse in an attempt to attract fish closer to the surface. The 1984 spring field tests showed only a slight improvement in FGE over 1983 levels; no improvement in FGE occurred for summer migrating fish (Gessel et al. 1985).

In 1985, we tried two means of altering the flow in the area intercepted by the STS: 1) lowering an STS to increase the gap and flow above the screen, and 2) placing streamlined trashracks in the upper half of the test intake to smooth flows above the STS. We found that lowering the STS 0.8 m (30 in), in conjunction with streamlining the trashracks, increased FGE to about 40% for yearling chinook salmon. However, FGE estimates during the 1985 summer outmigration of subyearling chinook salmon did not change (Gessel et al. 1986).

Model studies conducted in 1985 at the U.S. Army Corps of Engineers (COE) Waterways Experiment Station indicated that a turbine intake extension (TIE) might reduce forebay eddies. Model flow patterns were observed by releasing dye in both a 1:25 sectional turbine intake model and a 1:80 model of the Bonneville Dam Project. These observations indicated such extensions could dampen the lateral flows and at the same time provide a more uniform vertical flow into the turbine intakes. Thus, TIEs were designed and constructed for testing during the 1986 spring and summer outmigrations.

In 1986, we installed TIEs in front of Slots 11C, 12A, 12B, 12C, 13A, and 13B. In addition, we retested the best 1985 guidance modifications. Under these conditions, mean FGE was 71% and mean screen effectiveness [FGE ÷ theoretical FGE (an estimate of the percentage of fish theoretically guidable based upon hydraulic model studies and the vertical distribution of fish)] increased to 80%. However, while these guidance levels were encouraging, they were obtained during restricted powerhouse operation. During full powerhouse operation a high-velocity lateral current developed at the face of the TIEs. This lateral current reduced mean guidance and screen effectiveness for yearling chinook and coho salmon to below 50 and 60%, respectively. Also, guidance for subyearling chinook salmon during the summer outmigration remained between 18 and 24% (Gessel et al. 1987).

During the spring 1987 outmigration, TIEs were tested with an alternate intake configuration in front of Slots 11A, 11C, 12B, 13A, 13C, and 14B, along with streamlined trashracks and 0.8-m lowered STSs. These tests were conducted during full powerhouse operation. The alternate TIE configuration broke up the lateral current and created vortices. We speculated that these vortices concentrated fish and pulled them to the top of the turbine intake ceiling, resulting in higher fish guidance in slots without TIEs. For example, the number of fish passing into Slot 12A was almost 1.7 times higher than the number of fish passing into Slot 12B. We estimated weighted mean FGEs of 60% for yearling chinook salmon and 53 and 47% for steelhead and subyearling chinook salmon, respectively (Gessel et al. 1988). However, during the summer outmigration, the alternate TIE configuration did not improve FGE results for subyearling chinook salmon.

In 1988, we retested the best configuration from 1987 (alternate TIEs, with STSs lowered 0.6-m, and streamlined trashracks) with mercury vapor lights in an attempt to attract fish and improve guidance. In addition, we tested the submersible bar screen with 45% porosity (compared to a standard porosity of 22% for STSs). Mercury vapor lights did not improve guidance under any conditions tested, but the higher porosity bar screen did produce an average FGE of over 80%. However, descaling was also increased by almost threefold with the bar screen (Gessel et al. 1989).

In 1989, a raised operating gate was tested with a 45% porosity bar screen. It was hoped that descaling problems found in 1988 could be reduced while maintaining the increased guidance achieved with the bar screen. The raised operating gate did not significantly improve the effectiveness of the bar screen in guiding yearling chinook salmon nor did it help reduce descaling. The porosity of the bar screen was then decreased to about 33% which reduced fish descaling to levels equal to those obtained with the STS. During a 3-day period in mid-May, we calculated mean FGEs of 78% for yearling chinook salmon and 69% for steelhead. These were the highest FGE averages obtained at the second powerhouse since 1983. After a 1-week layoff, we again compared FGE with the STS to FGE with the 33% porosity bar screen. Guidance for yearling chinook and coho salmon was significantly higher with bar screen than with the STS; however, mean FGEs were only 60 and 51% for the bar screen and STS, respectively. No statistically significant differences in mean FGE were found between the two screens for steelhead (41%) and subyearling chinook salmon (52%). The mean FGE of 25% for subyearling chinook salmon during the 1989 summer outmigration was similar to results from previous years (Gessel et al. 1990).

Research at Bonneville Dam Second Powerhouse from 1983 to 1989 indicated that modifications to increase flows above the STS and smooth flows into and within the turbine intake could substantially increase juvenile salmonid guidance during the spring outmigration (Gessel et al. 1991). At that time, lowering the STS by 0.8 m, using streamlined trashracks, and installing alternating TIEs, appeared to be the best way to accomplish this (Fig. 1). Therefore, even though most FGE testing was done at the south end of the powerhouse (Unit 12), we recommended lowering all STSs at Bonneville Dam Second Powerhouse 0.8 m, and installing streamlined trashracks and alternating TIEs across the entire width of the powerhouse. Tests in 1987 showed that, with these modifications in place, FGE in Unit 12 was higher with seven turbine units in operation than with four turbine units in operation (Gessel et al. 1988). However, tests were not conducted in other units across the powerhouse.

Our research objective during the 1993 spring and summer outmigrations was to evaluate the effects of these modifications (alternating TIEs, lowered STSs, and streamlined trashracks) on FGE in south, middle, and north turbine units, under full and partial powerhouse operation.

METHODS AND MATERIALS

Procedures and methods for FGE tests were similar to those used at Bonneville Dam in previous years (Gessel et al. 1989, 1990; Monk et al. 1992). Dipnet catches from the gatewell were used to estimate the numbers of guided fish; catches from gap and fyke nets attached to the STS provided estimates of the numbers of unguided fish (Fig. 2). Fish guidance efficiency for each salmonid species was calculated by dividing the gatewell catch by the total number caught during the test period.

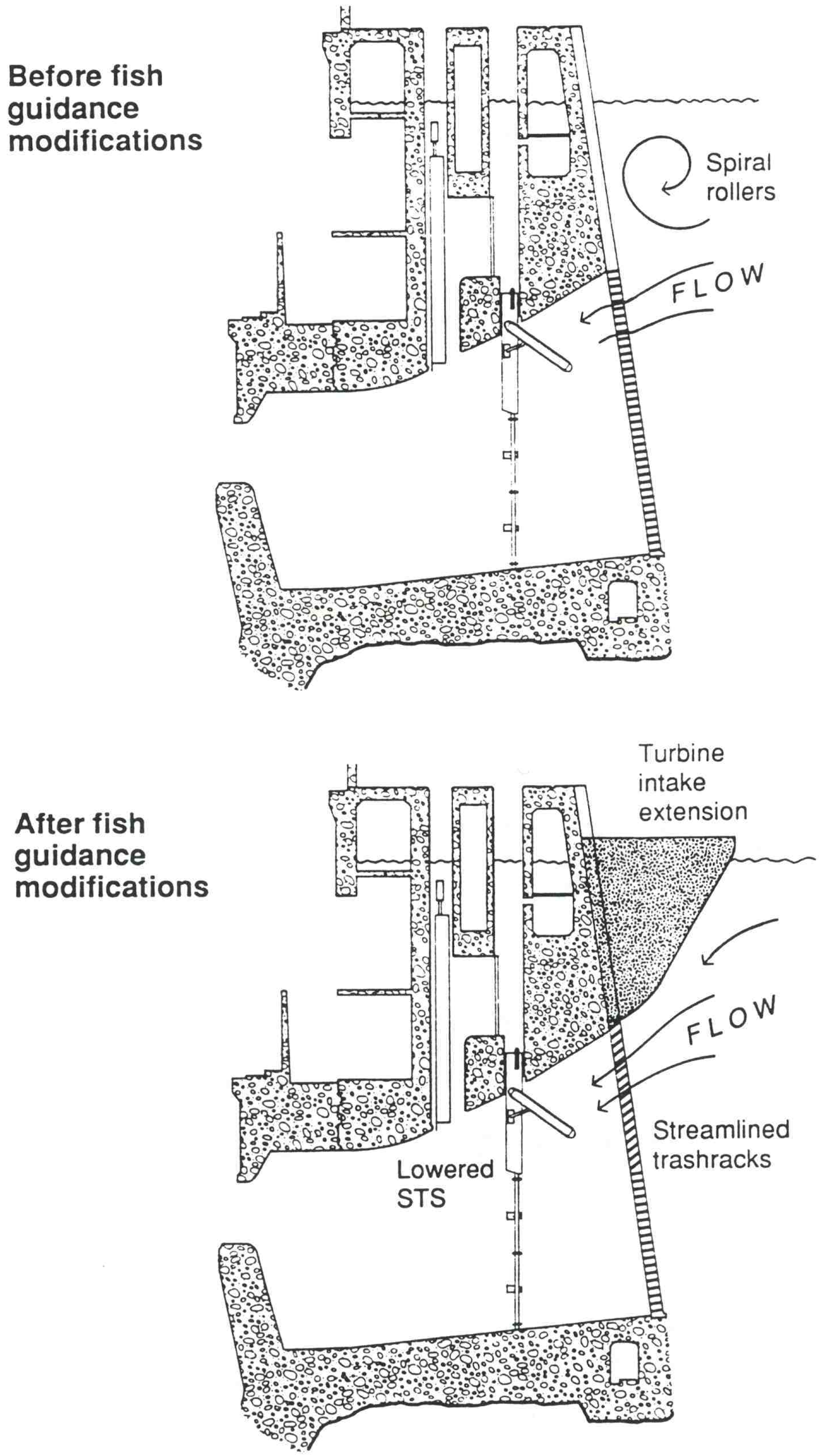

Figure 1.--Cross sections of turbine intake at Bonneville Dam Second Powerhouse, showing three major modifications installed across face of powerhouse prior to 1993 fish guidance efficiency testing [turbine intake extensions, streamlined trashracks, and lowered submersible traveling screens (STS)].

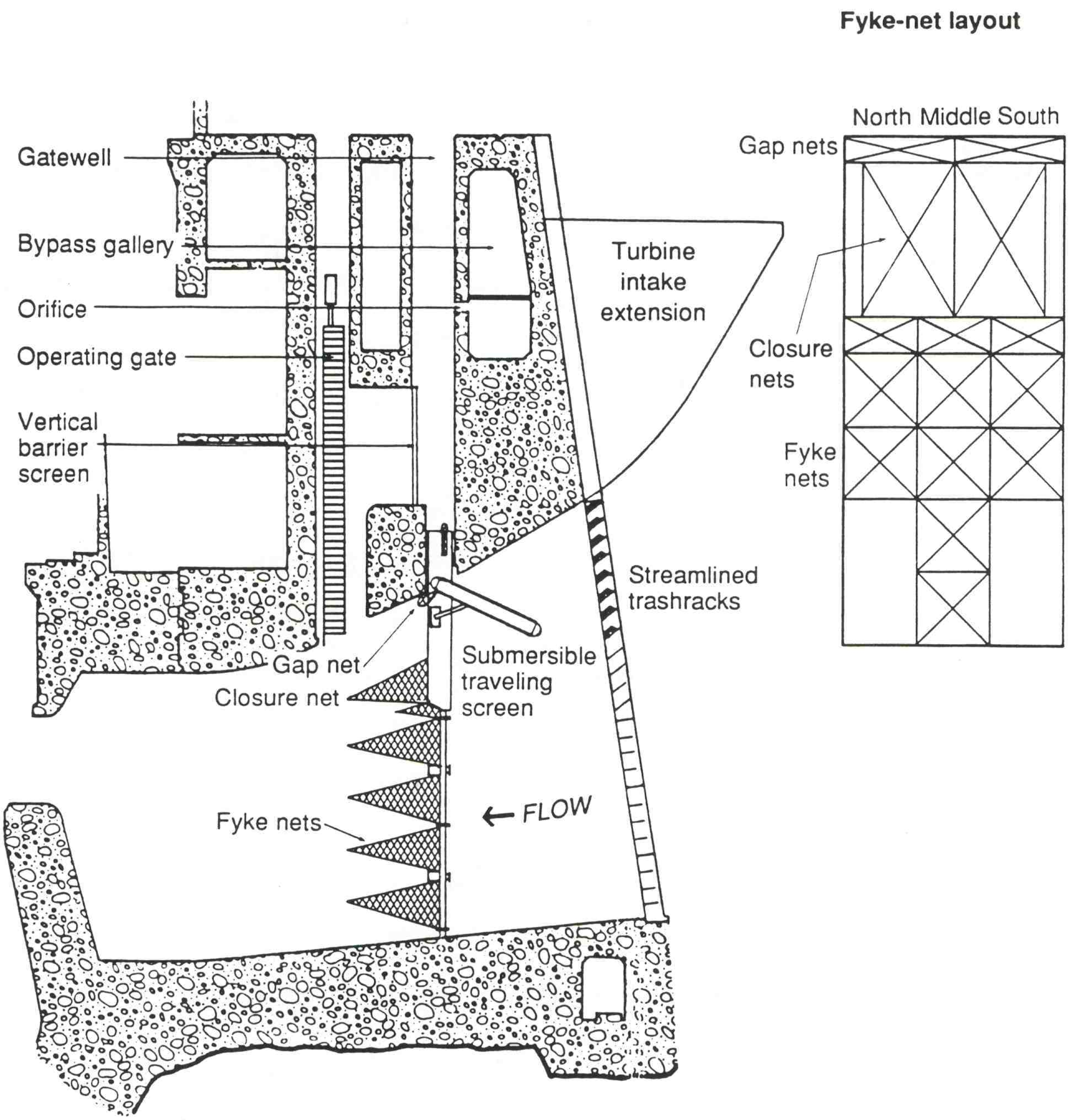

Figure 2.--Cross section of turbine intake at Bonneville Dam Second Powerhouse, showing submersible traveling screen, fyke nets, fish bypass system, stored operating gate, and associated structures.

$$FGE = \frac{GW}{GW + GN + 3(FN)} \times 100\%$$

GW = gatewell catch
GN = gap-net catch
FN = fyke-net catch (1/3 sample)

Fish guidance efficiency tests targeted yearling chinook salmon during the spring outmigration (20 April-2 June) and subyearling chinook salmon during the summer outmigration (6 July-17 July). Data on other salmonid species [coho and sockeye salmon (*O. nerka*) and steelhead] were also collected.

Individual tests lasted a minimum of 1 hour, beginning at 2000 h and ending between 2100 and 2300 h, depending on numbers of fish guided (preferably 250 to 300 fish of the target species). When mixed stocks of fish were passing the powerhouse, fewer numbers of the target species were recovered to limit the effects on other temporarily more abundant species.

Measurements of FGE were made in Turbine Units 12, 15, and 17. Since previous research at Bonneville Second Powerhouse had indicated that FGE varied with the number of turbine units in operation, these measurements were conducted under full (all eight turbine units in operation) and partial (four and six units in operation) powerhouse loading. Turbine units operated during testing under partial load conditions were the priority units specified by the Juvenile Fish Passage Plan (COE, revised August 1992). Testing under the load conditions specified by this plan helped ensure that our test conditions were representative of typical operating conditions. Since Turbine Units 12 and 17 were specified as priority units, we were able to measure FGE in these units under both full and partial powerhouse load conditions. Unit 15, however, is one of the last units brought on line at the second powerhouse, and FGE measurements in this unit could only be taken under full powerhouse load conditions.

To evaluate the impact of the guidance devices on the juvenile salmonids, all fish were examined for descaling and injuries. Descaling was monitored using standard Fish Transportation Oversight Team fish descaling criteria (Ceballos et al. 1992).

Statistical Analysis

During the spring outmigration, FGE tests were conducted concurrently in Slots A and B (one with and one without a TIE) of the test unit (12, 15, or 17). The FGE for each turbine unit (for each test) was then estimated by weighting the FGE in each slot by the percentage of total fish in each slot.

All analyses were conducted using analysis of variance (ANOVA). Separate mean FGE estimates with corresponding 95%-confidence intervals were calculated for TIE vs. non-TIE conditions and for 4-, 6-, and 8-unit operation. The Fisher's Protected Least Significant Difference method was used to compare treatments from ANOVAs with significant F-test differences (Petersen 1985). Statistical significance was established at $\alpha = 0.05$.

Separate analyses were done for yearling and subyearling chinook salmon, coho salmon, and steelhead (sockeye salmon numbers were too low for meaningful analysis). Tests where total sample size was less than 50 yearling chinook salmon or 30 of the other species were not analyzed. For yearling chinook salmon, the species of primary interest, the 50-fish cutoff affected only four replicates at the end of the spring season. A 50-fish cutoff for the other less abundant species would have precluded meaningful analyses in most cases.

During the summer outmigration, FGE tests with subyearling chinook salmon were conducted concurrently in non-TIE slots of Units 12 and 17 (i.e., Slots 12A and 17B). These results were analyzed by two-factor ANOVA, with units tested and units in operation (four or six) being the two factors. Mean FGE levels were estimated with 95%- confidence intervals for Slots 12A and 17B for 4- and 6-unit operation.

RESULTS

Spring Migration

Because of lower-than-expected flows in the Columbia River during the early part of the spring 1993 outmigration, most tests involving 4- and 6-unit operation (Units 12 and 17) were conducted from 20 April to 16 May. During the latter part of the outmigration (16 May to 3 June) high flows made it necessary to operate all eight units during most of the tests. Altogether, over twice as many 8-unit tests were conducted as were 4- or 6-unit tests (20 vs. 7 and 9, respectively). Tests involving 4- and 6-unit operation were mostly in Unit 17 (24 of 32 tests), which was involved in only 5 (of 33) 8-unit tests. Therefore, since any unit effect was confounded both by time (during the overall outmigration) of testing and by the number of units in operation, a statistical analysis of FGE among the three turbine units or a comparison of 4- or 6-unit operation to 8-unit operation was not considered appropriate.

The results of individual replicates of FGE tests in Turbine Units 12, 15, and 17 during the spring outmigration are presented in Appendix Table 1. The ANOVAs and detectable differences found between TIE and non-TIE slots and between 4- and 6-unit operation for all species during the spring outmigration are given in Appendix Table 2.

As reported in previous years (Gessel et al. 1988, 1989, 1990), there was a significant difference between numbers of spring migrating fish passing into adjacent slots with and without TIEs but only with 4- and 6-unit operation (Fig. 3). With four turbine units in operation, approximately 75% more fish of all species (except steelhead) entered the slot without a TIE (significant at $\alpha = 0.05$). With six units in operation, 26% more yearling chinook salmon entered the non-TIE slot; there were no significant differences between TIE and non-TIE slots for the other species. With eight units in operation, however, there were no significant differences between numbers of fish entering TIE and non-TIE slots for any species.

With four or six turbine units in operation, FGE for yearling and spring migrating subyearling chinook salmon was significantly higher in the non-TIE slot. Although this trend continued for coho salmon and steelhead, the increases were not significant (Fig. 4). With eight units in operation, FGE for all

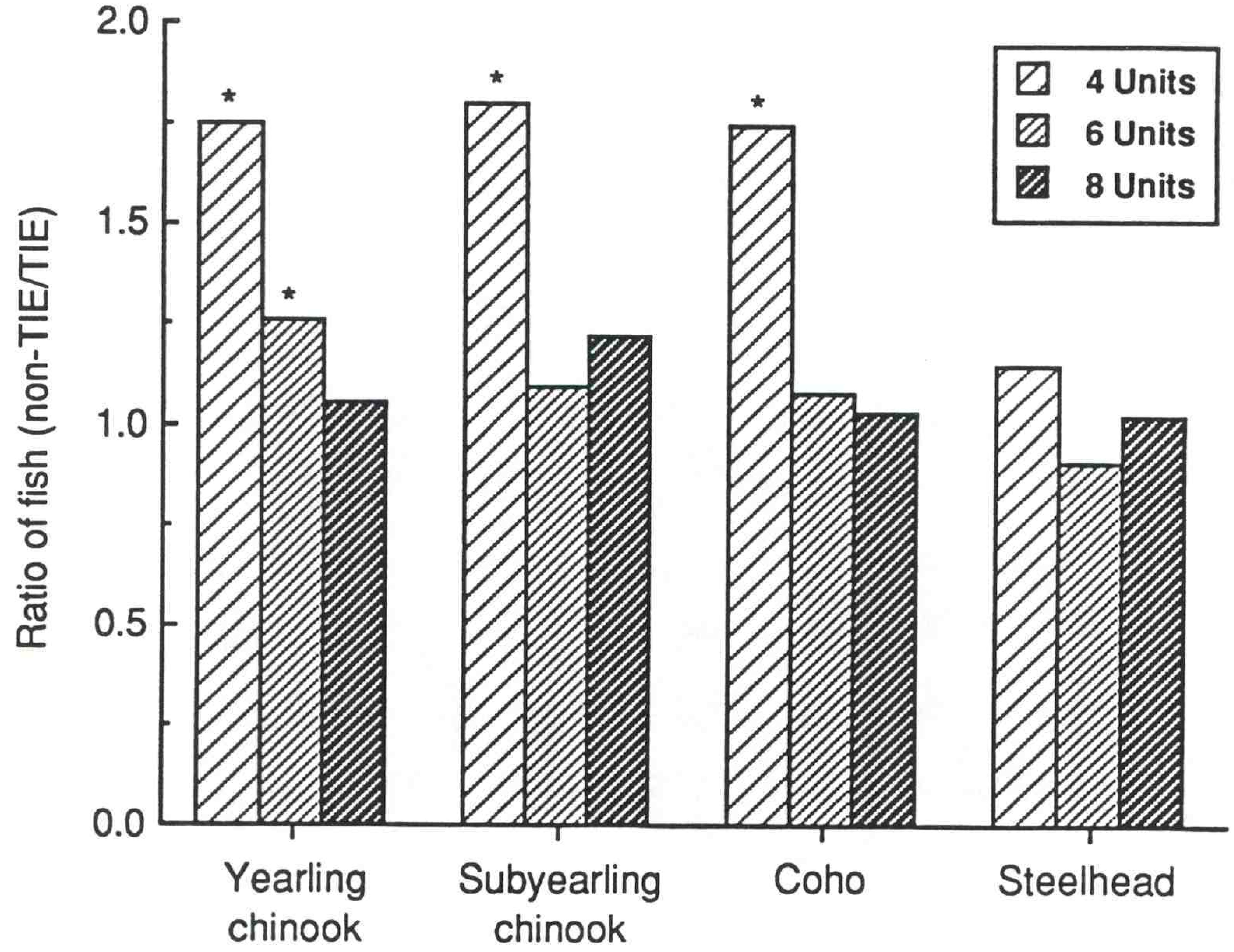

Figure 3.--Ratio of number of fish in slot without a turbine intake extension (TIE) to the number of fish in slot with a TIE, in Turbine Units 12, 15, and 17 combined, with 4, 6, or 8 units in operation at Bonneville Dam Second Powerhouse, spring migration 1993 (* denotes significant difference from 1, $\alpha = 0.05$).

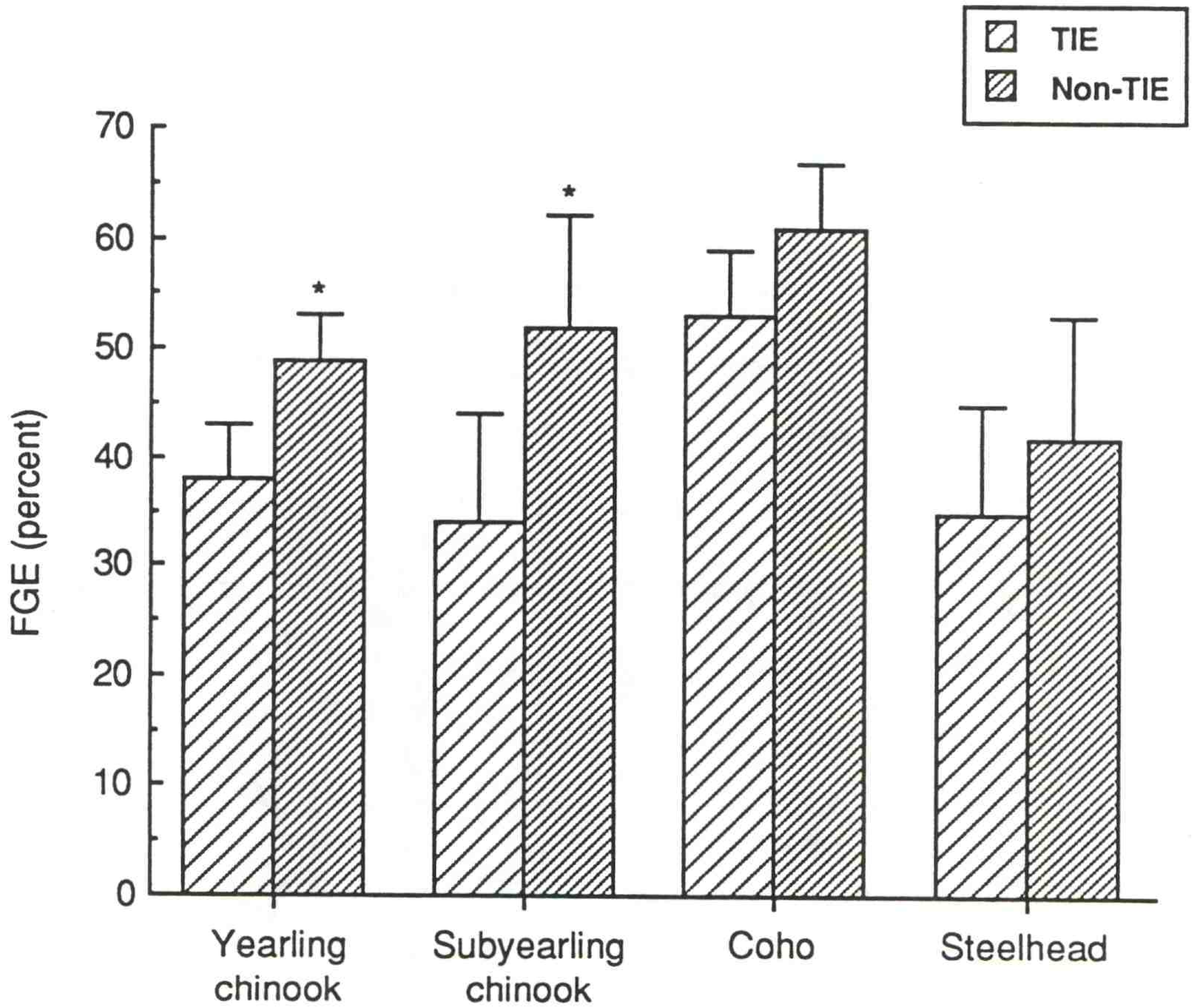

Figure 4.--Mean fish guidance efficiency (FGE) in slots with and without turbine intake extensions (TIEs), Bonneville Dam Second Powerhouse, spring migration 1993. Turbine Units 12 and 17 with 4- and 6-unit operation, are combined. Small bars (T) represent one-half 95% confidence limits (* denotes significant difference between TIE and non-TIE slot at $\alpha = 0.05$).

species was not significantly different between the TIE and non-TIE slots (Fig. 5).

Because of the differences in fish numbers between TIE and non-TIE slots (with four or six units in operation), mean FGE values for each unit were weighted for each test with a significant non-TIE/TIE ratio (Table 1). As stated above, we did not feel a statistical comparison of FGE values among units was appropriate, but mean FGE estimates with 95%-confidence intervals were calculated as a general indication of FGE values across the second powerhouse under different load conditions.

By combining data from Units 12, 15, and 17, mean FGE estimates were computed for each salmonid species at 4-, 6-, and 8-unit powerhouse load conditions (Table 2). For all species except coho salmon, FGE was higher with all eight turbine units in operation than with four or six. However, no statistical comparisons were made between powerhouse load conditions because they were not evenly distributed throughout the season. Mean FGE ranged from 35 to 50% for yearling and subyearling chinook salmon and steelhead and from 50 to 60% for coho salmon, with four or six units in operation. Mean FGE ranged from 45 to 55% for all salmonid species when eight units were in operation.

During spring FGE tests, descaling of yearling chinook salmon averaged 5.2%. Descaling results for all salmonids examined during spring FGE tests are summarized in Appendix Table 4.

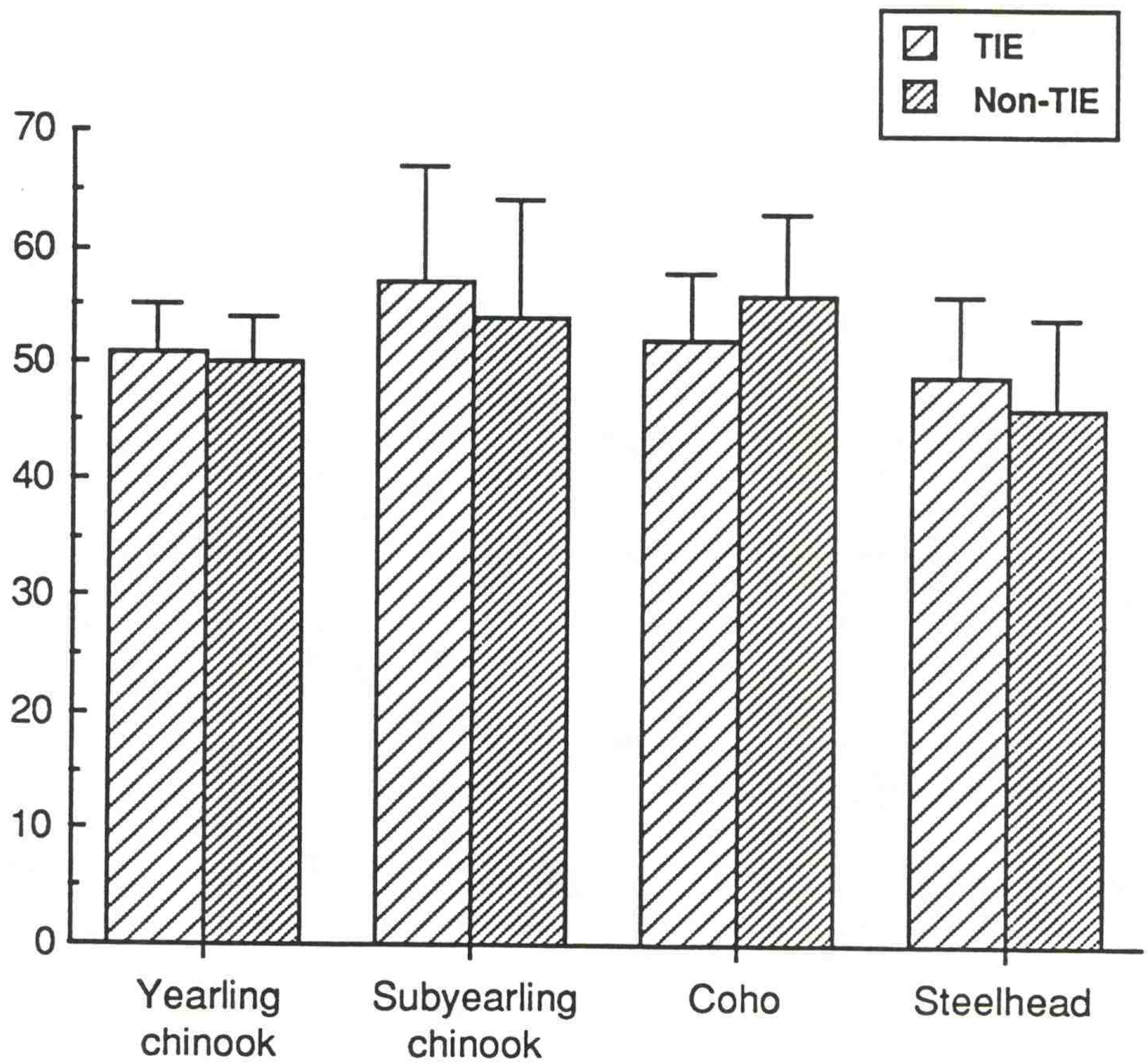

Figure 5.--Mean fish guidance efficiency (FGE) in slots with and without turbine intake extensions (TIEs), Bonneville Dam Second Powerhouse, spring migration 1993. Turbine Units 12, 15, and 17, with 8 units in operation, are combined. Small bars (┬) represent one-half 95% confidence limits.

Table 1.--Number of replicates, mean fish guidance efficiency (FGE), and 95% confidence intervals for each test unit at three different powerhouse loading conditions (4, 6, and 8 units) for yearling chinook salmon at Bonneville Dam Second Powerhouse, spring migration 1993.

Turbine unit (slots)	No. units in operation	Replicates	FGE (%)
<u>20 April to 3 June</u>			
12 (A,B)	4	2	51 (39-63)
12 (A,B)	6	2	42 (24-60)
12 (A,B)	8	5	49 (44-54)
15 (A,B)	8	9	54 (53-55)
17 (A,B)	4	5	42 (41-43)
17 (A,B)	6	7	47 (43-51)
17 (A,B)	8	6	34 (30-38)

Table 2.--Mean fish guidance efficiency (%) and 95% confidence intervals for all salmonid species in Turbine Units 12, 15, and 17 combined, with 4, 6, and 8 units in operation at Bonneville Dam Second Powerhouse, spring migration 1993.

Species	Number of units in operation		
	4	6	8
Yearling chinook	45 (40-50)*	43 (38-47)*	50 (47-54)
Subyearling chinook	47 (37-57)*	42 (33-52)	55 (48-63)
Coho	61 (54-67)	54 (49-60)	54 (49-59)
Steelhead	40 (30-49)	37 (25-49)	47 (42-53)

*Weighted by ratio of the number of fish in slot without a turbine intake extension (TIE) to number of fish in slot with a TIE.

Summer Migration

The initial test on 7 July in Unit 12 produced an abnormally high FGE estimate of 62% for subyearling chinook salmon. This value was two to three times higher than subsequent test results in Unit 12 and up to three times higher than FGE estimates in Unit 17. In the ANOVA, this value had a large relative residual, and it increased the mean square for error by nearly two. Because of its disproportionate statistical influence, we omitted this apparent outlier from the overall analysis.

The results of individual replicates of FGE tests in Turbine Units 12 and 15 during the summer outmigration are presented in Appendix Table 1. The ANOVAs and detectable differences between TIE and non-TIE slots and between 4- and 6-unit load conditions for subyearling chinook salmon during the summer outmigration are given in Appendix Table 3.

Mean FGE for subyearling chinook salmon ranged from 23 to 27% in Unit 12 (mean 25%) and from 26 to 42% in Unit 17 (mean 34%) (Table 3). The mean was significantly higher in Unit 17 than in Unit 12. There was also a significant increase in FGE with six units in operation compared to four units (34 vs. 25%). Mean FGE in Unit 17 with six turbine units in operation was higher than FGE in any unit with four turbine units in operation. It was also higher than FGE in Unit 12 with six units in operation, but this difference was not statistically significant, possibly due to the relatively short sampling season.

During summer FGE tests, descaling for subyearling chinook salmon averaged 1.5%. Descaling results for all salmonids

Table 3.--Number of replicates, mean fish guidance effiency (FGE), and 95% confidence intervals for subyearling chinook salmon in each test unit with 4 or 6 units in operation at Bonneville Dam Second Powerhouse, 7-17 July 1993.

Turbine unit (slot)	No. units in operation	Replicates	FGE (%)
12 (A)	4	4	23 (16-30)
12 (A)	6	5	27 (20-34)
17 (B)	4	4	26 (19-33)
17 (B)	6	5	42 (19-33)

examined during summer FGE tests are summarized in Appendix Table 4.

DISCUSSION

In 1989, under conditions similar to those tested in 1993, mean FGE for yearling chinook salmon in Unit 12 ranged from 74 (15 to 17 May) to 49% (26 May to 4 June). The earlier tests in 1989 involved larger numbers of fish than later tests (in which 11 of 20 replicates had less than 100 fish), and were completed during the peak of the yearling chinook salmon outmigration. Therefore, the 74% FGE obtained during earlier tests was considered more representative of actual FGE for yearling chinook salmon. However, in 1993, overall, weighted mean FGE values for Units 12, 15, and 17 combined (with either 4-, 6-, or 8-unit operation) were closer to the mean FGE of 49% obtained in the later tests in 1989. Moreover, the FGE values for yearling chinook salmon in Unit 12 tests in 1993 were as low as or lower than FGE in the other test units.

In addition to being significantly higher than concurrent FGE measurements in Unit 12, the mean FGE in Unit 17 for subyearling chinook salmon during the summer outmigration (34%) was also higher than FGE results in previous years in Unit 12 (22 to 27%, Gessel et al. 1989, 1990). Horizontal distribution studies at Bonneville Dam First Powerhouse and at other dams on the Columbia River have shown that subyearling chinook salmon tend to orient toward the shoreline (Krcma et al. 1982). Since the south shore of Bonneville Dam Second Powerhouse (near

Unit 12) is an island, subyearling chinook salmon with a shoreline orientation would tend to be on the north shoreline (near Unit 17). This was apparently true in 1993 during concurrent FGE studies in Units 12 and 17, because it was usually necessary to operate Unit 12 for an additional 30 to 60 minutes to obtain numbers of fish approximately equal to those in Unit 17. To date there has been no relationship established between shoreline orientation and FGE, but the 1993 test results suggest a possible correlation.

CONCLUSIONS

Spring Migration

1) With four or six turbine units in operation, mean FGE for yearling chinook salmon was 44%. With eight units in operation, mean FGE was 50%.
2) With four, six, or eight turbine units in operation, FGE for all other species ranged from 35 to 60%.
3) With four turbine units in operation, 75% more fish of all species (except steelhead) entered the non-TIE slot. With six units in operation, 25% more yearling chinook salmon entered the non-TIE slot. With eight units in operation, equal numbers of fish of all species entered the TIE and non-TIE slots.
4) With four or six turbine units in operation, FGE for yearling and subyearling chinook salmon was significantly higher in the non-TIE slot. With eight units in operation,

FGE for all species was not significantly different between the TIE and non-TIE slots.

Summer migration

1) With four or six turbine units in operation, FGE for subyearling chinook salmon ranged from 23 to 42% (non-TIE slots).
2) Mean FGE for subyearling chinook salmon in Unit 17 (34%) was significantly higher than in Unit 12 (25%).
3) Mean FGE for subyearling chinook salmon was significantly higher with six units in operation than with four.

RECOMMENDATIONS

Based on past results, FGE for yearling chinook salmon at Bonneville Dam Second Powerhouse was lower than expected with guidance modifications in place. Because it is necessary to establish and confirm accurate FGE values at this dam, it is recommended that a short series of FGE tests be conducted during the 1994 spring outmigration. One or two series of tests, with conditions similar to those of 1993, should provide an indication of how representative or anomalous the 1993 FGE results were.

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Appendix Table 1.--Numbers of fish collected in individual replicates of fish guidance efficiency (FGE) tests in Turbine Units 12, 15, and 17 at Bonneville Dam Second Powerhouse, 1993 (SC = subyearling chinook, YC = yearling chinook, ST = steelhead, CO = coho, and SO = sockeye).

Date (test unit and slot) (number of units in operation)

	20 April (17A) (4)					20 April (17B) (4)					21 April (17A) (6)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	6	202	3	22	0	9	487	3	35	0	6	306	1	55	0
Gap Net	0	9	0	0	0	3	8	0	0	0	1	10	0	1	0
Closure	1	104	3	1	0	1	155	0	7	0	39	87	1	5	0
First	1	31	0	0	0	2	77	1	2	0	8	19	1	0	0
Second	2	85	4	5	0	2	241	2	2	0	3	75	2	9	0
Third	6	60	2	0	0	9	78	0	3	0	2	42	0	10	0
Fourth	3	39	0	3	0	0	45	0	0	0	0	39	0	3	0
Fifth	0	3	0	0	0	0	0	0	0	0	3	9	0	0	0
Totals	**19**	**533**	**12**	**31**	**0**	**26**	**1,091**	**6**	**49**	**0**	**62**	**587**	**5**	**83**	**0**
FGE (%)	**32**	**38**	**25**	**71**		**35**	**45**	**50**	**71**		**10**	**52**	**20**	**66**	

	21 April (17B) (6)					22 April (17A) (6)					22 April (17B) (6)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	8	522	1	38	0	5	157	10	21	0	11	381	4	42	0
Gap Net	0	4	0	1	0	2	4	0	0	0	1	8	0	0	0
Closure	3	157	0	10	0	0	57	4	4	0	3	113	3	4	0
First	0	42	0	8	0	1	20	0	1	1	1	36	1	1	0
Second	2	118	1	12	0	0	51	7	6	0	3	80	2	7	0
Third	2	39	0	2	0	1	27	4	3	0	0	28	3	2	0
Fourth	0	21	0	3	0	0	27	0	3	0	3	12	0	6	0
Fifth	0	9	0	0	0	0	9	0	0	0	0	9	0	0	0
Totals	**15**	**912**	**2**	**74**	**0**	**9**	**352**	**25**	**38**	**1**	**22**	**667**	**13**	**62**	**0**
FGE (%)	**53**	**57**	**50**	**51**		**56**	**45**	**40**	**55**	**0**	**50**	**57**	**31**	**68**	

	23 April (17A) (6)					23 April (17B) (6)					24 April (17A) (4)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	3	127	0	21	0	20	269	0	27	0	12	98	11	22	0
Gap Net	0	1	0	0	0	1	4	0	1	0	0	8	2	0	0
Closure	9	47	2	1	0	7	124	0	9	0	11	60	6	1	0
First	1	10	1	2	0	1	43	0	2	0	2	14	4	3	0
Second	6	67	1	9	0	5	66	0	6	0	8	63	7	9	0
Third	10	54	0	4	1	5	30	2	7	0	4	28	2	4	0
Fourth	0	27	0	6	0	0	18	0	0	0	2	21	0	2	0
Fifth	0	6	0	0	0	0	0	0	0	0	0	3	0	0	0
Totals	**29**	**339**	**4**	**43**	**1**	**39**	**554**	**2**	**52**	**0**	**39**	**295**	**32**	**41**	**0**
FGE (%)	**10**	**37**	**0**	**49**	**0**	**51**	**49**	**0**	**52**		**31**	**33**	**34**	**54**	

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

Location	24 April (17B) (4) SC	YC	ST	CO	SO	25 April (17A) (4) SC	YC	ST	CO	SO	25 April (17B) (4) SC	YC	ST	CO	SO
Gatewell	22	287	11	49	0	10	109	24	30	2	27	286	15	87	1
Gap Net	0	5	0	0	0	0	4	0	0	0	2	5	0	0	0
Closure	18	98	9	6	2	5	74	9	12	0	18	136	12	5	0
First	2	29	0	4	0	1	33	4	8	0	4	39	5	2	0
Second	11	86	6	13	2	6	79	12	10	0	5	99	23	12	1
Third	5	67	5	7	0	3	47	10	9	0	6	62	16	10	0
Fourth	0	15	0	3	0	3	15	3	9	0	3	39	6	6	0
Fifth	0	3	0	0	0	3	3	0	0	0	0	0	0	0	0
Totals	**58**	**590**	**31**	**82**	**4**	**31**	**364**	**62**	**78**	**2**	**65**	**666**	**77**	**122**	**2**
FGE (%)	**38**	**49**	**35**	**60**	**0**	**32**	**30**	**39**	**38**	**100**	**42**	**43**	**19**	**71**	**50**

Location	26 April (17A) (4) SC	YC	ST	CO	SO	26 April (17B) (4) SC	YC	ST	CO	SO	27 April (17A) (6) SC	YC	ST	CO	SO
Gatewell	14	156	13	33	0	37	347	5	50	0	27	242	6	53	0
Gap Net	2	6	0	0	0	1	16	0	4	0	0	11	1	0	0
Closure	10	78	7	8	0	16	70	3	22	0	8	83	3	9	2
First	1	28	4	4	0	3	58	0	8	1	11	17	2	3	0
Second	6	69	8	11	0	14	124	8	14	0	9	102	10	13	0
Third	2	62	6	6	0	8	79	7	8	0	7	58	7	9	0
Fourth	0	13	0	0	0	9	30	0	6	0	0	45	3	6	0
Fifth	0	0	0	3	0	0	0	0	0	0	0	6	0	0	0
Totals	**35**	**412**	**38**	**65**	**0**	**88**	**724**	**23**	**112**	**1**	**62**	**564**	**32**	**93**	**2**
FGE (%)	**40**	**38**	**34**	**51**		**42**	**48**	**22**	**45**	**0**	**44**	**43**	**19**	**57**	**0**

Location	27 April (17B) (6) SC	YC	ST	CO	SO	28 April (17A) (6) SC	YC	ST	CO	SO	28 April (17B) (6) SC	YC	ST	CO	SO
Gatewell	35	457	2	60	0	16	140	4	47	0	36	267	2	50	0
Gap Net	1	5	0	0	0	0	5	0	0	0	0	2	0	0	0
Closure	9	111	1	7	0	3	72	1	9	1	8	100	0	14	0
First	6	34	1	4	0	2	30	0	4	1	3	20	1	8	0
Second	6	100	1	5	2	6	75	0	15	0	4	69	0	15	0
Third	1	51	0	4	0	13	35	4	7	1	4	40	1	5	0
Fourth	0	18	0	0	0	0	36	0	12	0	3	15	0	6	0
Fifth	0	6	0	0	0	0	3	0	0	0	0	3	0	0	0
Totals	**58**	**782**	**5**	**80**	**2**	**40**	**396**	**9**	**94**	**3**	**58**	**516**	**4**	**98**	**0**
FGE (%)	**60**	**58**	**40**	**75**	**0**	**40**	**35**	**44**	**50**	**0**	**62**	**52**	**50**	**51**	

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

	29 April (12A) (6)					29 April (12B) (6)					30 April (12A) (4)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	20	151	52	59	0	11	109	25	54	0	30	216	38	99	0
Gap Net	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0
Closure	8	48	7	13	1	1	58	7	14	2	6	52	14	9	0
First	6	22	3	7	0	10	24	4	4	0	3	32	4	4	0
Second	17	92	6	12	0	18	93	20	9	1	6	59	13	16	1
Third	6	48	6	9	1	6	67	9	15	0	0	15	2	5	0
Fourth	6	33	0	9	0	15	24	3	6	0	0	15	0	3	0
Fifth	0	6	0	0	0	0	6	0	0	0	0	6	0	0	0
Totals	**63**	**401**	**74**	**109**	**2**	**62**	**382**	**68**	**102**	**3**	**46**	**396**	**71**	**136**	**1**
FGE (%)	**32**	**38**	**70**	**54**	**0**	**18**	**29**	**37**	**53**	**0**	**65**	**55**	**54**	**73**	**0**

	30 April (12B) (4)					3 May (12A) (8)					3 May (12B) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	17	116	39	65	0	11	132	39	94	0	25	160	50	82	0
Gap Net	0	1	0	1	0	0	3	1	2	0	0	2	1	1	0
Closure	5	53	9	13	0	4	36	18	27	0	7	75	12	33	0
First	1	20	2	6	0	7	49	10	31	0	1	19	8	14	0
Second	8	65	19	14	0	10	127	10	49	0	13	76	14	29	0
Third	7	45	8	6	0	6	49	7	22	0	7	50	5	26	0
Fourth	3	27	6	0	0	9	18	0	12	0	0	24	0	6	0
Fifth	0	9	3	0	0	0	6	0	3	0	0	9	0	3	0
Totals	**41**	**336**	**86**	**105**	**0**	**47**	**420**	**85**	**240**	**0**	**53**	**415**	**90**	**194**	**0**
FGE (%)	**41**	**35**	**45**	**62**		**23**	**31**	**46**	**39**		**47**	**39**	**56**	**42**	

	4 May (15A) (8)					4 May (15B) (8)					5 May (15A) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	29	142	15	153	0	24	196	7	127	0	27	122	19	185	0
Gap Net	0	2	0	4	0	0	2	0	1	0	0	0	0	3	0
Closure	5	50	6	31	0	8	63	3	25	0	9	31	3	44	0
First	0	16	2	10	0	3	17	0	10	0	0	10	1	18	0
Second	4	34	6	21	0	3	28	3	16	0	2	48	4	36	0
Third	1	22	7	10	0	1	15	5	5	0	3	27	2	15	0
Fourth	0	18	0	15	0	0	6	0	6	0	0	21	6	15	0
Fifth	0	6	0	0	0	0	0	0	0	0	0	0	0	9	0
Totals	**39**	**290**	**36**	**244**	**0**	**39**	**327**	**18**	**190**	**0**	**41**	**259**	**35**	**325**	**0**
FGE (%)	**74**	**49**	**42**	**63**		**62**	**60**	**39**	**67**		**66**	**47**	**54**	**57**	

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

Location	5 May (15B) (8) SC	YC	ST	CO	SO	6 May (15A) (8) SC	YC	ST	CO	SO	6 May (15B) (8) SC	YC	ST	CO	SO
Gatewell	18	131	13	232	0	11	117	12	187	0	30	188	16	252	0
Gap Net	0	4	0	4	0	1	1	0	0	0	1	1	0	6	0
Closure	6	48	6	35	0	6	31	5	43	0	4	65	9	55	0
First	1	12	3	18	0	1	13	3	21	0	2	13	2	22	0
Second	2	36	7	31	0	2	22	6	23	0	1	31	5	30	0
Third	3	27	6	13	0	0	13	11	10	0	1	15	6	8	0
Fourth	0	3	6	12	0	0	3	6	3	0	0	0	3	6	0
Fifth	0	0	0	0	0	0	3	0	0	0	0	3	0	1	0
Totals	**30**	**261**	**41**	**345**	**0**	**21**	**203**	**43**	**287**	**0**	**39**	**316**	**41**	**380**	**0**
FGE (%)	**60**	**50**	**32**	**67**		**52**	**58**	**28**	**65**		**77**	**59**	**39**	**66**	

Location	7 May (17A) (8) SC	YC	ST	CO	SO	7 May (17B) (8) SC	YC	ST	CO	SO	8 May (17A) (6) SC	YC	ST	CO	SO
Gatewell	25	125	23	304	0	12	46	11	65	0	16	93	43	99	1
Gap Net	0	5	0	11	0	0	0	0	0	0	0	0	0	4	0
Closure	6	33	16	44	0	3	13	7	11	0	2	35	39	43	0
First	1	14	5	10	0	1	6	4	6	0	0	16	9	18	0
Second	1	38	18	28	0	0	20	15	10	0	9	85	58	83	0
Third	1	31	33	31	0	1	12	12	10	0	4	50	50	75	0
Fourth	2	21	21	27	0	0	9	6	6	0	0	39	12	51	1
Fifth	0	6	0	3	0	0	6	3	3	0	3	12	0	9	0
Totals	**36**	**273**	**116**	**458**	**0**	**17**	**112**	**58**	**111**	**0**	**34**	**330**	**211**	**382**	**2**
FGE (%)	**69**	**46**	**20**	**66**		**71**	**41**	**19**	**59**		**47**	**28**	**20**	**26**	**50**

Location	8 May (17B) (6) SC	YC	ST	CO	SO	9 May (17A) (4) SC	YC	ST	CO	SO	9 May (17B) (4) SC	YC	ST	CO	SO
Gatewell	19	90	13	124	0	14	115	55	444	0	38	176	50	807	0
Gap Net	0	0	0	1	0	0	5	0	10	0	0	2	0	16	0
Closure	3	29	18	38	0	4	40	22	107	0	2	84	24	204	0
First	1	16	5	17	0	1	14	4	43	0	0	17	20	60	0
Second	4	52	30	43	0	0	51	24	114	0	7	67	27	132	1
Third	4	38	20	39	0	3	27	14	70	0	4	36	17	67	0
Fourth	1	21	3	15	0	0	9	3	33	0	2	9	3	33	0
Fifth	0	9	0	9	0	0	0	0	3	0	0	0	0	3	0
Totals	**32**	**255**	**89**	**286**	**0**	**22**	**261**	**122**	**824**	**0**	**53**	**391**	**141**	**1,322**	**1**
FGE (%)	**59**	**35**	**15**	**43**		**64**	**44**	**45**	**54**		**72**	**45**	**35**	**61**	**0**

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

Location	10 May (12A) (8) SC	YC	ST	CO	SO	10 May (12B) (8) SC	YC	ST	CO	SO	11 May (12A) (6) SC	YC	ST	CO	SO
Gatewell	3	52	67	215	4	6	89	64	225	0	13	141	160	373	8
Gap Net	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1
Closure	1	11	27	25	0	2	27	38	56	1	0	23	51	35	1
First	1	16	10	21	1	1	18	13	21	0	0	13	20	22	2
Second	4	42	43	61	1	0	42	37	52	0	0	35	71	30	5
Third	0	19	22	15	0	0	14	31	36	0	0	12	29	13	4
Fourth	0	6	12	18	0	3	6	6	3	1	3	3	12	3	0
Fifth	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	**9**	**146**	**181**	**355**	**6**	**12**	**197**	**189**	**394**	**2**	**16**	**227**	**343**	**477**	**21**
FGE (%)	**33**	**36**	**37**	**61**	**67**	**50**	**45**	**34**	**57**	**0**	**81**	**62**	**47**	**78**	**38**

Location	11 May (12B) (6) SC	YC	ST	CO	SO	12 May (12A) (4) SC	YC	ST	CO	SO	12 May (12B) (4) SC	YC	ST	CO	SO
Gatewell	5	87	124	172	8	24	166	125	400	22	12	80	59	123	6
Gap Net	0	0	1	4	0	0	1	3	7	0	1	2	1	2	1
Closure	0	23	53	32	3	1	38	50	65	13	3	23	18	44	8
First	0	49	23	13	1	1	18	15	19	2	0	7	10	13	4
Second	0	28	34	36	2	0	41	23	36	5	3	24	39	26	6
Third	0	10	30	22	2	0	18	13	12	8	0	12	14	7	7
Fourth	0	18	15	0	0	0	6	0	9	6	0	1	6	12	12
Fifth	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0
Totals	**5**	**215**	**280**	**279**	**16**	**26**	**288**	**229**	**551**	**56**	**19**	**149**	**147**	**230**	**44**
FGE (%)	**100**	**40**	**44**	**62**	**50**	**92**	**58**	**55**	**73**	**39**	**63**	**54**	**40**	**53**	**14**

Location	13 May (15A) (8) SC	YC	ST	CO	SO	13 May (15B) (8) SC	YC	ST	CO	SO	14 May (15A) (8) SC	YC	ST	CO	SO
Gatewell	11	109	66	233	14	11	96	39	208	15	2	120	40	238	3
Gap Net	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0
Closure	1	30	14	57	5	1	32	14	38	3	0	34	14	46	1
First	0	10	3	19	3	0	9	5	14	2	2	13	4	19	1
Second	0	14	12	35	0	0	21	6	13	6	0	26	16	20	4
Third	0	9	15	16	4	0	13	7	9	3	0	13	18	29	4
Fourth	0	0	0	6	0	0	6	0	0	3	0	9	12	6	0
Fifth	0	0	0	6	0	0	0	3	0	0	0	6	0	0	3
Totals	**12**	**173**	**110**	**374**	**26**	**12**	**177**	**74**	**282**	**33**	**4**	**221**	**104**	**358**	**16**
FGE (%)	**92**	**63**	**60**	**62**	**54**	**92**	**54**	**53**	**74**	**45**	**50**	**54**	**38**	**66**	**19**

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

Location	14 May (15B) (8) SC	YC	ST	CO	SO	15 May (15A) (8) SC	YC	ST	CO	SO	15 May (15B) (8) SC	YC	ST	CO	SO
Gatewell	13	83	29	207	4	4	104	28	197	0	5	87	14	154	1
Gap Net	0	1	0	1	0	0	1	0	2	0	0	2	0	0	0
Closure	0	27	8	50	3	2	42	6	106	2	1	44	1	39	0
First	0	10	2	20	0	0	5	0	15	0	0	3	3	8	3
Second	1	17	4	33	2	0	16	4	21	2	0	9	1	16	3
Third	0	5	5	10	2	0	10	4	17	6	0	7	1	9	3
Fourth	1	6	3	21	0	0	6	0	6	3	0	3	0	3	0
Fifth	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0
Totals	**15**	**149**	**51**	**345**	**11**	**6**	**184**	**42**	**367**	**13**	**6**	**155**	**20**	**229**	**10**
FGE (%)	**87**	**56**	**57**	**60**	**36**	**67**	**57**	**67**	**54**	**0**	**83**	**56**	**70**	**67**	**10**

Location	16 May (17A) (6) SC	YC	ST	CO	SO	16 May (17B) (6) SC	YC	ST	CO	SO	17 May (7A) (8) SC	YC	ST	CO	SO
Gatewell	8	40	30	160	0	6	30	17	87	1	6	88	15	135	2
Gap Net	0	1	1	1	0	0	0	0	1	0	1	2	0	3	0
Closure	3	28	10	41	0	0	14	4	35	3	1	20	4	28	2
First	0	15	5	15	1	0	7	0	10	0	0	7	0	1	1
Second	4	35	15	49	8	2	25	8	30	5	5	19	2	139	3
Third	1	32	9	38	8	3	27	6	25	0	1	23	3	22	13
Fourth	3	15	0	36	3	0	9	3	9	3	3	12	3	9	9
Fifth	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0
Totals	**19**	**166**	**70**	**343**	**20**	**11**	**112**	**38**	**200**	**12**	**17**	**171**	**27**	**340**	**30**
FGE (%)	**42**	**24**	**43**	**47**	**0**	**55**	**27**	**45**	**44**	**8**	**35**	**51**	**56**	**40**	**7**

Location	17 May (17B) (8) SC	YC	ST	CO	SO	18 May (17A) (8) SC	YC	ST	CO	SO	18 May (17B) (8) SC	YC	ST	CO	SO
Gatewell	12	18	5	69	1	5	30	3	67	5	6	9	1	27	3
Gap Net	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
Closure	3	10	2	21	1	2	7	2	18	5	0	5	0	13	4
First	1	9	0	13	0	0	1	1	7	5	1	1	0	3	5
Second	2	9	3	17	8	0	9	2	14	14	2	12	2	14	11
Third	1	9	1	18	5	1	9	6	17	19	1	14	1	12	16
Fourth	3	12	0	15	6	0	15	3	15	18	0	3	0	3	9
Fifth	0	3	0	3	0	0	6	0	0	0	0	0	0	0	0
Totals	**22**	**70**	**11**	**157**	**21**	**8**	**78**	**17**	**139**	**66**	**10**	**44**	**4**	**72**	**48**
FGE (%)	**55**	**26**	**45**	**44**	**5**	**63**	**38**	**18**	**48**	**8**	**60**	**20**	**25**	**38**	**6**

Appendix Table 1.--Continued.

	Date (test unit and slot) (number of units in operation)														
	19 May (17A) (8)					19 May (17B) (8)					24 May (12A) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	5	13	1	26	0	1	3	1	9	0	9	100	93	51	302
Gap Net	0	0	0	0	0	0	0	0	0	0	0	4	0	1	13
Closure	0	2	1	7	1	0	4	0	4	1	1	21	19	8	91
First	0	6	0	2	3	0	2	1	0	3	0	10	4	4	38
Second	0	8	3	8	9	0	8	1	1	12	0	24	25	6	126
Third	1	7	2	13	9	0	7	1	17	11	0	13	5	5	82
Fourth	3	12	0	3	9	0	0	3	6	12	3	3	3	0	27
Fifth	0	0	3	3	0	0	3	0	0	3	3	3	3	0	27
Totals	**9**	**48**	**10**	**62**	**31**	**1**	**27**	**7**	**37**	**42**	**16**	**178**	**152**	**75**	**706**
FGE (%)	**56**	**27**	**10**	**42**	**0**	**100**	**11**	**14**	**24**	**0**	**56**	**56**	**61**	**68**	**43**

	24 May (12B) (8)					25 May (12A) (8)					25 May (12B) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	1	41	40	13	169	35	127	219	103	208	28	71	180	58	169
Gap Net	0	1	2	0	6	0	0	4	1	7	0	1	0	1	18
Closure	0	12	3	6	102	2	16	52	6	44	5	15	17	13	130
First	0	7	4	1	51	0	5	16	3	36	1	3	13	3	60
Second	1	10	8	13	107	9	20	72	19	162	3	21	43	17	163
Third	2	9	4	6	95	9	21	24	5	141	0	12	23	3	119
Fourth	0	9	3	0	33	0	6	9	3	54	0	6	3	9	78
Fifth	0	0	0	0	3	0	0	0	0	3	0	0	0	0	6
Totals	**4**	**89**	**64**	**39**	**566**	**55**	**195**	**396**	**140**	**655**	**37**	**129**	**279**	**104**	**743**
FGE (%)	**25**	**46**	**63**	**33**	**30**	**64**	**65**	**55**	**74**	**32**	**76**	**55**	**65**	**56**	**23**

	26 May (12A) (8)					26 May (12B) (8)					27 May (15A) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	23	128	172	90	62	11	57	91	23	67	21	34	26	19	7
Gap Net	0	0	1	1	2	0	1	2	0	8	1	0	0	0	0
Closure	6	30	59	17	31	4	15	32	6	50	9	6	5	7	2
First	0	12	17	4	15	4	1	12	2	16	0	2	1	2	1
Second	3	24	37	15	39	6	10	29	3	59	0	9	3	4	0
Third	3	26	23	11	43	2	18	24	2	42	2	6	6	3	1
Fourth	6	9	12	3	36	0	12	12	6	27	6	6	0	0	0
Fifth	0	0	0	0	3	0	0	3	0	6	3	0	0	0	3
Totals	**41**	**229**	**321**	**141**	**231**	**27**	**114**	**205**	**42**	**275**	**42**	**63**	**41**	**35**	**14**
FGE (%)	**56**	**56**	**54**	**64**	**27**	**41**	**50**	**44**	**55**	**24**	**50**	**54**	**63**	**54**	**50**

Appendix Table 1.--Continued.

	Date (test unit and slot) (number of units in operation)														
	27 May (15B) (8)					28 May (15A) (8)					28 May (15B) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	33	22	14	13	11	34	39	29	13	27	41	31	19	11	38
Gap Net	0	0	0	0	0	0	0	0	0	4	0	1	0	0	1
Closure	12	6	2	7	5	9	3	4	2	14	7	10	4	6	26
First	1	2	1	3	0	2	3	2	1	3	4	6	2	0	9
Second	6	10	9	4	3	6	13	7	2	19	5	9	3	2	19
Third	2	7	0	2	6	2	7	11	3	25	4	3	2	0	17
Fourth	3	3	0	0	12	0	12	3	3	24	3	6	3	0	15
Fifth	3	0	0	0	0	0	0	0	3	0	0	0	0	0	3
Totals	**60**	**50**	**26**	**29**	**37**	**53**	**77**	**56**	**27**	**116**	**64**	**66**	**33**	**19**	**128**
FGE (%)	**55**	**44**	**54**	**45**	**30**	**64**	**51**	**52**	**48**	**23**	**64**	**47**	**58**	**58**	**30**

	1 June (15A) (8)					1 June (15B) (8)					2 June (17A) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	21	54	14	26	5	57	43	4	21	2	25	13	5	18	2
Gap Net	0	0	0	0	0	1	1	0	0	0	2	1	0	0	1
Closure	1	5	2	9	4	13	11	4	5	3	3	8	7	15	5
First	3	5	0	6	1	4	4	0	4	0	5	0	1	6	0
Second	6	14	1	4	2	6	10	3	5	5	8	8	4	12	3
Third	6	7	2	4	5	4	7	0	0	3	9	17	4	12	3
Fourth	3	3	0	0	3	3	0	0	3	0	9	0	0	6	3
Fifth	0	0	0	3	0	0	0	3	0	3	0	0	0	0	0
Totals	**40**	**88**	**19**	**52**	**20**	**88**	**76**	**14**	**38**	**16**	**61**	**47**	**21**	**69**	**17**
FGE (%)	**53**	**61**	**74**	**50**	**25**	**65**	**57**	**29**	**55**	**13**	**41**	**28**	**24**	**26**	**12**

	2 June (17B) (8)					3 June (17A) (8)					3 June (17B) (8)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	22	10	1	8	0	15	8	4	18	1	18	7	1	9	0
Gap Net	2	0	0	0	1	2	0	0	0	2	0	1	0	0	0
Closure	7	9	2	6	6	5	5	0	7	1	4	1	0	4	1
First	2	2	0	1	1	1	0	0	3	0	1	0	0	1	0
Second	12	10	1	4	2	7	3	4	4	3	13	6	2	5	1
Third	8	2	0	4	6	13	3	1	6	1	12	4	0	5	2
Fourth	9	6	0	0	6	9	9	3	15	3	6	12	0	6	0
Fifth	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
Totals	**62**	**39**	**4**	**23**	**22**	**52**	**31**	**12**	**53**	**11**	**54**	**34**	**3**	**30**	**4**
FGE (%)	**35**	**26**	**25**	**35**	**0**	**29**	**26**	**33**	**34**	**9**	**33**	**21**	**33**	**30**	**0**

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

Location	7 July (12A) (6)					7 July (17B) (6)					8 July (12A) (4)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	357	40	0	2	0	268	16	0	1	0	114	12	0	0	0
Gap Net	12	0	0	1	0	6	0	0	0	0	1	0	0	0	0
Closure	20	4	0	1	0	137	15	0	0	0	24	1	0	0	0
First	24	4	0	0	0	28	2	0	0	0	24	2	0	0	0
Second	78	7	0	0	0	78	9	0	0	0	68	7	0	1	0
Third	39	4	0	0	0	54	6	0	0	0	63	7	1	0	0
Fourth	42	6	0	0	0	33	0	0	0	0	72	9	0	0	0
Fifth	3	0	0	0	0	3	0	0	0	0	6	6	0	0	0
Totals	**575**	**65**	**0**	**4**	**0**	**607**	**48**	**0**	**1**	**0**	**372**	**44**	**1**	**1**	**0**
FGE (%)	**62**	**62**		**50**		**44**	**33**		**100**		**31**	**27**	**0**	**0**	

Location	8 July (17B) (4)					9 July (12A) (6)					9 July (17B) (6)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	501	29	0	7	0	115	1	0	0	0	87	21	0	0	0
Gap Net	9	0	0	0	0	2	0	0	0	0	2	0	0	0	0
Closure	270	20	0	1	0	11	0	0	0	0	66	0	0	0	0
First	72	4	0	0	0	45	0	0	0	0	14	0	0	0	0
Second	295	17	0	0	0	66	0	0	0	0	43	0	0	1	1
Third	235	12	0	2	0	61	1	0	0	0	32	0	0	0	0
Fourth	186	15	0	0	0	45	0	0	0	0	12	0	0	0	0
Fifth	24	0	0	0	0	0	0	0	0	0	9	0	0	0	0
Totals	**1,592**	**97**	**0**	**10**	**0**	**345**	**2**	**0**	**0**	**0**	**265**	**21**	**0**	**1**	**1**
FGE (%)	**32**	**30**		**70**		**33**	**50**				**33**	**100**		**0**	**0**

Location	10 July (12A) (4)					10 July (17B) (4)					13 July (12A) (6)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	110	2	0	0	0	185	1	0	0	0	67	4	0	1	0
Gap Net	3	0	0	0	0	12	0	0	0	0	1	0	0	0	0
Closure	64	0	0	0	0	159	0	0	0	0	35	0	0	0	0
First	29	0	0	0	0	47	0	0	0	0	20	1	0	0	0
Second	97	1	0	0	0	204	1	0	0	0	64	1	0	0	0
Third	117	0	0	0	0	162	4	0	0	0	60	1	0	0	0
Fourth	72	1	0	0	0	123	1	0	0	0	24	0	0	0	0
Fifth	12	0	0	0	0	15	0	0	0	0	3	0	0	0	0
Totals	**504**	**4**	**0**	**0**	**0**	**907**	**7**	**0**	**0**	**0**	**274**	**7**	**0**	**1**	**0**
FGE (%)	**22**	**50**				**20**	**14**				**24**	**57**		**100**	

Appendix Table 1.--Continued.

Date (test unit and slot) (number of units in operation)

	13 July (17B) (6)					14 July (12A) (4)					14 July (17B) (4)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	111	8	0	0	1	76	0	0	0	0	174	1	0	0	0
Gap Net	0	0	0	0	0	5	0	0	0	0	4	0	0	0	0
Closure	30	0	0	0	0	58	2	0	0	0	140	0	0	0	0
First	9	0	0	0	0	28	1	0	0	0	57	0	0	0	0
Second	41	0	0	0	0	99	0	0	0	0	152	2	0	0	1
Third	19	0	0	0	0	88	0	0	0	0	118	3	0	0	0
Fourth	6	0	0	0	0	48	0	0	0	0	54	0	0	0	0
Fifth	0	0	0	0	0	3	0	0	0	0	21	0	0	0	0
Totals	**216**	**8**	**0**	**0**	**1**	**405**	**3**	**0**	**0**	**0**	**720**	**6**	**0**	**0**	**1**
FGE (%)	**51**	**100**			**100**	**19**	**0**				**24**	**17**			**0**

	15 July (12A) (6)					15 July (17B) (6)					16 July (12A) (4)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	77	1	0	0	0	110	3	0	0	0	68	3	0	0	0
Gap Net	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0
Closure	63	0	0	0	0	47	1	0	0	0	31	1	0	0	0
First	24	0	0	0	0	17	0	0	0	0	15	0	0	0	0
Second	80	1	0	0	0	25	0	0	0	0	64	1	0	0	0
Third	64	1	0	0	0	31	0	0	0	0	73	1	0	0	0
Fourth	54	3	0	0	0	6	0	0	0	0	57	0	0	0	0
Fifth	9	0	0	0	0	0	0	0	0	0	12	0	0	0	0
Totals	**371**	**6**	**0**	**0**	**0**	**238**	**4**	**0**	**0**	**0**	**321**	**6**	**0**	**0**	**0**
FGE (%)	**21**	**17**				**46**	**75**				**21**	**50**			

	16 July (17B) (4)					17 July (12A) (6)					17 July (17B) (6)				
Location	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	125	4	0	0	0	122	7	0	0	0	102	2	0	0	0
Gap Net	2	0	0	0	0	6	0	0	0	0	3	0	0	0	0
Closure	75	1	0	0	0	68	2	0	0	0	69	0	0	0	0
First	14	1	0	0	0	27	1	0	0	0	12	0	0	0	0
Second	85	1	0	0	0	88	0	0	0	0	55	3	0	0	0
Third	84	1	0	0	0	66	2	0	0	0	32	1	0	0	0
Fourth	51	0	0	0	0	30	0	0	0	0	21	3	0	0	0
Fifth	15	0	0	0	0	3	0	0	0	0	6	0	0	0	0
Totals	**451**	**8**	**0**	**0**	**0**	**410**	**12**	**0**	**0**	**0**	**300**	**9**	**0**	**0**	**0**
FGE (%)	**28**	**50**				**30**	**58**				**34**	**22**			

Appendix Table 2.--ANOVAs, means of fish guidance efficiency (FGE), 95% confidence intervals, and detectable differences for various comparisons for all species tested during the spring migration, Bonneville Dam Second Powerhouse, 1993 (TIE = turbine intake extension).

YEARLING CHINOOK SALMON

ANOVA for non-TIE/TIE fish number ratio for 4 units running vs. 6 units, including means, 95% confidence intervals, and detectable differences.

Source	df	Sum of Squares	Mean Square	F	P
Units	1	0.96	0.96	7.11	0.0184
Error	14	1.89	0.13		
Total	15	2.85			

Units running	Mean non-TIE / TIE	95% confidence interval	4 vs. 6 detectable difference
4	1.75[a]	(1.45, 2.05)	0.40
6	1.26	(1.00, 1.52)	
8	1.05	(0.79, 1.31)	

a/ 4 significantly higher than 1.00.

Two-factor ANOVA for TIE vs. non-TIE and 4 unit vs. 6 unit operation, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	890.5	890.5	10.31	0.0033
Units	1	8.7	8.7	0.10	0.7571
T x U	1	3.0	3.0	0.03	0.8565
Error	28	2417.6	86.3		
Total	31	3346.9			

Factor Level	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	38[a]	(33, 43)	7
Non-TIE	49	(44, 53)	
4 Units	45[b]	(40, 50)	
6 Units	43[b]	(38, 47)	

a/ TIE significantly lower than non-TIE.
b/ Weighted by non-TIE/TIE fish number ratio.

Appendix Table 2.--Continued.

ANOVA for TIE vs. non-TIE for 8 units running, including means, 95% confidence intervals, and detectable difference.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	10.9	10.9	0.13	0.7288
Error	31	2674.0	86.3		
Total	32	2684.9			

TIE condition	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	51	(46, 55)	7
Non-TIE	50	(45, 54)	
8 Units	50	(47, 54)	

<u>SUBYEARLING CHINOOK SALMON</u>

ANOVA for non-TIE/TIE fish number ratio for 4 units running vs. 6 units, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
Units	1	1.03	1.03	4.64	0.0747
Error	6	1.33	0.22		
Total	7	2.36			

Units running	Mean non-TIE / TIE	95% confidence interval	4 vs. 6 detectable difference
4	1.80	(1.23, 2.37)	0.82
6	1.09	(0.52, 1.66)	
8	1.22	(0.89, 1.56)	

Appendix Table 2.--Continued.

Two-factor ANOVA for TIE vs. non-TIE and 4 unit vs. 6 unit operation, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	1605.8	1605.8	8.57	0.0104
Units	1	12.5	12.5	0.07	0.8022
T x U	1	39.2	39.2	0.21	0.6588
Error	15	2809.9	187.3		
Total	18	4519.9			

Factor Level	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	34[a]	(24, 44)	13
Non-TIE	52	(43, 62)	
4 Units	47[b]	(37, 57)	
6 Units	42	(33, 52)	

a/ TIE significantly lower than non-TIE.
b/ Weighted by non-TIE/TIE fish number ratio.

ANOVA for TIE vs. non-TIE for 8 units running, including means, 95% confidence intervals, and detectable difference.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	40.4	40.4	0.16	0.6970
Error	19	4765.5	250.8		
Total	20	4805.8			

TIE condition	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	57	(46, 67)	14
Non-TIE	54	(44, 64)	
8 Units	55	(48, 63)	

Appendix Table 2.--Continued.

COHO SALMON

ANOVA for non-TIE/TIE fish number ratio for 4 units running vs. 6 units, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
Units	1	1.69	1.69	12.21	0.0036
Error	14	1.94	0.14		
Total	15	3.62			

Units running	Mean non-TIE / TIE	95% confidence interval	4 vs. 6 detectable difference
4	1.74[a]	(1.44, 2.04)	0.40
6	1.08	(0.81, 1.35)	
8	1.03	(0.66, 1.40)	

a/ 4 significantly higher than 6.

Two-factor ANOVA for TIE vs. non-TIE and 4 unit vs. 6 unit operation, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	492.0	492.0	3.76	0.0628
Units	1	219.4	219.4	1.68	0.2062
T x U	1	36.7	36.7	0.28	0.6062
Error	28	3668.2	131.0		
Total	31	4390.6			

Factor Level	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	53	(47, 59)	8
Non-TIE	61	(55, 67)	
4 Units	61[a]	(54, 67)	
6 Units	54	(49, 60)	

a/ Weighted by non-TIE/TIE fish number ratio.

Appendix Table 2.--Continued.

ANOVA for TIE vs. non-TIE for 8 units running, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
TIE	1	172.4	172.4	0.94	0.3501
Error	34	6253.5	183.9		
Total	35	6425.9			

TIE condition	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	52	(46, 58)	9
Non-TIE	56	(50, 63)	
8 Units	54	(49, 59)	

STEELHEAD

ANOVA for non-TIE/TIE fish number ratio for 4 units running vs. 6 units, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of Squares	Mean Square	F	P
Units	1	0.11	0.11	0.93	0.3810
Error	6	0.69	0.11		
Total	7	0.79			

Units running	Mean non-TIE / TIE	95% confidence interval	4 vs. 6 detectable difference
4	1.15	(0.78, 1.52)	0.60
6	0.91	(0.43, 1.39)	
8	1.02	(0.66, 1.37)	

Appendix Table 2.--Continued.

Two-factor ANOVA for TIE vs. non-TIE and 4 unit vs. 6 unit operation, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of squares	Mean square	F	P
TIE	1	202.2	202.2	0.94	0.3586
Units	1	31.4	31.4	0.15	0.7119
T x U	1	198.6	198.6	0.93	0.3627
Error	14	3007.6	214.8		
Total	17	3393.5			

Factor Level	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	35	(25, 45)	15
Non-TIE	42	(30, 53)	
4 Units	40	(30, 49)	
6 Units	37	(25, 49)	

ANOVA for TIE vs. non-TIE for 8 units running, including means, 95% confidence intervals, and detectable differences.

ANOVA Source	df	Sum of squares	Mean square	F	P
TIE	1	35.3	35.3	0.19	0.6703
Error	25	4624.5	185.0		
Total	26	4659.8			

TIE condition	Mean FGE (%)	95% confidence interval (%)	Detectable difference (%)
TIE	49	(41, 56)	11
Non-TIE	46	(38, 54)	
8 Units	47	(42, 53)	

Appendix Table 3.--ANOVAs, means of fish guidance effeciency (FGE), and 95% confidence intervals, for subyearling chinook salmon during the summer migration, Bonneville Dam Second Powerhouse, 1993.

SUBYEARLING CHINOOK SALMON

Two-factor ANOVA comparing Unit 12 to Unit 17 and 4 unit vs. 6 unit operation.

Source	df	Sum of squares	Mean square	F	P
Unit	1	321.6	321.6	8.36	0.0126
Units on	1	410.3	410.3	10.67	0.0061
U x Uo	1	146.9	146.9	3.82	0.0726
Error	13	500.1	38.5		
Total	16	1476.4			

Mean FGE and 95% confidence intervals for combinations of test unit and number of units in operation.

Unit	Units in operation	Mean FGE (%)	95% conf. interval
12A	4	23	(16, 30)
12A	6	27	(20, 34)
17B	4	26	(19, 33)
17B	6	42	(36, 48)

Appendix Table 4.--Total numbers of fish in the gatewells and percent descaling for all salmonids examined during FGE tests conducted at Bonneville Dam Second Powerhouse, 1993. Units = the number of turbine units operating during the test.

			Yearling chinook		Subyearling chinook		Sockeye		Coho		Steelhead	
Unit	Date	Units	No.	%	No.	%	No.	%	No.	%	No.	%
17A	4-20	4	487	1.4	9	0.0	0	NA	35	5.7	3	0.0
17B	4-20	4	202	2.9	6	0.0	0	NA	22	9.1	3	0.0
17A	4-21	6	306	2.6	6	0.0	0	NA	55	0.0	1	0.0
17B	4-21	6	522	1.0	8	0.0	0	NA	38	2.6	1	6.9
17A	4-22	6	157	1.9	5	0.0	0	NA	21	4.8	25	0.0
17B	4-22	6	381	2.9	10	0.0	0	NA	42	0.0	4	9.2
17A	4-23	6	127	2.4	3	0.0	0	NA	21	0.0	4	5.7
17B	4-23	6	269	0.4	20	4.0	0	NA	27	0.0	2	2.2
17B	4-24	4	287	2.8	22	0.0	0	NA	49	0.0	11	8.0
17A	4-25	4	109	1.9	10	0.0	2	50.0	30	0.0	24	3.1
17B	4-25	4	286	3.5	27	0.0	1	0.0	87	3.4	15	2.1
17A	4-26	4	154	3.9	14	0.0	0	NA	33	6.0	13	5.2
17B	4-26	4	336	2.7	37	0.0	0	NA	50	2.0	5	0.0
17A	4-27	6	242	2.1	27	0.0	0	NA	53	0.0	6	5.2
17B	4-27	6	457	0.7	35	0.0	0	NA	60	0.0	2	3.1
17A	4-28	6	140	1.4	16	6.2	0	NA	47	2.1	4	2.1
17B	4-28	6	267	0.7	36	19.0	0	NA	50	8.0	2	0.0
12A	4-29	6	151	2.6	20	0.0	0	NA	59	0.0	52	0.0
12B	4-29	6	109	5.5	11	0.0	0	NA	54	0.0	25	4.0
12A	4-30	4	216	8.7	30	0.0	0	NA	99	3.0	38	2.6
12B	4-30	4	116	5.2	17	5.9	0	NA	65	4.6	39	0.0
12A	5-03	8	132	6.1	11	0.0	0	NA	94	2.1	39	0.0
12B	5-03	8	160	7.5	25	4.0	0	NA	25	2.4	50	10.0
15A	5-04	8	142	1.4	29	3.4	0	NA	153	4.6	15	6.6
15B	5-04	8	196	4.6	24	0.0	0	NA	127	0.8	7	0.0
15A	5-05	8	122	4.1	27	3.7	0	NA	185	1.1	19	10.5
15B	5-05	8	131	5.3	18	0.0	0	NA	232	0.0	13	15.4
15A	5-06	8	117	6.8	10	0.0	0	NA	187	1.1	12	0.0

Appendix Table 4.--Continued.

			Yearling chinook		Subyearling chinook		Sockeye		Coho		Steelhead	
Unit	Date	Units	No.	%	No.	%	No.	%	No.	%	No.	%
15B	5-06	8	188	10.1	30	6.7	0	NA	252	4.0	16	0.0
17A	5-07	8	125	7.2	25	0.0	0	NA	304	3.9	23	8.7
17B	5-07	8	46	4.3	12	8.3	0	NA	65	1.5	11	27.3
17A	5-08	6	93	4.3	16	6.2	1	0.0	99	4.0	43	25.6
17B	5-08	6	90	5.5	19	0.0	0	NA	124	4.0	13	7.7
17A	5-09	4	115	3.5	14	7.1	0	NA	444	1.1	55	3.6
17B	5-09	4	176	6.8	38	0.0	0	NA	807	1.9	50	2.0
12A	5-10	8	52	11.5	3	0.0	4	50.0	215	4.2	67	14.9
12B	5-10	8	89	10.1	6	0.0	0	NA	225	3.1	64	4.7
12A	5-11	6	141	5.0	13	7.6	8	50.0	373	2.7	160	1.9
12B	5-11	6	87	14.9	5	0.0	8	25.0	172	2.3	124	8.1
12A	5-12	4	166	10.8	24	8.3	22	22.7	400	2.5	125	0.8
12B	5-12	4	80	10.0	13	0.0	6	16.7	123	2.4	59	1.7
15A	5-13	8	109	11.9	11	9.0	14	21.4	233	6.4	66	18.2
15B	5-13	8	96	20.8	11	0.0	15	0.0	208	6.7	39	5.1
15A	5-14	8	120	8.3	2	0.0	3	66.7	238	5.0	40	12.5
15B	5-14	8	85	17.6	13	0.0	4	25.0	207	6.8	29	3.4
15A	5-15	8	104	8.6	4	0.0	0	NA	197	3.0	28	7.1
15B	5-15	8	87	9.1	5	0.0	1	100.0	154	2.6	14	7.1
17A	5-16	6	40	22.5	8	0.0	0	NA	160	0.0	30	16.7
17B	5-16	6	30	6.7	6	0.0	1	0.0	87	1.1	17	0.0
17A	5-17	8	88	20.5	6	0.0	2	50.0	135	5.2	15	33.3
17B	5-17	8	18	22.2	12	0.0	1	100.0	69	4.3	5	20.0
17A	5-18	8	30	23.3	5	3.4	5	0.0	67	4.5	3	0.0
17B	5-18	8	9	11.1	6	16.7	3	0.0	27	3.7	1	0.0
17A	5-19	8	13	15.4	5	0.0	0	NA	26	7.7	1	0.0
17B	5-19	8	3	0.0	1	0.0	0	NA	9	11.1	1	0.0
12A	5-24	8	100	6.0	9	0.0	302	32.1	51	0.0	93	8.6

Appendix Table 4.--Continued.

			Yearling chinook		Subyearling chinook		Sockeye		Coho		Steelhead	
Unit	Date	Units	No.	%	No.	%	No.	%	No.	%	No.	%
12B	5-24	8	41	63.4	1	100.0	169	84.6	13	15.4	40	32.5
12A	5-25	8	127	3.1	35	0.0	208	48.6	103	1.9	219	5.5
12B	5-25	8	71	8.5	28	0.0	169	32.0	40	0.0	180	0.0
12A	5-26	8	128	8.5	23	0.0	62	33.9	90	4.4	172	19.2
12B	5-26	8	57	15.8	11	0.0	67	29.8	23	8.6	91	18.7
15A	5-27	8	34	8.8	21	0.0	7	28.6	19	0.0	26	23.1
15B	5-27	8	22	4.5	33	0.0	11	18.2	13	0.0	14	7.1
15A	5-28	8	39	15.4	34	0.0	27	33.3	13	0.0	29	3.4
15B	5-28	8	31	3.2	41	2.4	38	39.5	11	0.0	19	15.7
15A	6-01	8	54	18.5	21	0.0	5	0.0	26	7.7	14	0.0
15B	6-01	8	43	30.2	57	3.5	2	0.0	21	9.5	4	0.0
17A	6-02	8	13	30.8	25	0.0	2	50.0	18	16.7	5	0.0
17B	6-02	4	10	0.0	22	4.5	1	0.0	8	25.0	1	0.0
17A	6-03	8	8	12.5	15	0.0	1	0.0	18	11.1	4	50.0
17B	6-03	8	7	14.3	18	0.0	0	NA	9	22.2	1	0.0
TOTALS (spring)			**9486**	**5.2**	**1220**	**2.4**	**1167**	**41.8**	**7896**	**3.0**	**2445**	**8.3**

Appendix Table 4.--Continued.

			Subyearling chinook	
Unit	Date	Units	No.	%
12A	7-07	6	357	2.5
17B	7-07	6	268	0.0
12A	7-08	4	501	0.2
17B	7-08	4	114	3.5
12A	7-09	6	87	0.0
17B	7-09	6	115	0.0
12A	7-10	4	185	2.1
17B	7-10	4	110	0.0
12A	7-13	6	111	2.7
17B	7-13	6	67	0.0
12A	7-14	4	76	2.6
17B	7-14	4	174	1.1
12A	7-15	6	110	3.6
17B	7-15	6	77	3.9
12A	7-16	4	68	0.0
17B	7-16	4	125	1.6
12A	7-17	6	122	3.3
17B	7-17	6	102	2.9
TOTALS (summer)			**2769**	**1.5**