Descaling and orifice passage efficiency studies at McNary Dam, 1995

Coastal Zone and Estuarine Studies Division

Northwest Fisheries Science Center

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Seattle, Washington

by
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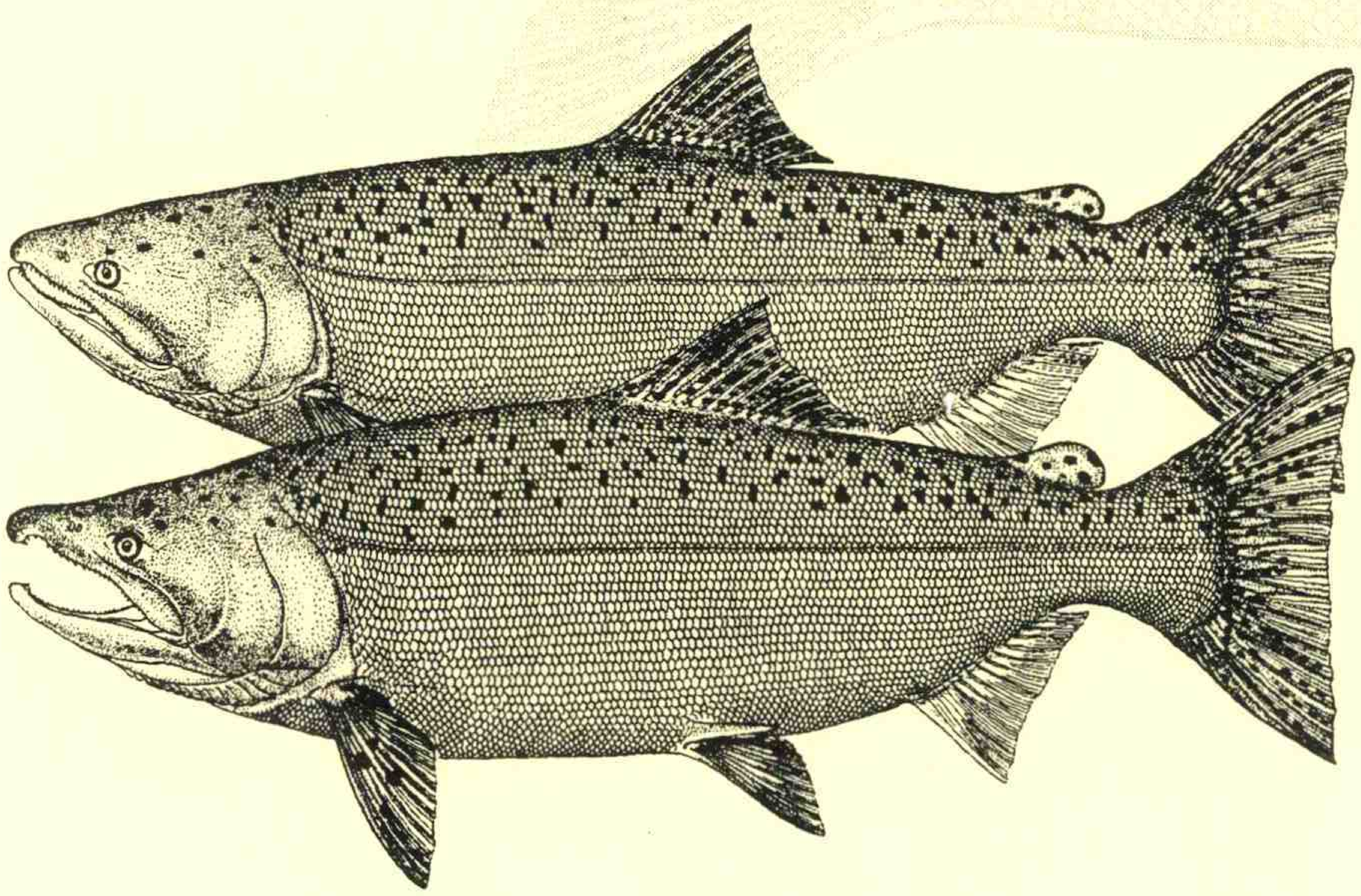

DESCALING AND ORIFICE PASSAGE EFFICIENCY STUDIES AT MCNARY DAM, 1995

by

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EXECUTIVE SUMMARY

Extended-length submersible bar screens (ESBSs) have been tested at McNary Dam since 1991 as alternatives to standard-length submersible traveling screens (STSs) for guiding downstream migrating juvenile salmonids out of turbine intakes. During the 1995 spring and summer outmigration periods, the National Marine Fisheries Service conducted studies to evaluate the gatewell orifice passage efficiency (OPE) for chinook salmon and steelhead using an ESBS with a newly designed vertical barrier screen and an inlet flow vane. An auxiliary study compared juvenile fish descaling associated with two beam extension modifications in gatewells equipped with these new guidance devices.

Two methods were used to compare OPE between north and south orifices for each of the outmigration periods. First, orifice traps provided an absolute measure of the proportion of migrants passing through the test slot during a 22-hour period. Second, a mark/recapture method furnished an estimate of marked chinook salmon egress from the gatewell over 22 hours. Mean orifice passage efficiency was >70% (range: 43-100%) for all salmonids using either method. Mark/recapture OPE estimates were significantly higher than orifice trap estimates for both yearling and subyearling chinook salmon.

There was no significant difference in OPE between north and south orifices for either yearling or subyearling chinook salmon using orifice traps, or for yearling chinook salmon using the mark/recapture method.

There was no significant difference in descaling for any species between gatewell and orifice traps, or between beam extension types in ESBS test slots. Descaling in the gatewell of the STS control slot (11.2% for yearling chinook salmon and 13.9% for steelhead) was significantly higher than in either ESBS test slot for yearling chinook salmon (7.2 and 8.9%) and steelhead (9.1 and 9.3%). There were no statistical differences in descaling for subyearling chinook salmon among the three test slots.

INTRODUCTION

The National Marine Fisheries Service (NMFS) has been evaluating extended-length screens for guiding juvenile salmonids (*Oncorhynchus* sp.) out of turbine intakes at McNary Dam since 1991 (Brege et al. 1992;, McComas et al. 1993, 1994, 1995). Based on the results of these studies, the extended-length submersible bar screen (ESBS), combined with a newly designed vertical barrier screen (VBS), was chosen as the guidance system to replace standard-length submersible traveling screens (STSs) and modified balanced-flow vertical barrier screens (MBFVBSs).

The two VBS systems evaluated as replacements for the MBFVBS have been described in detail by McComas et al. (1995). Briefly, VBS1 uses a turning vane, or inlet flow vane, to change the flow of water up into the gatewell which results in a reduction of flow separation and turbulence in the gate slot. However, use of the inlet flow vane requires lowering the guidance device into the turbine intake 0.61 m (2 ft) below the standard elevation, which creates a comparable increase in the gap between the intake ceiling and the downstream end of the guidance screen. For testing in 1994, a beam extension was bolted to the ceiling of the intake to eliminate the increased gap (McComas et al. 1995). In 1995 NMFS, in partnership with the COE, conducted tests to determine whether an analogous device mounted on the frame of the guidance screen would function similarly without adversely affecting juvenile chinook salmon condition. The two alternative beam extension designs were compared using descaling as the evaluation criterion.

The juvenile fish bypass system at McNary Dam is typical of most facilities on the Snake and Columbia Rivers (Fig. 1). Migrant fish are guided into an upstream gatewell

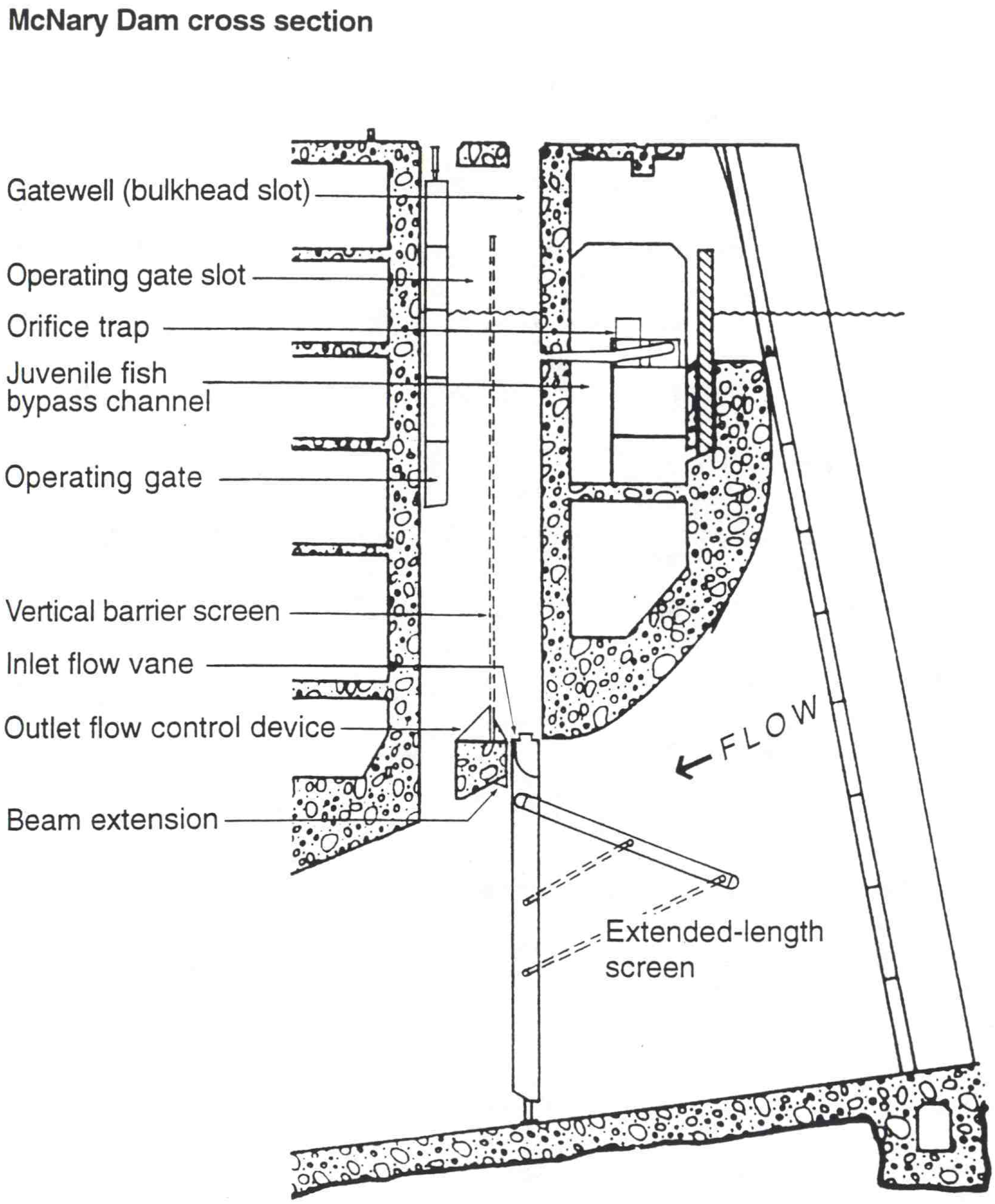

Figure 1. Cross section of turbine unit at McNary Dam with extended-length bar screen, inlet flow vane, outlet flow control device, beam extension, and orifice trap in place.

from which an egress path to the juvenile fish bypass channel is provided through submerged orifices in the upstream wall of the gatewell. Two 30.5-cm (12-in)-diameter orifices have been shown to provide effective orifice passage efficiency (OPE) for chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*) at most facilities (Long et al. 1977, Harmon and Park 1980, Swan et al. 1984, Krcma et al. 1986). Backlighting orifices also improves OPE (Krcma et al. 1978, Krcma et al. 1983), and vertical barrier screen modifications that allow flow attraction near the orifices have been shown to aid fish passage (Swan et al. 1984, Krcma et al. 1985).

Orifice submergence below the gatewell water surface may also affect OPE. For example, Gessel et al. (1986) found that OPE values of up to 85% could be obtained with an orifice submergence of 0.76 m (2.5 ft) at Bonneville Dam First Powerhouse. An OPE value of about 75% was attained at John Day Dam with 1.8-m (7.1-ft) orifice submergence (Krcma et al. 1986). Brege et al. (1987) described variable OPE for orifices in test gatewells at John Day Dam (ranging from 45 to 89%) with a mean submergence of 1.2 m (4.0 ft). At McNary Dam, Krcma et al. (1985) reported mean subyearling chinook salmon OPE values ≥79% with 1.8 to 2.43-m (6 to 8-ft) orifice submergence.

Several methods have been used to evaluate OPE. Where space permits, an orifice trap can provide the absolute number of fish exiting within a specified time period. However, in addition to construction and installation constraints, traps require constant monitoring during the sample period to ensure fish safety, and not all bypass facilities are large enough to accommodate traps and the necessary access to them. One alternative that has been used as a direct estimate of OPE involves releasing a known number of marked fish into the test gatewell, and recapturing those remaining after a given time interval

(Krcma et al. 1986, Brege et al. 1987). This mark/recapture technique is easier to employ than an orifice trap, but OPE values obtained using the two methods are not directly comparable.

Extended-length guidance screens create higher gatewell flows from the turbine intake into the gatewell than STSs. Mean fish guidance efficiency is also higher with the ESBS and newly designed vertical barrier screens, but little is known about the effects of these devices on OPE. As a final phase in testing before installation of the new extended-length guidance systems at McNary Dam, NMFS personnel conducted tests to evaluate OPE with the new systems. Both orifice trap and mark/recapture methods were used to provide better estimates and to offer a basis for comparing results from the two techniques. Specific research objectives for McNary Dam in 1995 were as follows:

1) Evaluate the effects of two alternative beam extension designs (with newly designed vertical barrier screen systems, extended-length bar screen, and inlet flow vane) on descaling for yearling and subyearling chinook salmon.

2) Evaluate yearling and subyearling chinook salmon orifice passage efficiency (with newly designed vertical barrier screen, extended-length bar screen, and inlet flow vane).

3) Compare orifice trap and mark/recapture methods of estimating orifice passage efficiency for yearling and subyearling chinook salmon.

OBJECTIVE 1: EVALUATE THE EFFECTS OF TWO ALTERNATIVE BEAM EXTENSION DESIGNS (WITH NEWLY DESIGNED VERTICAL BARRIER SCREEN SYSTEMS, EXTENDED-LENGTH BAR SCREEN, AND INLET FLOW VANE) ON DESCALING FOR YEARLING AND SUBYEARLING CHINOOK SALMON

Approach

The use of inlet flow vanes requires lowering the ESBS 0.61 m (2 ft) below standard elevation. However, lowering the guidance screen increases the gap between the downstream end of the ESBS and the beam which forms the intake ceiling between the bulkhead and operating gate slots. To reduce this gap, a vertical continuation of the beam, called a beam extension, was used (Fig. 1). Gatewells 5B and 6B were used to compare fish condition using two different beam-extension designs. The beam extension in Slot 6B was bolted to the turbine intake ceiling, while the extension device used in Slot 5B was mounted to the downstream side of the ESBS frame (Fig. 2). VBSI was installed in Slot 5B, and VBS2 was placed in Slot 6B.

Based on 1994 test results (McComas et al. 1995), inlet flow vanes were chosen for installation at McNary Dam, in place of expansion shapes, for minimizing the separation of flows entering the gatewell. The expansion shape previously used with VBS2 was therefore replaced with an inlet flow vane identical to that used with VBS1. Vertically variable perforated plate panels, specific to each VBS type, were used as a downstream surface to disperse flows evenly through the entire VBS surface.

Both test gatewells were equipped with ESBSs with a 30% porosity perforated plate and were lowered 0.61 m below standard elevation to adjust for the inlet flow vanes. Extended-length guidance screens (either ESBSs or extended-length submersible

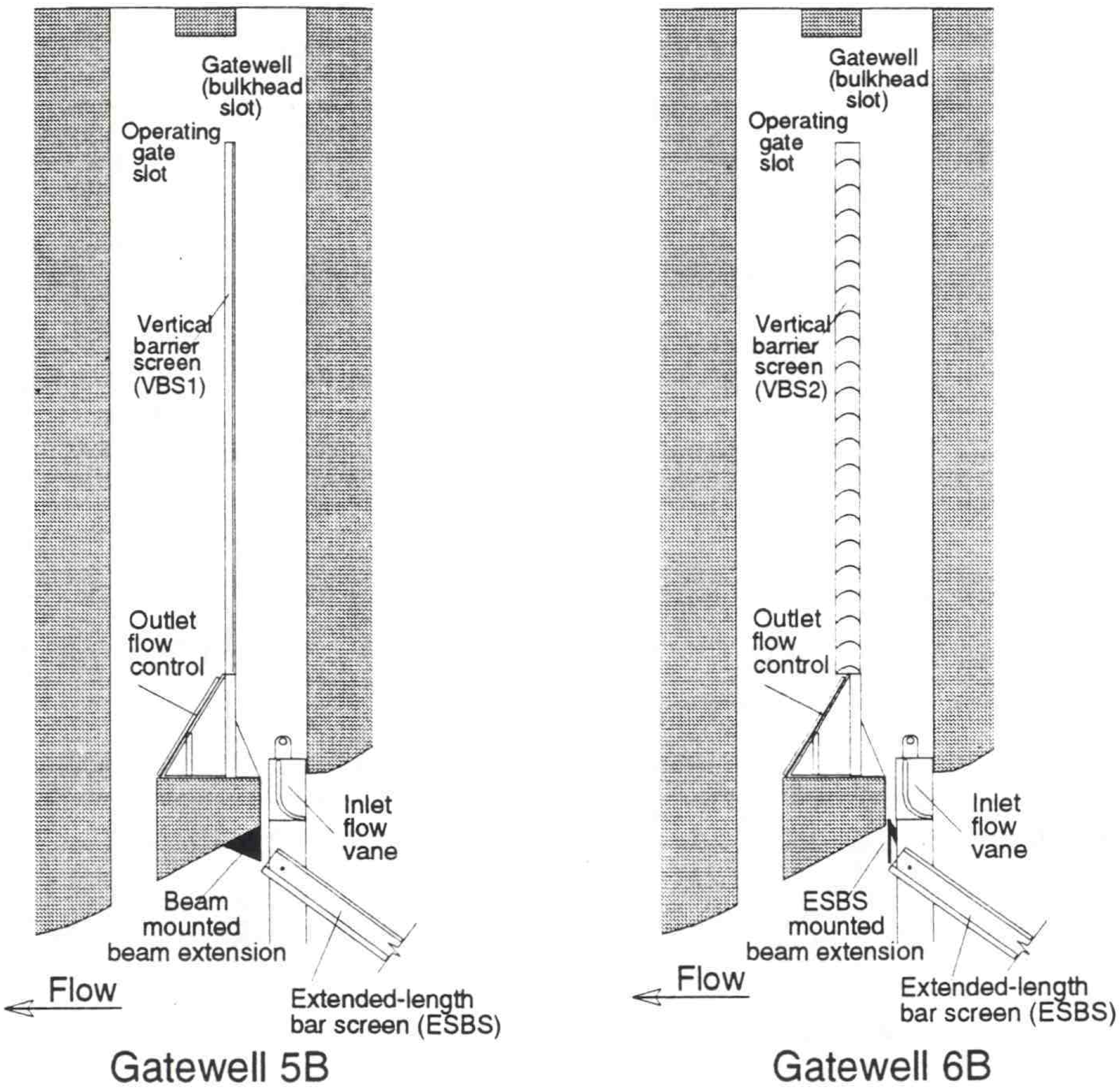

Figure 2. Cross section of test Gatewells 5B and 6B showing components evaluated during descaling and orifice passage efficiency studies at McNary Dam, 1995.

traveling screens) were also placed in Slots A and C of Turbine Units 5 and 6 to provide consistent flows across all three intakes of each unit. The A and C slots did not contain inlet flow vanes and therefore the guidance screens in these slots were not lowered.

Slot 7B was used as a control and represented the default guidance screen/VBS configuration for McNary Dam. This consisted of an STS at standard elevation with an MBFVBS, and a fully raised operating gate.

No operating gates were used in downstream gatewells of test slots, and all guidance screen angles were fixed at 55° for both spring and summer outmigration test periods. Flows through test and control units were maintained at 360 m^3/s (12,000 cfs), representing maximum turbine efficiency for McNary Dam turbines, at turbine-unit loads of about 70 MW. Outlet flow control devices were installed in test slots, but were not tested in 1995.

Fish condition was assessed by percent descaling according to Fish Transportation Oversight Team descaling criteria (Ceballos et al. 1992). The descaling percentage was defined by species as the number of fish identified as descaled divided by the total number of fish captured during the sample period.

Daily descaling samples were collected from test and control gatewells using a dip basket similar to the one described by Swan et al. (1979). For Slots 5B and 7B, sample size was limited to approximately 100 chinook salmon; for Slot 6B, however, sample size consisted of the total number of fish present because of concurrent OPE testing in that gatewell. Samples with fewer than 25 fish were considered inadequate for statistical analysis (McComas et al. 1995); on days when fewer than 25 fish were captured, catches from 2 or more successive days were combined.

Results and Discussion

Spring Outmigration

Descaling was significantly higher in the control slot than in either of the beam extension test slots for yearling chinook salmon ($F = 10.66$, $df = 3, 102$, $P < 0.0001$) and steelhead ($F = 9.06$, $df = 3, 80$, $P < 0.0001$). Sockeye salmon (*O. nerka*) descaling was significantly higher in the control slot than in the beam mounted beam extension test slot (6B), but not statistically different from the screen mounted condition ($F = 6.78$, $df = 3, 95$, $P = 0.0003$). Mean descaling values for the beam mounted and screen mounted extensions were statistically similar for all three species, and there was no real difference in mean coho salmon (*O. kisutch*) descaling values among any of the three treatments ($F = 2.19$, $df = 3, 25$, $P = 0.1140$). Mean descaling values (and standard error) for each treatment are summarized below.

Beam extension treatment	Percent descaling (SE)			
	Yearling chinook	Steelhead	Coho	Sockeye
Screen mounted	8.9 (0.7)	9.3 (1.5)	7.4 (1.4)	13.1 (1.7)
Beam mounted	7.2 (0.7)	9.1 (1.1)	1.7 (1.7)	9.3 (1.3)
Control	11.2 (0.7)	13.9 (1.3)	4.9 (1.8)	15.2 (1.5)

Summer Outmigration

No significant difference in mean descaling values was found for subyearling chinook salmon among the beam extension and control treatments ($F = 1.79$, $df = 3, 100$, $P = 0.1536$). Descaling means were 5.8 (SE = 0.9), 6.5 (SE = 0.8), and 5.6 (SE = 0.9) for beam mounted, screen mounted, and control conditions, respectively.

Gatewell catch descaling data for individual replicates are presented in Appendix Table 1. Results of statistical comparisons among descaling treatments are summarized in Appendix Table 2.

OBJECTIVE 2: EVALUATE YEARLING AND SUBYEARLING CHINOOK SALMON ORIFICE PASSAGE EFFICIENCY (WITH NEWLY DESIGNED VERTICAL BARRIER SCREEN, EXTENDED-LENGTH BAR SCREEN, AND INLET FLOW VANE)

Approach

Each gatewell at McNary Dam is equipped with two backlit 30.5-cm (12-in) orifices to provide volitional fish passage into the juvenile fish bypass channel. Orifices are located approximately 1.1 m (3.5 ft) from the north and south ends of the gatewell, at 100 m (330 ft) elevation. The range of potential orifice submergence is from 3 m (10 ft) at high turbine operating pool, to 1.5 m (5 ft) at minimum operating pool.

Gatewell 6B was used for OPE testing. Orifice passage efficiency was estimated and comparisons were made between north and south orifices using orifice trap and mark/recapture methods. The test period was set at 22 hours, from 1300 to 1100 the following day. This allowed concurrent testing, using both methods in the same gatewell, with 2 hours between replicates for fish handling.

Orifice Trap

Two orifice traps were constructed on platforms suspended above the juvenile fish bypass channel to capture emigrants from either the north or south orifice of Gatewell 6B (Fig. 3). Each trap unit included dewatering, holding, fish handling, and recovery facilities. One trap was operated continuously during each test period, alternating between north and

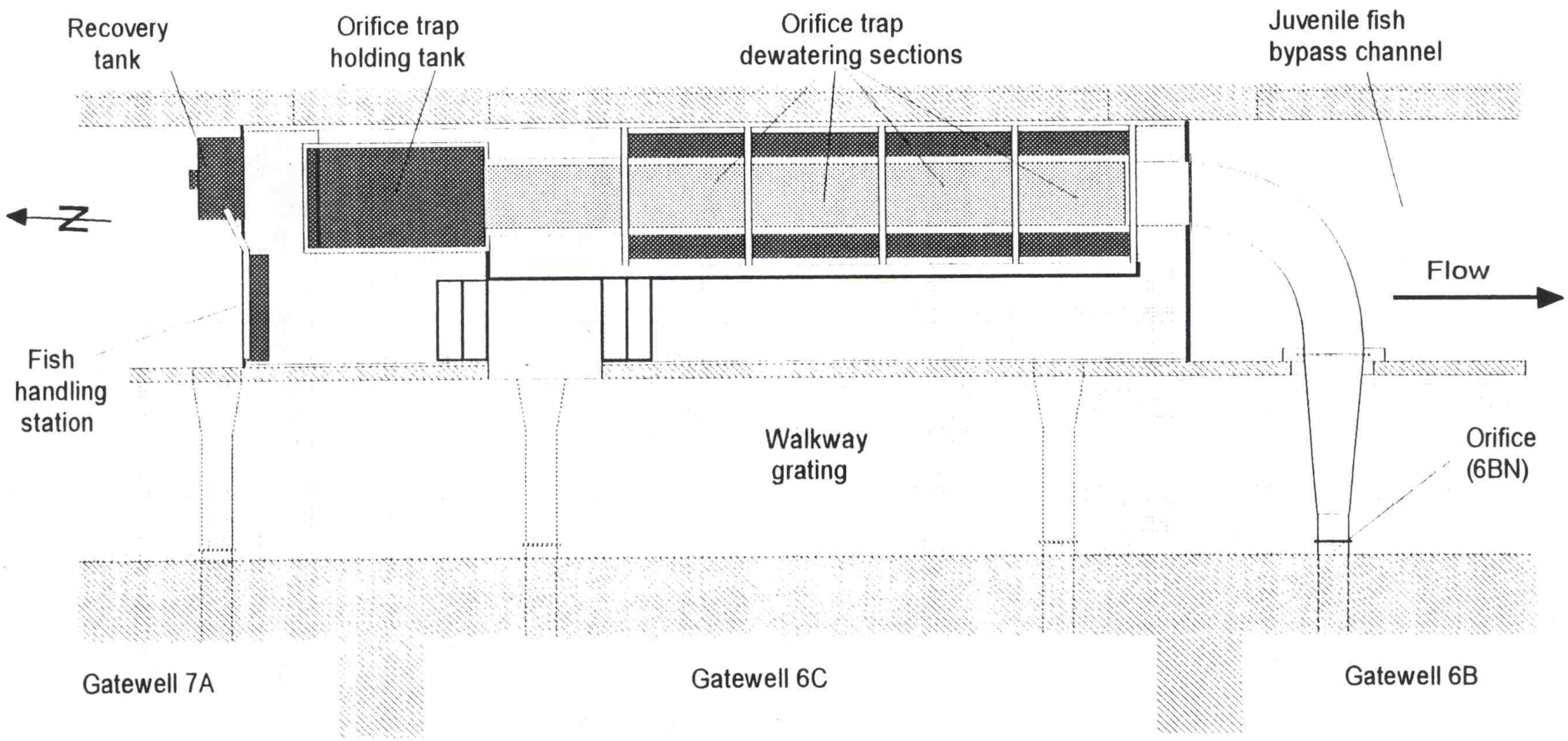

Figure 3. Plan view of a section of the juvenile fish bypass channel at McNary Dam showing the relationship between the north orifice of Gatewell 6B and components of the north orifice trap used during OPE studies at McNary Dam, 1995.

south traps on successive replicates. Fish were removed as they accumulated, anesthetized, enumerated by species, and checked for descaling. Following recovery from anesthetic, all fish were released directly into the fish bypass channel.

At the end of the 22-hour sample period, the test orifice was closed and fish remaining in the trap and gatewell were removed, enumerated, and checked for descaling. For each species, OPE using the orifice trap (OPE_T) method was defined as the ratio of the number of fish captured in the orifice trap to the total number of fish recovered from the orifice trap and gatewell combined.

$$OPE_T = \frac{T}{T + G} \times 100\%$$

where T = orifice trap captures during the sample period
G = gatewell captures after the end of the sample period

Mark/Recapture Method

Up to 100 chinook salmon obtained during gatewell cleanout each day were marked using partial caudal fin clips. To minimize the risk of counting marks from previous releases, clips were alternated between upper and lower lobes on successive replicates.

To begin testing, marked fish were released approximately 9 m (30 ft) below the water surface in the center of the test gatewell between 15 and 30 minutes after orifices were opened. In addition to being approximately the midpoint between the intake ceiling and the gatewell water surface, the 9-m depth was selected as the point below orifice depth which would provide realistic upward movement through the gatewell, without risking additional stress and possible injury associated with increased flows at a lower release point. To ensure that all fish were released simultaneously and at the same depth, marked fish were carefully lowered and released into the gatewell using a release capsule designed specifically for the purpose.

Marked fish and other residuals remaining in the gatewell at the end of the sample period were captured with a dip basket. Incidence of marks was noted, and orifice passage efficiency using the mark/recapture method ($OPE_{M/R}$) was defined as the ratio of marked fish that exited the gatewell by the end of the sample period to the total number of marked fish released at the beginning of the sample period.

$$OPE_{M/R} = \frac{M - R}{M} \times 100\%$$

where M = number of marks released at time t
R = number of marks recaptured at time t+1

Dip-basket efficiency (DBE) testing was conducted as in past FGE studies (Krcma et al. 1985). Yearling chinook salmon and steelhead were marked with caudal clips and released into the gatewell of Slot 6B during the interval between OPE replicates. The DBE group remained in the gatewell for 1 hour, after which they were removed along with the gatewell catch during cleanout just prior to beginning the next replicate. Dip-basket efficiency was defined for each species as the number of recaptured caudal-clipped fish divided by the total number of marked fish released:

$$DBE = \frac{R}{M} \times 100\%$$

where R = caudal-clipped fish recaptured
M = caudal-clipped fish released.

Results and Discussion

A list of non-salmonid species incidentally captured in orifice traps during both spring and summer sampling periods is presented by catch frequency in Appendix Table 3.

Dip-basket efficiency testing conducted 2 June resulted in 99% efficiency for chinook salmon and 100% for steelhead.

Spring Outmigration

Releative to the gatewell water surface, orifice submergence over the spring outmigration sample period ranged from approximately 1.6 to 2.1 m (5.3 to 7 ft), with a mean of 1.9 m (6.3 ft) (SE = 0.0620). Mean operating pool elevation during the spring test period was 101.69 m (338.95 ft). From 20 April through 7 June, a total of 36 replicates were completed using the orifice trap, and 29 replicates were completed using the mark/recapture method. Yearling chinook salmon data from four orifice trap replicates (28 April; 2, 5, and 24 May) were omitted from analysis due to suspected enumeration errors.

Using orifice traps, there was no significant difference in mean OPE values between north and south orifices for yearling chinook salmon (t = 0.05, df = 30, P = 0.9586), steelhead (t = 0.62, df = 30, P = 0.5399), coho salmon (t = 0.47, df = 12, P = 0.6483), or sockeye salmon (t = 0.10, df = 26, P = 0.9241). Estimated mean OPE (with standard errors) using orifice traps is summarized below for each species.

	Percent OPE (SE)			
Orifice	Yearling chinook	Steelhead	Coho	Sockeye
North	74 (2.2)	93 (1.3)	93 (2.5)	87 (3.1)
South	74 (3.0)	92 (1.0)	94 (2.1)	87 (2.5)

Mean mark/recapture OPE estimates for yearling chinook salmon were 79% (SE = 3.1) and 78% (SE = 3.8) for the north and south orifices, respectively. The difference was not significant (t = 0.06, df = 13, P = 0.9559).

A paired t-test using successive 2-day blocks as pairs revealed no difference in mean descaling values for yearling chinook salmon (t = 1.11, df = 16, p = 0.2846), steelhead (t = 0.27, df = 17, p = 0.7872), coho salmon (t = 0.56, df = 5, p = 0.5977), or sockeye salmon (t = 1.17, df = 15, p = 0.2614) passing through the north and south orifices. For each species, mean descaling using north and south orifices is summarized below.

	Percent descaling (SE)			
Orifice	Yearling chinook	Steelhead	Coho	Sockeye
North	6.4 (0.7)	6.0 (0.7)	3.9 (0.8)	7.8 (1.0)
South	7.3 (0.8)	6.2 (0.8)	4.6 (1.5)	6.7 (0.8)

Fisher's Protected Least Significant Difference procedure detected no significant difference in mean descaling between gatewell and orifice trap catches for any of these four salmonid species.

Daily orifice trap, mark/recapture, and OPE data for yearling chinook salmon are presented in Appendix Table 4, and statistical comparisons between OPE treatments are summarized in Appendix Table 5. Orifice trap catch and OPE data for non-target salmonids are included in Appendix Table 6.

Summer Outmigration

Orifice submergence below the gatewell water surface ranged from approximately 1.5 to 2.1 m (5 to 7 ft), with a mean of 1.9 m (6.3 ft) (SE = 0.0677). Mean operating pool elevation during the summer test period was 101.57 m (338.56 ft). Sampling for subyearling chinook salmon comprised 30 orifice trap replicates from 21 June through 1 August, and 18 mark/recapture replicates beginning 28 June. Mark/recapture tests were terminated after 22 July to minimize negative impacts on fish associated with elevated water temperatures and higher levels of descaling in test gatewells.

Respective mean OPE estimates for north and south orifices were 81 (SE = 2.7) and 86% (SE = 2.6) using orifice traps, and 95 (SE = 1.9) and 99.6% (SE = 0.2) using the mark/recapture method. Estimates using orifice traps were not statistically different ($t = 1.16$, $df = 28$, $P = 0.2555$); however there was a significant difference between mean subyearling chinook salmon OPE values for the north and south orifices using the mark/recapture method ($t = 2.13$, $df = 7$, $P = 0.0706$).

As with yearling chinook salmon during the spring series, there was no difference between gatewell and orifice trap descaling for subyearling chinook salmon. However, the difference between mean descaling values for the north orifice (4.8%, SE = 0.4) and the south orifice (3.2%, SE = 0.4) was significant ($t = 3.86$, $df = 14$, $P = 0.0017$) for subyearling chinook salmon.

Daily orifice trap, mark/recapture, and OPE data for subyearling chinook salmon are presented in Appendix Table 7.

OBJECTIVE 3: COMPARE ORIFICE TRAP AND MARK/RECAPTURE METHODS OF ESTIMATING ORIFICE PASSAGE EFFICIENCY FOR YEARLING AND SUBYEARLING CHINOOK SALMON

Approach

Orifice trap and mark/recapture methods of estimating OPE were compared using paired t-tests for yearling and subyearling chinook salmon. Comparisons were made only for those days when both methods were used simultaneously.

Results and Discussion

Spring Outmigration

There was a significant 4% difference between the two methods of measuring OPE for yearling chinook salmon ($t = 2.56$, $df = 24$, $P = 0.0174$). Combined mean OPE estimates for both orifices were 78% (SE = 1.4) using the mark/recapture method and 74% (SE = 1.8) using orifice traps.

Summer Outmigration

The combined mean OPE estimates for both orifices were 83% (SE = 1.9) using orifice traps and 97% (SE = 1.2) with the mark/recapture method. The 14% difference was significant ($t = 6.14$, $df = 17$, $P < 0.0001$).

There are two readily apparent factors contributing to the difference in mean OPE values between estimation techniques. The mark/recapture method relied on a point release at the beginning of the sample period, allowing nearly the entire 22-hour period for egress, while the orifice trap technique relied on migrants accumulating over the entire period. It is possible that fish entering the gatewell just prior to the end of the test period did not have time to acclimate and find the exit point before the test terminated. In addition, orifice passage was bimodal; distinct peaks were generated during late evening and early morning (Fig. 4). The morning peak extended later into the replicate as the season progressed, with increased numbers of fish exiting closer to the end of the sample period. This undoubtedly resulted in more fish in the gatewell at the end of the test, particularly during the subyearling chinook salmon outmigration, and may have contributed to the greater disparity in mean OPE values between the two methods in summer.

The result of this comparison indicates fundamental differences for the application of results from the two approaches. The mark/recapture method furnishes a measure of individual residence time in the gatewell. Orifice traps can be used to provide seasonal and diel passage timing data, and can provide the opportunity to assess condition associated with orifice passage. Methods selected for future investigations will depend on the goals of the study.

SUMMARY

1) There was no significant difference in mean descaling values for yearling and subyearling chinook salmon between beam and screen-mounted beam extensions used with extended-length bar screens and inlet flow vanes.
2) Mean descaling for yearling chinook salmon was significantly higher with the control MBFVBS and a standard-length traveling screen than for either beam extension treatment used with extended-length bar screens and inlet flow vanes. Mean descaling differences among the three treatments for subyearling chinook salmon were not significant.
3) Orifice passage efficiency was >70% for both orifice trap and mark/recapture estimation methods using an extended-length bar screen and VBS2 with an inlet flow vane.

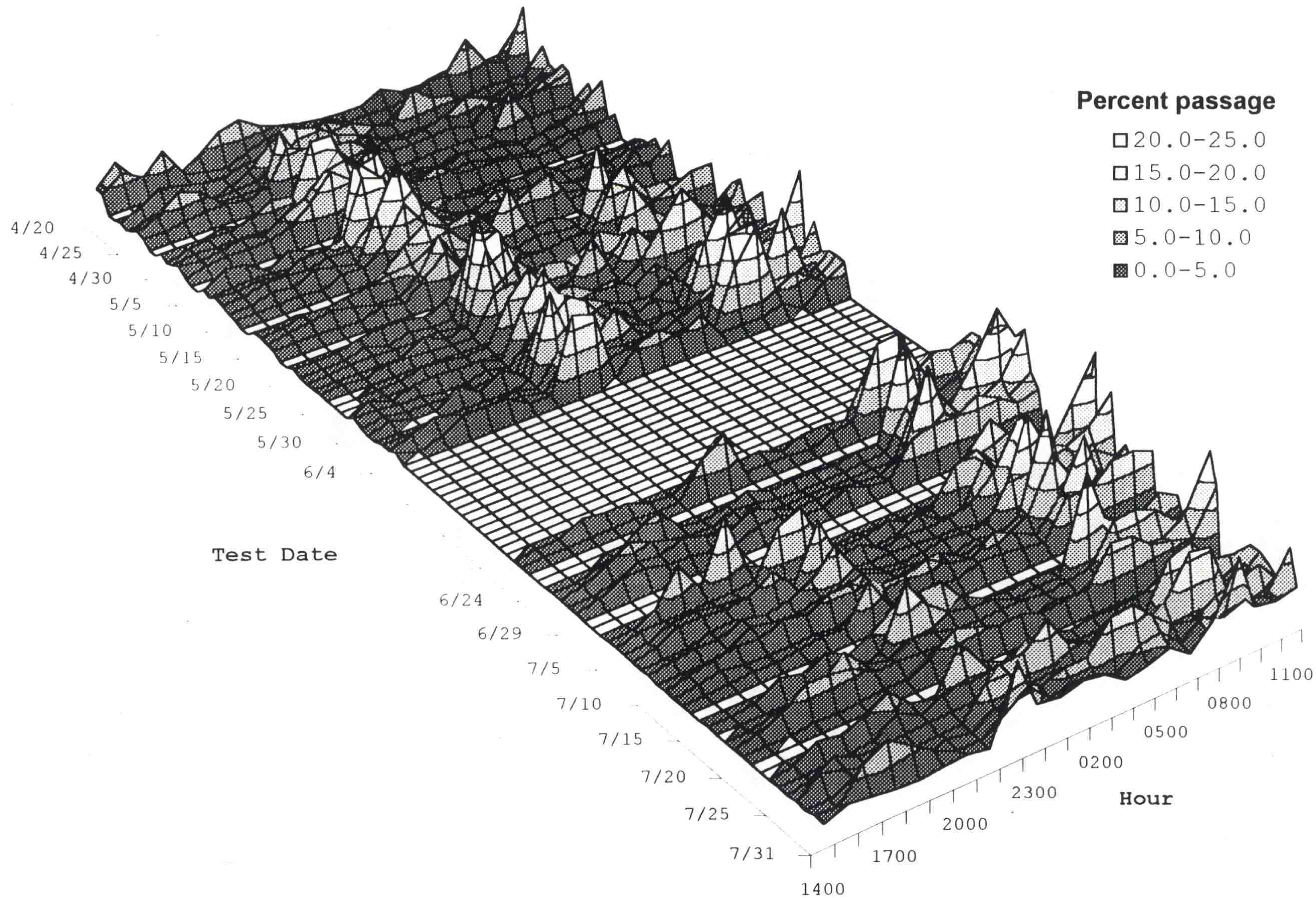

Figure 4. Chinook salmon diel orifice passage, McNary Dam, 1995.

4) There was no significant difference between orifice passage efficiency values for the north and south orifices using orifice traps for yearling and subyearling chinook salmon or the mark/recapture method for yearling chinook salmon. Subyearling chinook salmon orifice passage efficiency was significantly higher for the south orifice than for the north orifice using the mark/recapture method.
5) Differences in mean descaling values between gatewell and orifice traps for yearling and subyearling chinook salmon were not significant.
6) Descaling was significantly higher for subyearling chinook salmon using the north orifice than for those using the south orifice. Mean yearling chinook salmon descaling values were statistically similar for both orifices.
7) Orifice passage efficiency estimated using the mark/recapture method was significantly higher than OPE estimated using orifice traps for both yearling and subyearling chinook salmon.

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APPENDIX

Appendix Table 1. Gatewell catch descaling data from orifice passage efficiency and descaling tests at McNary Dam, 1995.

Unit 5, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch[a]	Desc.[b]	%[c]	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
17 April	1		0.0	25	1	4.0	1		0.0						
18 April	2		0.0	32	1	3.1	5		0.0				4	1	25.0
19 April	6		0.0	46	2	4.3	5		0.0						
21 April				114	2	1.8									
22 April				102	1	1.0									
25 April				1102	20	1.8	42	2	4.8				4		0.0
26 April				101	2	2.0									
27 April				115	2	1.7	2		0.0				4		0.0
28 April				112	5	4.5	1		0.0				3		0.0
29 April				111	4	3.6							7	1	14.3
2 May				101	11	10.9	1		0.0				13		0.0
3 May	1		0.0	85	3	3.5	18		0.0	11		0.0	23	3	13.0
4 May				111	7	6.3	7	2	28.6	6		0.0	106	5	4.7
5 May				107	7	6.5	2		0.0	10		0.0	10		0.0
6 May				101	6	5.9				15		0.0	9	3	33.3
9 May				108	11	10.2	1		0.0	13	1	7.7	1		0.0
10 May				53	6	11.3	102	11	10.8	5	1	20.0	15	2	13.3
11 May				102	8	7.8	8		0.0	85	10	11.8	85	21	24.7
12 May	3		0.0	103	13	12.6	6	1	16.7	28	1	3.6	5	1	20.0
13 May				103	9	8.7	19	2	10.5	98	9	9.2	157	19	12.1
16 May				103	4	3.6	113	5	4.4	11	1	9.1	12	1	8.3
17 May	8		0.0	109	9	8.3	12		0.0	9		0.0	110	11	10.0
18 May	2		0.0	109	14	12.8	2	1	50.0	59	4	6.8	3	3	100.0
19 May	25		0.0	103	8	7.8	38	4	10.5	20	3	15.0	47	9	19.1
20 May	27		0.0	110	7	6.4	20	3	15.0	2		0.0	29	2	6.9
23 MAY	8		0.0	141	2	1.4	3		0.0				25	1	4.0
24 May	7		0.0	113	12	10.6	2		0.0	2	1	50.0	2	2	100.0
25 May	16		0.0	100	12	12.0	3		0.0	1		0.0	14	4	28.6
26 May	84	2	2.4	150	12	8.0	20	3	15.0	2		0.0	48	7	14.6
27 May	29	1	3.4	99	13	13.1	6	1	16.7				17	2	11.8
29 May	124	7	5.6	103	11	10.7	13	3	23.1				18	3	16.7

[a] Total gatewell catch.

[b] Number of descaled fish captured by dip net from gatewell.

[c] Percent descaling [(number descaled/total gatewell catch) x 100].

Appendix Table 1. Continued.

Unit 5, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
31 May	161	2	1.2	71	6	8.5	3	1	33.3				28	2	7.1
1 June	208	18	8.7	51	9	17.6	8		0.0				24	9	37.5
2 June	414	14	3.4	91	11	12.1	52	9	17.3				34	1	2.9
3 June	233	5	2.1	62	12	19.4	12		0.0				37	6	16.2
4 June	278	8	2.9	59	12	20.3	18	2	11.1				55	7	12.7
5 June	251	27	10.8	153	26	17.0	12	2	16.7				42	5	11.9
6 June	517	35	6.8	64	14	21.9	19		0.0				25	4	16.0
7 June	183	17	9.3	6		0.0							1		0.0
22 June	101	14	13.9												
24 June	182	3	1.6	1		0.0									
27 June	139	7	5.0	7	1	14.3									
28 June	236	6	2.5	9		0.0									
29 June	112	5	4.5	12		0.0									
30 June	129	4	3.1	15		0.0									
1 July	117	10	5.6	19	2	10.5									
6 July	115	8	5.2	19		0.0									
7 July	115		0.0	11	1	9.1									
8 July	118	9	7.6	4		0.0									
9 July	104	2	1.9	4	1	25.0									
10 July	100	5	5.0	1		0.0									
11 July	250	4	1.6	6	1	16.7									
12 July	124	3	2.4	2	1	50.0									
13 July	133	3	2.3	32	2	6.3									
14 July	304	10	3.3	21	3	14.3									
15 July	120	9	7.5	11	4	36.4									
18 July	120	6	5.0	11	2	18.2									
19 July	127	11	8.7	21	2	9.5									
20 July	106	3	2.8	7	1	14.3									
21 July	100	11	11.0	6	2	33.3									
22 July	152	41	27.0	4		0.0									

Appendix Table 1. Continued.

Unit 6, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
17 April				30	2	6.7	7		0.0				1		0.0
18 April	1		0.0	52	2	3.8	6		0.0						
19 April	1		0.0	76	2	2.6	3		0.0						
21 April				381	10	2.6	2		0.0				2		0.0
22 April	2		0.0	592	15	2.5	19	1	5.3				2		0.0
25 April				655	10	1.5	35		0.0				3		0.0
26 April				749	27	3.6	11	1	9.1				8		0.0
27 April	2		0.0	287	9	3.1	14		0.0				10		0.0
28 April	2		0.0	541	15	2.8	12		0.0				33		0.0
29 April	9		0.0	419	11	2.6	17	1	5.9				42	1	2.4
2 May				294	20	6.8	28	3	10.7				89	2	2.2
3 May	4		0.0	234	8	3.4	33	2	6.1	8		0.0	268	8	3.0
4 May	5		0.0	407	19	4.7	35	2	5.7	4		0.0	228	3	1.3
5 May	3		0.0	387	19	4.9	27	1	3.7	2		0.0	190	6	3.2
6 May	6		0.0	597	16	2.7	30	2	6.4	21		0.0	49	2	4.1
9 May	2		0.0	610	40	6.6	78	5	6.4	10		0.0	68	1	1.5
10 May	1		0.0	808	89	11.0	74	8	10.8	6	1	16.7	36	6	16.7
11 may				780	54	6.9	51	3	5.9	9	1	11.1	113	19	16.8
12 May	6		0.0	623	66	10.6	43	1	2.3	28		0.0	131	13	9.9
13 May	9		0.0	690	38	5.5	125	9	7.2	16	1	6.25	50	3	6.0
16 May	17		0.0	840	67	8.0	210	30	14						
17 may	25		0.0	671	39	5.8	126	7	5.6	5		0.0	48	4	8.3
18 May	79		0.0	669	41	6.1	112	11	9.8	7		0.0	67	10	14.9
19 May	196	2	1.0	807	58	7.2	119	9	7.6	11	1	9.1	174	35	20.1
20 May	71		0.0	755	34	4.5	78	13	16.7	4		0.0	212	23	10.8
23 May	102	1	1.0	283	10	3.5	44	3	6.8	1		0.0	42	5	11.9
24 May	91	6	6.6	449	89	19.8	12	3	25.0	1		0.0	71	21	29.6
25 May	80	1	1.3	76	1	1.3	15	3	20.0				39	1	2.6
26 May	59		0.0	123	5	4.1	14	1	7.1	1		0.0	39	7	17.9
27 May	97		0.0	235	20	8.5	15	2	13.3				36	2	5.6
29 May	64	1	1.6	48	5	10.4	4	2	50.0				13	3	23.1
31 May	15		0.0	5	1	20.0							2		0.0
1 June	244	25	10.2	47	5	10.6	4	2	50.0				30	7	23.3
2 June	332	5	1.5	141	14	9.9	30	8	26.7				54	3	5.6
3 June	39		0.0	8	1	12.5							3	0	0.0
4 June	182	8	4.4	42	8	19.0	5	2	40.0				20	2	10.0
5 June	129	4	3.1	53	10	18.9	3	1	33.3				25	1	4.0
6 June	280	13	4.6	30	5	16.7	2		0.0				13	1	7.7
7 June	246	33	13.4	16	3	18.8							2	1	50..0
22 June	424	45	10.6	44	4	9.1							9	1	11.1
23 June	379	25	6.6	2		0.0									

Appendix Table 1. Continued.

Unit 6, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
24 June	645	23	3.6	13		0.0									
27 June	1392	57	4.1	25	1	4.0							8	0	0.0
28 June	2419	93	3.8	121		0.0	1		0.0						
29 June	1656	73	4.4	73		0.0									
30 June	1515	28	1.8	144	7	4.9									
1 July	783	29	3.7	97	6	6.2									
6 July	1537	67	4.4	80	5	6.3									
7 July	610	11	1.8	27	1	3.7									
8 July	3157	157	5.0	175	16	9.1									
9 July	193	15	7.8	27	2	7.4									
10 July	731	53	7.3	31	4	12.9									
11 July	707	28	4.0	5	1	20.0									
12 July	556	16	2.9	7	6	85.7									
13 July	565	10	17.9	5		0.0									
14 July	17		0.0	6	1	16.7									
15 July	120	12	10.0	17	1	5.9							1	1	100.0
18 July	172	8	4.7	19		0.0									
19 July	31	4	12.9	15	5	33.3									
20 July	288	25	8.7	38	5	13.2							1		0.0
21 July	409	60	14.7	48	16	33.3									
22 July	819	91	11.1	5	2	40.0									
25 july	104	17	16.3	26	3	11.5									
26 July	102	2	2.0	20	5	25.0									
27 July	61	1	1.6	10	3	30.0									
28 July	56	1	1.8	14		0.0									
29 July	55		0.0	25	2	8.0									
30 July	38	3	7.9												
1 August	26	3	11.5												

Unit 7, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
17 April	2		0.0	100	7	7.0							1		0.0
18 April	2		0.0	100	11	11.0							1		0.0
19 April				103	4	3.9	2		0.0						
21 April				103	3	2.9									
22 April				107	7	6.5									

Appendix Table 1. Continued.

Unit 7, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
25 April				222	11	5.0									
26 April				132	13	9.8	2		0.0				9	1	11.1
27 April				100	4	4.0	1	1	100.0				3	1	33.3
28 April				106	9	8.5							16		0.0
29 April				102	8	7.8	5	1	20.0				56	3	5.4
2 May				102	16	15.7	8	1	12.5				33	2	6.1
3 May				105	14	13.3	17	2	11.8	4	1	25.0	123	9	7.3
4 May	2		0.0	102	7	6.9	11		0.0	5		0.0	208	13	6.3
5 May	2		0.0	118	11	9.3	9		0.0	3		0.0	41	4	9.8
6 May				100	11	11.0	9	1	11.1	11	1	9.1	15		0.0
9 May	1	1	100.0	100	27	27.0	6		0.0	3		0.0	25	9	36.0
10 May				104	11	10.6	58	7	14.3	7	1	14.3	11	2	18.2
11 May				109	10	9.2	6		0.0	13		0.0	21		0.0
12 May				107	9	8.4	6	1	16.7	3	1	33.3	16	4	25.0
13 May	3		0.0	115	3	2.6	2		0.0	24	1	4.2	62	4	6.5
16 May	1		0.0	116	12	10.3	355	29	8.2	2		0.0	7	5	71.4
17 May	15		0.0	104	10	9.6	98	16	16.3	1		0.0	162	18	11.1
18 May	8		0.0	91	10	11.0	95	15	15.8				240	22	9.2
19 May	32	1	3.1	127	12	9.4	16	1	6.3	5		0.0	91	17	18.7
20 May	19	1	5.3	103	7	6.8	50	11	22.0				165	21	12.7
23 MAY	9		0.0	101	5	5.0	28	1	3.6				20	4	20.0
24 May	11	5	45.5	120	16	13.3	28	4	14.3	1		0.0	13	10	76.9
25 May	35		0.0	100	5	5.0	24	2	8.3				39	4	10.3
26 May	50	3	6.0	113	9	8.0	65	8	12.3				84	13	15.5
27 May	21	1	4.8	102	24	23.5	4	1	25.0				18	6	33.3
29 May	26	3	11.5	100	11	11.0	17	2	11.8				20	7	35.0
31 May	77	10	13.0	100	13	13.0	14	3	21.4				60	11	18.3
1 June				52	2	3.8	5	1	20.0				10	1	10.0
2 June	180	13	7.2	80	12	15.0	129	22	17.1				34	6	17.6
3 June	236	40	16.9	104	19	18.3	48	8	16.7				30	9	30.0
4 June	253	24	9.5	85	31	36.5	61	13	21.3				42	9	21.4
5 June	262	28	10.7	71	11	15.5	37	4	10.8				37	1	2.7
6 June	279	28	10.0	51	10	19.6	14	3	21.4				11	4	36.4
7 June	154	23	14.9	9	2	22.2	3	3	100.0				2	1	50.0
22 June	112	12	10.7												
23 June	120	5	4.2												
24 June	120	3	3.5												
27 June	124	2	1.6	7		0.0									
28 June	155	3	1.9	10	1	10.0									
29 June	142	5	1.4	17	1	5.9									
30 June	106	7	6.6	12	1	8.3									

Appendix Table 1. Continued.

Unit 7, Slot B

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%	Catch	Desc.	%
1 July	145	10	6.9	9	1	11.1									
6 July	108	9	8.3	9		0.0									
7 July	215	14	6.5	15	3	20.0									
8 July	137	7	5.1	7	4	57.1									
9 July	114	3	2.6	5		0.0									
10 July	117	5	4.3	2		0.0									
11 July	142	5	3.5	2		0.0									
12 July	100	4	4.0	3	1	33.3									
13 July	121	5	4.1	27	1	3.7									
14 July	121	1	0.8	23	1	4.3									
15 July	271	26	9.6	37	2	5.4									
18 July	106	3	2.8	4		0.0									
19 July	257	13	5.1	84	5	6.0									
20 July	101	2	2.0	18	1	5.6									
21 July	276	39	14.1	22		0.0									
22 July	118	23	19.5	3		0.0									

Appendix Table 2. Statistical analyses of mean descaling estimates obtained during orifice passage efficiency (OPE) studies at McNary Dam, 1995. Asterisks indicate statistically significant differences between means.

Test series	Test dates	Species	Analysis type	Analysis source	Calculated test statistic	df	P
1a	21 - 29 April	Yearling chinook	RBANOVA[a]	Orifice trap vs. gatewell	F = 10.66	3,102	<0.0001
	1 - 31 May	Steelhead	ANOVA[b]		F = 9.06	3,80	<0.0001
	1 - 6 June	Coho	ANOVA		F = 2.19	3,25	0.1140
		Sockeye	ANOVA		F = 6.78	3,95	0.0003
1a	21 - 29 April	Yearling chinook	RBANOVA	Screen mounted beam extension vs. beam mounted beam extension vs. control	F = 10.66*	3,102	<0.0001
	1 - 31 May	Steelhead	ANOVA		F = 9.06*	3,80	<0.0001
	1 - 6 June	Coho	ANOVA		F = 2.19	3,25	0.1140
		Sockeye	ANOVA		F = 6.78*	3,95	0.0003
1b	21 - 29 April	Yearling chinook	paired t-test[c]	North orifice vs. south orifice	t = 1.11	16	0.2846
	1 - 31 May	Steelhead	paired t-test		t = 0.27	17	0.7872
	1 - 6 June	Coho	paired t-test		t = 0.56	5	0.5977
		Sockeye	paired t-test		t = 1.17	15	0.2614
2a	22 - 30 June 1 - 31 July 1 August	Subyearling chinook	ANOVA	Orifice trap vs. gatewell	F = 1.79	3,100	<0.1536
2a	21 - 29 April 1 - 31 July 1 August	Subyearling chinook	ANOVA	Screen mounted beam extension vs. beam mounted beam extension vs. control	F = 1.79	3,100	<0.1536
2b	22 - 30 June 1 - 31 July 1 August	Subyearling chinook	paired t-test	North orifice vs. south orifice	t = 3.86*	14	0.0017

a Randomized block analysis of variance.

b Single factor analysis of variance.

c Paired sample Student's t-test using 2-day block pairing.

Appendix Table 3. Nonsalmonid species incidentally captured in orifice traps at McNary Dam, 1995. Species are listed in order of total catch.

Common name	Scientific name	Total catch
lamprey	*Entosphenus tridentata*	1,136
shad	*Alosa sapidissima*	214
whitefish	*Prosopium williamsoni*	170
sucker	*Catostomus* spp.	96
chiselmouth	*Acrocheilus alutaceus*	83
yellow perch	*Perca flavescens*	77
peamouth	*Mylocheilus caurinus*	68
bass	*Micropterus* spp.	34
redside shiner	*Richardsonius balteatus*	32
squawfish	*Ptychocheilus oregonensis*	7
stickleback	*Gasterosteus aculeatus*	6
black crappie	*Pomoxis nigromaculatus*	4
carp	*Cyprinus carpio*	4
channel catfish	*Ictalurus punctatus*	3
sand roller	*Columbia transmontanus*	2
bluegill	*Lepomis macrochirus*	2
walleye	*Stizostedion vitreum*	1

Appendix Table 4. Daily yearling chinook orifice passage efficiency (OPE) estimates obtained using orifice traps (Trap OPE) and mark/recapture (M/R OPE) estimation methods, McNary Dam, 1995.

Test date	Orifice trap	Orifice trap estimation method			Mark/recapture estimation method		
		Gatewell catch[a]	Trap catch[b]	Trap OPE estimate	Marked released[c]	Marked recaptured[d]	M/R OPE estimate
21 April	S[e]	381	720	65.4			
22 April	N[f]	592	636	51.8			
25 April	S	655	1067	62.0			
26 April	N	749	1296	63.4			
27 April	S	287	788	73.3			
28 April	N				100	57	43.0
29 April	S	419	741	63.9	100	38	62.0
1 May	N				100	26	74.0
2 May	S	234	1003	81.1	73	18	75.3
4 May	N	407	1657	80.3	82	13	84.1
5 May	S				100	31	69.0
6 May	N	597	1966	76.7	100	16	84.0
9 May	S	610	1983	76.5	100	29	71.0
10 May	N	808	1450	64.2	100	36	64.0
11 May	S	780	3000	79.4	100	20	80.0
12 May	N	623	1402	69.2	100	32	68.0
13 May	S	690	1951	73.9	100	13	87.0
16 May	N	840	1814	68.3	95	26	72.6
17 May	S	671	2056	75.4	100	3	97.0
18 May	N	669	4462	87.0	100	14	86.0
19 May	S	807	1595	66.4	100	24	76.0
20 May	N	755	1193	61.2	100	15	85.0
23 May	S	283	718	71.1	100	40	60.0
24 May	N				100	36	64.0
25 May	S	76	418	84.6	100	14	86.0
26 May	N	123	269	68.6			
27 May	S	235	561	70.5	100	12	88.0
29 May	N	48	426	89.9	100	8	92.0
31 May	S	5	272	98.2	97	3	96.9
1 June	N	47	130	73.4	99	13	86.9
2 June	S	141	269	65.6	98	35	64.3
3 June	N	8	125	94.0			
4 June	S	42	112	72.7	103	24	76.7
5 June	N	53	328	83.8	100	17	83.0
6 June	S	30	153	83.6	100	12	88.0
7 June	N	16	66	80.5	95	1	98.9

[a] Fraction captured from gatewell using dip baskets at the end of the test.

[b] Fraction enumerated from orifice trap during the test.

[c] Number of marked fish released at the beginning of the test, time t.

[d] Number of marked fish recaptured at the end of the test, time t+1.

[e] South orifice trap.

[a] North orifice trap.

Appendix Table 5. Statistical analyses of mean orifice passage efficiency estimates for tests at McNary Dam, 1995. Asterisks indicate statistically significant differences between treatment means.

Test series	Test dates	Species	Analysis type	Analysis source	Calculated test statistic	df	P
1a	21 - 30 April	Yearling chinook	2 t-test[a]	North orifice trap[b] vs. south orifice trap	0.05	30	0.9586
	1 - 31 May	Steelhead	2 t-test		0.62	30	0.5399
	1 - 6 June	Coho	2 t-test		0.47	12	0.6483
		Sockeye	2 t-test		0.10	26	0.9241
1b	28 - 29 April 1 - 31 May 1 - 6 June	Yearling chinook	paired t-test[c]	North orifice M/R[d] vs. south orifice M/R	0.06	13	0.9559
1c	28 - 29 April 1 - 31 May 1 - 6 June	Yearling chinook	paired t-test	Orifice trap method vs. M/R method	2.56*	24	0.0174
2a	22 - 30 June 1 - 31 July 1 August	Subyearling chinook	2 t-test	North orifice trap vs. south orifice trap	1.16	28	0.2555
2b	28 - 30 June 1 - 22 July	Subyearling chinook	paired t-test	North orifice M/R vs. south orifice M/R	2.13*	7	0.0706
2c	28 - 30 June 1 - 22 July	Subyearling chinook	paired t-test	Orifice trap method vs. M/R method	6.14*	17	<0.0001

[a] Two sample Student's t-test.

[b] Orifice trap orifice passage efficiency estimation method.

[c] Paired sample Student's t-test using 2 day block pairing.

[d] Mark/recapture orifice passage efficiency estimation method.

Appendix Table 6. Daily non-target salmonid orifice passage efficiency (OPE) estimates obtained using the orifice trap (Trap OPE) estimation method, McNary Dam, 1995.

Test date	Orifice trap	Steelhead			Coho			Sockeye		
		Gatewell catch[a]	Trap catch[b]	Trap OPE estimate	Gatewell catch	Trap catch	Trap OPE estimate	Gatewell catch	Trap catch	Trap OPE estimate
21 April	S[c]	2	167	98.8				2	2	50.0
22 April	N[d]	19	220	92.1				2	17	89.9
25 April	S	35	373	91.4				3	28	90.3
26 April	N	11	159	93.5				8	80	90.9
27 April	S	14	183	92.9				10	71	87.7
28 April	N	12	177	93.7				33	289	90.0
29 April	S	17	300	94.6				42	557	93.0
1 May	N	28	347	92.5				89	856	90.6
2 May	S	33	416	92.7		14	100.0	268	1200	81.7
4 May	N	35	599	94.5	8	40	83.3	228	3303	93.5
5 May	S	27	540	95.2	4	82	95.3	190	1320	87.4
6 May	N	30	805	96.4	2	31	93.9	49	835	94.5
9 May	S	78	866	91.7	21	81	79.4	68	547	88.9
10 May	N	74	742	90.5	10	312	96.9	36	513	93.4
11 May	S	51	754	93.7	6	369	98.4	113	1244	91.7
12 May	N	43	524	92.4	9	882	99.0	131	1102	89.4
13 May	S	125	1364	91.6	28	656	95.9	50	858	94.5
16 May	N	210	2384	91.9	16	1361	98.8	40	679	94.4
17 May	S	126	1374	91.6	4	134	97.1	48	1279	96.4
18 May	N	112	1576	93.4	5	115	95.8	67	3667	98.2
19 May	S	119	979	89.2	7	167	96.0	174	1655	90.5
20 May	N	78	502	86.6	11	121	91.7	212	1454	85.4
23 May	S	44	212	82.8	4	32	88.9	42	373	89.9
24 May	N	12	146	92.4	1	8	88.9	71	188	72.6
25 May	S	15	137	90.1	1	1	50.0	39	238	85.9
26 May	N	14	58	80.6		5	100.0	39	120	75.5
27 May	S	15	88	85.4	1	5	80.0	36	164	82.0

a Fraction captured from gatewell using dip baskets at the end of the test.

b Fraction enumerated from orifice trap during the test.

c South orifice trap.

d North orifice trap.

Appendix Table 6. Continued.

Test date	Orifice trap	Steelhead			Coho			Sockeye		
		Gatewell catch	Trap catch	Trap OPE estimate	Gatewell catch	Trap catch	Trap OPE estimate	Gatewell catch	Trap catch	Trap OPE estimate
29 May	N	4	123	96.9		16	100.0	13	105	89.0
31 May	S		46	100.0		3	100.0	2	80	97.6
1 June	N	4	86	95.6		4	100.0	30	42	58.3
2 June	S	30	273	90.1		2	100.0	54	72	57.1
3 June	N		89	100.0		1	100.0	3	63	95.5
4 June	S	5	88	94.6		1	100.0	20	86	81.1
5 June	N	3	49	94.2		2	100.0	25	72	74.2
6 June	S	2	60	96.8		3	100.0	13	48	78.7
7 June	N		58	100.0		1	100.0	2	15	88.2

Appendix Table 7. Daily subyearling chinook orifice passage efficiency (OPE) estimates obtained using orifice traps (Trap OPE) and mark/recapture (M/R OPE) estimation methods, McNary Dam, 1995.

Test date	Orifice trap	Orifice trap estimation method			Mark/recapture estimation method		
		Gatewell catch[a]	Trap catch[b]	Trap OPE estimate	Marked released[c]	Marked recaptured[d]	M/R OPE estimate
22 June	N[e]	424	5504	92.8			
23 June	S[f]	379	701	64.9			
24 June	N	645	1393	68.4			
27 June	S	1392	3434	71.2			
28 June	N	2419	5242	68.4	100		100.0
29 june	S	1656	3973	70.9	100	1	99.0
30 June	N	1515	5275	77.7	100	2	98.0
1 July	S	783	7161	90.1	100		100.0
6 July	N	1537	16151	91.3	100	13	87.0
7 July	S	610	5482	90.0	100		100.0
8 July	N	3157	5440	63.3	100	17	83.0
9 July	S	193	2355	92.4	100		100.0
10 July	N	731	2020	73.4	100		100.0
11 July	S	707	9710	93.2	100		100.0
12 July	N	556	2731	83.1	100	4	96.0
13 July	S	56	803	93.5	100	1	99.0
14 july	N	17	477	96.6	100		100.0
15 July	S	120	1679	93.3	100		100.0
18 July	N	172	984	85.1	100	2	98.0
19 July	S	31	1027	97.1			
20 July	N	288	970	77.1	100	7	93.0
21 July	S	409	1459	78.1	100	1	99.0
22 July	N	819	1971	70.6	100		100.0
25 July	S	104	742	87.7			
26 July	N	102	812	88.8			
27 July	S	61	288	82.5			
28 July	N	56	6672	92.3			
29 July	S	55	296	84.3			
30 July	N	38	297	88.7			
1 August	S	26	436	94.4			

[a] Fraction captured from gatewell using dip baskets at the end of the test.

[b] Fraction enumerated from orifice trap during the test.

[c] Number of marked fish released at the beginning of the test, time t.

[d] Number of marked fish recaptured at the end of the test, time t+1.

[e] North orifice trap.

[f] South orifice trap.