Studies to evaluate the effectiveness of extended-length screens at The Dalles Dam, 1995

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Coastal Zone and Estuarine Studies Division

Northwest Fisheries Science Center

National Marine Fisheries Service

Seattle, Washington

by
Dean A. Brege, Randall F. Absolon,
Benjamin P. Sandford, and
Douglas B. Dey

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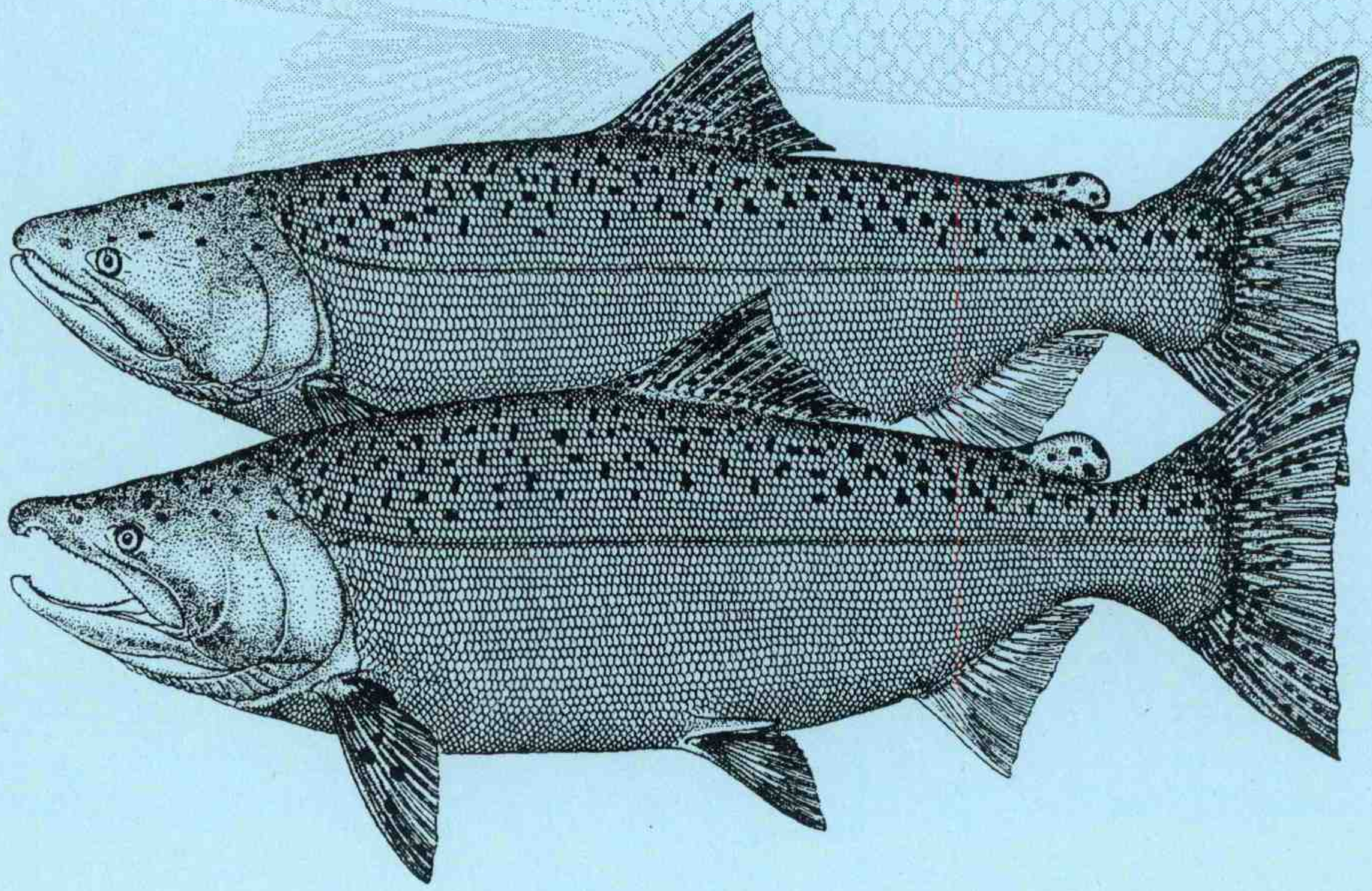

STUDIES TO EVALUATE THE EFFECTIVENESS OF EXTENDED-LENGTH SCREENS AT THE DALLES DAM, 1995

by

Dean A. Brege
Randall F. Absolon
Benjamin P. Sandford
and
Douglas B. Dey

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EXECUTIVE SUMMARY

As part of the continuing evaluation of extended-length screens at The Dalles Dam, orifice passage efficiency (OPE) tests using a mark/recapture method were conducted during spring and summer 1995 in Turbine Units 5 (west end of powerhouse), 12 (middle), and 17 (east end). In addition, descaling and the horizontal distribution of juvenile salmonids were monitored in these units, and dip-basket efficiency and gatewell mortality tests were conducted.

Orifice passage efficiency tests were conducted in each orifice (west and east) of each test slot with the number of replicates per orifice ranging from 8 to 10 in spring and 8 to 9 in summer. In spring with yearling chinook salmon, mean OPEs were 77.5, 80.3, and 82.8% for the west orifices in Slots 5B, 12B, and 17B, respectively. Mean OPEs for the east orifices were 65.4, 56.9, and 80.8% in Slots 5B, 12B, and 17B, respectively. In spring, mean OPEs were significantly higher for the west orifices in Slots 5B and 12B, but there was no statistical difference between the orifices in Slot 17B.

During summer, mean OPEs for subyearling chinook salmon were 78.8, 90.5, and 87.6% for the west orifices in Slots 5B, 12B, and 17B, respectively. Mean OPEs for the east orifices were 42.6, 57.9, 87.0% in Slots 5B, 12B, and 17B, respectively. As in spring, mean OPEs were significantly higher for the west orifices of Slots 5B and 12B, but there was no statistical difference between the two orifices in Slot 17B.

Descaling was low for both yearling chinook salmon in spring (<3%) and subyearling chinook salmon in summer (<1%).

Continuous spill at The Dalles Dam and open sluice gates in Slots 1B and 2B throughout the entire spring season reduced the number of juvenile salmonids entering the

gatewells and made it difficult to capture enough fish for OPE tests. The open sluice gates also appeared to influence the horizontal distribution of fish captured (all species combined) across the powerhouse. The relative horizontal distribution of fish in 1994 among Slots 2B, 12B, and 17B with sluice gates closed was 62, 25, and 13%, respectively. During spring 1995 OPE tests, the relative horizontal distribution among Slots 5B, 12B, and 17B with sluice gates open was 17, 50, and 33%, respectively.

During summer 1995, the relative horizontal distribution among Slots 5B, 12B, and 17B, for all species combined and with open sluice gates, was 28, 57, and 15%, respectively. In 1994 with sluice gates closed, the relative horizontal distribution among Slots 2B, 12B, and 17B was 65, 26, and 9%, respectively.

Dip-basket efficiency and gatewell mortality tests were conducted during both spring and summer outmigrations. Mean (weighted) dip-basket efficiency was 98.4% for spring tests and 96.5% for summer tests. Descaling and 24-hour gatewell mortality were minimal.

INTRODUCTION

The Dalles Dam, at River Mile 192 (River Kilometer 308), is operated by the U.S. Army Corps of Engineers (COE) and is the second in a series of hydroelectric dams upstream from the mouth of the Columbia River. Completed in 1957, The Dalles Dam is equipped with 22 turbine units, an ice and trash sluiceway, 20 spillbays, and a navigation lock (Fig. 1). Unlike most other hydroelectric dams on the Columbia River, the powerhouse at The Dalles Dam is oriented parallel to the river flow (Fig. 1).

The COE has proposed a juvenile fish bypass system for The Dalles Dam similar to those in use at other COE Columbia and Snake River dams. In 1985 and 1986, the National Marine Fisheries Service (NMFS) conducted research at The Dalles Dam to determine the potential fish guidance efficiency (FGE) for yearling chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), and steelhead (*O. mykiss*) attainable with standard-length submersible traveling screens (STSs) (Monk et al. 1986, 1987). Additionally, the vertical distribution of fish entering the turbine intake was measured to determine theoretical fish guidance efficiency (TFGE, an estimate of the percentage of fish theoretically guidable based upon hydraulic model studies and the vertical distribution of fish).

In 1985, the FGE of STSs at The Dalles Dam ranged from 44 to 55% for yearling chinook salmon, from 73 to 79% for steelhead, and from 8 to 14% (highest FGE obtained when the STS was lowered 0.8 m) for subyearling chinook salmon. From vertical distribution measurements, the TFGE of STSs was estimated to be 67% for yearling chinook salmon, 57% for sockeye salmon, 83% for steelhead, and only 22% for subyearling chinook salmon. In 1986, lowering the STS again appeared to enhance FGE compared to

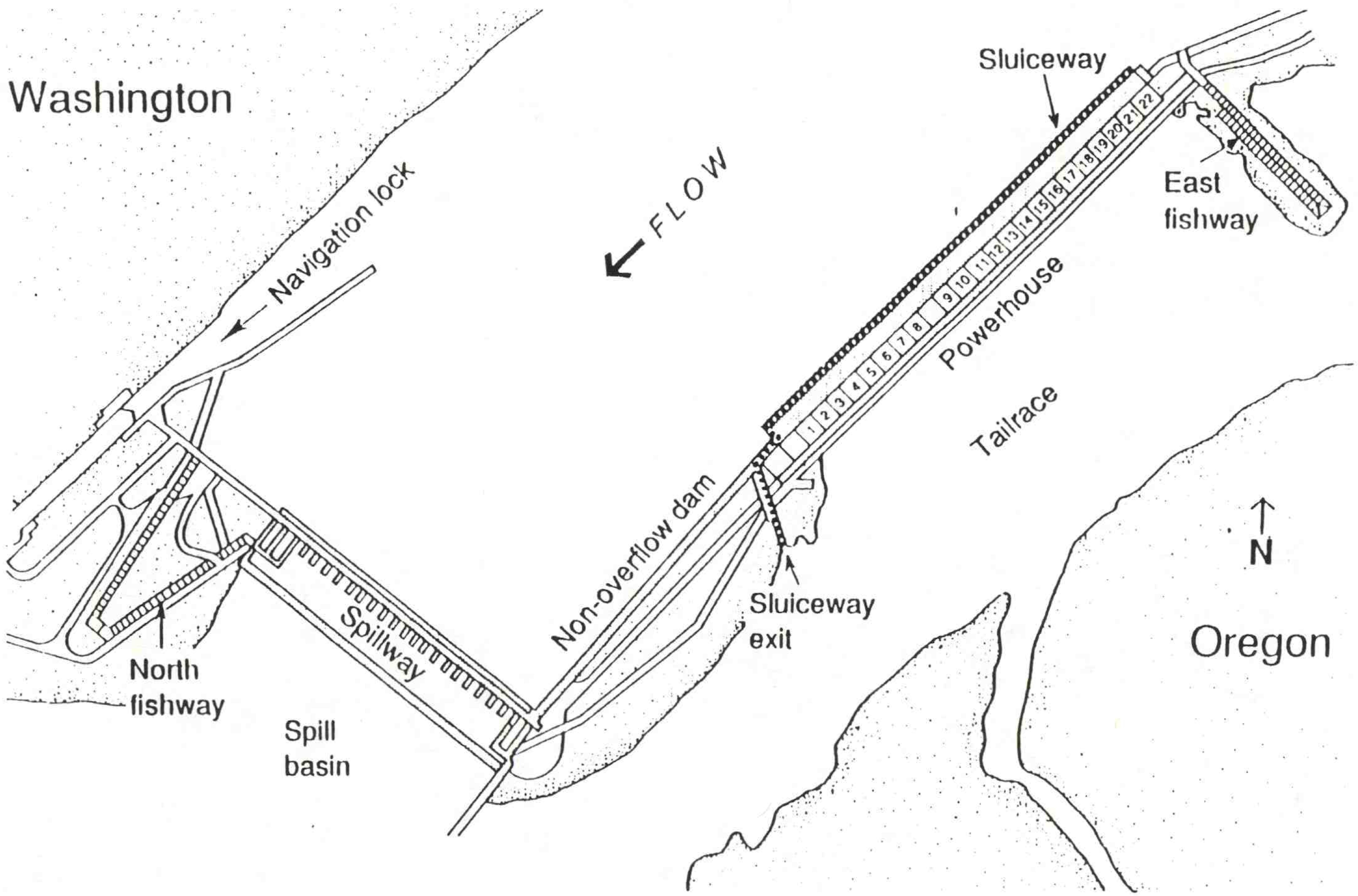

Figure 1. Overview of The Dalles Dam showing numbering sequence of turbine units and alignment of powerhouse relative to river flow.

an STS at standard elevation (56 vs. 44% for yearling chinook salmon). Although FGE for all species was nearly 90% of the TFGE expected with STSs, FGE was still well below a 80% fish passage efficiency (FPE) level. These data and the encouraging results from tests with extended-length screens at McNary Dam in 1991 and 1992 (Brege et al. 1992, McComas et al. 1993) suggested that FGE at The Dalles Dam might be improved with longer screens.

In 1993, FGE tests were conducted in Units 4, 5, and 6 on the west end of the powerhouse at The Dalles Dam using extended-length screens. Mean FGE for yearling chinook salmon was 73, 60, and 44% for the extended-length bar screen (ESBS), extended-length traveling screen (ESTS), and STS, respectively. Mean FGE for subyearling chinook salmon was 59, 51, and 23% for the extended-length bar screen, extended-length traveling screen, and STS, respectively.

In 1994, FGE tests were conducted in Units 18 and 19 on the east end of the powerhouse at The Dalles Dam using extended-length screens. Mean FGE for yearling chinook salmon was 69 and 65% for the extended-length bar screen (ESBS) and extended-length traveling screen (ESTS), respectively. Mean FGE for subyearling chinook salmon was 54, and 47% for the extended-length bar screen and extended-length traveling screen, respectively.

In 1995, as part of the continuing evaluation of extended-length screens at The Dalles Dam, orifice passage efficiency (OPE) tests using a mark/recapture method were conducted during the spring and summer juvenile salmonid outmigration. Extended-length bar screens and inlet flow vanes (McComas et al. 1995) were installed in Turbine Units 5 (west end of powerhouse), 12 (middle), and 17 (east end) for the test period. In addition, descaling and the horizontal distribution of juvenile salmonids were monitored in these units and dip-basket efficiency/gatewell mortality tests were conducted.

Specific research objectives at The Dalles Dam in 1995 were:

1) Evaluate the orifice passage efficiency of prototype juvenile fish bypass orifices in turbine units equipped with ESBSs and inlet flow vanes.

2) Evaluate the effects of ESBSs and inlet flow vanes on juvenile salmonid descaling.

3) Evaluate the horizontal distribution of juvenile salmonids as they enter turbine intakes across the powerhouse.

Spring testing for these objectives occurred from 23 April to 26 May. Summer testing was conducted from 20 June to 13 July.

OBJECTIVE 1: EVALUATE THE ORIFICE PASSAGE EFFICIENCY OF PROTOTYPE JUVENILE FISH BYPASS ORIFICES IN TURBINE UNITS EQUIPPED WITH ESBSs AND INLET FLOW VANES

Approach

Orifice passage efficiency measurements were conducted in Slots 5B, 12B, and 17B, located at west, center, and east areas of the powerhouse, respectively (Fig. 1). These slots were chosen with regard to discharge and approach flows to the unit. Discharge (flow) through Units 1-14 (west end of the powerhouse) is less than discharge through Units 15-22 (east end). In addition, approach flows to the west units are nearly perpendicular to the powerhouse, whereas approach flows to the east units are more angular. These variable flow conditions, as modeled by the COE's Waterways Experiment Station (WES), result in different flow patterns within the gatewells across the powerhouse.

Prior to the spring outmigration, each of the three test slots were retrofitted with two juvenile fish bypass orifices. These orifices consisted of a 13.25-in (inside diameter) stainless steel lined tube grouted into the gate-slot wall and oriented 60° downstream. The downstream orientation of the orifice channels resulted in an oval entrance 13.25-in high by 15.5-in wide. The orifices were located on 24-in centers from the ends of the gate slot at elevation 149 ft. Normal operating pool for the reservoir is elevation 160 ft, resulting in an orifice submergence of approximately 11 ft.

The methods for determining OPE were similar to those used in previous OPE studies with traveling screens (Brege et al. 1987) and the test turbine units were run continuously during the month-long test period. Test slots were dipnetted daily (Swan et al. 1979) and the collected fish were anesthetized with tricaine methane sulfonate (MS-222) and examined. Juvenile salmonids were caudal fin clipped, held for 1 hour to observe short-term effects, released into the test gatewells, and allowed to exit the gatewells through one of the two juvenile fish bypass orifices. One of the two orifices was blocked with a suspended steel plate during each OPE test. Open/closed configurations were alternated each day, with changes being made at the conclusion of each OPE test. The orifice discharge into the ice/trash sluiceway was checked twice a day to make sure the orifice cover plates remained in place. At a specified time each test day, all fish were dipnetted from the gatewells. A typical OPE test lasted 22 hours, beginning at 1800 h on 1 day and ending at 1600 h the next day. Orifice passage efficiency was calculated as the number of clipped fish that exited the gatewell divided by the total number released.

The gatewell dipnetting technique for OPE tests relies on the assumptions that fish survive the marking process in good condition, that fish exiting the gatewell do so via the bypass orifice, and that all fish remaining in the gatewell are captured by the dip net. To ensure the reliability of these assumptions, gatewell-efficiency/marked-fish-mortality tests were conducted periodically throughout the spring and summer outmigration. During these tests, fish were marked, held for 1 hour to observe short-term effects, and then were placed in the gatewell for 22 hours with both orifices closed. At the end of this test period, the gatewell was dipnetted and the catch examined and enumerated.

Guided fish were confined to the bulkhead slot by a modified balanced-flow vertical barrier screen (VBS) that separated the bulkhead slot from the gate slot (Fig. 2). This VBS, originally designed to be used with STSs, consisted of seven 8.9-ft (2.7-m) high panels, each of which extended across the full width of the slot. The front of each panel was covered with monofilament mesh and the back with perforated steel plate to control flow through the screen section.

Configurations for the VBSs used were modeled by WES prior to testing at the dam. The configuration for the seven panels of the VBSs in Slots 5B and 12B was slightly different from that of the VBS in Slot 17B due to the higher flows in Unit 17. The VBS configuration for Slots 5B and 12B consisted of a solid panel at the bottom, with 10, 22, 22, 22, 10, and 10% porosity panels from the second panel to the top. The VBS configuration for Slot 17B consisted of a solid panel at the bottom with 22, 17, 17, 17, 17, and 17% porosity panels from the second to the top (Fig. 2).

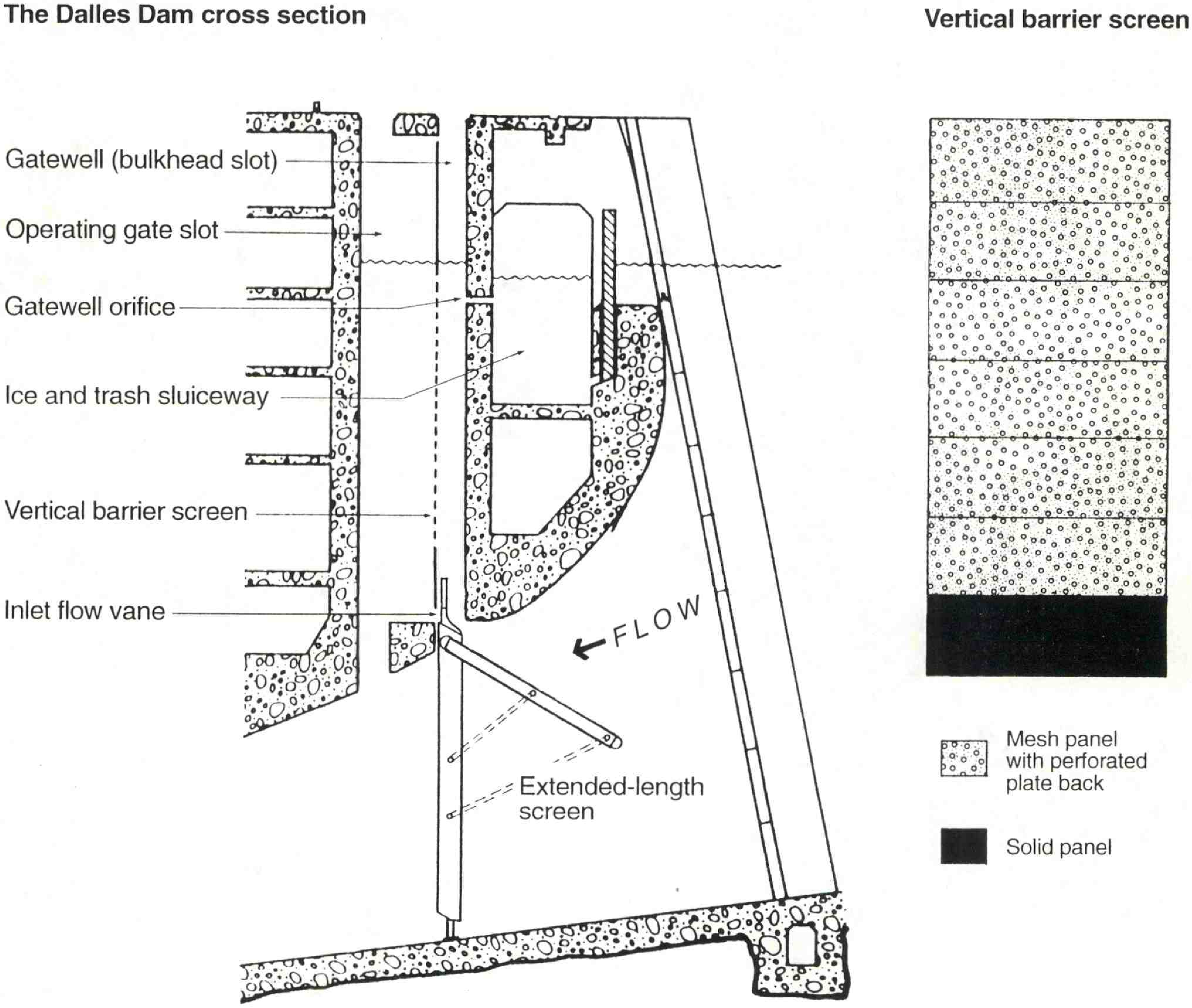

Figure 2. Cross section of turbine unit at The Dalles Dam with extended-length screen and inlet flow vane in place, and vertical barrier screen configuration.

Extended-length bar screens, as tested during FGE tests in 1993 and 1994 at The Dalles Dam, were used in the OPE test slots (Brege et al. 1994, Absolon et al. 1995). Again because of different turbine unit flows, Slots 5B and 12B had ESBSs with a perforated plate porosity of 50%, and Slot 17B had an ESBS with a perforated plate porosity of 30%.

The test design provided for 20 OPE measurements in each of the three test slots (west, center, and east) during both spring and summer juvenile salmonid outmigrations.

Results and Discussion

Yearling Fish

Testing for OPE began on 23 April and ended on 26 May when fish numbers dropped at the end of the spring outmigration (Appendix Table 1). For spring OPE tests, we handled the following numbers of juvenile salmonids: 3,871 subyearling chinook salmon, 6,560 yearling chinook salmon, 3,004 steelhead, 735 coho salmon, and 1,547 sockeye salmon, for a total of 15,717 fish. We marked and released 3,781 yearling chinook salmon during our spring OPE tests. Continuous spill (averaging 134 kcfs) at the dam and open sluice gates in Slots 1B and 2B through the entire spring season reduced the number of juvenile salmonids entering the gatewells and made it difficult to capture fish for marking. The number of OPE replicates conducted for each orifice of each test gate slot were: Slot 5B - 9 east, 10 west; Slot 12B - 9 east, 9 west; Slot 17B - 8 east, 9 west.

Figures 3, 4, and 5 show daily fluctuations in OPE for yearling chinook salmon for both the west and east orifices. Mean OPEs for yearling chinook salmon were 77.5, 80.3, and 82.8% (SE = 4.1) for the west orifices of Slots 5B, 12B, and 17B, respectively. Mean

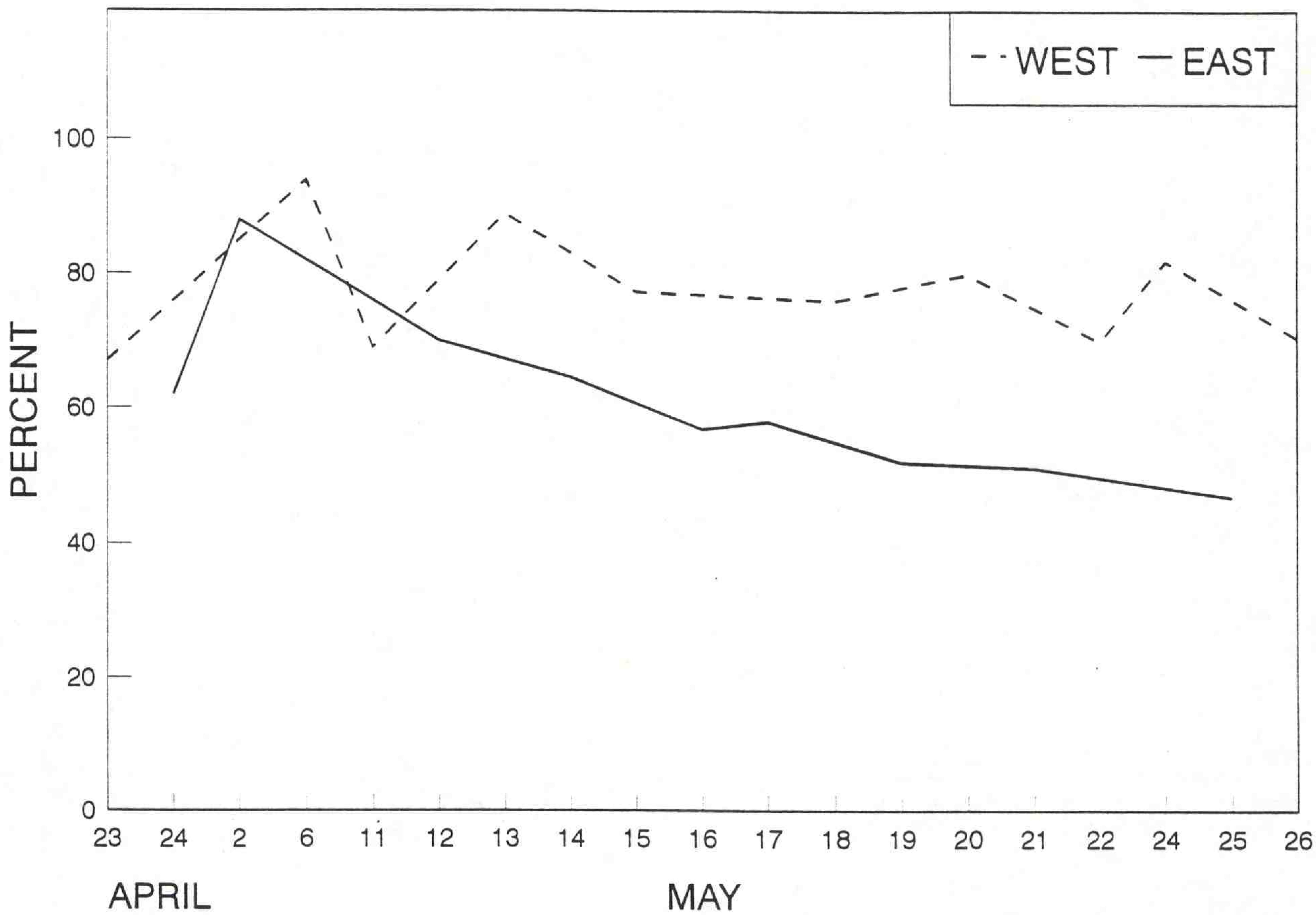

Figure 3. Daily orifice passage efficiency (OPE) for yearling chinook salmon in Slot 5B at The Dalles Dam, 1995.

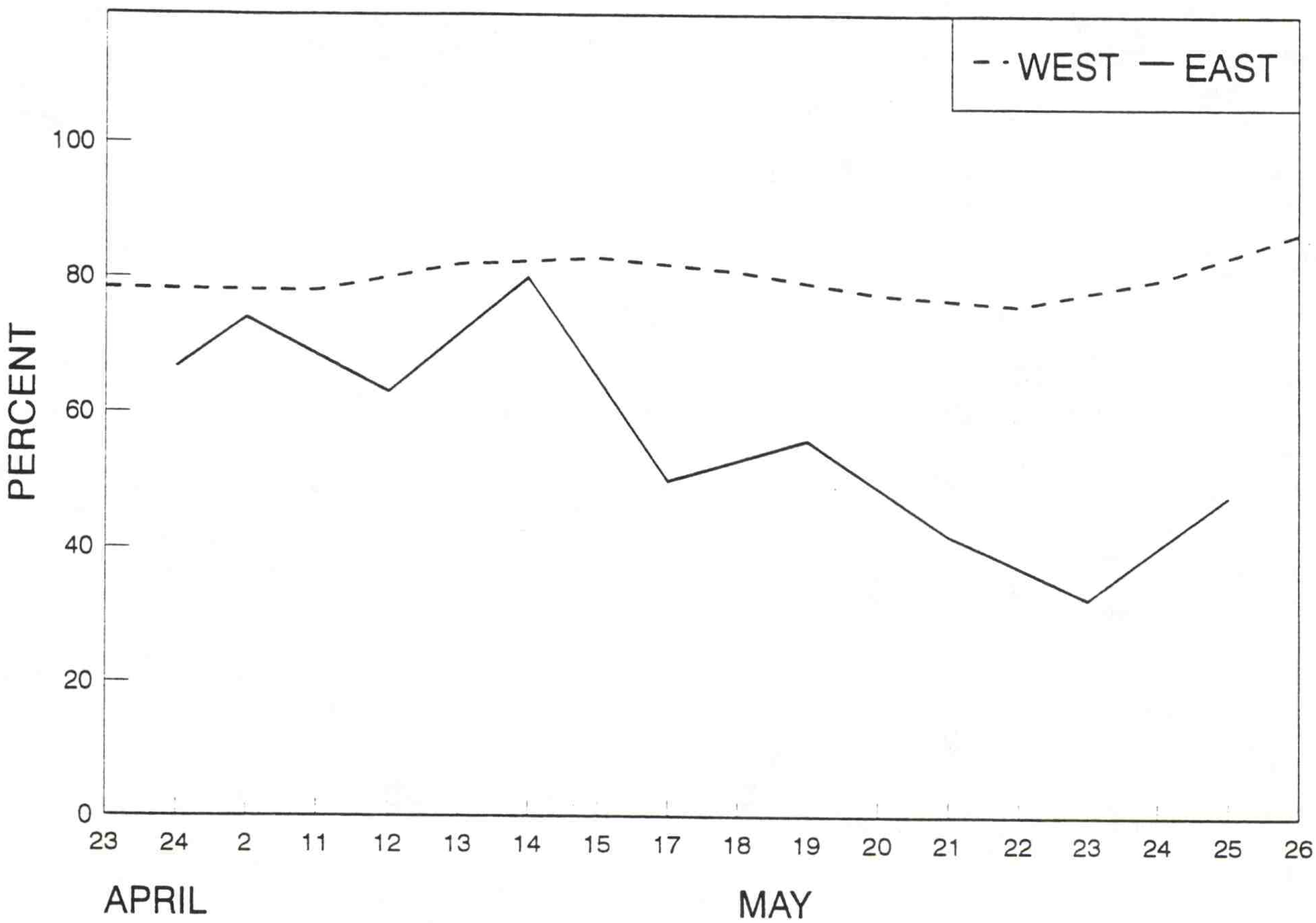

Figure 4. Daily orifice passage efficiency (OPE) for yearling chinook salmon in Slot 12B at The Dalles Dam, 1995.

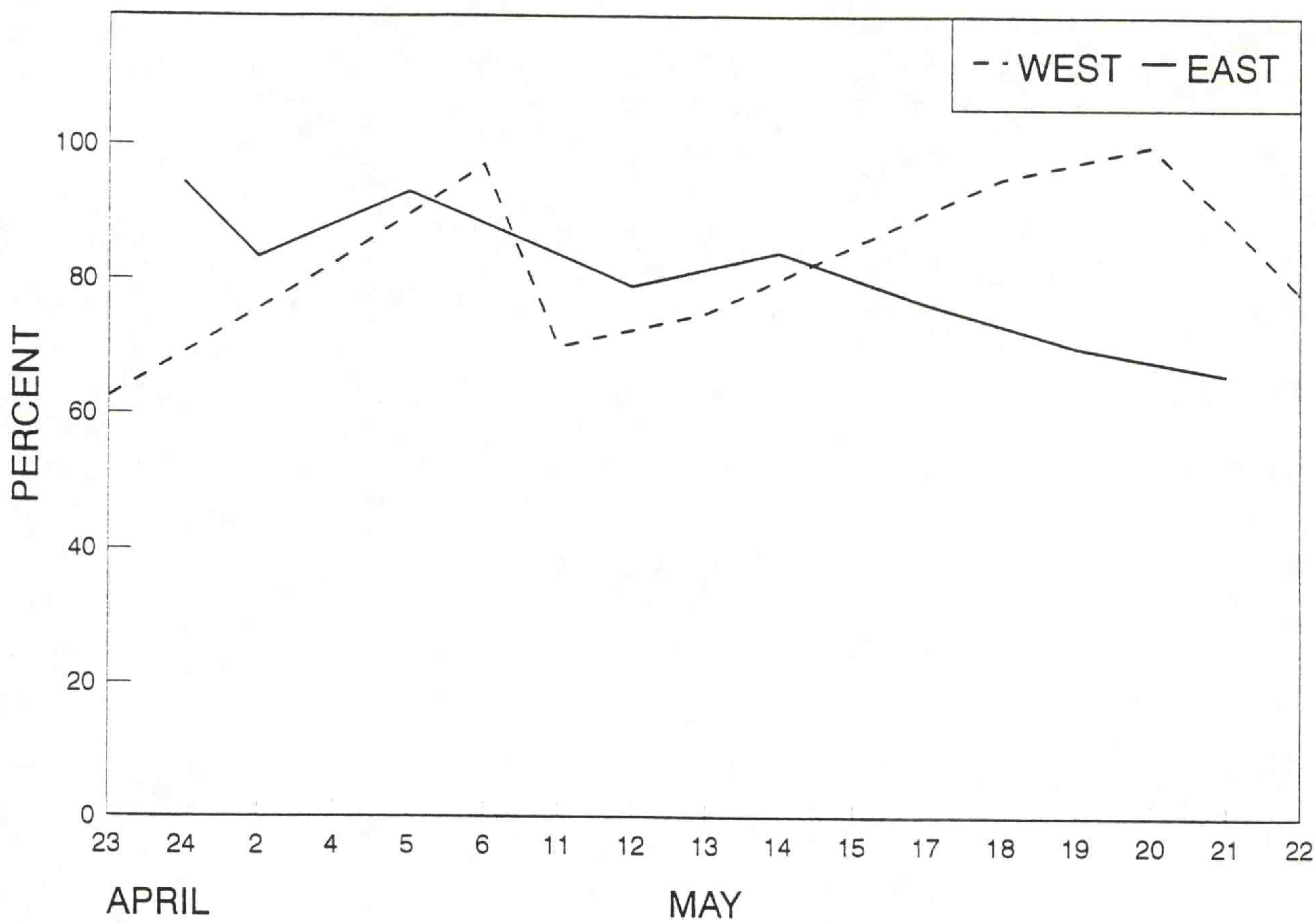

Figure 5. Daily orifice passage efficiency (OPE) for yearling chinook salmon in Slot 17B at The Dalles Dam, 1995.

OPEs in the east orifices were 65.4, 56.9, and 80.8% (SE = 4.1) for Slots 5B, 12B, and 17B, respectively. In spring, mean OPEs were significantly higher for the west orifices in Slots 5B and 12B, but there was no statistical difference in mean OPEs between the orifices in Slot 17B.

Efficiency/mortality tests on 25 April, 14 May, and 20 May resulted in efficiencies of 96, 99, and 100%, respectively, with a combined weighted mean of 98.4%. Marked fish were recovered in nearly the same condition as when they were released. Descaling and mortality due to handling was minimal.

Subyearling Fish

Subyearling chinook salmon OPE testing began on 20 June and concluded on 13 July. Spill during these summer FGE tests averaged 154 kcfs and occurred 24 hours a day throughout the study period.

Figures 6, 7, and 8 show daily fluctuations in OPE for subyearling chinook salmon for both west and east orifices. Mean OPE for subyearling chinook salmon was 78.8, 90.5, and 87.6% (SE = 4.2) for the west orifices of Slots 5B, 12B, and 17B, respectively. Mean OPE in the east orifices was 42.6, 57.9, and 87.0% (SE = 4.2) for Slots 5B, 12B, and 17B respectively. As in spring, mean OPEs were significantly higher for the west orifices of Slots 5B and 12B, but there was no statistical difference in mean OPE between the two orifices in Slot 17B.

Efficiency/mortality tests on 20 June, 26 June, and 12 July resulted in efficiencies of 96, 95, and 99%, respectively, with a combined weighted mean of 96.5%. Marked fish were recovered in nearly the same condition as when they were released. Descaling and mortality due to handling was minimal.

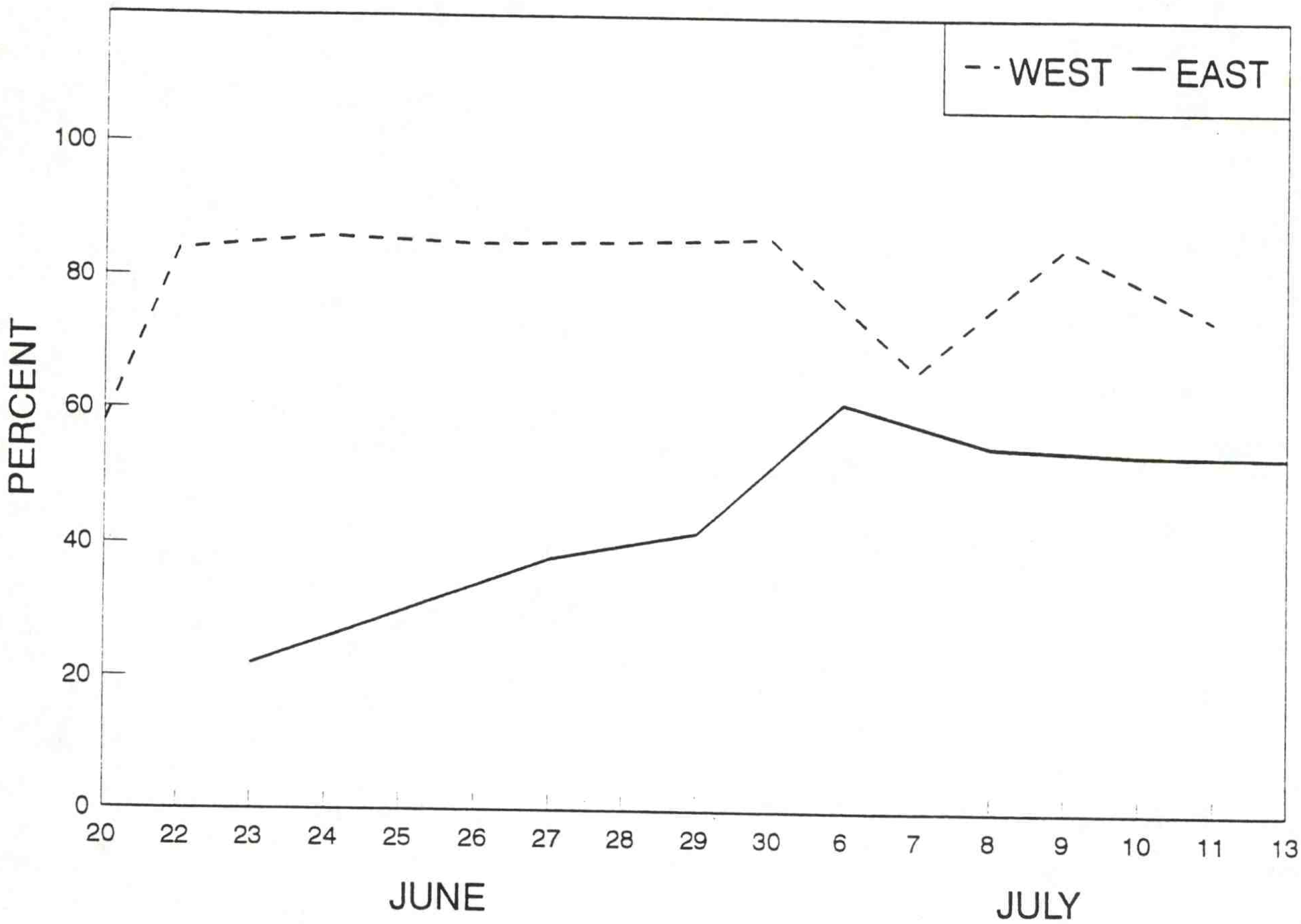

Figure 6. Daily orifice passage efficiency (OPE) for subyearling chinook salmon in Slot 5B at The Dalles Dam, 1995.

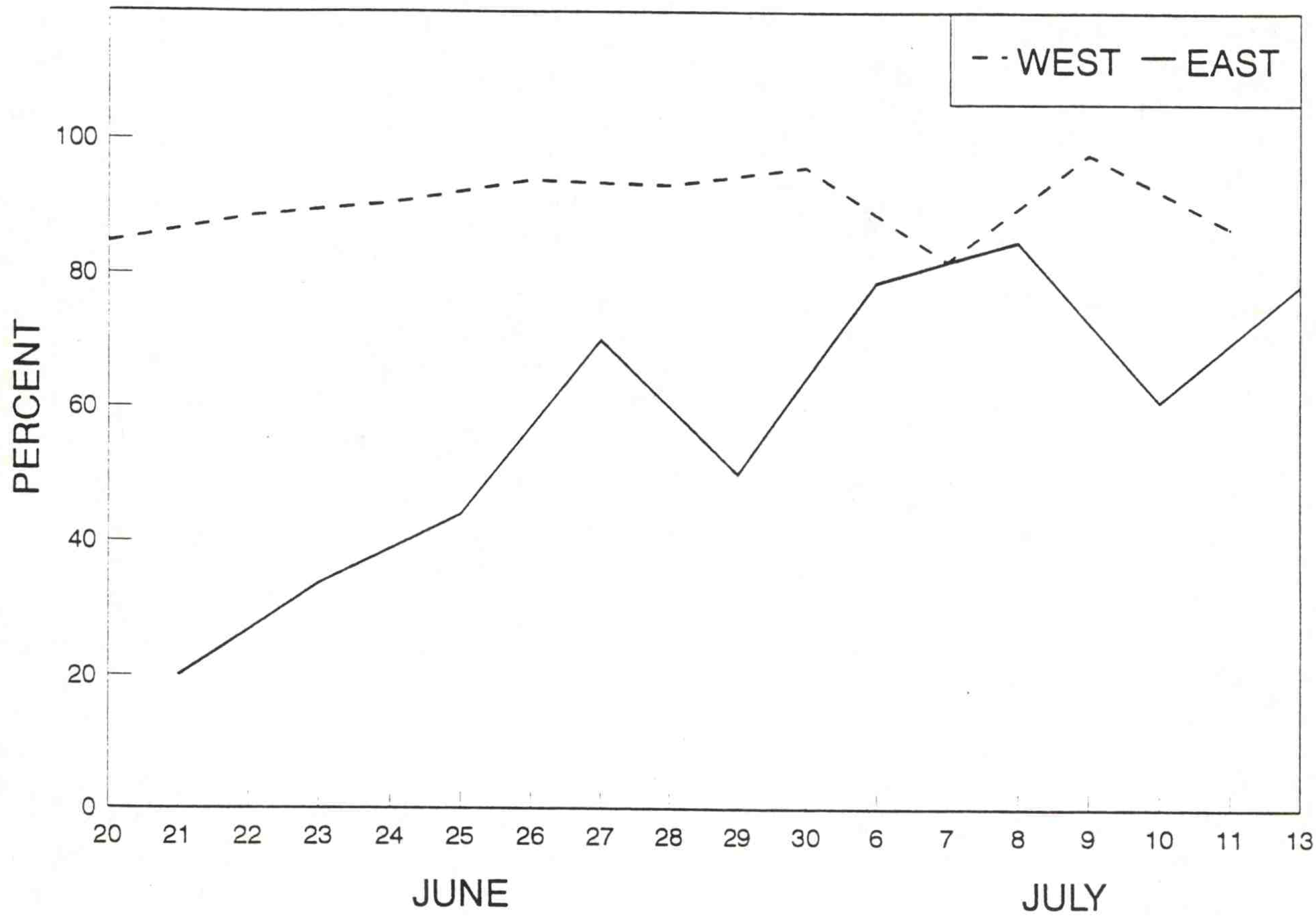

Figure 7. Daily orifice passage efficiency (OPE) for subyearling chinook salmon in Slot 12B at The Dalles Dam, 1995.

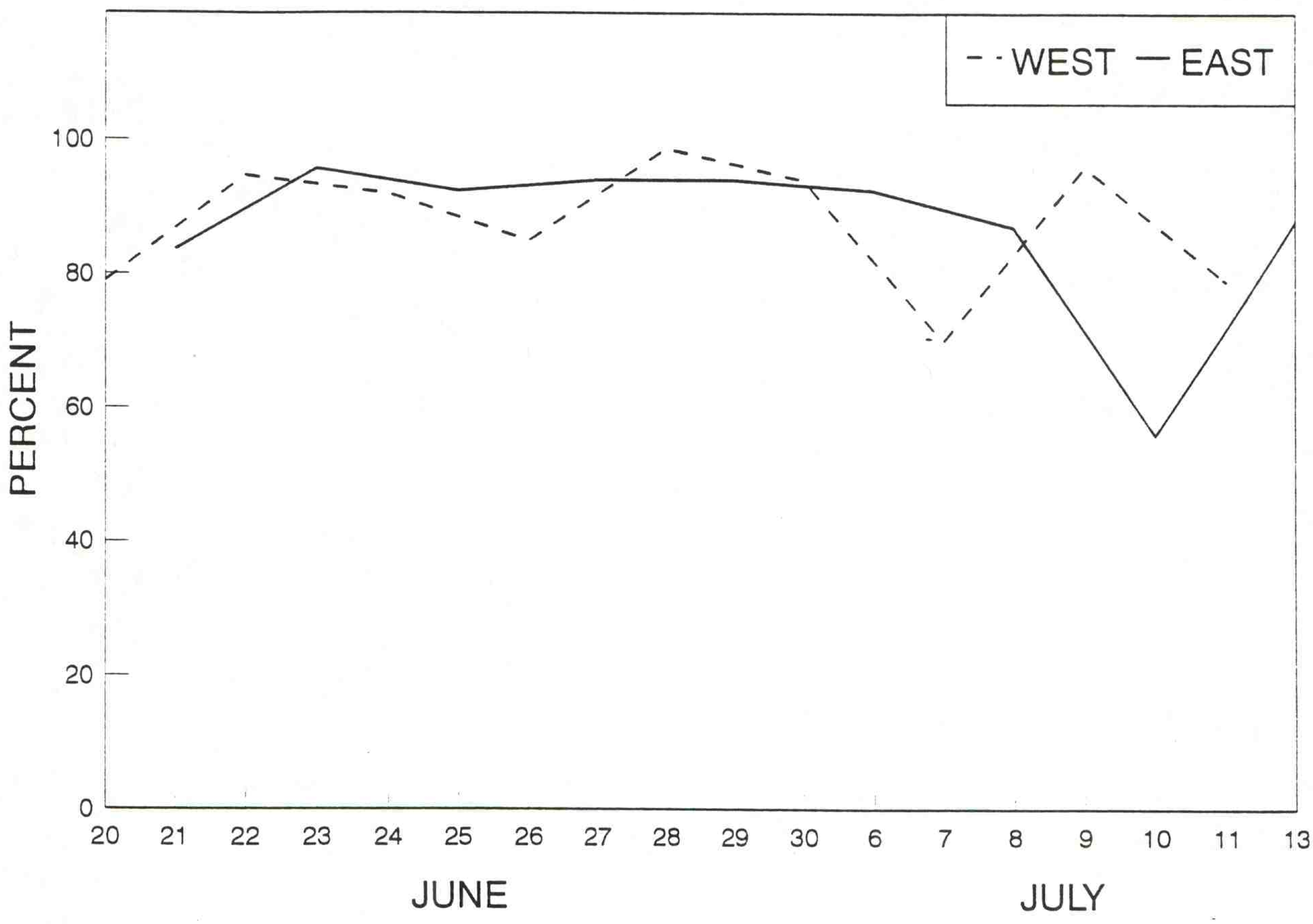

Figure 8. Daily orifice passage efficiency (OPE) for subyearling chinook salmon in Slot 17B at The Dalles Dam, 1995.

OBJECTIVE 2: EVALUATE THE EFFECTS OF EXTENDED-LENGTH BAR SCREENS AND INLET FLOW VANES ON JUVENILE SALMONID DESCALING

Approach

The condition of fish captured during OPE tests was monitored using standard Fish Transportation Oversight Team descaling criteria (Ceballos et al. 1993).

The test slots were dipnetted daily between 1630 and 1800 h. Captured fish were anesthetized with MS-222, identified by species, and enumerated.

Results and Discussion

Yearling Fish

Descaling was low (<3%) for yearling chinook salmon captured during OPE tests (Table 1). The low level of descaling precluded the need for statistical analysis. Detailed descaling data are shown in Appendix Table 2.

No descaling occured in the 22-hour period marked fish were in the gate slot during the efficiency/mortality tests.

Table 1. Descaling test results for yearling chinook salmon at The Dalles Dam, 1995 (ESBS = extended-length submersible bar screen). Mean descaling and total catch are combined results of fish collected during orifice passage efficiency tests.

	Slot		
	5B	12B	17B
Screen type	ESBS	ESBS	ESBS
Porosity of perf. plate (%)	50	50	30
Mean descaling (%)	0.6	2.4	0.6
Total catch	344	1,390	171

Subyearling Fish

Descaling was very low (<1%) for subyearling chinook salmon captured during OPE tests (Table 2). Low descaling precluded the need for statistical analysis. Detailed descaling data are shown in Appendix Table 2.

No descaling occured in the 22-hour period marked fish were in the gate slot during the efficiency/mortality tests.

Table 2. Descaling test results for subyearling chinook salmon at The Dalles Dam, 1995 (ESBS = extended-length submersible bar screen). Mean descaling and total catch are combined results of fish collected during orifice passage efficiency tests.

	Slot		
	5B	12B	17B
Screen type	ESBS	ESBS	ESBS
Porosity of perf. plate (%)	50	50	30
Mean descaling (%)	0.4	0.2	0.4
Total catch	516	1,056	267

OBJECTIVE 3: EVALUATE THE HORIZONTAL DISTRIBUTION OF JUVENILE SALMONIDS AS THEY ENTER TURBINE INTAKES ACROSS THE POWERHOUSE

Approach

The center slots of Turbine Units 5, 12, and 17 were dipnetted daily during OPE tests. Catches from these tests were used to determine the distribution of juvenile salmonids entering at different locations across the powerhouse. As shown in Figure 1, Unit 5 is situated at the west end of the powerhouse, Unit 12 near the center, and Unit 17 near the east end.

The test slots were dipnetted at the start of a test, then daily between 1630 and 1800 h. Captured fish were anesthetized with MS-222, identified by species, and enumerated.

Results and Discussion

Yearling Fish

Individual test results of all horizontal distribution measurements are presented in Appendix Table 3. The total number of juvenile salmonids (all species combined) obtained during daily gatewell dipnetting from 23 April through 26 May was 6,038. Horizontal distribution (all species combined) during 1995 OPE tests was 17, 50, and 33% of the total catch for Slots 5B, 12B, and 17B, respectively, with the highest catches in the center of the powerhouse. During the entire 1995 outmigration, the COE's Fisheries Field Unit conducted surface skimming operations in Slots 1A and 2A (at the west end of the powerhouse) as an additional method of passing fish. The open sluice gates appeared to influence the horizontal distribution of juvenile salmonids caught across the powerhouse. Horizontal distribution (all species combined) with sluice gates closed during 1994 FGE tests was 61, 25, and 14% of the total catch for Slots 2B, 12B, and 17B, respectively, indicating higher passage at the west end of the powerhouse (Fig. 9).

Also in April 1995, subyearling chinook salmon were present at The Dalles Dam as swimup fry and dominated the catch in Slot 17B (84% of the total). This atypical appearance of non-smolted subyearling chinook salmon further skewed the distribution. Excluding subyearling chinook salmon from the catch resulted in a horizontal distribution of 17, 73, and 10% in Slots 5B, 12B, and 17B, respectively.

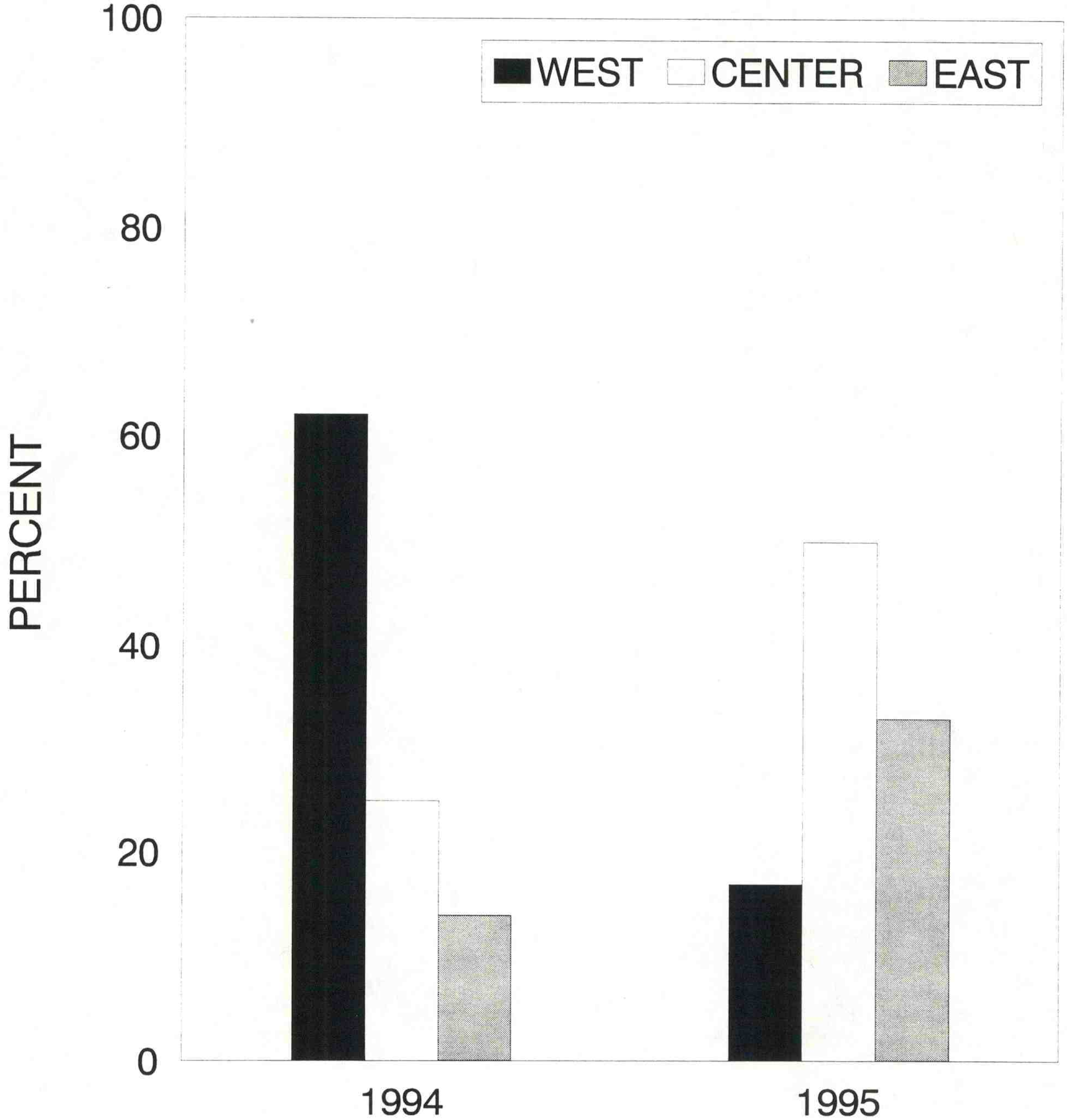

Figure 9. Horizontal distribution (% of total catch) across the powerhouse for all juvenile salmonids during the spring test period at The Dalles Dam, 1994-1995. Fish were collected from Slots 2B and 5B at the west end of the powerhouse, Slot 12B in the center, and Slot 17B at the east end.

Subyearling Fish

The total number of juvenile salmonids (all species combined) obtained during daily gatewell dipnetting from 19 June through 13 July was 1,859 fish. The catch was composed primarily of subyearling chinook salmon (99%). Summer horizontal distribution of catch (all species combined) in Slots 5B, 12B, and 17B was 28, 57, and 15%, respectively, with highest catches in the center of the powerhouse (Fig. 10). This was similar to the spring pattern, and also reflected the influence of the open sluice gates in Slots 1A and 2a. In 1994 with the sluice gates closed, summer horizontal distribution in Slots 2B, 12B, and 17B was 65, 26, and 9%, respectively, with the highest catches at the west end of the powerhouse.

SUMMARY

1) Mean OPEs for yearling chinook salmon were 77.5, 80.3, and 82.8% for the west orifices and 65.4, 56.9, and 80.8% for the east orifices in Slots 5B, 12B, and 17B, respectively. Mean OPEs for yearling chinook salmon in Slots 5B and 12B were significantly higher in the west orifice than in the east orifice, but there was no significant difference between mean OPEs in the east and west orifices in Slot 17B.
2) Mean OPEs for subyearling chinook salmon were 78.8, 90.5, and 87.6% for the west orifices and 42.6, 57.9, and 87.0% for the east orifices in Slots 5B, 12B, and 17B, respectively. Mean OPEs for subyearling chinook salmon in Slots 5B and 12B were significantly higher in the west orifice than in the east orifice, but there was no significant difference between mean OPEs in the east and west orifices in Slot 17B.
3) Descaling rates were low for both yearling chinook salmon (<3%) during the spring outmigration and subyearling chinook salmon (<1%) during the summer outmigration.

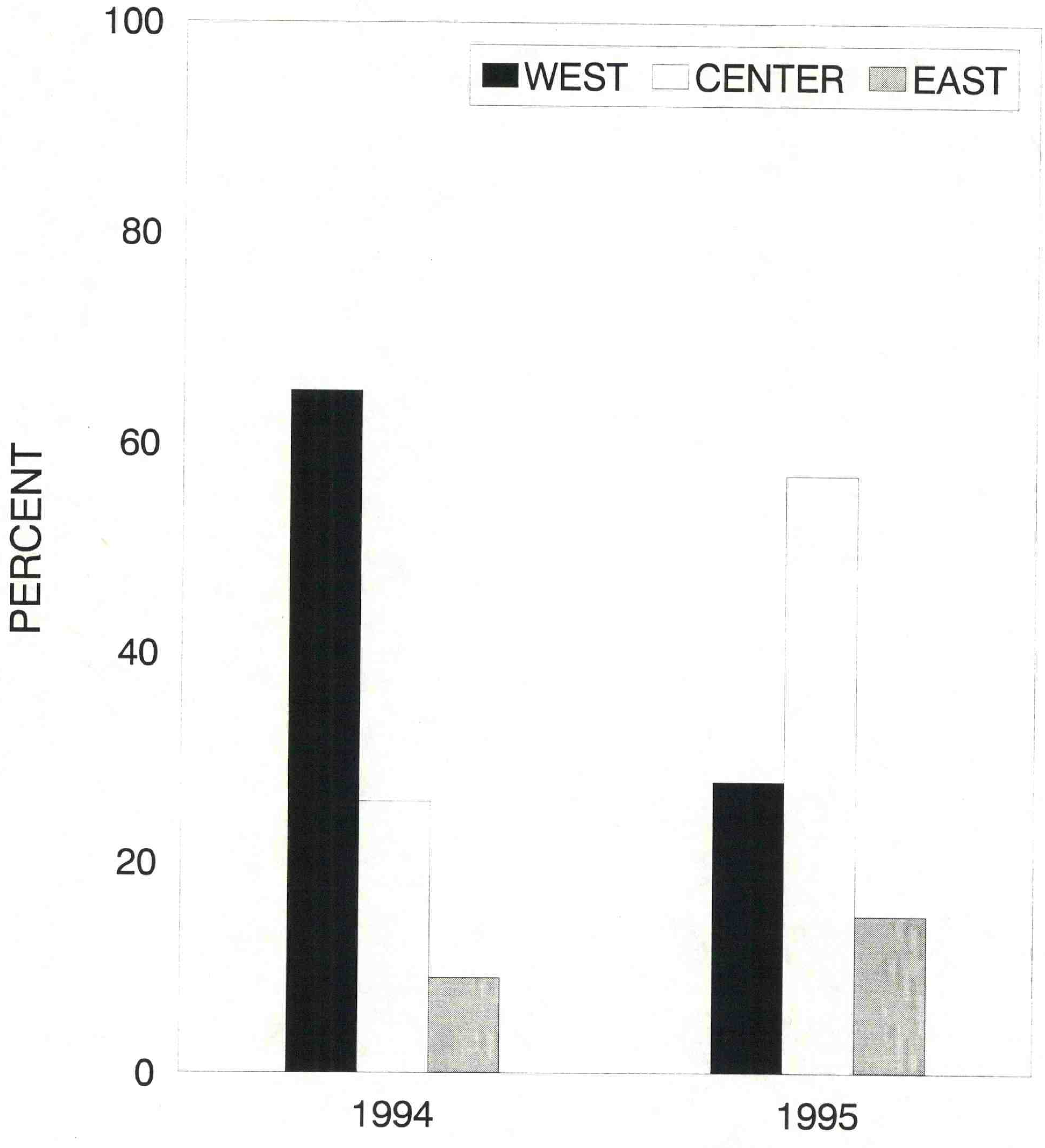

Figure 10. Horizontal distribution (% of total catch) across the powerhouse for all juvenile salmonids during the summer test period at The Dalles Dam, 1994-1995. Fish were collected from Slots 2B and 5B at the west end of the powerhouse, Slot 12B in the center, and Slot 17B at the east end.

4) Open sluice gates in Slots 1B and 2B (west end of powerhouse) throughout the entire test period in 1995 appeared to influence horizontal distribution of both spring and summer outmigrants. In 1994, relative horizontal distribution in west, center, and east test slots with sluice gates closed was 62, 25, and 13%, respectively, for spring fish and 65, 26, and 9%, respectively, for summer fish. In 1995 with sluice gates open, the relative horizontal distribution for west, center, and east test slots respectively was 17, 50, and 33% for spring fish and 28, 57, and 15% for summer fish.

ACKNOWLEDGMENTS

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Appendix Table 1. Orifice passage efficiency (OPE) data from tests at The Dalles Dam, 1995.

Unit 5 Slot B

Test date	Orifice open	Number marked	Number recovered	OPE (%)
23 April	W	100	33	67
24 April	E	50	19	62
26 April	W	27	13	52
2 May	E	50	6	88
6 May	W	50	3	94
11 May	W	100	31	69
12 May	E	100	30	70
13 May	W	100	11	89
14 May	E	79	28	65
15 May	W	22	5	77
16 May	E	51	22	57
17 May	W	100	42	58
18 May	W	100	24	76
19 May	E	50	24	52
20 May	W	50	10	80
21 May	E	41	20	51
22 May	W	80	24	70
24 May	W	50	9	82
25 May	E	100	53	47
26 May	W	34	10	71
20 June	W	100	42	58
22 June	W	50	8	84
23 June	E	50	39	22
24 June	W	50	7	86
25 June	E	100	70	30
26 June	W	100	15	85
27 June	E	50	31	38
28 June	W	75	11	85
29 June	E	50	29	42
30 June	W	50	7	86
6 July	E	80	31	61
7 July	W	100	34	66
8 July	E	100	45	55
9 July	W	100	15	85
10 July	E	100	46	54
11 July	W	100	26	74
13 July	E	65	30	54

Appendix Table 1. Continued.

Unit 12 Slot B

Test date	Orifice open	Number marked	Number recovered	OPE (%)
23 April	W	51	11	78
24 April	E	30	10	67
26 April	W	50	10	80
2 May	E	100	26	74
11 May	W	50	11	78
12 May	E	100	37	63
13 May	W	100	18	82
14 May	E	100	20	80
15 May	W	100	17	83
17 May	E	100	50	50
18 May	W	100	19	81
19 May	E	50	22	56
20 May	W	49	11	78
21 May	E	50	29	42
22 May	W	50	12	76
23 May	E	49	33	33
24 May	W	50	10	80
25 May	E	100	52	48
26 May	W	46	6	87
20 June	W	98	15	85
21 June	E	100	80	20
22 June	W	114	13	89
23 June	E	80	53	34
24 June	W	64	6	91
25 June	E	100	56	44
26 June	W	100	6	94
27 June	E	50	15	70
28 June	W	75	5	93
29 June	E	50	25	50
30 June	W	50	2	96
6 July	E	80	17	79
7 July	W	100	18	82
8 July	E	100	15	85
9 July	W	100	2	98
10 July	E	100	39	61
11 July	W	100	13	87
13 July	E	65	14	79

Appendix Table 1. Continued.

Unit 17 Slot B

Test date	Orifice open	Number marked	Number recovered	OPE (%)
23 April	W	72	27	63
24 April	E	18	1	94
26 April	W	32	5	84
2 May	E	114	19	83
4 May	W	45	8	82
5 May	E	57	4	93
6 May	W	35	1	97
11 May	W	50	15	70
12 May	E	100	21	79
13 May	W	100	25	75
14 May	E	100	16	84
15 May	W	100	15	85
17 May	E	98	23	77
18 May	W	100	5	95
19 May	E	50	15	70
20 May	W	50	0	100
21 May	E	50	17	66
22 May	W	60	13	78
20 June	W	100	21	79
21 June	E	43	7	84
22 June	W	75	4	95
23 June	E	47	2	96
24 June	W	50	4	92
25 June	E	105	8	92
26 June	W	100	15	85
27 June	E	50	3	94
28 June	W	75	1	99
29 June	E	50	3	94
30 June	W	50	3	94
6 July	E	80	6	93
7 July	W	100	30	70
8 July	E	100	13	87
9 July	W	100	4	96
10 July	E	100	44	56
11 July	E	100	21	79
13 July	E	100	12	88

Appendix Table 2. Descaling data from orifice passage efficiency and descaling tests at The Dalles Dam,1995 (ESTS = extended-length submersible traveling screen, ESBS = extended-length submersible bar screen).

Unit 5, Slot B: ESBS (50% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
23 April		5	0.0		43	0.0		1	0.0						
24 April		2	0.0		35	0.0		4	0.0						
25 April		3	0.0		28	0.0									
26 April		7	0.0		3	0.0									
1 May		12	0.0	1	88	1.1		8	0.0						
2 May		4	0.0		1	0.0									
3 May		10	0.0		7	0.0		3	0.0		1	0.0			
4 May		40	0.0		11	0.0		4	0.0		1	0.0		1	0.0
5 May		7	0.0		12	0.0		6	0.0		2	0.0		3	0.0
6 May		45	0.0		2	0.0		7	0.0				1	3	33.3
10 May		11	0.0		10	0.0		42	0.0		6	0.0		32	0.0
11 May		12	0.0		28	0.0		18	0.0		2	0.0		19	0.0
12 May		7	0.0		20	0.0		4	0.0					1	0.0
13 May		12	0.0		3	0.0		2	0.0					1	0.0
14 May		3	0.0		4	0.0		3	0.0					1	0.0
15 May		14	0.0		2	0.0		4	0.0					1	0.0
16 May		15	0.0		17	0.0		5	0.0					4	0.0
17 May		15	0.0		24	0.0		4	0.0		2	0.0		6	0.0
18 May		16	0.0		8	0.0		22	0.0		3	0.0			
19 May		19	0.0		8	0.0		7	0.0				1	3	33.3
20 May		23	0.0		4	0.0		2	0.0					5	0.0
21 May		47	0.0		2	0.0								4	0.0
22 May		7	0.0					1	0.0					3	0.0
23 May		37	0.0	1	13	7.7		12	0.0				1	11	9.1
24 May		11	0.0		3	0.0								3	0.0
25 May		35	0.0		2	0.0								2	0.0
26 May		30	0.0					1	0.0					6	0.0
19 June		62	0.0								1	0.0			
20 June		7	0.0					2	0.0						
21 June		20	0.0					1	0.0						
22 June		6	0.0												
23 June		16	0.0												
24 June		8	0.0												
25 June		11	0.0												
26 June		4	0.0												
27 June	1	21	4.8												

Appendix Table 2. Continued.

Unit 5, Slot B: ESBS (50% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
28 June		5	0.0												
29 June		23	0.0												
30 June		2	0.0												
5 July		87	0.0		1	0.0									
6 July	1	24	4.2												
7 July		2	0.0												
8 July		14	0.0												
9 July		70	0.0												
10 July		112	0.0											1	0.0
11 July		13	0.0												
12 July		1	0.0												
13 July		8	0.0												

Unit 12, Slot A: ESTS

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%	Desc	Catch	%
10 May		15	0.0		186	0.0		44	0.0		57	0.0		106	0.0
11 May		46	0.0	18	370	4.9		221	0.0		77	0.0		91	0.0
12 May		14	0.0	8	363	2.2		82	0.0		64	0.0		73	0.0
13 May		52	0.0	8	444	1.8		95	0.0		75	0.0		64	0.0
14 May		42	0.0		234	0.0		132	0.0		30	0.0		69	0.0
15 May		13	0.0	1	53	1.9		57	0.0		7	0.0		71	0.0
16 May		42	0.0		244	0.0		149	0.0		37	0.0		87	0.0
17 May		60	0.0	14	738	1.9		242	0.0		50	0.0		39	0.0
18 May		54	0.0	8	202	4.0		155	0.0		41	0.0		23	0.0
19 May		100	0.0	11	370	3.0		196	0.0		45	0.0		21	0.0
20 May		97	0.0	7	168	4.2		148	0.0		21	0.0		49	0.0
21 May		107	0.0	5	213	2.3		99	0.0		14	0.0		33	0.0
22 May		80	0.0	1	49	2.0		51	0.0		4	0.0		39	0.0
23 May		89	0.0	5	106	4.7		58	0.0		8	0.0	1	55	1.8
24 May		87	0.0		180	0.0		159	0.0		7	0.0		60	0.0
25 May		125	0.0		79	0.0		58	0.0		2	0.0		31	0.0
19 June		474	0.0		5	0.0		3	0.0					1	0.0
20 June		113	0.0		1	0.0		1	0.0					1	0.0

Appendix Table 2. Continued.

Unit 12, Slot A: ESTS

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
21 June		160	0.0		1	0.0		1	0.0						
22 June	2	125	1.6		3	0.0		3	0.0						
23 June		110	0.0												
24 June		299	0.0												
25 June	2	263	0.8					1	0.0						
26 June	2	165	1.2					2	0.0		1	0.0		1	0.0
27 June	2	251	0.8												
28 June	2	259	0.8												
29 June	2	285	0.7												
6 July		434	0.0		1	0.0								26	0.0
7 July		539	0.0		1	0.0		1	0.0					12	0.0
8 July		362	0.0					1	0.0					6	0.0
9 July	3	1260	0.2		1	0.0								2	0.0
11 July		2001	0.0											1	0.0
12 July	10	260	3.8												

Unit 12, Slot B: ESBS (50% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
23 April		9	0.0		38	0.0									
24 April		2	0.0		62	0.0		3	0.0						
25 April		19	0.0	1	63	1.6									
26 April		18	0.0		7	0.0									
1 May		12	0.0	1	89	1.1		8	0.0						
2 May		16	0.0		4	0.0		4	0.0						
3 May		8	0.0	1	27	3.7		9	0.0					1	0.0
4 May		3	0.0		43	0.0		13	0.0		1	0.0		3	0.0
5 May		9	0.0	2	85	2.4		40	0.0		16	0.0		19	0.0
10 May		21	0.0	1	94	1.1		171	0.0		25	0.0	1	104	1.0
11 May		1	0.0		87	0.0		51	0.0		4	0.0		27	0.0
12 May		6	0.0	3	68	4.4		21	0.0		4	0.0		4	0.0
13 May		8	0.0	1	60	1.7		16	0.0		2	0.0		6	0.0
14 May		6	0.0		20	0.0		4	0.0		1	0.0			

Appendix Table 2. Continued.

Unit 12, Slot B: ESBS (50% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
15 May		9	0.0		5	0.0		5	0.0					14	0.0
16 May		41	0.0		141	0.0		91	0.0		23	0.0		92	0.0
17 May		54	0.0	13	191	6.8		29	0.0		7	0.0		4	0.0
18 May		15	0.0	5	55	9.1	1	41	2.4		2	0.0		7	0.0
19 May		58	0.0	4	84	4.8		36	0.0		4	0.0		6	0.0
20 May		23	0.0		31	0.0		16	0.0		3	0.0		17	0.0
21 May		35	0.0	1	26	3.8		11	0.0					3	0.0
22 May		13	0.0		5	0.0		2	0.0					2	0.0
23 May		45	0.0	2	40	5.0		12	0.0		2	0.0		13	0.0
24 May		30	0.0		65	0.0		32	0.0		1	0.0		5	0.0
25 May		80	0.0		6	0.0		4	0.0					6	0.0
26 May		49	0.0		8	0.0		6	0.0					1	0.0
19 June		39	0.0		1	0.0	1	3	33.3					1	0.0
20 June		21	0.0												
21 June		72	0.0		1	0.0									
22 June		21	0.0		1	0.0									
23 June	1	44	2.3												
24 June		41	0.0												
25 June		120	0.0												
26 June		31	0.0												
27 June		63	0.0												
28 June		16	0.0												
29 June		84	0.0												
30 June		9	0.0												
5 July	1	147	0.7					1	0.0						
6 July		24	0.0												
7 July		8	0.0												
8 July		33	0.0											1	0.0
9 July		108	0.0												
10 July		143	0.0												
11 July		18	0.0												
12 July		10	0.0												
13 July		4	0.0												

Appendix Table 2. Continued.

Unit 12, Slot C: ESTS

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
10 May		2	0.0	3	28	10.7		32	0.0		12	0.0		45	0.0
12 May		7	0.0	1	65	1.5		43	0.0		36	0.0		35	0.0
14 May		2	0.0		11	0.0		12	0.0		6	0.0		8	0.0
15 May		2	0.0		5	0.0		2	0.0						
17 May		19	0.0	9	67	13.4		41	0.0		9	0.0		16	0.0
19 May		15	0.0		28	0.0		32	0.0		6	0.0		8	0.0
20 May		20	0.0	1	13	7.7		13	0.0		1	0.0		4	0.0
22 May		18	0.0		3	0.0								4	0.0
23 May		8	0.0		4	0.0		5	0.0					6	0.0
24 May		17	0.0		18	0.0		12	0.0		2	0.0		7	0.0
25 May		7	0.0		1	0.0		3	0.0					1	0.0
19 June	1	71	1.4		1	0.0		1	0.0					1	0.0
20 June		13	0.0												
22 June		31	0.0		1	0.0									
25 June		84	0.0												
26 June		30	0.0												
7 July		124	0.0											1	0.0
10 July		153	0.0												
11 July		100	0.0											1	0.0
12 July		7	0.0												

Unit 17, Slot B: ESBS (30% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
23 April		5	0.0		18	0.0									
24 April		22	0.0		2	0.0									
25 April		55	0.0		22	0.0									
26 April		45	0.0		1	0.0									
1 May		53	0.0		52	0.0		4	0.0		2	0.0			
2 May		313	0.0											2	0.0
3 May		40	0.0		14	0.0		3	0.0						
4 May		34	0.0		3	0.0		1	0.0						
5 May		137	0.0												
6 May		25	0.0		9	0.0		1	0.0		1	0.0			

Appendix Table 2. Continued.

Unit 17, Slot B: ESBS (30% porosity)

Test date	Subyearling chinook			Yearling chinook			Steelhead			Coho			Sockeye		
	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%	Desc.	Catch	%
10 May		201	0.0	1	9	11.1		22	0.0		1	0.0	1	28	3.5
11 May		95	0.0		3	0.0		3	0.0					3	0.0
12 May		12	0.0		1	0.0		1	0.0		1	0.0			
13 May		26	0.0					1	0.0						
14 May		33	0.0												
15 May		13	0.0		1	0.0		1	0.0					2	0.0
16 May		138	0.0		16	0.0		20	0.0		3	0.0		14	0.0
17 May		48	0.0		2	0.0		4	0.0		2	0.0		1	0.0
18 May		84	0.0		1	0.0		1	0.0					1	0.0
19 May		3	0.0					1	0.0					3	0.0
20 May		28	0.0					2	0.0					1	0.0
21 May		12	0.0		2	0.0					1	0.0		1	0.0
22 May		31	0.0											1	0.0
23 May		68	0.0		6	0.0		3	0.0					3	0.0
24 May		92	0.0		8	0.0		8	0.0					5	0.0
25 May		81	0.0		3	0.0		1	0.0					2	0.0
19 June		25	0.0												
20 June		5	0.0												
21 June		9	0.0												
22 June		6	0.0												
23 June		12	0.0					1	0.0						
24 June		8	0.0												
25 June		5	0.0												
26 June		5	0.0												
27 June		10	0.0												
28 June		1	0.0												
29 June		1	0.0												
30 June		5	0.0												
5 July		79	0.0					1	0.0						
6 July		4	0.0												
7 July		2	0.0												
8 July	1	2	50.0												
9 July		42	0.0												
10 July		35	0.0												
11 July		7	0.0												
12 July		4	0.0												
13 July		4	0.0												

Appendix Table 3. Horizontal distribution data from dip-net catch at The Dalles Dam, 1995.

Unit 5, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
23 April	5	43	1		
24 April	2	35	4		
25 April	3	28			
26 April	7	3			
1 May	12	1	8		
2 May	4	1			
3 May	10	7	3	1	
4 May	40	11	4	1	1
5 May	7	12	6	2	3
6 May	45	2	7		3
10 May	11	10	42	6	32
11 May	12	28	18	2	19
12 May	7	20	4		1
13 May	12	3	2		1
14 May	3	4	3		1
15 May	14	2	4		1
16 May	15	17	5		4
17 May	15	24	4	2	6
18 May	16	8	22	3	
19 May	19	8	7		3
20 May	23	4	2		5
21 May	47	2			4
22 May	7		1		3
23 May	37	1	12		1
24 May	11	3			3
25 May	35	2			2
26 May	30		1		6
19 June	62			1	
20 June	7		2		
21 June	20		1		
22 June	6				
23 June	16				
24 June	8				
25 June	11				
26 June	4				
27 June	21				
28 June	5				
29 June	23				
30 June	2				
5 July	87	1			
6 July	24				
7 July	2				
8 July	14				
9 July	70				
10 July	112				1
11 July	13				
12 July	1				
13 July	8				

Appendix Table 3. Continued.

Unit 12, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
23 April	9	38			
24 April	2	62	3		
25 April	19	63			
26 April	18	7			
1 May	12	89	8		
2 May	16	4	4		
3 May	8	27	9		1
4 May	3	43	13	1	3
5 May	9	85	40	16	19
10 May	21	94	171	25	104
11 May	1	87	51	4	27
12 May	6	3	21	4	4
13 May	8	60	16	2	6
14 May	6	20	4	1	
15 May	9	5	5		14
16 May	41	141	91	23	92
17 May	54	191	29	7	4
18 May	15	55	41	2	7
19 May	58	84	36	4	6
20 May	23	31	16	3	17
21 May	35	26	11		3
22 May	13	5	2		2
23 May	45	40	12	2	13
24 May	30	65	32	1	5
25 May	80	6	4		6
26 May	49	8	6		1
19 June	39	1	3		1
20 June	21				
21 June	72	1			
22 June	21	1			
23 June	44				
24 June	41				
25 June	120				
26 June	31				
27 June	63				
28 June	16				
29 June	84				
30 June	9				
5 July	147		1		
6 July	24				
7 July	8				
8 July	33				1
9 July	108				
10 July	143				
11 July	18				
12 July	10				
13 July	4				

Appendix Table 3. Continued.

Unit 17, Slot B

Test date	Subyearling chinook	Yearling chinook	Steelhead	Coho	Sockeye
23 April	5	18			
24 April	22	2			
25 April	55	22			
26 April	45	1			
1 May	53	52	4	2	
2 May	313				2
3 May	40	14	3		
4 May	34	3	1		
5 May	137				
6 May	25	9	1	1	
10 May	201	9	22	1	28
11 May	95	3	3		3
12 May	12	1	1	1	
13 May	26		1		
14 May	33				
15 May	13	1	1		2
16 May	138	16	20	3	14
17 May	48	2	4	2	1
18 May	84	1	1		1
19 May	3		1		3
20 May	28		2		1
21 May	12	2	1	1	
22 May	31				1
23 May	68	6	3		3
24 May	92	8	8		5
25 May	81	3	1		2
19 June	25				
20 June	5				
21 June	9				
22 June	6				
23 June	12		1		
24 June	8				
25 June	5				
26 June	5				
27 June	10				
28 June	1				
29 June	1				
30 June	5				
5 July	79		1		
6 July	4				
7 July	2				
8 July	2				
9 July	42				
10 July	35				
11 July	7				
12 July	4				
13 July	4				