Studies to Determine the Effectiveness of Extended Traveling Screens and Extended Bar Screens at McNary Dam, 1991

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COASTAL ZONE AND ESTUARINE STUDIES

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CONTENTS

INTRODUCTION

McNary Dam, at river mile 292, is operated by the U.S. Army Corps of Engineers (COE), and is the fourth hydroelectric project from the mouth of the Columbia River. A juvenile fish bypass system at McNary Dam is used to collect juvenile salmonids for transport either to release sites below Bonneville Dam, the lower most dam on the Columbia River, or to bypass them to the river below McNary Dam. Submersible traveling screens (STS) are fish guidance devices designed to divert juvenile salmonids away from turbines and into the bypass system.

Previous research at McNary Dam indicated that FGE for coho salmon (Oncorhynchus kisutch), yearling chinook salmon (O. tshawytscha), and steelhead (O. mykiss) was greater than 70% (Swan and Norman 1987). However, subyearling chinook salmon, with their tendency to migrate deeper in the water column, were more difficult to guide. Tests at McNary Dam indicated that guidance for subyearling chinook salmon ranged from only 33 to 60%, although it was generally less than 50% (Brege et al. 1988).

In 1986, theoretical fish guidance efficiency (TFGE) for subyearling chinook salmon was calculated based on vertical distribution measurements of fish in the water column at McNary Dam. TFGE with standard submersible traveling screens (SSTS) was estimated to be 61% (Swan and Norman 1987). These results suggested that a screen extending deeper into the water column within the turbine intake would be needed to achieve FGE of 70% for subyearling chinook salmon. As a consequence, the COE designed an extended STS (ESTS) and an extended submersible bar screen (ESBS) that were double the 20-ft length of the SSTS. The 40-ft length was selected for prototype testing because it was the maximum screen length that could be used without major modifications to the gantry crane, overhead electrical lines, and other existing equipment on the turbine intake deck.

The ability of STS to divert juvenile salmonids from turbine intakes is influenced by the physiological status of the fish. Research conducted by the National Marine Fisheries Service (NMFS), in cooperation with the COE, demonstrated that FGE changed not only from year to year and among dams, but also during the outmigration season. Data acquired at Lower Granite and Little Goose Dams from 1985 to 1989 suggested that fully smolted yearling chinook salmon were more susceptible to guidance by traveling screens (Swan et al. 1987; Giorgi et al. 1988; Muir et al. 1988, 1990). We hypothesized that over the course of the outmigration, the proportion of fully smolted fish in the population increased, which would explain intra-seasonal increases in FGE.

Little information exists about the relationship between the typically low guidance rates and smolt development in subyearling chinook salmon. Research at Bonneville Dam in July 1988 found no significant relationship between gill Na^{+}-K^{+} ATPase levels, which indicate smolt readiness to enter saltwater, and FGE (Muir et al. 1989).

In 1991, research was conducted during spring and summer juvenile salmonid outmigrations to assess the effectiveness of newly designed extended length screens. Concurrently, measurements were made of the smoltification status of the fish. Specific 1991 objectives were:

1) Determine the depth distribution of juvenile fish entering turbine intakes during the spring and summer salmonid outmigration.

2) Evaluate the ability of ESTS and ESBS to improve subyearling chinook salmon FGE.

3) Determine the effect of extended guidance devices (ESTS and ESBS) on juvenile salmonid descaling and impingement.

4) Measure levels of smoltification in yearling and subyearling chinook salmon collected in gatewells and from fyke nets at different depths within turbine intakes.

OBJECTIVE 1.--VERTICAL DISTRIBUTION OF JUVENILE FISH ENTERING THE TURBINE UNIT

Approach

Vertical distribution measurements were conducted in the intake of Turbine Unit 4 using standard materials and methods (Krcma et al. 1986). The entire fyke-net frame was outfitted with nets, but only nets in the center column had cod-ends. The fully netted fyke-net frame produced more uniform water flow patterns within the test slot, while capturing the same percentage of fish as in previous tests conducted without nets in the north and south columns (Fig. 1). Fish that entered the gatewell volitionally were captured using a dipbasket (Swan et al. 1979). Dipbasket efficiency tests (Krcma et al. 1986) and diel passage tests (Brege et al. 1988) were conducted as in past FGE studies (Krcma et al. 1986). Based upon hydraulic model studies, the new extended screens intercepted fish to a depth equal to approximately 3 1/2 fyke nets on the vertical distribution frame (Fig. 1). The TFGE was estimated by dividing the sum of the gatewell catch plus the number of fish caught in the upper 3 1/2 nets (catch at net level 4 was divided in half) by the total number of fish entering the turbine intake (gatewell catch plus total fyke-net catch). All fyke-net catches were

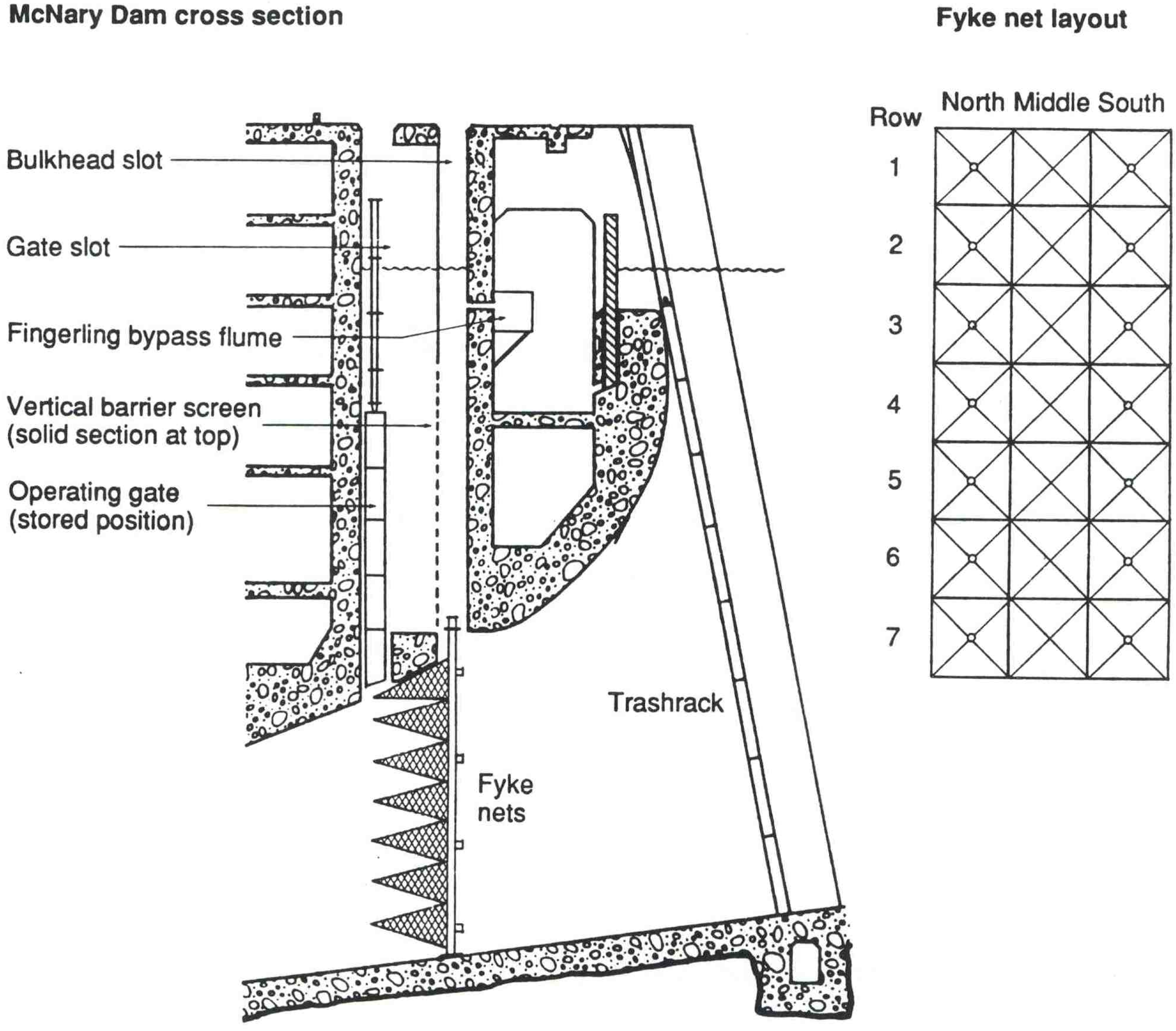


Figure 1.--Transverse section of McNary Dam turbine unit with vertical distribution fyke-net frame in place.

multiplied by three to estimate total numbers of fish passing through each depth level. The TFGE was compared to the actual FGE (see Objective 2) to determine the potential effectiveness of the two guidance devices (ESTS and ESBS).

Vertical distribution measurement series consisted of three or four replicates, one per day on consecutive dates. Turbine Units 3 and 5 were run concurrently with test Unit 4 during vertical distribution measurements to ensure an even flow into the test unit. Turbine Unit 3 had a full complement of SSTS and turbine Unit 5 had a full complement of ESTS. Tests began at 2000 h and lasted 2 to 3 hours each day. Diel tests from past research (Brege et al. 1988) indicated that movement of juvenile salmonids into the turbine intakes began at about 2000 h and peaked around 2400 h. Therefore, this period was selected for measurements of vertical distribution. Discharge through each turbine unit was maintained at 16 kcfs throughout the test period. Yearling chinook salmon were the target species during the spring outmigration and subyearling chinook salmon during the summer outmigration. Data for other salmonids were collected as available through incidental catches.

Results and Discussion

Dipbasket efficiency tests were conducted on 8 and 12 May. Fin-clipped yearling chinook salmon and steelhead were released into the gatewell at the beginning of each test and removed with the gatewell catch. These tests resulted in a recapture rate of 98% with less than 1% descaling (Appendix Table 1).

From 27 to 28 June, hourly fish collections were made from the Turbine Unit 8b gatewell to determine diel passage for subyearling chinook salmon. Peak passage occurred between 2100 and 2200 h (Appendix Table 2). Vertical distribution measurements and FGE tests were also conducted during this period.

Low numbers of juvenile salmonids were present during both series of vertical distribution measurements conducted during the spring outmigration (11-13 and 26-29 April, Appendix Table 3). Only yearling chinook salmon were present in significant numbers in the first series, during which the pooled TFGE was 89.6%. In the second series, yearling chinook salmon, steelhead, and sockeye salmon (O. nerka) were collected, with pooled TFGEs of 98.6, 97.8, and 91.7%, respectively. Subyearling chinook and coho salmon were not present in significant numbers during either series.

Large numbers of subyearling chinook salmon were present for vertical distribution measurements at the beginning of the summer outmigration, from 21 to 23 June. The TFGE for subyearling chinook salmon was 97.4% during this time period. This was slightly higher than in 1986 during a similar time period using the upper 3-1/2 nets to calculate TFGE (Swan and Norman 1987). Other species were not present in significant numbers. However, in previous vertical distribution measurements, only 2 1/2 nets were used to calculate TFGE because SSTS do not extend as far into the water column of the turbine intake.

Vertical distribution measurements in spring and summer indicated that nearly all juvenile salmonids passed through the turbine intakes at a level above the interception point of extended guidance devices. Only one vertical distribution measurement series was conducted during the subyearling chinook salmon outmigration because FGE tests and vertical distribution measurements could not be conducted concurrently, and FGE tests were given higher priority. A measurement later in the season might have explained the significant decrease in FGE observed during the third week of July (Test series 14). At McNary Dam in 1987, TFGE and FGE of subyearling chinook salmon decreased as the season progressed (Brege et al.

1988). Temporal changes in TFGE and FGE were also observed at John Day Dam and were attributed to varying migrational behavior in the many stocks making up the subyearling chinook salmon seaward migration (Brege et al. 1987).

OBJECTIVE 2.--FISH GUIDANCE EFFICIENCY OF EXTENDED STS AND EXTENDED SBS

Approach

Methods for determining FGE were similar to those used in previous STS studies (Swan et al. 1987, Brege et al. 1988). As with vertical distribution measurements, a dipbasket was used to collect guided fish from the gatewell. Tests on SSTS utilized nets attached to a frame beneath the STS to collect unguided fish. Extended screens do not allow this procedure since the screen framework fills the entire slot from the turbine floor to ceiling (Fig. 2). Therefore, a fyke-net frame was placed in the downstream gate slot. A full complement of 27 fyke nets per frame was used and all nets had cod-ends. The top two rows contained half nets. The fyke-net catch provided the number of unguided fish. Fish guidance efficiency for each species was calculated as the gatewell catch divided by the total number of fish (by species) entering the turbine intake.

$$FGE = \frac{GW}{GW+FN} X\ 100$$

GW = gatewell catch
FN = fyke-net catch

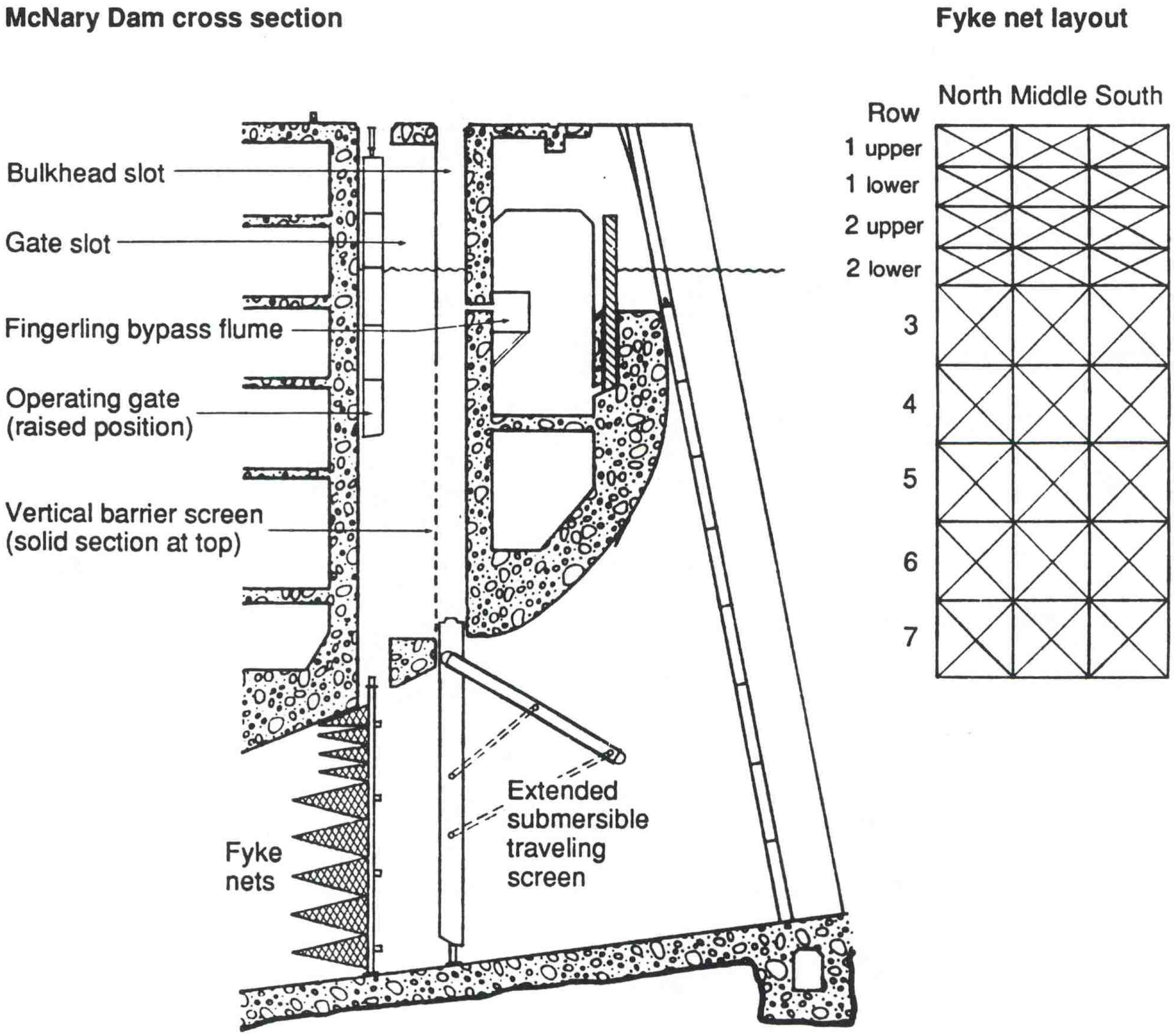


Figure 2.--Transverse section of McNary Dam turbine unit with ESTS and fyke-net frame in place.

Fish entering the gatewell from the turbine intake were confined to the bulkhead slot by vertical barrier screens (VBS) which separate the bulkhead slot from the gate slot (Figs. 1 and 2). The VBS at McNary Dam consist of eight sections, each 8.5 ft high by 20 ft wide, which span the gatewell from top to bottom. The standard vertical barrier screen (SVBS) configuration consists of three solid panel sections on the top portion of the VBS and five nylon monofilament mesh panel sections on the bottom portion. As a result of earlier fish passage studies at McNary Dam (Krcma et al. 1985) and COE Waterways Experiment Station modeling studies, a modified balanced flow vertical barrier screen (MBFVBS) was developed and tested at McNary in 1991. The mesh sections of these screens have perforated plate backing to reduce the flow through the mesh. Beginning at the top, the MBFVBS configuration consists of the following: two solid plate sections; two sections divided in thirds, with solid plate in the center third and mesh on either side; three mesh sections; and a solid plate bottom section.

Tests for FGE began at about 2000 h and terminated when enough fish (at least 200) of the target species were collected in Slot 4B (control) or after several hours if fish were not sufficiently abundant. Individual test conditions are specified in Table 1. Turbine Unit 5 was outfitted with a full complement of three ESTS and Turbine Unit 6 had a full complement of three ESBS. FGE testing with ESTS and ESBS occurred simultaneously in Slots 5B and 6B, respectively. At the end of each test, the turbine units were shut down slowly, the fyke-net frames were raised from the gate slot, and the catch was removed from each net and placed in individual containers. The catch was enumerated by species and fish were examined for descaling or other injuries.

Table 1.--Test schedule for the 1991 field season at McNary Dam.

Test series number	Dates	Test unit	Flow (kcfs)	Guidance device	Test type	Vertical barrier screen	Gate position	Porosity of perforated plate	Screen angle
1	11,12,13 April	4B	16	none	VD[a]	SVBS[b]	SOG[c]	-	55
2	22,23,25 April	5B	16	ESTS[d]	FGE	MBFVBS[e]	ROG[f]	45%	55
		6B	16	ESBS[g]	FGE	MBFVBS	ROG	30%	55
3	26,27,28,29 April	4B	16	none	VD	SVBS	SOG	-	55
4	27,28,29 April	5B	16	ESTS	DES[h]	MBFVBS	ROG	45%	55
5	27,28,29,30 April 1,2,3,4,5 May	7B	16	SSTS	DES	SVBS	SOG	48%	55
6	30 April 1,2,3,4,5 May	4B	16	SSTS	DES	SVBS	SOG	48%	55
		5B	16	ESTS	FGE	MBFVBS	ROG	45%	55
		6B	16	ESBS	FGE	MBFVBS	ROG	30%	55
7	8,9,10,11,12,13 May	4B	16	SSTS	DES	SVBS	SOG	48%	55
		5A	16	ESTS	DES	MBFVBS	SOG/ROG	45%	55
		5B	16	ESTS	DES	MBFVBS	ROG/SOG	45%	55
8	17,18,19,20,21 May	4B	16	SSTS	DES	SVBS	SOG	48%	55
		5B	16	ESTS	DES	MBFVBS	SOG	34%	55
		6B	16	ESBS	DES	MBFVBS	SOG	30%	55
		6C	16	ESBS	DES	MBFVBS	SOG	26%	55
9	22,23,24 May	4B	16	SSTS	DES	SVBS	ROG	48%	55
		5B	16	ESTS	DES	MBFVBS	PROG[j]	34%	55
		6A	16	ESBS	DES	MBFVBS	ROG	26%	55
		6B	16	ESBS	DES	MBFVBS	PROG	30%	55
		7B	16	SSTS	DES	SVBS	SOG	48%	55
10	28,29,30,31 May 1,3 June	4B	16	SSTS	DES	SVBS	ROG	48%	55
		5B	16	ESTS	FGE	MBFVBS	PROG	34%	55
		6B	16	ESBS	FGE	MBFVBS	PROG	30%	55
		7B	16	SSTS	DES	MBFVBS	SOG	48%	55
11	21,22,23 June	4B	16	none	VD	SVBS	SOG	-	55
12	24,25,26,27, 28,29,30 June 1,2 July	4B	16	SSTS	DES	SVBS	SOG	48%	55
		5B	16	ESTS	FGE	MBFVBS	ROG	34%	55
		6B	16	ESBS	FGE	MBFVBS	ROG	30%	55
13	8,9,10,11,12,13,14 July	4B	16	SSTS	DES	SVBS	ROG	48%	55
		5B	16	ESTS	FGE	MBFVBS	ROG	34%	62
		6B	16	ESBS	FGE	MBFVBS	ROG	30%	55
14	16,17,18,21,22, 23,24,25 July	4B	16	SSTS	DES	SVBS	ROG	48%	55
		5B	12	ESTS	FGE	MBFVBS	ROG	34%	55
		6B	16	ESBS	FGE	MBFVBS	ROG	30%	55

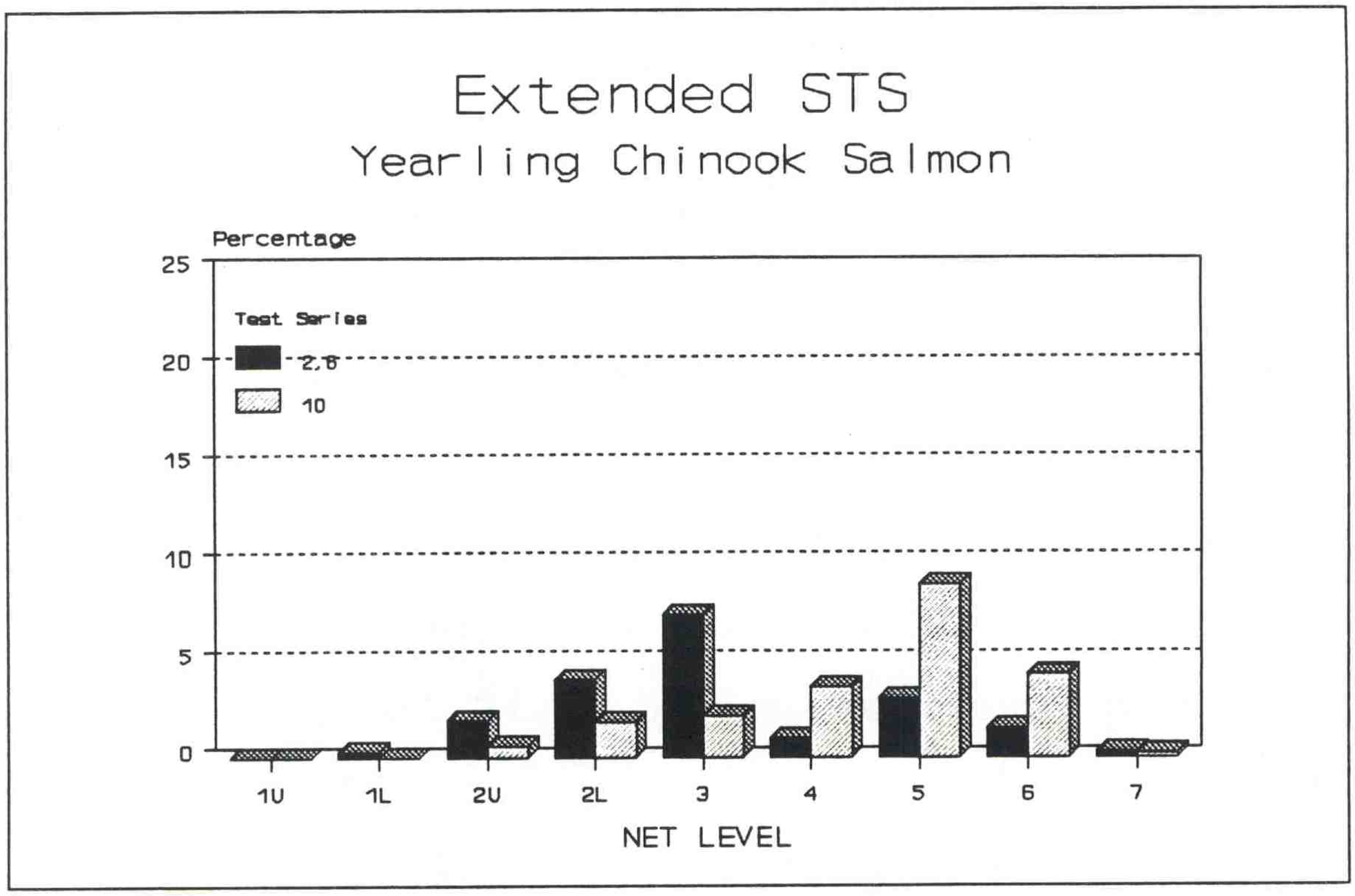
[a] Vertical distribution.
[b] Standard vertical barrier screen.
[c] Stored operating gate.
[d] Extended STS.
[e] Modified balanced flow vertical barrier screen.
[f] Raised operating gate.
[g] Extended submersible bar screen.
[h] Descaling.
[j] Partially raised operating gate (7.8 ft).

Results and Discussion

Yearling Fish

Testing for FGE began on 22 April and initial guidance for yearling chinook salmon was high, averaging 81% (SE = 2.9) for the ESTS and 80% (SE = 2.1) for the ESBS. However, unacceptably high descaling rates with the extended screens prompted a temporary shift in research efforts (see Objective 3). Tests for FGE were not conducted during the subsequent descaling tests. Screen conditions that resulted in lower descaling were determined and used when FGE testing resumed.

After descaling tests were completed, a final FGE test series was conducted at the end of the spring outmigration, from 28 May to 3 June. The FGE test on 3 June was excluded from the final analysis due to low numbers of fish. The final FGE test sequence during the spring outmigration of yearling chinook salmon compared partially raised operating gates (PROG, raised 7.8 ft) combined with extended screens, to a fully raised operating gate (ROG) in control Slot 4B, and to a stored operating gate (SOG) in control Slot 7B. The perforated plate on the back of the ESTS had been changed from 45% to 34% on 17 May as a result of descaling tests. A noticeable difference in the distribution of the net catch occurred after this porosity change (Fig. 3). Before the porosity change on the ESTS perforated plate, the highest catches were in Net-level 3; after the change, they were in Net-level 5. The net-level catch with the ESBS remained unchanged during the same time period, with Net-level 5 having the highest catch. Net-level 5 generally had the highest catch, independent of the extended guidance device used throughout the subyearling chinook salmon outmigration (Fig. 4). This change in net-level distribution pointed to a change in



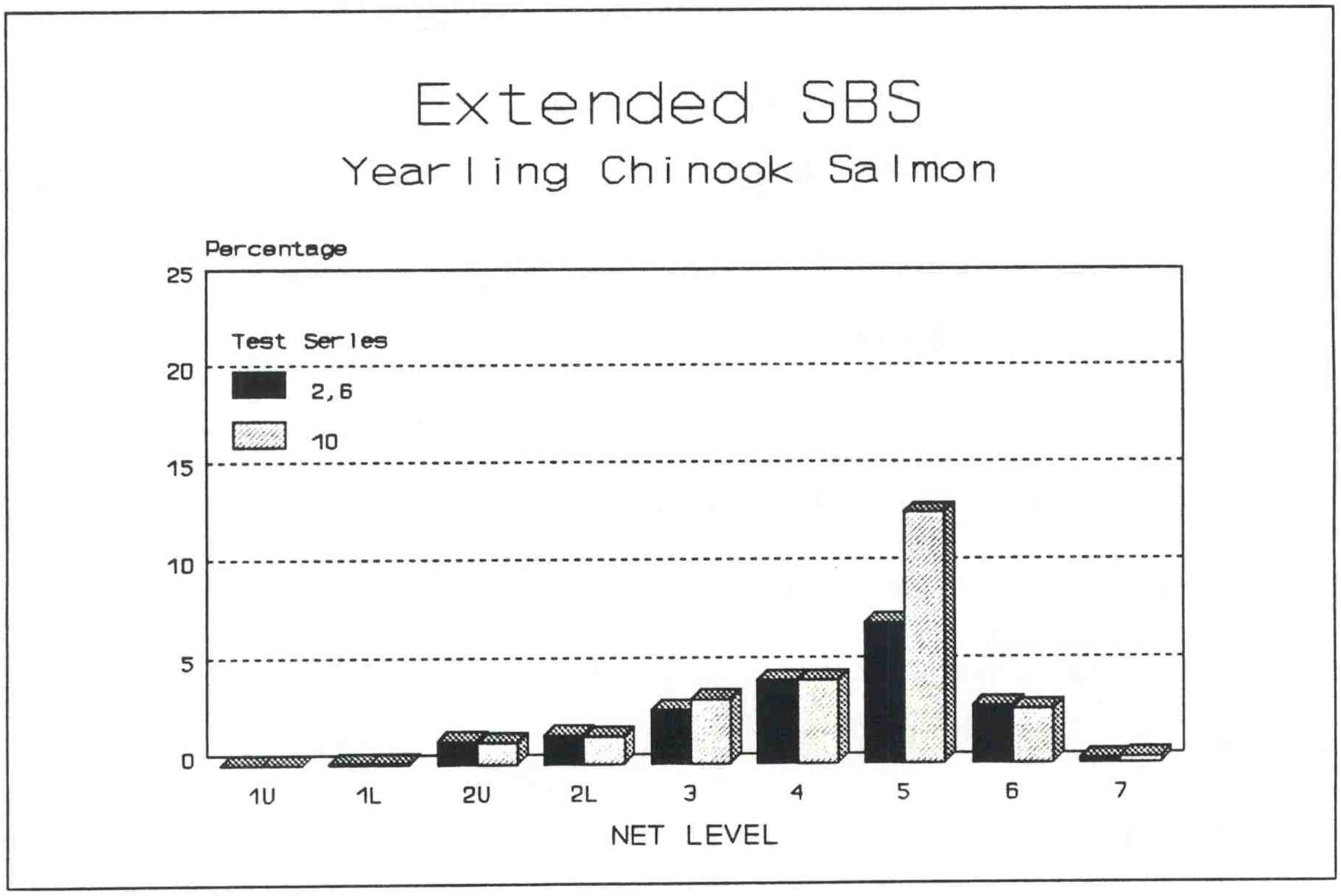
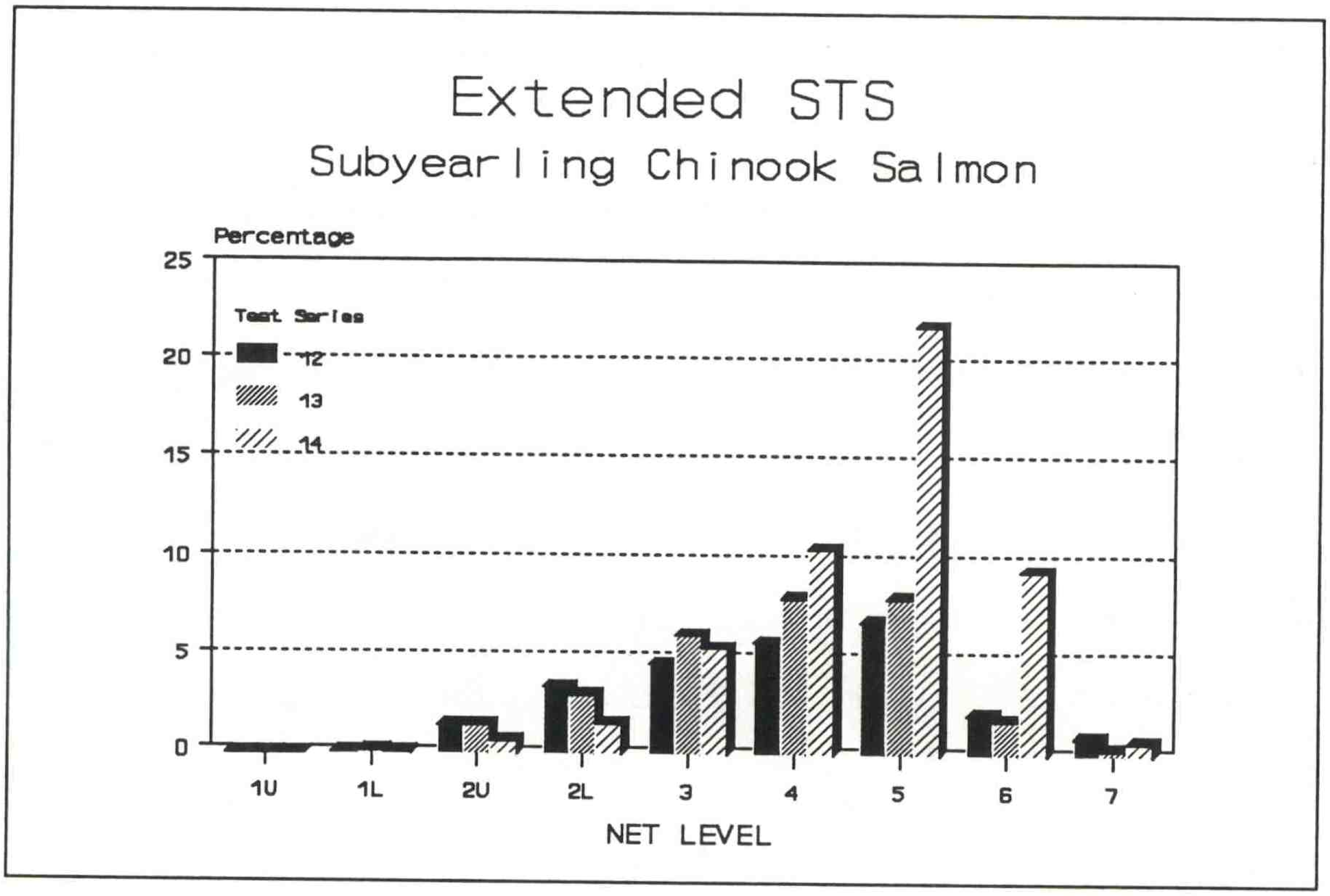


Figure 3.--Yearling chinook salmon distribution by net level during FGE tests at McNary Dam, 1991.



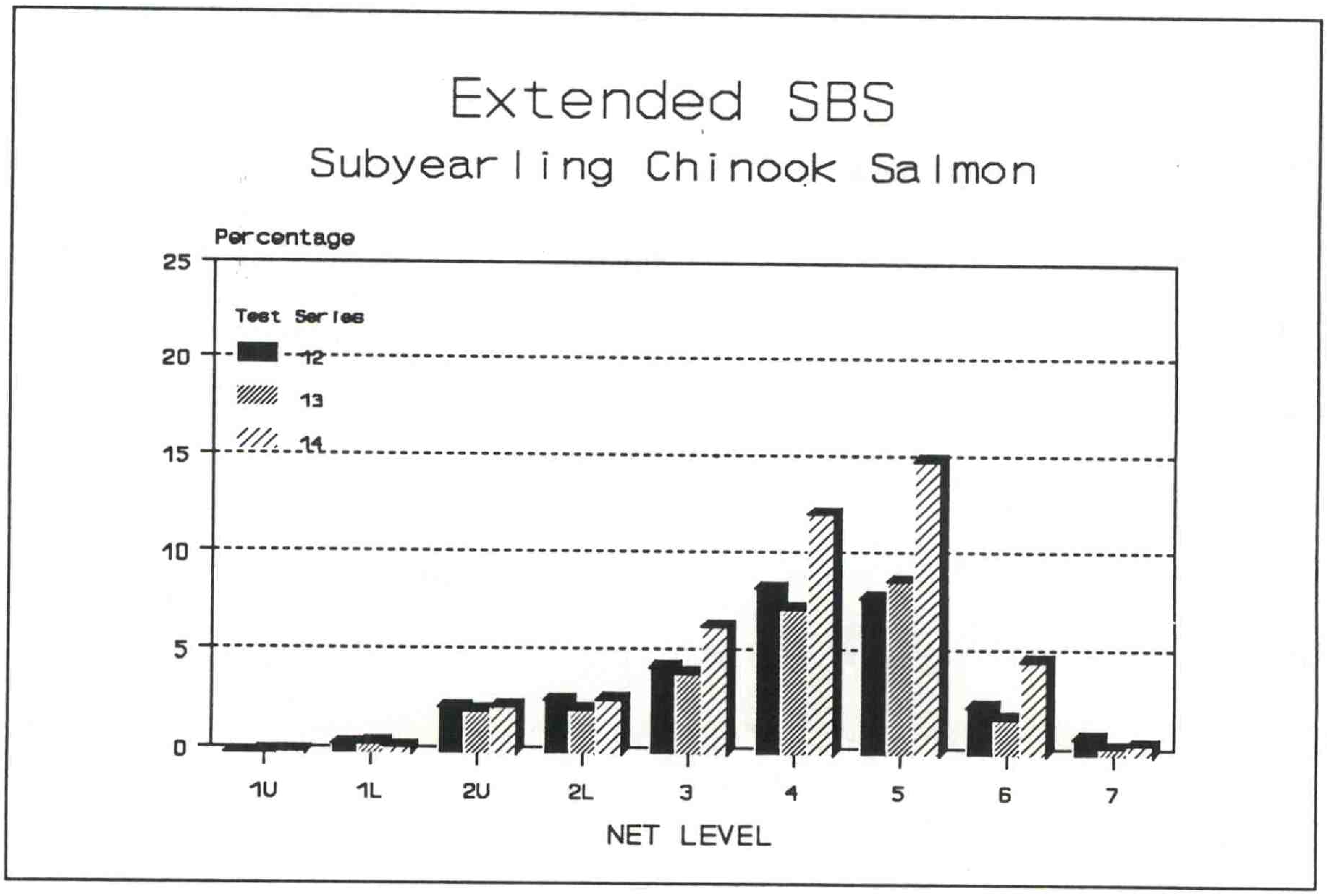


Figure 4.--Subyearling chinook salmon distribution by net level during FGE tests at McNary Dam, 1991. Test series numbers refer to Table 1.

flow pattern through and around the ESTS due to the change in porosity of the perforated plate.

The FGE for yearling chinook salmon with the ESTS and ESBS ranged from 73 to 81% through the spring (Fig. 5). The FGE for the ESTS averaged 81% (SE = 2) for the period 17 May-1 June, when the porosity of the perforated plate was 34%. The FGE for the ESBS through the spring outmigration averaged 78% (SE = 2). The 3% difference in FGE between the ESBS and ESTS was not significant (t = 3.1, P = 0.26). After modifications to the screens, the final spring test series for yearling chinook salmon resulted in FGE values of 81% (SE = 3) for the ESTS and 73% (SE = 2) for the ESBS.

Screen effectiveness (FGE/TFGE) has been used in past reports to indicate how successful a device is in intercepting fish entering a turbine intake (Krcma et al. 1986, Gessel et al. 1987, Brege et al. 1988). Using this method of evaluation, the FGE of 81% for the ESTS would result in screen effectiveness values of 90 and 82% based on the 89.6 and 98.6% TFGE found during the vertical distribution measurements. The FGE of 78% for the ESBS would result in screen effectiveness values of 87 and 79% based on the same TFGE measurements.

Steelhead, coho salmon, and sockeye salmon were captured incidentally during FGE tests. Between 22 April and 5 May, steelhead FGE averaged 91% for the ESTS and 88% for the ESBS. Between 28 May and 1 June, respective FGE for the ESTS and ESBS averaged 92 and 96% for steelhead, 93 and 92% for coho salmon, and 68 and 66% for sockeye salmon. Appendix Table 4 contains complete data for all FGE tests during 1991.

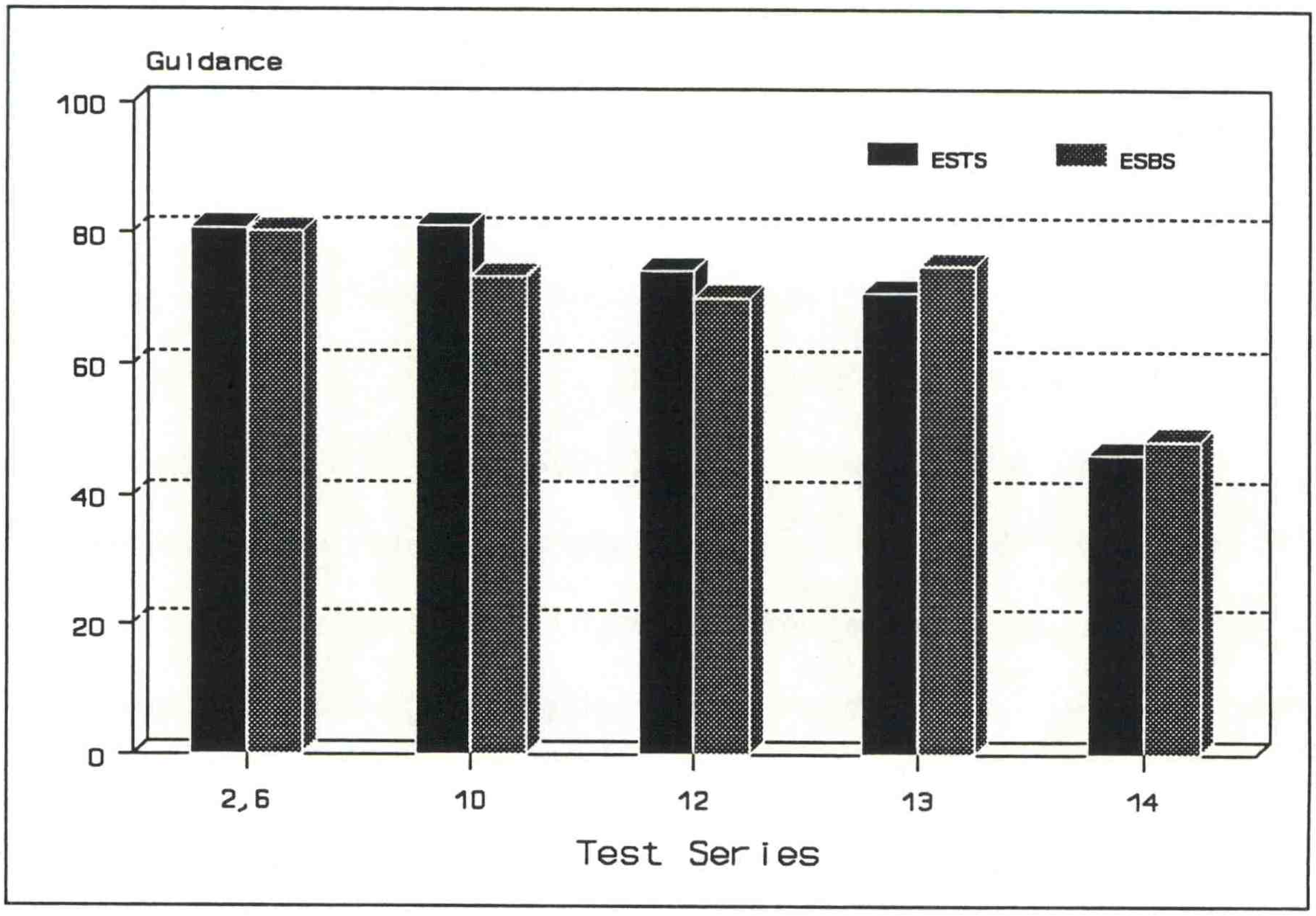


Figure 5.--Fish guidance efficiency for yearling (Test Series 2, 6, and 10) and subyearling (Test Series 12, 13, and 14) chinook salmon with ESTS and ESBS at McNary Dam, 1991. Test series numbers refer to Table 1.

Subyearling Fish

Three FGE test series were conducted from 24 June to 25 July. Numbers of fish were adequate for all test series. Fully raised operating gates (Fig. 2) were used for the ESTS and ESBS during all three series, and the ESTS was fitted with a 34% porosity perforated plate. A stored operating gate (Fig. 1), the existing operating gate condition at McNary Dam, was used for the control SSTS in Slot 4B. For Test Series 12 (24 June-2 July), the ESTS produced an average FGE of 74% (SE = 3) and the ESBS produced an average FGE of 70% (SE = 3) (Fig. 5).

Screen effectiveness values for the ESTS with an FGE of 74% and the ESBS with an FGE of 70% were 76 and 72%, respectively. Screen effectiveness values for subyearling chinook salmon at John Day Dam and Bonneville Dam Second Powerhouse using SSTS have been considerably lower, 53 and 52% respectively (Krcma et al. 1986; Gessel et al. 1987).

For Test Series 13 (8-14 July), the ESTS screen angle was changed from 55 to 62° to decrease approach velocity to the screen and to see if this reduction would result in lower descaling. The ESBS screen angle remained unchanged at 55°. Fish guidance efficiencies were 71 (SE = 3) and 75% (SE = 2) for the ESTS and ESBS, respectively (Fig. 5).

Since adjusting the ESTS angle to 62° did not reduce descaling, the angle was returned to 55° (Table 1). The final test series for subyearling chinook salmon (Test Series 14, 16-25 July) was conducted with a reduced flow of 12 kcfs through Unit 5 in another attempt to reduce descaling with the ESTS and to try to define the lower boundary of approach velocity for redesign considerations. Flow through Unit 6 with the ESBS remained unchanged at 16 kcfs. The FGE decreased dramatically in both units and averaged 46 (SE = 4) and 48% (SE = 6) for the ESTS and ESBS, respectively (Fig. 5). It is interesting to note that a late-season decrease in FGE for subyearling chinook salmon was also observed by researchers at Wanapum Dam on the mid-Columbia River (Stuart Hammond, Grant County PUD, Ephrata, Washington, pers. commun.). A corresponding increase in catch at net levels 4, 5, and 6 accompanied the decreasing FGE (Fig 4).

We found no significant differences in FGE between the ESTS and the ESBS for the three sets of conditions.

OBJECTIVE 3.--EFFECT OF EXTENDED GUIDANCE DEVICES ON DESCALING AND IMPINGEMENT

Approach

Fish condition was measured using standard Fish Transportation Oversight Team fish descaling criteria (Ceballos et al. 1992). Fish from vertical distribution, FGE, descaling, and impingement tests were all examined for descaling. Individual descaling tests are listed in Table 2.

Impingement tests were conducted from 0001 h to 0700 h after FGE or descaling tests were completed. Fyke-net frames were removed from the gate slot and the units re-started. The mesh belt on the ESTS and the cleaning brush mechanism on the ESBS were not operated at any time during the test. During an impingement test, a crew monitored fish numbers in Slot 4B (control). If high numbers of fish entered Slot 4B before the scheduled end of the impingement test, the test was terminated; this reduced the chance of excessive impingement/mortality of fish on the screens. The test was terminated after only 4 hours on 30 June and 10 July because of high numbers of fish. The following morning, guided fish were dipped out of the

Table 2.--Descaling during FGE testing on yearling and subyearling chinook salmon and steelhead at McNary Dam, 1991.

Test series number	Dates	Species	Test unit	Guidance device	Descaling (%) Mean	SE
2,6	22,23,25,30 April 1,2,3,4,5 May	Yearling chinook salmon	4B	SSTS[a]	7.1	0.6
			5B	ESTS[b]	19.2	2.0
			6B	ESBS[c]	11.8	1.2
		Steelhead	5B	ESTS	5.8	0.6
			6B	ESBS	4.4	0.7
4,5	27,28,29,30 April 1,2,3,4,5 May	Yearling chinook salmon	5B	ESTS	22.1	6.8
			7B	SSTS	7.9	2.3
		Steelhead	5B	ESTS	8.1	3.9
			7B	SSTS	7.1	1.0
7	8,9,10,11,12,13 May	Yearling chinook salmon	4B	SSTS	8.3	1.5
			5A/5B[d]	ESTS	14.2	1.5
			5A/5B[e]	ESTS	16.8	1.5
		Steelhead	4B	SSTS	7.1	1.2
			5A/5B[d]	ESTS	11.6	1.2
			5A/5B[e]	ESTS	11.0	1.2
8	17,18,19,20,21 May	Yearling chinook salmon	4B	SSTS	13.0	1.9
			5B[f]	ESTS	11.2	1.9
			6B	ESBS	9.5	1.9
			6C	ESBS	6.7	1.9
		Steelhead	4B	SSTS	5.5	0.9
			5B[f]	ESTS	6.9	0.9
			6B	ESBS	4.4	0.9
			6C	ESBS	4.9	0.9
9,10	22,23,24,28,29,30,31 May 1,3[i] June	Yearling chinook salmon	4B[e]	SSTS	15.5	1.3
			5B	ESTS	11.0	1.3
			6B	ESBS	9.4	1.3
			7B	SSTS	10.7	1.3
		Steelhead	4B	SSTS	10.8	2.5
			5B	ESTS	14.5	2.6
			6B	ESBS	9.4	2.5
			7B	SSTS	13.7	2.5
12	24,25,26,27,28,29,30 June 1,2 July	Subyearling chinook salmon	4B	SSTS	2.9	0.7
			5B	ESTS	9.3	0.7
			6B	ESBS	3.7	0.7
13	8,9,10,11,12,13,14 July	Subyearling chinook salmon	4B	SSTS	5.6	1.3
			5B[g]	ESTS	12.3	1.3
			6B	ESBS	6.7	1.3
14	16,17,18,21,22 23,24,25 July	Subyearling chinook salmon	4B	SSTS	6.1	1.6
			5B[h]	ESTS	11.5	1.6
			6B	ESBS	8.2	1.6

[a]Standard submersible traveling screen.
[b]Extended submersible traveling screen.
[c]Extended submersible bar screen.
[d]Stored operating gate.
[e]Raised operating gate.
[f]Porosity of perforated plate changed to 34%
[g]Screen angle increased to 62°
[h]Discharge reduced to 12 kcfs.
[i]Deleted from final analysis, too few fish.

gatewell and the guidance device was inspected by video camera and/or removed for detailed examination. This method did not give an absolute measure of impingement, but it did provide a relative estimate for comparison between the ESTS and ESBS. Impingement, expressed as a percentage, was calculated by dividing the number of impinged fish by the total number of fish collected during the time period:

$$Impingement = \frac{IC}{IC+GW} X\ 100$$

$$IC = IMPINGED\ CATCH$$
$$GW = GATEWELL\ CATCH$$

Although impingement tests were originally scheduled for every 5th day during the outmigration, daily FGE/descaling tests and the limited availability of COE personnel allowed us to complete only eight tests (Table 3). Descaling differences between screens and conditions were tested using paired t-tests and Randomized Block ANOVA (Petersen 1985).

Results and Discussion

Yearling Fish

Yearling chinook salmon descaling was higher with the ESTS than with the ESBS during the entire spring outmigration (Fig. 6). Changing the porosity of the perforated plate from 45 to 34% on 17 May (Test Series 8) significantly decreased the rate of descaling associated with the ESTS from 22.1 to 11.2% ($t = 2.72$, $P = 0.02$). As the season progressed, descaling in the control slot increased (Fig. 6). Increased descaling in the control slot over time may explain the lack of a significant difference in descaling ($t = 2.09$, $P = 0.15$) between the ESBS (mean = 9.5%) and the SSTS (mean = 13.0%), even though earlier test series indicated some effect on descaling by

Table 3.--Impingement of yearling and subyearling chinook and sockeye salmon during descaling and impingement testing at McNary Dam, 1991.

Test date	Test unit	Flow (Kcfs)	Guidance device	Vertical barrier screen	Gate position	Porosity of perforated plate	Impingement
26 April	6B	16	ESBS	MBFVBS	ROG	30%	1 Subyearling
6 May	6B	16	ESBS	MBFVBS	ROG	30%	50 Subyearling 1 Yearling[1] 1 Sockeye[1]
11 May	5A	16	ESTS	MBFVBS	ROG	45%	239 Yearling 60 Subyearling
17 May	4B	16	SSTS	SVBS	SOG	48%	16 Subyearling 8 Yearling
	6B	16	ESBS	MBFVBS	SOG	30%	37 Subyearling[2] 3 Yearling[2] 2 Sockeye[2]
24 May	5B	16	ESTS	MBFVBS	SOG	34%	21 Subyearling 3 Yearling 4 Sockeye
30 June	5B	16	ESTS	MBFVBS	ROG	34%	56 Subyearling[3]
	6B	16	ESBS	MBFVBS	ROG	30%	20 Subyearling[3]
10 July[4]	5B	16	ESTS	MBFVBS	ROG	34%	None
	6B	16	ESBS	MBFVBS	ROG	30%	None
18 July	5B	12	ESTS	MBFVBS	ROG	34%	None
	6B	16	ESBS	MBFVBS	ROG	30%	None

[1]These fish were impinged in the cleaning brush and were probably caught during an earlier FGE test and swept off the screen surface by the brush.

[2]One yearling, 2 subyearlings, and 1 sockeye were found in the cleaning brush.

[3]These fish were not positively identified as subyearlings, but this portion of the run is comprised almost entirely of subyearlings.

[4]Screen angle of ESTS was changed from the standard 55° to 62°.

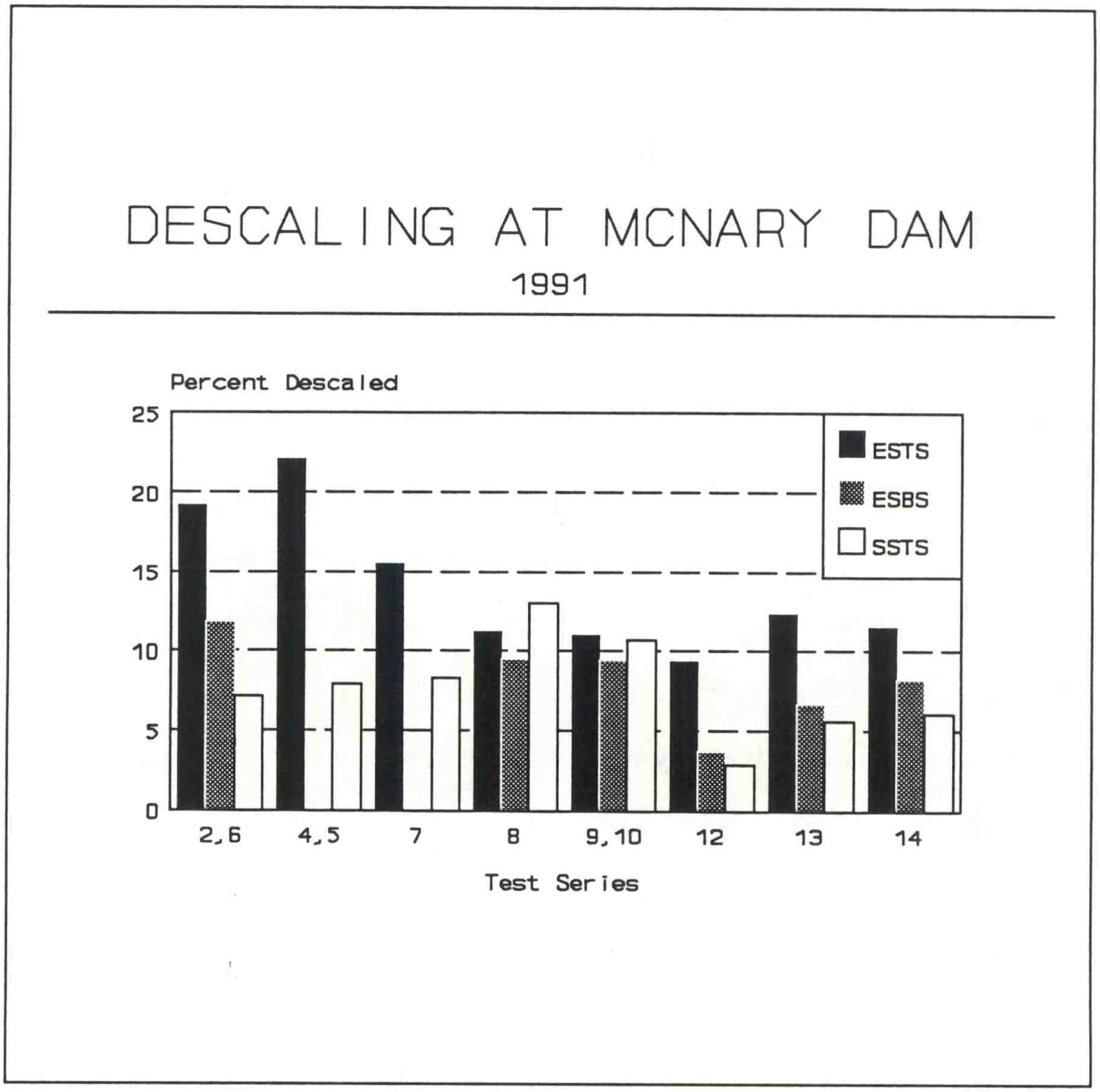


Figure 6.--Descaling of yearling and subyearling chinook salmon at McNary Dam, 1991. Test series numbers refer to Table 1. The SSTS represented control conditions.

the ESBS (Table 2). No changes in porosity were made to the perforated plate of the ESBS during the season.

We suspected that excessive flows up the bulkhead slot associated with a ROG contributed to descaling. From 8-13 May, a ROG/SOG crossover test series was conducted with an ESTS in Unit 5 to determine the influence of gate position on descaling. Operating gates in Slots 5A and 5B were alternated daily between raised and stored positions during the tests, with one in a ROG position and the other in a SOG position. Identical ESTS (with 45% porosity perforated plate) were used in both slots. An SSTS in Slot 4B with a SOG was used as the control. Results of the ROG/SOG crossover test indicated that descaling with a ROG (mean = 16.8%) was not significantly different than with a SOG (mean = 14.2%), but descaling for both ROG and SOG positions was significantly higher with ESTS ($F = 9.08$, $P = 0.01$) than 2 with SSTS (mean = 8.3%) (Table 2).

Descaling results obtained during the last FGE test series (22 May-3 June) also supported earlier findings that a raised operating gate had no significant effect on descaling compared to a stored operating gate. During this test series, partially raised operating gates were used in Slot 5B with an ESTS and in Slot 6B with an ESBS. Two controls were used: Slot 4B with an SSTS and a ROG, and Slot 7B with an SSTS and a SOG. The PROG in Slots 5B and 6B provided bulkhead slot flows equivalent to those with a ROG in Slot 4B. There were no significant differences in descaling among the PROG with the ESTS in Slot 5B (mean = 11.0%), the PROG with the ESBS in Slot 6B (mean = 9.4%), and the Slot 7B control with a SOG and SSTS (mean = 10.7%). An unexpectedly higher rate of descaling occurred with the ROG with SSTS in Slot 4B (mean = 15.5%). The difference in descaling rate between Slot 4B and the other three slots was probably due to the SVBS in Slot 4B rather than the

MBFVBS in Slots 5B and 6B, since flows up Slots 4B, 5B, and 6B were the same (Table 2) (Krcma et al. 1985).

The first two impingement tests concentrated on the ESBS because its smooth surface allowed the frame of the video camera to easily slide down the length of the screen for visual inspection. Few fish were found impinged on this device. Unacceptably high descaling with the ESTS shifted emphasis of the impingement tests from the ESBS to the ESTS. An impingement test on 11 May using the ESTS with a 45% porosity perforated plate and a ROG resulted in 239 yearling and 60 subyearling chinook salmon swimup fry impinged on the mesh (Table 3). As a result of this impingement test and the observation of high descaling from previous descaling tests, the porosity of the perforated plate on the ESTS was changed on 17 May from 45 to 34%. The change in porosity of the perforated plate reduced the approach velocity to the ESTS, and fewer fish became impinged on the mesh (Table 3). Some impingement of subyearling chinook salmon swimup fry was observed for both the ESTS and ESBS during the spring outmigration.

Subyearling Fish

Descaling for subyearling chinook salmon was recorded during FGE tests conducted from 24 June through 25 July. Tests were conducted with 34% porosity perforated plate on the ESTS, 30% porosity perforated plate on the ESBS, and a ROG in both units. The ESBS conditions remained unchanged throughout all test series.

During FGE Test Series 12 (24 June-2 July), descaling was significantly higher ($F = 23.11$, $P < 0.01$) for the ESTS than either the ESBS or SSTS (means = 9.3, 3.7, and 2.9%, respectively) (Table 2).

During the next series, the angle of the ESTS was changed from 55 to 62° to reduce the area of flow intercepted by the screen and thereby decrease the velocity through the screen. Descaling of subyearling chinook salmon on the ESTS at 62° was again significantly higher ($F = 8.33$, $P = 0.01$) than on the ESBS and the SSTS while both were at 55° (Table 2).

In the final test series, 16-25 July, the screen angle for the ESTS was returned to 55° and the flow through the unit was decreased to 12 kcfs. The ESBS conditions remained unchanged. Descaling with the ESTS was still high, but not significantly different ($F = 2.96$, $P = 0.09$) from the ESBS or SSTS (means = 11.5, 8.2, and 6.1%, respectively) (Table 2). Descaling was not significantly different ($t = 1.57$, $P = 0.13$) between the ESBS and SSTS for any of the three test series with subyearling chinook salmon (means = 6.0 and 4.7%, respectively).

Comparative impingement tests were conducted using both the ESTS and ESBS for subyearling chinook salmon on 30 June, 10 July, and 18 July (Table 3). Conditions during these three impingement tests were the same as those during the FGE tests: ROG for both devices; a 62° angle for the ESTS and a 55° angle for the ESBS; and 12 kcfs flow for the ESTS with 16 kcfs flow for the ESBS. Only the first of the three tests resulted in measurable impingement, with 5.4% impingement for the ESTS and 2.3% for the ESBS.

Appendix Table 5 summarizes descaling observed during testing at McNary Dam in 1991.

Additional video observations by COE Waterways Experiment Station personnel, as part of a pilot study with advanced underwater video systems, revealed some problems with juvenile impingement on the ESTS. This will require further studies, and the results of this work to date will be reported under separate cover.

OBJECTIVE 4.--LEVELS OF SMOLTIFICATION IN YEARLING AND SUBYEARLING CHINOOK SALMON

Approach

To examine the relationship between fish guidance and smolt development, fish were collected during vertical distribution or FGE tests and assayed for gill Na^+-K^+ ATPase. Groups of twenty fish were taken, with yearling chinook salmon sampled during the spring, and subyearling chinook salmon sampled during the summer. Groups were sampled from the gatewell catch on each occasion and placed on ice until gill samples could be taken. The 20-fish samples were chosen at random, either from all of the nets combined or from individual net levels. Fish were measured and gill filaments were trimmed from the gill arch and placed into 1.5-ml microcentrifuge tubes filled with a buffer solution containing sucrose, ethylenediamine, and imidazole (SEI). Samples were immediately placed on dry ice and later stored at < -70°C in a freezer until assayed. After gill removal, fish were individually stored in labeled plastic bags and placed on dry ice for later delivery to researchers with the U.S. Fish and Wildlife Service, who assayed the samples for bacterial kidney disease (results to be published by USFWS in a separate report).

To assure that observed differences in gill Na^+-K^+ ATPase between live gatewell and dead fyke-net fish were not caused by deterioration of this enzyme in the dead fish, gatewell fish were killed and placed in water at ambient river temperature until the fyke nets were removed from the water. Net catches were then processed at random so that the time between death and gill removal did not consistently favor any net level or the gatewell. Gills that showed signs of excess deterioration were discarded. Assays for gill Na^+-K^+ ATPase were conducted using procedures described by Zaugg (1982), with minor modification.

To characterize the physiological status of the smolt population on each sample date, the mean Na^{+}-K^{+} gill ATPase level was determined for each net level, weighted for the number of fish captured at that depth, and averaged. Correlations between smoltification and FGE were then examined. A paired t-test was used to evaluate seasonal differences in enzyme levels between guided and unguided fish.

We intended to sample only from vertical distribution tests since this was the only constant test condition throughout the field season. However, fish from FGE tests were sampled from 28 May through the summer because vertical distribution tests were too infrequent. Samples of yearling chinook salmon were collected from Unit 4B during vertical distribution tests on three test dates beginning on 26 April (Table 4). Additional yearling chinook salmon samples were collected from FGE tests conducted in Unit 5B on three dates beginning on 28 May. During the summer outmigration, subyearling chinook salmon were sampled on eight dates from FGE tests in Unit 5B (Table 4).

Results and Discussion

Yearling chinook salmon gill Na^{+}-K^{+} ATPase activity changed little during the spring sampling period; however, sampling occurred only at the beginning and end of the spring outmigration (Table 4). Mean Na^{+}-K^{+} ATPase levels ranged from 24.3 to 28.1 $\mu mol\ P_i \cdot mg\ Prot^{-1} \cdot h^{-1}$. There was no significant difference in gill Na^{+}-K^{+} ATPase activity levels between guided (gatewell) and unguided (fyke net) yearling chinook salmon ($t = -0.40$, $df = 2$, $P = 0.73$) (Table 5). There were not enough sample dates for correlating FGE and gill Na^{+}-K^{+} ATPase activity for yearling chinook salmon. However, high FGE estimates obtained at McNary Dam throughout the spring indicated that the degree of smolt development would probably have little effect on yearling chinook salmon guidance with installations of extended length

Table 4.--FGE results, weighted mean gill Na^+-K^+ ATPase level (μmol $P_i \cdot Prot^{-1} \cdot h^{-1}$), and test conditions during smoltification studies at McNary Dam, 1991.

Date	Unit, slot	Test conditions	Species	Sample size	FGE (%)	Gill Na^+-K^+ ATPase
26 Apr	4B	Vert. Dist.	Yr. chin.[a]	13	---	28.0
27 Apr	4B	Vert. Dist.	Yr. chin.	28	---	25.1
28 Apr	4B	Vert. Dist.	Yr. chin.	29	---	27.1
28 May	5B	ESTS	Yr. chin.	89	83.2	28.1
29 May	5B	ESTS	Yr. chin.	36	87.3	24.3
30 May	5B	ESTS	Yr. chin.	40	81.4	27.0
24 Jun	5B	ESTS	Sub. chin.[b]	40	77.9	32.6
25 Jun	5B	ESTS	Sub. chin.	84	82.8	36.7
26 Jun	5B	ESTS	Sub. chin.	40	84.7	34.7
30 Jun	5B	ESTS	Sub. chin.	40	59.5	36.9
1 Jul	5B	ESTS	Sub. chin.	111	75.6	30.5
2 Jul	5B	ESTS	Sub. chin.	40	72.4	36.2
16 Jul	5B	ESTS	Sub. chin.	40	62.1	46.7
17 Jul	5B	ESTS	Sub. chin.	25	77.8	40.6

[a]Yearling chinook salmon
[b]Subyearling chinook salmon

Table 5.--Gill Na^+-K^+ ATPase activity (µmol $P_i \cdot Prot^{-1} \cdot h^{-1}$) for guided (gatewell) vs. unguided (fyke nets) fish at McNary Dam, 1991.

Date	Na⁺-K⁺ ATPase (mean) Gatewell	Fyke net
Yearling chinook salmon		
28 May	27.6	30.9
29 May	24.0	26.8
30 May	27.7	24.2
Subyearling chinook salmon		
24 June	32.4	33.1
25 June	37.3	33.9
26 June	34.8	34.2
30 June	36.8	37.1
1 July	31.7	27.0
2 July	37.8	32.2
16 July	46.9	46.3
17 July	41.2	38.6

screens. Beeman et al. (1990) found that gill Na^+-K^+ ATPase levels in yearling chinook salmon were generally high throughout the spring outmigration at McNary Dam in 1989.

Gill Na^+-K^+ ATPase activity levels in subyearling chinook salmon increased on the last two sample dates and ranged from 30.5 to 46.7 $\mu mol\ P_i \cdot mg\ Prot^{-1} \cdot h^{-1}$ over the summer outmigration period (Table 4). During the summer, guided subyearling chinook salmon generally had significantly higher gill Na^+-K^+ ATPase levels than unguided fish ($t = 2.47$, $df = 7$, $P = 0.043$) (Table 5). Correlations between smolt development and FGE estimates were examined using the weighted mean enzyme level vs. FGE on each sampling date. No strong correlation between smolt development and FGE was found ($r^2 = 0.23$). Appendix Tables 6 and 7 summarize gill Na^+-K^+ ATPase results for all sampling dates at McNary Dam in 1991.

Weighted mean gill Na^+-K^+ ATPase levels for subyearling chinook salmon increased at McNary Dam near the end of the July sample period, while FGE fluctuated daily; however, there was little correlation between the two. Whether there is a relationship between FGE and smolt development in subyearling chinook salmon is unclear. Other factors, such as unit discharge, turbidity, water temperature, predators, or dam operation may overshadow the influence of smolt development on FGE for subyearling chinook salmon.

CONCLUSIONS

1) Based upon vertical distribution measurements, extended length screens should guide a high proportion of all juvenile salmonids.

2) Gate position, screen angle, and/or flow through the turbine unit did not significantly change descaling rates with extended screens. However, some baseline descaling (low levels) likely occurred because of these factors.

3) Varying the porosity of the perforated plate on the ESTS appeared to have the greatest effect on descaling rates.

4) For the 1991 season, mean FGE for subyearling chinook salmon was 64% for both the ESTS and ESBS. This was significantly higher than the 33 and 42% seasonal FGE means obtained in 1986 and 1987, respectively, using standard length screens at McNary Dam.

5) For the 1991 season, mean FGE for yearling chinook salmon was 81 and 78% for the ESTS and ESBS, respectively. Previous SSTS FGE tests with yearling chinook salmon averaged 75%.

6) Smoltification status of yearling or subyearling chinook salmon was not a good predictor of changes in FGE at McNary Dam in 1991. However, the restricted spring sampling period for yearling chinook salmon and consistently high FGE may have obscured the possible relationship between smoltification status and FGE.

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Appendix Table 1.--Dipbasket efficiency tests on yearling chinook salmon and steelhead from Turbine Unit 5B with raised operating gate, McNary Dam, 1991.

	Yearling chinook salmon		Steelhead	
Date	Total[a]	Descaled	Total[a]	Descaled
8 May	97/94	0	97/95	0
12 May	96/93	1	-[b]	-

[a]Total number of fish marked/recaptured.
[b]Steelhead were not available for this test.

Appendix Table 2.--Diel passage of subyearling chinook salmon into Turbine Unit 8B at McNary Dam, 27-28 June 1991.

Time	Catch/hour	Time	Catch/hour
1700	Clean out gatewell		
1800	246	0600	386
1900	297	0700	327
2000	238	0800	321
2100	429	0900	398
2200	1,287	1000	329
2300	729	1100	156
2400	254	1200	349
0100	311	1300	39
0200	162	1400	34
0300	175	1500	29
0400	114	1600	30
0500	72	1700	11

Total catch from 1800 h, 27 June to 1700 h, 28 June was 6,723.

Appendix Table 3.--Vertical distribution, McNary Dam, 1991.

SUBYEARLING CHINOOK SALMON

Test Unit	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B
Test Date	11 April	12 April	13 April	26 April	27 April	28 April	29 April	21 June	22 June	23 June
Gatewell	-	-	-	-	-	2	-	71	90	27
First Net	-	-	-	-	-	-	6	114	75	75
Second Net	-	-	-	-	-	-	-	9	36	39
Third Net	-	-	-	-	-	3	-	6	3	9
Fourth Net	-	-	-	-	-	-	-	3	6	6
Fifth Net	-	-	-	-	-	-	-	-	-	-
Sixth Net	-	-	-	-	-	-	-	-	-	-
Seventh Net	-	-	-	-	-	-	-	-	-	-
Totals	-	-	-	-	-	5	6	203	210	156

YEARLING CHINOOK SALMON

Test Unit	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B
Test Date	11 April	12 April	13 April	26 April	27 April	28 April	29 April	21 June	22 June	23 June
Gatewell	16	6	14	9	25	22	44	2	-	-
First Net	6	3	6	9	21	18	12	12	-	-
Second Net	-	3	9	3	3	3	24	-	-	-
Third Net	-	-	-	-	-	3	12	-	3	-
Fourth Net	3	-	-	-	-	-	-	-	-	3
Fifth Net	-	-	-	-	-	3	-	-	-	-
Sixth Net	-	-	-	-	-	-	-	-	-	-
Seventh Net	6	-	-	-	-	-	-	-	-	-
Totals	31	12	29	21	49	49	92	14	3	3

STEELHEAD

Test Unit	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B
Test Date	11 April	12 April	13 April	26 April	27 April	28 April	29 April	21 June	22 June	23 June
Gatewell	-	-	2	36	63	73	54	1	-	2
First Net	-	-	3	18	27	51	36	-	-	-
Second Net	-	-	-	9	24	24	12	-	-	-
Third Net	-	-	3	3	12	15	3	-	-	-
Fourth Net	-	-	-	-	-	3	-	-	-	-
Fifth Net	-	-	-	3	-	3	-	-	-	-
Sixth Net	-	-	-	-	-	-	-	-	-	-
Seventh Net	-	-	-	-	3	-	-	-	-	-
Totals	-	-	8	69	129	169	105	1	-	2

Appendix Table 3.--Continued.

COHO SALMON

Test Unit	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B
Test Date	11 April	12 April	13 April	26 April	27 April	28 April	29 April	21 June	22 June	23 June
Gatewell	-	-	-	6	4	2	1	-	1	1
First Net	-	-	-	-	-	-	-	-	-	-
Second Net	-	-	-	-	-	-	-	-	-	-
Third Net	-	-	-	-	-	-	-	-	-	-
Fourth Net	-	-	-	-	-	-	-	-	-	-
Fifth Net	-	-	-	-	-	-	-	-	-	-
Sixth Net	-	-	-	-	-	-	-	-	-	-
Seventh Net	-	-	-	-	-	-	-	-	-	-
Totals	-	-	-	6	4	2	1	-	1	1

SOCKEYE SALMON

Test Unit	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B
Test Date	11 April	12 April	13 April	26 April	27 April	28 April	29 April	21 June	22 June	23 June
Gatewell	-	-	-	7	8	21	13	2	1	-
First Net	-	-	-	9	6	6	6	-	-	-
Second Net	3	-	-	-	3	6	6	-	-	-
Third Net	-	-	-	-	-	3	3	-	-	-
Fourth Net	-	-	-	-	-	3	3	-	-	-
Fifth Net	-	-	-	-	3	-	3	-	-	-
Sixth Net	-	-	-	-	-	-	-	-	-	3
Seventh Net	-	-	-	-	-	-	-	-	-	-
Totals	3	-	-	16	20	39	34	2	1	3

Appendix Table 4.--Numbers of fish collected for individual replicates of FGE tests at McNary Dam, 1991.

Date (Test Unit) and (series number)[a]

Location	22 April (6B) (2)					23 April (6B) (2)					25 April (6B) (2)					22 April (5B) (2)				
	SC	YC	ST	CO	SO[b]	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	0	156	39	1	3	0	45	66	2	1	0	37	92	1	10	0	127	41	0	2
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 upper	0	1	1	0	0	0	0	1	0	0	0	1	3	0	0	0	1	0	0	0
2 lower	0	0	1	0	0	0	3	0	0	0	0	0	0	0	1	0	3	0	0	0
third	0	2	0	0	0	0	2	2	0	0	0	1	1	0	0	0	11	1	0	0
fourth	0	6	0	0	0	0	3	2	0	0	0	1	2	0	1	0	0	1	0	0
fifth	0	1	1	0	0	0	5	7	0	0	1	3	6	0	2	1	7	0	0	0
sixth	0	2	0	0	0	0	3	0	0	0	0	1	2	0	2	0	1	0	0	0
seventh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total	0	168	42	1	3	0	61	78	2	1	1	44	106	1	17	1	150	43	0	2
FGE (%)[c]		93											87				85			

Location	23 April (5B) (2)					25 April (5B) (2)					30 April (5B) (6)					1 May (5B) (6)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	0	71	98	0	4	0	40	134	2	24	1	46	102	2	30	0	38	156	0	21
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2 upper	0	1	1	0	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0
2 lower	0	7	0	0	1	0	1	2	0	0	0	0	1	0	4	0	0	0	0	0
third	0	1	3	0	0	0	1	7	0	0	2	7	3	0	5	0	1	7	0	2
fourth	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	2	1	0	4
fifth	0	0	3	0	0	0	0	5	0	1	0	3	0	0	6	0	2	3	0	1
sixth	0	1	5	0	0	0	1	4	0	0	0	1	2	0	1	0	0	3	0	5
seventh	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
Total	0	81	111	0	5	0	46	154	2	26	3	59	109	2	47	2	44	171	0	33
FGE (%)			88					87					94					91		

Location	2 May (5B) (6)					3 May (5B) (6)					4 May (5B) (6)					5 May (5B) (6)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	4	68	140	4	30	1	268	238	0	42	1	283	149	10	48	4	209	95	8	11
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0
2 upper	0	3	1	0	2	0	5	3	0	1	1	16	1	0	5	0	2	0	1	1
2 lower	1	9	0	0	7	4	20	0	0	6	3	11	2	0	1	3	16	1	0	6
third	0	17	5	0	8	10	27	7	0	9	2	19	2	0	3	9	33	1	0	0
fourth	0	2	3	0	2	0	0	0	0	1	0	2	1	1	5	1	1	3	0	1
fifth	0	7	9	0	1	0	0	5	0	3	0	1	3	0	0	3	14	3	0	1
sixth	0	6	1	0	3	2	1	6	0	3	1	4	2	0	0	1	2	3	0	0
seventh	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Total	5	112	159	4	54	17	322	261	0	65	8	339	160	12	62	21	277	106	9	20
FGE (%)		61	88				83	91				84	93				75	90		

[a] Refers to Table 1.
[b] SC = Subyearling chinook salmon, YC = Yearling chinook salmon, ST = Steelhead, CO = Coho salmon, SO = Sockeye salmon.
[c] FGE calculated for samples with 100 or more fish.

Appendix Table 4.--continued.

Date (Test Unit) and (series number)

Location	30 April (6B) (6)					1 May (6B) (6)					2 May (6B) (6)					3 May (6B) (6)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	2	45	60	2	25	1	68	147	2	27	3	111	92	0	37	6	238	281	0	46
1 upper	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
2 upper	0	0	0	0	4	0	3	1	0	1	0	1	0	0	1	1	3	0	0	1
2 lower	0	0	0	0	2	1	0	2	0	2	0	1	1	0	1	0	2	3	0	3
third	0	1	1	0	1	0	4	1	0	6	0	5	2	0	1	4	5	6	0	1
fourth	0	5	0	0	3	0	5	3	0	6	0	7	10	0	5	2	7	4	0	1
fifth	0	4	3	0	1	0	11	8	1	5	1	7	7	0	4	1	22	12	0	2
sixth	0	2	2	0	2	0	2	8	0	8	0	2	2	0	3	2	5	2	0	6
seventh	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1
Total	2	58	66	2	39	2	93	170	3	55	5	134	114	0	53	17	284	308	0	61
FGE (%)								87				83	81				84	91		

Location	4 May (6B) (6)					5 May (6B) (6)					28 May (5B) (10)					29 May (5B) (10)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	2	248	174	5	82	2	236	119	4	26	103	420	68	132	9	35	117	16	52	34
1 upper	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1 lower	0	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 upper	1	6	1	0	1	1	3	2	0	1	12	2	0	0	1	1	0	0	0	0
2 lower	2	7	1	0	1	1	11	1	0	2	22	6	0	0	1	7	2	0	2	2
third	5	11	3	0	4	2	10	0	0	1	41	5	0	2	2	14	3	0	0	2
fourth	2	7	5	0	5	6	13	4	0	2	9	19	1	3	0	7	1	0	1	1
fifth	2	33	5	0	4	3	24	9	0	0	14	33	1	1	1	17	5	1	2	3
sixth	0	14	2	0	2	3	7	3	0	0	8	18	0	0	1	16	6	0	2	1
seventh	0	0	0	0	1	0	0	0	0	0	7	0	0	0	0	4	0	0	0	1
Total	14	327	193	5	100	18	304	138	4	32	216	505	70	138	15	101	134	17	59	44
FGE (%)		76	90		82		78	86			48	83		96		35	87			

Location	30 May (5B) (10)					28 May (6B) (10)					29 May (6B) (10)					30 May (6B) (10)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	30	219	30	121	60	48	200	52	116	16	25	114	22	77	35	50	109	33	54	49
1 upper	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	1	1	0	0	0
2 upper	4	0	0	0	3	40	5	1	0	2	7	1	0	0	1	16	0	1	1	3
2 lower	33	2	1	0	2	35	8	1	0	1	6	3	0	0	1	23	1	0	0	1
third	30	5	0	6	5	24	6	0	0	2	3	4	0	1	2	17	2	0	0	3
fourth	9	8	1	1	5	14	16	0	1	5	17	8	0	2	0	15	6	1	0	8
fifth	30	22	1	0	6	25	39	1	0	2	31	16	0	4	2	44	19	0	3	4
sixth	26	11	2	1	1	11	13	0	0	2	14	7	0	1	3	18	3	0	1	0
seventh	1	2	0	0	0	4	1	0	0	0	2	0	0	0	0	9	1	0	0	0
Total	163	269	35	129	82	207	288	55	118	30	105	153	22	85	44	193	142	35	59	68
FGE (%)	18	81		94		23	69		98		24	75				26	77			

Appendix Table 4.--continued.

Date (Test Unit) and (series number)

Location	31 May (6B) (10) SC	YC	ST	CO	SO	1 June (6B) (10) SC	YC	ST	CO	SO	3 June (6B) (10) SC	YC	ST	CO	SO	31 May (5B) (10) SC	YC	ST	CO	SO
Gatewell	25	176	28	71	18	21	51	19	17	21	18	9	5	0	5	18	142	18	48	20
1 upper	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2 upper	13	9	1	0	1	8	0	0	0	4	3	0	0	0	0	4	3	0	0	1
2 lower	10	6	0	0	0	17	0	0	0	3	0	0	0	0	0	18	2	0	0	2
third	10	3	0	0	0	9	3	0	1	2	1	1	0	0	1	14	2	0	0	1
fourth	10	12	0	1	2	10	4	0	1	8	1	0	0	0	1	4	3	0	1	2
fifth	15	16	0	2	0	38	14	0	1	2	1	2	0	0	0	8	13	1	0	1
sixth	10	9	0	0	1	24	1	0	0	0	4	0	0	0	0	6	5	1	1	1
seventh	3	1	0	0	3	4	0	0	0	0	0	0	0	0	7	2	0	0	0	0
Total	96	232	30	74	25	131	73	19	20	41	28	12	5	0	7	74	170	20	50	28
FGE (%)		76				16											84			

Location	1 June (5B) (10) SC	YC	ST	CO	SO	3 June (5B) (10) SC	YC	ST	CO	SO	24 June (5B) (12) SC	YC	ST	CO	SO	25 June (5B) (12) SC	YC	ST	CO	SO
Gatewell	38	106	36	46	25	3	13	4	1	2	197	5	1	0	2	390	1	1	1	1
1 upper	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 upper	4	2	1	0	0	0	0	0	0	1	4	0	0	0	0	4	0	0	0	0
2 lower	11	2	0	1	3	1	1	0	0	0	3	0	0	0	0	13	0	0	0	0
third	34	2	0	0	7	1	1	0	0	0	18	0	0	0	0	18	0	0	0	0
fourth	3	11	1	0	3	2	1	0	0	1	14	0	0	0	0	14	0	0	1	0
fifth	25	19	0	1	6	2	3	0	0	1	10	1	0	0	0	18	1	0	0	0
sixth	14	9	2	1	0	1	1	0	0	0	6	0	0	0	0	10	1	0	0	0
seventh	5	1	0	1	1	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0
Total	134	152	40	50	45	10	20	5	1	5	253	6	1	0	2	471	3	1	2	1
FGE (%)	28	70									78					83				

Location	26 June (5B) (12) SC	YC	ST	CO	SO	27 June (5B) (12) SC	YC	ST	CO	SO	28 June (5B) (12) SC	YC	ST	CO	SO	29 June (5B) (12) SC	YC	ST	CO	SO
Gatewell	349	0	0	0	0	328	0	0	0	0	119	0	0	0	0	110	1	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 upper	9	0	0	0	0	6	0	0	0	0	4	0	0	0	0	1	0	0	0	0
2 lower	9	0	0	0	0	18	0	0	0	0	7	0	0	0	0	7	0	0	0	0
third	11	0	0	0	0	12	0	0	0	0	4	0	0	0	0	8	0	0	0	0
fourth	9	0	0	0	0	18	0	0	0	0	17	0	0	0	0	11	0	0	0	0
fifth	20	0	0	0	0	17	0	0	0	1	25	0	0	0	0	12	0	0	0	0
sixth	5	0	0	0	0	11	0	0	0	0	4	0	0	0	0	4	0	0	0	0
seventh	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	5	0	0	0	0
Total	412	0	0	0	0	411	0	0	0	1	182	0	0	0	0	158	1	0	0	0
FGE (%)	85					80					65					70				

Appendix Table 4.--Continued.

Date (Test Unit) and (series number)

Location	24 June (6B) (12)					25 June (6B) (12)					26 June (6B) (12)					27 June (6B) (12)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	82	3	0	0	0	165	1	1	1	0	481	0	0	0	0	240	0	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3	0	0	0	0
2 upper	2	0	0	0	0	3	0	0	0	0	9	0	0	0	0	11	0	0	0	0
2 lower	1	0	0	0	0	4	0	0	0	0	8	0	0	0	0	12	0	0	0	0
third	1	0	0	0	0	11	0	0	0	0	8	0	0	0	0	26	0	0	0	0
fourth	10	0	0	0	0	16	1	0	0	0	39	0	0	0	0	44	0	0	0	0
fifth	6	0	0	0	0	17	0	0	0	0	29	0	0	0	0	47	0	0	0	0
sixth	4	0	0	0	0	4	1	0	0	0	6	0	0	0	0	10	0	0	0	0
seventh	1	0	0	0	0	2	0	0	0	0	9	0	0	0	0	2	0	0	0	0
Total	107	3	0	0	0	223	3	1	1	0	591	0	0	0	0	395	0	0	0	0
FGE (%)	77					74					81					61				

Location	28 June (6B) (12)					29 June (6B) (12)					30 June (6B) (12)					1 July (6B) (12)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	87	0	0	0	0	147	0	0	0	0	383	0	1	0	0	505	1	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	
1 lower	0	0	0	0	0	1	0	0	0	0	8	0	0	0	0	4	0	0	0	0
2 upper	1	0	0	0	0	9	0	0	0	0	23	0	0	0	0	15	0	0	0	0
2 lower	6	0	0	0	0	9	0	0	0	0	23	0	0	0	0	12	0	0	0	0
third	4	0	0	0	0	18	0	0	0	0	33	0	0	0	0	26	0	0	0	0
fourth	16	0	0	0	0	13	0	0	0	0	28	0	0	0	0	48	0	0	0	0
fifth	8	0	0	0	0	20	0	0	0	0	26	0	0	0	0	47	0	0	0	0
sixth	3	0	0	0	0	5	0	0	0	0	6	0	0	0	0	21	0	0	0	0
seventh	1	0	0	0	0	3	0	0	0	0	1	0	0	0	0	8	0	0	0	0
Total	126	0	0	0	0	225	0	0	0	0	534	0	1	0	0	686	1	0	0	0
FGE (%)	69					65					72					74				

Location	2 July (6B) (12)					8 July (6B) (13)					9 July (6B) (13)					10 July (6B) (13)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	817	0	1	0	0	254	0	0	0	0	145	0	0	0	0	565	5	1	0	0
1 upper	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1 lower	6	0	0	0	0	1	0	0	0	0	2	0	0	0	0	12	0	0	0	0
2 upper	33	0	0	0	0	7	1	0	0	0	5	0	0	0	0	16	0	0	0	0
2 lower	37	0	0	0	0	6	0	0	0	0	3	0	0	0	0	21	0	0	0	0
third	65	0	0	0	0	9	0	0	0	0	7	0	0	0	0	38	0	0	0	0
fourth	159	0	0	0	0	15	0	0	0	0	15	0	0	0	0	79	0	0	0	0
fifth	207	0	0	0	0	33	0	0	0	0	23	0	0	0	0	86	0	0	0	0
sixth	62	0	0	0	0	3	0	0	0	0	5	0	0	0	0	13	0	0	0	0
seventh	12	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	0	0	0	0
Total	1398	0	1	0	0	329	1	0	0	0	206	0	0	0	0	838	5	1	0	0
FGE (%)	58					77					70					67				

Appendix Table 4.--continued.

Date (Test Unit) and (series number)

Location	11 July (6B) (13)					12 July (6B) (13)					13 July (6B) (13)					14 July (6B) (13)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	518	0	0	0	0	1482	0	0	0	0	117	0	0	0	0	574	0	0	0	0
1 upper	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	2	0	0	0	0	11	0	0	0	0	0	0	0	0	0	2	0	0	0	0
2 upper	18	0	0	0	0	58	0	0	0	0	1	0	0	0	0	14	0	0	0	0
2 lower	19	0	0	0	0	53	0	0	0	0	3	0	0	0	0	11	0	0	0	0
third	30	0	0	0	0	60	0	0	0	0	7	0	0	0	0	40	0	0	0	0
fourth	37	0	0	0	0	70	0	0	0	0	6	0	0	0	0	88	0	0	0	0
fifth	47	0	0	0	0	66	0	0	0	0	7	0	0	0	0	84	0	0	0	0
sixth	7	0	0	0	0	31	0	0	0	0	0	0	0	0	0	19	0	0	0	0
seventh	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Total	679	0	0	0	0	1836	0	0	0	0	141	0	0	0	0	836	0	0	0	0
FGE (%)	76					81					83					69				

Location	16 July (6B) (14)					17 July (6B) (14)					18 July (6B) (14)					21 July (6B) (14)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	515	0	0	0	0	136	0	0	0	0	159	3	1	0	0	674	0	0	1	0
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
1 lower	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0
2 upper	17	0	0	0	0	4	0	0	0	0	4	0	0	0	0	47	0	0	0	0
2 lower	17	0	0	0	0	0	0	0	0	0	9	0	0	0	0	94	0	0	0	0
third	40	0	0	0	0	4	0	0	0	0	39	0	0	0	0	165	0	0	0	0
fourth	80	0	0	0	0	11	0	0	0	0	69	0	0	0	0	276	0	0	0	0
fifth	70	0	0	0	0	12	0	0	0	0	108	0	0	0	0	358	0	0	0	0
sixth	18	0	0	0	0	5	0	0	0	0	35	0	0	0	0	123	0	0	0	0
seventh	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	14	0	0	0	0
Total	759	0	0	0	0	172	0	0	0	0	427	3	1	0	0	1780	0	0	1	0
FGE (%)	68					79					37					38				

Location	22 July (6B) (14)					23 July (6B) (14)					24 July (6B) (14)					25 July (6B) (14)				
	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO	SC	YC	ST	CO	SO
Gatewell	137	0	0	0	0	645	0	0	0	2	292	0	0	0	0	32	0	0	0	0
1 upper	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	1	0	0	0	0	5	0	0	0	0	2	0	0	0	0	0	0	0	0	0
2 upper	9	0	0	0	0	28	0	0	0	0	9	0	0	0	0	3	0	0	0	0
2 lower	13	0	0	0	0	30	0	0	0	0	17	0	0	0	0	2	0	0	0	0
third	14	0	0	0	0	54	0	0	0	0	47	0	0	0	0	8	0	0	0	0
fourth	41	0	0	0	0	83	0	0	0	0	102	0	0	0	0	12	0	0	0	0
fifth	44	0	0	0	0	98	0	0	0	0	104	0	0	0	0	18	0	0	0	0
sixth	8	0	0	0	0	22	0	0	0	0	30	0	0	0	0	9	0	0	0	0
seventh	3	0	0	0	0	2	0	0	0	0	3	0	0	0	0	1	0	0	0	0
Total	271	0	0	0	0	967	0	0	0	2	606	0	0	0	0	85	1	0	0	0
FGE (%)	51					67					48									

Appendix Table 4.--continued.

Date (Test Unit) and (series number)

Location	30 June (5B) (12) SC	YC	ST	CO	SO	1 July (5B) (12) SC	YC	ST	CO	SO	2 July (5B) (12) SC	YC	ST	CO	SO	8 July (5B) (13) SC	YC	ST	CO	SO
Gatewell	194	0	0	1	1	479	0	0	0	1	627	0	0	0	0	243	0	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1 lower	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2 upper	7	0	0	0	0	9	0	0	0	0	12	0	0	0	0	5	0	0	0	0
2 lower	24	0	0	0	0	22	0	0	0	0	18	0	0	0	0	15	0	0	0	0
third	26	0	0	0	0	37	0	0	0	0	43	0	0	0	0	9	0	0	0	0
fourth	23	0	0	0	0	36	0	0	0	0	70	0	0	0	0	7	0	0	0	0
fifth	34	0	0	0	0	36	0	0	0	0	66	0	0	0	0	14	0	0	0	0
sixth	11	0	0	0	0	11	0	0	0	0	28	0	0	0	0	3	0	0	0	0
seventh	5	0	0	0	0	4	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Total	326	0	0	1	1	634	0	0	0	1	866	0	0	0	0	299	0	0	0	0
FGE (%)	60					76					72					81				

Location	9 July (5B) (13) SC	YC	ST	CO	SO	10 July (5B) (13) SC	YC	ST	CO	SO	11 July (5B) (13) SC	YC	ST	CO	SO	12 July (5B) (13) SC	YC	ST	CO	SO
Gatewell	232	1	1	0	0	271	1	4	0	1	498	0	0	0	0	1054	0	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0
2 upper	2	0	0	0	0	8	1	0	0	0	14	0	0	0	0	28	0	0	0	0
2 lower	2	0	0	0	0	11	0	0	0	0	30	0	0	0	0	59	0	0	0	0
third	12	0	0	0	0	45	0	0	0	0	52	0	0	0	0	82	0	0	0	0
fourth	19	0	0	0	0	66	0	0	0	0	32	0	0	0	0	103	0	0	0	0
fifth	20	0	0	0	0	71	0	0	0	0	39	0	0	0	0	80	0	0	0	0
sixth	5	0	0	0	0	16	0	0	0	0	8	0	0	0	0	9	0	0	0	0
seventh	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	3	0	0	0	0
Total	292	1	1	0	0	488	2	4	0	1	683	0	0	0	0	1420	0	0	0	0
FGE (%)	79					56					73					74				

Location	13 July (5B) (13) SC	YC	ST	CO	SO	14 July (5B) (13) SC	YC	ST	CO	SO	16 July (5B) (14) SC	YC	ST	CO	SO	17 July (5B) (14) SC	YC	ST	CO	SO
Gatewell	138	0	0	0	0	642	1	0	0	0	149	0	1	0	0	35	0	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 upper	3	0	0	0	0	13	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2 lower	6	0	0	0	0	25	0	0	0	0	4	0	0	0	0	0	0	0	0	0
third	12	0	0	0	0	74	0	0	0	0	8	0	0	0	0	1	0	0	0	0
fourth	27	0	0	0	0	84	0	0	0	0	25	0	0	0	0	1	0	0	0	0
fifth	21	0	0	0	0	91	0	0	0	0	41	0	0	0	0	7	0	0	0	0
sixth	5	0	0	0	0	21	0	0	0	0	12	0	0	0	0	0	0	0	0	0
seventh	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Total	212	0	0	0	0	953	1	0	0	0	240	0	1	0	0	45	0	0	0	0
FGE (%)	65					67					62									

Appendix Table 4.--continued.

Date (Test Unit) and (series number)

Location	18 July (5B) (14) SC	YC	ST	CO	SO	21 July (5B) (14) SC	YC	ST	CO	SO	22 July (5B) (14) SC	YC	ST	CO	SO	23 July (5B) (14) SC	YC	ST	CO	SO
Gatewell	82	0	0	0	0	442	1	0	0	0	87	0	0	0	0	798	0	0	0	0
1 upper	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
2 upper	0	0	0	0	0	11	0	0	0	0	2	0	0	0	0	27	0	0	0	0
2 lower	2	0	0	0	0	3	0	0	0	0	9	0	0	0	0	30	0	0	0	0
third	8	0	0	0	0	65	0	0	0	0	9	0	0	0	0	93	0	0	0	0
fourth	26	0	0	0	0	122	0	0	0	0	26	0	0	0	0	114	0	0	0	0
fifth	60	0	0	0	0	231	0	0	0	0	49	0	0	0	0	168	0	0	0	0
sixth	34	0	0	0	0	71	0	0	0	0	21	0	0	0	0	57	0	0	0	0
seventh	6	0	0	0	0	4	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Total	218	0	0	0	0	950	1	0	0	0	205	0	0	0	0	1287	0	0	0	0
FGE (%)	38					47					42					62				

Location	24 July (5B) (14) SC	YC	ST	CO	SO	25 July (5B) (14) SC	YC	ST	CO	SO
Gatewell	177	0	0	0	0	14	1	0	0	0
1 upper	0	0	0	0	0	0	0	0	0	0
1 lower	0	0	0	0	0	0	0	0	0	0
2 upper	3	0	0	0	0	0	0	0	0	0
2 lower	6	0	0	0	0	1	0	0	0	0
third	31	0	0	0	0	4	0	0	0	0
fourth	57	0	0	0	0	4	0	0	0	0
fifth	94	0	0	0	0	9	0	0	0	0
sixth	42	0	0	0	0	7	0	0	0	0
seventh	2	0	0	0	0	0	0	0	0	0
Total	412	0	0	0	0	39	1	0	0	0
FGE (%)	43									

SC=Subyearling chinook salmon
YC=Yearling chinook salmon
ST=Steelhead
CO=Coho salmon
SO=Sockeye salmon

Appendix Table 5.--Descaling data from FGE and descaling tests at McNary Dam, 1991 (Total gatewell/Total descaled).

Unit 4, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
01 May	6/0	228/19	154/5	4/0	105/8
02 May	2/0	414/23	248/6	6/0	119/9
03 May	23/0	496/32	154/9	6/0	102/4
04 May	4/0	419/37	170/12	4/0	73/1
05 May	17/0	551/32	145/11	2/0	56/0
08 May	0/0	218/17	240/15	24/1	11/1
09 May	2/0	312/27	499/44	13/0	26/3
10 May	2/0	233/14	134/7	13/1	43/0
11 May	5/0	173/18	312/20	12/0	90/1
12 May	4/0	268/28	203/18	22/2	98/11
13 May	3/0	715/45	621/44	30/0	145/17
17 May	17/2	180/21	192/7	19/1	291/118
18 May	8/0	160/20	230/7	13/2	197/114
19 May	6/0	204/18	186/4	7/0	183/21
20 May	6/0	599/41	388/31	51/4	258/40
21 May	18/1	521/132	357/39	51/6	221/60
22 May	10/1	89/15	114/11	16/0	12/1
23 May	7/0	129/21	82/4	35/4	21/4
24 May	4/2	97/15	47/7	22/1	9/5
28 May	196/2	210/13	52/5	124/6	27/5
29 May	31/2	196/27	24/2	83/9	25/16
30 May	21/1	264/63	71/9	135/34	72/48
31 May	40/4	166/25	36/6	44/1	19/6
1 June	59/7	238/39	42/4	50/9	63/37
3 June	6/0	13/1	8/1	4/1	13/3
24 June	146/2	2/0	1/0	-	2/0
25 June	270/8	1/0	2/1	-	1/0
26 June	588/18	-	2/0	1/0	4/1
27 June	227/3	-	1/1	-	-
28 June	187/6	-	-	1/0	-
29 June	103/5	-	1/0	-	-
30 June	365/12	-	-	1/0	-
01 July	558/21	-	1/1	-	-
02 July	213/4	-	-	-	-

Appendix Table 5.--Continued.

Unit 4, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
08 July	373/15	1/1	1/0	-	-
09 July	290/11	1/0	1/1	-	-
10 July	177/22	-	2/2	-	-
11 July	203/9	-	1/1	-	1/0
12 July	513/17	-	-	-	-
13 July	247/15	1/0	-	-	-
14 July	739/41	1/0	-	-	-
16 July	245/14	-	2/2	-	-
17 July	141/6	-	-	-	-
18 July	73/4	-	-	-	-
21 July	455/32	-	-	-	-
22 July	251/6	5/0	-	-	-
23 July	599/16	-	-	-	-
24 July	139/2	-	-	-	-
25 July	24/4	-	-	-	-

Unit 5, Slot A

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
29 April	-	72/29	93/13	3/0	43/21
08 May	1/0	141/15	182/29	21/1	28/6
09 May	-	257/44	296/37	18/4	34/13
10 May	3/0	218/28	206/23	20/2	49/2
11 May	1/0	95/10	106/16	4/1	26/2
12 May	1/1	191/45	103/16	23/2	37/4
13 May	3/1	284/50	273/27	20/2	113/21

Appendix Table 5.--Continued.

Unit 5, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
22 April	-	127/24	41/1	-	2/1
23 April	-	71/22	98/7	-	4/2
25 April	-	40/4	134/6	2/0	24/19
27 April	-	25/4	35/1	2/0	10/9
28 April	1/0	41/6	64/10	4/1	23/17
29 April	-	53/11	109/11	2/0	37/16
30 April	1/0	46/11	102/7	2/0	30/9
01 May	-	38/7	156/6	-	21/7
02 May	4/0	68/10	140/8	4/0	30/5
03 May	1/0	268/61	238/18	-	42/12
04 May	1/0	283/50	149/12	10/2	48/10
05 May	4/0	209/33	95/6	8/0	11/4
08 May	1/0	174/36	246/26	22/4	33/13
09 May	1/0	152/23	232/13	14/1	27/9
10 May	4/0	160/20	195/16	13/2	36/1
11 May	2/0	179/33	152/17	8/1	94/19
12 May	3/0	312/45	150/16	14/1	81/22
13 May	3/0	163/21	158/15	13/1	84/12
17 May	14/0	244/17	60/3	23/1	502/163
18 May	4/0	222/45	212/8	23/3	393/235
19 May	8/0	243/21	247/23	26/3	515/203
20 May	5/0	540/45	231/17	43/3	229/68
21 May	15/0	781/94	226/20	60/9	205/61
22 May	6/0	72/8	4/2	29/3	18/6
23 May	6/0	146/18	110/13	48/8	23/10
24 May	9/0	92/9	60/6	33/4	45/14
28 May	103/5	420/27	68/9	132/8	9/2
29 May	35/0	117/14	16/5	52/5	34/10
30 May	30/1	219/22	30/4	121/14	60/23
31 May	18/0	142/19	18/2	48/3	20/5
01 June	38/1	106/14	36/4	46/5	25/15
03 June	3/0	13/1	4/1	1/0	2/1
24 June	197/19	5/1	1/0	-	2/0
25 June	390/42	1/1	1/0	1/0	1/0
26 June	349/24	-	-	-	-
27 June	328/18	-	-	-	-
28 June	119/18	-	-	-	-
29 June	110/6	1/0	-	-	-
30 June	194/26	-	-	-	-
01 July	479/38	-	-	-	1/1
02 July	627/55	-	-	-	-

Appendix Table 5.--Continued.

Unit 5, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
08 July	243/12	-	-	-	-
09 July	232/30	1/0	1/1	-	-
10 July	271/65	1/0	4/2	-	1/1
11 July	498/50	-	-	-	-
12 July	1054/125	-	-	-	-
13 July	138/16	-	-	-	-
14 July	642/72	1/0	-	-	-
16 July	149/15	-	1/1	-	-
17 July	2/35	-	-	-	-
18 July	82/4	-	-	-	-
21 July	442/70	1/1	-	-	-
22 July	87/5	-	-	-	-
23 July	798/117	-	-	-	-
24 July	177/30	-	-	-	-
25 July	14/3	1/0	-	-	-

Unit 6, Slot A

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
22 May	4/0	142/16	82/2	30/1	23/5
23 May	6/0	140/27	100/7	55/7	40/11
24 May	12/0	51/20	80/7	51/2	70/27

Appendix Table 5.--Continued.

Unit 6, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
22 April	-	156/28	39/1	1/0	3/1
23 April	-	45/5	66/4	2/0	1/0
25 April	-	37/2	92/2	1/0	10/1
30 April	2/0	45/6	60/1	2/0	25/3
01 May	1/0	68/8	147/7	2/0	27/7
02 May	3/0	111/9	92/7	-	37/3
03 May	6/0	238/31	281/15	-	46/6
04 May	2/0	248/35	174/11	5/0	82/2
05 May	2/0	236/28	119/4	4/0	26/3
17 May	10/0	269/25	128/1	14/0	759/154
18 May	1/1	269/24	228/7	26/3	552/217
19 May	6/0	253/15	208/7	15/1	381/79
20 May	4/0	361/32	190/11	44/3	245/51
21 May	8/0	511/75	127/11	52/2	176/56
22 May	10/0	149/21	99/6	34/1	31/9
23 May	5/0	134/13	96/6	39/4	32/18
24 May	3/0	127/12	115/8	49/5	75/44
28 May	48/1	200/8	52/4	116/11	16/2
29 May	25/0	114/15	22/3	77/16	35/18
30 May	50/0	109/9	33/2	54/5	49/12
31 May	25/1	176/29	28/5	71/9	18/6
01 June	21/3	51/2	19/2	17/0	21/12
03 June	18/0	9/1	5/0	-	5/1
24 June	82/4	3/3	-	-	-
25 June	165/6	1/0	1/0	1/0	-
26 June	481/12	-	-	-	-
27 June	240/9	-	-	-	-
28 June	87/2	-	-	-	-
29 June	147/7	-	-	-	-
30 June	383/19	-	1/0	-	-
01 July	505/22	1/0	-	-	-
02 July	817/18	-	1/1	-	-
08 July	254/5	-	-	-	-
09 July	145/11	-	-	-	-
10 July	565/33	5/0	1/1	-	-
11 July	518/46	-	-	-	-
12 July	1482/95	-	-	-	-
13 July	117/13	-	-	-	-
14 July	574/30	-			

Appendix Table 5.--Continued.

Unit 6, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
16 July	515/39	-	-	-	-
17 July	136/4	-	-	-	-
18 July	159/10	3/0	1/0	-	-
21 July	674/60	-	-	1/0	-
22 July	137/18	-	-	-	-
23 July	645/75	-	-	-	2/1
24 July	292/27	-	-	-	-
25 July	32/3	1/0	-	-	-

Unit 6, Slot C

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
17 May	2/0	87/8	42/0	2/0	231/35
18 May	2/0	112/8	94/5	8/0	164/48
19 May	-	106/7	68/4	15/0	135/1
20 May	-	140/5	61/4	18/1	110/3
21 May	4/0	167/15	62/4	27/1	124/19

Unit 7, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
27 April	4/0	1104/54	217/11	1/0	45/8
28 April	-	223/14	237/19	13/0	70/9
29 April	1/0	216/27	390/32	11/0	159/18
30 April	1/0	194/15	172/15	6/0	131/7
01 May	5/0	207/10	216/5	2/0	137/6
02 May	8/0	485/37	208/17	2/0	186/4
03 May	1/0	552/32	156/15	5/0	96/4
04 May	13/0	424/44	113/6	4/0	58/1
05 May	8/0	818/54	207/14	2/0	89/2
22 May	13/0	468/49	248/22	52/2	82/14
23 May	18/1	223/19	147/9	54/4	46/11
24 May	5/1	134/21	103/10	101/6	86/57
28 May	300/5	305/9	49/4	92/7	31/2
29 May	72/1	122/9	35/2	79/6	31/9
30 May	48/0	76/9	19/3	30/3	42/8
31 May	94/1	354/33	46/10	108/8	51/7
01 June	60/1	72/14	12/4	16/3	13/6
02 June	11/0	5/0	5/2	1/1	5/0

Appendix Table 6.--Gill Na^+-K^+ ATPase ($\mu mol\ P_i \cdot Prot^{-1} \cdot h^{-1}$) data for yearling chinook salmon from vertical distribution and FGE tests at McNary Dam, 1991.

Date	Statistic	Gatewell	Fyke-net row							All nets combined
			1	2	3	4	5	6	7	
26 Apr	$\bar{x}$	29.1	---	---	---	---	---	---	---	25.5
	SD	12.34	---	---	---	---	---	---	---	6.30
	n	9	---	---	---	---	---	---	---	4
27 Apr	$\bar{x}$	29.3	---	---	---	---	---	---	---	20.8
	SD	10.87	---	---	---	---	---	---	---	7.94
	n	20	---	---	---	---	---	---	---	8
28 Apr	$\bar{x}$	27.9	---	---	---	---	---	---	---	26.4
	SD	10.43	---	---	---	---	---	---	---	11.46
	n	20	---	---	---	---	---	---	---	9
28 May	$\bar{x}$	27.6	15.6	30.7	26.7	35.9	30.0	29.3	---	30.9
	SD	10.25	1.34	8.80	8.41	9.00	8.40	6.55	---	8.81
	n	20	2	8	5	19	19	16	0	69
29 May	$\bar{x}$	24.0	---	---	---	---	---	---	---	26.8
	SD	10.95	---	---	---	---	---	---	---	8.02
	n	20	---	---	---	---	---	---	---	16
30 May	$\bar{x}$	27.7	---	---	---	---	---	---	---	24.2
	SD	11.74	---	---	---	---	---	---	---	10.09
	n	20	---	---	---	---	---	---	---	20

Appendix Table 7.--Gill Na^{+}-K^{+} ATPase ($\mu mol\ P_i \cdot Prot^{-1} \cdot h^{-1}$) data for subyearling chinook salmon from FGE tests at McNary Dam, 1991.

Date	Statistic	Gatewell	Fyke-net row 1	2	3	4	5	6	7	All nets combined
24 Jun	$\bar{x}$	32.4	---	---	---	---	---	---	---	33.1
	SD	4.34	---	---	---	---	---	---	---	6.51
	n	20	---	---	---	---	---	---	---	20
25 Jun	$\bar{x}$	37.3	---	36.3	30.8	32.8	34.3	34.2	38.3	33.9
	SD	5.33	---	3.67	4.88	6.68	5.67	7.93	0.85	5.62
	n	19	0	15	13	11	19	5	2	65
26 Jun	$\bar{x}$	34.8	---	---	---	---	---	---	---	34.2
	SD	6.13	---	---	---	---	---	---	---	4.15
	n	20	---	---	---	---	---	---	---	20
30 Jun	$\bar{x}$	36.8	---	---	---	---	---	---	---	37.1
	SD	8.69	---	---	---	---	---	---	---	7.68
	n	20	---	---	---	---	---	---	---	20
1 Jul	$\bar{x}$	31.7	---	31.7	22.9	28.4	25.2	30.2	21.4	27.0
	SD	7.89	---	4.77	4.42	6.92	4.16	4.62	7.81	6.15
	n	20	0	19	20	20	20	8	4	91
2 Jul	$\bar{x}$	37.8	---	---	---	---	---	---	---	32.2
	SD	7.79	---	---	---	---	---	---	---	6.08
	n	20	---	---	---	---	---	---	---	20
16 Jul	$\bar{x}$	46.9	---	---	---	---	---	---	---	46.3
	SD	6.29	---	---	---	---	---	---	---	8.51
	n	20	---	---	---	---	---	---	---	20
17 Jul	$\bar{x}$	41.2	---	---	---	---	---	---	---	38.6
	SD	5.87	---	---	---	---	---	---	---	6.10
	n	20	---	---	---	---	---	---	---	5