PASSAGE EFFICIENCY AND MORTALITY STUDIES OF DOWNSTREAM MIGRANT SALMONIDS USING THE DALLES ICE TRASH SLUICEWAY DURING 1978

Funded By
U. S. Army Corps of Engineers
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Environmental Management Section

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INTRODUCTION

Juvenile salmon and steelhead produced in the Columbia River and its tributaries above Bonneville Dam must pass from one to nine dams in their migration to the ocean. Most migrants passing a dam are carried through the turbines or over the spillway. The proportion of fish passing either the turbines or spillway vary from year to year depending on the portion of water going through the turbines or over the spillway. Studies at main-stem Columbia River dams (Schoeneman, et al., 1961) have shown that migrants using the turbines have a much higher mortality than fish using the spillway. As more of the long-planned Columbia River hydroelectric and storage projects have been completed in recent years, spilling has generally decreased, forcing a higher percentage of the migrants through the turbines.

In recent years, state and federal fisheries agencies have been developing several techniques to safely pass juvenile fish around main-stem dams to avoid turbine associated mortalities. In varying stages of development, these are (1) collection of fish at upstream projects and transporting them by truck and barge to the estuary below Bonneville Dam, (2) various deflection devices in turbine intakes to guide fish to a bypass system around a project, (3) powerhouse and flow manipulations to spill fish over dams and pass them quickly through slack water reservoirs before they lose their natural urge to migrate, and (4) use of the ice-trash sluiceway as a surface skimming bypass system.

A study by Michimoto and Korn (1969) demonstrated the value of using the trash sluiceway for passing downstream migrants at Bonneville Dam. They felt

that mortalities to fish passing through the sluiceway would be similar to losses through the spillway. They recommended considering the use of sluiceways at other dams on the Columbia and Snake rivers.

Since 1971 the ice-trash sluiceway at The Dalles Dam has been operated to pass downstream migrant salmonids. During the peak passage period in the spring, the sluiceway provides a skimming attraction in the forebay using a total of about 2,200 cfs from four of the 70 adjustable gates across the powerhouse. Fish that collect in the bulkhead slots (gatewells) empty into the sluiceway through 70 6" orifice ports using a total of 280 cfs. During off-peak passage periods the sluiceway operates with orifice flow only. Downstream migrants using the sluiceway must drop onto a concrete apron as they pass from the sluiceway to the raceway which carries them to the tailrace. Resource management agencies have expressed concern that mortalities could occur under this condition, particularly with orifice flow only.

During 1977 a study was conducted by the Oregon Department of Fish and Wildlife to determine the number and percentage of downstream migrants using the sluiceway at The Dalles Dam under normal operating criteria (2' submerged opening on gates 1_1, 1_2, 2_1, and 22_3 1/). We found significant numbers of migrants (60,000+ on peak days) using the sluiceway, but the standard gate settings were thought not to be the best for optimum collection efficiency. We observed large hourly and daily fluctuations in sluiceway passage.

During 1978 a Corps' funded study was conducted by ODFW to (1) develop operating criteria to maximize the collection efficiency of the ice-trash

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1/ *The number defines the turbine unit (one of 22 numbered from west to east) and the subscript defines the particular gate (one of three per turbine unit numbered from west to east).*

sluiceway for downstream migrant salmonids with flows up to 4,000 cfs; and (2) estimate mortality and injury to juvenile salmonids passing through the sluiceway with orifice flow only (280 cfs).

METHODS

The trash sluiceway at The Dalles Dam is a large rectangular channel which extends along the forebay side of the powerhouse immediately above the penstocks and adjacent to the gatewells. The sluiceway is 2,200' long, 16.5' wide, and 49' deep from the underside of the deck to the bottom (elevation 134' above sea level). The forebay side of the sluiceway is composed of 70 adjustable gates. A sill in front of the gates is elevation 151'. Normal forebay level is elevation 155'-160'. Gates can be raised or lowered to allow water and trash to enter the sluiceway submerged or overflow. There are three gates for each of the 22 main turbines and two gates each for the two fish turbines which provide auxiliary water for the fishways. The gates are numbered from west to east with each corresponding turbine unit. A gate across the sluiceway at the west end controls water depth and velocity for fixed gate settings. This gate, termed the sluice or end gate, consists of two leaves. It is opened by lowering the bottom leaf, raising the upper, or both. Water entering the sluiceway flows west, plunges over the end gate onto a sloping concrete apron, and is discharged through a raceway into the tailrace below the powerhouse.

To maximize the collection efficiency of the sluiceway tests were run to determine the:

(1) general fish distribution across the face of the powerhouse (west vs east vs middle),

(2) specific fish distribution in a general area (adjacent vs spaced openings),

(3) optimum sluice gate opening (2' submerged vs 3' submerged vs maximum overflow) for fish collection, and

(4) effects of increased flow on collection efficiency.

Average daily fish passage in the sluiceway on Monday, Wednesday, and Friday with one set of gate conditions was compared with passage on Tuesday and Thursday with an alternate set of gates. This method will give good approximate differences in daily passage with various gate conditions. However, because of normal fluctuations in relative daily abundance of fish, this method does not measure small differences in passage efficiency as well as larger ones and does not lend itself to rigorous statistical analysis. The effect of changes in relative daily abundance is minimized, however, by averaging passage on several alternate days.

To estimate the number of downstream migrants using the sluiceway we fished one or two fyke nets in the sluiceway which sampled 4-10% of the cross sectional area. During early testing we fished two nets to compare two different sets of conditions simultaneously. The lower and upper nets were located below the gates in units one and 10, respectively. We discontinued sampling with the upper net when early results of fish distribution across the powerhouse indicated remaining tests should be done on the west end of the sluiceway below our upper net.

The nets were laced to metal frames suspended by cables which were attached to anchor plates on the sluiceway walls. For fishing, the nets were lowered into the sluiceway through holes in the deck. The nets (Figure 1) were divided into two sections with an overall length of 20'. The net

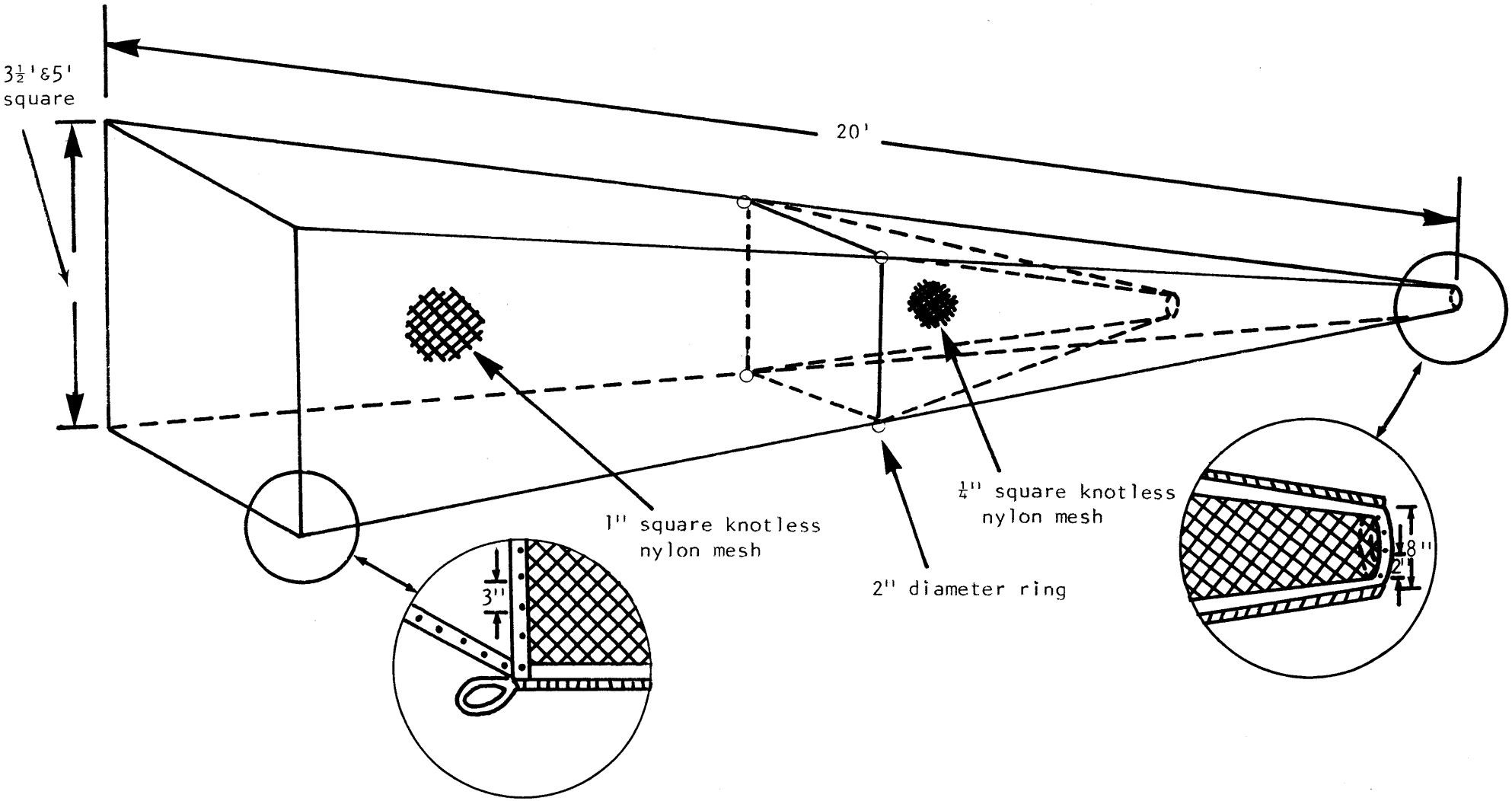


Figure 1. Schematic Diagram of Fyke Nets Used to Sample Juvenile Salmonids in The Dalles Trash Sluiceway

entrances were $3\frac{1}{2}$' or 5' square and tapered to an 8" cod end. The 10' front sections were composed of 1" square nylon mesh and the 10' back sections were $\frac{1}{4}$" square nylon mesh, with the fyke 5' from the cod end. The smaller net was fished on the west end of the sluiceway where there were more fish and the water velocities were higher.

The efficiency of the nets were determined by periodic releases and recaptures of marked juvenile salmonids into the sluiceway. Total daily passage of downstream migrant salmonids past a net in the sluiceway was then estimated from daily net catches. Since it was impractical to sample 24-hour periods everyday, the hourly distribution over a 24 hour period was estimated periodically throughout the emigration. These distributions were used to estimate passage during hourly periods that were not sampled. The detailed procedure for making the estimates is included in the Appendix. Orifice openings between the gatewells and sluiceway were blocked to prevent any fish from entering the sluiceway except from the forebay. Gatewells were dipped to salvage fish.

We fished the net(s) during all or a portion of 55 of 68 days between April 17 and June 23 and 15 of 15 days between July 21 and August 8, 1978.

To estimate mortality and injury to juvenile salmonids passing through the sluiceway under orifice flow (280 cfs) we released a group of fish above and below the concrete apron plunge and recovered them with an incline plane trap in the raceway. The fish were then held for 2 weeks.

Prior to the experiment, examination of the raceway had revealed a portion of the floor and wall to be very rough. Over a period of time the high velocity water had eroded the concrete surface. Several layers of epoxy were applied thus eliminating a possible source of injury.

Due to structural limitations of our trap and overflow weir in the raceway we were able to fish with only 150 cfs. However, we felt that mortality and injury if any would be greater under this lower flow.

On July 12, 1978, two groups of 1,000 branded hatchery coho (Klatskanie Hatchery, 90/lb) were hauled from Bonneville Hatchery in 50 F water. At The Dalles Dam the fish were transferred to stock tanks in the now 51 F water and held for about 1 hour. The test group was released towards the north sidewall of the sluiceway end gate (above the plunge) and the control group was released on the east side of the raceway (below the plunge) to estimate the effect of the plunge upon survival. Both groups were released simultaneously into the 64 F Columbia River water. The fish were recovered further down the raceway in an incline plane trap which sampled about 20% of the raceway flow.

Fish were dipped from the trap continuously as they entered for about 30 minutes after release. Then the sluiceway was shut off by closing the end gate. The pool formed above the trap by a 4' high stop-log barrier was drained to 1' depth and seined. All fish recovered in the trap and by seining were examined for injury and descaling. All fish were hauled back to Bonneville Hatchery in 51 F water and held for 2 weeks to observe for delayed mortality. The fish were held in 50 F water and fed daily.

A second test was conducted on July 17, 1978. Everything was similar to the first test except the test fish were released towards the south sidewall of the sluiceway end gate. Fish were trapped or seined and returned to Bonneville Hatchery.

RESULTS AND DISCUSSIONS

Many tests were run to maximize the collection efficiency of the sluiceway. These included determination of general and specific fish distribution across the powerhouse and optimum sluice gate openings and flows for fish collection. Results of the distribution tests are summarized in Table 1. Fish passage steadily increases the farther west you move across the powerhouse (April 17-21). We tested gates at turbine units 2 and 17 on Monday, Wednesday, and Friday against gates in units 7 and 22 on Tuesday and Thursday. Total flow each day was about 2,000 cfs which was balanced between each set of gates. To do this we opened the upper gates (7 and 22) 3' while the lower gates (2 and 17) were open 2'. This was necessary because when water enters the sluiceway, a portion of it backs upstream and raises the water level, which decreases the head differential and flow between the forebay and sluiceway. All gate openings were submerged. The decreasing passage efficiency from west to east is illustrated by Figure 2, showing the relative distribution through gates at turbine units 2, 7, 17, and 22. This agrees roughly with the distribution of gatewell caught fish during the same period of time (Figure 3). It should be noted that when these tests were run, only yearling juvenile salmonids were present in any significant numbers; therefore, this distribution may not be accurate for the later running fall chinook which are more strongly shore oriented.

Adjacent and spaced gate openings were tested April 24-28 (Table 1). On the west end of the powerhouse adjacent gates passed about twice as many fish as spaced openings. However, this may be due to moving into units 3 and 4, away from our best gates on the extreme west. On the east end, where this effect is minimized, adjacent gates passed about 50% more fish than spaced

Table 1. Estimated Daily Passage of Juvenile Salmonids Through The Dalles Trash Sluiceway with Various Combinations of Gates Open During 1978

Date		April 17-21				April 24-28			
Test		West vs East Distribution				Adjacent vs Spaced Opening			
		West ← → East				Adjacent	Spaced	Adjacent	Spaced
Gates Open 1/		$(2_1 2_2)$	$(7_1 7_2)$	$(17_2 17_3)$	$(22_2 22_3)$	$(2_1 2_2 2_3)$	$(2_2 3_2 4_2)$	$(17_1 17_2 17_3)$	$(16_2 17_2 18_2)$
Total Flow (cfs)			(2,000 each day)				(2,250 each day)		
Tot. Juv.	Mon.	10,400		3,900			27,600	2,300	
	Tues.		9,300		600	36,000			3,000
	Wed.	16,600		2,000			16,300	3,900	
	Thur.		5,800		200	53,400			3,400
	Fri.	24,100		7,500			27,500	7,600	
	Total	51,100	15,100	13,400	800	89,700	71,400	13,800	6,400
	Avg.	17,050	7,550	4,450	400	44,850	23,800	4,600	3,200

1/ *The number defines the turbine unit (one of 22 numbered from west to east) and the subscript defines the particular gate (one of three per turbine unit numbered from west to east).*

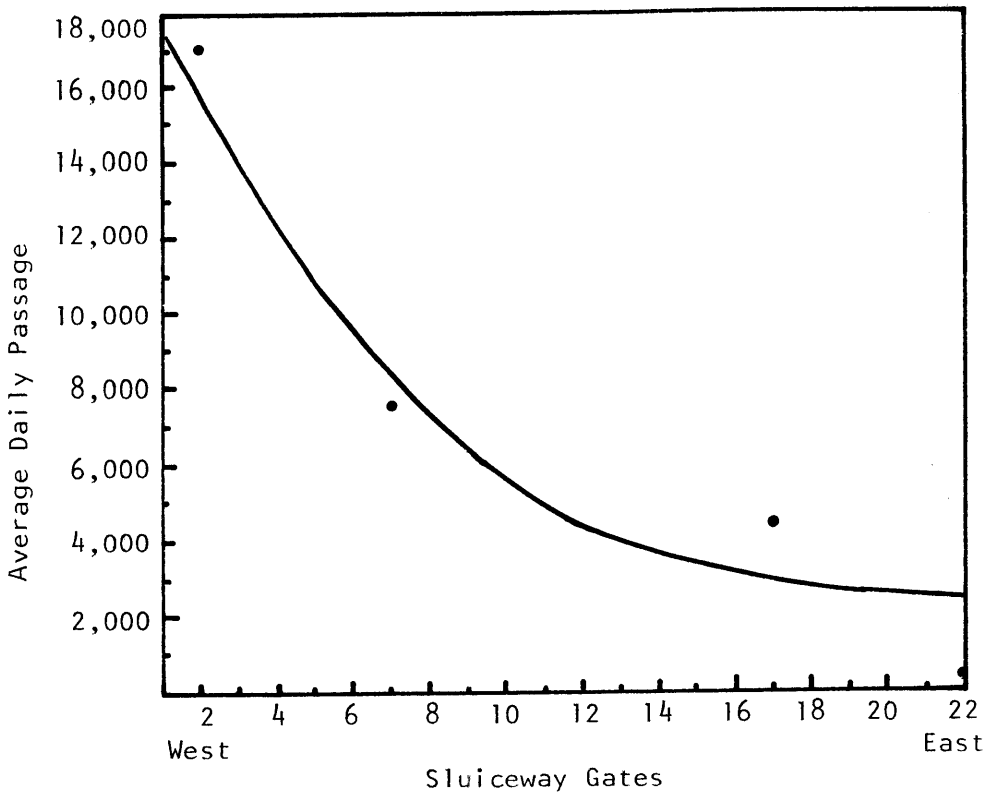


Figure 2. Estimated Average Daily Passage of Juvenile Salmonids Through The Dalles Trash Sluiceway with Various Gates Open April 17-21, 1978

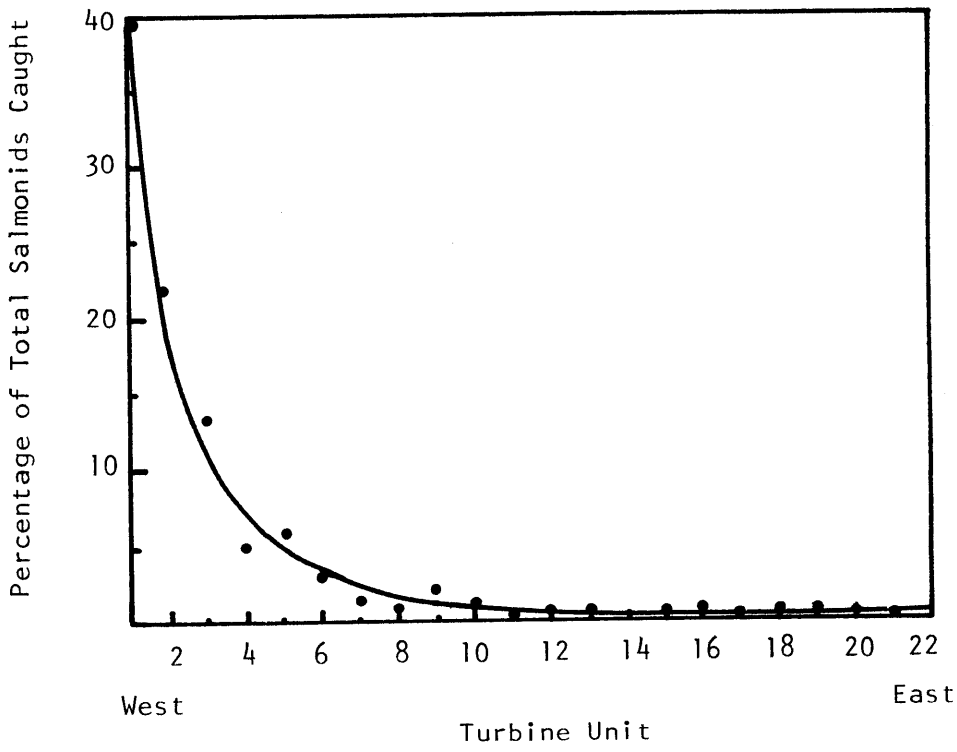


Figure 3. Distribution of Juvenile Salmonids Caught in Turbine Units at The Dalles Dam, April 10-28, 1978

openings. We used 2' submerged openings on all gates with a total daily flow of about 2,250 cfs. Flow was not balanced between lower and upper gates because the tests were between gate conditions within each end. Balancing would have required more water.

Results of efficiency tests with various amounts of gate openings and flows are summarized in Table 2. Two-foot and 3' submerged openings passed about the same numbers of fish (May 1-5). However, the 3' openings were spaced which may have reduced their collection efficiency. Three-foot and overflow openings passed about the same numbers of fish (June 5-9). However, when the forebay is near the bottom of its normal range a 3' submerged opening is overflow. Two gates passed over 20% more fish than one gate. This represents a 40% increase in flow.

Over 3½ million juvenile salmonids were estimated to have passed through the sluiceway between April 17 and August 4, 1978. This is shown by species by 5-day period in Table 3. The sluiceway was closed June 23 to prepare for the mortality study (normally closes June 30). However, after we got special authorization to reopen the sluiceway on July 21 for further collection efficiency tests, we passed over 300,000 fall chinook in 5 days. Undoubtedly, large additional numbers passed through the turbine when the sluiceway was closed. In recent years with the decreased spilling and reduced transportation flows in the reservoirs, the fish have been delayed. This has particularly affected fall chinook, the latest peaking downstream migrant. Consideration should be given to operation of the sluiceway through July to protect these migrants.

Although determining overall collection efficiency of juvenile salmonids through the sluiceway was not one of our objectives, it is interesting to consider. Two indirect estimates are presented in Table 4. The first is the estimated percentage passage through the sluiceway of two

Table 2. Estimated Daily Passage of Juvenile Salmonids Through The Dalles Trash Sluiceway with Various Gate Openings and Flows During 1978

Date		May 1-5		June 5-9		June 19-23	
Test		2' Submerged vs 3' Submerged Opening 1/		3' Submerged vs Maximum Overflow Opening 1/		2,500 cfs vs 3,500 cfs	
		2'	3'	3'	Overflow	2,500	3,500
Gates Open 2/		$\begin{pmatrix} 1_2 1_3 2_1 \\ 2_2 2_3 3_1 \end{pmatrix}$	$(1_2 2_2 3_2)$ 3/	$\begin{pmatrix} 1_2 1_3 2_1 \\ 2_2 2_3 \end{pmatrix}$	$(1_1 1_2 1_3)$	1_2 4/	$1_2 1_3$ 4/
Tot. Juv.	Mon.		62,000				
	Tues.	38,300			16,500	12,600	
	Wed.	116,200		12,000			16,400
	Thur.		80,600		12,800	13,200	
	Fri.	77,500		18,600			15,000
	Tot.	232,000	142,600	30,600	29,300	25,800	31,400
	Avg.	77,300	71,300	15,300	14,650	12,900	15,700

1/ *The total flow (cfs) through the sluiceway for both sets of gate openings within this test was approximately equal (2,750 cfs May 1-5; 3,750 cfs June 5-9).*

2/ *The number defines the turbine unit (one of 22 numbered from west to east) and the subscript defines the particular gate (one of three per turbine unit numbered from west to east).*

3/ *On Monday and Thursday 4_2 and 5_2 were open 2' but effectively, very little water entered these gates.*

4/ *These gates were open freeflow.*

Table 3. Total Estimated Passage of Juvenile Salmonids Through The Dalles Trash Sluiceway, April 17-August 4, 1978

Date	Spring Chinook	Fall Chinook	Coho	Sockeye	Steelhead	Total
Apr. 17-21	26,000	200	36,000	800	17,400	80,400
22-26	49,500	--	68,400	7,600	25,500	151,000
27-May 1	63,200	800	46,600	15,300	124,800	250,700
May 2-6	160,100	400	64,100	53,800	105,600	384,000
7-11	172,200	1,000	40,000	46,600	70,700	330,500
12-16	170,100	300	69,300	30,900	72,400	343,000
17-21	310,700	500	50,300	52,200	65,100	478,800
22-26	180,800	2,000	80,000	81,100	50,000	393,900
27-31	71,700	11,700	36,600	70,300	44,100	234,400
June 1-5	27,200	13,900	11,100	34,900	27,600	114,700
6-10	25,500	18,100	4,000	22,100	8,600	78,300
11-15	77,500	23,900	14,700	16,500	6,300	138,900
16-20	121,400	63,600	6,200	6,000	4,000	201,200
21-23 1/	25,800	16,900	300	1,000	600	44,600
Subtotal	1,481,700	153,300	527,600	439,100	622,700	3,224,400
24-July 20 -- The sluiceway was closed while the orifice flow mortality study was run --						
July 21-25	14,800	306,400	--	--	300	321,500
26-30	2,100	61,000	--	--	100	63,200
31-Aug.4	300	47,200	--	--	100	47,600
Grand Total	1,498,900	567,900	527,600	439,100	623,200	3,656,700

1/ *This period contains only 3 days so is not directly comparable to the others which are 5-day periods.*

Table 4. Two Estimates of Overall Collection Efficiency of Juvenile Salmonids Through The Dalles Trash Sluiceway During 1978

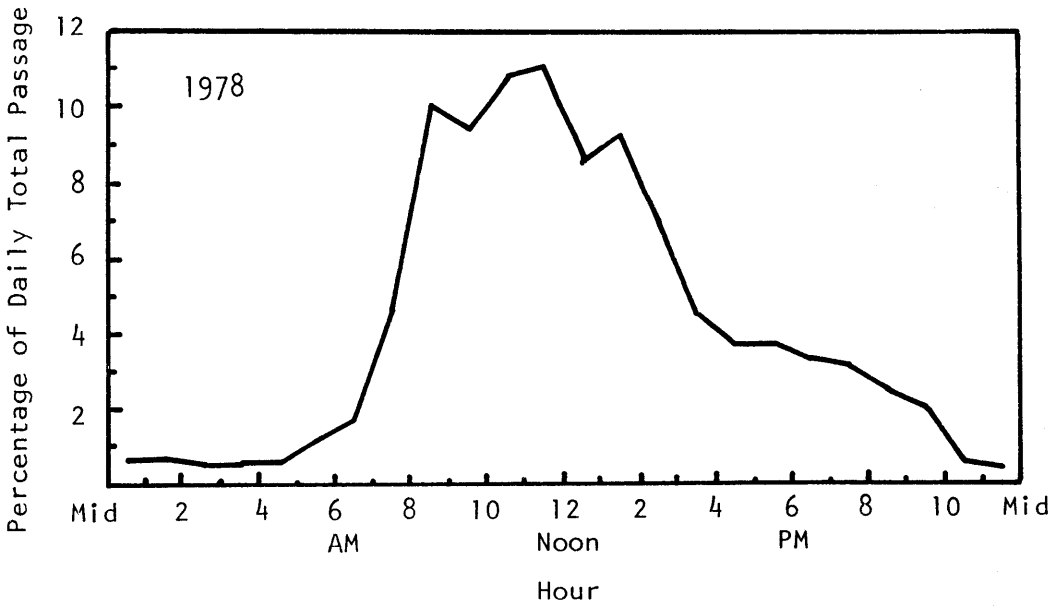
Estimate #1	Estimated sluiceway passage of NMFS branded coho released below John Day Dam,	Test #1.....	15,699
		Test #2.....	11,272
		Tests #1 & 2 combined	26,971
	Number of NMFS branded coho released below John Day Dam,	Test #1.....	48,274
		Test #2.....	49,000
		Tests #1 & 2 combined	97,274
	Estimated sluiceway passage efficiency of NMFS branded coho released below John Day Dam ($\frac{\text{passage}}{\text{releases}}$),	Test #1.....	32.5%
		Test #2.....	23.0%
		Tests #1 & 2 combined	27.7%
Estimate #2	ODFW estimated sluiceway passage April 17-June 20 (all species juvenile salmonids).....		3,180,000
	Total gatewell recoveries April 17-June 20 (all species).....		34,397
	Total estimated turbine passage April 17-June 20 assuming .039 1/recovery rate in gatewells (34,397/.039).....		882,000
	Estimated sluiceway passage efficiency ($\frac{\text{sluiceway}}{\text{sluiceway + turbine}}$).....		78.3%

1/ *Raymond, Howard L. 1978. Effects of dams and impoundments on migration of juvenile chinook salmon and steelhead trout from the Snake River, 1966-1975. Nat. Mar. Fish. Ser., Unpub. Rept.*

groups of NMFS branded coho released below John Day Dam. This was 27.7% for the combined releases. However, we feel this estimate is very minimal for two reasons: First, our net fishes in 12-15 fps and fish are descaled very badly, even to the point of eliminating many of the brands. While we had the fish in hand, the brand was missing. 1/ Secondly, there was an unknown mortality or residualism on the release groups between John Day and The Dalles dams. The second estimate of collection efficiency is based on estimated sluiceway and turbine passage. We have a sluiceway passage estimate of 3.18 million fish (all species). We have an actual gatewell recovery count of 34,397 fish (all species). Assuming a gatewell usage rate of .039 (Raymond, 1978) turbine passage is estimated at 882,000 ($\frac{34,397}{.039}$). Overall sluiceway efficiency is the percentage sluiceway passage (3.18 million) of total passage (3.18 million + 882,000) or 78.3%. We feel this estimate is the most reasonable of the two, since effects of mortality, residualism, or loss of mark are not included. Also, the total spring chinook passage estimate at The Dalles (sluiceway passage/collection efficiency = 1.5 million/.783 = 1.9 million) agrees reasonably well with the NMFS estimate to John Day (2.1 million) when mortality due to passing John Day and recruitment from the Deschutes River is considered.

Twenty-four hour counts were made on May 12, 13, 25, 26, 27, 28, 29, 30, 31, and June 1, 1978. The diel distribution is shown in Figure 4. From 10:00 PM through 7:00 AM hourly passage was fairly low, generally less than 0.5% of the daily total. At 7:00 AM the passage started increasing rapidly, sustained itself through 2:00 PM and then slowly decreased until 10:00 PM. This passage was with 3' submerged openings with five gates on the west end.

1/ *This did not affect the NMFS experiment since brand elimination should not be selective for test or control fish, though it did reduce the total number of marked fish recovered.*



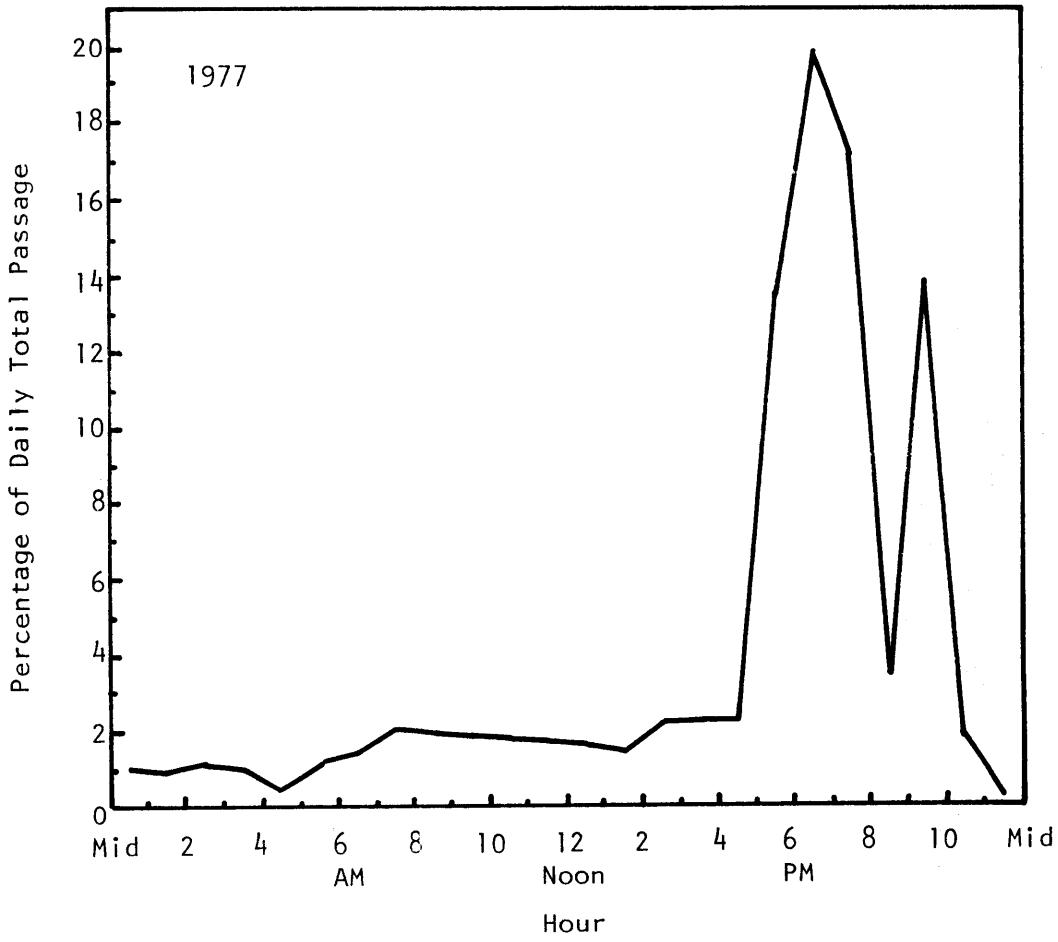


Figure 4. Diel Distribution of Juvenile Salmonids Using The Dalles Trash Sluiceway During 1977 and 1978

It is interesting to look at the diel distribution in 1977 (Figure 4) with 2' submerged openings on three adjacent gates on the west end and one gate on the east end. Passage was relatively uniform (and low) from midnight to 5:00 PM then jumped rapidly and maintained itself until 10:00 PM. Approximately 70% of the daily passage occurred between 5:00 PM and 10:00 PM. This year (1978) 66% of the daily passage occurred between 8:00 AM and 3:00 PM. The contrasting results in 1977 and 1978 tends to confirm the hypothesis that juvenile migrants approach the dam in the daylight hours, but lacking adequate bypass facilities wait until dusk to sound and pass through the turbines. We believe this change in peak passage period was caused by greatly improving the passage condition, going from 2' to 3' openings. The 2' opening probably delayed some fish until late afternoon and early evening when light levels started decreasing.

While we were interested primarily in catching juvenile salmonids, miscellaneous species were also caught. Rough estimates of total sluiceway passage by miscellaneous species were made per 5-day interval (Table 5). The total juvenile salmonid expansion was divided by actual catch and multiplied by actual catch of each miscellaneous species. Nearly 24,000 adult spawned out steelhead passed through the sluiceway along with several hundred upstream bound steelhead and spring chinook. Admittedly, estimates of 30 or 40 adult salmonids based on passage of one adult in a 5 day period would not be very precise. Over 300,000 shad passed through the sluiceway, primarily in July. The majority of these were spawn-outs. However, the majority of the shad passage in June (approximately 35,000 fish) had not spawned yet. It is interesting to note nearly 11,000 squawfish were passed, primarily in July. Undoubtedly, thousands more remained in the forebay.

Table 5. Estimated Passage of Miscellaneous Species for The Dalles Trash Sluiceway, April 17-August 4, 1979

Date	Spawned Adult Steelhead	Unspawned Adult Steelhead	Spr. Ch. Adults	Shad	Squawfish	Carp	Chub	Sucker	Dace	White-fish
Apr. 17-21	3,100									
22-26	3,400									
27-May 1	1,200									
May 2-6	2,500									
7-11	1,800							90		
12-16	2,500		30			30				
17-21	2,900									
22-26	2,100	40	40				80			
27-31	1,800	30	30	60	30	30	100			
June 1-5	1,200		40			40	40	100		
6-10	600	40	40	80						
11-15	300			1,300						
16-20	300			18,000	500	300	70	700		
21-23	200			16,900	300		30	400		70
24-July 20--the sluiceway was closed while the orifice flow mortality study was run--										
July 21-25	80	80		136,600	5,100	80	200	200	600	200
26-30		140		123,900	3,200		200	100		
31-Aug. 4				37,500	1,700	100	60	30	30	50
Total	23,980	330	180	334,340	10,830	580	780	1,620	630	320

The orifice flow mortality and injury results are summarized in Table 6. There was no significant injury, direct or delayed mortality to any release group.

CONCLUSIONS

1. Sluiceway collection efficiency was highest with:
   A. gates open only on the west (near unit 1) rather than east (near unit 22), or middle.
   B. several adjacent gates open rather than spaced openings,
   C. overflow weir or minimum 3' submerged opening,
   D. maximum flow possible into the sluiceway.
2. Approximately 3.7 million fish used the sluiceway between April 17 and August 4, 1978 including:
   A. 1,499,000 spring chinook,
   B. 568,000 fall chinook,
   C. 528,000 coho,
   D. 439,000 sockeye,
   E. 623,000 steelhead.
3. Overall sluiceway collection efficiency indirectly estimated at 78.3%.
4. There was no direct injury or mortality to fish using the sluiceway under suborifice flow (150 cfs).
5. There was no delayed mortality to fish using the sluiceway under suborifice flow (150 cfs).

Table 6. Mortality and Injury to Juvenile Salmonids Using The Dalles Trash Sluiceway Under Suborifice Flow (150 cfs) July 12 and 17, 1978

Date	Release Site	Number Released	Number Recovered	Descaled (Injury) 1/	Direct Mortality	Delayed Mortality 2/
July 12	North Sidewall (Above Plunge)	1,000	234	0	0	0
July 12	East Raceway (Below Plunge)	1,000	294	0	0	0
July 17	South Sidewall (Above Plunge)	1,000	256	0	2	2
July 17	East Raceway (Below Plunge)	1,000	278	0	0	1

1/ A fish was considered descaled if more than 10% of his scales were missing.

2/ Fish were held for 2 weeks at Bonneville Hatchery.

RECOMMENDATIONS

1. Present operating criteria for passing juvenile salmonids through The Dalles sluiceway calls for a 4-month operation (March 1-June 30) 24 hours per day with 2' submerged openings on gates 1_1, 1_2, 2, and 22_3 which produces a flow of about 2,200 cfs. In recent years, however, because of reduced transportation flows, the juvenile outmigration has been delayed. Also, the present gate settings are not the best for optimum sluiceway collection. Therefore, to maximize the number of juvenile salmonids passed by the sluiceway we recommend it be operated April 1-August 15 (4 1/2 months), 24 hours per day with maximum outflow weir on gates 1_1, 1_2, and 1_3 which produces a flow of about 3,750 cfs.
2. The sluiceway was very effective as a surface skimming bypass system with about an 80% collection efficiency. The Corps should consider developing portable or fixed skimmers at other projects where there is not safe passage conditions for downstream migrants, such as John Day Dam.
3. Thousands of squawfish were passed through the sluiceway and undoubtedly large additional numbers remained in the forebay. Squawfish pose a serious predation threat to juvenile salmonids. The Corps should consider developing techniques to remove squawfish or at least reduce their numbers around main stem dams where juvenile migrants are concentrated and delayed.

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APPENDIX

Method of Estimating Salmonid Use of Sluiceway

The estimate for the total number of downstream migrant salmonids using the sluiceway was made from the following procedure:

1. For each hour or portion of an hour that we fished we determined the salmonid catch per hour from the formula,

$$\frac{\text{total juvenile salmonids}}{\text{minutes fished}} \times 60 = \text{catch per hour}$$

A sample day is shown in Appendix Table 1.

2. On days when some hours were not sampled, the total catch for the 24-hour period was estimated using the following formula:

$$\frac{\text{Numbers passing during hours counted}}{\text{Percentage estimated to pass during hours counted } 1/} = \text{estimated 24-hour catch}$$

In Appendix Table 2 the diel distribution is determined for portions of May and June. Appendix Table 3 illustrates how the 24-hour estimates were made using this distribution.

3. We multiplied each estimated 24-hour catch by sluiceway expansion multiplier of 19.0 (Appendix Table 4). This is our net efficiency (lower net) in the sluiceway and is a ratio of recaptures to releases (176/3,339 = 5.3%; 3,339/176 = 19.0).

4. Sum sluiceway 24-hour totals per 5 days and multiply by sluiceway percentage species catch per 5 days (Appendix Table 5).

1/ *From diel distribution.*

Appendix Table 1. Salmonid Catch Per Hour for The Dalles Trash Sluiceway, May 27, 1978

Net In	Minutes Fished	Spring Chin.	Fall Chin.	Coho	SH	Sockeye	Total Salmonids	Misc.	Salmonid Catch/ Hour
0004	50.0	0	0	2	2	0	4		4.8
0104	50.0	2	4	4	1	0	11	Kelt	13.2
0203	50.0	2	0	0	2	0	4	Chub	4.8
0300	50.0	1	0	1	1	0	3	Kelt	3.6
0400	54.0	3	0	1	3	1	8		8.9
0500	94.0	6	0	10	6	8	30		19.1
0700	44.0	22	0	12	7	70	111	Adult Chin.kelt	151.4
0803	27.4	92	12	52	27	105	288		630.7
0910	17.9	69	10	31	28	57	195	Kelt	653.6
1018	22.3	92	10	21	20	39	182	Kelt	489.7
1104	29.4	152	20	46	31	50	299		610.2
1224	24.1	43	5	15	19	13	95		236.5
1325	25.0	41	3	25	16	22	107		256.8
1404	49.3	70	2	52	38	105	267		324.9
1515	40.1	23	0	19	18	70	130	Kelt	194.5
1605	40.0	25	0	23	21	36	105	Chub	157.5
1704	49.1	17	0	15	14	33	79		96.5
1810	48.7	18	0	19	16	69	122		150.3
1918	42.4	15	0	19	7	35	76	3 Kelts	107.5
2016	42.5	22	0	19	25	31	97		136.9
2104	47.4	20	1	30	14	26	91		115.2
2209	44.5	2	0	5	4	0	11	Kelt	14.8
2304	47.0	5	0	0	2	1	8	5 Kelts Chub	10.2

Appendix Table 2. Percentage Catch of Salmonids Per Hour for The Dalles Trash Sluiceway, May 25-June 1, 1978

Hour	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1	Hour Total	% of 24-Hour Total
0000-0100	26.8	9.5	4.8	9.6	20.0	12.5	12.5	8.0	103.7	0.5
0100-0200	21.0	19.6	13.2	10.8	13.0	11.3	13.5	16.4	118.8	0.6
0200-0300	13.8	14.7	4.8	12.0	9.1	8.3	12.3	9.8	84.8	0.4
0300-0400	26.7	6.1	3.6	8.4	15.6	15.6	10.6	6.5	93.1	0.4
0400-0500	33.1	9.4	8.9	11.1	9.5	11.9	14.7	11.5	110.1	0.5
0500-0600	80.5	27.5	19.1	14.7	29.7	26.6	11.6	32.2	241.9	1.1
0600-0700	45.0	62.9	19.1	20.9	32.2	41.3	26.1	35.2	282.7	1.3
0700-0800	149.1	364.5	151.4	26.7	30.3	71.0	43.9	143.6	980.5	4.6
0800-0900	268.4	661.9	630.7	53.8	65.8	151.1	170.2	288.5	2,290.4	10.7
0900-1000	303.1	528.3	653.6	92.7	187.8	138.2	207.8	201.4	2,312.9	10.8
1000-1100	294.8	489.3	489.7	224.2	205.2	169.0	196.8	153.6	2,222.6	10.4
1100-1200	394.8	390.1	610.2	281.3	160.2	164.6	201.1	97.8	2,300.1	10.7
1200-1300	360.4	130.6	236.5	295.3	214.8	190.0	147.8	108.9	1,684.3	7.9
1300-1400	349.8	443.8	256.8	254.5	214.8	181.5	142.9	106.0	1,950.1	9.1
1400-1500	182.7	361.4	324.9	224.0	102.0	150.6	56.3	88.9	1,490.8	6.9
1500-1600	213.8	61.5	194.5	190.9	103.8	122.3	56.7	61.4	1,004.9	4.7
1600-1700	121.2	80.4	157.5	109.1	75.4	105.7	89.6	62.2	801.1	3.7
1700-1800	148.5	90.0	96.5	81.7	83.6	61.5	82.9	65.3	710.0	3.3
1800-1900	139.9	66.5	150.3	72.8	88.7	31.4	61.7	48.5	659.8	3.1
1900-2000	97.6	61.3	107.5	124.4	75.4	41.6	67.9	73.8	649.5	3.0
2000-2100	94.6	30.6	136.9	128.6	95.8	33.5	75.3	71.4	666.7	3.1
2100-2200	26.2	8.2	115.2	193.2	92.9	25.8	42.4	39.7	543.6	2.5
2200-2300	16.6	7.5	14.8	3.2	9.1	13.9	4.6	4.7	74.4	0.3
2300-2400	29.2	5.2	10.2	15.1	7.7	7.2	5.2	5.7	85.5	0.4
Total									21,462.3	100.0

Appendix Table 3. Salmonid Catch Per Hour and Estimated 24-Hour Total for The Dalles Trash Sluiceway, May 21-25, 1978

Hour	24-Hour Percentage	5/21	5/22	5/23	5/24	5/25
0000-0100	0.5					26.8
0100-0200	0.6					21.0
0200-0300	0.4					13.8
0300-0400	0.4					26.7
0400-0500	0.5					33.1
0500-0600	1.1					80.5
0600-0700	1.3		42.3	21.3		45.0
0700-0800	4.6		51.1	179.5		149.1
0800-0900	10.7		49.2	762.3	1,053.3	268.4
0900-1000	10.8		96.4	692.5	595.5	303.1
1000-1100	10.4	25.0	340.4	632.8	524.5	294.8
1100-1200	10.7	87.1	494.9	372.3	411.2	394.8
1200-1300	7.9	217.3	517.1	359.2	336.7	360.4
1300-1400	9.1	217.3	466.7	334.8	289.4	349.8
1400-1500	6.9	206.6	313.5	156.0	244.0	182.7
1500-1600	4.7	205.9	190.6	234.3	136.8	213.8
1600-1700	3.7	204.5	168.0	168.0	215.0	121.2
1700-1800	3.3	219.5	186.0	167.7	149.5	148.5
1800-1900	3.1		213.6	114.0	87.3	139.9
1900-2000	3.0		213.5	112.8	120.8	97.6
2000-2100	3.1		148.6	97.7	116.1	94.6
2100-2200	2.5		145.2		78.8	26.2
2200-2300	0.3				26.7	16.6
2300-2400	0.4				26.8	29.2
Total Known	100.0	1,383.2	3,637.1	4,405.2	4,412.4	3,437.6
Known %		56.7	95.8	93.3	90.6	100.0
Est. 24-Hour Catch		2,440	3,797	4,722	4,870	3,437

Appendix Table 4. Fyke Net Efficiency for The Dalles Trash Sluiceway During 1978 (Lower Net)

Date	Number Released	Number Recovered	Percentage Recovered	Percentage Area Fished
May 11	500	12	2.4	3.6
19	254	22	8.7	3.6
19	99	6	6.1	3.5
22	311	13	4.2	3.6
22	335	14	4.2	3.7
23	319	15	4.7	3.7
24	297	16	5.4	3.7
June 5	225	9	4.0	3.6
5	319	15	4.7	3.5
19	285	22	7.7	4.5
19	312	25	8.0	4.5
20	83	7	8.4	4.1
Total	3,339	176	5.3	3.8

Appendix Table 5. Number and Percentage Catch by Species for The Dalles Trash Sluiceway During Spring 1978

Date	Total Salmonids	Identifiable Salmonids	Spring Chinook	Fall Chinook	Coho	Steel-head	Sockeye	Percentage Spring Chinook	Percentage Fall Chinook	Percentage Coho	Percentage Steel-head	Percentage Sockeye
Apr. 17-21	600	594	192	1	266	129	6	32.3	0.2	44.8	21.7	1.0
22-26	763	763	250	0	346	129	38	32.8	0.0	45.3	16.9	5.0
27-May 1	1,426	1,423	359	4	264	709	87	25.2	0.3	18.6	49.8	6.1
May 2-6	3,735	3,735	1,559	2	622	1,027	525	41.7	0.1	16.7	27.5	14.0
7-11	3,871	3,871	2,015	12	469	829	546	52.1	0.3	12.1	21.4	14.1
12-16	10,288	10,288	5,104	1	2,077	2,175	931	49.6	0.1	20.2	21.1	9.0
17-21	5,131	5,130	3,328	7	539	699	557	64.9	0.1	10.5	13.6	10.9
22-26	9,501	9,499	4,362	51	1,930	1,203	1,953	45.9	0.5	20.3	12.7	20.6
27-31	7,917	7,915	2,423	398	1,235	1,489	2,370	30.6	5.0	15.6	18.8	30.0
June 1-5	2,621	2,621	622	316	255	632	796	23.7	12.1	9.7	24.1	30.4
6-10	1,968	1,968	641	455	101	216	555	32.6	23.1	5.1	11.0	28.2
11-15	2,749	2,748	1,535	473	291	123	326	55.8	17.2	10.6	4.5	11.9
16-20	2,959	2,955	1,781	933	92	60	89	60.3	31.6	3.1	2.0	3.0
21-25	1,332	1,332	771	503	10	17	31	57.9	37.8	0.7	1.3	2.3
July 21-25	3,893	3,893	178	3,712	1	2	0	4.6	95.3	0.0	0.1	0.0
26-30	1,302	1,302	43	1,258	0	1	0	3.3	96.6	0.0	0.1	0.0
31-Aug. 4	1,533	1,533	11	1,518	0	3	1	0.7	99.0	0.0	0.2	0.1
Total	61,589	61,570	25,174	9,644	8,498	9,443	8,811					