Fish Guiding Efficiency Studies at Ice Harbor Dam, 1987

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COASTAL ZONE AND ESTUARINE STUDIES

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INTRODUCTION

Ice Harbor Dam, located on the Snake River, Washington (Fig. 1), was completed in 1962 with no specific structures designed to bypass juvenile salmonids away from turbines. Subsequent to construction, efforts have been made to provide some protection for juvenile outmigrants. Changes to the project have included: 1) in 1967, 6-inch orifices were drilled to provide access to the ice/trash sluiceway for juvenile fish volitionally attracted to bulkhead gatewells (Fig. 2); 2) in 1980, partial opening of sluiceway gates was begun to skim fish from the forebay to the ice/trash sluiceway; and 3) in 1983, sluicegates were opened to the maximum extent possible to provide 57.8 m^3/sec (2,700 cfs) skimming flow to attract fish from the forebay. Seasonal hydroacoustic estimates of sluiceway passage have ranged from 30 to 70%.

Some hydroelectric projects on the Snake and Columbia rivers with similar construction to Ice Harbor Dam have been retrofitted with submersible traveling screens (STS) and bypass systems. These screens guide juvenile fish away from the turbine intakes into gatewell bypass systems. After entering the bypass, fish can be released in the tailrace or, at collector dams, loaded into barges for transportation to a release point below Bonneville Dam. For example, STS systems at John Day and McNary dams have fish guidance efficiencies (FGE) greater than 70% during the spring outmigration (Krcma et al. 1983; Krcma et al. 1986).

This 1987 study was conducted by the National Marine Fisheries Service (NMFS) in conjunction with the U.S. Army Corps of Engineers (COE) to evaluate the potential guidance of a prototype installation of STSs at Ice Harbor Dam. The objectives of the study were to determine the following:

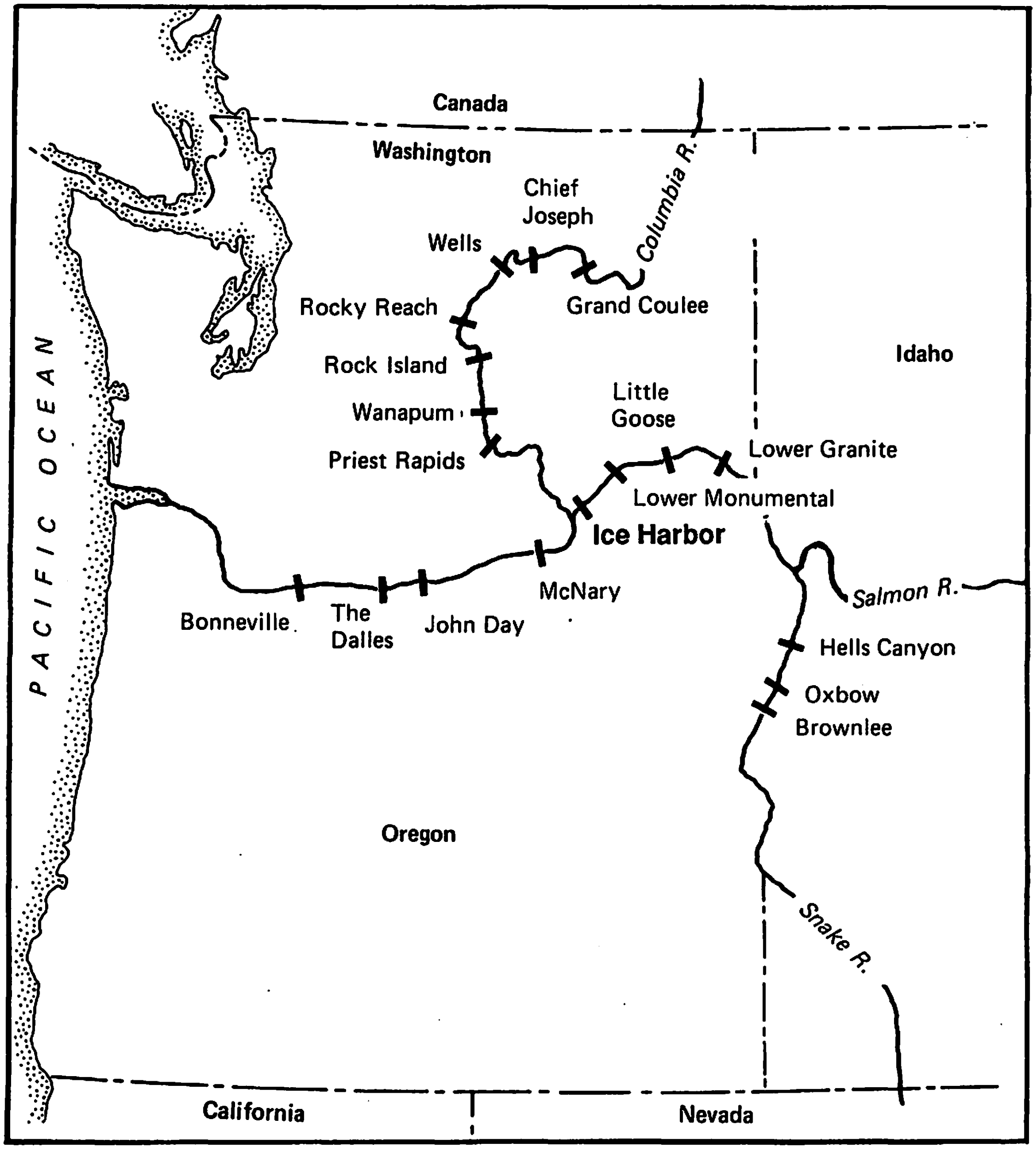

Figure 1.--Site location.

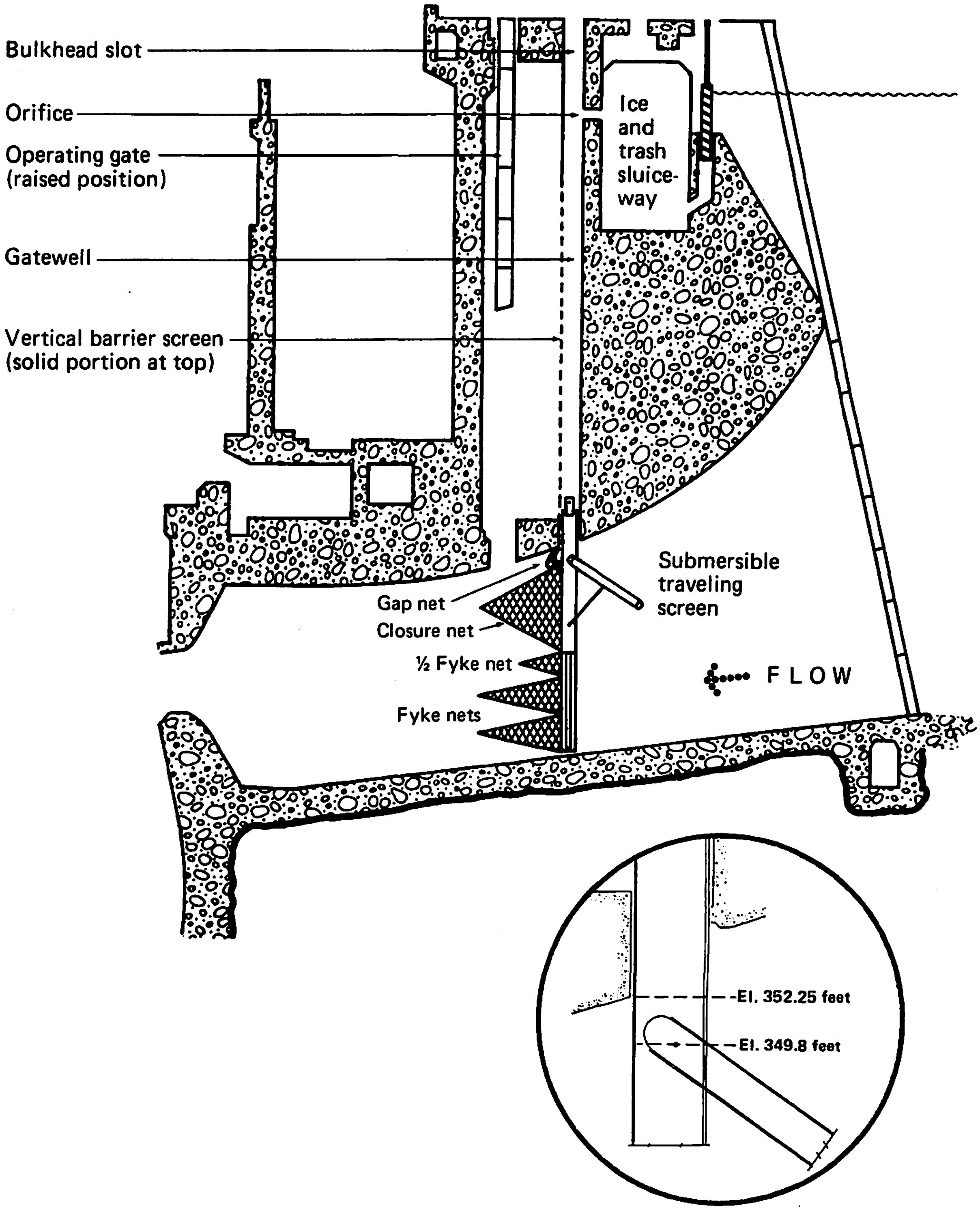

Figure 2.--Cross-section of a turbine intake with a submersible traveling screen and attached nets at Ice Harbor Dam, 1987.

1) fish guidance efficiency of STSs for spring and summer migrants,

2) benefit of a 6-m (20-foot) raised operating gate, and

3) theoretical fish guidance efficiency from vertical fish distribution measurements.

MATERIALS AND METHODS

Testing was to begin by mid-April with three STSs borrowed from Bonneville Dam, but as a consequence of problems associated with modifying the borrowed STSs for operation at Ice Harbor Dam, the test scenario was changed (Appendix A details problems). We planned to install the STSs in all three slots of Unit 3 and use the center slot for evaluation. However, the STSs would not deploy in Slot 3B. When this did not work, STSs were only installed in Slots 3A and 3C. All FGE tests were conducted in Slot 3A, and the vertical distribution test was conducted in Slot 3B.

The STSs were fished at a 55-degree angle and set in the bulkhead slots at a level where the top face of the STS corresponded to a plane that intersected the upstream lower corner of the concrete beam separating the bulkhead slot from the operating slot (Fig. 2). This was a configuration found beneficial in FGE testing at Bonneville Dam (Gessel et al. 1986) and The Dalles Dam (Monk et al. 1986, 1987), but was considered non-standard because it lowered the STS 27 inches from what was considered a standard position. The effect was to increase the throat opening and gap of the STS compared to earlier installations of STSs at most other projects. The operating gate was also raised 6 m (20 feet) to increase flow up the bulkhead slot. The hydraulic cylinder attached to the operating gate was removed, and the gate was suspended on dogging beams to eliminate further handling during testing. Due to lack of testing time as a result of problems (Appendix A), the operating gate was not tested in the standard position.

An array of nets was used to recover unguided fish. The standard net configuration consisted of two gap nets attached near the top of the STS (to capture fish which pass between the top roller of the STS and the intake ceiling), two closure nets attached to the back of the STS, and three fyke nets suspended in a column on a frame below the STS (Fig. 2). The gap nets and closure nets extended completely across the width of the gatewell. The single column of fyke nets covered the middle one-third of the area under the STS. It was assumed that the middle fyke nets caught one-third of the total fish passing through the intake; this assumption was based upon pooled seasonal FGE data collected prior to 1986 at various dams where a full complement of nets were used (Ossiander[1]). Further tests confirming the assumption were conducted at John Day Dam in 1986 by alternating between full and partial net coverage during FGE tests (Brege et al. 1987). The opening of the top fyke net was 0.75 by 2.0 m whereas the openings of the next two below were 2.0 by 2.0 m. (During FGE tests at most projects four 2.0- by 2.0-m fyke nets are used. Fewer are needed for the smaller turbines at Ice Harbor Dam).

The following was a typical sequence of events for an FGE test:

1. The gatewell orifice was closed by inserting and inflating a bladder rather than covering with a plate as is done at other projects.

2. Fish from the gatewell were removed using a dipbasket (Swan et al. 1979).

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[1] Memo 10 March 1986, F. Ossiander to Teri Barila, COE. "Comparisons of center and side net catches from FGE and vertical distribution tests."

3. The STS with attached fyke net frames was lowered into position with the gantry crane (turbine off).

4. The sluicegate in Slot 3A was closed 1 hour before the start of the test.

5. Unit 3 was brought to full generating capacity (100 MW) over a 5- to 10-minute period beginning at 2000 h.

6. The number of fish entering the gatewell of the test unit was monitored by periodic dipnetting.

7. The test was terminated when an estimated minimum of 250 fish had entered the test turbine intake slot.

8. The turbine was shut down over a 5- to 10-minute period, and the remaining gatewell fish were removed.

9. The STS and attached nets were brought to the deck, and fish were removed from the nets for identification and enumeration.

The methods for determining FGE were similar to those used in previous FGE tests (Swan et al. 1983). Gatewell dipbasket catches provided the number of guided fish; catches from the gap, closure, and fyke nets provided data for estimating the number of unguided fish. The FGE was calculated as gatewell catch divided by the total number of fish passing through the intake during the test period:

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

where: adjusted total net catch = gap net catch + closure net catch + center row fyke net catch X 3

To determine theoretical fish guiding efficiency (TFGE), one vertical distribution test was conducted in Slot 3B concurrently with an FGE test. A large net frame with seven fyke nets attached was lowered into the bulkhead slot prior to the test (Fig. 3). The nets in Levels 1, 2, and 3 sampled the area where fish would normally be intercepted by an STS. Fyke nets in Levels 1, 2, 5, 6, and 7 were the standard 2.0 by 2.0 m, and the nets in Levels 3 and 4 were 1.0 by 2.0 m. As in the FGE tests, only the center one-third of the turbine intake was fished. During the test, fish entering the gatewell were periodically removed by dipnetting, identified, and enumerated. At the conclusion of the test, the net frame was removed from the gate slot, and the catch from each net was identified and enumerated. The TFGE was calculated as follows:

$$\text{TFGE\%} = \frac{\text{gatewell catch} + \text{adjusted fyke net catches in Levels 1,2,\& 3}}{\text{gatewell catch} + \text{adjusted total fyke net catch}} \times 100$$

where: adjusted fyke net catch = center row fyke net catch X 3

Descaling of fish in the gatewells was monitored as a measure of fish condition for each FGE and vertical distribution test. Descaling was determined by dividing each side of the fish into five equal areas, and if any two areas on the same side were 50% or more descaled, the fish was classified as descaled.

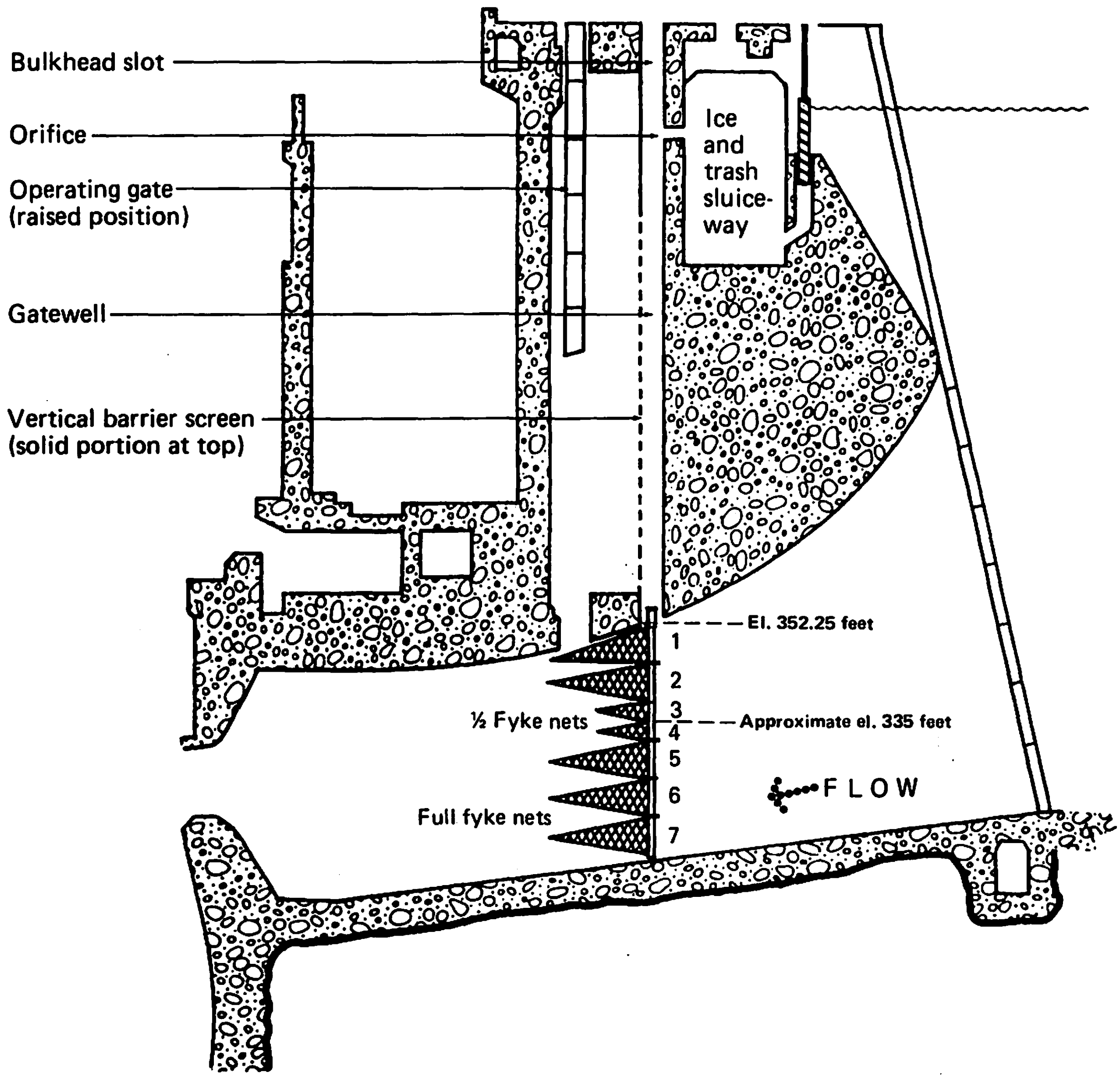

Figure 3.--Cross-section of a turbine intake at Ice Harbor Dam with a vertical distribution frame and fyke nets, 1987.

RESULTS AND DISCUSSION

Although tests were initially scheduled for 10 days, the extended period necessary to prepare the test equipment at Ice Harbor Dam and commitments for work at other projects limited time to conduct tests during the spring migration to a 5-day period. The 10-day period was scheduled for a cross-over test of a raised versus standard operating gate. It was decided that since raised operating gates have shown benefits at most projects where they have been tested, then that condition would be the best to test in the period available.

The research was originally designed to measure FGE in Slot 3B with STSs in all three slots of Unit 3. The design was chosen to limit "edge effects" of different conditions in adjacent slots. Had FGEs been low, then results might have been due to deflection away from the slot with the STS. However, as FGEs were high (details follow), we feel that the results obtained during the test period were indicative of the guidance potential of STSs at Ice Harbor Dam for spring migrants.

Testing for yearling migrants at Ice Harbor Dam began on 3 May and was completed on 8 May 1987. Mean FGEs and 95% C.I.s for yearling chinook salmon and steelhead for the five replicates were 77.7 $\pm$ 8.2 and 92.5 $\pm$ 6.1%, respectively (Table 1). (Detailed results are presented in Appendix Table B1.) The FGE values for yearling chinook salmon were equal to or exceeded values obtained in FGE studies at most other projects. The FGE values for steelhead were some of the highest ever recorded in the Columbia River System. The TFGEs for yearling chinook salmon and steelhead were 96.7 and 97.8%, respectively, for the one test conducted (detailed results are in Appendix Table B2). This indicated that approximately 80 and 93% of the chinook salmon and steelhead, respectively, that were assumed guidable, were guided.

Table 1.--Fish guidance efficiency (FGE) and theoretical fish guidance efficiency (TFGE) for tests at Ice Harbor Dam, 1987.

	FGE		TFGE	
Date	Yearling chinook salmon	Steelhead	Yearling chinook salmon	Steelhead
3 May	73.1	95.2	-	-
4 May	85.2	90.1	-	-
5 May	79.2	95.1	-	-
6 May	75.3	94.6	-	-
8 May	75.8	87.6	96.7	97.8
Mean	77.7% ± 8.2% (95% C.I.)	92.5% ± 6.1% (95% C.I.)		

Descaling was monitored for all tests and averaged 4.0% for yearling chinook salmon and 4.3% for steelhead. These values were similar to values obtained in other FGE testing at other Snake River projects.

On 10 and 23 June, FGE tests were attempted on subyearling chinook salmon. The target group was released 1 June from Lyons Ferry Hatchery, located approximately 80 Km upstream from the project. Few of these fish successfully migrated to Ice Harbor Dam during the test period, and thus, inadequate sample sizes were obtained for valid tests. The lack of fish migration during the testing period could be due to a number of things including low river flows and high water temperatures.

CONCLUSIONS

1. The mean FGEs for yearling chinook salmon and steelhead were approximately 78 and 92%, respectively. These values are reasonable estimates of the guidance levels that could be expected if an STS bypass system were installed at Ice Harbor Dam.
2. Due to insufficient numbers of subyearling chinook salmon during the testing period, additional field research is necessary to determine the potential guidance ability of STSs for these fish.

ACKNOWLEDGMENTS

We extend a very special thanks to the COE personnel at Ice Harbor Dam and the Walla Walla District Office for their assistance and cooperation in conducting this study. Numerous times during the study, COE personnel responded and worked during weekends and other than normal duty hours when unforseen problems arose. This cooperative effort resulted in a successful season even though less than favorable circumstances could have easily resulted in failure. We also wish to express appreciation to our seasonal personnel and regular maintenance staff, especially W. F. Cobb, M. Lianne Morris, Phillip Weitz, and Dennis Woodcock for their excellent assistance and cooperation in completing this study.

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APPENDIX A

Setup Problems

Numerous problems were encountered during the setup for the 1987 field season at Ice Harbor Dam. As a result, the testing was delayed from the originally scheduled start of 15 April. The STSs did not arrive at the project until 17 April, and as a consequence, crews were worked 10-14 h/day, 7 d/week to correct problems. The specific problems encountered, with solutions ( ), were as follows:

1) The STSs did not fit into the bulkhead slots because the guide shoes did not allow enough end to end clearance. (Project COE and NMFS personnel removed the old shoes and installed new ones on site.)
2) The pendant cable master link did not fit the gantry block. (Project COE personnel located a workable link.)
3) The hoist pendant cables were massive and cumbersome increasing normal rigging operation time. (Longer work periods were scheduled to complete the work.)
4) The STS lifting beam guides were located in the wrong place. (Project COE personnel modified them to allow attachment of the STS to the lifting beam.)
5) The lifting beam would not initially work to extend the STS. (Project COE modified the beam for use in extending the STS.)
6) Extension cables were not provided with the STSs. (Three days were required to procure them from the Tri-Cities area.)
7) The STSs would not work in Gateslots 3B or 4B. (STSs were only used in Gateslots 3A and 3C.)
8) The gantry crane was extremely slow. (Longer hours were scheduled to complete work and only one fyke net frame was used for each test night.)

APPENDIX B

Data Summaries

Appendix Table B1.--Catch data and fish guiding efficiency (FGE) from submersible traveling screen evaluation studies in Turbine Unit 3, Slot A, Ice Harbor Dam, 1987.

	Time			Nets[c]									
Date[a]	Start	End	Spp.[b]	LG	RG	LC	RC	M1	M2	M3	Adjusted total[d]	Gatewell catch	FGE[e]
3 May	1903	2227	5	2	9	22	39	12	10	1	141	384	73.1
			6	0	1	4	4	0	3	0	18	357	95.2
			1	0	0	0	0	0	0	0	0	1	----
			4	0	0	0	0	0	0	0	0	1	----
			9	0	0	1	0	0	0	0	1	1	----
4 May	1900	0048	5	3	2	6	10	1	1	0	27	156	85.2
			6	0	0	6	5	4	2	2	35	318	90.1
			1	0	0	0	0	0	0	0	0	1	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	0	0	0	0	0	0	0	3	----
5 May	1900	0230	5	1	0	15	13	5	2	1	53	202	79.2
			6	1	1	2	9	3	2	1	31	604	95.1
			1	0	0	0	0	0	0	0	0	3	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	0	0	1	0	0	0	1	2	----
6 May	1900	0145	5	3	2	10	16	6	5	1	67	204	75.3
			6	1	0	2	6	1	2	1	21	369	94.6
			1	0	0	0	0	0	0	0	0	2	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	0	0	0	0	0	0	0	3	----
8 May	1900	2230	5	2	2	17	15	9	4	0	75	235	75.8
			6	0	0	3	7	4	5	1	40	283	87.6
			1	0	0	0	0	0	0	0	0	2	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	0	0	0	0	0	0	0	1	----
10 Jun	2000	2400	5	0	0	0	0	0	0	0	0	0	----
			6	0	0	0	0	0	0	0	0	1	----
			1	0	0	0	0	0	0	0	0	0	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	0	0	0	0	0	0	0	1	----
23 Jun	2000	2400	5	0	0	0	0	0	0	0	0	0	----
			6	0	0	0	0	0	0	0	0	1	----
			1	0	0	0	0	0	0	0	0	1	----
			4	0	0	0	0	0	0	0	0	0	----
			9	0	1	2	0	0	1	0	6	4	----

Appendix Table B1.---cont.

a/ Month/day
b/ Species codes: 1=sockeye, 4=coho, 5=yearling chinook salmon, 6=steelhead, 9=subyearling chinook salmon.
c/ Net codes: 1st character, L=left, M=middle, R=right
2nd character, G=gap, C=closure
1-3=fyke net level (Fig. 2)
d/ Adjusted total = RG+LG+RC+LC+3(M1+M2+M3)
e/ FGE = Gatewell catch/(Gatewell catch + Adjusted Total) X 100

---- denotes insufficient sample size.

Appendix Table B2.--Catch data and theoretical fish guiding efficiency from a vertical distribution test during submersible traveling screen evaluation studies in Turbine Unit 3, Slot B, Ice Harbor Dam, 1987.

	Time			Nets[c]									
Date[a]	Start	End	Spp.[b]	M1	M2	M3	M4	M5	M6	M7	Adjusted total[d]	Gatewell catch	FGE[e]
8 May	1900	2230	5	334	140	17	13	5	1	0	1530	184	96.7
			6	274	31	5	5	1	1	1	954	134	97.8
			1	0	0	0	0	0	0	0	0	0	----
			4	0	0	0	0	0	0	0	0	0	----
			9	2	1	0	0	0	0	0	9	1	----

a/ Month/day
b/ Species codes: 1=sockeye, 4=coho, 5=yearling chinook salmon, 6=steelhead, 9=subyearling chinook salmon.
c/ Net codes: M=middle net column, 1-7=fyke net level.
d/ Adjusted net total = (M1+M2+M3+M4+M5+M6+M7) X 3.
e/ TFGE = gatewell catch +(M1+M2+M3) / total catch X 100
where total catch = adjusted net total + gatewell catch.

---- denotes insufficient sample size.