Evaluation of the Juvenile Collection and Bypass System at Bonneville Dam—1983

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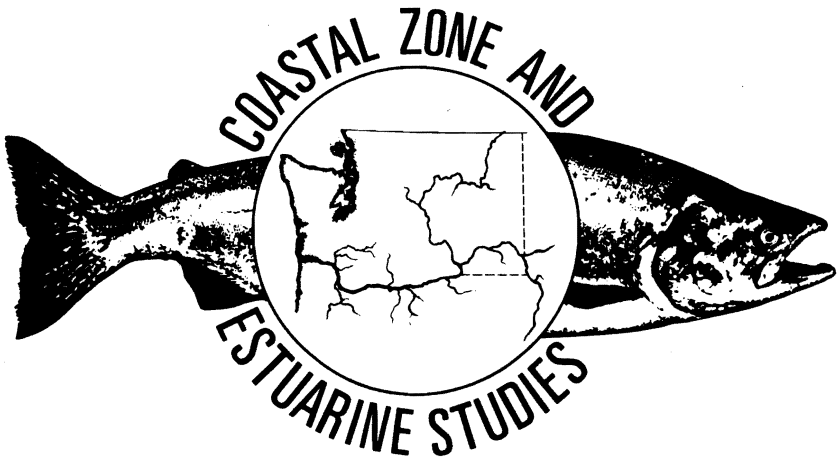

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TABLE OF CONTENTS

Page

INTRODUCTION. 1

EFFICIENCY OF THE STS AND GATEWELL ORIFICE BYPASS SYSTEM OF THE SECOND POWERHOUSE. 2

Vertical Distribution Tests 2

Methods and Procedures. 2

Results 4

STS FGE Tests 11

Methods and Procedures. 11

Results 12

Orifice Passage Efficiency Tests. 17

Methods and Procedures. 17

Results 17

FISH QUALITY AND STRESS THROUGH THE COLLECTION AND BYPASS SYSTEM. . . . 19

Fish Quality. 19

Methods and Procedures. 19

Results 20

Stress Tests. 27

Methods and Procedures. 27

Results 28

THE SMOLT COLLECTION SYSTEM AND ITS POTENTIAL FOR INDEXING SMOLT MIGRATIONS. 31

Determining the Accuracy of the Smolt Sampler and Measures of Delay in Passing Through the System 31

Methods and Procedures. 33

Results 34

Page

Evaluation of the Wet Separator 40

Methods and Procedures. 40

Results 40

Determining the Potential Use of Bonneville Dam as an Index Site for the Smolt Migration 42

Methods and Procedures. 42

Results 43

THE POTENTIAL OF SCREEN CYCLING AT THE FIRST AND SECOND POWERHOUSES . . 46

Methods and Procedures. 46

Results 46

THE FEASIBILITY OF USING THE DOWNWELL RELEASE INTO THE OBSERVATION ROOM AS A RELEASE SITE FOR TRANSPORTED FINGERLINGS. 49

Methods and Procedures. 49

Results 50

GENERAL SUMMARY 50

GENERAL RECOMMENDATIONS 53

ACKNOWLEDGEMENTS. 55

LITERATURE CITED. 56

APPENDIX--Tables 1 through 7. 57

INTRODUCTION

The fingerling collection and bypass system for the Bonneville Second Powerhouse was completed in 1982 and was in full scale operation during the 1983 smolt migration. The National Marine Fisheries Service (NMFS), under contract to the U.S. Army Corps of Engineers (CofE), conducted a research program during the 1983 smolt migration to evaluate this bypass system, attempt to identify problem areas, and make recommendations if necessary. In addition, we conducted a study to determine the potential of a screen cycling operation for submersible traveling screens (STS) at both the 1st and 2nd Powerhouses.

The primary objectives of the research at Bonneville Dam during the 1983 smolt migration were as follows:

1. Evaluate the efficiency of the STS and the gatewell orifice bypass system (2nd Powerhouse).

2. Monitor fish quality and stress through the collection and bypass systems (both powerhouses).

3. Evaluate the smolt collection system and its potential for indexing smolt migration (2nd Powerhouse).

4. Evaluate the potential of screen cycling (both powerhouses).

5. Determine the feasibility of using the downwell release site in the observation room at the 2nd Powerhouse as a release site for transported fingerlings.

This report provides the final analysis of the results by objectives of the 1983 research program.

EFFICIENCY OF THE STS AND GATEWELL ORIFICE BYPASS SYSTEM OF THE SECOND POWERHOUSE

Vertical Distribution Tests

Vertical distribution data for the juvenile salmonids entering the turbine intakes at the Bonneville Second Powerhouse were needed to determine the potential for STS fish guiding efficiency (FGE).

Methods and Procedures

Vertical distribution was determined with the use of a fyke net frame and a series of nets operated in the upstream gate slot (Figure 1). A full complement of nets fished the upper portion of the intake where normally 70-80% of the fish are found. The remainder of the intake was sampled with a single vertical row of nets, and the net catch expanded to obtain and estimate for this area of the intake. Each net was 6.0 x 6.5 ft at the mouth, approximately 15 ft long, tapered to an 8-inch diameter metal ring to which a 3-ft cod-end bag was attached. A standard replicate began by shutting the turbine off, closing the orifice, lowering the frame into the intake with the gantry crane, dipnetting the gatewell to remove all residual fish, and restarting the turbine. The gatewell was then dipnetted periodically until sufficient numbers of fish had entered the unit for statistical evaluation (usually 2 to 4 h). The test was ended by shutting the unit off and dipnetting any remaining fish from the gatewell. The fyke net frame was then brought to the dock and each individual net catch enumerated by species. Vertical distribution was then determined by the percentage of the total fish captured that were taken in each horizontal row of nets. Tests were conducted from 1800 to 2300 h in Units 11C, 12B, 14B, and 15A.

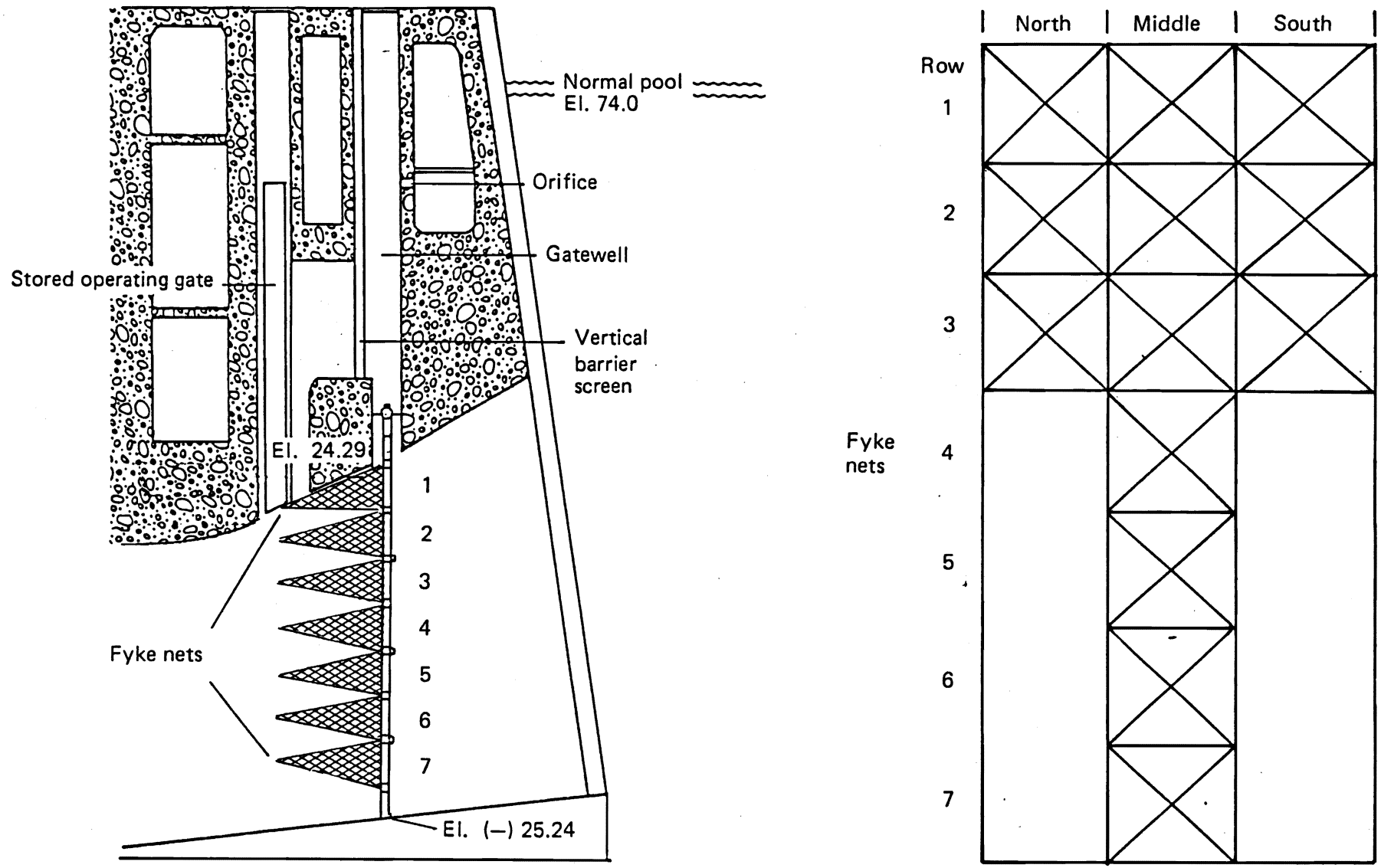


Figure 1.--Cross-section of the turbine intake at Bonneville Dam Second Powerhouse with a vertical distribution frame and fyke nets including a view showing the layout net - 1983.

Results

Fifteen replicates of vertical distribution tests were conducted between 21 April and 17 June. Information indicated that downstream migrants entering the turbine intake of the Bonneville Second Powerhouse were not as concentrated along the ceiling of the intake as at other powerhouses including the First Powerhouse at Bonneville Dam. Less than 50% of the chinook salmon were found in the water mass normally intercepted by the STS (approximately 14 ft below the ceiling of the intake). Normally 75 to 85% is needed to obtain an acceptable FGE of about 75% with the STS. Steelhead had the highest level of concentration (64%) and subyearling chinook salmon the lowest (42%) as shown in Table 1. Figures 2-6 depict vertical distribution curves for each species. Confidence intervals (CI) for each net catch at the 95% level were defined using the formula:

$$P \pm t(1 - \frac{\alpha}{2}, K - 1) \frac{S}{K}$$

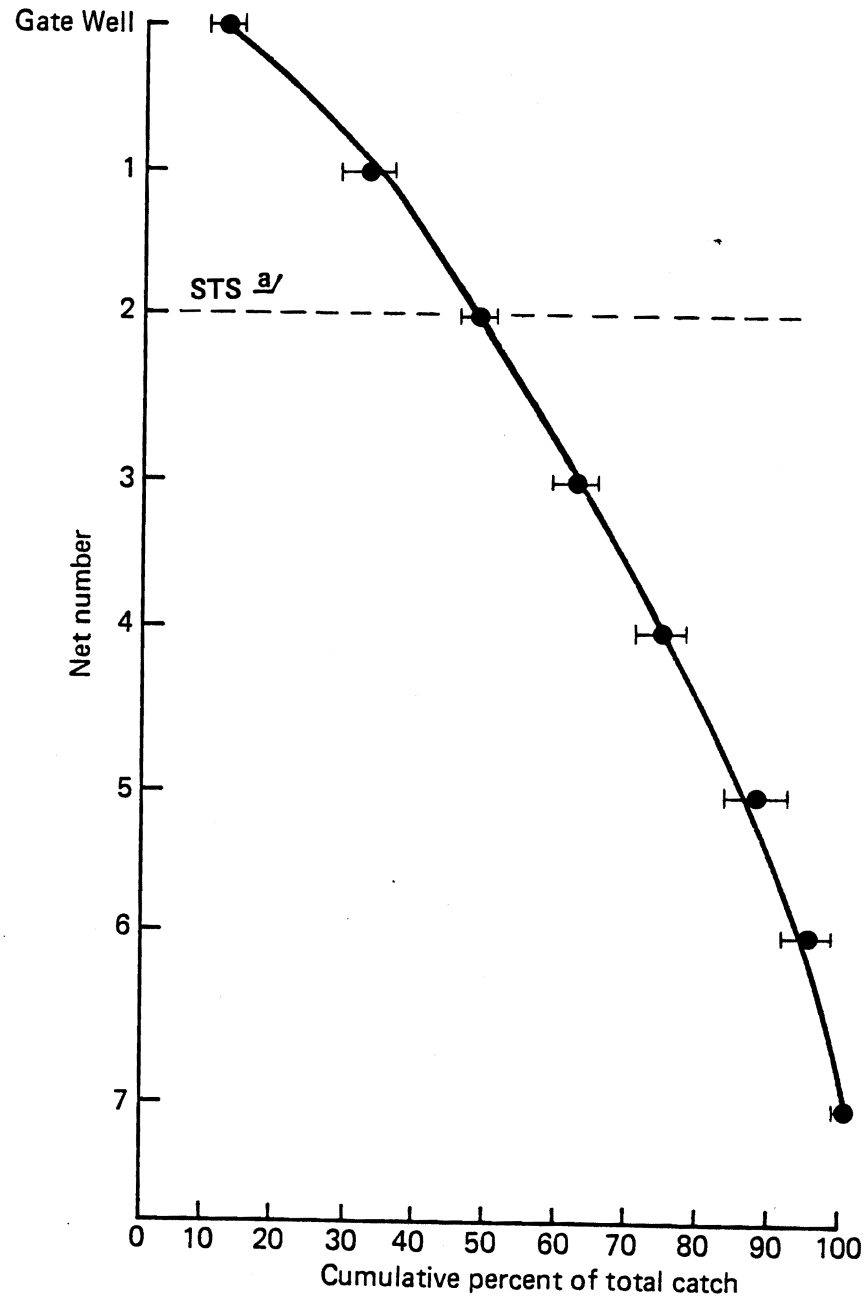
Where: K = number of replicates.
S = standard deviation among replicates.

Statistically, the vertical distribution data collected from Units 11, 12, and 15 fell within the confidence limits (95% CI) of similar vertical distribution data collected from Unit 14 (powerhouse operating constantly at nearly maximum capacity throughout the testing. From these data, it was concluded that the distribution of fish entering the intakes available for STS guiding was uniform across the powerhouse. Therefore, FGE measurements made in any of the turbine units would be representive of the FGE for the entire Second Powerhouse.

Table 1.--Percentage of fish by species in the gatewells and fyke nets during vertical distribution studies conducted at Bonneville Dam 2nd Powerhouse in 1983 (includes combined data from Units 11, 12, 14, and 15.

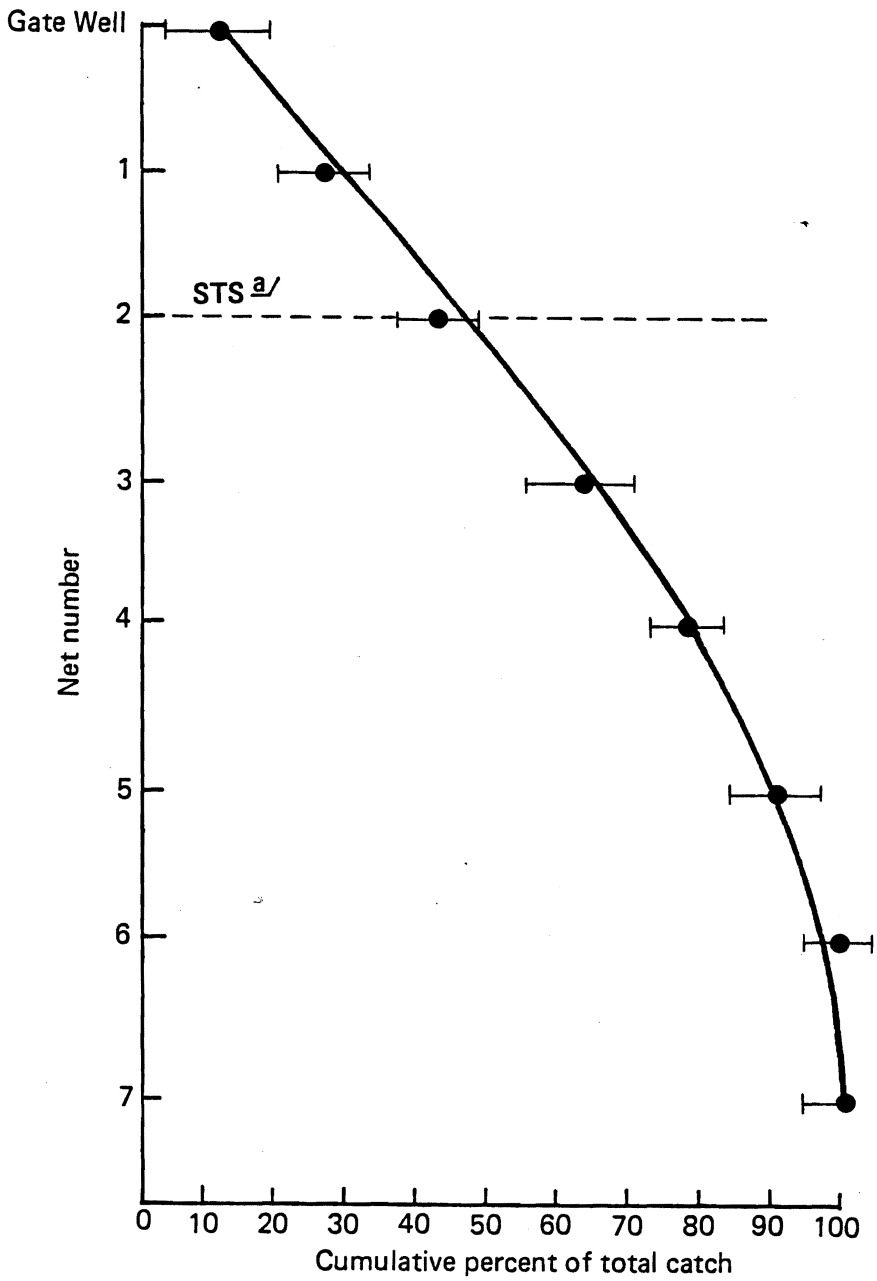
Location	Approximate distance from intake ceiling (ft)	Yearling chinook		Subyearling chinook		Steelhead		Coho		Sockeye	
		Individual	Cumulative	Individual	Cumulative	Individual	Cumulative	Individual	Cumulative	Individual	Cumulative
Gatewell		12.1		11.3		30.1		21.8		14.4	
Net 1	6.5	20.0	32.2	15.0	26.3	19.3	49.4	12.1	33.9	18.1	32.5
Net 2	13.0[a/]	15.7	47.9	15.9	42.2	14.2	63.6	13.6	47.8	15.9	48.4
Net 3	19.5	13.4	61.3	20.4	62.6	13.2	76.8	18.7	66.5	13.4	61.8
Net 4	26.0	13.4	74.7	13.2	75.8	8.8	85.6	10.3	76.8	14.7	76.5
Net 5	32.5	12.3	87.0	11.4	87.2	7.5	93.1	11.1	87.9	11.4	87.9
Net 6	39.0	9.8	96.8	8.2	95.4	5.8	98.9	7.7	95.6	10.7	98.6
Net 7	45.5	3.1	99.9	4.5	99.9	1.1	100.0	4.4	100.0	1.3	99.0

a/ Level that should theoretically be intercepted by the STS.



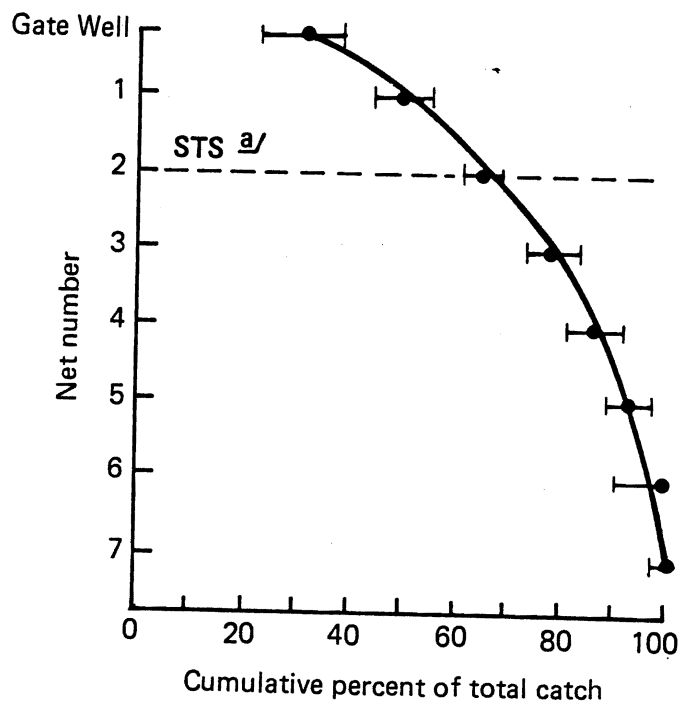
a/ Approximate lowest point of intercept with STS at 47° angle.

Figure 2.--Vertical distribution curve for yearling chinook salmon at Bonneville Dam Second Powerhouse, 1983. The symbol ⊢—⊣ represents upper and lower 95% confidence limits about the individual points on the curve.



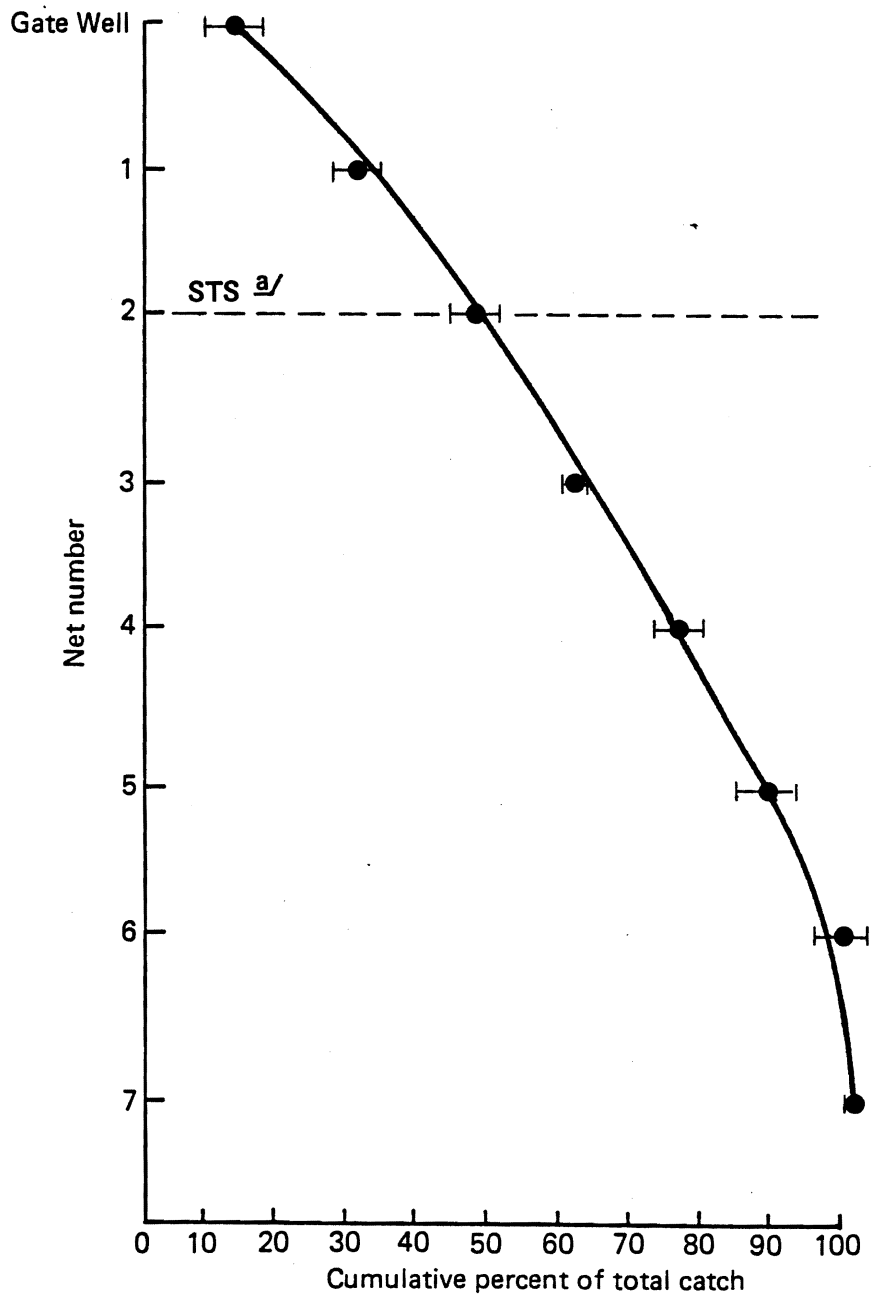
a/ Approximate lowest point of intercept with STS at 47° angle.

Figure 3.--Vertical distribution curve for subyearling chinook salmon at Bonneville Dam Second Powerhouse, 1983. The symbol ├──┤ represents upper and lower 95% confidence limits about the individual points on the curve.



a/ Approximate lowest point of intercept with STS at 47° angle.

Figure 4.--Vertical distribution curve for steelhead at Bonneville Dam Second Powerhouse, 1983. The symbol ├──┤ represents upper and lower 95% confidence limits about the individual points on the curve.



a/ Approximate lowest point of intercept with STS at 47° angle.

Figure 6.--Vertical distribution curve of sockeye salmon at Bonneville Dam Second Powerhouse, 1983. The symbol ├──┤ represents upper and lower 95% confidence limits about the individual points on the curve.

STS FGE Tests

Methods and Procedures

Initial FGE testing began in Unit 14. However, due to small numbers of fish and poor FGE, it was decided to move additional testing to Unit 12. The maximum (47°) and an intermediate (60°) angles of the STS were tested. All tests were conducted with the turbine at full load.

The testing program was divided into two phases with the first phase concentrating on yearling chinook salmon and the second phase on subyearling chinook salmon (information on other species was collected as available).

Most conditions were replicated about five times with a goal of obtaining approximately 200 STS guided fish per replicate. Four properties related to the determination of the number of observations and number of replicates: (1) the specified statistical significance level, (2) the discrimination of the test, (3) the magnitude of the variability, and (4) the number of treatment or factor levels. The following formula for calculating confidence intervals for multinomial proportions was used to determine sample size per treatment:

$$C.I. = P \pm (B \times P \times (1-P /N)*1/2$$

where P is the estimated probability for one of the treatment categories, B is the tabular value for the upper percentile of the chi-square distribution with one degree of freedom at the specified significance level for discrimination, and N is the total sample size. The variables used to determine the number of replicates are related by the formula:

$$(H \times S) / (N *1/2)$$

where H is an analysis of means factor and S is the estimated pooled standard deviation. The means factor is determined as a product of tabular values of

the t-distribution at the specified statistical significance level and the number of replicates and sample size per replicate.

The FGE tests were conducted in the same manner as the vertical distribution tests, i.e., shutting the unit off, lowering a traveling screen into the intake with an attached fyke net frame, and dipnetting the guided fish from the gatewell. The fingerling bypass orifices were closed during each test. Figure 7 illustrates a traveling screen with fyke net frame attached and the location of the nets used for sampling unguided fish.

FGE is the percentage of the fish (by species) that are guided by the STS out of the turbine intake into the gatewell for a particular time interval and test condition. This was determined with the following formula:

$$FGE = \frac{GW}{GW+GN+3(FN)+1.5(CN)} \times 100$$

GW = gatewell catch
GN = gap net catch
FN = fyke net catch
CN - closure net catch

During the second phase of testing, in an attempt to increase FGE, the STS was lowered 1 foot further into the intake to provided more flow interception. This also increased the throat opening (distance between the ceiling and the face of the traveling screen) and reduced the constriction at the entrance of the gatewell slot to allow more water and presumable more fish to enter the gatewell.

Results

Phase I of the test program ran from 9 to 19 May and consisted of 14 replicates, seven at the 47° and seven at the 60° STS guiding angles. Yearling chinook salmon were the predominant species during the first phase of testing. Other species also present in adequate numbers for some of the test replicates were coho and sockeye salmon and steelhead.

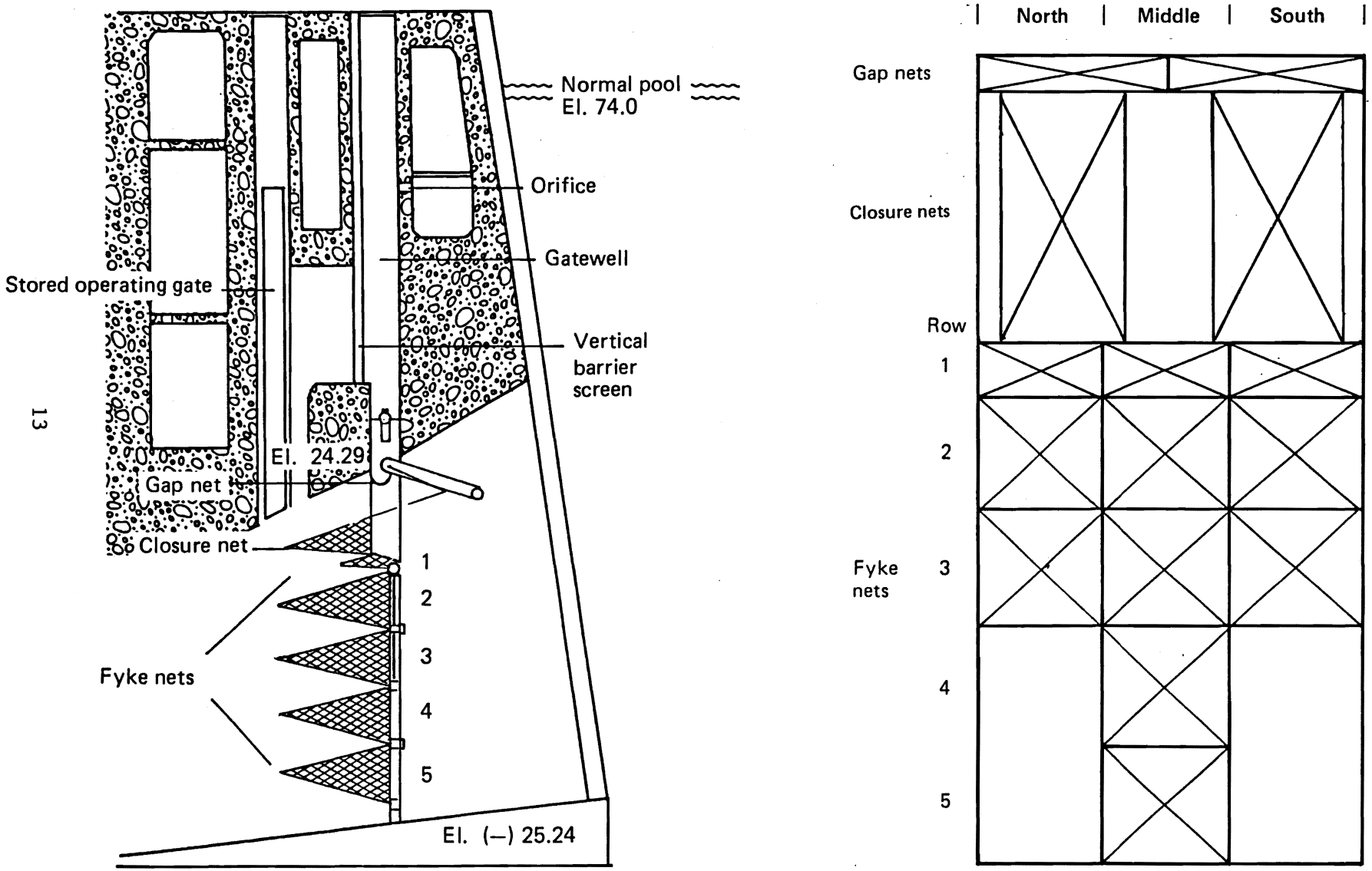


Figure 7.--Cross-section of the turbine intake with a traveling screen and various attached nets at Bonneville Dam Second Powerhouse and also a view showing the net layout - 1983.

Phase II tests were conducted from 2 to 13 June and consisted almost entirely of subyearling chinook salmon. These tests consisted of three replicates for each of the two guiding angles.

No significant differences in FGE were noted (G-test, Sokal and Rohlf, 1981)for the 60° or 47° angles tested in either test phase at the 95% CI (G = 0.834, df = 1). Therefore, data for these test conditions were pooled to obtain an overall FGE by species shown in Table 2 (individual test data are reported in Appendix Table A1).

The results of these tests indicated that FGE for the STS in the Bonneville Dam 2nd Powerhouse were disturbingly low for all species and all conditions tested. Average FGE for the various species ranged from a low of 14% for sockeye salmon to 34% for steelhead; FGE for chinook salmon was 21% for yearlings and 24% for subyearlings.

Lowering the STS 1 foot did not result in an increase in FGE as had been expected but actually may have had a negative affect. Average FGE was only 12% for subyearling chinook salmon (four replicates) and 8% for coho salmon (one replicate).

FGE of 47% were measured with subyearling chinook salmon during two particular tests that were conducted totally during daylight conditions (1800 - 2030 h). These were conducted at the beginning of Phase II testing prior to lowering the STS 1 foot into the intake. During this time, large numbers of subyearling chinook salmon were present. To keep from needlessly sacrificing fish in the fyke nets, the test period was shortened; therefore, both tests began and ended during daylight conditions. The later tests with the lowered STS, that showed a 12% FGE, were conducted when fewer numbers were present and terminated after dark. In studies conducted at McNary Dam in 1978 and 1979 (Krcma et al. 1979, 1980), it was also noted that higher FGE were recorded

Table 2.--Percent fish guiding efficiency for the submersible traveling screens in the Bonneville Second Powerhouse (pooled data from tests of the 60 and 47° guiding angles).

	Chinook				
	Yearling	Subyearling	Steelhead	Coho	Sockeye
No. replicates	14	6	11	5	14
Gatewell catch (guided fish)	1,080	704	524	508	538
Net catch (unguided fish)	4,503	2,194	984	1,546	3,294
FGE (%)[a]	19.3±7.0	24.3±16.1[b]	34.7±7.3	24.7±10.8[b]	14.0±4.0
Potential for guiding[c]	47.9	42.2	63.6	47.8	48.4

a/ ± 0.90 confidence interval.

b/ Includes pooled data for STS lowered 1 foot and daytime and nighttime tests.

c/ Based on vertical distribution data.

for tests conducted during daylight hours, indicating a possible correlation between light and depth of travel for migrating salmonids entering the turbine intakes. However, since the STS position was not constant during Phase II testing at Bonneville Dam, there was no way to determine the degree that day or night and/or a lowered STS influenced FGE. Because all results were unacceptably low, it did not seem appropriate to conduct more testing in an attempt to identify these differences.

In summary, FGE for the STS were disturbingly low for all species and conditions tested. In fact, except for chinook salmon, the percentage of fish that entered a gatewell with or without an STS was about the same (Tables 1 and 2). This would indicate that the STS provided moderate protection only for chinook salmon fingerlings and very little, if any, for other species. Deeper than normal vertical distribution accounted for part of the low FGE, but it was certainly not the only reason. In general, measured FGE were 50% or less than the potential for guidance based on vertical distribution. Some of the possible reasons for deeper vertical distribution and poor FGE include:

1. Relatively shallow shelf in the river channel immediately upstream from the powerhouse.

2. Design of the turbine intakes.

3. Restricted flow into the gatewells.

Model studies are scheduled prior to the 1984 smolt outmigration to test various approaches that would offer the best potential for improving FGE of the STS in the Bonneville 2nd Powerhouse. Results from these studies will form the basis for prototype testing of potential solutions.

Orifice Passage Efficiency Tests

Tests conducted in FY83 were designed to determine what the orifice passage efficiency (OPE) was at the Bonneville 2nd Powerhouse. In the event of unacceptable OPE, several test options were planned, but due to initial problems in operation of the orifice trap and FGE tests taking precedence in Unit 12, these alternatives were not tested.

Methods and Procedures

A trap attached to an orifice in Unit 12B was used for the limited testing in 1983. Target species were yearling and subyearling chinook salmon, with data gathered on other species as available. All tests conducted were for 24 h using the north orifice in Gatewell 12B. OPE was determined by a direct comparison of the number of fish that were collected in the orifice trap with the number of fish that remained in the gatewell at the end of 24 h. A typical OPE test started by dip netting the gate slot to remove all fish, opening the orifice and checking the trap periodically during the 24-h period, and then closing the orifice and dipnetting the gatewell clear of any residual fish. An OPE approaching 75% in a 24-h period has been considered acceptable.

Results

A series of four tests was conducted between 26 April and 3 May. OPE was 54.2% for yearling chinook salmon and 66.5% for steelhead (Table 3). OPE testing with yearling chinook salmon had to be discontinued due to problems with the orifice trap. The trap was modified in time to conduct a series of OPE tests on subyearling chinook salmon from 21 to 30 June; OPE was an acceptable 85.8%. Additional OPE testing is being delayed until more acceptable FGE are achieved.

Table 3.--Results of OPE test conducted on the 12B fingerling bypass orifice at Bonneville Dam 2nd Powerhouse in 1983.

	Subyearling chinook	Yearling chinook	Steel-head	Coho	Sockeye
Number replicates	6	4	4	2	2
24-h trap catch	2697	1959	739	258	1211
Residual (gatewell catch)	445	1653	373	144	847
TOTAL	3142	3612	1112	402	2058
OPE %	85	54	66	64	59

FISH QUALITY AND STRESS THROUGH THE COLLECTION AND BYPASS SYSTEM

Quality of fish was determined from measures of descaling, stress, injury, and mortality. Stress was measured by seawater challenge and blood chemistry tests. Measurements were taken on fish passing through the bypass system of the 2nd Powerhouse and fish sampled from the following test comparisons: (1) screened vs unscreened turbines of 2nd Powerhouse, (2) 47° vs 60° STS guiding angle, and (3) screened units 1st vs 2nd Powerhouse. Trap turbulence prevented any measures of fish quality for the OPE tests.

A special delayed mortality test program was devised about mid May due to concerns by the fishery agencies regarding the quality of fish being collected at the 2nd Powerhouse. The primary reason for this test was to gather evidence for making an urgent decision as to whether or not the STS at the 2nd Powerhouse were doing more harm than good.

Fish Quality

Methods and Procedures

To monitor the quality of fish passing through the bypass system, fish collected by the smolt sampler were examined. Twice a day (more often when necessary) fish were crowded to the downstream end of the raceways and hand dipnetted into the anesthetic (MS 222) trough. The anesthetized fish were enumerated and examined for marks, descaling, and injury. When large numbers of fish were captured, subsamples of 200 fish per species or race were examined and the remainder enumerated and released. During most weeks, the smolt sampler system was operated Monday through Friday, 24 h a day. Marked fish released at various points from the gatewell to the raceway provided additional data on effects of the bypass system on fish condition.

Fish quality determinations for the various test scenarios were determined from measures of descaling on fish collected in gatewells during vertical distribution, FGE, and screen cycling tests.

Groups of fish used for the special delayed mortality tests were dipnetted from screened and unscreened gatewells at both powerhouses and held for 24 and 48 h. Testing was conducted between 25 and 28 May, after the major migration of yearling fish. Measurements of stress by seawater challenge tests were also considered for these groups of fish, but because of poor FGE (that resulted in low numbers of fish), we were unable to conduct seawater challenge measurements.

Results

The smolt sampler was operated for 1,375.5 h in 1983 for an average of 98.3 h per week. During this time a total of 84,581 juvenile salmonids were captured, of which 40,763 were examined for descaling and injury (Table 4). The amount of descaling varied between species. Sockeye salmon had the highest descaling rate (16.9%), and subyearling chinook salmon had the lowest (1.0%). Coho salmon descaling was also low (2.3%). Yearling chinook salmon and steelhead had descaling rates of 8.3 and 7.2%, respectively. The overall descaling rate fluctuated weekly, but in general declined as the season progressed. The descaling rate for subyearling chinook salmon was low throughout the study.

The overall mortality rate for the year in the observation room was 3.1% (Table 4). Sockeye salmon had the highest mortality rate (18.7%) and coho salmon the lowest (0.6%). The mortality rate for sockeye was nearly six times higher than any of the other species. Mortality rates varied from day to day. This was partly caused by stranding in the wet separator during periods of low

Table 4.--Weekly and cumulative totals of fish captured by the smolt sampler in the Second Powerhouse at Bonneville Dam in 1983.

	Weekly Totals								Cumulative Totals						
	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Date	Hours Fished	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Hours fished
No. captured	2,956	13,709	361	204	75	17,305	April	139.5	2,956	13,709	361	204	75	17,305	139.5
No. examined	1,244	1,573	178	86	27	3,108	25		1,244	1,573	178	86	27	3,108	
No. descaled	68	20	5	3	6	102	April		68	20	5	3	6	102	
No. mortalities	96	79	9	2	3	189	30		96	79	9	2	3	189	
% descaled	5.5	1.3	2.8	3.5	22.2	3.3			5.5	1.3	2.8	3.5	22.2	3.3	
% mortality	3.2	0.6	2.5	1.0	4.0	1.1			3.2	0.6	2.5	1.0	4.0	1.1	
No. captured	5,851	3,925	796	511	2,261	13,344	May	120.0	8,807	17,634	1,157	715	2,336	30,649	259.5
No. examined	1,907	1,894	498	479	1,000	5,778	1		3,151	3,467	676	565	1,027	8,886	
No. descaled	151	4	24	8	161	348	May		219	24	29	11	167	450	
No. mortalities	204	27	9	9	577	826	5		300	106	18	11	580	1,015	
% descaled	7.9	0.2	4.8	1.7	16.1	6.0			7.0	0.7	4.3	1.9	16.3	5.1	
% mortality	3.5	0.7	1.1	1.8	25.5	6.2			3.4	0.6	1.6	1.5	24.8	3.3	
No captured	5,615	1,599	1,767	780	2,713	12,474	May	135.0	14,422	19,233	2,924	1,495	5,049	43,123	394.5
No. examined	1,957	1,323	1,199	759	1,542	6,780	8		5,108	4,790	1,875	1,324	2,569	15,666	
No. descaled	208	8	68	18	192	494	May		427	32	97	29	359	944	
No. mortalities	197	22	6	4	467	696	13		497	128	24	15	1,047	1,711	
% descaled	10.6	0.6	5.7	2.4	12.5	7.3			8.4	0.7	5.2	2.2	14.0	6.0	
% mortality	3.5	1.4	0.3	0.5	17.2	5.6			3.4	0.7	0.8	1.0	20.7	4.0	
No. captured	2,523	5,306	1,097	4,225	797	13,948	May	87.0	16,945	24,539	4,021	5,720	5,846	57,071	481.5
No. examined	1,035	1,131	683	1,512	680	5,041	16		6,143	5,921	2,558	2,836	3,249	20,707	
No. descaled	99	12	55	18	102	286	May		526	44	152	47	461	1,230	
No. mortalities	91	26	56	4	77	254	20		588	154	80	19	1,124	1,965	
% descaled	9.6	1.1	8.1	1.2	15.0	5.7			8.6	0.7	5.9	1.7	14.2	5.9	
% mortality	3.6	0.5	5.1	0.1	9.7	1.8			3.5	0.6	2.0	0.3	19.2	3.4	
No. captured	1,656	992	558	2,550	743	6,499	May	99.0	18,601	25,531	4,579	8,270	6,589	63,570	580.5
No. examined	1,000	835	472	1,282	500	4,089	23		7,143	6,756	3,030	4,118	3,749	24,796	
No. descaled	102	7	47	50	113	319	May		628	51	199	97	574	1,549	
No. mortalities	58	6	11	8	143	226	27		646	160	91	27	1,267	2,191	
% descaled	10.2	0.8	10.0	3.9	22.6	7.8			8.8	0.8	6.6	2.4	15.3	6.2	
% mortality	3.5	0.6	2.0	0.3	19.2	3.5			3.5	0.6	2.0	0.3	19.2	3.4	

Table 4.--Continued

	Weekly Totals								Cumulative Totals						
	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Date	Hours Fished	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Hours fished
No. captured	457	4,253	561	558	380	6,209	May	74.0	19,058	29,784	5,140	8,828	6,969	69,779	654.5
No. examined	450	2,567	560	558	308	4,443	31		7,593	9,323	3,590	4,676	4,057	29,239	
No. descaled	31	18	49	20	110	228	June		659	69	248	117	684	1,777	
No. mortalities	5	92	1	0	48	146	3		651	252	92	27	1,315	2,337	
% descaled	6.9	0.7	8.8	3.6	35.7	5.1			8.7	0.7	6.9	2.5	16.9	6.1	
% mortality	1.1	2.2	0.2	0.0	12.6	2.4			3.4	0.8	1.8	0.3	18.9	3.3	
No. captured	454	4,358	174	322	50	5,358	June	70.0	19,512	34,142	5,314	9,150	7,019	75,137	724.5
No. examined	386	2,226	142	254	38	3,046	6		7,979	11,549	3,732	4,930	4,095	32,285	
No. descaled	26	20	15	5	10	76	June		685	89	263	122	694	1,853	
No. mortalities	8	46	3	1	2	60	8		659	298	95	28	1,317	2,397	
% descaled	6.7	0.9	10.6	2.0	26.3	2.5			8.6	0.8	7.0	2.5	16.9	5.7	
% mortality	1.8	1.1	1.7	0.3	4.0	1.1			3.4	0.9	1.8	0.3	18.8	3.2	
No. captured	149	2,155	60	1,220	17	3,601	June	97.0	19,661	36,297	5,374	10,370	7,036	78,738	821.5
No. examined	136	1,425	59	1196	15	2831	13		8,115	12,974	3,791	6,126	4,110	35,116	
No. descaled	9	25	9	19	2	64	June		694	114	272	141	696	1,917	
No. mortalities	5	49	1	10	0	65	17		664	347	96	38	1,317	2,462	
% descaled	6.6	1.8	15.3	1.6	13.3	2.3			8.6	0.9	7.2	2.3	16.9	5.5	
% mortality	3.4	2.3	1.7	0.8	0.0	1.8			3.4	1.0	1.8	0.4	18.7	3.1	
No. captured	77	1,947	25	398	1	2,448	June	98.0	19,738	38,244	5,399	10,768	7,037	81,186	919.5
No. examined	68	1,931	19	320	1	2,389	20		8,183	14,905	3,810	6,496	4,111	37,505	
No. descaled	1	31	2	8	0	42	June		695	145	274	149	696	1,959	
No. mortalities	9	16	6	28	0	59	24		673	363	102	66	1,317	2,521	
% descaled	1.5	1.6	10.5	2.2	0.0	1.8			8.5	1.0	7.2	2.3	16.9	5.2	
% mortality	11.7	0.8	24.0	7.0	0.0	2.4			3.4	0.9	1.9	0.6	18.7	3.1	
No. captured	231	1,824	5	112	---	2,172	June	96.0	19,969	40,068	5,404	10,880	7,037	83,358	1,015.5
No. examined	221	1,710	5	112	---	2,048	27		8,404	16,615	3,815	6,608	4,111	39,553	
No. descaled	3	18	0	0	---	21	July		698	163	274	149	696	1,980	
No. mortalities	10	114	0	0	---	124	1		683	477	102	66	1,317	2,645	
% descaled	1.4	1.1	0.0	0.0	---	1.0			8.3	1.0	7.2	2.3	16.9	5.0	
% mortality	4.3	6.3	0.0	0.0	---	5.7			3.4	1.2	1.9	0.6	18.7	3.2	

Table 4.--Continued

	Weekly Totals								Cumulative Totals						
	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Date	Hours Fished	Yearling chinook	Subyearling chinook	Sthd.	Coho	Sock.	Total	Hours fished
No. captured	1	401	2	1	---	405	July	72.0	19,970	40,469	5,406	10,881	7,037	83,763	1,087.5
No. examined	1	396	2	1	---	400	6		8,405	17,011	3,817	6,609	4,111	39,953	
No. descaled	0	1	0	0	---	1	July		698	164	274	149	696	1,981	
No. mortalities	0	5	0	0	---	5	8		683	482	102	66	1,317	2,650	
% descaled	0.0	0.3	0.0	0.0	---	0.3			8.3	1.0	7.2	2.3	16.9	5.0	
% mortality	0.0	1.2	0.0	0.0	---	1.2			3.4	1.2	1.9	0.6	18.7	3.2	
No. captured	17	305	---	---	---	322	July	96.0	19,987	40,774	5,406	10,881	7,037	84,085	1,183.5
No. examined	17	303	---	---	---	320	12		8,422	17,314	3,817	6,609	4,111	40,273	
No. descaled	0	6	---	---	---	6	July		698	170	274	149	696	1,987	
No. mortalities	0	2	---	---	---	2	15		683	484	102	66	1,317	2,652	
% descaled	0.0	2.0	---	---	---	1.9			8.3	1.0	7.2	2.3	16.9	4.9	
% mortality	0.0	0.7	---	---	---	0.6			3.4	1.2	1.9	0.6	18.7	3.2	
No. captured	---	414	---	---	---	414	July	96.0	19,987	41,188	5,406	10,881	7,037	84,499	1,279.5
No. examined	---	411	---	---	---	411	18		8,422	17,725	3,817	6,609	4,111	40,684	
No. descaled	---	5	---	---	---	5	July		698	175	274	149	696	1,992	
No. mortalities	---	3	---	---	---	3	22		683	487	102	66	1,317	2,655	
% descaled	---	1.2	---	---	---	1.2			8.3	1.0	7.2	2.3	16.9	4.9	
% mortality	---	0.7	---	---	---	0.7			3.4	1.2	1.9	0.6	18.7	3.1	
No. captured	---	82	---	---	---	82	July	96.0	19,987	41,270	5,406	10,881	7,037	84,581	1,375.5
No. examined	---	79	---	---	---	79	25		8,422	17,804	3,817	6,609	4,111	40,763	
No. descaled	---	3	---	---	---	3	July		698	178	274	149	696	1,995	
No. mortalities	---	3	---	---	---	3	28		683	490	102	66	1,317	2,658	
% descaled	---	3.8	---	---	---	3.8			8.3	1.0	7.2	2.3	16.9	4.9	
% mortality	---	3.7	---	---	---	3.7			3.4	1.2	1.9	0.6	18.7	3.1	

water due to a malfunction of the automatic water level control equipment in the downstream migrant bypass system. Stranding especially affected the large fish (steelhead and yearling chinook salmon) since they were too large to fit through the grading bars in the first compartment of the wet separator. Throughout the study, stranding occurred at least once a week, even though water levels were adjusted manually (because the automatic controls were not functioning) in an attempt to control the problem. Another cause of occasional mortality was a temporary end trap installed on the wet separator overflow to catch fish carried over during times when too much water was in the system. The trap periodically clogged with debris trapping fish behind it.

On 8 June, the downstream migrant bypass system was drained to allow the installation of a new orifice trap by NMFS. When the emergency relief gate (ERG) was opened, the water supply to the wet and dry separators was completely stopped, stranding fish in the wet separator and in the pipe between the two separators. After the ERG was closed and the water level brought up to normal levels (about 6 h later), 362 dead salmonids came out of the upwell in the wet separator. Apparently these fish had suffocated in the pipeline between the wet and dry separators. These mortalities were not included in Table 4.

Mortality and descaling rates for the marked chinook salmon released to evaluate the smolt sampler were low. The descaling rate for subyearling chinook salmon is normally low whereas the low descaling rate for the hatchery yearling chinook salmon used for testing may have been influenced by their physiological condition. The fish had a non-smolting appearance which made it difficult to accurately ascertain descaling. The low descaling and mortality rates for all test groups, though, indicated that there were no major problems in the bypass system (from the gatewell to the raceway) that could cause mechanical injury.

Tests at the 47° and 60° guiding angles resulted in a significantly higher descaling rate for sockeye salmon at the 60° angle ($G = 9.294$, $df = 1$, $P<0.05$). It is difficult to explain why a shallower guiding angle would cause higher descaling on sockeye salmon when results of stress tests (see Stress Test section) at this same guiding angle showed lower stress levels on yearling chinook salmon (no stress studies were conducted on sockeye salmon).

The results of the special delayed mortality tests in late May generally showed no significant adverse affects from the STS comparing delayed mortality and descaling for the 1st and 2nd Powerhouses on yearling chinook salmon, coho salmon, and steelhead. There was, however, a highly significant increase in descaling on sockeye salmon in units with STS (43 vs 14%, $G = 41.803$ for the 1st Powerhouse and 53 vs 20%, $G = 62.206$ for the 2nd Powerhouse) (Table 5). Unfortunately, there were insufficient numbers of subyearling chinook and sockeye salmon available for meaningful comparisons of delayed mortality.

There was a significant increase in descaling for subyearling chinook salmon for the 2nd Powerhouse vs 1st Powerhouse, but it did not appear to have reached a critical level (6.9 vs 3.6%). Based on this information the agencies decided to continue operating STS at the 2nd Powerhouse but concentrate power operation at the 1st Powerhouse and reduce power operation at the 2nd as much as possible.

In summary, only sockeye salmon appeared to be adversely affected by passage at Bonneville Dam. Descaling and delayed mortality on other species was low whether STS were operating or not. In contrast, descaling on sockeye salmon was at least double and up to three times that of other species. They were also the only species that showed an increased descaling rate for gatewells associated with an STS. Their delayed mortality in the 1st Powerhouse was 20% , over 10 times that of other species (Table 5). Although delayed mortality of sockeye salmon in the 2nd Powerhouse could not be

Table 5.--Average descaling and delayed mortality rates from gatewell captured fish at the First and Second Powerhouse at Bonneville Dam during the special delayed mortality tests conducted between 25 May and 28 May 1983.

Test condition	Chinook Subyearling % descaled	Chinook Subyearling Delayed mort.	Chinook Yearling % descaled	Chinook Yearling Delayed mort.	Steelhead % descaled	Steelhead Delayed mort.	Coho % descaled	Coho Delayed mort.	Sockeye % descaled	Sockeye Delayed mort.
1st Pwhse[a/] w/STS	3.6	1.3	13.7	1.9	6.3	0.7	6.8	0.9	42.6	20.3
1st Pwhse w/o STS	2.7	0.7	8.0	0.5	9.7	2.2	3.0	b/	14.4	b/
G-Values	0.550	0.338	6.806[c/]	1.788	4.555[c/]	2.453	5.497[c/]	---	41.803[c/]	---
2nd Pwhse[d/] w/STS	6.9	b/	14.9	1.5	4.6	2.5	7.9	0.3	52.8	b/
2nd Pwhse w/o STS	b/	b/	12.3	1.1	8.0	0.7	5.9	0.6	19.8	b/
G-Values	---	---	1.334	0.171	7.006[c/]	4.283[c/]	1.279	0.147	62.206[c/]	---
1st Pwhse w/STS	3.6	1.3	13.7	1.9	6.3	0.7	6.8	0.9	24.6	20.3
2nd Pwhse w/STS	6.9	b/	14.9	1.5	4.6	2.5	7.9	0.3	52.8	b/
G-Values	4.960[c/]	---	0.529	0.139	2.157	3.701	0.618	0.760	12.860[c/]	---
1st Pwhse w/o STS	2.7	0.7	8.0	0.5	9.7	2.2	3.0	b/	14.4	b/
2nd Pwhse w/o STS	b/	b/	12.3	1.1	8.0	0.7	5.9	0.6	19.8	b/
G-Values	---	---	2.991	0.326	0.971	2.723	2.624	---	1.520	---

a/ STS operating at 47° angle.

b/ Insufficient sample (<100 fish).

c/ Significant (df = 1,, P <0.05).

d/ STS operating at 60° angle.

measured, their mortality through the downstream migrant bypass system averaged 19% for the season, over six times the rate of other species (Table 4).

Stress Tests

Methods and Procedures

Seawater challenge was the primary method used for measuring stress. Yearling and subyearling chinook salmon sampled from various points in the bypass system and from the gatewells were transferred into artificial seawater in 10-gallon aquariums using water to water transfer techniques. The fish were held in a dark environment during testing. Water temperature was maintained at ambient river temperature by using an external water bath circulating system.

Mortality in seawater challenge tests was used as an indicator of stress. At the termination of each test, counts of live and dead fish were made along with total weight. Live and dead fish counts were used to form contingency tables utilizing the G-statistic described by Sokal and Rohlf (1981). Data were also collected on individual length, descaling, injuries, and disease symptoms. Significance was set at $P < 0.05$, df = n for comparing relative differences of the mortalities between test groups as an indicator of stress.

For yearling chinook salmon, blood chemistry was used to measure stress through the bypass system when insufficient numbers were available for seawater challenge tests. Data for blood chemistry work were collected and analyzed by Oregon State University Cooperative Fishery Unit personnel and provided to NMFS for this report. Analysis of variance was used to compare results obtained for the different test groups. Significance was set at $P < 0.05$, df = n between test groups.

Results

Seawater challenge tests were conducted between 9 and 28 May on yearling and 7 to 15 June on subyearling chinook salmon. As noted earlier, poor FGE and subsequently small numbers of fish at the 2nd Powerhouse made it difficult to obtain adequate sample sizes for seawater challenge tests, especially on yearling chinook salmon (Appendix A2-A5). The only test where there were adequate replication and sample size with yearling chinook salmon were tests comparing the two guiding angles of the STS at the 2nd Powerhouse. The results of these tests showed that the 47° angle caused significantly higher stress in yearling chinook salmon than the 60° angle ($P < 0.01$, $n=1$). As indicated previously there is no explanation why this apparently contradicts the findings with sockeye using descaling as an indicator of fish quality.

Differences in stress levels were observed on yearling and subyearling chinook salmon as they passed through the collection and bypass system. However, as previously noted, adequate seawater challenge data were only available on subyearling chinook salmon. Figure 8 shows the relative differences in stress for yearling chinook salmon as determined from blood chemistry analysis data. The data indicated there was a significant increase in stress on yearling chinook salmon taken from a gatewell associated with an STS over those sampled from a non STS gatewell. An additional increase in stress occurred as they passed through the collection system, as indicated by a higher stress level reading for the fish sampled from the raceway. Figure 9 shows that subyearling chinook salmon (as measured by seawater challenge) had a similar increase in stress between an STS gatewell and a non STS gatewell. However, a decrease in stress occurred after the fish had passed through the collection system and entered the raceway. Even though different techniques are employed in blood chemistry and seawater challenge testing, the

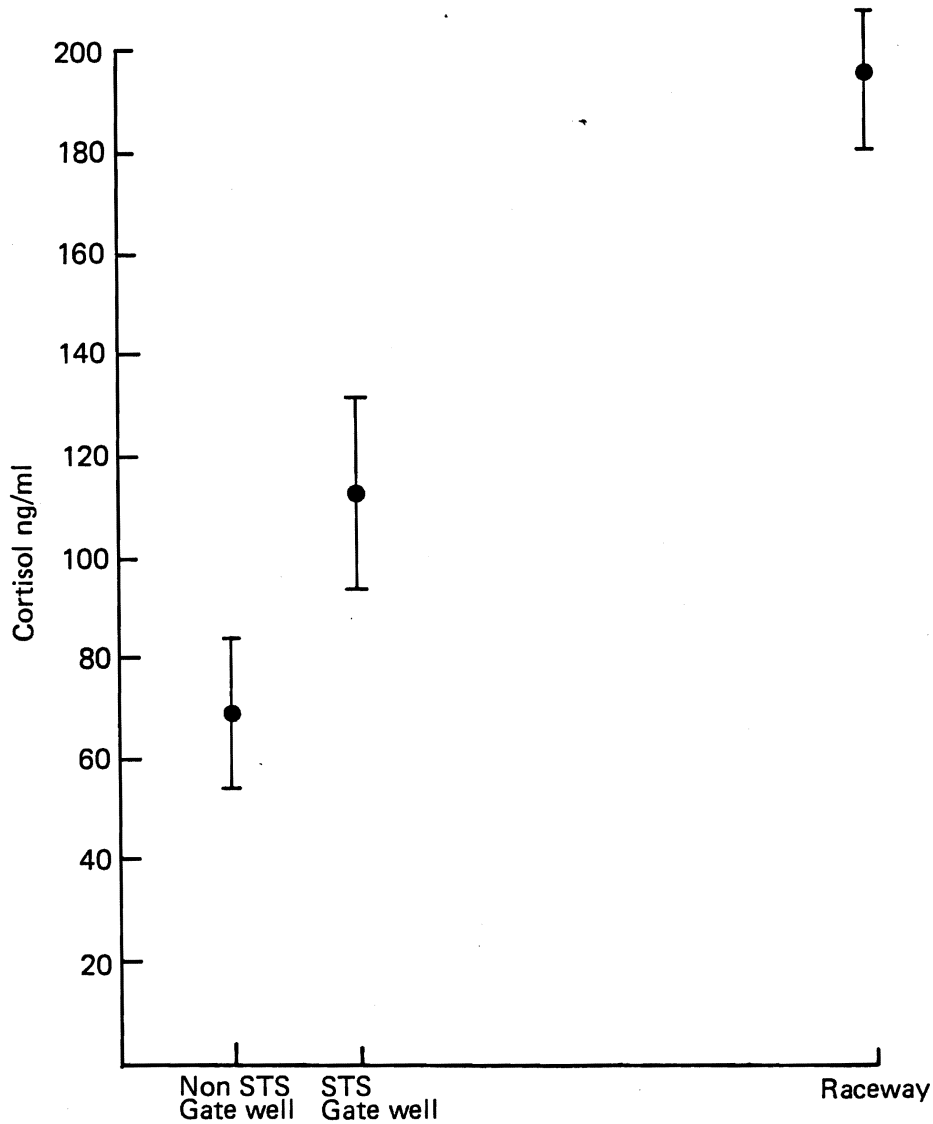


Figure 8.--Blood cortisol tests for relative stress of yearling chinook salmon sampled at various points within the juvenile bypass system of the Second Powerhouse of Bonneville Dam.

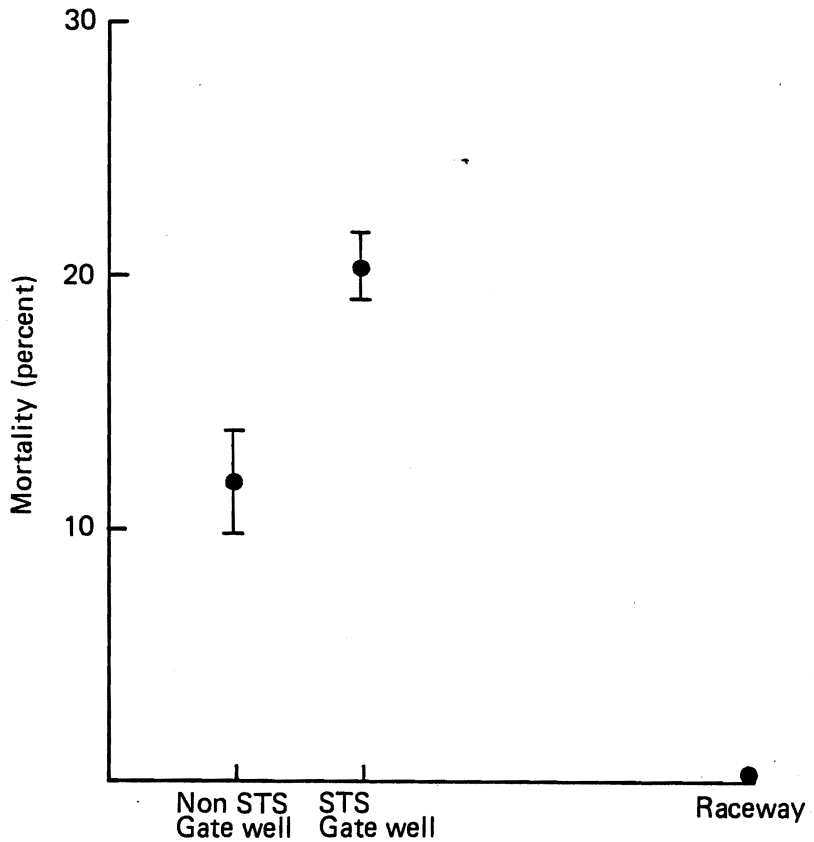


Figure 9.--Seawater challenge tests for relative stress of subyearling chinook salmon sampled at various points within the juvenile bypass system in the Second Powerhouse of Bonneville Dam.

results generally have proven comparable.[1/] Therefore, data would seem to indicate that passage through the bypass system was less stressful on subyearling chinook salmon than on yearling chinook salmon.

THE SMOLT COLLECTION SYSTEM AND ITS POTENTIAL FOR INDEXING SMOLT MIGRATIONS

The collection system in the 2nd Powerhouse provides the means to examine the condition of fish passing through the fingerling bypass and to index smolt migrations passing Bonneville Dam. It consists of a smolt sampler that is designed to randomly collect 10% of the juvenile migrants passing through the downstream migrant bypass system, a dry separator for removing adult fish and debris, a wet separator in the migrant observation room for separating juvenile migrants by size, and four raceways to hold fish graded by the wet separator (Figure 10). Objectives of this phase of the study were to: (1) detemine the accuracy of the smolt sampler, (2) determine if fish are being unduly delayed in passing through the fingerling bypass, (3) evaluate the wet separator for separating subyearling chinook salmon from yearling salmonids, and (4) initiate studies to determine the potential use of Bonneville Dam as an indexing site for smolt migration.

Determining the Accuracy of the Smolt Sampler and Measures of Delay in Passing Through the System

The smolt sampler consists of a chute that is 10% of the width of the inclined screen channels. It collects fish randomly by continuously traversing back and forth accross the width of the channel (Figure 10).

1/ Personal communication: Gene M. Matthews, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98112.

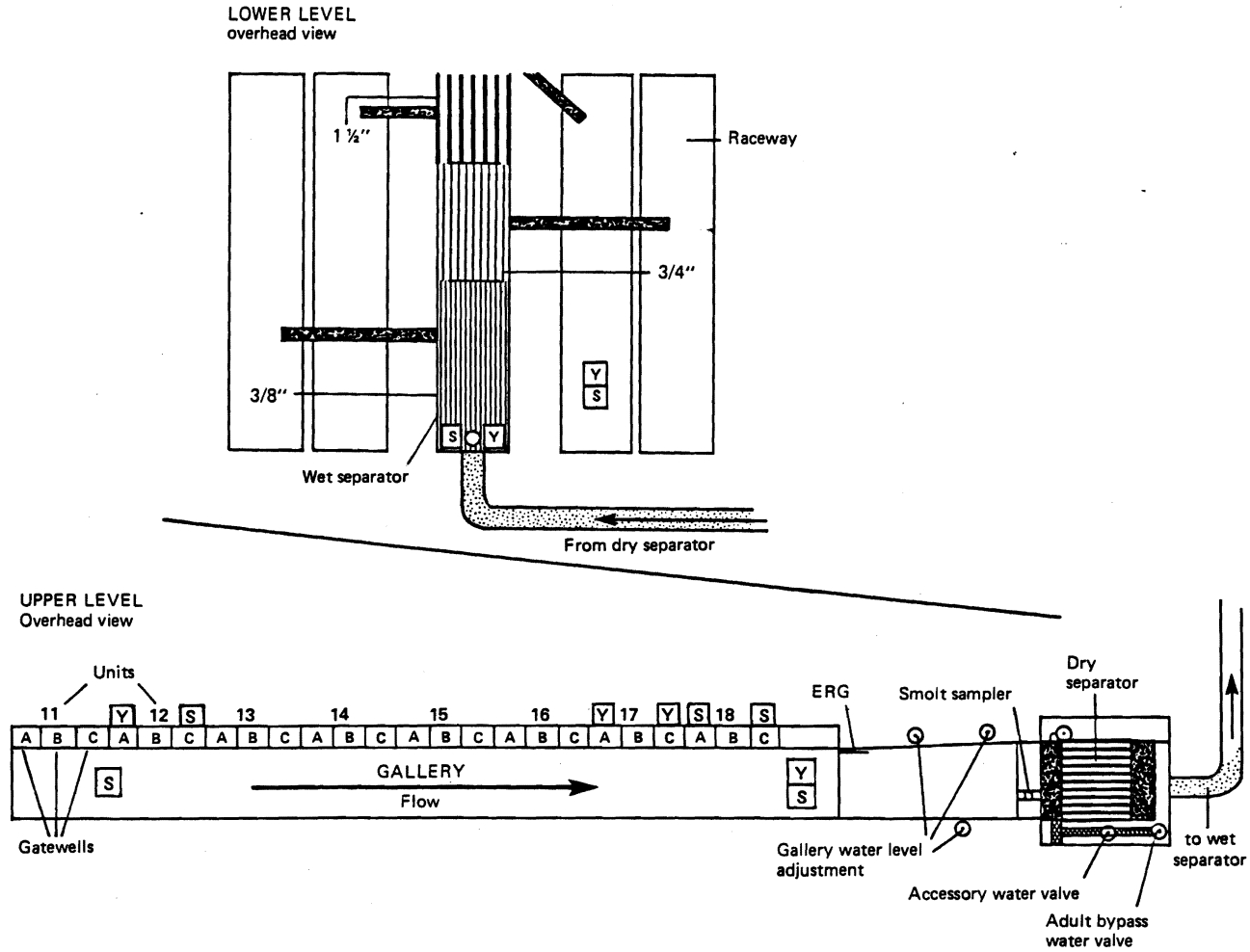


Figure 10.--The smolt sampling system and the observation room in the Second Powerhouse at Bonneville Dam. Symbols [Y] and [S] indicate locations where yearling and subyearling marked fish releases were made.

Methods and Procedures

To determine the accuracy of the smolt sampler and measures of delay in the system, releases of freeze branded yearling chinook salmon [from Carson National Fish Hatchery (NFH)] and subyearling chinook salmon (from Spring Creek NFH) were made upstream from the smolt sampler. Test groups of yearling chinook salmon were released into Gatewells 12A, 17A, and 17C and the lower gallery. Test groups of subyearling chinook salmon were released into Gatewells 12 C, 18A, and 18C and the upper and lower gallery. In addition, test groups of yearling and subyearling chinook salmon were released directly into the dry separator, the upwell of the wet separator, and into a raceway in the observation room. Each test group consisted of three replicates of approximately equal size. All releases were made during the late afternoon (1700-1900 h).

The raceways in the observation room were checked 2 h after each release and every 2 h thereafter for 48 h. After 48 h, they were checked every 4 h for the duration of the test. Branded fish were examined for descaling and mortality. At the conclusion of the test, gatewells were dipped with a dipnet basket to check for any residual marked fish. Information from these tests was used to identify areas in the system causing mortality, descaling, and/or delay in passage.

The G-statistic (Sokal and Rohlf 1981) was calculated for the replicates in each test group. Test groups with no significant differences between replicates were then combined to determine the efficiency of the smolt sampler for both races of marked fish. Test groups with significant differences between replicates at the 90% confidence level were not used. Confidence intervals for the recapture rates at the 95% level were developed using the formula by Fleiss (1981)

$$p \pm \left[Z_{\frac{\alpha}{2}} \sqrt{\frac{pq}{n} + \frac{1}{2n}} \right]$$

Results

The recapture rates for most releases of marked fish (Tables 6 and 7) indicated that the smolt sampler was working as designed. The overall recapture rate for yearling chinook salmon released in gatewells was 10.6% (95% C.L. = 9.9 to 11.3%). The overall rate for subyearling chinook salmon was 11.3% (95% C.L. = 10.9 to 11.7%). The explanation for the significantly higher (13.8%) recapture rate for lower gallery releases of yearling chinook salmon (G statistic 30.22, df=2, $P<0.001$) is their proximity to the smolt sampler. Because the release point was relatively close to the smolt sampler the fish probably did not distribute randomly (horizontally) across the gallery. The recapture rate for each replicate was dependent on the location of the smolt sampler when the marked fish were released. During the subyearling chinook salmon releases, an effort was made to keep the smolt sampler in the center of the gallery at the time of release. This eliminated the large differences between replicates for the lower gallery releases.

To isolate any areas where fish were being delayed in the system, the cumulative percentage of the total recapture for each test group was plotted against time. Yearling chinook salmon released in Gatewell 12A were delayed the longest (Figure 11). After 48 h, less than 30% of the total recapture had been collected. Fish were caught up to 15 days after their release. Since the gatewell had been dipped 5 days after release, they were probably holding up somewhere in the upper gallery where water velocities were very low.

Subyearling chinook salmon moved through the system much faster than yearling chinook salmon (Figure 12). Over 80% of those released in Gatewell 12C were recaptured after 24 h as contrasted to less than 30% of the yearling chinook salmon after 48 h. Like yearling chinook salmon the area of longest delay was in the upper gallery (Gatewell 12C and upper gallery releases).

Table 6.--Results from the release of marked yearling chinook salmon in the the downstream migrant bypass system at Bonneville Dam Second Powerhouse, 1983. Each release group consisted of three replicates unless otherwise indicated.

Release location	Gatewell 17A	Gatewell 17C	Gatewell 12A	Lower gallery
Number released	2892	1880[a]	2224	2753
Number recaptured	326	231	188	381
Percent recapture	11.3	12.3	8.5	13.8
G-statistic (for replicates)	0.40	4.45	9.07	30.22[b]

a/ Two replicates

b/ = $p<0.001$

Table 7.--Results from the release of marked subyearling chinook salmon in the downstream migrant bypass system at Bonneville Dam Second Powerhouse, 1983. Each release group consisted of three replicates unless otherwise indicated.

Release location	Gatewell 18A	Gatewell 18C	Gatewell 12C	Upper gallery	Lower gallery
Number released	2967	2984	2620	2032[a]	3000
Number recaptured	311	344	315	223	389
Percent recapture	10.5	11.5	12.0	11.0	13.0
G-statistic (for replicates)	0.06	1.60	2.74	3.28	6.97

a/ Two replicates.

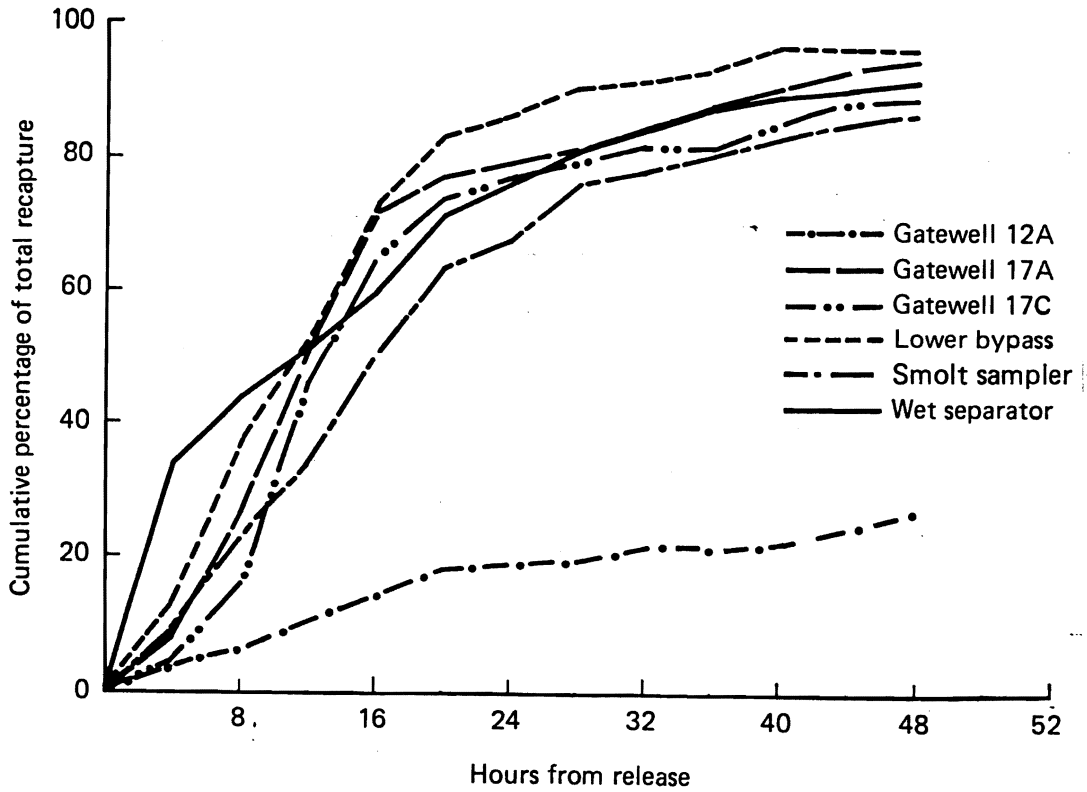


Figure 11.--Cumulative percentage of the total recapture (to 48 hours) of marked yearling chinook salmon in the downstream migrant bypass system at Bonneville Dam Second Powerhouse.

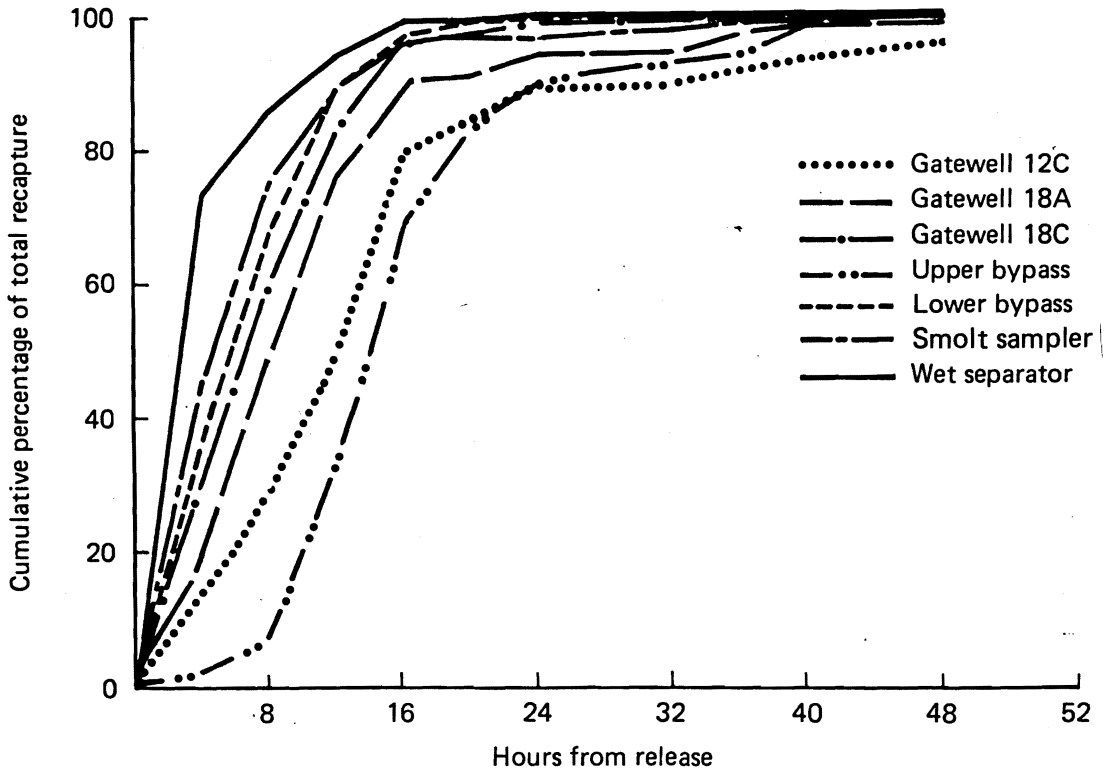


Figure 12.--Cumulative percentage of the total recapture (to 48 hours) of marked subyearling chinook salmon in the downstream migrant bypass system at Bonneville Dam Second Powerhouse.

The faster movement through the bypass may help explain why subyearling chinook salmon showed a lower stress problem passing through the downstream migrant bypass system than the yearling chinook salmon as reported earlier. The added delay to yearling fish may well be causing additional stress on these fish.

One area of delay that was not identified in the mark release tests was in the dry separator. During the 1982 DSM evaluation (McConnell and Muir 1982), the dry separator water level was kept very low. These low water levels caused a holdup of fish in the pipe connecting the two separators and periodic flooding because of water level control problems in the galley. In 1983, an effort was made to keep the dry separator completely filled by adding water from the accessory water valve. This should have helped reduce or eliminate the fluctuation of the water level in the wet separator down in the observation room. The additional head would also create a higher velocity in the pipe connecting the two separators to hopefully reduce fish holdup in this area. By operating the dry separator in this manner, however, an area holdup developed in the dry separator due to the increased water depth in the hopper. The first time the system was drained (20 May 1983), 8,203 salmonids, which represented over 50% of the week's total catch, came out of the dry separator. Subsequent dewatering also produced large numbers of fish. Even with the accessory water valve in the dry separator wide open and the adult bypass water turned down to near zero (to add additional water), the dry separator still drained at least once a week. Without this periodic draining, the accumulation of fish in the dry separator would have have been greater. During the mark release tests, the dry separator drained numerous times masking any holdup in this area.

Evaluation of the Wet Separator

Methods and Procedures

The wet separator consists of three grading compartments and an overflow area. In the first compartment there is 3/8-inch spacing between the grading bars, 3/4-inch in the second compartment, and 1 and 1/2-inch in the third compartment. Each compartment empties into a separate raceway. The overflow was diverted into a fourth raceway be using a temporary end trap.

The separator was evaluated by comparing species composition, length frequencies, descaling, and mortality for the four raceways. The automatic water level control system for the DSM never functioned properly. Therefore, the water levels in both the wet and dry separators were routinely being adjusted throughout the study period in an attempt to find a water level that would allow separation without causing mortality or descaling.

Results

Overall, the wet separator performed quite well considering the problems associated with water level control. In general, the water in the wet separator was maintained above the optimum level for separation to ensure an adequate amount of water for the larger fish above the grading bars of the first compartment (small grading bars). At night or any other time the system was unattended, the water level was adjusted even higher as a precautionary move to aid in keeping large fish from being stranded above the grading bars in the first compartment.

Separation by size is shown in Table 8. Overall, steelhead and yearling chinook salmon separated the best by size. Subyearling chinook salmon separation varied from week to week depending on the water level in the wet separator. Sockeye salmon separated poorly by size.

Table 8.--Species composition with mean fork length for each raceway (grader size) in the Observation Room of the Second Powerhouse at Bonneville Dam, 25 April to 24 June 1983.

Grader size	Yearling chinook		Subyearling chinook		Steelhead		Coho		Sockeye		Total
	Percent capture	Mean fork length (mm)	Percent capture	Mean fork length (mm)	Percent capture	Mean fork length (mm)	Percent capture	Mean fork length (mm)	Percent capture	Mean fork length (mm)	Percent capture
3/8"	6.7	130	54.0	86	1.8	174	6.9	136	14.6	108	29.4
3/4"	38.0	138	23.1	87	19.1	176	33.7	144	22.1	108	27.8
1-1/2"	53.4	142	20.3	87	77.5	203	51.1	142	58.3	107	39.6
Overflow	1.9	135	2.6	86	1.6	194	8.3	138	5.0	104	3.2

Although the 3/9-inch grader worked well for separating subyearling chinook salmon from yearling fish, it also increased the mortality rate for for the larger fish during periods of extremely low water caused by the failure of the automatic water level controls in the downstream migrant bypass system to operate properly. Replacing the 3/8-inch grader bars with a larger size, such as 5/8-inch, would separate the majority of the steelhead and larger chinook and coho salmon from the smaller subyearling chinook salmon and eliminate some portion of this mortality. However, stranding will still occur if the automatic controls in the system continue to function improperly.

Determining the Potential Use of Bonneville Dam as an Index Site for the Smolt Migration

Methods and Procedures

The first step in determining the potential use of Bonneville Dam as an indexing site was to ascertain if the information collected at the 2nd Powerhouse collection system was representative of the migration passing Bonneville Dam. Gatewell catches, which were collected by dipnet, at the 1st Powerhouse were compared with the information collected in the observation room of the 2nd Powerhouse. Information was collected daily at each powerhouse and combined weekly for analysis. Species composition and mean length for each species were compared. Data were also recorded for all marked fish collected at each powerhouse, but no attempt was made to compare these data. This information was made available to interested agencies.

Results

A relative comparison of the data indicated that the 2nd Powerhouse appeared to collect a higher proportion of yearling chinook, coho, and sockeye salmon (Table 9) and a lower proportion of the subyearling chinook salmon and steelhead. This occurred fairly consistently especially for the coho and sockeye salmon.

In addition to the differences in species composition, there were also differences in length frequencies between the two powerhouses, especially for subyearling chinook salmon. Fish collected at the 1st Powerhouse were slightly longer in most weeks for all species except coho salmon (Table 10).

Three major factors may account for these differences. First, the method for collecting this information at the two powerhouses is different. The data collected at the 1st Powerhouse were from Gatewell 5B and may not have been an accurate representation of the total salmonid population passing through this powerhouse (Krcma et al. 1982). Second, Bonneville Dam is located in close proximity to several state and federal hatcheries. Large releases of salmonids from these hatcheries were easily recognized at the two powerhouses by sudden increases in catch; however, these increases were not always equal. Third, variations in spill and power generation can influence the horizontal distribution of salmonids as they approach the dam by altering the amount of flow through either of two powerhouses or over the spillway. In 1984, the 1st Powerhouse juvenile bypass system will be operating and should provide a more random sample with which to compare the 2nd Powerhouse. If large differences still exist between the two powerhouses, then the second and third factors should be examined more closely.

During the 1983 evaluation, 1,936 adipose fin clipped and upriver branded salmonids were also recaptured.

Table 9.--Chi-square comparisons of species composition between the First and Second Powerhouse (P.H.) at Bonneville Dam, 1983.

	Yearling chinook			Subyearling chinook			Steelhead			Coho			Sockeye		
	% capture			% capture			% capture			% capture			% capture		
Date	1 P.H.	2 P.H.	X^2	1 P.H.	2 P.H.	X^2	1 P.H.	2 P.H.	X^2	1 P.H.	2 P.H.	X^2	1 P.H.	2 P.H.	X^2
05-01/05-07	58.3	43.8	33*.4***	2.5	29.4	1,750.0***	23.2	6.0	1,208.1***	2.1	3.8	39.9***	13.9	17.0	27.2***
05-08/05-14	58.5	45.0	228.0***	5.3	12.8	181.6***	23.9	14.2	212.8***	3.2	6.3	55.7***	9.1	21.7	330.2***
05-16/05-21	4.9	18.1	1,529.3***	83.9	38.0	7,545.4***	2.6	7.9	498.8***	7.6	30.3	2,993.5***	1.0	5.7	620.2***
05-22/05-28	22.9	25.5	12.0***	22.3	15.3	104.4***	19.6	8.6	324.1***	24.0	39.2	341.4***	11.2	11.4	0.22
05-31/06-03	9.3	7.4	13.5***	64.1	68.5	23.6***	16.2	9.0	132.1***	8.1	9.0	2.6	2.3	6.1	97.6***
06-05/06-11	6.1	8.5	19.8***	91.9	81.3	219.8***	1.1	3.2	51.5***	0.4	6.1	220.5***	0.5	0.9	3.7
06-20/06-24	1.0	3.2	32.8***	96.8	79.5	381.2***	0.4	1.0	6.04**	1.8	16.3	339.2***	0.0	0.0	—
06-27/07-01	4.3	10.6	31.3***	94.0	84.0	55.1***	0.1	0.2	—	1.4	5.2	23.2***	0.2	0.0	--
07-06/07-08	0.4	0.3	--	99.1	99.0	--	0.0	0.5	--	0.5	0.2	--	0.0	0.0	—
07-12/07-15	0.4	5.3	53.2***	99.5	94.7	46.8***	0.0	0.0	--	0.1	0.0	--	0.0	0.0	--
07-18/07-22	0.0	0.0	--	94.6	100.0	—	0.0	0.0	--	5.0	0.0	--	0.4	0.0	—
07-25/07-28	0.3	0.0	—	99.7	100.0	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0	--
Yearly total	17.3	26.5	1,412.0***	61.8	39.9	5,537.1***	9.4	7.8	97.4***	7.2	14.9	1,665.9***	4.3	10.9	1,728.4***

** = P<0.01
*** = P<0.001

Table 10.--Mean fork length (mm) comparisons between salmonids collected at the First and Second Powerhouses at Bonneville Dam, 1983. SE = standard error, N = number of fish measured.

		Yearling chinook			Subyearling chinook			Steelhead			Coho			Sockeye		
Dates	Powerhouse	N	$\bar{X}$ length (mm)	2SE	N	$\bar{X}$ length (mm)	2SE	N	$\bar{X}$ length (mm)	2SE	N	$\bar{X}$ length (mm)	2SE	N	$\bar{X}$ length (mm)	2SE
May 1 to May 7	1	332	143.1	1.9	61	85.0	3.8	179	196.4	4.0	40	141.0	5.0	116	106.3	2.0
	2	656	140.3	1.5	516	86.9	0.9	95	186.7	7.7	64	145.7	2.6	235	109.2	1.5
May 8 to May 14	1	610	139.8	1.3	147	89.8	1.8	124	162.8	3.0	109	144.7	2.3	319	107.5	1.4
	2	1251	138.9	0.9	327	82.2	1.8*	358	196.5	3.0*	151	141.4	1.8	483	101.5	0.7*
May 15 to May 21	1	595	138.4	1.0	285	91.5	1.0	449	205.4	2.6	521	142.2	1.0	203	111.7	1.6
	2	430	137.4	1.2	117	84.9	2.9*	156	206.8	5.2	97	140.3	2.3	87	104.8	1.8*
May 22 to May 28	1	709	139.6	1.1	1292	99.5	0.8	656	199.5	2.2	655	142.3	0.8	555	113.5	0.7
	2	518	139.3	1.2	373	86.1	1.2*	160	197.1	4.5	365	147.4	1.3*	127	111.1	1.2*
May 29 to June 4	1	523	134.7	1.0	355	87.3	1.1	297	208.1	3.5	281	142.0	1.4	137	116.1	1.3
	2	182	134.3	2.0	818	80.9	0.7*	221	203.5	3.5	170	143.1	1.6	91	114.0	1.4
June 5 to June 11	1	165	122.8	1.5	393	90.1	0.9	43	213.3	9.2	18	137.8	6.9	22	114.5	2.5
	2	121	126.0	1.6*	1093	82.8	0.5*	52	209.7	9.4	66	142.5	2.9	4	113.3	4.8
June 19 to June 25	1	26	133.0	4.0	98	97.1	1.2	11	209.3	12.8	48	137.1	2.1	---	-----	---
	2	26	126.0	5.4	328	95.3	0.8	---	-----	---	129	141.3	1.7*	---	-----	---
June 26 to July 2	1	9	128.1	3.2	194	103.8	1.2	---	-----	---	10	125.0	10.0	---	-----	---
	2	33	133.4	5.6	593	102.9	0.6	---	-----	---	21	135.3	3.9	---	-----	---
July 3 to July 9	1	---	-----	---	213	102.3	1.6	---	-----	---	---	-----	---	---	-----	---
	2	---	-----	---	216	101.1	1.6	---	-----	---	---	-----	---	---	-----	---
July 10 to July 16	1	---	-----	---	322	106.0	1.3	---	-----	---	---	-----	---	---	-----	---
	2	---	-----	---	342	104.3	1.3	---	-----	---	---	-----	---	---	-----	---
July 17 to July 23	1	---	-----	---	423	110.2	1.2	---	-----	---	---	-----	---	---	-----	---
	2	---	-----	---	408	106.5	1.2*	---	-----	---	---	-----	---	---	-----	---
July 24 to July 30	1	---	-----	---	208	112.6	1.4	---	-----	---	---	-----	---	---	-----	---
	2	---	-----	---	60	106.0	3.2*	---	-----	---	---	-----	---	---	-----	---

* = $P<0.05$.

THE POTENTIAL OF SCREEN CYCLING AT THE FIRST AND SECOND POWERHOUSES

Methods and Procedures

Intermittent operation of submersible traveling screens (screen cycling) was proposed as a method to prolong the life of screen components and to reduce maintenance costs and downtime in the fish guidance system. Screen cycling was tested by NMFS during the spring and summer of 1982 at McNary and Lower Granite Dams with generally favorable results. However, significant numbers of subyearling chinook salmon were being impinged during the screen cycling studies conducted at McNary Dam (McCabe and Krcma 1983).

Impingement (determined by gap net catch) and descaling were measured under two operational configurations; an off period of 15 min or 2 h, each followed by a 2-min rotation period. The gap net, in a non-fishing mode during an off cycle, would be raised to the fishing position just prior to the 2-min rotation period. The gap net catch, therefore, represents mostly screen impinged fish especially for the 2-h off cycling tests. The duration of an individual test, which in turn would determine the number of complete on-off cycles, was based on the rate of fish passage through the system. In an effort to make test replicates comparable, tests were run until it had been determined (by dipnetting) that about 200 fish had entered the gatewell.

Results

Screen cycling tests with yearling chinook salmon were conducted in May, with research shifting to subyearling chinook salmon as they became more available in June. A total of 17 days of testing was done at the 1st Powerhouse and 6 days testing at the 2nd Powerhouse. Second Powerhouse

testing could not be carried out as planned due to the low FGE discussed previously. In the 6 days of testing in Unit 15B (2nd Powerhouse), the total catch of chinook salmon was less than 200 fish. The higher priority placed on vertical distribution and FGE tests precluded movement to Unit 12 gatewells where more fish were available.

Results of the testing in the 1st Powerhouse are summarized in Table 11. Gap net catches for species other than subyearling chinook salmon were minor. Virtually no steelhead were found in the gap net for either cycle. Gap net catches of yearling chinook salmon and sockeye salmon during the 15-min off cycle, were only 1.9 and 2.2%, respectively. However during the 2-h off cycle, it fell to 0.5 to 0.3%, respectively, indicating some degree of loss through the gap by fish passing through of their own volition (not impinged). The test series for subyearling chinook salmon took place in early June, immediately after a production release of 8.4 million 80-to 85-mm long subyearling chinook salmon from Little White Salmon NFH. As was the case at McNary Dam, impingement was intolerably high as indicated by gap net catches of 15.2% for the 15-min cycle and 9.6% for the 2-h cycle.

Descaling percentages for yearling chinook salmon and sockeye salmon, the species most susceptible to this type of injury, were not significantly different for the two cycles. Debris accumulation was very light under both cycles. Under heavy debris conditions, more material would have accumulated on the screen during the 2-h off cycle, and corresponding increases in descaling might have been observed.

Table 11.--Results of screen cycling tests with juvenile salmon and steelhead at Bonneville Dam 1st Powerhouse, May and June 1983.

Species	Percent of catch taken in gap net a/	Percent descaling b/ Mean	Range
Screen cycle: 15 min off - 2 min rotation			
Chinook salmon (yearlings)	1.9 (5)	17.1	8.0-27.0
Chinook salmon (subyearlings)	15.2 (4)	0.0	-
Sockeye salmon	2.2 (3)	23.0	17.0-29.0
Steelhead	0.0 (3)	10.0	6.0-12.0
Screen cycle: 2 h off - 2 min rotation			
Chinook salmon (yearlings)	0.5 (5)	16.2	10.0-25.0
Chinook salmon (subyearlings)	9.6 (4)	1.0	0.0-2.0
Sockeye salmon	0.3 (2)	23.0	20.0-26.0
Steelhead	0.2 (3)	4.0	2.0-6.0

a/ Mean gap net catch for replicates with 100 of more fish. Number of replicates is shown in parenthesis.

b/ Based on subsamples of 100 or more fish.

THE FEASIBILITY OF USING THE DOWNWELL RELEASE INTO THE OBSERVATION ROOM AS A RELEASE SITE FOR TRANSPORTED FINGERLINGS

The juvenile bypass system at the 2nd Powerhouse is equipped with a downwell for release of migrants after examination in the observation room. This site is also planned for use as a release point for all upriver truck transported smolts. The purpose of this portion of the study was to determine if this release site was at least as satisfactory as the previous release location for trucked juveniles below the 1st Powerhouse.

Methods and Procedures

Four groups of approximately 50,000 subyearling chinook salmon were marked by freeze branding with liquid nitrogen. These groups provide two replicates to each of the release locations (control - below the 1st Powerhouse and test - downwell in DSM of 2nd Powerhouse). The fish were marked at Spring Creek NFH during the week of 20 April and held in separate raceways until their release. Fish were loaded, transported to the release sites via truck, and released on a same-day basis. All releases were made at 2100 h. Samples were taken from each release and held 48 h to determine delayed mortality and brand retention. Numbers released for each group have been adjusted based on this information. Recapture data were collected from beach seine operations at Jones Beach, approximately 155 river kilometers downstream from the release site.

Results

Table 12 lists the release and recapture data for evaluation of the downwell release site. There was no significant difference in the survival rates for the two release locations. Calculating the power of the test for these data using the methods of Guenther (1977) yields an approximate power of 0.92 for the first replicate and 0.89 for the second. These data, therefore, have a 0.90 probability of detecting the specified survival difference if it occurred.

GENERAL SUMMARY

1. Vertical distribution tests in the intakes of the 2nd Powerhouse showed that less than 50% of the chinook salmon were located in the water mass intercepted by an STS (75 - 85% is required for an acceptable FGE).

2. Guiding efficiency of the STS was disturbingly low for all species and all conditions tested. FGE ranged from a low of 14% for sockeye salmon to 34% for steelhead and 21 and 24% for yearling and subyearling chinook salmon, respectively. Even more disturbing, (except for chinook salmon) the percentage of fish that entered a gatewell with or without an STS was about the same. This would indicate that the STS was providing some protection for chinook salmon but very little if any for the other species.

3. Only limited OPE testing was done due to initial problems with the orifice trap and also because FGE testing in Unit 12 took precedence. The limited information indicated acceptable (86%) OPE for subyearling chinook salmon and unacceptable (54 and 67%) OPE for yearling chinook salmon and steelhead, respectively,

Table 12.--Downwell evaluation Bonneville Dam Second Powerhouse, 1983.

Release site	Date	Brand and position	Number transported	% delayed mortality	% brand loss	Adjusted number released	Number recap.	Percent recap.
Traditional release site (Control #1)	05-02-83	RDU(1st)	53,158	0.0	0.0	53,158	100	0.0018
2nd Powerhouse downwell *(Test #1)	05-02-83	RDU(3rd)	51,392	0.0	0.0	51,392	89	0.0017
Traditional release site (Control #2)	05-03-83	LDU(1st)	52,775	0.0	4.8	50,242	107	0.0021
2nd Powerhouse **downwell (Test #2)	05-03-83	LDU(3rd)	53,909	1.07	4.2	51,068	107	0.0021

* Water depth in downwell was at elevation 44 ft.
** Water depth in downwell was at elevation 45 ft.

4. The degree of mortality and descaling for the fish passing through the downstream migrant bypass system varied between species and from day to day. Part of this was due to periodic fluctuations in the amount of water needed for the system to operate properly because the automatic water level control equipment did not work. This deficiency was also noted and reported after the 1982 preliminary bypass system studies (McConnell and Muir, 1982). The downstream migrant bypass system, however, does not appear to cause any major problems when it is operating properly as indicated with marked fish used to evaluate the system.

5. Only the sockeye salmon appear to be adversely affected by passage at Bonneville Dam. These fish were the only species that showed an increased descaling rate for gatewells associated with an STS. Also, mortality measurements on sockeye salmon were between 6 and 10 times higher than on other species.

6. Data from seawater and blood chemistry testing indicates that passage through the bypass system was less stressful on subyearling than on yearling chinook salmon.

7. Recapture rates for most releases of marked fish indicated that the smolt sampler was working as designed.

8. There is some delay especially to yearling chinook salmon in passing through the fingerling bypass of the 2nd Powerhouse. Most of the delay appears to be in the upper gallery where water velocities are low.

9. Overall the wet separator performed quite well considering the problems that were encountered in the water level controls.

10. It is premature to make any significant observations regarding the potential of Bonneville Dam as an index site.

11. Results from screen cycling tests, as expected, showed that only subyearling chinook salmon were being significantly impinged during the off cycle of the STS.

12. There was no significant difference in recoveries of fish marked and released as controls below the 1st Powerhouse and those marked and released in the downwell at the downstream migrant bypass system in the 2nd Powerhouse.

GENERAL RECOMMENDATIONS

1. Attempts to improve STS FGE with modifications to the STS; lighting the forebay; and/or use of trash rack deflectors, louvers, or baffles should be explored. Model studies are underway to test various methods for improving FGE, and the things showing best potential will be tested in the prototype in 1984.

2. Further OPE testing should be conducted after satisfactory FGE is accomplished.

3. Automatic water level controls should be made to work properly to eliminate fluctuations throughout the downstream migrant bypass system.

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

5. An auxilliary water supply system is needed to provide water to the dry separator in the event that the emergency relief gate opens. Large losses of fish can occur by being stranded in the system if the water supply suddenly stops.

6. Modifications need to be made to the smolt sampler if intermittent operation is proposed (to random sample only a percentage of the time). Samper will not go into position without reducing the water level from its designed flow.

7. Increasing the width between the grading bars of the fish compartment of the wet separator from 3/8-inch to 5/8-inch would reduce some portion of the mortality caused by fluctuating water levels in the downstream migrant bypass system (effectiveness would also be reduced to some degree).

8. Screen cycling should not be used during subyearling chinook salmon migrations at Bonneville Dam.

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1. Efficiency of the STS and gatewell orifice bypass system of the Second Powerhouse--Michael H. Gessel and Bruce H. Monk.

2. Fish quality and stress through the collection and bypass system--C. Scott McCutcheon and William D. Muir.

3. The smolt sampler and the potential of the collection system for indexing smolt migrations--William D. Muir.

4. The potential of screen cycling at the First and Second Powerhouses--Lyle G. Gilbreath.

5. The feasibility of using the downwell release into the observation room as a release site for transported fingerlings--Michael H. Gessel.

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APPENDIX

Tables 1 through 7

Appendix Table A1.--FGE for individual species, Bonneville Dam Second Powerhouse, 1983.

Date	Test angle & degree	Subyearling chinook Gate-well	Subyearling chinook Nets	Subyearling chinook FGE	Yearling chinook Gate-well	Yearling chinook Nets	Yearling chinook FGE	Steelhead Gate-well	Steelhead Nets	Steelhead FGE	Coho Gate-well	Coho Nets	Coho FGE	Sockeye Gate-well	Sockeye Nets	Sockeye FGE
							PHASE I									
5/9	47		a/		85	163	34.3	39	50	43.8		a/		18	115	13.5
5/9	60		a/		43	92	31.9		a/			a/		10	78	11.4
5/10	47		a/		113	252	31.0	23	63	26.7		a/		36	103	25.9
5/10	60		a/		83	1233	6.3		a/			a/		21	57	26.9
5/11	47		a/		82	430	16.0	18	100	15.3		a/		30	107	21.9
5/11	60		a/		49	261	15.8	12	61	16.4		a/		12	91	11.7
5/12	47		a/		60	529	10.2	15	77	16.3		a/		33	223	12.9
5/12	60		a/		54	305	15.0	20	65	23.5		a/		0	159	0.0
5/13	47		a/		42	41	50.6	16	32	33.3		a/		34	117	22.5
5/13	60		a/		26	45	36.6		a/			a/		34	85	28.6
5/16	47		a/		150	409	26.7	95	102	48.2	122	286	29.9	128	543	19.1
5/17	60		a/		67	218	23.5	50	73	40.7	104	205	33.6	44	424	9.4
5/18	60		a/		174	287	37.7	162	287	36.1	182	528	25.6	98	872	10.1
5/19	47		a/		52	238	17.9	74	74	50.0	67	124	35.0	40	320	11.1
							PHASE II									
6/2 b/	60	244	197	55.3		a/			a/			a/			a/	
6/3 b/	60	272	377	41.9		a/			a/			a/			a/	
6/8 c/	60	50	188	21.0		a/			a/			a/			a/	
6/9 c/	47	37	184	16.7		a/			a/			a/			a/	
6/10 c/	47	10	126	7.4		a/			a/			a/			a/	
6/13 c/	47	91	1122	7.5		a/			a/		33	403	7.6		a/	
TOTALS (AVERAGED)		704	2194	24.3%	1080	4503	19.3%	524	984	34.7%	508	1546	24.7%	538	3294	14.0%

a/ Insufficient numbers for testing (usually less than 50 fish.
b/ Test was terminated before dark.
c/ STS was lowered one (1) foot into gate slot.

Appendix Table A2.--Seawater challenge test data for chinook salmon from screened and unscreened intakes of the First and Second Powerhouses of Bonneville Dam collection and bypass system. Data includes test numbers, descaling, total biomass, and average length of live and dead fish by sampling area and replicate after 24-h exposure to 25 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
TEST CONDITION - GATEWELL 5A UNSCREENED 1ST POWERHOUSE																															
1/1	5/25	0	0	-	0	-	0	0	-	0	-	-----	-----	-----	-----	-----	2	9	--	17	--	1	0	-	0	-	138.0	86.9	-----	141.3	-----	580.0
1/2	"	0	0	0	0	0	0	0	0	0	0	-----	-----	-----	-----	-----	3	9	7	9	2	0	0	1	0	0	141.3	86.4	184.0	145.8	99.0	795.0
1/3	"	1	0	0	0	0	0	0	1	0	0	122.0	-----	192.0	-----	-----	1	7	0	15	5	1	0	0	0	0	144.5	87.0	-----	145.9	109.2	658.0
2/1	5/26	0	0	0	0	-	0	0	0	0	-	-----	-----	-----	-----	-----	5	7	4	6	-	0	0	0	0	-	137.8	87.3	179.3	143.8	-----	439.0
2/2	"	0	0	0	0	0	0	0	0	0	0	-----	-----	-----	-----	-----	2	10	6	9	5	1	0	3	1	0	129.3	88.0	160.1	142.8	103.6	718.0
2/3	"	0	0	0	0	1	0	0	0	0	1	-----	-----	-----	-----	96.5	8	6	1	8	6	1	1	1	0	0	134.3	82.6	164.0	144.5	101.3	602.0
3/1	5/27	0	1	0	0	0	0	0	0	0	0	-----	59.0	-----	-----	-----	9	10	9	8	5	1	0	1	0	1	140.0	83.5	166.0	135.3	103.4	902.0
3/2	"	0	0	0	0	0	0	0	0	0	0	-----	-----	-----	-----	-----	8	10	10	4	6	0	0	1	1	0	141.5	83.1	178.4	149.6	103.2	854.0
3/3	"	0	2	0	2	0	0	0	0	0	1	-----	77.5	-----	123.5	101.0	7	8	6	10	1	0	0	1	0	1	128.9	85.0	174.3	133.8	105.5	562.0
4/1	5/28	0	1	0	0	4	0	0	0	0	1	-------	92.0	-----	-----	104.8	6	2	3	5	0	0	1	0	1	1	134.6	83.3	159.0	139.5	96.0	467.0
4/2	"	0	0	0	0	2	0	0	0	0	0	-----	-----	-----	-----	100.5	6	10	8	12	5	2	2	0	1	0	137.4	92.0	166.8	136.4	99.6	1189.7
4/3	"	0	0	-	0	1	0	0	-	0	1	-----	-----	-----	-----	111.0	2	6	-	3	0	2	0	-	0	0	140.4	86.7	-----	135.0	-----	258.0
Totals or averages		1	4	0	2	8	0	0	1	0	4	122.0	76.1	192.0	123.5	102.8	59	94	54	106	35	9	4	8	4	3	137.3	86.0	170.2	141.1	102.3	668.7

a/ Biomass contains incidental catches of other species.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A2.--Continued.

		DEAD FISH															LIVE FISH														
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					Total[a/] biomass (gms)
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
												TEST CONDITION - GATEWELL 5B SCREENED 1ST POWERHOUSE																			
1/1	5/25	1	0	0	0	0	0	0	0	0	2	138.0	-----	-----	-----	101.0	1	8	1	29	1	0	0	0	1	2	121.0	82.9	200.0	141.7	103.3	980.0
1/2	"	0	1	1	0	0	0	1	0	0	4	-----	75.5	191.0	-----	97.3	4	4	2	23	0	2	0	0	0	2	137.0	86.3	177.5	138.5	105.5	991.5
1/3	"	0	2	-	0	0	0	0	-	0	5	-----	78.5	-----	-----	99.2	4	5	-	15	2	2	0	-	2	0	135.0	78.4	-----	140.1	121.3	672.5
2/1	5/26	0	2	0	0	1	0	0	0	0	0	-----	60.0	-----	-----	99.0	1	4	3	13	3	1	0	0	3	3	143.0	83.5	163.3	136.4	109.3	638.5
2/2	"	0	3	0	0	0	0	0	0	0	1	-----	71.3	-----	-----	103.0	1	7	1	14	3	0	0	0	1	2	122.0	92.8	159.0	140.9	105.0	542.9
2/3	"	0	2	0	0	0	1	0	0	1	2	148.0	72.5	-----	129.0	109.0	2	5	1	8	2	1	1	0	3	1	140.0	95.2	185.0	140.8	102.3	581.0
3/1	5/27	0	0	0	2	0	1	1	0	0	3	110.0	100.0	-----	125.0	95.3	3	4	3	11	0	0	0	0	0	0	131.6	94.8	177.7	133.9	-----	588.6
3/2	"	0	0	0	0	1	2	2	0	0	1	131.5	82.0	-----	-----	106.5	2	2	3	13	1	1	2	0	1	0	129.3	82.5	177.3	136.3	101.0	667.8
3/3	"	-	0	0	0	0	-	1	0	0	3	-----	84.0	-----	-----	106.0	-	5	4	10	0	-	0	0	4	1	-----	82.2	173.0	138.2	100.0	568.0
4/1	5/28	0	0	0	0	0	0	0	0	0	0	-----	-----	-----	-----	-----	4	6	3	4	1	1	0	2	0	0	133.0	87.7	173.0	137.0	109.0	472.7
4/2	"	0	1	0	0	0	0	0	0	0	0	85.0	-----	-----	-----	-----	3	8	3	8	1	1	0	0	0	0	139.0	87.0	164.7	140.0	111.0	480.7
4/3	"	0	0	0	0	1	0	0	0	0	0	-----	-----	-----	-----	91.0	1	10	4	3	3	0	0	0	0	0	142.0	88.1	157.2	139.7	107.6	352.7
Totals or averages		1	11	1	2	3	4	5	0	1	21	122.5	80.0	191.0	127.0	100.7	26	68	28	151	17	9	3	2	5	11	133.9	86.8	173.4	138.6	106.8	628.1

a/ Biomass includes incidental catches of other species.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A2.--Continued.

		DEAD FISH															LIVE FISH														
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					Total[a/] biomass (gms)
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
												TEST CONDITION - GATEWELL 12B UNSCREENED 2ND POWERHOUSE																			
1/1	5/25	0	1	0	0	1	0	0	1	0	0	-----	96.0	156.0	-----	95.0	4	1	6	9	5	0	1	1	0	2	134.5	86.5	202.3	140.6	105.8	967.0
1/2	"	0	1	0	0	1	2	0	0	0	0	136.0	80.0	-----	-----	110.0	3	1	5	11	5	1	0	2	0	0	134.0	85.0	186.9	129.1	110.6	949.5
1/3	"	-	-	0	0	0	-	-	0	0	0	-----	-----	-----	-----	-----	-	-	12	12	2	-	-	0	1	0	-----	-----	191.8	144.8	100.5	1081.0
2/1	5/26	0	-	0	0	0	0	-	0	0	0	-----	-----	-----	-----	-----	5	-	7	8	1	0	-	3	3	1	136.0	-----	185.8	146.5	106.0	b/
2/2	"	0	0	0	0	1	0	0	0	0	0	-----	-----	-----	-----	109.0	3	2	7	15	1	3	0	4	1	2	129.8	98.5	188.1	149.4	108.3	1353.5
2/3	"	0	0	0	0	0	0	0	0	0	2	-----	-----	-----	-----	98.5	8	4	9	9	0	0	0	1	4	1	138.3	94.0	182.8	148.3	106.0	546.5
3/1	5/27	1	0	0	1	4	0	0	0	0	0	128.0	-----	-----	106.0	94.0	7	3	3	16	3	1	0	0	1	1	134.8	76.3	167.0	144.3	103.0	900.4
3/2	"	-	0	0	0	0	-	0	0	0	0	-----	-----	-----	-----	-----	-	7	1	10	3	-	0	0	1	1	-----	88.6	167.0	145.5	115.5	454.8
3/3	"	0	0	0	0	0	1	0	0	0	0	139.0	-----	-----	-----	-----	2	3	1	10	2	2	0	0	1	4	128.8	83.7	157.0	145.2	103.7	488.2
4/1	5/28	0	0	0	0	1	0	0	0	0	0	-----	-----	-----	-----	112.0	10	1	5	2	7	1	0	1	0	1	138.2	95.0	180.8	152.0	107.1	700.1
4/2	"	-	-	-	-	-	-	-	-	-	-	-----	-----	-----	-----	-----	3	1	1	1	1	0	0	2	0	0	128.3	105.0	162.6	156.0	125.0	231.3
4/3	"	0	1	0	-	-	0	0	0	-	-	-----	88.0	-----	-----	-----	5	2	2	-	-	1	0	0	-	-	136.5	83.5	198.0	-----	-----	288.1
Totals or Averages		1	3	0	1	8	3	0	1	0	2	134.3	88.0	156.0	106.0	103.1	50	25	59	103	30	9	1	14	12	13	133.9	89.6	180.8	145.6	108.3	723.6

a/ Biomass includes incidental catches of other species.
b/ No weight taken.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A2.--Continued.

		DEAD FISH															LIVE FISH														
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					Total[a/] biomass (gms)
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
												TEST CONDITION - GATEWELL 12A SCREENED 2ND POWERHOUSE																			
1/1	5/25	3	3	0	2	0	3	0	0	0	5	138.5	79.3	-----	131.5	100.8	4	3	3	15	0	3	7	1	4	1	132.4	94.5	185.0	137.8	107.0	1277.0
1/2	"	0	1	0	1	0	1	0	0	0	4	135.0	70.0	-----	121.0	100.4	6	7	1	17	3	2	0	0	2	5	131.9	77.7	202.0	146.6	111.4	898.0
1/3	"	0	0	0	0	0	0	1	0	0	5	-----	83.0	-----	-----	102.2	6	1	3	18	0	1	0	0	0	3	145.4	80.0	177.7	138.8	102.7	865.0
2/1	5/26	0	1	0	0	0	0	1	0	0	8	-----	86.5	-----	-----	97.4	5	3	2	8	6	4	0	0	0	0	141.9	92.7	134.5	137.6	103.2	676.5
2/2	"	0	0	0	0	0	0	1	0	0	7	-----	74.0	-----	-----	100.7	3	2	5	15	9	0	1	0	1	4	133.0	70.3	196.6	132.9	104.3	939.2
2/3	"	0	0	0	1	1	1	0	0	2	5	129.0	-----	-----	138.0	98.6	4	6	5	17	2	0	0	0	0	3	135.8	78.8	168.4	136.6	102.6	925.5
3/1	5/27	0	0	0	0	0	0	0	0	1	6	-----	-----	-----	109.0	107.2	4	6	1	7	9	2	1	0	0	4	138.8	95.0	130.0	138.4	104.2	596.7
3/2	"	0	0	0	1	0	1	0	0	0	9	138.0	-----	-----	149.0	105.1	1	2	2	8	5	2	0	0	0	2	138.6	85.0	199.0	142.8	100.0	504.8
3/3	"	0	0	0	0	1	1	0	0	1	6	136.0	-----	-----	132.0	102.9	3	1	1	12	1	2	0	0	2	5	133.6	74.0	198.0	140.1	133.8	653.9
4/1	5/28	0	1	0	0	2	0	0	0	0	5	-----	95.0	-----	-----	104.3	5	3	3	4	0	2	0	0	2	2	137.1	85.3	152.0	132.0	96.5	778.8
4/2	"	1	2	0	0	2	1	0	0	0	0	123.5	89.0	-----	-----	105.5	8	0	7	0	0	2	1	1	1	3	135.2	92.0	183.4	122.0	99.3	743.0
4/3	"	0	2	0	0	-	1	0	0	0	-	148.0	90.0	-----	-----	-----	12	0	1	8	-	1	0	0	1	-	141.8	-----	180.0	138.6	-----	671.8
Totals or Averages		4	10	0	5	6	9	3	0	4	60	135.4	83.4	-----	130.1	102.3	61	34	34	129	35	21	10	2	13	32	137.1	84.1	175.6	137.0	105.9	794.2

a/ Biomass includes incidental catches of other species.

YC Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A3.--Seawater challenge test data for yearling chinook salmon from intakes containing screens cycled at 15-minute or 2-h intervals at the First Powerhouse, Bonneville Dam. Data includes test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 25 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
TEST CONDITION - GATEWELL 4C 2-HOUR CYCLE 1ST POWERHOUSE																															
1/1	5/4	2	4	1	-	2	1	0	0	-	0	129.0	74.5	155.0	-----	107.5	22	-	2	-	-	5	-	0	-	-	131.7	-----	161.0	-----	-----	746.8
1/2	5/4	3	-	-	-	1	0	-	-	-	0	125.0	-----	-----	-----	100.0	14	3	3	-	1	0	0	1	-	0	144.4	80.8	173.0	-----	94.0	477.9
1/3	5/4	1	-	-	-	1	1	-	-	-	0	128.0	-----	-----	-----	118.0	25	4	2	-	2	3	0	0	-	0	135.2	101.3	169.5	-----	102.0	818.3
2/1	5/6	2	4	1	-	-	3	-	-	-	-	118.6	63.8	152.0	-----	-----	17	3	5	-	3	0	-	0	-	0	128.8	75.7	174.6	-----	92.0	666.6
2/2	5/6	2	4	-	-	1	1	0	-	-	0	127.7	61.3	-----	-----	96.0	17	5	1	-	7	0	0	0	-	0	132.5	63.4	185.0	-----	97.7	545.8
2/3	5/6	0	3	-	-	1	1	0	-	-	2	135.0	62.7	-----	-----	98.0	15	5	2	-	1	0	0	0	-	0	133.3	77.6	137.0	-----	96.0	459.0
Totals or averages		10	15	2	-	6	7	0	0	-	2	127.2	65.6	153.0	-----	103.9	110	20	15	-	14	8	0	1	-	0	134.3	79.8	166.7	-----	96.3	619.1
TEST CONDITION - GATEWELL 4C 15 MINUTE CYCLED 1ST POWERHOUSE																															
1/1	5/5	0	4	-	-	2	2	0	-	-	1	120.5	58.8	-----	-----	91.3	15	7	7	-	3	4	2	1	-	1	128.6	65.7	178.1	-----	95.3	884.0
1/2	5/5	1	2	-	-	2	1	0	-	-	0	116.5	65.0	-----	-----	91.5	17	2	7	-	4	3	1	0	-	0	127.8	78.7	172.1	-----	108.3	791.0
1/3	5/5	1	-	1	-	3	1	-	0	-	1	125.0	-----	159.0	-----	93.8	17	7	7	-	2	3	0	0	-	0	133.8	76.9	170.3	-----	94.0	903.5
2/1	5/9	3	4	-	-	3	2	0	-	-	2	119.2	64.5	-----	-----	88.0	19	2	-	-	1	1	0	-	-	0	131.9	85.0	-----	-----	94.0	611.8
2/2	5/9	1	4	-	-	4	0	0	-	-	0	122.0	62.5	-----	-----	91.8	19	4	1	-	1	0	0	0	-	0	124.2	82.5	156.0	-----	98.0	555.7
2/3	5/9	1	-	-	-	3	1	-	-	-	0	125.5	-----	-----	-----	93.7	19	3	-	-	2	2	0	-	-	0	121.1	77.7	-----	-----	92.0	464.4
Totals or averages		7	14	1	-	17	7	0	0	-	4	121.5	62.7	159.0	-----	91.7	106	25	22	-	13	13	3	1	-	1	127.9	77.6	169.1	-----	96.9	701.7

a/ Biomass includes incidental catches of other species.

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

Appendix Table A4.--Seawater challenge test data for subyearling chinook salmon from intakes containing screens cycled at 15-minute or 2-h intervals at the First Powerhouse, Bonneville Dam. Data include test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 23 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH																	Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
TEST CONDITION - GATEWELL 4C 2-HOUR CYCLE 1ST POWERHOUSE																																		
1/1	6/4	-	3	-	-	-	-	0	-	-	-	-----	73.3	-----	-----	-----	-	38	-	-	-	-	0	-	-	-	-----	79.2	-----	-----	-----	202.0
1/2	6/6	-	3	-	-	-	-	0	-	-	-	-----	70.0	-----	-----	-----	1	39	-	-	-	0	0	-	-	-	130.0	78.5	-----	-----	-----	207.4
1/3	6/6	-	1	-	-	-	-	0	-	-	-	-----	75.0	-----	-----	-----	-	57	-	-	-	-	0	-	-	-	-----	80.1	-----	-----	-----	299.5
2/1	6/8	-	-	-	-	-	-	-	-	-	-	-----	-----	-----	-----	-----	-	10	-	-	-	-	0	-	-	-	-----	84.8	-----	-----	-----	65.4
2/2	6/8	-	-	-	-	-	-	-	-	-	-	-----	-----	-----	-----	-----	2	20	-	1	-	0	0	-	0	-	114.5	84.5	-----	124.0	-----	175.1
2/3	6/8	-	-	-	-	-	-	-	-	-	-	-----	-----	-----	-----	-----	-	14	1	-	-	-	0	0	-	-	-----	84.5	189.0	-----	-----	145.0
Totals or Averages		-	7	-	-	-	-	0	-	-	-	-----	72.8	-----	-----	-----	3	178	1	1	-	0	0	0	0	-	122.3	81.9	189.0	124.0	-----	182.4
TEST CONDITION - GATEWELL 4C 15 MINUTE - CYCLED 1ST POWERHOUSE																																		
1/1	6/7	-	2	-	-	-	-	1	-	-	-	-----	71.0	-----	-----	-----	-	32	-	-	-	-	0	-	-	-	-----	82.1	-----	-----	-----	206.9
1/2	6/7	-	0	-	-	-	-	1	-	-	-	-----	87.0	-----	-----	-----	-	37	-	-	-	-	0	-	-	-	-----	82.1	-----	-----	-----	224.5
1/3	6/7	-	-	-	-	-	-	-	-	-	-	-----	-----	-----	-----	-----	-	34	-	-	-	-	0	-	-	-	-----	81.7	-----	-----	-----	197.4
Totals or Averages		-	2	-	-	-	-	2	-	-	-	-----	79.0	-----	-----	-----	-	103	-	-	-	-	0	-	-	-	-----	81.9	-----	-----	-----	209.6

a/ Biomass includes incidental catches of other species.

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

Appendix Table A5.--Seawater challenge tests data for chinook salmon from intakes containing screens cycled at 15-minute or 2-h intervals at the Second Powerhouse, Bonneville Dam. Data include test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 25 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
TEST CONDITION - GATEWELL 15B SCREENED CYCLED 2ND POWERHOUSE																															
1/1	5/25	0	0	0	0	-	0	0	1	0	-	-----	-----	165.0	-----	-----	8	5	1	3	-	0	0	0	0	-	141.6	81.4	159.0	130.0	-----	356.5
1/2	"	0	1	0	0	1	0	0	0	0	0	-----	75.0	-----	-----	103.0	12	8	1	1	0	4	0	0	0	0	137.4	82.1	167.0	138.0	-----	538.4
1/3	"	1	1	0	0	-	0	0	0	0	-	126.0	76.0	-----	-----	-----	9	6	1	7	-	0	0	0	1	-	136.1	78.0	159.0	138.4	-----	463.4
2/1	5/26	0	1	0	0	1	0	0	0	0	0	-----	81.0	-----	-----	110.0	11	10	1	3	3	4	0	0	0	0	130.1	78.9	162.0	145.0	101.6	505.0
2/2	"	b/																													
2/3	"	b/																													
3/1	5/27	b/	0	1	-	-	0	0	0	-	-	0	-----	75.0	-----	-----	-----	6	11	-	-	2	0	0	-	-	0	142.2	84.1	-----	-----	105.5	234.5
3/2	"	b/																													
3/3	"	b/																													
Totals or Averages			1	4	0	0	2	0	0	1	0	0	126.0	76.8	165.0	-----	106.5	46	40	4	14	5	8	0	0	1	0	137.4	80.9	161.8	137.9	103.6	419.6
TEST CONDITION - GATEWELL 12A SCREEN NON-CYCLED 2ND POWERHOUSE																															
1/1	5/25	3	3	0	2	0	3	0	0	0	5	138.5	79.3	-----	131.5	100.8	4	3	3	15	0	3	7	1	4	1	132.4	94.5	185.0	137.8	107.0	1277.0
1/2	"	0	1	0	1	0	1	0	0	0	4	135.0	70.0	-----	121.0	100.4	6	7	1	17	3	2	0	0	2	5	131.9	77.7	202.0	146.6	111.4	898.0
1/3	"	0	0	0	0	0	0	1	0	0	5	-----	83.0	-----	-----	102.2	6	1	3	18	0	1	0	0	0	3	145.4	80.0	177.7	138.8	102.7	865.0
2/1	5/26	0	1	0	0	0	0	1	0	0	8	-----	86.5	-----	-----	97.4	5	3	2	8	6	4	0	0	0	0	141.9	92.7	134.5	137.6	103.2	676.5
2/2	"	0	0	0	0	0	0	1	0	0	7	-----	74.0	-----	-----	100.7	3	2	5	15	9	0	1	0	1	4	133.0	70.3	196.6	132.9	104.3	939.2
2/3	"	0	0	0	1	1	1	0	0	2	5	129.0	-----	-----	138.0	98.6	4	6	5	17	2	0	0	0	0	3	135.8	78.8	168.4	136.6	102.6	925.5
3/1	5/27	0	0	0	0	0	0	0	0	1	6	-----	-----	-----	109.0	107.2	4	6	1	7	9	2	1	0	0	4	138.8	95.0	130.0	138.4	104.2	596.7
3/2	"	0	0	0	1	0	1	0	0	0	9	138.0	-----	-----	149.0	105.1	1	2	2	8	5	2	0	0	0	2	138.6	85.0	199.0	142.8	100.0	504.8
3/3	"	0	0	0	0	1	1	0	0	1	6	136.0	-----	-----	132.0	102.9	3	1	1	12	1	2	0	0	2	5	133.6	74.0	198.0	140.1	133.8	653.9
Totals or Averages			3	5	0	4	2	7	3	0	4	55	135.3	78.6	-----	130.1	101.7	36	31	23	117	35	16	9	1	9	27	136.8	83.1	176.8	139.1	107.7	815.2

a/ Biomass includes incidental catches of other species.
b/ Insufficient numbers of fish for evaluation.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A6.--Seawater challenge tests data for chinook salmon from intakes containing screens set at 47 and 62 degrees. Tests conducted at the Second Powerhouse at Bonneville Dam. Data include test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after exposure to 25 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	FS	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SFC	ST	CO	SO	
TEST CONDITION - GATEWELL 15A FISH GUIDING EFFICIENCY AT 47° ANGLE																															
1/1	5/9	1	0	-	-	0	5	1	-	-	2	127.2	78.0	-----	-----	86.0	14	2	-	-	0	1	0	-	-	0	136.6	91.0	-----	-----	-----	496.0
1/2	"	1	-	0	0	0	2	-	0	0	6	121.0	-----	-----	-----	101.7	13	-	3	1	0	1	-	0	0	0	138.8	-----	180.3	150.0	-----	681.5
1/3	"	0	-	0	-	0	3	-	0	-	4	134.3	-----	-----	-----	109.5	8	-	6	-	0	1	-	0	-	0	145.4	-----	179.0	-----	-----	669.5
2/1	5/10	3	-	0	-	1	7	-	0	-	5	130.0	-----	-----	-----	90.0	27	-	2	-	0	2	-	0	-	0	135.5	-----	193.0	-----	-----	1053.0
2/2	"	1	0	0	-	0	7	0	0	-	1	126.3	-----	-----	-----	91.0	16	1	2	-	0	3	0	0	-	0	142.2	99.0	182.0	-----	-----	829.0
2/3	"	0	-	0	-	0	2	-	0	-	4	129.0	-----	-----	-----	90.5	17	-	3	-	3	5	-	0	-	0	137.0	-----	180.7	-----	107.7	779.0
3/1	5/11	2	-	0	-	0	4	-	0	-	2	126.2	-----	-----	-----	102.5	24	-	1	-	0	6	-	0	-	0	136.6	-----	217.0	-----	-----	889.0
3/2	"	1	1	0	-	0	8	1	0	-	6	122.1	78.5	-----	-----	92.7	31	0	1	-	1	4	0	0	-	0	134.2	-----	237.0	-----	85.0	1155.0
3/3	"	1	-	0	-	2	6	-	0	-	3	128.0	-----	-----	-----	106.6	18	-	1	-	0	8	-	0	-	0	136.8	-----	176.0	-----	-----	891.0
Totals or Averages		10	1	0	0	3	44	2	0	0	33	127.1	78.3	-----	-----	96.7	168	3	19	1	4	31	0	0	0	0	193.1	95.0	184.1	150.0	96.4	827.0
TEST CONDITION - GATEWELL 15B FISH GUIDING EFFICIENCY AT 62° ANGLE																															
1/1	5/9	2	1	0	0	0	2	2	0	0	1	127.0	84.3	-----	-----	90.0	22	1	2	1	0	4	0	0	1	2	141.3	94.0	172.5	138.0	100.3	929.0
1/2	"	3	1	0	0	1	0	0	0	0	3	128.0	81.0	-----	-----	93.8	14	0	2	2	1	1	0	0	0	0	141.7	-----	176.5	140.0	92.0	661.5
1/3	"	1	0	0	0	2	1	1	0	0	2	125.5	91.0	-----	-----	94.3	11	6	1	1	2	1	0	0	0	0	140.8	90.6	210.0	133.0	96.5	558.0
2/1	5/10	0	0	0	-	1	3	0	0	-	1	142.0	-----	-----	-----	126.0	26	2	1	-	4	2	0	0	0	0	142.2	93.5	205.0	-----	101.0	1003.5
2/2	"	1	0	-	-	4	1	0	-	-	1	123.0	-----	-----	-----	102.2	19	3	-	-	0	4	0	-	-	0	138.0	90.0	-----	-----	-----	683.5
2/3	"	3	0	0	-	2	0	0	0	-	2	128.0	-----	-----	-----	91.3	26	3	1	-	2	4	0	0	-	0	139.3	89.0	147.0	-----	93.0	924.5
3/1	5/11	1	0	-	-	0	1	0	-	-	0	120.5	-----	-----	-----	-----	29	3	-	-	2	3	0	-	-	0	138.4	84.3	-----	-----	97.5	868.7
3/2	"	1	2	0	-	1	2	1	0	-	1	130.3	90.3	-----	-----	88.5	26	2	2	-	1	2	0	1	-	0	136.3	92.0	199.7	-----	104.0	995.7
3/3	"	1	-	0	-	2	4	-	0	-	0	130.0	-----	-----	-----	94.5	29	-	3	-	0	2	-	0	-	0	133.7	-----	158.7	-----	-----	966.5
Totals or Averages		13	4	0	0	13	14	4	0	0	11	128.3	86.6	-----	-----	97.6	202	20	12	4	12	23	0	1	1	2	139.1	90.5	181.3	137.0	97.8	843.4

a/ Biomass includes incidental catches of other species.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A7.--Seawater challenge test data for subyerling chinook salmon from the bypass system at the Second Powerhouse, Bonneville Dam. Data include test numbers, descaling, total biomass, and average length of live and dead fish by sample area and replicate after 24 h exposure to 23 ppt artificial seawater (includes data for coho, sockeye, and steelhead which were sampled with chinook salmon in some tests).

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
																	TEST CONDITION - GATEWELL 12B UNSCREENED														
1/1	6/7	0	3	0	0	0	0	0	0	0	0	-----	72.3	-----	-----	-----	1	18	3	1	1	2	0	0	0	0	123.3	93.0	176.3	141.0	114.0	440.0
1/2	"	0	1	0	0	1	0	0	0	0	0	-----	88.0	-----	-----	102.0	6	11	1	1	1	0	0	1	0	0	127.7	102.9	180.0	139.0	105.0	397.7
1/3	"	0	1	0	-	-	0	0	0	-	-	-----	71.0	-----	-----	-----	3	11	1	-	-	2	0	0	-	-	117.6	90.2	188.0	-----	-----	b/
1/4	"	-	2	-	-	-	-	0	-	-	-	-----	69.0	-----	-----	-----	0	30	-	-	-	-	1	-	-	-	-----	80.9	-----	-----	-----	235.5
2/1	6/14	-	1	-	-	0	-	0	-	-	0	-----	91.0	-----	-----	-----	-	15	-	-	1	-	0	-	-	0	-----	91.4	-----	-----	123.0	144.0
2/2	"	-	3	-	0	0	-	0	-	0	0	-----	84.0	-----	-----	-----	-	18	-	1	1	-	0	-	0	0	-----	93.7	-----	119.0	115.0	192.0
2/3	" c/																															
3/1	6/15 c/																															
3/2	" c/																															
3/3	" c/																															
Totals or Averages		0	11	0	0	1	0	0	0	0	0	-----	79.2	-----	-----	102.0	10	103	5	3	4	4	1	1	0	0	122.9	92.0	181.4	133.0	114.3	281.8
																	TEST CONDITION - GATEWELL 12A SCREENED														
1/1	6/7	-	9	-	-	-	-	1	0	0	0	-----	74.9	-----	-----	-----	-	27	-	-	-	-	1	-	-	-	-----	75.1	-----	-----	-----	222.6
1/2	"	-	8	-	0	-	-	1	-	0	-	-----	69.9	-----	-----	-----	-	44	-	1	-	-	0	-	0	-	-----	77.7	-----	132.0	-----	369.9
1/3	"	0	7	-	-	1	0	1	-	-	0	-----	73.1	-----	-----	104.0	2	48	-	-	0	-	0	-	-	0	116.5	79.0	-----	-----	-----	350.7
1/4	"	0	3	0	-	0	0	0	0	-	0	-----	74.0	-----	-----	-----	3	9	1	-	1	0	1	0	0	0	112.6	85.1	171.0	-----	108.0	180.3
1/5	"	0	4	0	-	1	0	0	0	-	0	-----	82.5	-----	-----	106.0	4	15	1	-	0	0	0	0	-	0	114.5	80.8	162.0	-----	-----	269.8
1/6	"	0	3	-	-	-	0	1	-	-	-	-----	76.3	-----	-----	-----	1	15	-	-	-	1	-	-	-	-	104.5	77.6	-----	-----	-----	168.0
2/1	6/14	-	3	-	-	-	-	0	-	-	-	-----	86.7	-----	-----	-----	-	17	-	-	-	-	0	-	-	-	-----	91.3	-----	-----	-----	126.1
2/2	"	-	1	-	0	-	-	0	-	0	-	-----	88.0	-----	-----	-----	-	31	-	-	-	-	1	-	0	-	-----	94.4	-----	130.0	-----	295.0
2/3	"	-	0	-	0	-	-	0	-	0	-	-----	-----	-----	-----	-----	-	43	-	-	-	-	2	-	0	-	-----	96.3	-----	122.0	-----	430.0
3/1	6/15 c/																															
3/2	" c/																															
3/3	" c/																															
Totals or Averages		0	38	0	0	2	0	4	0	0	0	-----	78.2	-----	-----	105.0	10	249	2	1	1	1	5	0	0	0	112.0	84.1	166.5	128.0	108.0	268.0

a/ Biomass includes incidental catches of other species.
b/ No weight taken.
c/ Insufficient numbers of fish for evaluation.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO - Sockeye

Appendix Table A7.--Continued.

		DEAD FISH															LIVE FISH														Total[a/] biomass (gms)
		Number Nondescaled					Number Descaled					Average Fork Length (mm)					Number Nondescaled					Number Descaled					Average Fork Length (mm)					
Test	Date	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	YC	SC	ST	CO	SO	
																	TEST CONDITION - RACEWAY 1(A)															
1/1	6/7	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	22	-	-	-	-	0	-	-	-	-----	79.0	-----	-----	-----	114.0
1/2	"	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	28	-	-	-	-	0	-	-	-	-----	77.8	-----	-----	-----	140.0
1/3	"	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	32	-	-	-	-	0	-	-	-	-----	78.7	-----	-----	-----	159.5
2/1	6/14	-	0	-	-	0	-	0	-	-	0	-----	-----	-----	-----	-----	-	22	-	-	1	-	0	-	-	0	-----	92.4	-----	-----	111.0	193.4
2/2	"	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	35	-	-	-	-	0	-	-	-	-----	92.9	-----	-----	-----	295.8
2/3	"	-	0	-	0	-	-	0	-	0	-	-----	-----	-----	-----	-----	-	34	-	1	-	-	0	-	0	-	-----	94.1	-----	122.0	-----	293.2
3/1	6/15 b/	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	26	-	-	-	-	0	-	-	-	-----	95.5	-----	-----	-----	224.0
3/2	" b/	0	0	-	-	-	0	0	-	-	-	-----	-----	-----	-----	-----	3	29	-	-	-	0	0	-	-	-	122.3	94.1	-----	-----	-----	308.0
3/3	" b/	-	0	-	-	-	-	0	-	-	-	-----	-----	-----	-----	-----	-	29	-	-	-	-	0	-	-	-	-----	92.5	-----	-----	-----	224.0
Totals or Averages		0	0	-	0	0	0	0	-	0	0	-----	-----	-----	-----	-----	3	257	0	1	1	0	0	-	0	0	122.3	88.6	-----	122.0	111.0	216.9

a/ Biomass includes incidental catches of other species.
b/ Data not used - no sample taken on same day in other tests for evaluation.

YC - Yearling Chinook, SC - Subyearling Chinook, ST - Steelhead, CO - Coho, SO -Sockeye