A PRELIMINARY ASSESSMENT OF JUVENILE SALMON MORTALITY THROUGH THE ELWHA RIVER DAMS

Robert C. Wunderlich

December, 1983

U.S. Fish and Wildlife Service
Fisheries Assistance Office
2625 Parkmont Lane
Olympia, Washington 98506

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ACKNOWLEDGEMENTS

This study was funded by Olympic National Park under Interagency Agreement IA-9000-3-0003. John Aho of Olympic National Park initiated the effort, arranged necessary funding, provided logistical support, and furnished the scoop trap crew. Basic study design was developed by Don Cole, Olympic National Park, and John Meyer, Olympia Fisheries Assistance Office. The Lower Elwha Tribe provided fish and hatchery space, and the cooperation of Ken Gilliam, tribal hatchery manager, is appreciated. Fish marking and distribution were primarily accomplished by Steve Dilley, Steve Hager and Mike Paiya of the Olympia Fisheries Assistance Office staff.

INTRODUCTION

The Elwha River drains a major portion of the Olympic Peninsula including Olympic National Park. In its natural state, the Elwha River and its tributaries were considered the most prolific producers of food and game fish on the Olympic Peninsula (Schoeneman and Junge, 1954). The Elwha was historically renowned for production of spring chinook and a race of exceptionally large fall run chinook. Coho, steelhead, pink, chum, cutthroat, and dolly varden probably also utilized the areas above the dams. However, the Elwha River has been blocked to passage of anadromous salmonids since construction of two dams, the Lower Elwha Dam and Glines Canyon or Upper Elwha Dam, in 1910 and 1926, respectively (Figure 1). No fish passage facilities were provided at either structure and runs of salmon and steelhead were blocked from the upper watershed above river mile five.

Restoration of anadromous fish to the upper Elwha River is a major goal of Olympic National Park, state, tribal, and other entities. Achievement of this goal is contingent upon safe passage of juveniles through the Elwha River dams. Schoeneman and Junge (1954) examined mortality rates of juvenile salmonids introduced into the spillways and turbines at the two dams. They found mortalities of 30% or more for coho yearlings through the Glines Canyon turbine. They also found mortalities of 30% or more for chinook fingerlings through both the Glines Canyon turbine and the Lower Elwha Dam spillway. Subsequent modifications to the Lower Elwha spillway may have improved passage, however.

The studies by Schoeneman and Junge were generally well designed and provide important information but are insufficient for assessing mortality under present conditions. Their work did not assess the relative rates of juvenile coho mortality through the turbines and spillways at Lower Elwha Dam or the expected mortality of juvenile salmonids emigrating naturally through either dam. Subsequent modifications of the Lower Elwha spillway may have reduced mortality rates through this outlet. Additional studies were needed to assess total mortality past both dams under present conditions.

Olympic National Park entered into a cooperative agreement with the Olympia Fisheries Assistance Office of the U.S. Fish and Wildlife Service to assess total mortality of juvenile salmonids emigrating freely through the Elwha River dams. Due to time constraints and complexity of study design, a feasibility study was conducted in 1983 to develop preliminary estimates of fish passage mortality and to evaluate trapping gear, release sites, and release numbers for a more comprehensive evaluation of passage mortality in 1984. This progress report describes the results of the 1983 feasibility study and provides recommendations regarding a second year of study in 1984, including a proposed study design.

STUDY AREA

The Elwha River is the largest river draining the north Olympic Peninsula into the Strait of Juan De Fuca. Mean annual flow at river mile 8 is 1,505 cubic feet per second (cfs) over 59 years of record. Mean monthly flows recorded during the outmigration months of April, May, and June are 1,302, 1,990, and 2,334 cfs, respectively.

The Lower Elwha Dam, at river mile 5 (Figure 1), forms Lake Aldwell. Nominal head of the dam is 100 ft. Spillways are located on the left and right banks and discharge onto rock. The left bank spillway is most frequently used. The power plant has four Francis type turbines (2 vertical and 2 horizontal) which draw from the forebay surface. Each turbine utilizes about 500 cfs at full load. The project is run-of-the-river with very little storage capability.

Glines Canyon or Upper Elwha Dam is located at approximately river mile 13 and forms Lake Mills. The dam is 200 ft high with a spillway on the left bank discharging directly into a pool at the dam base. The power plant contains a single Francis type turbine utilizing about 1500 cfs. The turbine intake is at a depth of 65 ft and is located in a pier 100 ft upstream of the dam. A penstock 500 ft long delivers water to the turbine.

METHODS

Coho salmon smolts were used to assess mortality rates past both dams. Coho were chosen as the test species because of their availability at the Lower Elwha Tribal Hatchery, and because coho are a candidate species for reintroduction in the upper watershed should restoration of upriver runs prove feasible. The Lower Elwha Tribal Hatchery coho stock is also largely endemic to the watershed. Smolt-sized fish were utilized to reduce the possibility of residualism in the reservoirs following release.

Three experimental groups of approximately 4,600 fish were released near the forebay of Lake Mills during the period of expected natural outmigration between late April and mid May. Three more experimental groups of 3,000 each were released near the head of Lake Aldwell during the same time period. Five control groups of approximately 1,200 were released below Lower Elwha Dam between late April and late May. Release sites were largely dictated by road access. Figure 1 shows specific locations of release.

Each group was uniquely marked by freeze branding with liquid nitrogen. Test and control groups were held in net pens in a common earth pond at the Lower Elwha Tribal Hatchery until release. Due to a break in one control pen partition, the 4th and 5th control groups intermixed prior to release. However, release dates for the latter groups were spaced sufficiently far apart to prevent any overlapping recoveries. Mortalities during the holding period were recorded for each group. Fish were transported to release sites via tank truck. A sample of each group was examined for length, legibility of the brand, and fish condition at time of loading. All releases were made at mid day. Table 1 lists release dates, numbers, brands, and sizes of each group at release.

Test and control groups were recovered in an inclined plane scoop trap positioned 1.5 river miles downstream of Lower Elwha Dam immediately below the ITT Rayonier-operated water diversion structure at river mile 3.5 (Figure 1). The scoop trap was of Washington Department of Fisheries' design and consisted of two 38-ft long pontoons spaced about 10 ft apart supporting an inclined screen section 6-ft wide by 6-ft deep at the mouth and 18-ft long (Figure 2). In operation, downstream migrants were swept up the inclined screen by the current and deposited in the live box. Flow into the trap was regulated by positioning the trap (side to side and fore and aft) in the current with the main winch cables anchored at each bank, and by adjusting the level and angle of the inclined screen through its four winches. Due to strong back eddy currents at the trap site, additional lines were run from the stern to each bank to aid in positioning.

Trap position was checked daily and adjusted as necessary to ensure direct alignment into the main current and water velocities of approximately 6 to 8 ft/sec at the trap mouth. This provided maximum trapping efficiency for coho smolts (Seiler et al., 1981) without excessive turbulence in the live box at higher flows which can lead to fish injury as well as mechanical damage to the trap. Velocities were measured with a Price AA current meter suspended in the center of the trap mouth over a 30-lb sounding weight. During periods of current meter failure, velocities were estimated visually.

Scoop trap catches were checked at 1- to 2-hr intervals to reduce potential stress on captured fish and to remove any debris from screen surfaces. Forklength and physical condition of recoveries were noted. Marked migrants were caudal punched to prevent recounting, and then released off the stern of the trap following enumeration. Numbers and lengths of other salmonids captured were recorded as time allowed.

Efforts were made to adjust the period of trap operation to intercept the maximum number of coho migrants possible. The trap was typically fished from 1800 hrs until 0800 hrs nightly from the date of first release, April 25th, until June 23rd when recoveries of marked fish no longer occurred. Additionally, the trap was test fished during mid day on eight occasions over the recovery period to evaluate the need for 24-hr per day fishing. However, operational problems, including mechanical breakdown and extreme high water, precluded trap operation during portions of two nights (May 26th and 29th) and five days (May 26th through May 30th) when continuous fishing should have occurred. To account for missed fishing effort during these periods, catch figures were expanded in two ways:

1) Missed nighttime fishing (0000-0800 hrs, May 26th and 29th). The average of the two preceeding and succeeding nights p.m./a.m. catch ratios was used to develop expansion factors of 2.6 and 2.4 for the May 26th and 29th catches, respectively.

2) Missed daytime fishing (0800-1800 hrs, May 26th through 30th). The average of the daytime/nighttime catch ratios during the 24-hr fishing period from May 31st through June 2nd was used to develop a daily expansion factor of 1.33 for the entire period.

The capture rates of control groups in the trap were used to define trap efficiency and ultimately the survival rates of each test group to the trap. As streamflow at the trap site was considered the primary determinant of trap efficiency, mean nightly streamflow (1200 hrs to 1200 hrs) was calculated from hourly flow levels recorded at the USGS Elwha River stream guage (No. 12045500, river mile 8), less the ITT Rayonier water diversion immediately above the trap. Travel time and tributary inflow between the gauge and the trap were considered negligible for purposes of this study. Calculated mean nightly stream flows at the trap site were then regressed against per cent recoveries of control groups to develop the linear regression equation $Y = 4{,}467 - 292X$ ($r^2 = 0.9973$). This expression was used to predict trap efficiencies over most flow levels encountered during the recovery period. Extremes in flow (>3,100 cfs) were considered beyond the predictive ability of this model; a conservative value of 4.5% efficiency was therefore used for flow extremes. Additionally, the second control group release (May 6th) produced an anomalous recovery rate unrelated to trap efficiency and was not included in the regression calculation (Figure 3). Reasons for the anomalous rate were not apparent, but size selectivity and flow variations at the trap were not factors. Under these constraints, daily catches of experimental groups were expanded by the inverse of the predicted daily trap efficiency, summed over the recovery period, and expressed as a percentage of release group size to estimate survival rates to the trap.

To augment scoop trap recoveries, a fyke trap was temporarily installed in the ITT Rayonier water diversion project which, during the study, continuously withdrew between 90 and 140 cfs of water immediately above the scoop trap site. The fyke trap was installed in the fish return channel approximately 1/4 mile below the project's fish screen facility. At this location, approximately 50% of the return flow was trapped. The fyke trap was fished May 18th and 19th following the third control group release to assess the proportion of smolts using the side channel and the feasibility of trapping it on a continuous basis, if desired. The trap was subsequently removed on May 21st because design of the trap allowed emergent coho fry to become impinged on the net wings.

RESULTS

The mark and recapture techniques employed were generally satisfactory and accomplished the first year study objectives. Legibility of the freeze brand was excellent in all groups (>99.5%), and mortality during marking, holding, and distribution was negligible (<0.01%). Length comparisons of control releases and scoop trap recoveries indicated no significant size selectivity at recovery in any of the groups at the 0.05 level of significance. The number of observed recoveries of most test and control groups was adequate (100-200 recoveries per group) for a study of this nature (Steve Neuhauser, Washington Department of Fisheries, personal communication).

Preliminary estimates of survival to the trap for test group releases in both reservoirs were very similar. They ranged from 57.5% to 68.6% and averaged 63.4% for Lake Aldwell releases and 62.2% for Lake Mills releases. Moreover, the survival estimates for both reservoir releases were ordered in the same manner with the second release highest, followed by the third and then first. Table 2 lists survival estimates for all groups.

The patterns of recovery were markedly different between Lake Aldwell and Lake Mills releases, however. Initial scoop trap recoveries of all Lake Aldwell releases occurred the same night as release and peaked only one to two nights later. Total recovery periods ranged from 38 days for the first Aldwell group to 23 days for the last. In contrast, scoop trap recoveries of Lake Mills releases lagged considerably behind all Lake Aldwell groups. Recoveries of the first Mills release group began 16 days after release, peaked 14 days later, and continued another 16 days until final recovery. Recoveries of the second and third Lake Mills groups occurred sooner with initial catches at 4 and 3 days and peak catches at 20 and 8 days after release, respectively. Appendix A provides a detailed listing of daily catches by group including respective expansion factors.

Substantial differences in injury rates between Lake Aldwell and Lake Mills groups were also observed. Smolts planted in Lake Mills exhibited an overall injury rate of 27.0% versus only 3.2% for Lake Aldwell plants and 0.5% for control plants (Table 3). Varying degree of scale loss was the primary injury type observed. Injuries to control fish are attributed to capture in the scoop trap, while the greater rates of test fish injury are attributed to passage through the dams. The observed injuries were generally serious enough to jeopardize long term survival.

Trapping the ITT Rayonier water diversion fish bypass channel produced 10 marked coho versus a scoop trap catch of 234 marked coho over the same fishing period. Assuming 50% of the bypass flow was trapped, the scoop trap catch could likely be augmented by approximately 10% with complete trapping of the bypass channel using suitable gear.

Incidental scoop trap catches of coho, chinook, and trout are provided in Appendixes B, C, and D respectively.

DISCUSSION

Examining the number and pattern of recoveries of the experimental groups in relation to operation of the dams offers some insight into possible sources of the mortalities and injuries observed. Figure 4 depicts estimated streamflow (both spill and turbine) at the lower dam versus scoop trap recoveries (expanded catches) of lower reservoir releases. As the figure indicates, the majority of recoveries occurred prior to the estimated start of spill on May 20th. Recoveries before this date necessarily passed through the dam via the turbines and losses of approximately 37% in the Lake Aldwell groups should largely be due to turbine mortality. Schoeneman and Junge found negligible mortality due to the turbines in the lower dam, however smaller chinook fingerlings were used as test fish. The larger coho smolts used in this evaluation could be more susceptible to injury in Francis style turbines (Bell, 1981).

Comparison of spill and turbine flows at both dams versus recoveries of Lake Mills releases suggests that the bulk of the Mills fish passed both dams under high spill conditions (Figure 5). Migrational delay and the higher observed injury rate may have resulted. Delay at the upper dam is indicated by lack of recoveries prior to increased spill at this facility. Such behavior would be consistent with the findings of Schoeneman and Junge which showed coho yearlings lingered in the forebay of Lake Mills until spilling began rather than sounding to the 65-ft deep turbine exit.

The higher frequency of injury among Lake Mills releases may be associated with spill conditions at the lower dam. Schoeneman and Junge found neglible injuries among coho yearlings introduced into the upper dam spillway, but a relatively high rate of injury (to chinook fingerlings) at the lower dam spillway. If fish planted in Lake Mills delayed there until spills increased substantially (as the scoop trap recoveries suggest), the higher rate of injury among all Mills groups may be associated with passage through the lower dam spillway. Observed injuries in the second and third Aldwell release groups tend to confirm this possibility, as the limited number of Aldwell recoveries after May 20th (beginning of spill at the lower dam) had more injuries than those fish recovered before that date, even though the overall injury rate for these Aldwell groups was relatively modest. Specifically, in the second Aldwell group, only 3 of 191 recoveries were injured before spill versus 4 of 16 after spill, and in the third group only 1 of 128 recoveries were injured before spill versus 6 of 50 after spill.

The survival estimates and possible sources of mortality and injury are influenced by a number of factors which should be considered in next year's evaluation. These factors include:

1) Efficiency expansions for scoop trap catches. Additional data points are needed to better define the relationship between flow and trap efficiency over the entire range of streamflows encountered. This lack of data particularly affected the expanded catch values for Lake Mills recoveries, as no control releases were made during the highest flow period of late May

when many of the Lake Mills plants were recovered. (Assuming a minimum trap efficiency of 4.5% during this period provides a conservative expansion estimate, however.)

2) Effort expansions for scoop trap operation. Expansions for missed fishing, particularly daytime periods, are only approximations. Survival estimates for Lake Mills plants are again most influenced by these approximations, as many of these fish were recovered when fishing effort was not consistent during higher flows. The effort expansions used, however, are believed to be conservative. Continuous fishing effort is necessary during higher flow periods in the Elwha which evidently incite fish movement irrespective of time of day.

3) Test group release locations for total mortality estimates. Release of test groups in standing water could adversely affect their migratory disposition. Release sites in the Elwha mainstem above each reservoir would be preferrable to those used this year.

4) Specific sources of mortality and injury. Without sampling between the dams or introducing fish into specific exits, sources of mortality and injury can only be determined indirectly by examining operating regimens at each dam. Spillway and turbine mortalities for coho smolts at the lower dam should be specifically examined, and the presumed lack of injuries from passage over the upper dam spillway should be confirmed.

5) Annual streamflow variations. Mean monthly flows encountered this past spring fell within the normal range recorded over the lengthy period of record for the Elwha gauging station. Daily flows for late May and early June may have been somewhat atypical, however, due to extremely high air temperatures during this period which triggered relatively high snowmelt and daily flows. A second year evaluation would provide insight into annual variations and related fish passage problems.

RECOMMENDATIONS

Preliminary estimates of total mortality obtained this year need to be confirmed and refined. A study of essentially the same design incorporating some modifications in release sites, release numbers, and recovery effort is recommended. In addition, specific mortality/injury estimates for the upper dam spillway, and the lower dam spillway and turbine need to be developed. The following elements are therefore proposed for total and specific mortality/injury estimates:

Total Mortality Estimates

Multiple releases of coho smolts above Lake Mills and Lake Aldwell over the outmigration period from mid April to mid May are recommended. Releases above Lake Mills would require airlift. Weekly control releases over the entire recovery period (mid April to late June) should be made to satisfactorily define scoop trap efficiency over the entire range of flows encountered. The scoop trap should be operated continuously over peak outmigration periods, as determined by frequent test fishing and close attention to river flow. The water diversion bypass channel should also be trapped to enhance recovery rates. Results would yield mean survival rates for respective release groups. Confidence intervals would be generated for each. Tentative group sizes and numbers are:

Group	Size	No.	Total
Mills	4,600	3	13,800
Aldwell	3,000	3	9,000
Control	2,000	10	20,000
			42,800

Specific Mortality/Injury Estimates

Lower Dam - Paired releases of marked coho smolts should be introduced directly into the spillway (left bank) and turbine penstock under different flows to estimate respective mortality and injury rates. Recovery would be accomplished at the trap concurrently with total mortality studies. Group sizes and numbers are:

Group	Size	No.	Total
Lower Dam Penstock	2,850	3	8,550
Lower Dam Spillway	2,850	3	8,550
			17,100

Upper Dam - Three groups of unmarked coho smolts should be released directly into the spillway under different flows to assess relative injuries through this exit. Recovery would occur in the vicinity of the powerhouse via floating fyke trap or similar gear. Releases would be timed to reduce overlapping recoveries and thus the need to differentially brand and hold the groups. Group sizes are:

Group	Size	No.	Total
Upper Dam Spillway	2,000	3	6,000

Table 1. Release data for test and control groups.

Release Group	Release Date	No. Released	Brand	Forklength(mm)	Standard Deviation	Sample Size
1st Mills	4/25/83	4,596	Right side X	140.3	10.5	98
2nd Mills	5/4/83	4,598	Left side T	140.7	8.3	101
3rd Mills	5/16/83	4,593	Left side E	146.3	8.8	100
1st Aldwell	4/25/83	2,999	Right side 5*	141.2	11.6	100
2nd Aldwell	5/4/83	2,998	Left side O	143.8	10.0	100
3rd Aldwell	5/16/83	2,998	Right side V	145.9	8.4	101
1st Control	4/28/83	1,180	Left side X	142.2	10.8	102
2nd Control	5/6/83	1,200	Right side T*	141.9	11.3	99
3rd Control	5/18/83	1,196	Left side 5	144.9	10.9	100
4th Control	5/25/83	767	Right side E Right side O** Left side V	147.3	10.1	100
5th Control	6/1/83	1,558	Same as 4th control group	146.3	11.2	100

*Applied upside down and reversed.

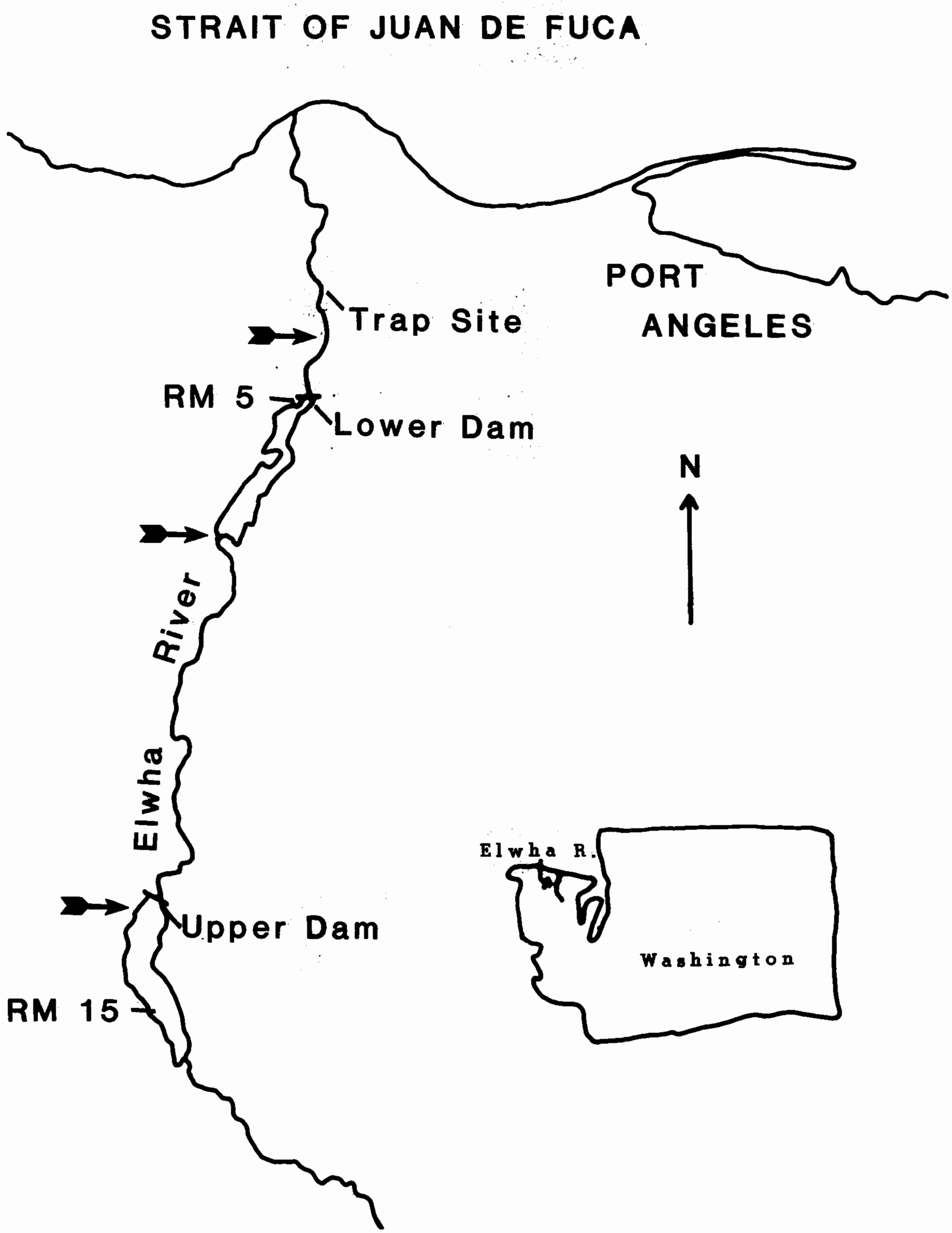
**Applied upside down.

Table 2. Per cent survival to the scoop trap for all release groups.

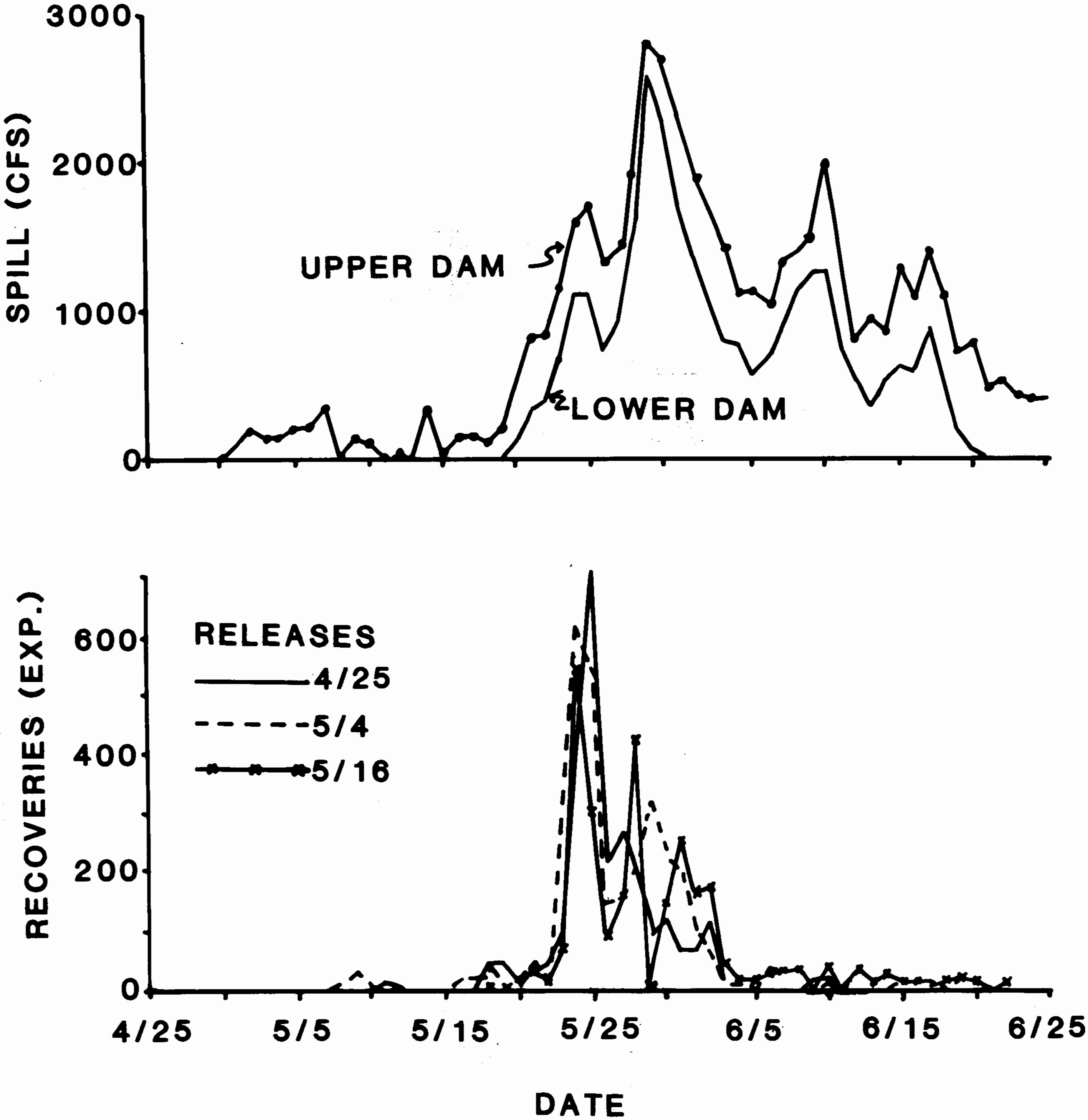
Release Date	% Survival to Scoop Trap	
	L. Aldwell Releases	L. Mills Releases
4/25/83	57.9	57.5
5/4/83	68.8	68.4
5/16/83	63.5	60.7
Mean:	63.4	62.2

Table 3. Numbers and types of injuries observed in scoop trap recoveries of Lake Mills, Lake Aldwell, and control group releases (combined).

Type of Injury	Recovery Group					
	L. Mills		L. Aldwell		Control	
	No.	% of Total Recoveries	No.	% of Total Recoveries	No.	% of Total Recoveries
Scale Loss (moderate to heavy in most cases)	85	23.1%	8	1.4%	3	0.5%
External Bleeding (at fin and/or operculum)	5	1.4%	2	0.3%	0	-
Torn Fin and/or Operculum	5	1.4%	2	0.3%	0	-
Bulging Eye	0	-	3	0.5%	0	-
Internal Bleeding (observed at vent, eye, and/or mouth)	4	1.1%	4	0.7%	0	-
Totals	99	27.0%	19	3.2%	3	0.5%



STRAIT OF JUAN DE FUCA
PORT ANGELES
Trap Site
RM 5
Lower Dam
N
River
Elwha
Upper Dam
RM 15
Elwha R.
Washington



3000
2000
1000
0
SPILL (CFS)
UPPER DAM
LOWER DAM
600
400
200
0
RECOVERIES (EXP.)
RELEASES
4/25
5/4
5/16
4/25
5/5
5/15
5/25
6/5
6/15
6/25
DATE

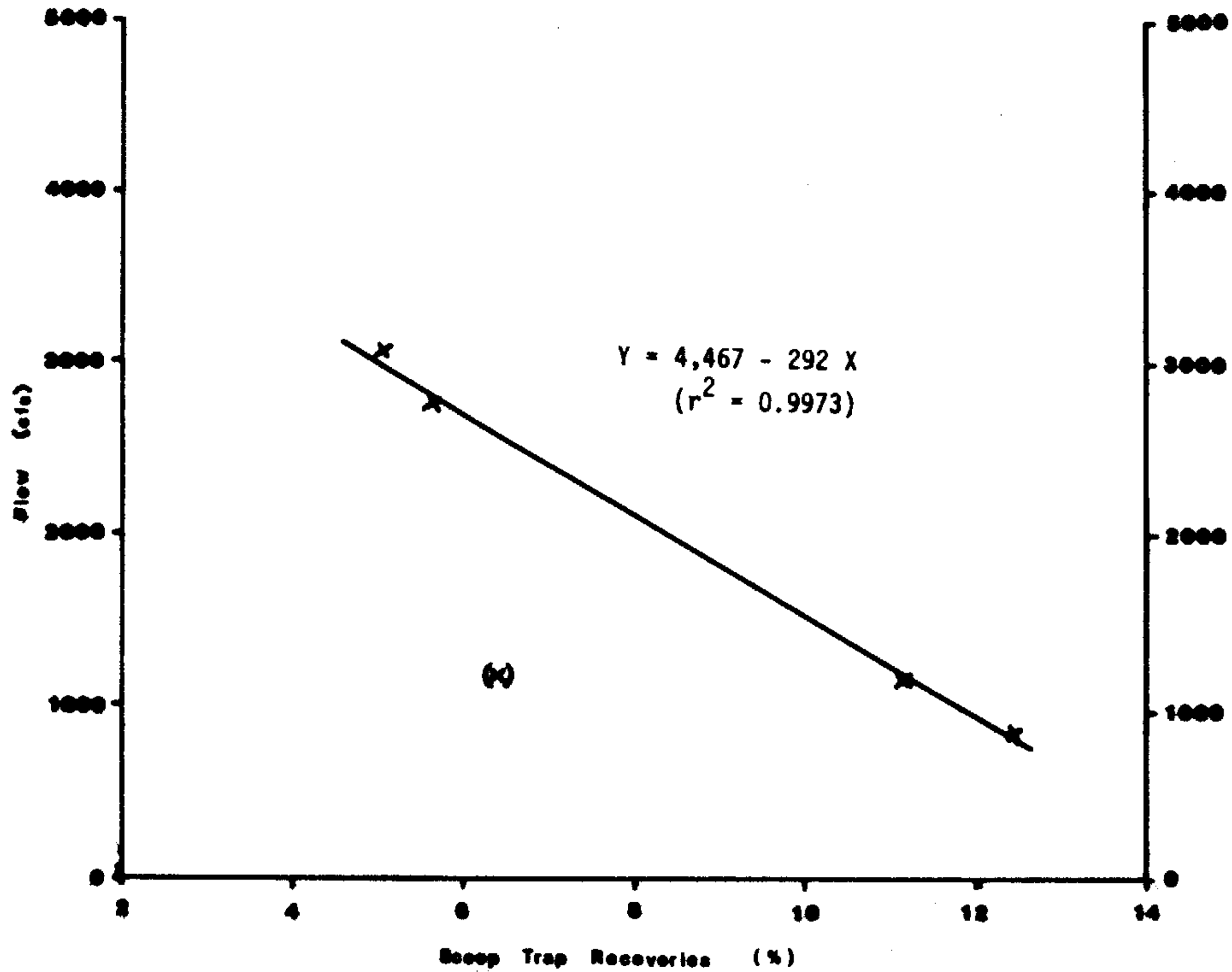


Figure 3. Per cent recovery of control group releases versus estimated streamflow at the scoop trap. The data point in parens was omitted from the regression calculation.

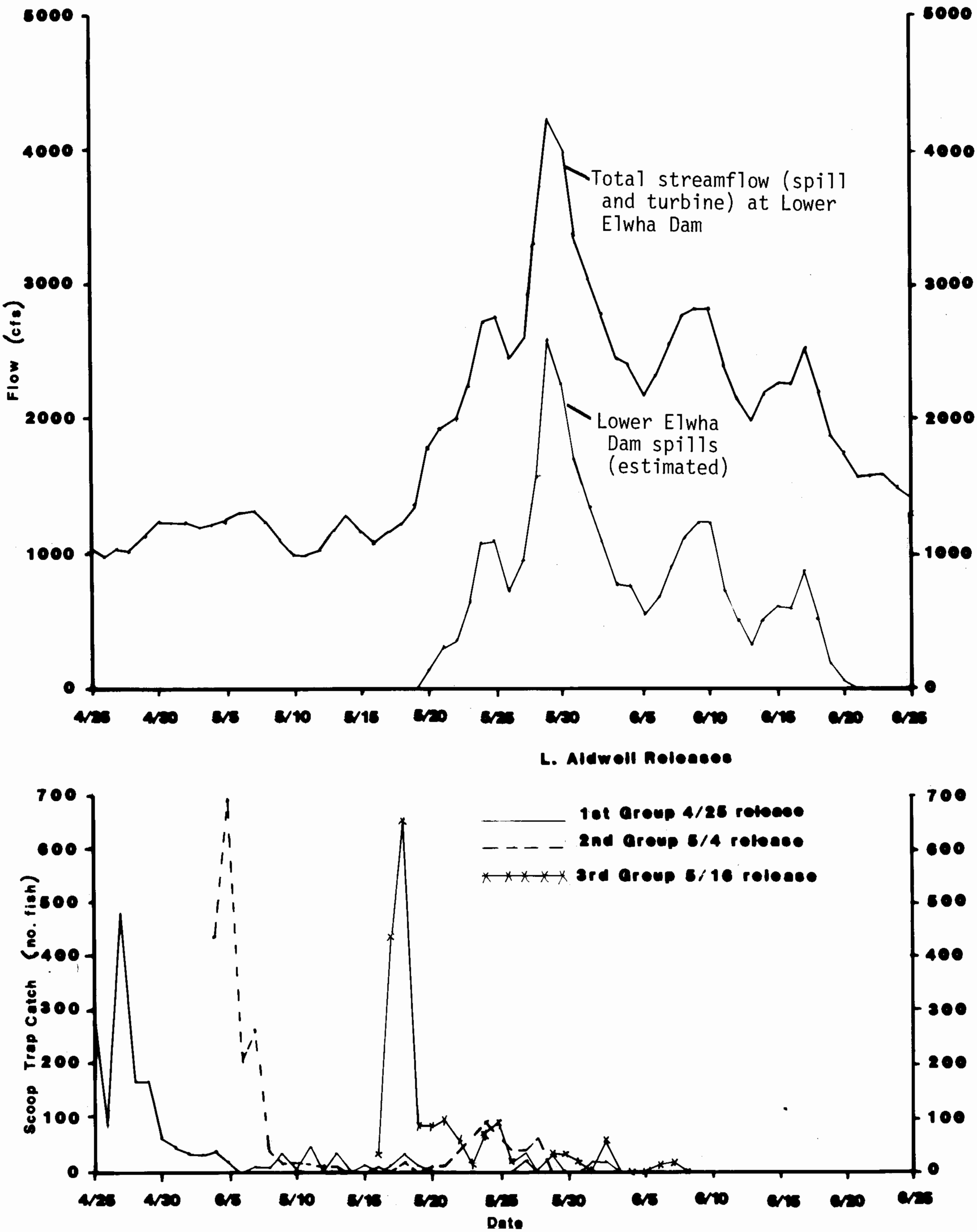


Figure 4. Lower Elwha Dam flows (upper graph) and scoop trap recoveries (expanded catches) of L. Aldwell releases (lower graph). Source of flow data: Crown Zellerbach.

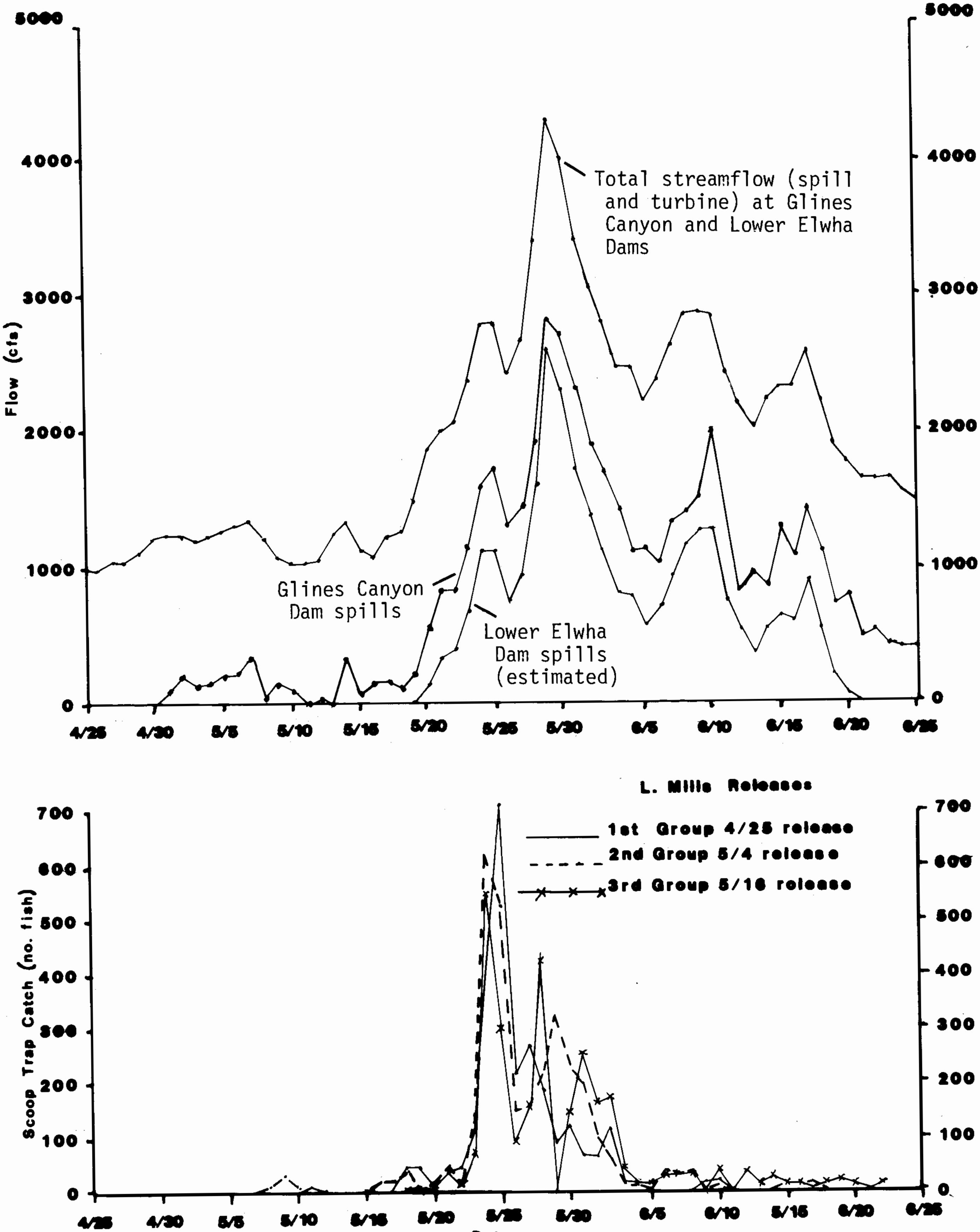


Figure 5. Glines Canyon and Lower Elwha Dam flows (upper graph) and scoop trap recoveries (expanded catches) of L. Mills releases (lower graph). Total daily streamflow at each dam was considered identical for purposes of this study. Source of flow data: Crown Zellerbach.

REFERENCES

Bell, M.C. 1981. Updated compendium on the success of passage of small fish through turbines. U.S. Army Corps of Engineers Contract No. DACW-68-76-C-0254. North Pacific Division, Portland.

Schoeneman, D.E. and C.O. Junge, Jr. 1954. Investigations of mortalities to downstream migrant salmon at two dams on the Elwha River. Research Bulletin No. 3. Washington Department of Fisheries, Olympia.

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/downstream salmonid trapping project, 1977-1980. Progress Report No. 144. Washington Department of Fisheries, Olympia.

Appendix A. Actual and expanded daily recoveries of Lake Mills and Lake Aldwell release groups.

Date 1/	Mean Flow 2/	Expansion Factor 3/		Recoveries											
				1st Mills		2nd Mills		3rd Mills		1st Aldwell		2nd Aldwell		3rd Aldwell	
		Efficiency	Effort	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded
4/25	1031	8.50								39	331.5				
4/26	955	8.32								10	83.2				
4/27	883	8.15								59	480.9				
4/28	876	8.14								21	170.9				
4/29	845	8.07								21	169.5				
4/30	845	8.07								8	64.6				
5/1	1233	9.04								5	45.2				
5/2	1216	8.99								3	27.0				
5/3	1164	8.85								3	26.6				
5/4	1216	8.99								4	36.0	49	440.5		
5/5	1340	9.34								2	18.7	74	691.2		
5/6	1164	8.85										23	203.6		
5/7	1277	9.16								1	9.2	29	265.6		
5/8	1037	8.52				1	8.5			1	8.5	5	42.6		
5/9	1172	8.87				3	26.6			3	26.6	2	17.7		
5/10	1079	8.62				1	8.6			1	8.6	2	17.2		
5/11	1004	8.44		1	8.4					5	42.2	2	16.9		
5/12	1004	8.44										1	8.4		
5/13	923	8.25								4	33.0	1	8.3		
5/14	1395	9.51													
5/15	1172	8.87								2	17.7				
5/16	1207	8.96				2	17.9					1	9.0	3	26.9
5/17	1164	8.85				2	17.7			1	8.9			49	433.7
5/18	1190	8.92		5	44.6	3	26.8			3	26.8	2	17.8	74	660.1
5/19	1251	9.09		5	45.5			1	91	1	9.1			9	81.8
5/20	1720	10.64		1	10.6	2	21.3	1	10.6			1	10.6	8	85.1
5/21	1886	11.32		3	34.0	4	45.3	3	34.0			1	11.3	8	90.6
5/22	1993	11.81		4	47.2	1	11.8	2	23.6			3	35.4	5	59.1
5/23	2382	14.01		8	112.1	9	126.1	5	70.1			1	14.0	1	14.0

Appendix A. (Continued)

Date 1/	Mean Flow 2/	Expansion Factor 3/		Recoveries											
				1st Mills		2nd Mills		3rd Mills		1st Aldwell		2nd Aldwell		3rd Aldwell	
		Efficiency	Effort	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded	Actual	Expanded
5/24	2924	18.93		20	378.6	34	643.6	29	549.0			5	94.7	5	94.7
5/25	2770	17.22	1.33x2.6	12	714.6	9	535.9	5	297.7					2	119.1
5/26	2657	16.14	1.33	10	214.7	7	150.3	4	85.9			2	42.9	1	21.5
5/27	2745	16.97	1.33	12	270.8	7	158.0	7	158.0	1	22.6	2	45.1	2	45.1
5/28	3528	(22.22)	1.33x2.4	3	212.8	3	212.8	6	425.6			1	70.9		
5/29	4604	(22.22)	1.33	3	88.7	11	325.1			1	29.6			1	29.6
5/30	4071	(22.22)	1.33	5	147.8	8	236.4	5	147.8					1	29.6
5/31	3612	(22.22)		3	66.7	9	200.0	12	266.6					1	22.2
6/1	3068	20.88		3	62.6	5	104.4	8	167.0	1	20.9				
6/2	2950	19.26		6	115.6	3	57.8	9	173.3	1	19.3			3	57.8
6/3	2583	15.51		1	15.5	1	15.5	3	46.5						
6/4	2260	13.24		1	13.2	1	13.2	1	13.2						
6/5	2283	13.38						1	13.4						
6/6	2328	13.66				3	41.0	2	27.3						
6/7	2539	15.15				2	30.3	2	30.3					1	15.1
6/8	2809	17.62						2	35.2					1	17.6
6/9	2885	18.47		1	18.5										
6/10	3322	(22.22)		1	22.2	2	44.4	2	44.4						
6/11	2328	13.66													
6/12	2059	12.13				2	24.3	3	36.4						
6/13	2070	12.19						1	12.2						
6/14	2147	12.59						2	25.2						
6/15	2411	14.21				1	14.2	1	14.2						
6/16	2271	13.31				1	13.3	1	13.3						

Appendix A. (Continued)

Date 1/	Mean Flow 2/	Expansion Factor 3/ Efficiency	Effort	1st Mills Actual	1st Mills Expanded	2nd Mills Actual	2nd Mills Expanded	Recoveries 3rd Mills Actual	3rd Mills Expanded	1st Aldwell Actual	1st Aldwell Expanded	2nd Aldwell Actual	2nd Aldwell Expanded	3rd Aldwell Actual	3rd Aldwell Expanded
6/17	2655	16.12				1	16.1								
6/18	2241	13.13						1	13.1						
6/19	1890	11.34						2	22.7						
6/20	1954	11.63						1	11.6						
6/21	1570	10.09													
6/22	1774	10.85						1	10.9						
Totals:				108	2,644.7	138	3,147.2	123	2,788.2	201	1,737.1	207	2,063.7	175	1,903.6
Per Cent of Release Group:					57.5%		68.4%		60.7%		57.9%		68.8%		63.5%

1/ 24-hr period beginning 1200 hours on the date indicated.

2/ Mean hourly flow over the corresponding 24-hr period as measured at the USGS Elwha R. guaging station (No. 12045500).

3/ The efficiency expansion factors are the inverse of estimated daily trap efficiencies. A minimum trap efficiency of 4.5% was assumed for all mean flows over 3100 cfs. The effort expansion factors account for lack of 24-hr fishing from 5/25 to 5/30, and also lost fishing time on 5/25 and 5/28 due to mechanical breakdown and extreme high water, respectively.

Appendix B. Catches of unmarked coho in the scoop trap, April 25 - June 23, 1983.

Date	Catch	Mean Forklength(mm)	Notes
4/26	1	152	Smolt
4/26	1	-	Smolt
5/1	13	-	Fry
5/3	1	-	Fry
5/5	18	-	Fry
5/6	3	-	Fry
5/6	1	130	Smolt
5/8	1	127	Smolt
5/9	3	-	Fry
5/9	1	119	Smolt
5/11	3	-	Fry
5/11	4	120	Smolt
5/12	1	43	Fry
5/15	2	113	Smolt
5/16	2	-	Fry
5/17	2	112	Smolt
5/18	6	131	Smolt
5/19	3	140	Smolt
5/20	1	108	Smolt
5/21	1	155	Smolt
5/24	7	115	Smolt
5/25	2	115	Smolt
5/26	1	117	Smolt
5/27	1	110	Smolt
5/28	2	128	Smolt
5/31	1	121	Smolt
6/1	1	115	Smolt
6/1	1	70	Fry
6/3	2	-	Fry
6/3	1	123	Smolt
6/4	1	-	Fry
6/5	3	-	Fry
6/6	8	-	Fry
6/8	3	-	Fry
6/9	3	-	Fry
6/11	3	-	Fry
6/12	6	-	Fry
6/13	7	-	Fry
6/14	1	-	Fry
6/15	2	-	Fry
6/16	1	-	Fry
6/18	1	-	Fry
6/19	1	-	Fry
6/20	4	-	Fry
6/22	3	-	Fry

Appendix C. Chinook catches in the scoop trap, April 25 - June 23, 1983.

Date	Catch	Mean Forklength(mm)	Notes
4/26	1	-	Fry
4/27	23	-	Fry
4/28	9	-	Fry
4/29	8	-	Fry
4/30	2	-	Fry
5/1	18	-	Fry
5/2	7	-	Fry
5/3	2	-	Fry
5/6	1	-	Fry
5/7	1	127	Smolt
5/8	2	-	Fry
5/9	1	95	Fry
5/10	2	121	Smolt
5/12	4	119	Smolt
5/13	2	-	Fry
5/13	2	133	Smolt
5/14	2	124	Smolt
5/15	1	71	Fry
5/15	3	119	Smolt
5/16	1	115	Smolt
5/17	5	118	Smolt
5/18	2	127	Smolt
5/19	8	117	Smolt
5/20	6	118	Smolt
5/21	8	119	Smolt
5/22	1	110	Smolt
5/23	6	115	Smolt
5/25	3	116	Smolt
5/26	1	-	Fry
5/27	2	124	Smolt
5/28	5	123	Smolt
5/29	1	110	Smolt
5/30	2	108	Smolt
6/6	5	-	Fry

Appendix D. Trout catches in the scoop trap, April 25 - June 23, 1983.

Date	Catch	Mean Forklength(mm)	Notes
4/28	2	183	Steelhead smolt
	1	200	Cutthroat
4/29	3	190	Steelhead smolt
4/30	5	-	" "
5/1	4	-	" "
5/2	5	-	" "
5/3	1	374	Steelhead
5/3	1	-	Steelhead smolt
5/4	7	171	" "
5/5	3	195	" "
5/6	2	153	" "
5/7	1	140	Cutthroat
5/7	5	159	Steelhead smolt
5/8	4	207	" "
5/8	1	-	Trout fry
5/9	8	164	Steelhead smolt
5/10	3	168	" "
5/10	1	222	Steelhead hatchery smolt-upper caudal clip
5/10	1	73	Trout fry
5/11	5	184	Steelhead smolt
5/11	1	-	Trout fry
5/12	2	190	Steelhead smolt
5/12	2	68	Trout fry
5/13	6	179	Steelhead smolt
5/14	12	168	" "
5/15	11	176	" "
5/16	1	210	" "
5/17	6	184	" "
5/18	17	174	" "
5/19	7	163	" "
5/20	12	171	" "
5/21	12	173	" "
5/22	3	170	" "
5/23	5	170	" "
5/24	19	173	" "
5/24	1	-	Steelhead hatchery smolt-lower caudal clip
5/25	4	170	Steelhead smolt
5/26	1	164	" "
5/27	6	183	" "
5/28	11	172	" "
5/29	3	176	" "
5/30	4	158	" "
5/31	6	171	" "
6/1	1	173	" "

Appendix D.(continued)

Date	Catch	Forklength(mm)	Notes
6/2	2	180	Steelhead smolt
6/5	1	168	" "
6/6	1	170	" "
6/9	1	195	" "
6/10	2	200	" "
6/14	1	197	" "
6/14	1	279	Resident rainbow
6/18	1	192	Steelhead smolt