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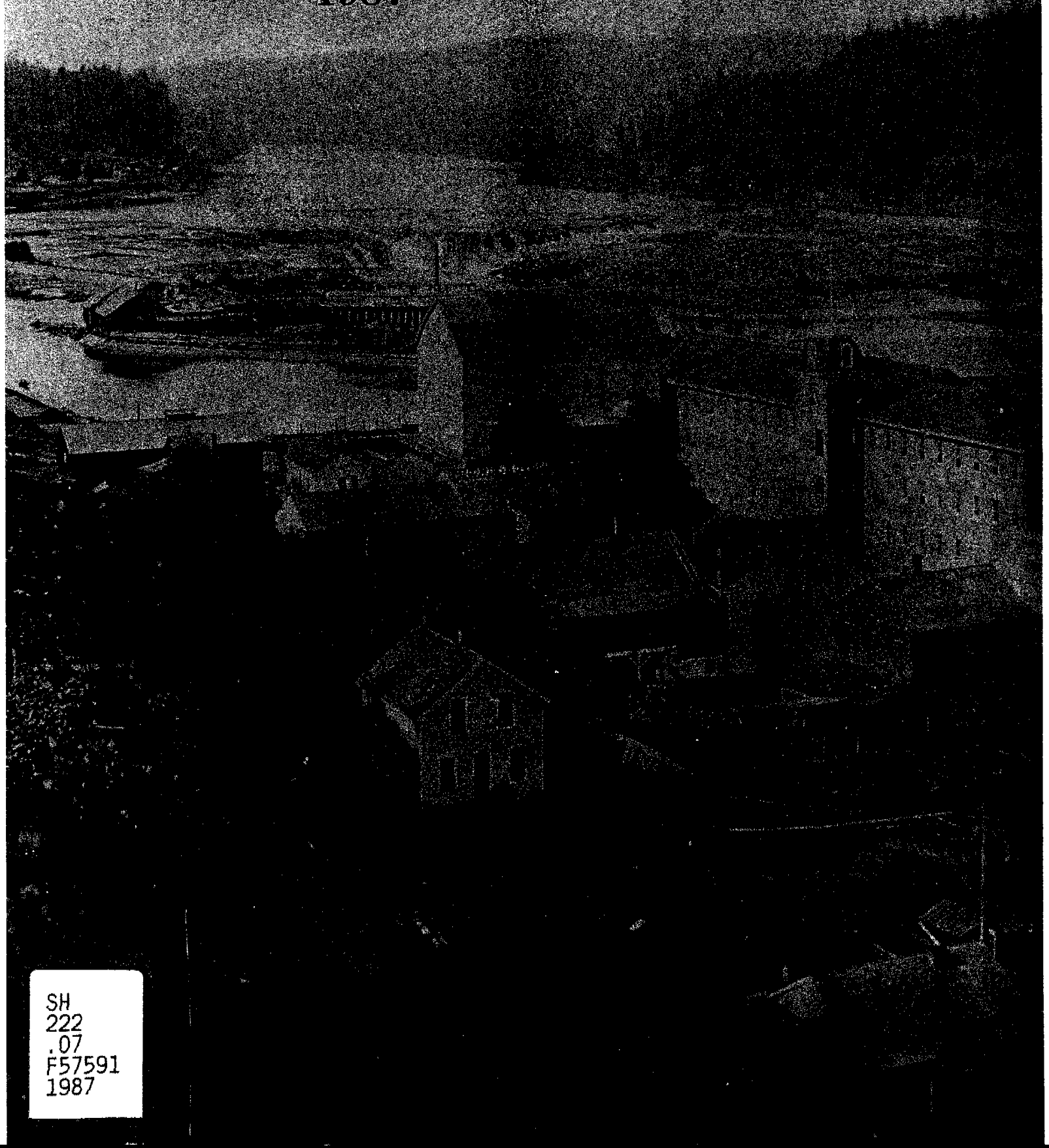
FISH PASSAGE AT WILLAMETTE FALLS 1987



FISH PASSAGE AT WILLAMETTE FALLS IN 1987

ANNUAL REPORT
January 1-December 31, 1987

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Oregon Department of Fish and Wildlife
Columbia River Management

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INTRODUCTION

Historical records of the time early pioneers arrived document that Willamette Falls partially obstructed the migration of salmon and steelhead. As water-powered industry developed at the falls, and concern for the preservation of salmon and steelhead runs increased, fishways were constructed to aid in their timely passage. Conflicting historical records indicate the first crude fishway was devised from rock in the late 1880's or early 1890's. It was followed by a more effective fish ladder in the mid-1890's, and by other fish ladders as changing conditions required. The present fishway, completed in 1971, has made possible the enhancement of existing salmonid runs and the development of new summer and fall runs. Since 1976 flashboards have been installed annually in June or July to reduce overflow on the dam crest at the west side of the horseshoe-shaped falls.

The present fishway, with three legs joining below the counting station located just downstream from twin exits into the forebay (Figure 1), requires 1,080 cubic feet per second (cfs) of water when all entrances are operating at maximum flow. The cul-de-sac leg, which has been designated Entrance No. 1, began operating February 21, 1968. This entrance is located farthest downstream in a large bay where up to 29 industrial hydro-turbines discharge. Proper operation of this leg requires 32 cfs of water through the fishway, with an auxiliary water requirement of 88-328 cfs at the entrance, depending on the river level. Large numbers of fall-run fish and smaller portions of other runs use this entrance. Entrance No. 2, located on the west side of the falls' horseshoe area, was completed on October 22, 1970. This leg requires 48 cfs of water in the fishway for fish migration, with anauxiliary water requirement of 72-312 cfs at the entrance. The majority of the winter steelhead and spring chinook runs presently use this entrance. Entrance No. 3, located on the uppermost leg near the falls apex, began operating on October 8, 1971. The flow requirements of this leg are identical to number 2 leg, with 48 cfs needed in the fishway for transportation and 72-312 cfs of auxiliary water needed at the entrance. Entrance No. 4 was added to the uppermost leg, about 20' above Entrance No. 3, to compensate for inadequacies in the number 3 entrance resulting from conflicting water currents. This entrance began operating September 9, 1975.

The numbers of salmon and steelhead in each race passing Willamette Falls is important to their effective management. In 1987 salmon and steelhead were counted at Willamette Falls on a 13- to 21-hour day, 12-month basis. Counting of spring chinook has continued annually since 1946, while other species have been counted for fewer years.

METHODS

More than 90% of the fish passing through the facility in 1987 were counted at the fishway viewing window. An observer stationed at the window usually counted 3-4 hours daily. When an observer was not present, a camera and video tape recorders were used to complete the record of 24-hour daily

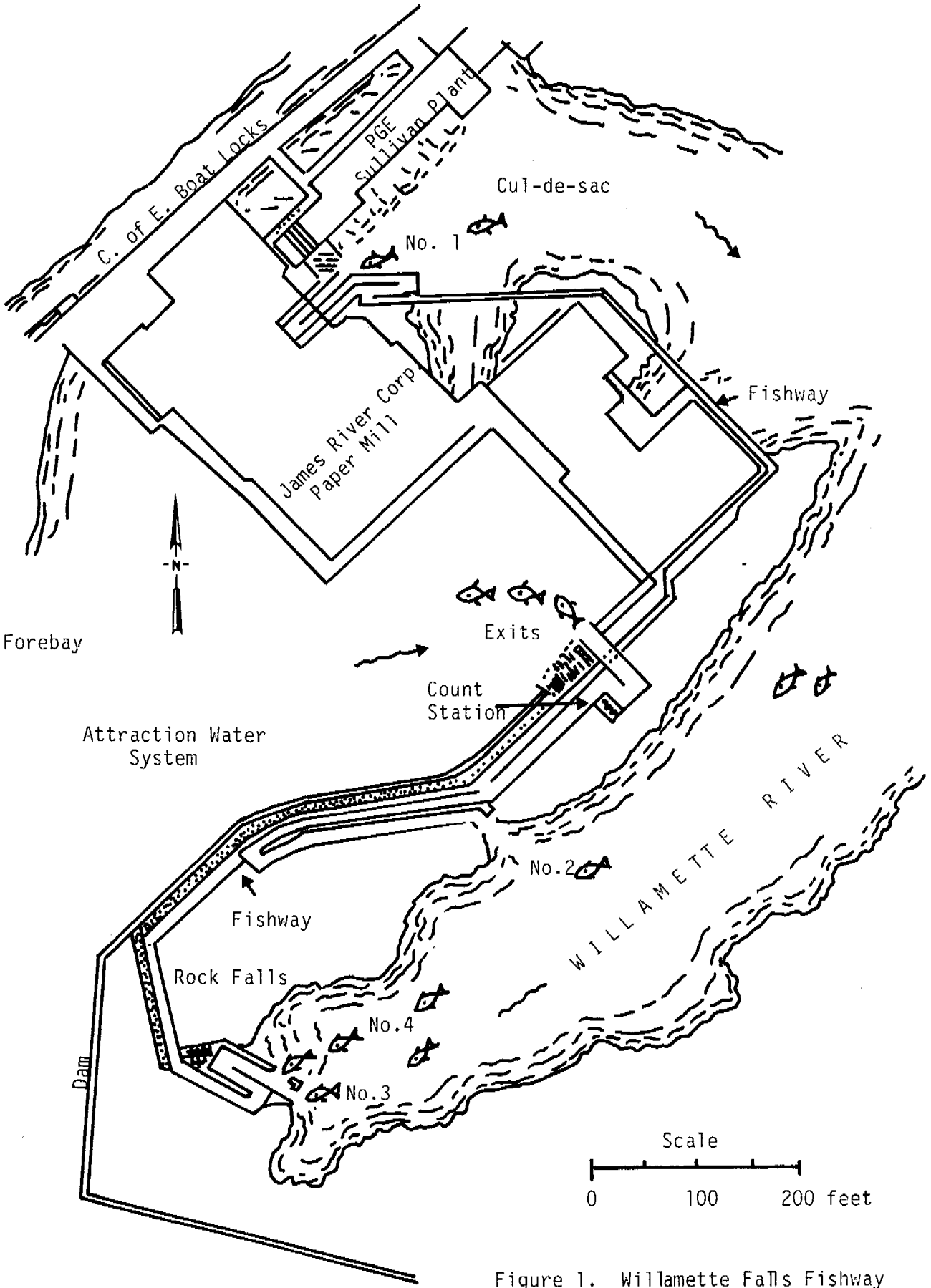

Figure 1. Willamette Falls Fishway

passage. The recorders were adapted to operate in a series to provide complete records spanning weekends. The tapes were usually read at a later date.

The counter rested 10 minutes in each 1-hour visual count period; thus daily counts were corrected by increasing actual counts by 20%. When a recorder malfunctioned, the missing counts were estimated by calculating the average daily portion of the count occurring during the same time period on adjacent days. Beginning in 1986 counting was suspended during the late evening and early morning hours because of low passage. Actual counts were increased by 1-6% to determine the daily counts. The percentage of increase varied with the month and hours counted and was based on hourly counts conducted during 1981-85. Time periods counted were determined by identifying the counting hours that would produce the fewest hours worked by the counter and maintain counts of at least 95% of total passage. The time period from 5 AM to 8 PM was counted on all days, while the time period from 11 PM to 2 AM was counted on no days. The time periods from 2 AM to 5 AM and 8 PM to 11 PM were counted during late spring, summer, and early fall when the days were longer and daily fish passage was protracted.

Fin-marked salmon and steelhead were recorded during visual counting but marks could not be observed on video tapes. Since 1972 all salmon under 22" in length have been classed as jacks. Prior to 1972 those under 21" were classed as jacks.

Winter and summer steelhead runs are intermixed at Willamette Falls during the period from March through May. Separation of the two races is accomplished by means of coloration and fin marks observed during visual count periods. This percentage is then applied to total daily tape counts.

RESULTS

Three species of salmon (including two races of chinook) and two races of steelhead were counted at Willamette Falls in 1987. Passage totals are summarized by race and month in Table 1.

Spring Chinook

Passage of spring chinook is considered to be complete on July 31. The passage of 54,832 spring chinook was composed of 52,797 adults and 2,035 jacks (3-year-old fish). The 1987 total count was the fourth highest on record and 50% higher than the 10-year (1977-86) average of 36,510 (Table 2). This year's count represents the largest escapement total since 1967. The peak daily count of 2,232 adults is the second highest since 1972.

In comparison to other years when passage was unhindered, the 1987 spring chinook run passed very early. The peak daily count of adults occurred on April 27 and was the earliest and only peak count to occur in April since 1972.

Table 1. Willamette Falls Passage of Salmon and Steelhead by Race and Month in 1987.

Month	Spring Chinook				Fall Chinook			Coho			Sockeye	Winter Steelhead[1]	Summer Steelhead
	Adults	Jacks	Total	Mini-Jacks	Adults	Jacks	Total	Adults	Jacks	Total			
January	0	0	0	0	0	0	0	0	0	0	0	2,504	0
February	0	0	0	0	0	0	0	0	0	0	0	3,964	0
March	82	0	82	0	0	0	0	0	0	0	0	4,585	2,502
April	16,547	342	16,889	8	0	0	0	0	0	0	0	2,051	3,220
May	31,118	1,423	32,541	43	0	0	0	0	0	0	0	592	3,964
June	4,210	226	4,436	11,895	0	0	0	0	0	0	5	0	6,003
July	840	44	884	14,144	0	0	0	0	0	0	23	0	5,820
August	0	0	0	827	418	34	452	15	36	51	21	0	880
September	0	0	0	93	8,314	144	8,458	1,160	2,356	3,516	20	0	738
October	0	0	0	0	34	5	39	384	790	1,174	0	0	615
November	0	0	0	0	0	0	0	30	42	72	0	380	0
December	0	0	0	0	0	0	0	0	0	0	0	2,689	0
Total	52,797	2,035	54,832	27,010	8,766	183	8,949	1,589	3,224	4,813	69	16,765	23,742

[1] The winter steelhead run extended from November 1986 to May 1987. The November-December counts shown are for 1986 to provide a complete summary of the 1986-87 winter steelhead passage. Counts for November-December 1987 will be reported in the 1988 count report.

Table 2. Escapement of Spring Chinook Over Willamette Falls, 1946-87.

Year(s)		Adults	Jacks[1]	Total	Mini-Jacks[2]
1946-52	Average			36,571	
	Range			14,500-53,000	
1953-59	Average	41,380	2,131	43,510	
	Range	20,500-72,300	600-4,146	22,000-76,446	
1960-64	Average	22,629	2,549	25,178	
	Range	13,000-31,747	1,400-4,543	14,400-36,290	
1965-69	Average	33,231	2,504	35,735	Some
	Range	25,607-53,689	2,394-2,623	28,230-56,199	Some
1970-74	Average	37,454	825	38,279	2,792
	Range	25,339-44,090	440-1,465	26,154-44,569	328-6,063
1975		17,844	1,235	19,079	957
1976		21,031	1,123	22,154	773
1977		38,509	1,503	40,012	663
1978		45,711	1,801	47,512	1,884
1979		25,492	1,131	26,623	2,174
1975-79	Average	29,717	1,359	31,076	1,290
1980		26,364	609	26,973	22,433
1981		28,640	1,417	30,057	26,679
1982		45,107	1,088	46,195	9,438
1983		28,692	1,897	30,589	14,999
1984		42,363	1,089	43,452	26,174
1980-84	Average	34,233	1,220	35,453	19,945
1985		33,095	1,438	34,533	10,939
1986		37,300	1,855	39,155	12,639
1987		52,797	2,035	54,832	27,010

[1] Prior to 1972 fish under 21" were classed as jacks. Since 1972 fish under 22" were classed as jacks.

[2] Since 1969 2-year-old jacks instead of the usual 3-year olds have been present in late spring and summer months. These are not included in the normal jack count total.

As of May 6, 50% of the total run had passed. The date of 50% passage was 11 days earlier than the 10-year (1977-86) average of May 17 and is the second earliest date since 1972.

On May 24 the counts rose to above 1,000 adults per day and remained above that level until May 14 (21 consecutive days) when 70% of the adults had passed (Figure 2).

Only 10% of the run remained to pass after May 31. This is the second lowest percentage of fish passing during June and July since 1972 and is 11% below the 10-year (1977-86) average of 21%.

The early passage in 1987 was the result of unusually low flows and high water temperatures in the Willamette River during late April and May. After April 23 the flow at Salem never rose above 10,500 cfs and the water temperature at Willamette Falls did not decrease below 55° F.

The passage of 27,010 mini-jacks (2-year-old fish) was the highest count on record and 106% above the 10-year (1977-86) average of 12,802 (Table 2). Passage timing in 1987 was similar to previous years with 96% of the mini-jacks passing during June and July (Figure 3).

Fall Chinook

The escapement of 8,949 fall chinook over Willamette Falls in 1987 consisted of 8,766 adults and 183 jacks. The total count was 26% of the record 1974 count, a 36% decrease below the 1986 count, and the second lowest since 1972. The peak daily count was 1,560 adults (Table 3). No counts were made in 1961-64. A small, but undetermined, amount of early returning, late spawning, Cowlitz River stock fall chinook were included in the total count.

The first fall chinook was recorded on August 1 and the last on October 30, with a peak daily count occurring on September 15 (Figure 4). The peak count date was the latest since 1972. Late timing of fall chinook passage in 1987 was due to low flows and high water temperatures in the Willamette River during late September and early October. From September 16 through October 15 flow at Salem ranged from 7,900 cfs to 8,400 cfs and water temperature at Willamette Falls ranged from 61° F to 64° F.

Coho

During 1987, 1,589 adult and 3,224 jack coho passed over Willamette Falls. The combined adult and jack total of 4,813 was 113% of the 10-year (1977-86) average of 4,273 (Table 4). Coho were not counted in 1961-64. The first coho was observed on August 1 and the last on November 30. The peak day of passage for adult and jack coho occurred on September 21 (Figure 5).

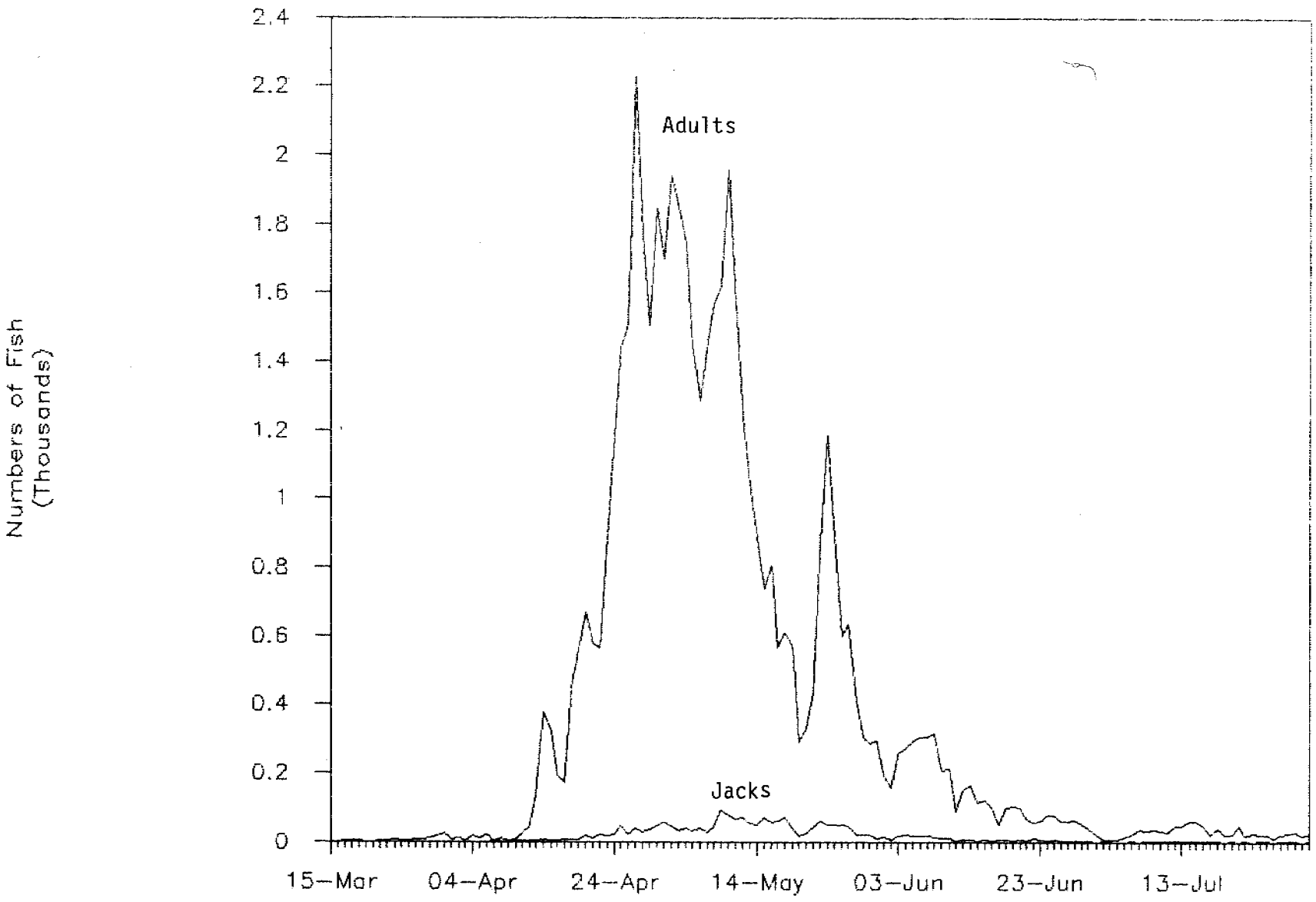

Figure 2. Daily Counts of Spring Chinook Passing Willamette Falls, 1987.

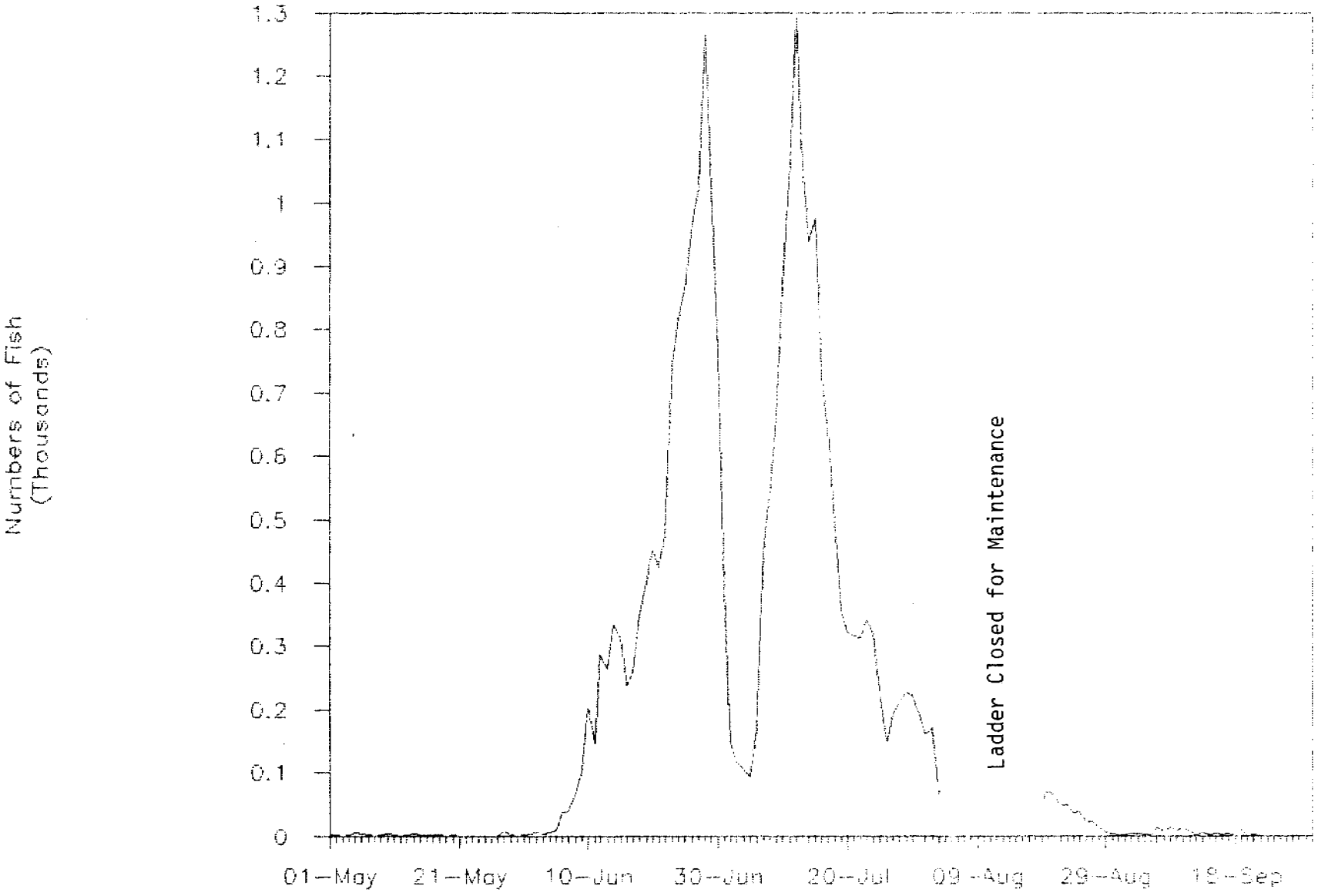

Figure 3. Daily Counts of Spring Chinook Mini-Jacks Passing Willamette Falls, 1987.

Table 3. Escapement of Fall Chinook Over Willamette Falls 1954-60 and 1965-87.

Year(s)		Counts			Trapped[1]		
		Adults	Jacks	Total[2]	Marked Adults	Marked Jacks	Unmarked Fish
1954-60	Average	61	35	96			
	Range	5-225	0-145	9-370			
1965-69	Average	2,722	142	2,864			
	Range	77-6,817	2-255	79-6,957			
1970-74	Average	15,947	233	16,180			
	Range	4,880-33,924	101-376	5,090-34,189			
1975		32,877	895	33,772			
1976		29,269	931	30,200			
1977		25,742	382	26,124			
1978		17,437	465	17,902			
1979		9,905	436	10,341			
1975-79	Average	23,046	622	23,668			
1980		7,760	625	8,385			
1981		16,690	1,085	17,775	143	3	1
1982		25,760	1,123	26,883	338	2	12
1983		13,205	528	13,733	105	3	1
1984		20,060	1,084	21,144	235	4	157
1980-84	Average	16,695	889	17,584	--	--	--
1985		29,089	1,114	30,203	322	2	11
1986		14,037	810	14,847	180	2	5
1987		8,766	183	8,949	177	5	12

[1] Fish taken from the cul-de-sac leg fish trap for research purposes were not included in the Willamette Falls counts.

[2] The passage totals are not corrected beyond the 8-hour period for the years 1955-60 and 1965-66. However, they do include the calculated passage for days of partial counting or no counting and for 10-minute counter rest periods in the years 1955 and 1958. No corrections were applied to the small numbers counted in 1956 and 1957, and only counter rest period corrections were applied in 1959 and 1960. Since 1967 counts were fully corrected for total 24-hour day passage.

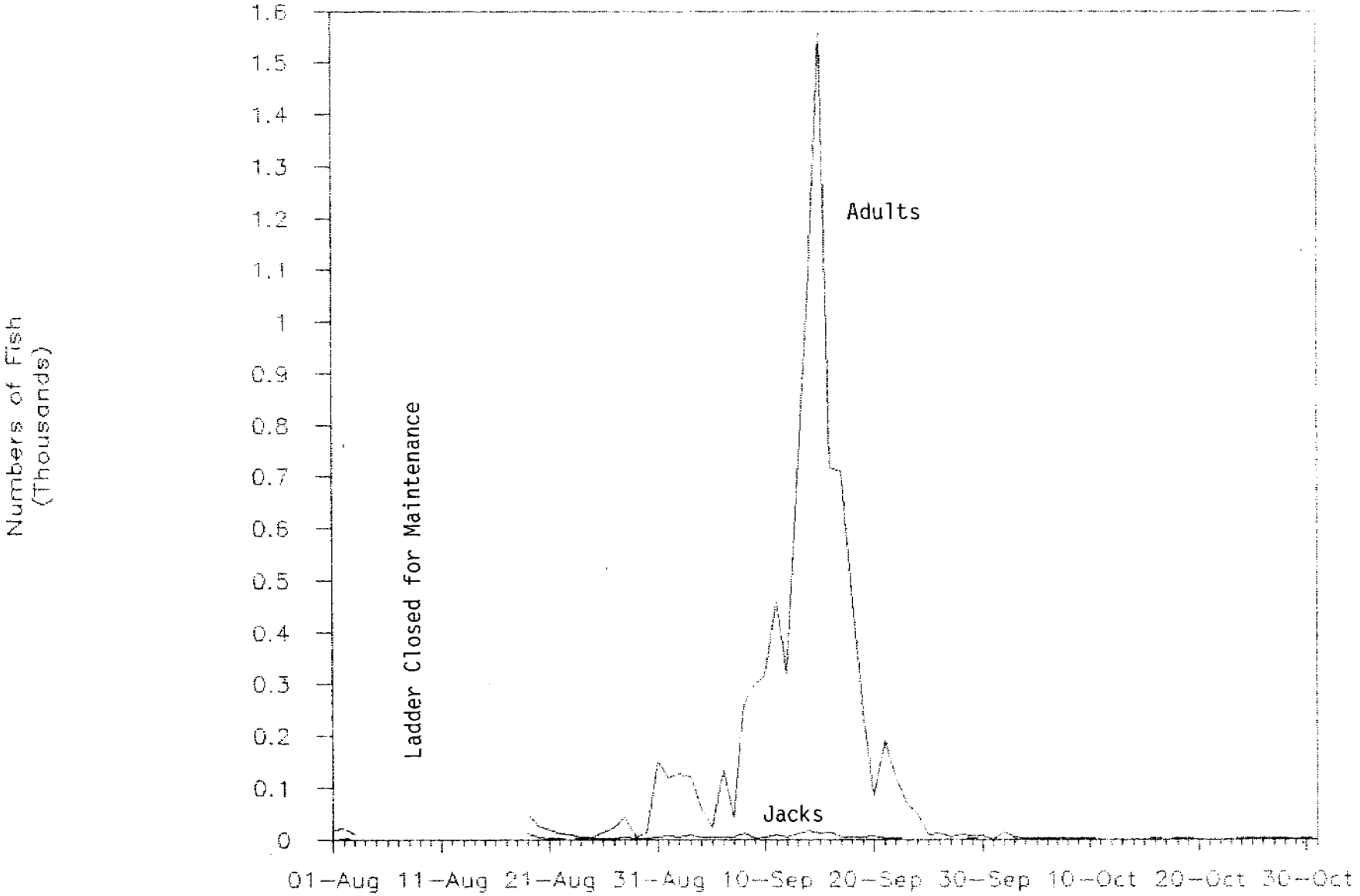

Figure 4. Daily Counts of Fall Chinook Passing Willamette Falls, 1987.

Table 4. Escapement of Coho Over Willamette Falls, 1954-60 and 1965-87.

Year(s)		Adults	Jacks	Total[1]
1954-60	Average	1,311	1,640	2,951
	Range	315-2,950	160-6,035	475-8,635
1965-69	Average	6,779	5,075	11,854
	Range	3,260-12,400	1,614-14,032	6,318-17,700
1970-74	Average	10,394	7,761	18,155
	Range	1,501-17,902	1,583-19,453	5,442-37,355
1975		5,922	6,927	12,849
1976		2,333	2,217	4,550
1977		1,007	2,120	3,127
1978		1,711	3,891	5,602
1979		1,788	1,691	3,479
1975-79	Average	2,552	3,369	5,921
1980		1,276	1,365	2,641
1981		1,032	2,417	3,449
1982		1,702	3,517	5,219
1983		949[2]	2,840[2]	3,689
1984		2,735	2,560	5,295
1980-84	Average	1,539	2,540	4,059
1985		2,788	2,278	5,066
1986		2,930	2,240	5,170
1987		1,589	3,224	4,813

[1] Totals through 1960 are corrected for 8-hour daytime passage. They are expanded to include 24-hour passage since 1965.

[2] Counts as recorded at Willamette Falls fishway. Corrected estimates from scale analysis are 1,586 adults and 2,103 jacks.

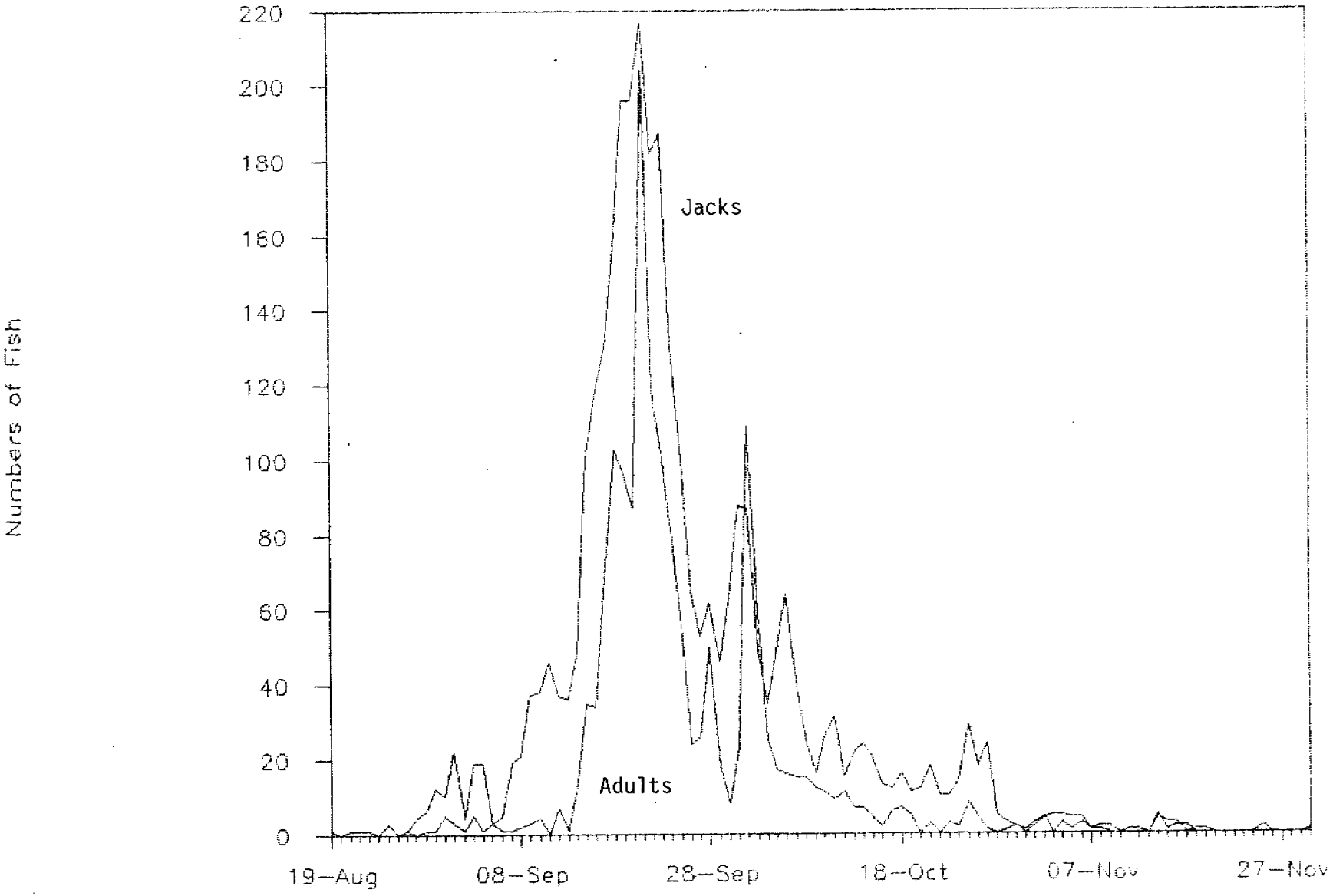

Figure 5. Daily Counts of Coho Passing Willamette Falls, 1987.

Winter Steelhead

All steelhead passing the falls from November through February are considered winter run. During March through May separation of winter and summer runs is based upon coloration and fin marks. The first winter steelhead were counted on November 1, 1986, and the last on May 15, 1987. A peak daily count of 511 early-run winters occurred on February 10 and a peak daily count of 363 late-run winters occurred on March 7 (Figure 6). The total escapement of 16,765 was 5% above the 10-year (1977-86) average of 15,976. The count of 7,630 late-run winter steelhead is the fifth lowest count since 1971 (Table 5).

Summer Steelhead

Summer steelhead began passing Willamette Falls prior to termination of the winter run. The first summer steelhead was recorded on March 1 in 1987. Summer and winter steelhead were separated by coloration and fin marks from March 1 through May 15. From May 16 through October 31 all steelhead were classified as summer steelhead. The major portion of the run passed the falls from mid-May through July with the peak daily count of 480 occurring on July 11 (Figure 7). The total count of 23,742 is the third highest count on record and 44% above the 10-year (1977-86) average of 16,432. Annual counts of this race at Willamette Falls and at Foster and Leaburg dams are summarized in Table 6.

Partial counts of summer steelhead passing Willamette Falls are strongly correlated to the total count. Linear regressions using 1973-86 counts related the total number of summer steelhead passing Willamette Falls to the cumulative counts through May 31, June 15, and June 30 (Figures 8-10). These regressions explained 92-98% of the variation in total escapement and provided a good fit through the range of data. Run size predictions produced were very close to the actual escapement of summer steelhead during 1987 (Table 7). The predictions based on counts through May 31, June 15, and June 30 differed from actual escapement by 3.4%, 6.5%, and 7.0%, respectively.

Sockeye

Sockeye salmon are not indigenous to the Willamette River. Experimental releases of 1966-brood Columbia River sockeye (143,000) and 1967-brood Adams River (British Columbia) stock (243,000) were made into Green Peter Reservoir on the Middle Fork Santiam River. Adults from these releases returned in 1970 and 1971 and were allowed to spawn naturally above Green Peter Reservoir. No further releases were made; however, natural reproduction continued (Table 8). The total 1987 escapement of 69 was the second lowest count since 1980. The first sockeye passing Willamette Falls was observed on June 25 and the last on September 19 (Figure 11).

Shad

The first observation on record of shad using the fishway occurred on July 9, 1980, when one shad passed. Six shad were observed using the fishway in 1981, four shad were observed passing in 1982, and only one shad was observed passing in 1983. For the fourth consecutive year no shad were observed using the fishway.

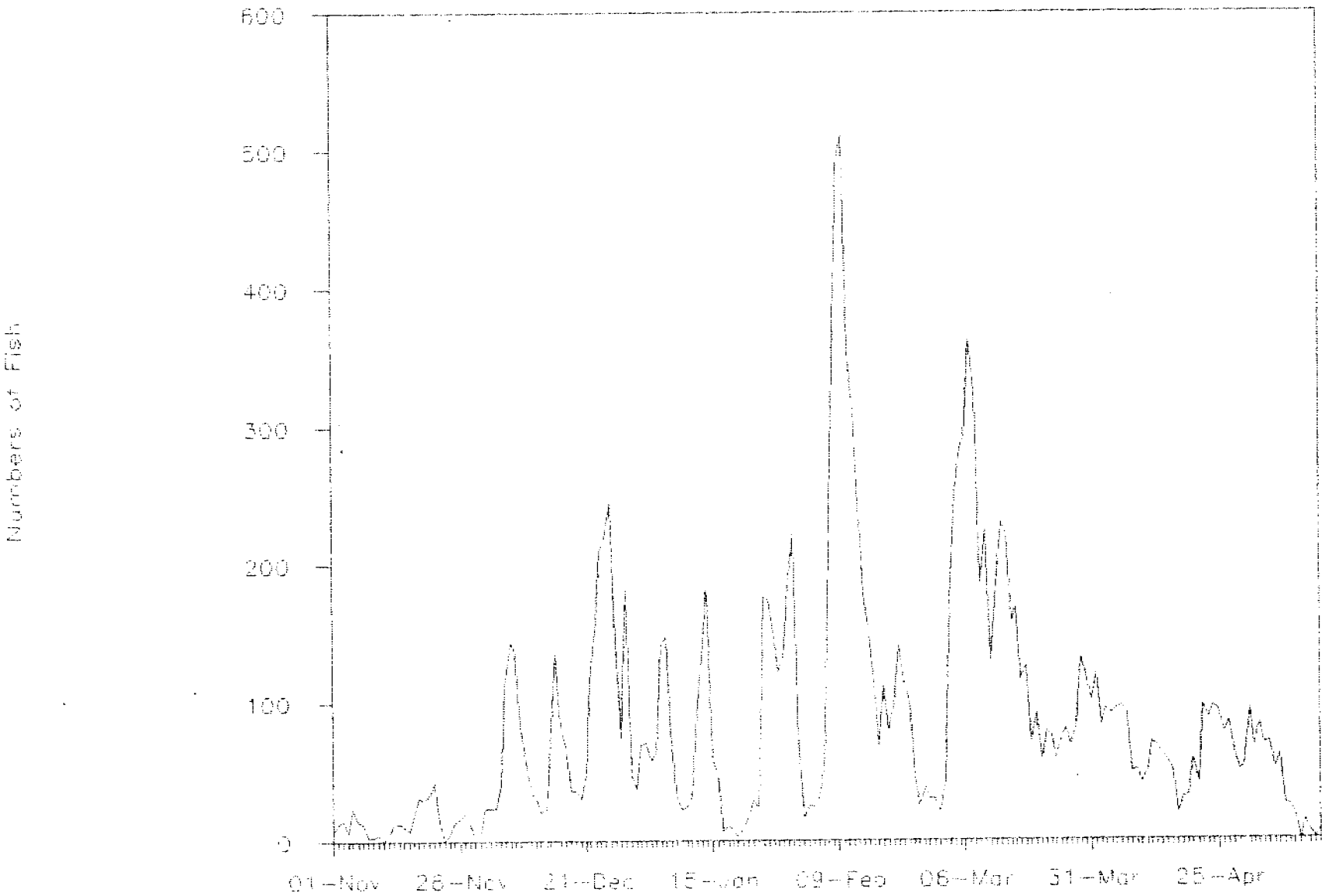

Figure 6. Daily Counts of Winter Steelhead Passing Willamette Falls, November 1, 1986-May 15, 1987.

Table 5. Escapement of Winter Steelhead Over Willamette Falls, 1950-87 and Over North Fork Dam on the Clackamas River, 1971-87.

Year(s)	Willamette Falls			North Fork Dam
	Corrected Total[1]	Early Stock[2]	Late Stock[3]	
1950-54 Average	2,640			
Range	1,200-5,200			
1955-59 Average	4,516			
Range	2,000-7,529			
1960-64 Average	3,308			
Range	939-6,500			
1965-70 Average	8,383			
Range	1,500-14,700			
1971	26,647	8,152	18,495	4,352
1972	23,257	6,572	16,685	2,634
1973	17,900	6,389	11,511	1,899
1974	14,824	5,733	9,091	680
1971-74 Average	20,657	6,712	13,946	2,391
1975	6,130	3,096	3,034	1,509
1976	9,398	4,204	5,194	1,488
1977	13,604	5,327	8,277	1,525
1978	16,869	8,599	8,270	2,019
1979	8,726	2,861	5,865	1,517
1975-79 Average	10,945	4,817	6,128	1,612
1980	22,356	6,258	16,097	2,065
1981	16,666	7,662	9,004	2,700
1982	13,011	6,117	6,894	1,446
1983	9,298	4,596	4,702	1,099
1984	17,384	6,664	10,720	1,238
1980-84 Average	15,743	6,259	9,483	1,710
1985	20,592	4,549	16,043	1,225
1986	21,251	8,475	12,776	1,432
1987	16,765	8,543	7,630	1,318

[1] Total estimates of passage have been obtained since 1971. Problems of access to the old fishway during higher flow periods seriously affected the completeness of counts prior to 1971.

[2] November 1 through February 15. These are mainly introduced Big Creek stock.

[3] February 16 through May 15. These are mainly indigenous Willamette stock.

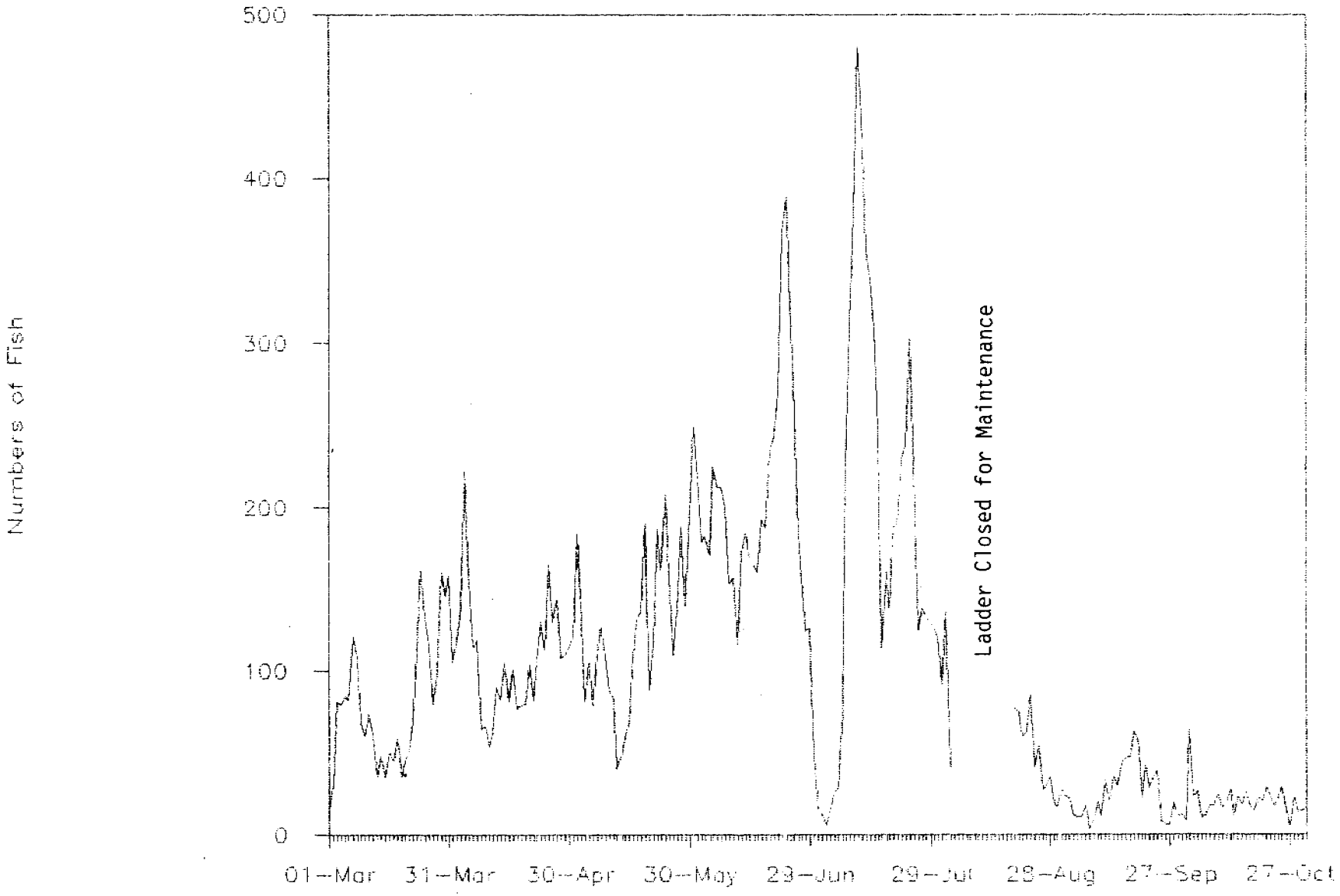

Figure 7. Daily Counts of Summer Steelhead Passing Willamette Falls, March 1, 1987-October 31, 1987.

Table 6. Escapement of Summer Steelhead Over Willamette Falls, Foster Dam on the South Santiam River, and Leaburg Dam on the McKenzie River, 1970-87 Runs.[1]

Year(s)	Willamette Falls Passage	Foster Dam Counts	Leaburg Dam Counts
1970	146	154	1
1971	2,310	2,740	96
1972	690	858	11
1973	1,686[2]	1,365	9
1974	4,858	4,568	175
1970-74 Average	1,938	1,937	58
1975	2,910	1,157	236
1976	3,876	1,526	1,467
1977	9,244	4,809	840
1978	15,172	4,997	2,614
1979	7,638	2,641	1,497
1975-79 Average	7,768	3,026	1,331
1980	11,222	2,184	982
1981	15,224	2,429	1,371
1982	12,571	2,161	927[3]
1983	5,301	1,296	364[4]
1984	25,002	4,930	1,310[5]
1980-84 Average	13,864	2,600	991
1985	22,223[6]	4,466	679[7]
1986	40,719	5,146	540
1987	23,742	3,908	667

1 Summer steelhead not present prior to 1970.
2 May include 200-plus sockeye salmon. It is difficult to separate sockeye from summer steelhead on video tape.
3 Estimate was made to correct for equipment failure. Actual count was 745.
4 Estimate was made to correct for equipment failure. Actual count was 321.
5 Counting terminated on July 25 due to vandalism. Count includes 649 fish trucked from McKenzie River Hatchery.
6 Includes 156 fish removed from potholes below the falls and put above the counting window.
7 Count ended September 30 due to a fish counter personnel change. Using data from past years, 78 to 99% of the run passed by the end of September. Correcting for passage after September, the run passing Leaburg Dam ranged between 685 and 870.

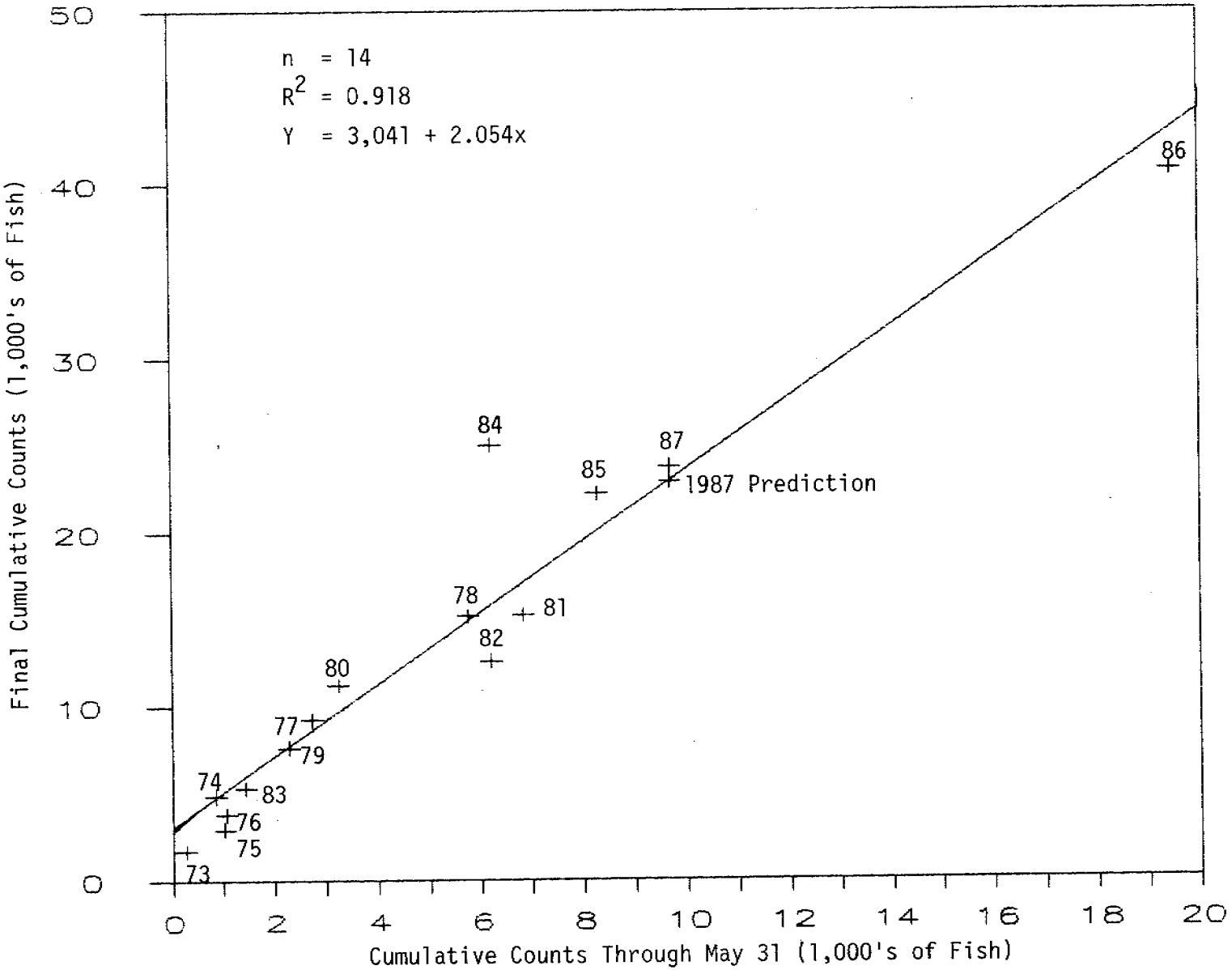

Figure 8. Correlation Between the Total Number of Summer Steelhead Passing Willamette Falls and the Number of Summer Steelhead Passing Willamette Falls by May 31.

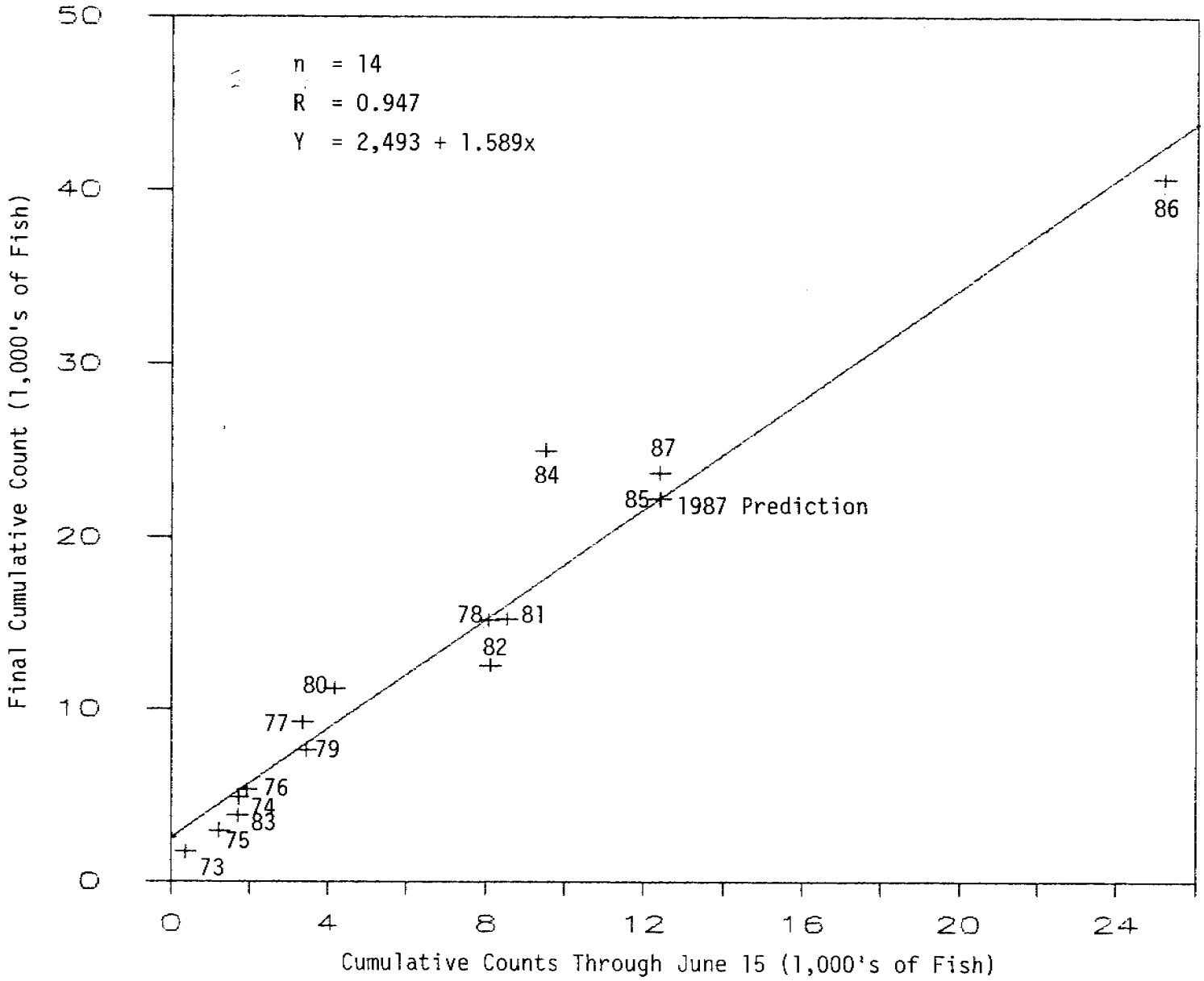

Figure 9. Correlation Between the Total Number of Summer Steelhead Passing Willamette Falls and the Number of Summer Steelhead Passing Willamette Falls by June 15.

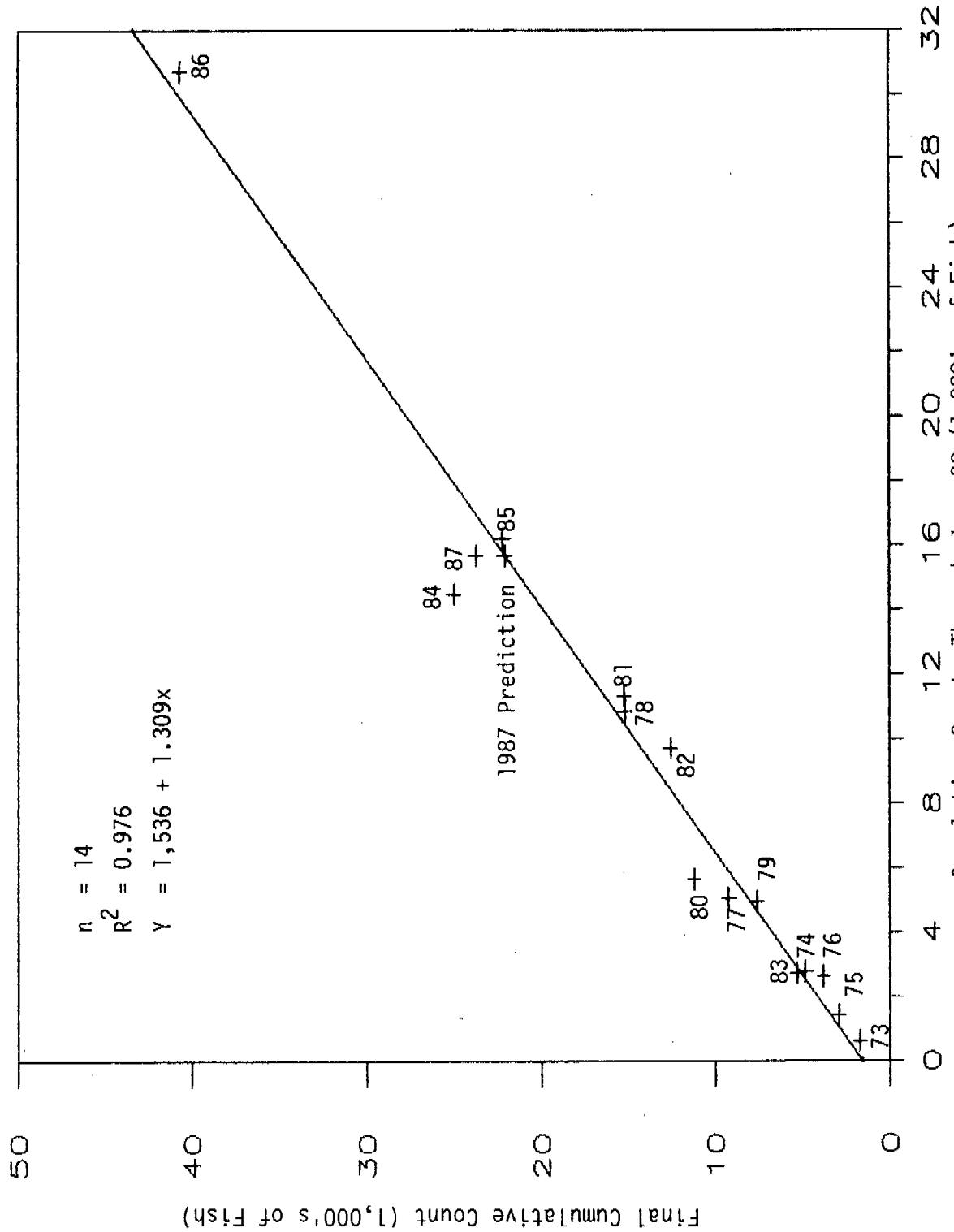

Figure 10. Correlation Between the Total Number of Summer Steelhead Passing Willamette Falls and the Number of Summer Steelhead Passing Willamette Falls by June 30.

Table 7. Predicted Escapements Calculated by Linear Regression Compared to Actual Escapements Calculated from Counts of Summer Steelhead Over Willamette Falls, 1987.

Independent Variable Count by Dates	Total Escapement Predicted	Actual	Difference Predicted-Actual
9,686 by May 31	22,934	23,742	-808
12,405 by June 15	22,206	23,742	-1,536
15,689 by June 30	22,076	23,742	-1,666

Table 8. Escapement of Sockeye Over Willamette Falls and Foster Dam on the South Santiam River, 1969-87.

Year	Willamette Falls Passage[1]	Foster Dam Counts[2]
1969	0	40 (40)
1970	887	636 (305)
1971	1,070	614 (4)
1972	0	7 (3)
1973	26	202 (3)
1974	21	69 (0)
1975	1	15 (0)
1976	575	528 (8)
1977	151	46 (1)
1978	16	2 (0)
1979	16	23 (0)
1980	3,194	1,835 (23)
1981	1,521	840 (1)
1982	3	10 (0)
1983	120	81 (10)
1984	663	223[3]
1985	70	29[3]
1986	69	53[3]
1987	69	23[3]
10-Year Avg. 1977-86	582	312[3]

[1] Willamette Falls totals are sometimes less than Foster Dam totals because sockeye are easily misidentified as steelhead at Willamette Falls, especially with tape counts.
[2] Three-year-old jacks given in parentheses are included in totals.
[3] All fish were killed.