CZES Coastal Zone and Estuarine Studies

# FINAL REPORT

# EVALUATION OF THE FINGERLING BYPASS SYSTEM AT JOHN DAY DAM AND THE FINGERLING BYPASS OUTFALL AT McNARY DAM

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# INTRODUCTION

In 1973, the National Marine Fisheries Service initiated evaluation studies of the fingerling bypass at John Day Dam. The evaluation had the following objectives: (1) define the relative passage efficiency of the bypass system as designed, (2) determine the condition of fish that have passed through the system, and (3) develop ways of improving fingerling passage in the event that the system was found to be deficient.

Initial research indicated that while injury and mortality of fish passing through the system at John Day Dam were minimal, the system, as designed, did not adequately pass fingerlings from the turbine intake gatewells. Subsequent research concentrated on development of the following techniques to enhance fingerling passage: (1) increasing operational velocity by eliminating bell-mouth orifices and by closing orifices in some gatewells, (2) installing lighted orifice inserts, and (3) installing vertical barrier screens in the turbine intake gatewell to concentrate fish in the area of the escape orifice. While these techniques improved passage, the system was still not functioning as well as desired[1/].

Tests to evaluate the passage enhancement potential of a simulated corner orifice (SCO) and a "crowder" device were initiated in 1975 but were not completed. At the request of the fishery agencies and the Corps of Engineers, testing of these two devices was continued in 1976.

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1. NOAA, NMFS, NWAFC, Seattle, WA. Progress Report, U.S. Army Corps of Engineers. Contract DACW57-74-F-0542 (Processed).

Research was also begun in 1976 to determine the extent of fingerling mortality at existing fingerling bypass outfalls below John Day and McNary Dams. Before planned screening programs at the two dams are implemented, it must be determined that existing outfalls are safe. A bypass system that discharges fingerlings into predator infested areas of the tailrace could produce greater mortality than passing the fingerlings through the turbines. Because of screening priorities, our research in 1976 was concentrated at McNary Dam, where mortality at both the north and south outfalls was evaluated.

## METHODS

Exit ports are located in the center of the gatewells at John Day Dam. At other dams, where fingerling passage from gatewells is much better, orifices are located in the corners. A lighted, 6-inch diameter SCO provided a means of evaluating benefits of a corner orifice at John Day Dam (Figure 1). The SCO was tested during high (>265') and low (<262') reservoir levels. Different orifice submergence depths were achieved by lengthening or shortening the 6-inch diameter PVC pipe connecting the corner orifice to the standard center orifice and adjusting connecting ropes to the intake deck.

A "crowder" designed to force the fish into the orifice area was also tested at John Day Dam in 1976 (Figure 2). The crowder was essentially the same as tested in 1975 except that a baffle was added to reduce turbulence. This baffle proved to be ineffective and was removed after one test.

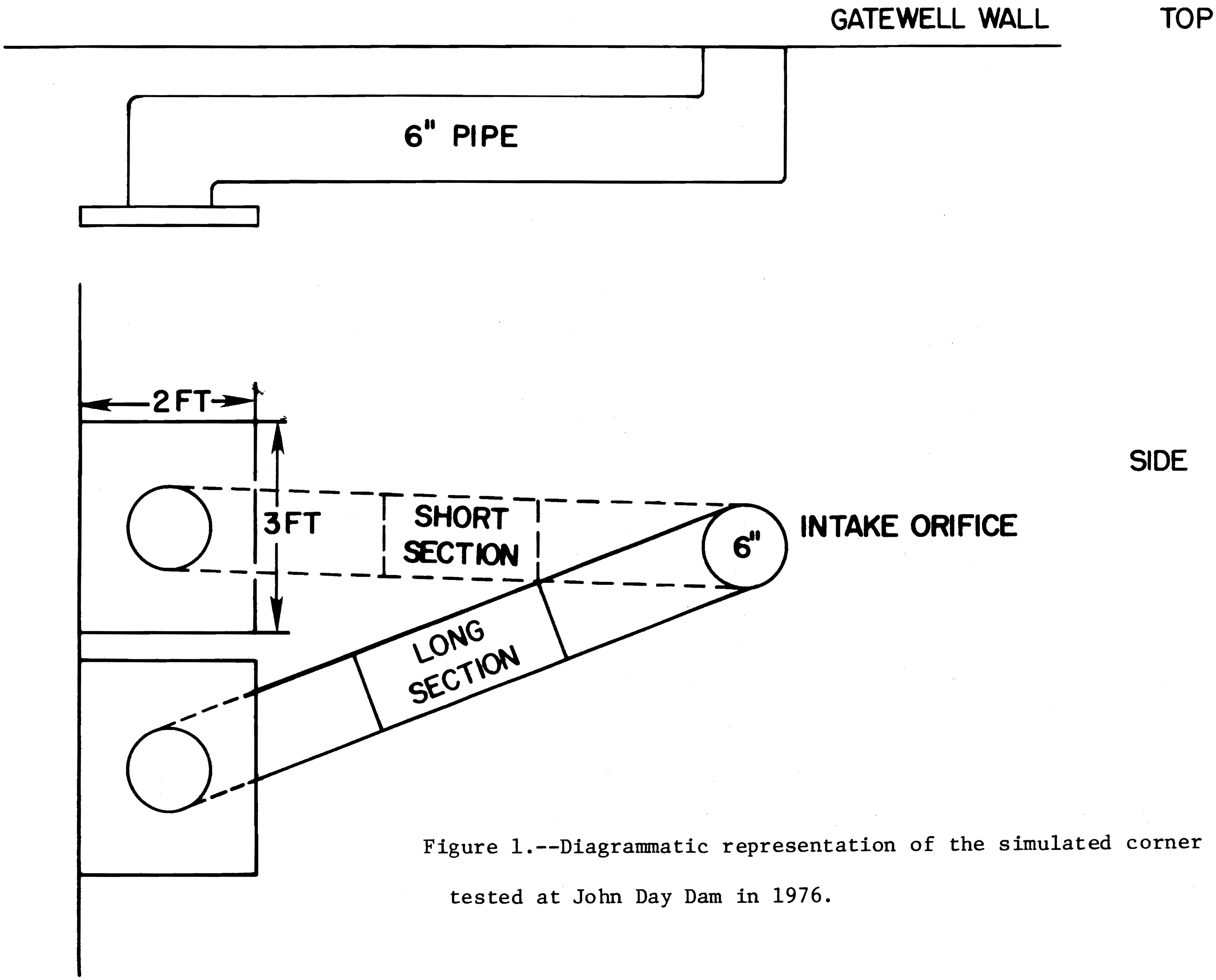


Figure 1.--Diagrammatic representation of the simulated corner orifice tested at John Day Dam in 1976.

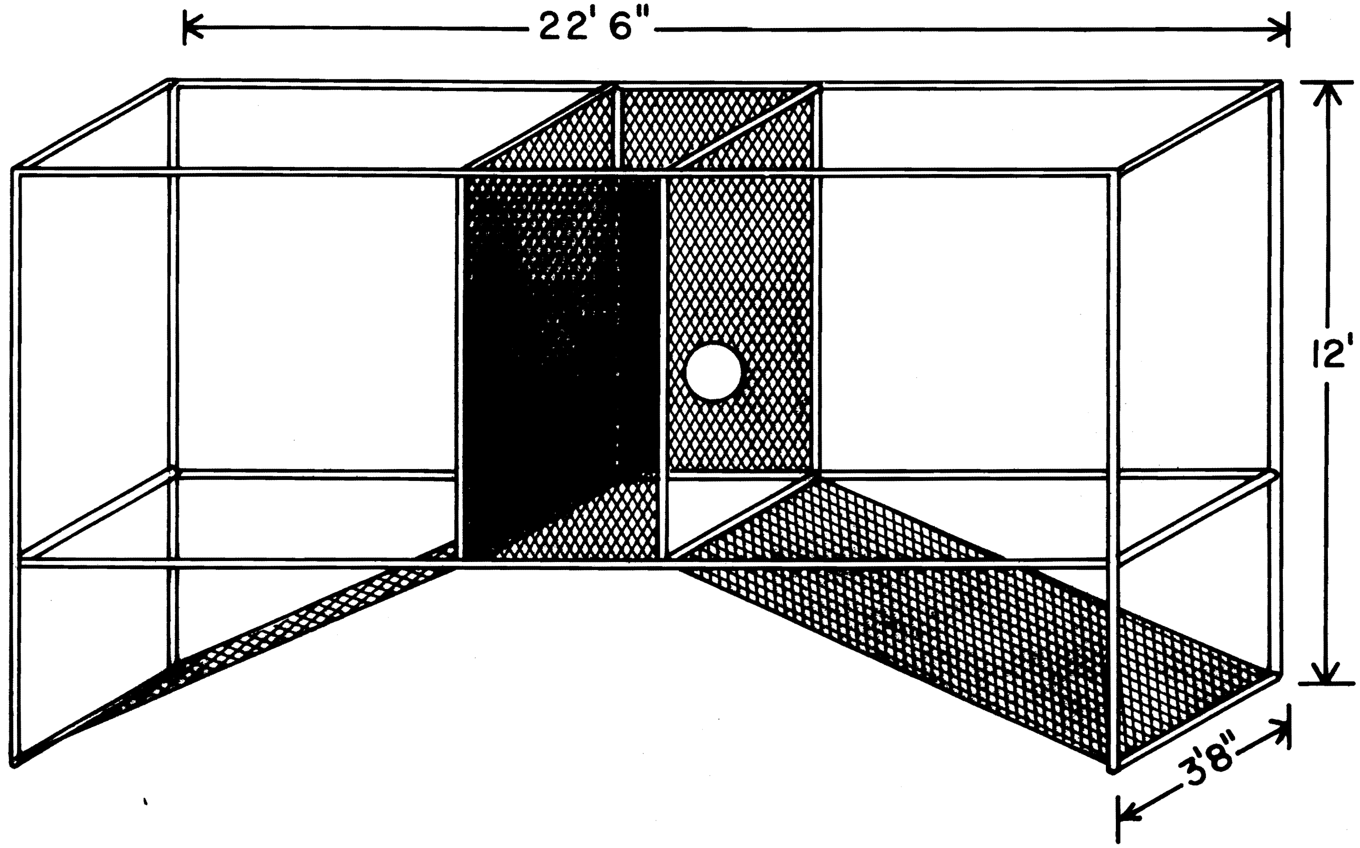


Figure 2.--Diagrammatic representation of the gatewell fish "crowder" tested at John Day Dam in 1976.

Evaluation of both devices was based on a system of dipnetting the gatewells and comparing the number of fish captured after each 24-hour test period. Throughout this years evaluation, turbine unit 3A was used as the test gatewell and unit 3B served as the control. To enable us to compare these two units on an equal basis, an entry rate was established for each unit. This was accomplished by closing the exit ports, dipnetting the fish from the gatewell, waiting a given period, dipnetting each unit again, and counting the fish obtained in the second dipping. By comparing the numbers in the two units, we arrived at an adjustment factor that allowed us to equalize the entry rate for the two gatewells. By using this method of evaluation, we were able to remove the fish trap from the lower end of the bypass and operate the bypass system at maximum design velocity.

To determine the adjustment factor, measurements were made on twelve occasions during the 1976 season (Table 1). Results indicated that 4,207 fingerlings entered unit 3B while 2,764 entered unit 3A. This required that the catch from all SCO and "crowder" tests in unit 3A be adjusted by a factor of 1.5 before comparing them to catches in the control gatewell (unit 3B).

All gatewell sampling was done on a "clean-out" basis. Continuing dips would be made in any given gatewell until the catch diminished to $\leq$ 10% of the number of fish contained in the first dip. Based on diel sampling results and marked fish recoveries, the efficiency of sampling in units 3A and 3B (both contained vertical barrier screens) approached 100%.

Table 1.-- Number of juvenile chinook salmon dipnetted from turbine intake gatewells 3A and 3B during periods when bypass orifices were closed, John Day Dam, 1976.

| Date | | Unit 3A | Unit 3B |
|---|---|---|---|
| 5/28 | | 499 | 702 |
| 6/16 | | 270 | 339 |
| 6/18 | | 198 | 292 |
| 6/23 | | 160 | 309 |
| 6/25 | | 302 | 475 |
| 7/9 | | 82 | 134 |
| 7/17 | | 106 | 188 |
| 7/22 | | 52 | 117 |
| 8/10 | | 102 | 201 |
| 8/11 | | 301 | 426 |
| 8/12 | | 465 | 671 |
| 8/25 | | 227 | 353 |
| | Totals | 2,764 | 4,207 |

Fingerling mortalities at the two outfalls from the bypass system at McNary Dam were evaluated in 1976. This evaluation was based on comparative recoveries at John Day Dam from six groups of marked "0"-age chinook salmon released at various locations below McNary Dam during mid-July. Day and night experimental releases were made at both the north and south outfall. Control releases were made beneath the Umatilla Bridge on the Oregon shore, approximately 1.5 miles downstream from the dam.

Test fish for the outfall evaluation were obtained from the spawning channel at Priest Rapids Dam (WDF), freeze branded, and transferred to holding facilities at Little Goose Dam for additional rearing. Releases at McNary Dam were made on July 20, 21, and 22. River flows during the release period ranged from 340,000 to 257,000 cfs total discharge with spill ranging from 99,000 to 51,000 cfs. River temperature was 64°F.

## ENHANCEMENT TEST RESULTS - JOHN DAY DAM

Thirty-six SCO and six "fish-crowder" tests provided sufficient data to determine their potential for enhancing passage of fingerlings from gatewells at John Day Dam. (Individual test data are presented in Appendix Tables 1, 2, and 3). The SCO and "crowder" were tested during both high and low forebay levels, but only low forebay tests were conducted during the spring outmigration. High forebay tests were restricted to the summer months. Catch composition at John Day Dam during the spring is approximately 39% yearling chinook salmon, 48% steelhead trout, 9% sockeye salmon, 5% coho salmon and only 0.5% "0"-age chinook salmon. In contrast, catches during the summer months are about 99% "0"-age chinook salmon. Therefore, evaluation tests during high and low forebay levels utilized different stocks of fish.

A summary of the SCO evaluation tests is presented in Table 2. Results were not encouraging. During the low forebay level tests of design velocities, the SCO failed to pass fingerlings as effectively as the control orifice at all depths tested. During low forebay level tests at increased velocities, a small (17%) increase in passage was achieved at 5 feet of SCO submerged (only submergence level tested). During high forebay level testing, a 17% increase in passage was achieved at 15 feet of SCO submergence. At the 5 and 10-foot submergence levels, the SCO efficiency failed to equal that of the control orifice.

Failure of the SCO to pass fish appeared to be related to excessive turbulence in the test gatewell. This turbulence, resulting from unbaffled barrier screens, continuously forced fingerlings away from the exit port of the SCO. The effect of this turbulence on the passage efficiency of the SCO was demonstrated during the late summer when several tests were run with turbine unit 3 shut down from 3 a.m. to 7 a.m. during each 24-hour test period. Since 80 to 90% of the fish enter the gatewells between 10 p.m. and 3 a.m., this shutdown provided a 4-hour period with no turbulence during which time most of the fish could exit from the gatewell. While numbers of fish taken during these shutdown tests were not significant, the passage efficiency of the SCO was enhanced 63% at the 10-foot orifice submergence level and 74% at the 5-foot submergence level. No increase was noted at the 15-foot orifice submergence level.

Table 2.--Summary of the Simulated Corner Orifice (SCO) testing program at John Day Dam, 1976. (Catch = Number of fish remaining in gatewells after 24-hour test period).

| Test conditions | No. of tests | Experimental Gatewell 3A | | Control Gatewell 3B catch (B) | Increase in fish passage $\frac{(B-A)}{B}$ |
|---|---|---|---|---|---|
| | | Catch | Adj. catch[1] (A) | | |
| | No. | No. | No. | No. | % |
| Design Velocity (All ports open) | | | | | |
| High Forebay[2] | | | | | |
| 5' Orifice submergence | 2 | 2,964 | 4,446 | 3,012 | 0 |
| 10' Orifice submergence | 8 | 5,554 | 8,331 | 4,662 | 0 |
| 15' Orifice submergence | 3 | 793 | 1,190 | 1,428 | 17 |
| Low Forebay[3] | | | | | |
| 2' Orifice submergence | 2 | 1,078 | 1,617 | 1,473 | 0 |
| 5' Orifice submergence | 4 | 5,625 | 8,438 | 5,365 | 0 |
| 10' Orifice submergence | 7 | 2,770 | 4,155 | 4,489 | 0 |
| Increased Velocity | | | | | |
| (15 ports open) | | | | | |
| Low Forebay | | | | | |
| 5' | 4 | 1,085 | 1,628 | 1,964 | 17 |

1/ Catch x 1.5 adjustment factor

2/ $\geq$265' forebay elevation

3/ $\leq$262' forebay elevation

The effectiveness of the fish "crowder" also proved to be minimal (Table 3). Increases in passage effectiveness ranged from 0 to 12%--levels that do not indicate significant improvement. The major difficulty with the "crowder" was that it tended to funnel debris as well as fish into the exit orifice. This resulted in continuous orifice plugging and related operational difficulties.

## FUTURE CONSIDERATIONS AT JOHN DAY DAM

Research relative to the fingerling bypass system at John Day Dam has been conducted since 1973. The thrust of this research has been concerned with developing some simple and inexpensive method of increasing the fish passage efficiency of the existing system to an acceptable level. Several of the enhancement modifications developed and tested did significantly increase passage efficiency over design capability; however, an acceptable bypass system must operate at a level of efficiency that will prevent the build-up of large numbers of fingerlings in the turbine intake gatewells for extended periods of time. None of the modifications tested, alone or in combination, achieved this level of effectiveness.

Continued searching for an inexpensive and simple solution appears to have little chance of success; therefore, new and different approaches to the problem must be researched. In view of the increasing numbers of fingerlings from the mid-Columbia that will be passing John Day Dam in the future, it is important that expanded research at that dam be initiated as soon as possible. Even with scheduled collection and transportation of fingerlings from McNary Dam, several million salmonid

Table 3.--Summary of the "Fish Crowder" testing program at John Day Dam, 1976 (Catch = number of fish remaining in the gatewells after 24-hour test period).

| Test conditions | No. of tests | Experimental Gatewell 3A | | Control Gatewell 3B | Increase in fish passage |
|---|---|---|---|---|---|
| | | Catch | Adj. catch[1] (A) | catch (B) | $\frac{(B-A)}{B}$ |
| | No. | No. | No. | No. | % |
| High Forebay[2] | | | | | |
| with light | 1 | 168 | 252 | 273 | 8 |
| without light | 1 | 372 | 558 | 636 | 12 |
| Low Forebay[3] | | | | | |
| with baffle | 1 | 2,306 | 3,459 | 2,594 | 0 |
| without baffle | 1 | 597 | 896 | 946 | 5 |

1/ Catch x 1.5 adjustment factor

2/ ≥265' forebay elevation

3/ ≤262' forebay elevation

smolts will enter John Day Reservoir each year because of spilling at McNary Dam (2nd powerhouse will not be completed for at least 10 years). Until an efficient fingerling bypass is operational at John Day Dam, it will be necessary to maintain some sort of gatewell dipping salvage operation there during periods of major outmigration.

## MCNARY OUTFALL EVALUATION

Four experimental and two control groups of marked fish were released below McNary Dam to evaluate differential mortality at the two fingerling bypass outfalls during daytime and at night. Under normal operating conditions, only the north outfall is operated at McNary Dam. The south outfall was made operational only for this test.

Test results are summarized and presented in Table 4. (Detailed mark recovery data can be found in Appendix Table 4.) Based on recoveries of test and control fish, no differential mortality was found between the north and south outfall during the daytime or between the day and night releases at the south outfall. By contrast, night releases at the north outfall showed an approximate 50% increase in mortality over other releases. The increased night mortality at the north outfall suggests a predation problem. It should be remembered that at the time these tests were made, most fingerlings were passing through the bypass system at night. It is logical to assume that predator fish would key their feeding activity to the major period of fingerling migration. Since no fingerlings are normally passing over the south outfall, it is also logical to assume that predator species would not be concentrated in this area. Since the tailrace deck near the outfalls is well lighted, this

Table 4.--Summary of the McNary Dam outfall evaluation, 1976.

| Release site - McNary Dam | Number released | Recovered at John Day Dam No. | % |
|---|---|---|---|
| Experimental | | | |
| North outfall (Day) | 13,281 | 105 | 0.8 |
| South outfall (Day) | 6,140 | 50 | 0.8 |
| Control | | | |
| Umatilla Bridge (Day) | 13,253 | 92 | 0.7 |
| Umatilla Bridge (Night) | 11,829 | 78 | 0.7 |
| Experimental | | | |
| North outfall (Night) | 14,477 | 64 | 0.4 |
| South outfall (Night) | 9,528 | 75 | 0.8 |

may be aiding the predators in their capture of prey. Tests will be made in 1977 to determine the effect on predation of turning the lights out on the tailrace deck near the north outfall.

## SUMMARY AND CONCLUSIONS

Results obtained in 1976 are summarized as follows:

1. The 6-inch simulated corner orifice tested at John Day Dam did not significantly increase fingerling passage from turbine intake gatewells. Failure appeared related to low operating velocities combined with excessive gatewell turbulence caused by the vertical barrier screens in the units tested. Turbulence can be controlled by baffling the vertical screens, but increasing the velocities will require drilling larger exit ports into the bypass conduit as well as other major system modifications.

2. Passage enhancement potential of the fish "crowder" proved to be limited. Tests showed a maximum increase in passage effectiveness over the control condition of only 12%. In addition, the "crowder" tended to concentrate debris as well as fish in the vicinity of the exit orifice and resulted in serious clogging problems.

3. Until a solution of the bypass problem at John Day Dam is found, a salvage dipnetting operation will be required to remove fingerlings from these gatewells.

4. Test fish released at night into the north outfall at McNary Dam showed about a 50% increase in mortality over fish released into the north outfall during the day and over both day and night releases

into the south outfall. This mortality may be related to increased predator activity generated by the availability of large numbers of fingerlings normally exiting the north outfall at night. Lighting on the deck may be enhancing the effectiveness of predators in the area.

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Appendix Table 4.--Marked juvenile chinook salmon recaptured at John Day Dam, July 23 - December 16, 1976, for McNary Dam outfall evaluation.

Appendix Table 1.--Numbers of juvenile salmonids remaining in test and control gatewells at John Day Dam at the end of "Simulated Corner Orifice" test periods in 1976.

| Test Period | Test Conditions: Design Velocity | Test Conditions: Increased Velocity | Test Conditions: High reservoir 1/ | Test Conditions: Low Reservoir 2/ | Experimental Gatewell 3A, Simulated Corner Orifice, Depth Tested: 2 ft | 5 ft | 10 ft | 15 ft | Control Gatewell 3B |
|---|---|---|---|---|---|---|---|---|---|
| 5/7 | X | | | X | | 915 | | | 1079 |
| 5/11 | X | | | X | | 1802 | | | 1709 |
| 5/12 | X | | | X | | | 2388 | | 1627 |
| 5/13 | X | | | X | | | 1589 | | 1174 |
| 5/14 | X | | | X | | 2230 | | | 1671 |
| 5/15-17 | X | | | X | | | 2773 | | 2166 |
| 5/18 | X | | | X | | | 982 | | 1409 |
| 5/19 | X | | | X | | | 812 | | 1062 |
| 5/20 | X | | | X | | | 925 | | 1299 |
| 5/25 | X | | | X | | 678 | | | 906 |
| 5/26 | X | | | X | 494 | | | | 702 |
| 5/27 | X | | | X | 584 | | | | 771 |
| 6/2 | | X | | X | | 201 | | | 432 |
| 6/3 | | X | | X | | 227 | | | 414 |
| 6/4 | | X | | X | | 234 | | | 482 |
| 6/6-7 | | X | | X | | 423 | | | 636 |
| 6/8 | X | | | X | | | 168 | | 309 |
| 6/9 | X | | | X | | | 100 | | 135 |
| 6/12-14 | X | | X | | | | | 179 | 250 |
| 6/29-30 | X | | X | | | | 91 | | 173 |
| 7/1-2 | | X | X | | | | 64 | | 304 |
| 7/13 | | X | X | | | | 47 | | 146 |
| 7/14 | | X | X | | | 14 | | | 81 |
| 7/15 | | X | X | | | | | 67 | 41 |
| 7/20-21 | | X | X | | | 13 | | | 48 |
| 7/24-26 | X | | X | | | | 319 | | 491 |
| 7/27 | X | | X | | | | 472 | | 720 |
| 7/28 | X | | X | | | | 680 | | 908 |
| 7/29 | X | | X | | | | 324 | | 422 |
| 7/30 | X | | X | | | | 346 | | 785 |
| 7/31-8/2 | X | | X | | | 2763 | | | 2816 |
| 8/3 | X | | X | | | | 461 | | 707 |
| 8/4 | X | | X | | | | 168 | | 456 |
| 8/5 | X | | X | | | | | 325 | 725 |
| 8/6 | X | | X | | | | | 289 | 453 |
| 8/31 | X | | X | | | 201 | | | |

1/ Elevation 266' or higher
2/ Elevation 261' or lower

Appendix Table 2.--Numbers of juvenile salmonids remaining in test and control gatewells at John Day Dam at the end of "Crowder" test periods in 1976.

| Test Period | Test Conditions: Design Velocity | Test Conditions: Increased Velocity 1/ | Test Conditions: High Reservoir 1/ | Test Conditions: Low Reservoir 2/ | Experimental Gatewell 3A: Standard Crowder | Experimental Gatewell 3A: Baffled Crowder | Control Gatewell 3B |
|---|---|---|---|---|---|---|---|
| 5/21 | X | | | X | 597 | | 946 |
| 5/22-24 | X | | | X | | 2306 | 2594 |
| 6/19-21 | X | | X | | 168 3/ | | 273 3/ |
| 6/26-28 | X | | X | | 372 | | 636 |
| 7/10-12 | | X | X | | 120 | | 339 |
| 7/16 | | X | X | | 87 | | 105 |

1/ Elevation 266' or higher

2/ Elevation 261' or lower

3/ Orifice light off

Appendix Table 3.--Numbers of juvenile salmonids remaining in test and control gatewells at John Day Dam at the end of various test periods in 1976.

| | Test Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Test Period | Design Velocity | Increased Velocity | High Reservoir 1/ | Low Reservoir 2/ | Ports Open | Ports Closed | Experimental Gatewell 3A | Control Gatewell 3B |
| 5/28 | | | | X | | X | 499 | 702 |
| 5/29-6/1 | | X | | X | X | | 1171 | 1265 |
| 6/15-16 | | | X | | | X | 270 | 339 |
| 6/17-18 | | | X | | | X | 198 | 292 |
| 6/22-23 | | | X | | | X | 160 | 309 |
| 6/24-25 | | | X | | | X | 302 | 475 |
| 7/3-6 | | X | X | | X | | 687 | 901 |
| 7/9 | | | X | | | X | 82 | 134 |
| 7/17-19 | | | X | | | X | 106 | 188 |
| 7/22-23 | | | X | | | X | 52 | 117 |
| 8/10 | | | X | | | X | 102 | 201 |
| 8/11 | | | X | | | X | 301 | 426 |
| 8/12 | | | X | | | X | 465 | 671 |
| 8/13 | X | | X | | X | | 240 | 331 |
| 8/14-16 | X | | X | | X | | 365 | 350 |
| 8/21-23 | X | | X | | X | | 790 | 675 |
| 8/24 | X | | X | | X | | 856 | 845 |
| 8/25 | | | X | | | X | 227 | 353 |
| 8/27 | X | | X | | X | | 171 | 177 |
| 8/28 | X | | X | | X | | 683 | 579 |
| 8/29 | X | | X | | X | | 348 | 391 |
| 8/30 | X | | X | | X | | 372 | 494 |

1/ Elevation 266' or higher

2/ Elevation 261' or lower

Appendix Table 4.--Marked juvenile chinook salmon recaptured at John Day Dam July 23 - December 16, 1976, for McNary Dam outfall evaluation.

| Experimental Conditions | Test | | Control | | Test | |
|---|---|---|---|---|---|---|
| Release time | Day | Day | Day | Night | Night | Night |
| | LD U | LD ⊃ | RD U | LD ∩ | RD ⊃ | RD ∩ |
| Release site | North outfall | South outfall | Umatilla Bridge | Umatilla Bridge | North outfall | South outfall |
| Recovery date | | | | | | |
| 7/23 | 1 | | | | | |
| 8/10 | | | 1 | | | |
| 11 | | | | | | 1 |
| 23 | | 1 | | | | |
| 24 | 2 | 1 | 3 | | | 1 |
| 25 | 1 | | 5 | | | 1 |
| 26 | 1 | 1 | 4 | 1 | | 4 |
| 27 | 4 | | 1 | 1 | | 1 |
| 28 | 2 | | 2 | 2 | 1 | 1 |
| 29 | 2 | | | 2 | | |
| 30 | 2 | | 1 | 2 | 1 | 1 |
| 31 | 2 | 2 | 1 | 1 | | |
| 9/ 1 | 4 | | 3 | 1 | | 1 |
| 7 | 2 | | | | | |
| 8 | 2 | 3 | | | | 1 |
| 13 | 1 | 1 | 2 | 2 | 1 | 1 |
| 15 | 2 | | 2 | | | |
| 17 | 2 | 1 | | 1 | | |
| 23 | 1 | | | 4 | 2 | 2 |
| 27 | 3 | 2 | 6 | 2 | | 2 |
| 29 | 1 | 2 | 2 | | | 1 |
| 10/ 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 5 | 8 | 1 | 11 | 1 | 2 | 10 |
| 7 | 6 | 1 | 8 | 7 | 10 | 10 |
| 12 | 8 | 2 | 3 | 1 | 6 | 3 |
| 13 | 4 | 1 | 6 | 1 | 1 | |

Appendix Table 4.--Continued

| Experimental Conditions | Test | | Control | | Test | |
|---|---|---|---|---|---|---|
| Release time | Day | Day | Day | Night | Night | Night |
| Brand | LD U | LD ⊃ | RD U | LD ∩ | RD ⊃ | RD ∩ |
| Release site | North outfall | South outfall | Umatilla Bridge | Umatilla Bridge | North outfall | South outfall |
| Recovery date | | | | | | |
| 10/14 | | | 1 | | 1 | 3 |
| 15 | | | 1 | 1 | | |
| 18 | 5 | 4 | 4 | 10 | 6 | 4 |
| 19 | 4 | 1 | 3 | | 1 | |
| 20 | 4 | 4 | 1 | 3 | 5 | 2 |
| 21 | 3 | 1 | 1 | | 2 | 1 |
| 22 | | 2 | 1 | 3 | 1 | |
| 26 | 2 | 1 | | | 1 | 2 |
| 27 | 1 | 3 | 4 | 5 | 2 | 3 |
| 29 | 6 | 5 | 2 | 9 | | 8 |
| 11/ 1 | 5 | | 2 | 2 | 4 | 1 |
| 2 | | | | 1 | 1 | |
| 3 | 1 | 2 | 1 | 2 | 1 | 2 |
| 4 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | 2 | 1 | 2 | | |
| 8 | | | | 1 | | 1 |
| 9 | | | 1 | 1 | | 1 |
| 15 | 1 | | | 1 | | 1 |
| 19 | 1 | | 1 | 1 | | |
| 23 | | | 2 | | 1 | |
| 30 | 1 | 2 | | | 1 | 1 |
| 12/ 7 | 3 | | 2 | | | 2 |
| 14 | 3 | 2 | | 4 | 1 | |
| 16 | 1 | | | | 4 | |
| TOTALS | 105 | 50 | 92 | 78 | 64 | 75 |