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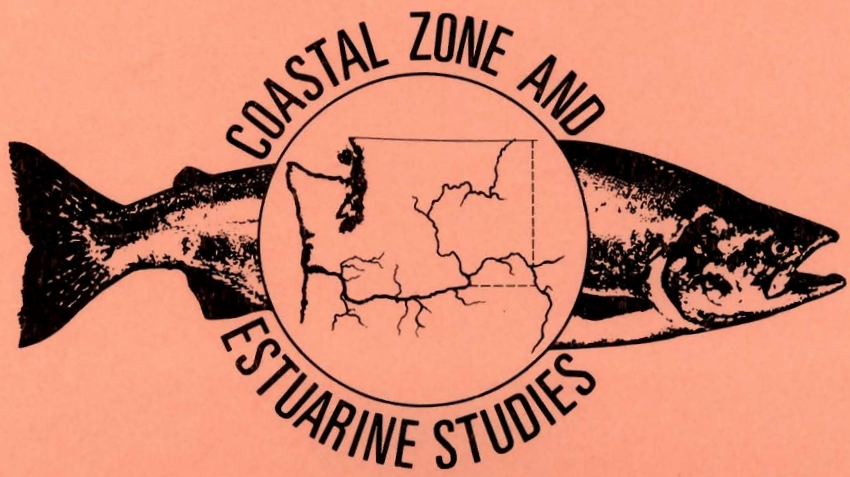

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INTRODUCTION

At the present time, juvenile salmonids passing The Dalles Dam on their downstream migration must pass through the turbines or be bypassed by means of the ice and trash sluiceway or spillway. During periods of no spill, Willis (1982) estimated that passage through the sluiceway was about 40%. To increase the overall percent passage, a fingerling bypass system similar to that being used at other U.S. Army Corps of Engineers (COE) projects was proposed. These systems consist of submersible traveling screens (STS) in the turbine intakes, vertical barrier screens and orifices in the gatewells, and a bypass channel (Fig. 1). In 1986, the National Marine Fisheries Service, under contract to the COE, continued studies begun in 1985, to evaluate the potential benefits of this type of system.

Fish guiding efficiency (FGE) test results obtained during 1985 indicated the use of a standard length STS would result in unacceptably low FGEs (<70%) for all salmonid species except steelhead, Salmo gairdneri. Vertical distribution (VD) tests conducted at the same time in Units 2, 12, and 18 showed that all salmonid species except steelhead were distributed too deeply in the turbine intakes to be intercepted by a standard length STS. Therefore, the STS would probably have to be either lengthened and/or lowered in the intake to increase FGE.

Tests conducted with subyearling chinook salmon, Oncorhynchus tshawytscha, in 1985 compared the FGEs of a standard STS and an STS modified to operate 30 inches lower in the intake. During these tests, the lowered screen significantly increased the FGE for subyearling chinook salmon from 8.4 to 13.9% A similar proportionate increase would be more than sufficient to

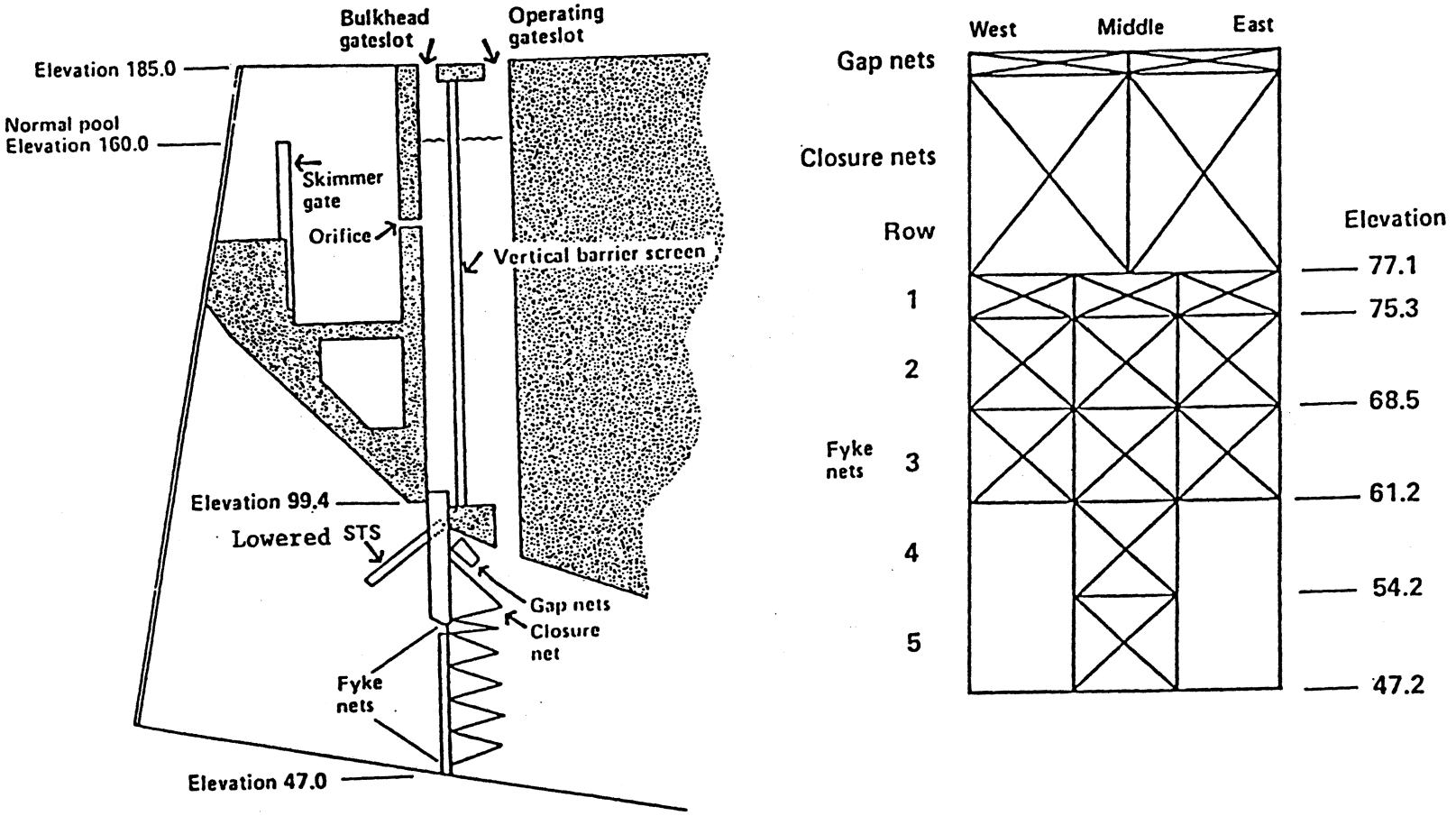

Figure 1.--Transverse section through a typical turbine intake at the Dalles Dam showing the STS and the layout and elevations of the fyke nets used for FGE testing.

provide for acceptable FGEs for yearling salmonids. Therefore, in 1986, all testing was done with a 30-inch lowered STS to determine if similar benefits could be realized for spring chinook and sockeye salmon, O. nerka.

Tests in 1985 were conducted from 16 to 21 April with the ice and trash sluiceway closed and from 30 April to 3 May with the sluiceway operating under normal conditions (0600 to 2200 h). In the later tests, the FGE for yearling chinook salmon increased by 12%. The FGE test schedule in 1986 was designed to determine if this increase was actually due to sluiceway operation or due to a change in vertical distribution of the later arriving migrants.

APPROACH

Studies from other COE projects indicated that FGE increases for yearling chinook salmon as they advance in their parr smolt transformation (Swan et al. 1987). Therefore, the 1986 FGE testing was conducted in two phases: Phase I (11-20 April) with early hatchery releases of yearling salmonids, primarily from the Deschutes and Umatilla Rivers and Phase II (5-10 May) with later arriving yearling salmonids migrating from the upper Columbia and Snake Rivers. During Phase I, all tests were conducted with and without sluiceway operation on alternate days to determine its effect on FGE. Because FGE without sluiceway operations was significantly higher in Phase I, Phase II testing was conducted without sluiceway operation. All tests were conducted in Unit 2-2.

METHODS

The methods for determining FGE were the same as those used at The Dalles Dam in 1985 (Monk et al. 1986). Figure 1 shows the position of the STS in operation with the various nets attached. The gap nets collected fish

that escaped over the top of the STS into the turbine intake, and the closure nets (large fyke nets) collected fish from the area between the bottom edge of the STS and the top of the fyke net frame. The first three fyke net rows contained a full complement of three nets so the entire width of the intake was fished. The lower two rows contained only a middle net, and the individual net catch was expanded (3X) to obtain an estimated total catch at these depths.

Tests usually began at sunset (1800-2000 h) and ran from 2 to 5 h. During testing, the load on the test unit was maintained at approximately 80 mega-watts, with an average discharge ranging from 15.2 to 16.0 kcfs. Before the start of each test, the orifice was closed and fish were removed by means of a dip basket (Swan et al. 1979). During the test, fish were removed periodically from the gatewell to determine when sufficient numbers had accumulated for statistical evaluation. To terminate the test, the unit was shut down and all remaining fish were removed from the gatewell. Live salmonids collected in the gatewell were anesthetized, enumerated, and examined for descaling and injury. Gatewell dipnet catches provided the number of guided fish; catches from the gap and fyke nets attached to the STS provided the number of unguided fish.

FGE was calculated as gatewell catch divided by the total number of fish passing the intake during the test period:

$$FGE = \frac{GW}{GW+GN+FN+CN} \times 100$$

where: GW = gatewell catch
GN = gapnet catch
FN = fyke net catch (3X when fishing only the center net)
CN = closure net catch

For statistical evaluation, each test condition required three to five replicates (depending on variance) with 200-250 fish per replicate,[1/] to detect a 10% difference at $\alpha = 0.05$ and level of significance with a power of test $1 - \beta = 0.80$. Contingency tables and the log-likelihood G-test (Sokal and Rohlf 1981) were used to compare FGE replicates within conditions, between conditions (sluiceway open vs sluiceway closed), and between Phase I and Phase II.

RESULTS AND DISCUSSION

The numbers of yearling chinook salmon, sockeye salmon, and steelhead taken in the gatewell and in the various net levels for all of the 1986 tests are in the Appendix. Since yearling chinook salmon were the only species with sufficient sample sizes for statistical evaluation, the FGEs for the other species are given only as an indication of the results which may be expected with further testing and larger sample sizes.

The 55.6% FGE for yearling chinook salmon with the sluiceway closed was significantly higher than the 47.0% FGE under sluiceway open conditions [G = 23.0 (Table 1)]. Apparently, fish in the upper water column which would have been intercepted by the STS were being diverted into the ice and trash sluiceway when the skimmer gates were open, thus accounting for the lower FGE.

[1/] Criterion of 200 to 250 fish per replicate (depending on net coverage) for VD and FGE tests was established at the 11 April 1986 meeting between COE and NMFS biologists and statisticians.

Table 1.--Summary of FGE test results for a 30-inch lowered STS showing the percent FGE, standard deviations (SD), and G - statistic for various test conditions - Unit 2, The Dalles Dam, 1986.

Species	Date	Sluiceway operation	No. reps.	Total sample size	FGE (%)	S.D. (n-1)	G
Yearling chinook	4/11-19	Open	5	1,625	47.0	3.7	
	4/12-20	Closed	4	1,517	55.6	0.8	23.0***
	5/5-10	Closed	6	1,163	62.9	7.3	14.8***
Sockeye	5/5-10	Closed	6	473	51.8	11.1	a/
Steelhead	4/11-19	Open	5	168	68.4	6.7	
	4/12-20	Closed	5	309	70.9	5.9	
	5/5-10	Closed	5	624	68.3	7.4	

a/ Sample sizes of sockeye salmon and steelhead were not sufficient for statistical evaluation.

*** = $P < 0.001$

During the Phase II tests (with the sluiceway closed), the FGE for yearling chinook salmon (62.9%) was significantly higher than the earlier sluiceway closed tests (G = 14.8). These data tend to substantiate 1985 results indicating that the earlier fish in The Dalles pool (mainly from Deschutes River Hatchery releases) are lower in the water column than the later running Snake and Upper Columbia River yearling chinook salmon stocks. Therefore, the 1985 results (showing significantly higher FGE on later running fish under sluiceway open conditions than on earlier running fish under sluiceway closed conditions) were not a valid measure of sluiceway effect. Instead the difference measured resulted from differences in FGE between early and late running stocks of fish.

One concern with lowering the STS an additional 30 inches into the intake was that a larger percentage of fish would escape through the increased space between the top of the screen and the ceiling intake. Since any fish going over the top of the screen were caught in the gap net, an increase in the percentage of gap net caught fish would indicate that this was the case. However, the gap net catches for all species remained minimal and were very similar to the 1985 FGE results with the screen in the standard position (Fig. 2). Excluding the gatewell catches, the largest percentage of all species were caught in Net Level 2 (EL 68.5-75.3) well below the area intercepted by the STS.

Since the FGE at The Dalles Dam in both 1985 and 1986 increased for yearling chinook salmon from the beginning to the end of April (as a result of a change in composition of the downstream migrants), only data from the earlier sets of tests (16 to 21 April in 1985 and 11 to 19 April in 1986) were used to compare FGE results of the standard STS (1985) to the lowered STS (1986).

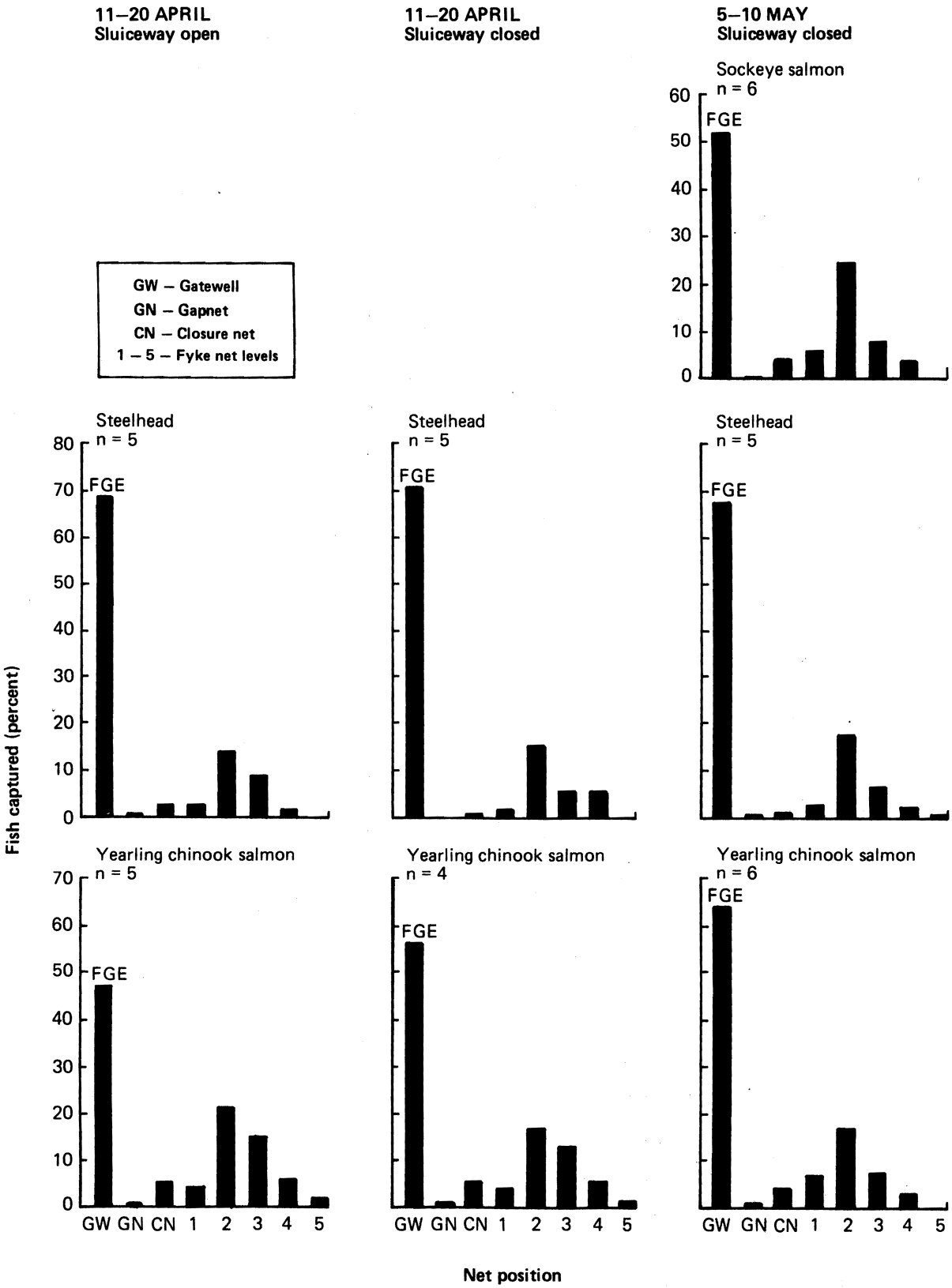

Figure 2.--Summary of STS test results for yearling chinook salmon, sockeye salmon, and steelhead showing FGE and percentage of fish caught at various net levels, Unit 2, The Dalles Dam,1986.

These comparisons showed an increase in FGE for yearling chinook salmon (43.5 to 55.6%) and sockeye (38.4 to 51.8%) (Fig. 3). Since these results were from two different years, we felt that no statistical inferences should be made.

Descaling rates for the three species collected in the gatewell during the various tests did not change appreciably over the 1985 levels and remained within acceptable levels (Appendix Table 2). For yearling chinook salmon this ranged from 0.0 to 7.4%, with a weighted mean of 2.5%; for sockeye salmon the range was from 0.0 to 4.3%, with a weighted mean of 3.3%; and for steelhead the range was from 0.0 to 12.5%, with a weighted mean of 2.5%.

SUMMARY AND CONCLUSIONS

In 1986, FGE studies were conducted in Unit 2 at The Dalles Dam to evaluate an STS modified to extend 30 inches lower in the gatewell in an effort to increase FGE for yearling chinook salmon to an acceptable target level of 70%. Major findings were:

1. The lowered STS tested in 1986 appeared to enhance FGE when compared to the standard STS tested at the same time in 1985. The increased FGE, from 43.5 to 55.6%, for yearling chinook salmon, was still well below the interim target FGE of 70%.

2. The FGE for the early run of yearling chinook salmon (primarily composed of Umatilla River and Deschutes River stocks) was significantly less than the FGE for the later-running yearling chinook salmon (primarily from the upper Columbia and Snake rivers). The early fish were also lower in the water column than the later fish. Apparently certain behavioral mechanisms that change during smoltification can affect the performance and position of fish in the water column and hence their tendency to be guided by the STS. Therefore, to correctly measure or compare FGEs, between various STS types or

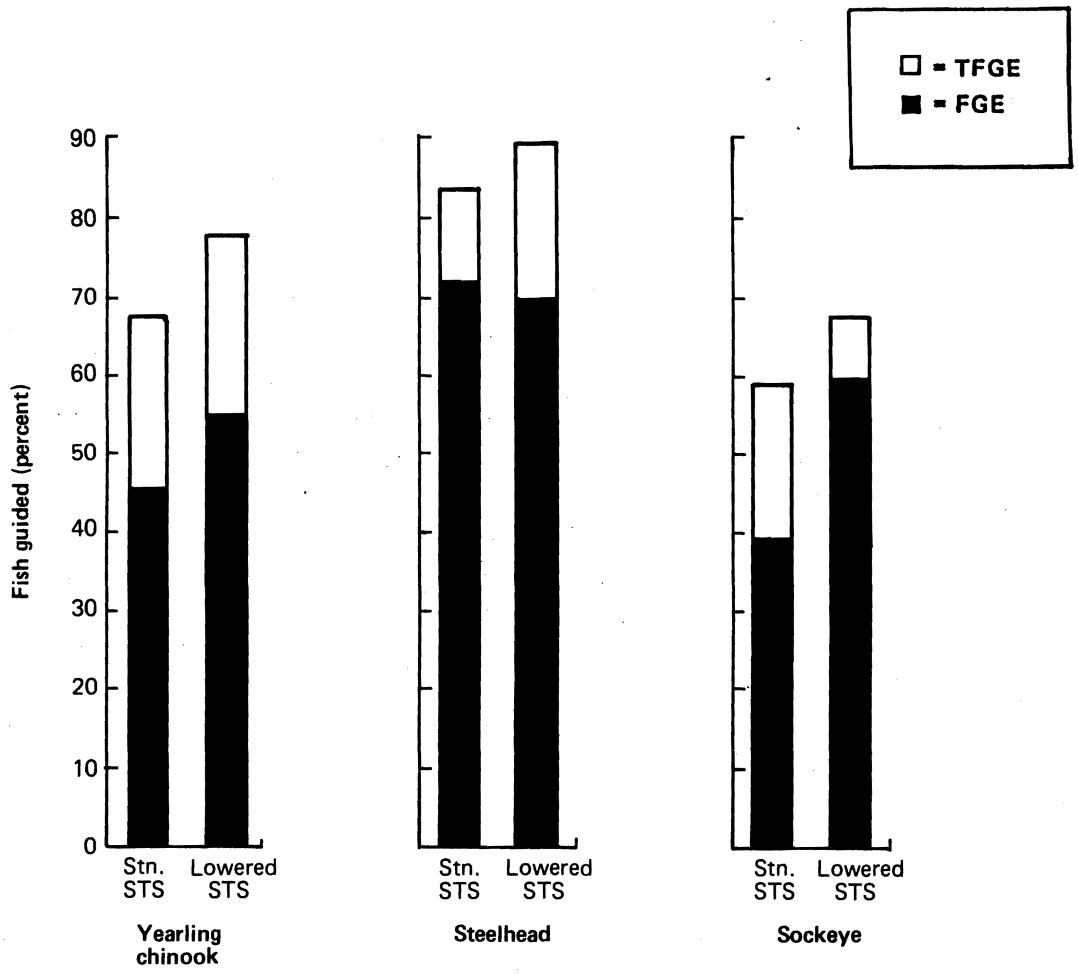

Figure 3.--Comparison of FGE test results for a standard STS (1985 data) and a lowered STS (1986 data) for yearling chinook salmon, steelhead, and sockeye salmon under sluiceway closed conditions at The Dalles Dam, 1986.

between operating conditions at The Dalles Dam, the composition of the run should be considered.

3. Operating the sluiceway by opening the skimmer gates seems to draw off a percentage of the surface oriented yearling salmonids, as evidenced by significantly lower FGEs than measured with the sluiceway closed.

RECOMMENDATIONS

To reach a minimum target level of 70% FGE for yearling chinook salmon at The Dalles Dam, it appears that either an extended STS will be required to intercept more flow or the vertical distribution of the salmonids in the turbine intake will have to be altered by secondary mechanical devices similar to those being tested at other COE projects.

ACKNOWLEDGMENTS

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APPENDIX

Appendix Table 1.--Numbers of fish (YC-yearling chinook, ST-steelhead, SO-sockeye) collected in the individual replicates of STS FGE tests during Phase 1 (April 11 to 20) and Phase 2 (May 5 to 10), in Unit 2, The Dalles Dam, 1986.

	Date and (Test Condition)[a/]					
	11 April (1)		12 April (2)		13 April (1)	
Location	YC	ST	YC	ST	YC	ST
Gatewell	78	15	180	61	273	32
Gap net	0	0	5	0	1	0
Closure net	14	0	21	0	28	1
Net 1	7	1	11	3	29	2
Net 2	47	4	53	12	110	9
Net 3	23	3	32	7	63	1
Net 4[b/]	18	0	12	0	18	0
Net 5[b/]	3	0	3	3	15	0
Totals	190	23	317	86	537	45

	14 April (2)		15 April (1)		16 April (2)	
Location	YC	ST	YC	ST	YC	ST
Gatewell	260	35	75	14	290	31
Gap net	0	0	1	0	1	0
Closure net	32	1	20	1	28	2
Net 1	24	2	9	0	15	1
Net 2	118	9	40	2	80	4
Net 3	104	2	25	3	66	0
Net 4[b/]	75	3	3	3	33	12
Net 5[b/]	9	0	0	0	12	0
Totals	622	52	173	23	525	50

	17 April (1)		18 April (2)		19 April (1)	
Location	YC	ST	YC	ST	YC	ST
Gatewell	177	46	190	60	161	8
Gap net	2	1	7	0	1	0
Closure net	21	1	23	1	15	2
Net 1	16	2	17	1	15	0
Net 2	68	7	58	12	66	2
Net 3	67	6	35	3	74	2
Net 4[b/]	24	0	12	0	15	0
Net 5[b/]	0	0	0	0	3	0
Totals	375	63	342	77	350	14

Appendix Table 1.--Cont.

Location	Date and (Test Condition)[a/] 20 April (2) YC	ST	5 May (2) YC	ST	SO	6 May (2) YC	ST	SO
Gatewell	183	32	63	58	8	139	119	56
Gap net	0	0	0	0	0	0	0	0
Closure net	13	0	4	0	0	11	3	7
Net 1	12	1	9	3	4	24	5	7
Net 2	62	8	36	2	7	49	33	30
Net 3	42	3	5	2	2	25	16	13
Net 4[b/]	21	0	0	3	6	3	3	3
Net 5[b/]	0	0	0	0	0	0	0	0
Totals	333	44	117	68	27	251	179	116

Location	7 May (2) YC	ST	SO	8 May (2) YC	ST	SO	9 May (2) YC	ST	SO
Gatewell	122	34	34	95	25	25	126	177	93
Gap net	1	0	0	2	1	0	1	0	1
Closure net	9	1	5	4	0	0	6	2	8
Net 1	18	1	7	4	5	1	11	9	10
Net 2	23	10	12	19	7	11	23	43	42
Net 3	8	5	4	7	3	3	17	11	14
Net 4[b/]	6	6	6	0	3	0	0	3	0
Net 5[b/]	0	0	0	0	0	0	0	3	3
Totals	187	57	68	131	44	40	184	248	168

Location	10 May (2) YC	ST	SO
Gatewell	187	71	29
Gap net	4	1	0
Closure net	15	3	1
Net 1	19	5	5
Net 2	42	14	11
Net 3	14	2	5
Net 4[b/]	12	0	3
Net 5[b/]	0	0	0
Totals	293	96	54

[a/] Condition 1 = with sluiceway operation (skimmer gates open); Condition 2 = without sluiceway operation (skimmer gates closed).

[b/] These numbers are middle net catches expanded by 3.

Appendix Table 2.--Rates of descaling for yearling chinook salmon, steelhead, and sockeye salmon taken in gatewell catches during FGE tests in Unit 2 - The Dalles Dam, 1986.

Date	Yearling chinook			Steelhead			Sockeye		
	N	No. descaled	%	N	No. descaled	%	N	No. descaled	%
11 Apr	78	0	0.0	15	0	0.0	-	-	-
12 Apr	127	1	0.8	61	0	0.0	-	-	-
13 Apr	169	1	0.6	32	1	3.1	-	-	-
14 Apr	142	1	0.7	35	3	8.6	-	-	-
15 Apr	75	3	4.0	14	0	0.0	-	-	-
16 Apr	150	2	1.3	31	1	3.2	-	-	-
17 Apr	131	2	1.5	46	0	0.0	-	-	-
18 Apr	131	7	5.3	60	2	3.3	-	-	-
19 Apr	160	0	0.0	8	1	12.5	-	-	-
20 Apr	183	2	1.1	32	0	0.0	-	-	-
5 May	63	1	1.5	58	1	1.7	8	0	0.0
6 May	100	4	4.0	100	1	1.0	56	2	3.6
7 May	122	9	7.4	34	0	0.0	34	1	2.9
8 May	95	7	7.4	25	0	0.0	25	0	0.0
9 May	100	4	4.0	100	4	4.0	93	4	4.3
10 May	100	4	4.0	71	4	5.6	29	1	3.4
Total	1,926	48	2.5	722	18	2.5	245	8	3.3