CZES Coastal Zone and Estuarine Studies

THE MID-COLUMBIA JUVENILE SALMONID OUTMIGRATION 1977

by
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January 1979

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Final Report
Financed by
Chelan, Douglas, and Grant County
Public Utility Districts of Washington

and

NOAA
National Marine Fisheries Service
Northwest and Alaska Fisheries Center
Coastal Zone and Estuarine Studies Division
2725 Montlake Boulevard East
Seattle, Washington 98112

January 1979

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INTRODUCTION

The development of the mid-Columbia for hydroelectric production has adversely affected the runs of salmon and steelhead in the area. Priest Rapids, Wanapum, and Rocky Reach Dams, completed in the early 60's, and Wells Dam, completed in 1967, have created barriers which fish must negotiate (Figure 1). Since 1972, regulation of the river through use of Canadian storage reservoirs has significantly altered the natural flow patterns of the river and reduced river flows and spill at dams during the major outmigration of juvenile salmonids. Research conducted over the years, resulting in many improvements in dam construction and operation, coupled with increased hatchery production has enabled salmon and steelhead stocks to maintain their own.

However, the continued survival of salmonids appears to be seriously threatened as the demands of industry and agriculture increase dramatically with the rising population. The spring of 1977 was an ominous warning of what is expected in future years.

Due to extreme dryness at lower elevations and lack of snowpack at higher elevations, the spring of 1977 set records for the lowest river flow in recent history--a total January to July "modified" flow of only 54 million acre feet (maf). The previous record all-time low flow was 61 maf in 1944. Before 1977, the most recent low-flow year (71 maf) was 1973, when virtually all flow passed through the turbines. In 1973, an estimated 95% of the downstream migrants from the Salmon River died as a result of passage through turbines and delays in passing through reservoirs (Raymond 1974). Juvenile salmonids in the mid-Columbia faced a possible similar fate in 1977.

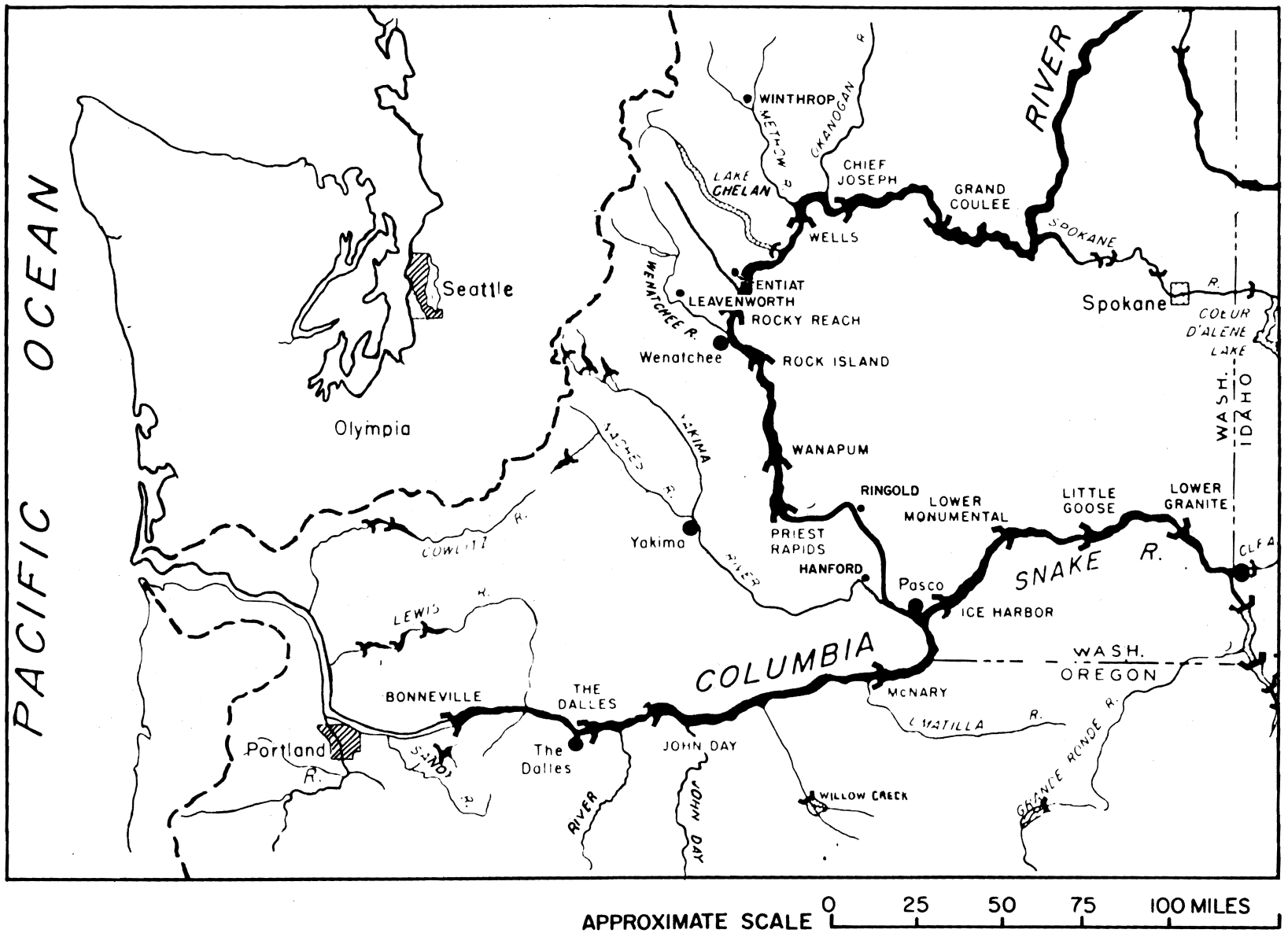

Figure 1 --- The Columbia River System showing the area of study.

In view of the above, fisheries agencies requested an artificial freshet, "Operation Fish Flow 1977," covering a 5- to 6-wk period over the peak of the fish outmigration, to minimize the anticipated losses from turbine mortality, predation, and delay. The plan was tailored to have minimum impact on energy production while providing protection for downstream migrant salmon and steelhead.

As there was an extreme lack of water throughout the Pacific Northwest, the plan met with considerable opposition from agricultural and industrial groups. At the insistence of the Federal Power Commission, a court order was issued to force the use of a specified amount of water for fish protection. In normal or higher flow years there will be more water available and this conflict of interests will hopefully not be as intense.

In 1977, the National Marine Fisheries Service and the Chelan, Douglas, and Grant County Public Utility Districts of the State of Washington initiated a program to define the migrational characteristics of juvenile salmonids in the mid-Columbia River under extreme low flow conditions and to determine the possible influence of controlled spilling on these migrations. The program had the following specific objectives: (1) determine when special flow and spill should be provided for fish at Wanapum and Priest Rapids Dams and for fish migrating between Wanapum and McNary Dams; (2) determine amount of spill required at Priest Rapids Dam; and (3) quantify benefits of the special freshet and spill for fish.

METHODS

The downstream migration of juvenile salmon and steelhead trout passing through the mid-Columbia River in 1977 was monitored by dipnetting turbine intake gatewells (Bentley and Raymond 1968) at Priest Rapids and McNary Dams. The information obtained was used to define timing and migrational behavior of the migrating smolts, and for meeting the three objectives of the program.

Sampling periods at the various projects were as follows:

Sample Site	Sample Period
Priest Rapids Dam	19 April to 15 June and 1 to 15 August
McNary Dam	12 April to 15 September

At Priest Rapids Dam, turbine intake gatewells were dipnetted on a 5 to 7 d/wk schedule from 19 April through 15 June, and again 1 through 15 August on a 3 d/wk schedule. All gatewell dipping was done during daylight hours except for the diel migrational behavior sampling on 7 and 8 May, and the period 9 through 27 May when dipping took place from 7:00 p.m. to 6:00 a.m. Similar sampling took place at the Corps of Engineers' dams.

OPERATION FISH FLOW 1977

Water releases were divided into three phases covering approximately 7 wk with the beginning, ending, and duration of each phase dependent on the actual smolt migration. Phase I involved the area from Priest Rapids Dam (river mile 397.1) upstream to Wells Dam (river mile 516.6). During the main part of the migration, total river flow in this area was to average 100,000 cubic feet per second (cfs) with the requested spill to average 7,000 cfs. The time and amount of spill at Priest Rapids and Wanapum Dams would be determined by extensive monitoring of the smolts at Priest Rapids

Dam. Phase II involved the McNary Dam and John Day Dam areas, and Phase III involved the Dalles Dam and Bonneville Dam areas with area river flows of 180,000 cfs and 140,000 cfs, respectively. The initiation of Phase I was to begin when approximately 25% of the migration passed Rocky Reach Dam; Phase II, was to begin when the peak passed Priest Rapids Dam and/or 25% of the migration reached McNary Dam; and Phase III was to begin when the mid-Columbia peak passed John Day Dam.

In general, National Marine Fisheries Service personnel were responsible for monitoring the migrating salmonids to determine their location and abundance and forwarding recommendations to the Bonneville Power Administration, who were responsible for providing the requested river flows and spills. Spills were planned for a few hours each night to coincide with the time of main smolt movement through dams, and maximum river flows were to occur during daylight hours to coincide with peak power requirements and migrational movement times of smolts through reservoirs. During the nighttime spill, total river flows were to be kept at a minimum to maximize the benefits from the spill.

TIMING AND TRAVEL TIME

Peak timing at Priest Rapids Dam was determined by calculating the date when 50% of the juvenile salmonid outmigration (median) passed the dam. Travel time between two points was defined as the difference in time between the median dates of recovery at the two points.

SURVIVAL ESTIMATES

Marked salmonid smolts released in the forebay and tailrace of Priest Rapids Dam and recovered at McNary Dam were used to define fish passage mortality in the vicinity of Priest Rapids Dam.

DIEL MOVEMENT

To determine the most efficient time to spill for "Operation Fish Flow," diel movement patterns were monitored and compared with previous results. Fish were dipnetted from the turbine intake gatewells at Priest Rapids Dam at 2-h intervals over a 30-h test period to define patterns for migrants at the dam.

CODED WIRE TAG RECOVERIES

Juvenile chinook salmon at several hatcheries had a magnetized coded wire tag (CWT) inserted into their snout and were marked for visual observation with an adipose fin clip. To monitor the timing of these various hatchery releases passing Priest Rapids Dam, samples of ad-clipped chinook salmon recovered by gatewell dipping were sacrificed. The magnetized CWT was removed from the snout after the flesh had been dissolved with a potassium hydroxide solution, and the CWT was then read under a microscope.

EFFECTS OF SPILL

The effect of controlled spilling on passage behavior of smolting salmonids at Priest Rapids Dam was evaluated by comparing the distribution of fish, based on gatewell catches, across the powerhouse during periods of spill and nonspill. Marked smolts were also released from the deck of the dam in front of unit 2B, directly into the forebay during periods of spill to aid in determining how strong an attraction force, if any, the spill provided.

Spill was limited to one or two spillways as near to the powerhouse as possible. The number of spillways opened and duration of spill were varied, while the total amount of water spilled per night was kept constant. Test gatewells were cleaned out prior to spilling and again immediately after spill, thus giving a direct comparison of the distribution of fish moving into the gatewells during the spill nonspill situations. The results were also compared to the number of fish entering the gatewells during a normal diel period of no spill. Recaptures at McNary Dam provided additional information.

07 90 steelhead in 1977
0690 " 1976
05 " 75

RESULTS AND DISCUSSION

Turbine intake gatewells were dipnetted on a 5- to 7- day per week schedule at Priest Rapids Dam from 19 April through 15 June. Fingerlings taken from the gatewells totaled 15 fall and/or summer chinook salmon ("0"-age class); 53,795 spring chinook salmon ("1"-age class); 6,948 steelhead trout; 32,204 sockeye salmon; and 9,377 coho salmon. To determine sampling efficiency, approximately 26,756 salmonid smolts were cold branded and released in the upper forebay, 12 miles above Priest Rapids Dam. An additional 21,088 smolts were branded and released in the tailrace 1/2 mile below the dam to provide a measure of mortality at Priest Rapids Dam; while 5,475 additional smolts were branded and released into the forebay directly in front of unit 2B to aid in determining how strong an attraction force the spill provided.

Turbine intake gatewells were again sampled from 1 through 15 August 1977 on a 3-day per week schedule. Fingerlings taken from the gatewells totaled 4,097 "0"-age chinook salmon, 387 "1"-age chinook salmon, 77 steelhead, 28 sockeye salmon, and 80 coho salmon. None of these fish were branded.

All the data collected during 1977 have been compiled and analyzed. Sampling and marking summaries are presented in Appendix Tables 1 through 8. Detailed results are presented and discussed in appropriate sections of this report.

TIMING

Most species of salmonids began migrating in late April or early May, peaked in mid-May, and had generally passed Priest Rapids Dam by mid-June (Figure 2). The peak of migration was 17 May for "1"-age chinook salmon, 25 May for coho salmon, 14 May for sockeye salmon, and 17 May for steelhead. Timing in 1977 was comparable to that measured in previous years (Table 1).

Recaptures of marked chinook salmon from Leavenworth, Winthrop, Wells, and Entiat Hatcheries provided a measure of the timing of these fish past Priest Rapids Dam. Leavenworth and Winthrop chinook salmon were present throughout the migration period; whereas, Wells fish passed late in the run and Entiat fish early in the run (Figure 3).

TRAVEL TIME

Recaptures at McNary Dam of specific groups of marked salmonids released in the tailrace of Priest Rapids Dam provided a measure of migration rate and travel time through the 105 miles separating the two dams. Travel time varied from 7 to 15 days. As expected, the fastest rate (15 miles per day) occurred when the run was at its peak and river flows were highest (Table 2).

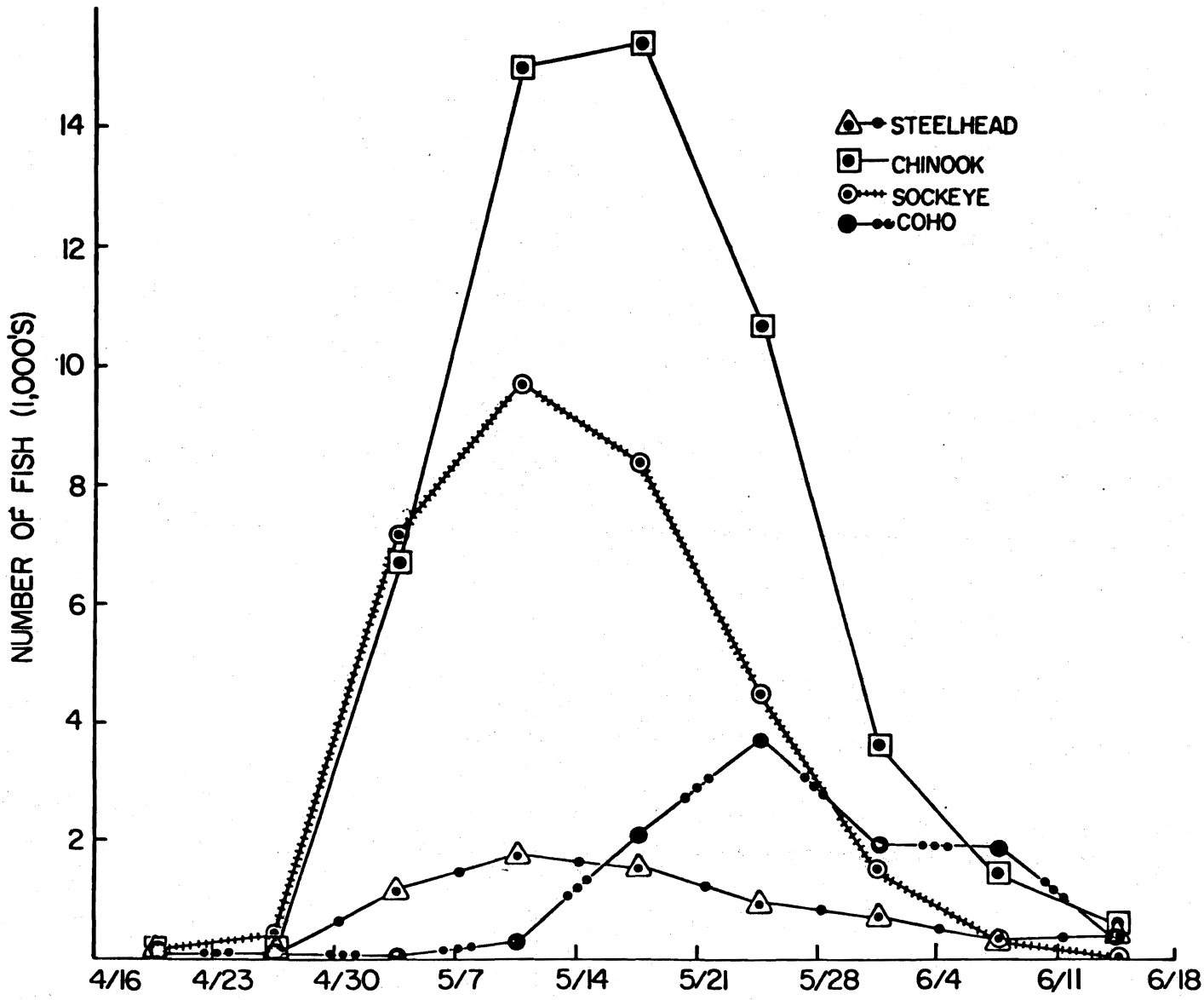

Figure 2 -- Weekly catches of juvenile salmonids in the gatewells at Priest Rapids Dam, 1977.

Table 1.--Timing (peak of migration) of juvenile salmonids at Priest Rapids Dam 1965, 1966, 1967, 1976, and 1977.

Year[1/]	"1"-age Chinook	"0"-age Chinook	Coho	Sockeye	Steelhead
1965	19 May	11 August	12 May	3 May	20 May
1966	17 May	12 August	29 April	1 May	25 May
1967	23 May	8 August	20 May	1 May	18 May
1976	14 May	11 August	19 May	19 May	14 May
1977	17 May	---- [2/]	25 May	14 May	17 May

1/ 1965, 66, and 67 data from Donn L. Park, unpublished report.
1976 data from Sims and Miller, 1977.

2/ Insufficient sampling to verify timing.

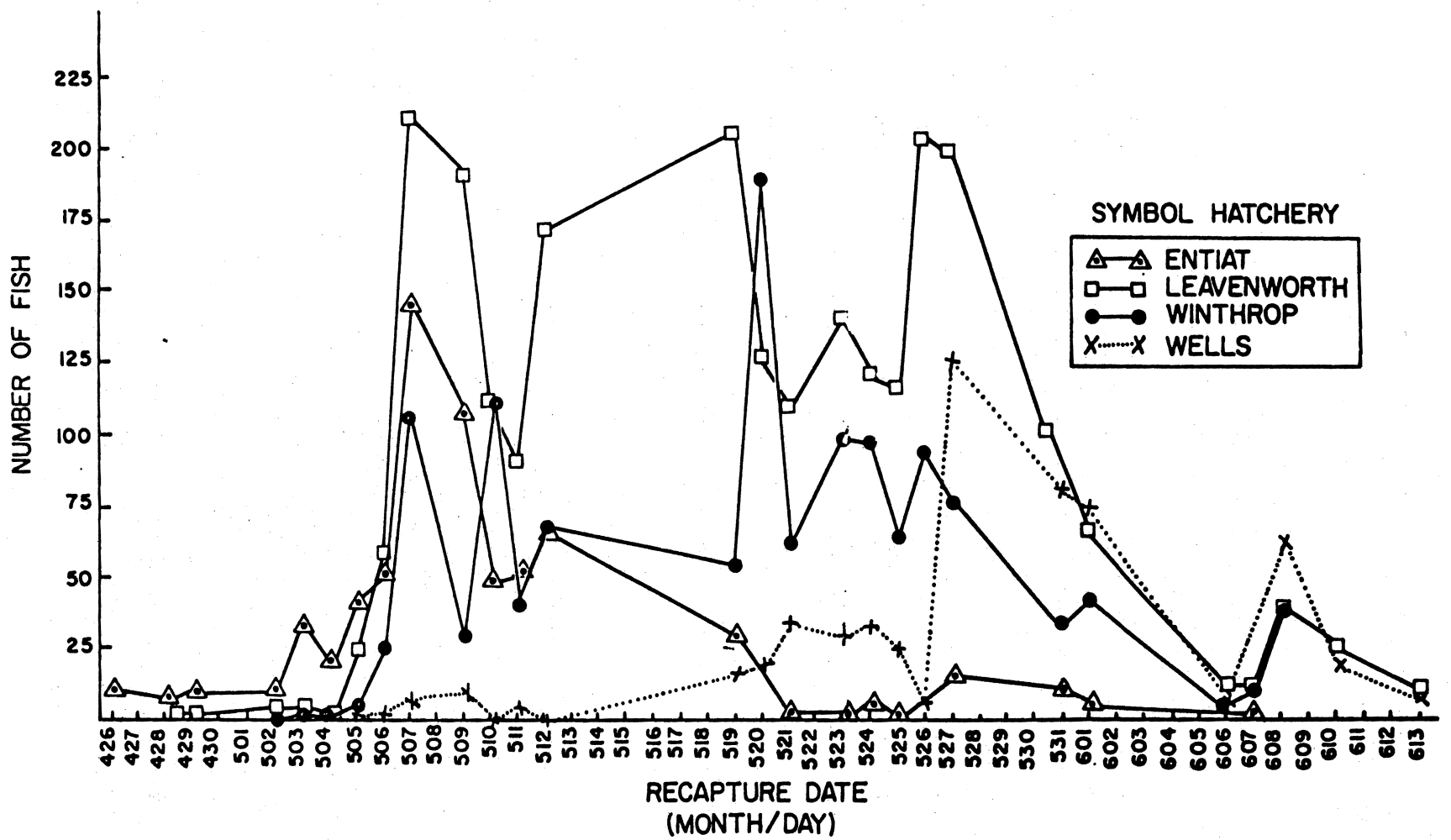

Figure 3.--Timing of "1"-age chinook salmon from specific hatcheries passing Priest Rapids Dam in 1977.

Table 2.--Rate of migration and travel time (days) from Priest Rapids to McNary Dams in 1977.

Median Release Date	Median Recovery Date	Travel Time (days)	Migration Rate (miles/day)	Average River Flow at McNary Dam (1,000's of cfs)
3 May	16 May	13	8	134
12 May	21 May	9	12	137
18 May	25 May	7	15	145
25 May	6 June	11	9	136
1 June	13 June	12	9	129

SURVIVAL

Survival of "1"-age chinook salmon passing Priest Rapids Dam was 82% (Table 3). Insufficient recoveries of other species marked and released were made to ascertain their survival. The estimated mortality of 18% in 1977 is considerably higher than the 8% measured for "1"-age chinook salmon in 1976. The difference may be attributed to higher spill in 1976. Average daily spill was 30,000 cfs in May of 1976 compared to 3,600 cfs in May of 1977.

DIEL MOVEMENT PATTERNS

Diel movement patterns of spring chinook salmon, steelhead trout, and sockeye salmon were examined at Priest Rapids Dam in 1977 (Appendix Table 6). Tests conducted on 7 and 8 May showed that approximately 60% of the salmonid smolts entered the turbine intake gatewells after dark; peak movement occurred between 10:00 p.m. and 4:00 a.m. (Figure 4A).

Diel movement patterns of spring chinook salmon at Priest Rapids Dam followed the pattern of the overall fish movement, with 66% entering the gatewells between 10:00 p.m. and 4:00 a.m. and 53% entering between 10:00 p.m. and 2:00 a.m. (Figure 4B).

Sockeye salmon started their activity approximately 2 hours earlier than the spring chinook salmon; 64% entered the gatewells during darkness and 75% entered between 8:00 p.m. and 4:00 a.m. (Figure 4C). This is quite different from the results in 1976 when only 50% of the sockeye salmon entered the gatewells after dark and peak movement was between 2:00 and 4:00 p.m.

Table 3.--Mortality of smolts at Priest Rapids Dam based upon releases of marked salmonid smolts above and below the dam, 1977.

Priest Rapids Dam Release Site	Number Released	McNary Dam Recoveries Number	McNary Dam Recoveries %	Relative Mortality %
"1"-age Chinook				
Forebay Releases	17,290	216	1.25	18
Tailrace Releases	13,195	202	1.53	0
Steelhead				
Forebay Releases	2,381	25	1/	
Tailrace Releases	3,079	24		
Coho				
Forebay Releases	2,438	29	1/	
Tailrace Releases	7,013	70		
Sockeye				
Forebay Releases	3,808	5	1/	
Tailrace Releases	2,592	3		

1/ Insufficient recoveries.

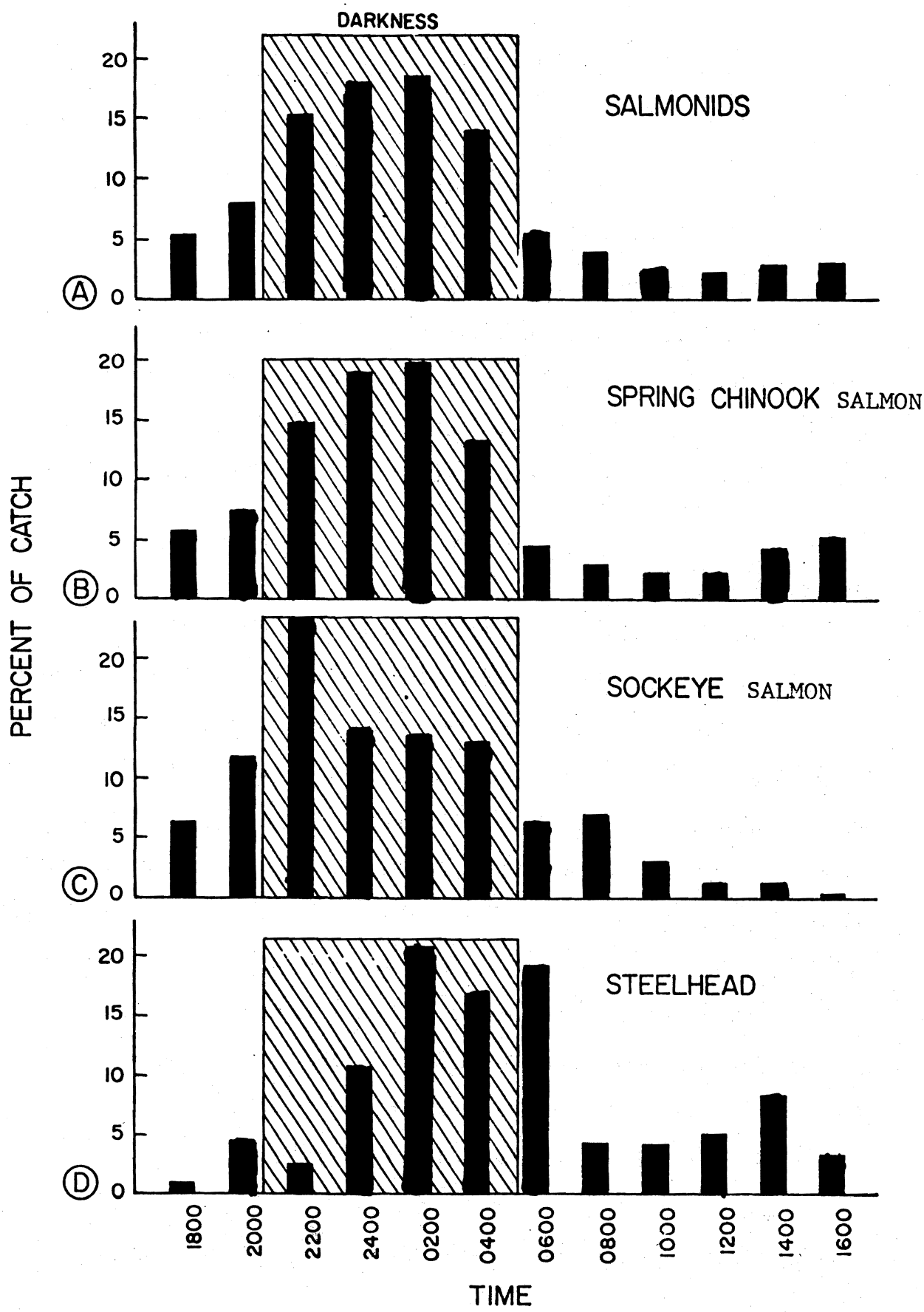

Figure 4 -- Diel movement patterns of salmonid smolts at Priest Rapids Dam May 7-8, 1977.

Diel movement of steelhead trout at Priest Rapids Dam was approximately 2 hours later than the movement of spring chinook salmon; 51% entered the turbine intake gatewells during darkness, while 68% entered between midnight and 6:00 a.m. (Figure 4D).

The diel movement patterns of coho salmon could not be determined since the outmigration did not start until a week after our test.

The results of this and previous year's diel movement experiments were the biological basis for the selection of the 9:00 p.m. to 3:00 a.m. as optimum spill times for "Operation Fish Flow" at Wanapum and Priest Rapids Dams.

EFFECTS OF SPILL

In 1977, the effects of nighttime spill on smolt passage were examined at Priest Rapids Dam in conjunction with "Operation Fish Flow." Results were not conclusive. There were some indications that spilling was effective in attracting fish away from the turbines. For example, Figures 5A and 5B show the distribution of salmonid smolts during the periods of spill and no spill during 2, 24-hour periods (10 May and 11 May). Both cases show a shift in the distribution of fish toward the spillway during times of spill. There were also cases that did not show as pronounced a shift or no shift at all. The spill manipulations on those two dates were an effort to determine if a greater spill for a shorter time (4 h) or a smaller spill for a longer time (6 h) was more effective. No determination could be made from these results, so the decision was made to opt for the longer spill (the same amount of water was spilled each night) as it coincided more with the diel movement patterns found in the 7 and 8 May diel test (Appendix Table 6).

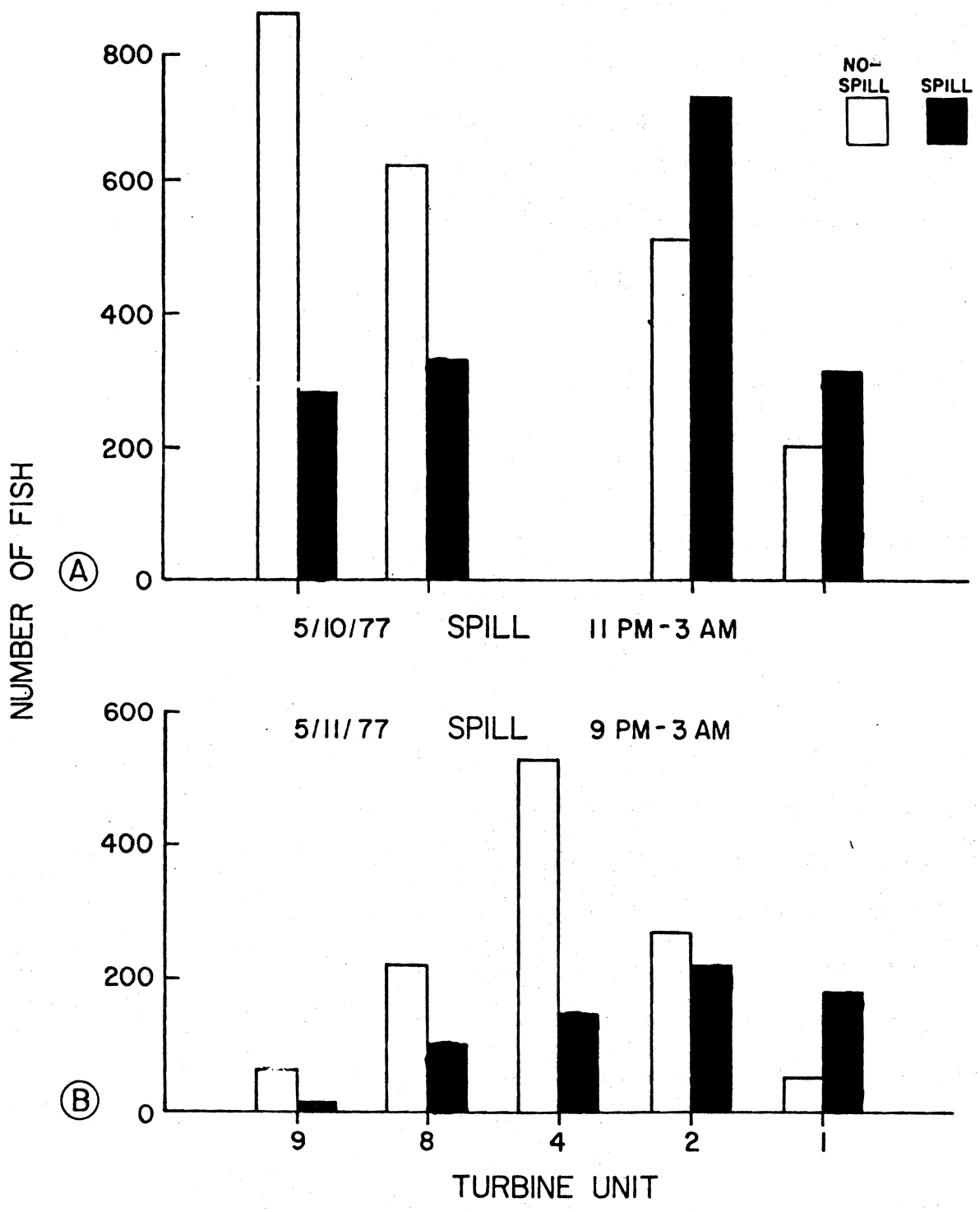

Figure 5 -- Gatewell catch distribution during periods of spill and no-spill at Priest Rapids Dam in 1977.

SUMMARY

Juvenile salmonid migrations from the mid-Columbia River were sampled by dipnetting turbine intake gatewells at Priest Rapids and McNary Dams. Estimates were made for timing to, and mortality at Priest Rapids Dam, and travel time between Priest Rapids and McNary Dams. Diel movement at Priest Rapids Dam was also measured.

Results from the 1977 study are as follows:

1. Peak of the spring chinook salmon and steelhead trout smolts migrating at Priest Rapids Dam occurred on 17 May.
2. Sockeye salmon peaked on 14 May and coho salmon on 25 May at Priest Rapids Dam.
3. Timing of all species compared to previous years.
4. Travel time for juvenile salmonids from Priest Rapids Dam to McNary Dam ranged between 7 and 13 days with the fastest travel occurring during the higher river flows.
5. Mortality of "1"-age chinook salmon at Priest Rapids Dam was 18% in 1977 compared to 8% in 1976.
6. About 67% of the spring chinook salmon smolts, 64% of the sockeye salmon smolts, and 52% of the steelhead trout smolts migrated by Priest Rapids Dam during hours of darkness.
7. The result of our effort to measure the effectiveness of spill to enchancing smolt survival was inconclusive.

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APPENDIX

Appendix Table 1.--A total dipnet catch from turbine intake gatewells at Priest Rapids Dam in 1977.

Date	Chinook Salmon '0's	Chinook Salmon '1's	Steelhead	Sockeye Salmon	Coho Salmon	Total
April						
19	0	4	1	0	1	6
20	0	17	5	7	2	31
22	0	5	5	75	0	85
25	0	46	10	91	7	154
28	1	68	22	208	3	302
29	0	88	17	50	5	160
May						
2	0	130	50	425	4	609
3	1	403	131	2355	13	2903
4	0	337	83	1004	0	1424
5	0	563	165	929	1	1658
6	0	1260	259	1330	0	2849
7[1]	0	3983	450	1116	0	5549
9	0	2796	233	1380	12	4421
10[2]	0	2975	625	2388	27	6015
11	1	1986	287	2338	66	4678
12	0	2328	174	878	32	3412
13	1	2710	197	995	73	3976
14	0	2156	250	1701[3]	93	4200
16	0	3888	269	1183	333	5673
17	1	3077[3]	449[3]	2563	182	6272

(Continued)

Appendix Table 1. (Continued)

Date	Chinook Salmon '0's	Chinook Salmon '1's	Steelhead	Sockeye Salmon	Coho Salmon	Total
May						
18	0	3476	378	2635	569	7058
20	1	3036	292	1784	750	5863
21	0	1954	161	243	263	2621
23	0	2776	242	1092	1229	5339
24	1	2233	270	1185	678	4367
25	0	1617	129	359	394[3/]	2499
26	0	1981	141	1309	946	4377
27	0	2107	203	587	492	3389
31	1	2278	405	811	1078	4573
June						
1	1	1386	313	723	897	3320
6	3	238	117	62	209	629
7	0	261	65	59	229	614
8	1	602	78	155	359	1195
10	1	405	71	99	111	687
13	0	147	164	9	49	369
14	1	257	144	46	158	606
15	0	221	103	31	112	467
Aug						
2	1007	166	25	9	9	1216
3	557	31	11	6	23	628

(Continued)

Appendix Table 1. (Continued)

Date	Chinook Salmon '0's	Chinook Salmon '1's	Steelhead	Sockeye Salmon	Coho Salmon	Total
Aug 5	176	22	4	3	7	212
8	239	4	8	1	7	259
9	1585	147	21	6	26	1785
10	282	7	7	2	5	303
12	251	10	1	1	3	266
Totals	4112	54182	7035	32233	9457	107,019

1/ Diel Test - Test units dipped every 2 hours.

2/ Nighttime spill during the period 5/10 - 5/27/77.

3/ Median fish.

Appendix Table 2A.--Distribution of dipnet catches by turbine units at Priest Rapids Dam in 1977.

Date	Number of Salmonids Turbine 10	9	8	7	6	5	4	3	2	1	Total	Number of gatewells sampled	Catch Per Effort
April 22		31	25	5	3		2	9	3	7	85	8	10.6
25		9	40	43	16		10	6	15	15	154	22	7.0
28		60	55	92	9		11	12	50	8	297	22	13.5
29		18	32	59	7		24	10	2	8	160	22	7.3
May 2		38	107	131	92		210	1	11	19	609	22	27.7
3		164	485	1108	578		288	60	104	72	2859	22	130.0
4		10	149	194	233		304	367	135	19	1411	22	64.1
5		90	146	110	164		618	153	282	95	1658	22	75.4
6		105	258	177	396		365	173	854	521	2849	22	129.5
7[1/]		563	1663						1760	1367	5353	48	111.5
9		88	163						491	322	1064	12	88.7
10[2/]		1049	932						1238	502	3721	4	930.3
11		65	316	448	513		665	720	485	231	3443	8	430.4
12		128	354	262	255		306	214	471	386	2376	11	216.0
13		127	392	415	666		502	14	471	345	2932	8	366.5
14		67	205	246	240		542	259	760	855	3174	8	396.8

(Continued)

Appendix Table 2A.--Distribution of dipnet catches by turbine units at Priest Rapids Dam in 1977. (Continued)

Date		Number of Salmonids Turbine 10	9	8	7	6	5	4	3	2	1	Total	Number of gatewells sampled	Catch per Effort
May	16							1696	1371	1543	1063	5673	4	1418.3
	17		263	42	414		838	1141	640	673	394	4405	8	550.6
	18		333	478	622		602	642	1142	1547	1679	7045	8	880.6
	20		41	125	223		825	1118	594	998	701	4625	9	513.9
	21		8	14	20		77	123	269	318	251	1080	8	135.0
	23		141	284	623		1165	930	585	869	752	5349	8	668.6
	24		43	114	198		604	788	620	694	349	3410	8	426.3
	25		40	73	34		170	78	280	234	159	1068	8	133.5
	26		128	176	76		139	459	526	2429	444	4377	8	547.1
	27		153	256	193		188	311	288	175	365	1929	8	241.1
	31		77	133	137		219	324	538	440	71	1939	8	242.4
June	1	363	172	270	146		443	642	341	627	317	3321	25	132.8
	6	38	39	49	46		229	153	34	29	62	679	25	27.2
	7	22	19	68	18		152	145	46	54	22	546	25	21.8
	8	0	30	34	30		191	394	213	159	184	1235	25	49.4
	10	84	36	42	42		140	160	86	43	48	681	25	27.2
	13	19	12	5	60		105	68	3	64	24	360	25	14.4
	14	101	60	63	28		128	141	55	34	6	616	25	24.6
	15	37	41	96	61		0	70	86	62	11	464	25	18.6

Appendix Table 2A.--Distribution of dipnet catches by turbine units at Priest Rapids Dam in 1977. (Continued)

Date	Number of Salmonids Turbine 10	9	8	7	6	5	4	3	2	1	Total	Number of gatewells sampled	Catch per Effort
August													
2	340	308	568								1216	9	135.1
3	112	117	37	362							628	12	52.3
5	94	49	41	28							212	12	17.7
8	67	53	118	21							259	12	21.6
9							665	131	888	101	1785	12	148.8
10	71	32	8[illegible]	114							303	12	25.3
12	98	44	4[illegible]	79							266	12	22.2
Totals	1446	4851	8539	6865	3172	6215	13895	9846	19012	11775	85616	649	131.9

1/ Diel Test.--Test units dipped every 2 hours.

2/ C Slots only dipped 5/10 - 5/31.

Appendix Table 2B.--Distribution of "1"-age chinook salmon smolt dipnet catches by turbine units at Priest Rapids Dam in 1977.

Date	Turbine 10	9	8	7	6	5	4	3	2	1	Total	No. Gatewells Sampled	Catch per Effort
May 2		5	19	23	26		57	0	10	6	146	22	6.6
3		9	35	92	158		86	33	31	5	449	22	20.4
4		1	12	38	67		85	82	70	11	366	22	16.6
5		9	39	32	50		290	46	154	23	643	22	29.2
6		14	110	80	171		87	85	500	354	1401	22	63.7
7 1/		352	1078						1295	1062	3787	48	78.9
9		51	97						326	267	741	12	61.8
10 2/		193	351						603	391	1538	4	384.5
11		17	63	93	207		269	310	279	149	1387	8	173.4
12		62	189	113	104		217	167	326	286	1464	11	133.1
13		71	188	294	481		363	13	334	224	1968	8	246.0
14		24	53	89	103		150	61	338	542	1360	8	170.0
16							993	938	1031	819	3781	4	945.3
17		99	18	126		336	529	207	385	275	1975	8	246.9
18		128	126	118		276	280	591	899	1058	3476	8	434.5
20		18	50	90		373	569	351	515	419	2385	9	265.0
21		4	11	15		43	76	169	227	165	710	8	88.8
23		58	132	335		705	560	266	351	369	2776	8	347.0

(Continued)

1/ Diel Test.--Test units dipped every 2 hours.

2 C Slots only dipped 5/10 - 5/31.

Appendix Table 2B.--Continued.

Date	Turbine 10	9	8	7	6	5	4	3	2	1	Total	No. Gatewells Sampled	Catch per Effort
May													
24		25	67	102		291	349	249	284	204	1571	8	196.4
25		22	43	19		91	138	178	105	90	686	8	85.8
26		70	66	39		61	170	167	337	213	1123	8	140.4
27		40	106	95		103	186	155	99	116	900	8	112.5
31		32	62	48		110	98	261	178	50	839	8	104.9
June													
1		83	118	20		222	255	155	227	227	1307	25	52.3
6		5	16	10		101	62	14	9	8	225	25	9.0
7		6	15	0		85	70	23	20	31	250	25	10.0
8		16	10	12		126	209	92	63	74	602	25	24.1
10		24	14	24		92	111	58	21	32	376	25	15.0
13		6	2	29		35	36	13	19	12	152	25	6.1
14		31	25	12		49	72	20	9	1	219	25	8.8
15		18	32	29		0	35	68	26	6	214	25	8.6
TOTALS		1493	3147	1977	1367	3099	6402	4772	9071	7489	38817	494	81.5

1/ Diel Test.--Test units dipped every 2 hours.

2/ C Slots only dipped 5/10 - 5/31.

Appendix Table 3.--Priest Rapids and McNary Dams recoveries of cold branded salmonid smolts released into the Priest Rapids Dam forebay in 1977.

Release Date 1/	Brand	Number Released	Priest Rapids Dam Recoveries Number	%	McNary Dam Recoveries Number	%
Spring Chinook						
4/29 - 5/6	LD 1C	1722	41	2.38	39	2.26
5/9 - 5/14	LD 1C	5950	47	0.79	110	1.85
5/15 - 5/23	LD 01	4608	49	1.06	31	0.67
5/24 - 5/27	LD 1C	2943	40	1.36	25	0.85
5/31 - 6/1	RD 1C	1268	10	0.79	3	0.24
6/6 - 6/10	RD 1C	675	2/	2/	8	1.19
6/13 - 6/15	RD 01	124	2/	2/	0	0.0
TOTALS		17290	187	1.23 3/	216	1.25
Sockeye 4/						
4/29 - 5/6	LD 1C	2978	81	2.72	5	0.17
5/9 - 5/14	LD 1C	830	3	0.36	0	0.0
TOTALS		3808	84	2.21	5	0.13

1/ Nighttime spill during the period 5/10 - 5/27/1977.
2/ Sampling terminated at Priest Rapids Dam before all test fish had passed.
3/ Based on test releases 4/29 - 6/1.
4/ Sockeye were branded only when there were insufficient numbers of other fish.

Appendix Table 3 (continued).

Release Date 1/	Brand	Number Released	Priest Rapids Dam Recoveries Number	%	McNary Dam Recoveries Number	%
Steelhead						
4/29 - 5/6	LD 1C	402	4	1.00	8	1.99
5/9 - 5/14	LD $\overline{\text{m}}$	684	8	1.17	5	0.73
5/15 - 5/23	LD ɔ1	599	7	1.17	1	0.17
5/24 - 5/27	LD $\underline{\text{ψ}}$	299	5	1.67	3	1.00
5/31 - 6/1	RD 1C	205	4	1.95	6	2.93
6/6 - 6/10	RD $\overline{\text{m}}$	192	2/	2/	1	0.52
6/13 - 6/15	RD ɔ1	163	2/	2/	1	0.61
TOTALS		2544	28	1.28 3/	25	0.98
Coho						
4/29 - 5/6	LD 1C	8	7	87.50	3	37.50
5/9 - 5/14	LD $\overline{\text{m}}$	139	12	8.63	2	1.44
5/15 - 5/23	LD ɔ1	938	34	3.62	9	0.96
5/24 - 5/27	LD $\underline{\text{U}}$	834	37	4.44	10	1.20
5/31 - 6/1	RD 1C	519	12	2.31	4	0.77
6/6 - 6/10	RD $\overline{\text{n}}$	609	2/	2/	0	0.00
6/13 - 6/15	RD ɔ1	49	2/	2/	1	2.04
TOTALS		3096	102	4.18 3/	29	0.94

1/ Nighttime spill during the period 5/10 - 5/27/1977.

2/ Sampling terminated at Priest Rapids Dam before all test fish had passed.

3/ Based on test releases 4/29 - 6/1.

4/ Sockeye were branded only when there were insufficient numbers of other fish.

Appendix Table 4.--McNary Dam recoveries of cold branded salmonid smolts released above and below Priest Rapids Dam in 1977.

Species	Brand position LD1	LD2	LD3	LD4	RD1	RD2	RD3	
Priest Rapids forebay release (IC)								
Sockeye	5							5
Coho	3	2	9	10	4		1	29
Chinook	39	110	31	25	3	8		216
Steelhead	8	5	1	3	6	1	1	25
Totals	55	117	41	38	13	9	2	275
Numbers branded	5128	7603	6145	4076	1992	1476	336	26,756
Percent recovered	1.07	1.54	0.67	0.93	0.65	0.61	0.60	1.03%
Priest Rapids tailrace release (IF)								
Sockeye	3							3
Coho	3	5	35	18	3	4	2	70
Chinook	28	66	60	32	7	6	3	202
Steelhead	8	3	2	3	3	3	2	24
Totals	42	74	97	53	13	13	7	299
Number branded	4022	3242	5968	4159	1743	1034	920	21,088
Percent recovered	1.04	2.28	1.63	1.27	0.75	1.26	0.76	1.42%

Appendix Table 5.--Recoveries of cold branded salmonid smolts released into the Priest Rapids Dam forebay directly in front of unit 2B.

Date	Brand	Released	Number recaptured Priest Rapids	Number recaptured Mc Nary	Percent recaptured Priest Rapids	Percent recaptured Mc Nary	Priest Rapids recaptures: Within 4 hours	Priest Rapids recaptures: Within 24 hours	Priest Rapids recaptures: Greater than 24 hours
5/11	RA U	1178	7	13	0.59	1.10	6 from unit 2	1 from unit 2	--
5/12	RA)(	1179	14	12	1.27	1.02	6 from unit 2	--	1 from units 1 & 4 7 from unit 2
5/13	RA ⌣	1018	11	12	1.08	1.18	6 from unit 2	4 from unit 2	1 from unit 7
5/16	RA 0	1040	13	10	1.35	0.96	1 from unit 2 1 from unit 3	--	8 from unit 2 1 from units 8 & 10 2 from unit 5
5/17	RA ↄl	1060	4	17	0.38	1.60	1 from unit 2	--	2 from unit 2 1 from unit 4
5/31	LA)(	1149	12	1 1/	1.04	0.09 1/	3 from unknown	3 from unit 2 4 from unit 3 2 from unit 9	--
TOTALS (5/11-17)		6624	61	65	0.92	0.98	24 0.36%	14 0.21%	23 0.35%

1/ Insufficient time for complete recovery data.

Appendix Table 6.--Catches of juvenile salmonids[3] from gatewells 1, 2, 8 and 9 at Priest Rapids Dam during diel test 7/8 May 1977.

		CATCH					
		"1"-age Chinook Salmon		Steelhead		Sockeye Salmon	
Date	Time	No.	%	No.	%	No.	%
7 May	1800	65	6	1	1	21	6
	2000[1]	83	7	5	4	26	8
	2200	165	15	3	3	78	24
	2400	214	19	13	11	46	14
8 May	0200	223	20	25	21	45	14
	0400	149	13	20	17	53	16
	0600[2]	49	4	23	19	21	6
	0800	31	3	5	4	23	7
	1000	24	2	5	4	10	3
	1200	24	2	6	5	4	1
	1400	46	4	10	8	4	1
	1600	58	5	4	3	0	0
TOTALS		1131	100	120	100	331	100

1/ Sunset, 2009

2/ Sunrise, 0530

3/ No "0"-age chinook or coho salmon caught during entire test.

Appendix Table 7.--Marked salmonids captured in gatewells at Priest Rapids Dam from sources other than Priest Rapids.

Date	Chinook Salmon ad clip	Steelhead RV clip	Coho Salmon LV clip	♀ Cold Brand Rocky Reach Dam 5/2-6 ♀	5/9-13 ♂	5/16-20 ♂	5/23-27 ♂
April							
25	8						
28	10						
29	10						
May							
2	16						
3	46						
4	28						
5	82						
6	141						
7	274			1			
8	212						
9	360	13					
10	368	46					
11	188	29		1		1	
12	230	10					
13	221	2		2			
14	178	4			1		
16	251	6		3			
17	216	11	6	3		1	1
18	445	8	23	3	2		1
20	445	8	19	1	3		
21	275	6	26		1		
23	304	15	64	6	3	1	

Appendix Table 7.--Marked salmonids captured in gatewells at Priest Rapids Dam from sources other than Priest Rapids.
(continued)

Date	Chinook Salmon ad clip	Steelhead RV clip	Coho Salmon LV Clip	♀ Cold Brand Rocky Reach Dam 5/2-6 ♀	5/9-13 ♂	5/16-20 ♂	5/23-27 ♂
May							
24	252	12	76	7	20	1	
25	219	7	47	1	6	1	
26	318	9	87	2	7	4	1
27	427	2	78	1	7	6	1
31	243	11	95	6	7	8	5
June							
1	195	4	82	4	11	20	3
6	20	1	13	4	4	9	1
7	36	1	17	0	1	2	3
8	144	1	35	3	1	3	3
10	68	0	16	0	2	0	1
13	23	1	8	0	0	0	1
14	44	1	9	0	0	0	4
15	32	1	6	0	0	1	0
TOTALS	6329	209	707	48	76	58	25

Appendix Table 8.--"Operation Fish Flow 77" spill information at Priest Rapids Dam 1977.

Date	Spill duration From to	Number of gates spilling	Ave. Flow thru turbines during spill (cfs)	Ave. Spill (cfs)	Percent of river flows spilled
5/10	11 p.m.-3 a.m.	2	58,400	42,000	42
5/11	9 p.m.-3 a.m.	1	61,750	28,000	31
5/12	9 p.m.-1 a.m.	2	60,825	42,000	41
5/13	9 p.m.-3 a.m.	1	67,900	28,000	29
5/14	10 p.m.-4 a.m.	1	62,483	28,000	31
5/15		NO SPILL			
5/16	9 p.m.-3 a.m.	1	73,617	28,000	28
5/17	9 p.m.-3 a.m.	1	73,067	28,000	28
5/18	9 p.m.-3 a.m.	1	70,350	28,000	28
5/19	9 p.m.-3 a.m.	1	68,150	28,000	29
5/20	9 p.m.-3 a.m.	1	71,117	28,000	28
5/21	9 p.m.-3 a.m.	1	62,017	28,000	31
5/22		NO SPILL			
5/23	9 p.m.-3 a.m.	1	81,483	28,000	26
5/24	9 p.m.-3 a.m.	1	109,183	28,000	20
5/25	9 p.m.-3 a.m.	1	122,383	28,000	19
5/26	9 p.m.-11 p.m., 1 a.m.-3 a.m.	1	136,750	28,000	17
5/27	9 p.m.-10 p.m., 12 a.m.-1 a.m.	3	68,850	56,000	45