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EVALUATION OF FISH PROTECTIVE FACILITIES AT LITTLE GOOSE AND LOWER GRANITE DAMS AND REVIEW OF MASS TRANSPORTATION ACTIVITIES 1977

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Final Report of Research
Financed by
U.S. Army Corps of Engineers
(Contract No. DACW68-77-C-0043)

and

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Coastal Zone and Estuarine Studies
2725 Montlake Boulevard East
Seattle, Washington 98112

April 1978

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INTRODUCTION

During 1977, the National Marine Fisheries Service (NMFS), under contract to the U. S. Army Corps of Engineers, continued to evaluate the following: (1) a mass transport system for increasing the survival of downstream migrant salmonids and (2) fish protective facilities for juvenile salmonids at Lower Granite and Little Goose Dams.

Early in 1977, it was apparent that the drought in the Pacific Northwest would produce record low flows in the Columbia and Snake Rivers during the period when juvenile salmonids would be migrating to the sea. Concerned fishery agencies perceived that if the downstream migrants were to avoid catastrophic losses such as those sustained during the low flows of 1973, an emergency mass transportation program for the juvenile salmonids would be necessary. Because the NMFS in cooperation with The Corps had basic expertise and facilities to conduct such a program, it was incorporated along with the ongoing transportation research. To supplement the trucking capacity and to accommodate the large numbers of fish anticipated, barging was included for the first time as an integral part of the overall transportation plan.

At Lower Granite Dam, research emphasis was placed on comparing benefits of transportation of smolts from that dam with benefits obtained by hauling from Little Goose Dam. It is extremely important to determine if transportation, found to be successful at Little Goose Dam, can be equally successful at Lower Granite Dam which is nearer the smolt rearing areas. Transport modes included trucks, airplanes, and barges, with trucks transporting the largest numbers of fish. The hauling phase of the study to determine the feasibility of transporting smolts by air was completed and we initiated research to determine the effectiveness of using barges to transport large numbers of smolts from the Snake River.

Additional research at Lower Granite Dam was done on the following: (1) alleviating stress on fish during collection and transportation and (2) investigating the mechanical aspects of adjustable angle traveling screens.

At Little Goose Dam, emphasis was placed on mass transportation of juvenile salmonids by truck and evaluation of adult returns. Evaluation of the new orifice system that was installed and mechanically checked out was delayed until 1978 because of power generation problems associated with the low flow conditions.

Adult returns examined in 1977 were from juveniles released at Dworshak National Fish Hatchery and releases of juveniles marked and transported from Lower Granite Dam (1975-76) and Little Goose Dam (1976). Examination of adult returns to Little Goose Dam is the primary method of evaluating the success of the transportation program. However, supplemental information was obtained by evaluating adult returns to the Indian fishery in the lower river and returns to hatcheries and spawning grounds upstream from Little Goose Dam.

EMERGENCY MASS TRANSPORT OF SMOLTS

By late winter 1976-77, state and federal fisheries agencies agreed that because of drought conditions in the Pacific Northwest, river flows would be so low that only an emergency effort by the Corps of Engineers and NMFS to mass haul fingerlings could save the 1977 outmigration from total loss.

With the prospect of transporting increased numbers of smolts due to the no-spill situation, additional fish hauling trucks were made available from Idaho Department of Fish and Game, Idaho Power Company, and Dworshak National Fish Hatchery. In addition, two experimental transportation barges were made available by the Corps of Engineers.

Approximately 2 million chinook salmon and 1.4 million steelhead trout fingerlings were estimated to have arrived at Lower Granite Dam in 1977; this was less than 50% of the number estimated to have started their migrations from upriver tributaries. The failure of these fish to arrive at Lower Granite Dam was due to a combination of mortality and delay in migration as a result of low river flows in the Snake River and its tributaries. Sport fishing success and purse seining in Lower Granite reservoir indicated significant numbers of juvenile chinook salmon and steelhead trout remained in the reservoir after the spring migration period. NMFS was prepared to haul these fish if they appeared in the collection facilities in significant numbers after waters cooled in the fall. However, very few fish resumed migrations in the fall. Only 11,000 fish were collected and transported below Bonneville Dam during October and November. It is of interest to note that two of these fish were subsequently captured in the estuary within 3 to 4 weeks after release, indicating these fish continued their migration to the ocean after release below Bonneville Dam.

Nearly 81% of the 3.4 million fingerlings arriving at Lower Granite Dam were collected (2.0 million at Lower Granite Dam and 0.7 million at Little Goose Dam). About 2.3 million fish or 65% of the migration were transported from these two dams and released below Bonneville Dam. The numbers of smolts transported from the Snake River by truck, airplane, and barge in 1977 are shown in Table 1. Table 2 summarizes the number of smolts and the percent of the total outmigration hauled each year since 1971.

Fingerlings collected at Lower Granite and Little Goose Dams in 1977 were in poor condition. Measurements of rate of descaling and delayed mortality after transport were the highest ever recorded. Precise cause was difficult to isolate. It probably was a combination of delay in migration and exposure to various facets of the collection and bypass system (see sections on "Research - Lower Granite Dam" and "Research - Little Goose Dam" for additional discussion).

The poorer quality and fewer numbers of smolts migrating to the upper dam in 1977 compared to previous years will probably result in a below-average return of adults from the 1977 outmigration. Even though many fish were of poor quality, mass hauling of 65% of the outmigration should assure return of sufficient numbers of adults to maintain most upriver stocks. If no fish had been hauled, there would have been a complete disaster. Over 95% of the fingerlings that did migrate would have died enroute to the ocean and fewer than 6,000 chinook salmon and 5,000 adult steelhead trout would have returned. (These data are based on returns from outmigrants in 1973 when similar, but less severe low flows existed.)

Table 1.--Number of Fingerlings Transported from the Snake River in 1977.

	Lower Granite Dam		
	Chinook	Steelhead	Total
Truck	750,895	554,951	1,305,846
Barge	214,809	163,515	378,324
Air	76,425	2,172	78,597

	Little Goose Dam		
	Chinook	Steelhead	Total
Truck	330,932	184,892	515,824

	Hatcheries		
	Chinook	Steelhead	Total
Kooskia (Barge)	360,000	--	360,000
Dworshak(Barge)	--	200,000	200,000

	Chinook	Steelhead	Total
TOTAL	1,733,061	1,105,530	2,838,591

Table 2.--Number of smolts and percent of total Snake River outmigration transported below Bonneville Dam 1971 to 1977.

	CHINOOK SMOLTS			STEELHEAD TROUT SMOLTS		
Year	No. at upper dam (1,000)	No. hauled (1,000)	% hauled	No. at upper dam (1,000)	No. hauled (1,000)	% hauled
1971	4,000	109	3	5,500	154	3
1972	5,000	360	7	2,500	227	9
1973	5,000	247	5	5,500	176	3
1974	3,500	Ø	Ø	5,000	Ø	Ø
1975	4,000	414	10	3,200	549	17
1976	5,000	751	15	3,200	435	14
1977	2,000	1,365	68	1,400	895	64

RESEARCH - LOWER GRANITE DAM

TRANSPORT EXPERIMENTS

Experimental Design and Procedures

Nine traveling screens provided full screening for three generating units at Lower Granite Dam; thus, diversion and collection of migrants for transportation was enhanced over previous years. Extreme low river flows eliminated spilling and further enhanced collection capability; for fish to pass the dam, they had to enter the generation units. Low flows also delayed the migration substantially; full operations didn't begin until 25 April, much later than in previous years.

The principal objective of research in 1977 was to examine whether large numbers of juvenile salmonids can be efficiently collected at Lower Granite Dam (nearer rearing areas than Little Goose Dam) and transported to locations below Bonneville Dam thereby increasing their survival without the migrants losing their homing ability. In question is the premise that if smolts are collected and transported too soon after they begin their seaward migration, it may result in returning adults straying due to destroyed or impaired homing ability. Therefore, it is especially important to test the transport concept at Lower Granite Dam because of its proximity to nearby rearing areas and compare the results with those obtained at Little Goose Dam where transportation has a known record of success.

Juvenile steelhead trout and chinook salmon collected were divided into six distinct groups--one control and five transported groups. The transported groups were hauled in trucks, planes, or barges. Two truck-transported groups were transported in 5 ppt salt water, Of these, one group was released at Dalton Point, Washington and the other group was released from a new location near Bonneville Dam at the south side of Bradford Island about 1/4 mile downstream from the powerhouse discharge. The two groups transported by airplane (PBY) were hauled in 5 ppt salt water; one group was released near Beacon Rock and the other near Astoria, Oregon (Tongue Point). The fifth group was transported by barge and was released below Bonneville Dam near Beacon Rock. The control group was transported in fresh water and released near Clarkston, Washington at the port of Clarkston barge loading facility on the south shore of the Snake River.

Each experimental group was marked with a distinctive wire tag code and brand symbol. Fish transported by truck and air had a fixed brand (nonrotated), whereas the fish in the control group had their brand rotated every 2 weeks. Fish in the barged group had a specific brand rotation (symbol) for each load. All fish had their adipose fin removed.

Evaluation of the survival and homing ability of all groups will be based on adult returns to the commercial fishery, Indian fishery, sports fishery, and the adult separator at Lower Granite or Little Goose Dams. Additional information will be collected from hatcheries and spawning ground surveys.

Juvenile salmonids guided into gatewell slots and thence through orifices into the bypass pipe were collected at the terminal end of the bypass system where they were held in raceways until fed by gravity into the holding tank in the marking facility. Fish were dip-netted from the holding tank into a sorting trough which contained a temperature controlled solution of MS 222 as an anesthetic. Previously marked, injured, or descaled fish were returned to the Snake River when marking for control or air transported groups; otherwise,they were transported downstream with the experimental groups.

Diverting, collecting, marking, and transporting all place a degree of stress on fingerlings; measures of descaling and delayed mortality provide criteria for assessment of this stress. Monitoring these parameters on smolts hauled each year from both Lower Granite and Little Goose Dams provides an index of fish condition in relation to efforts to reduce stress. In 1977, the rate of descaling on fingerlings at Lower Granite Dam was monitored at three locations: (1) in the forebay prior to entry into the turbine intake, (2) in the gatewell after diversion by the traveling screens, and (3) in the marking facility after passing through the bypass-collection system. Delayed mortality was measured on samples of fingerlings hauled by trucks.

Trucking

Chinook salmon and steelhead trout were hauled simultaneously, but in separate compartments in either 3,500 or 5,000-gallon tankers. All trucks used to transport test fish were equipped with life support systems consisting of filtration, aeration, and refrigeration units. Dissolved oxygen, carbon dioxide, and pH were taken as water quality measurements from trucks arriving at Bonneville Dam. Tank temperatures were monitored during transporting and filters were back flushed twice.

Samples of fish were taken from the transported groups and held 45 hours at Bonneville Dam to determine delayed mortality.

A total of 1,306,298 out of the 2 million smolts collected were hauled by truck to various release locations below Bonneville Dam. Of these, 126,794 chinook salmon and 116,828 steelhead trout were marked for subsequent evaluation of truck transportation experiments (Table 3). Appendix Tables 1 through 3 contain a detailed summary of all truck transport releases.

Delayed mortalities of transported chinook salmon and steelhead trout were more severe this year than in past years. In 1977, delayed mortalities of marked chinook salmon transported by truck in salt water ranged from 2.3 to 62.8% with an average of 30%. The delayed mortalities of unmarked chinook salmon varied from 5.3 to 67% with an average of 31.4%. In past years delayed mortalities ranged from 5 to 11%. In marked steelhead trout hauled in salt water, delayed mortalities ranged from 0 to 29.6% with an average of 6.5%, and the delayed mortalities of unmarked steelhead trout ranged from 0 to 40% with an average of 8.6%. In past years, delayed mortality of steelhead trout whether marked or unmarked was nil.

Salt treatment appeared to be of little or no value under conditions prevalent at Lower Granite Dam in 1977. The delayed mortality experienced with steelhead trout for the first time and the higher delayed mortality for chinook salmon resulted from the generally poorer condition of fish arriving at Lower Granite Dam in 1977 than in previous years. (See section on fish condition in relation to low river flows.)

Table 3.--Summary of transported marked and unmarked chinook salmon and steelhead trout collected at Lower Granite Dam by test condition and release sites, 1977.

	TRANSPORTED							
	MARKED				UNMARKED			
	SALTWATER		FRESHWATER		SALTWATER		FRESHWATER	
RELEASE SITES	Chinook (no.)	Steelhead (no.)	Chinook (no.)	Steelhead (no.)	Chinook (no.)	Steelhead (no.)	Chinook (no.)	Steelhead (no.)
Trucked (Test)								
Dalton Point	43,065	40,899	--	--	--	--	--	--
Powerhouse Tailrace	45,404	42,777	--	--	662,823	471,330	--	--
Air (Test) Bonneville	41,092	--	--	--	--	--	--	--
Estuary	35,333	--	--	--	--	--	--	--
Barged (Test) Below Bonneville Dam	--	--	31,628	30,330	--	--	183,181	133,195
Clarkston, WA (Control)	--	--	38,325	33,152	--	--	--	--
TOTALS	164,894	83,676	39,953	63,482	662,823	471,330	183,181	133,195

Flying

In 1977, we completed the fingerling marking phase of an air transport study designed to: (1) compare survival of chinook salmon fingerlings transported by air with survival of chinook salmon trucked and barged to release points below Bonneville Dam; and (2) determine if transporting smolts closer to the sea (near Astoria, Oregon) can further enhance their survival.

Chinook salmon smolts are more vulnerable to stresses and shocks than are steelhead trout; therefore, if transport stresses are significant, reduced transport time should benefit chinook salmon. Fish transported by air were handled and marked in the same manner as those hauled by truck or barge.

Air transporting of juvenile chinook salmon began on 29 April and 8 flights were made during the 14-day period ending 12 May 1977. In four flights a total of 41,092 marked chinook salmon smolts were flown in a PBY aircraft and air-dropped into the Columbia River below Bonneville Dam in the vicinity of Beacon Rock. A second drop zone was selected at Tongue Point near Astoria, Oregon where 35,333 marked fingerlings were released into the Columbia River. The average number of fish in each flight was 9,553. See Appendix Table 4 for specific marking data.

Fish behavior, water temperature, and dissolved oxygen were monitored during each flight. Fingerlings observed during flights were in good condition and appeared to be calm. Water temperature remained within one degree F of ambient river temperature and oxygen was in excess of saturation.

The feasibility of an air transport system cannot be fully evaluated until adults return. Only then can an economic value be placed on this system of transportation.

Barging

Shortly after the forecast of a record low runoff in the Snake River, the National Marine Fishereis Service alerted the Corps of Engineers that there would be insufficient numbers of trucks to haul all smolts collected during peak periods of downstream migration. The two agencies, working closely together, developed the concept of barging to supplement trucking during peak periods of migration. By 1 April, two barges were completed and available for testing.

Barge Design and Procedures

Two barges, modified for hauling fish, and a tugboat were used for the barging program. Each barge had a large tank 109 feet long and 28 feet wide. The cargo tank was divided into eight individual compartments by a longitudinal bulkhead and three transverse bulkheads. Hinged screens 9 feet by 3 feet were installed in the transverse bulkhead on each side of the longitudinal bulkhead. The six hinged screens, constructed of perforated plate (3/16 inch diameter perforations), permitted segregation of the fish.

Water was supplied to the barge by two diesel powered pumps; each pump had its own sea chest located near the bottom of the barge. A third standby pump was available in case a primary pump malfunctioned.

The total output of flow varied from 3100 to 5300 gpm depending on numbers of pumps used and idiosyncrasies of each pump. In addition to being able to pump water directly from the river, water could be recirculated in the barge by closing the sea chest valves and opening recirculation valves. (Each barge carried 15 oxygen gas cylinders which could be used in the event the recirculation system was required.) With two pumps operating (standard procedure) a complete turnover of water in the barge could be achieved in approximately 20 minutes. Oxygen levels under the spray bar were maintained near 100% saturation, and the values at different depths did not vary significantly. (The lowest recorded oxygen value in the aft compartment was 7.8 ppm at $55^{\circ}F$).

No specific temperature control equipment was incorporated in the barge. Consequently a wide range of water temperature was recorded in the barges due to changing meteorological conditions and different water sources. However, there was no increase in the water temperature between the forward and aft compartments.

Transported fish were released in the main channel of the Columbia River approximately 1.3 miles downstream from Bonneville Dam. We believe releases made in the main current reduces predation while enhancing dispersal and survival. Fish and water were released through two 10-inch diameter floor drains located in the stern of the cargo tank. While the juveniles were being discharged the tugboat was upstream from the barge backing into the current, thereby assuring that the fish weren't killed or injured by the tug's screws.

At Lower Granite Dam we modified the facilities by installing a 6-inch diameter, two-way valve so that fish could be either loaded directly into the barge or diverted to the marking building. A 4-inch diameter flexible hose was installed at the marking building so that marked fish could be piped to the barge.

Preliminary Tests

Juvenile fall chinook salmon from Spring Creek National Fish Hatchery were used to test the life support systems. Successful tests were conducted on 5 April with 50,000 fish and again on 11 and 12 April when approximately 2,000,000 fish were hauled from the hatchery to the release area below Bonneville Dam. On 19 April, approximately 360,000 spring chinook salmon from Kooskia Hatchery were barged from the Clearwater Arm of Lower Granite reservoir through all eight dams and reservoirs and released below Bonneville Dam. Following successful completion of this test, the tug and barges were dispatched to Lower Granite Dam and were available for the mass transport program.

Number of Smolts Transported and Mortality

From 5 April to 5 June 1977, a total of 3,517,242 juvenile salmonids were transported by barge from all sources to release points below Bonneville Dam (Table 4). The breakdown for the various species is as follows: coho salmon - 21,777; chinook salmon - 3,111,159; and steelhead - 384,306. Of these, 356,000 were marked for subsequent evaluation of the barging experiments.

Table 4.--A summary of transportation of juvenile salmonids by barging completed during the spring of 1977.

DATE (loading started) mo/day/yr	SPECIES	NUMBER Unmarked	NUMBER Marked	SOURCE	LOADING SITE	REMARKS
4/5/77	Fall chinook salmon	50,160		Spring Creek National Fish Hatchery	Spring Creek National Fish Hatchery	
4/11/77	Fall chinook salmon	935,939	76,057	Spring Creek National Fish Hatchery	Spring Creek National Fish Hatchery	
4/12/77	Fall chinook salmon	999,575		Spring Creek National Fish Hatchery	Spring Creek National Fish Hatchery	
4/19/77	Spring chinook salmon	329,430	31,200	Kooskia Nat'l Fish Hatchery	Lewiston, Idaho	Loaded barge remained in Clearwater River for 14 hours.
4/22/77	Coho salmon		21,777	Willard Nat'l Fish Hatchery	Drano Lake, Washington	
5/4/77	Chinook salmon Steelhead	103,200 70,118	10,510 10,115	Collector at Lower Granite Dam	Lower Granite Dam	
5/5/77	Steelhead	155,148	17,178	Dworshak National Fish Hatchery	Lewiston, Idaho	All fish, except last load of 28,200 remained in Clearwater River for 12 hours
5/26/77	Chinook salmon Steelhead	24,498 36,695	10,198 10,097	Collector at Lower Granite Dam	Lower Granite Dam	
6/1/77	Fall chinook salmon	241,000		Priest Rapids spawn. channel	North Richland Washington	
	Steelhead		48,455	Leavenworth National Fish Hatchery	"	Originally, fish came from Chelan Hatchery
	Summer chinook salmon	133,876	99,113	Wells spawning channel	"	
6/2/77	Chinook salmon Steelhead	55,483 26,382	10,920 10,118	Collector at Lower Granite Dam	Lower Granite Dam	An additional 110 adult steelhead (spawned out) were also transported.
TOTALS		3,161,504	355,738			

The majority of the fish were barged from hatcheries. Relatively few fish were hauled from Lower Granite Dam because the large numbers of fish originally anticipated (4 to 5 million) were not captured at the collector. At Lower Granite Dam we barged about 375,000 fingerlings. Of these about 62,000 were marked to evaluate the effect of barging vs. other transport modes. See Appendix Table 5 for specific marking data.

The estimated mortality rates of the transported Lower Granite chinook salmon and steelhead trout were 3.6 to 7.5% and 2.2 to 5.3%, respectively; however, the greatest percentage of these deaths was due to debilitated condition of the fish prior to loading. Mortality associated with the loading, transporting, and unloading was estimated to be less than 0.5%.

TRAVELING SCREEN STUDIES

In 1977, Lower Granite Dam became the first dam on the Columbia River system to have fully screened operating turbines. However, because of low spring runoff, one or more generators ran on an intermittent schedule. Priority for operation was, therefore, placed with Unit 1 which had three of the new adjustable angle traveling screens installed. Units 2 and 3 were screened with standard traveling screens and operated whenever sufficient water was available.

Traveling screen research in 1977 had the following objectives: (1) monitor the prolonged operation of standard traveling screens in all bulkhead slots of Units 2 and 3 while providing diversion of fingerlings for collection and transportation; (2) monitor the condition of fingerlings after they entered the bulkhead slots; and (3) test and evaluate the adjustable angle traveling screens for guidance and descaling effects on natural migrant chinook salmon smolts in relation to optimum screen angle, percent open-area perforated plate, lighting condition, and the preferable slot (bulkhead or fish screen) for operation.

Monitoring - Standard Traveling Screen

During 1977, the standard traveling screens operated without mechanical problems. Minimal wear was noted on drive chains, wire mesh, and guide material. Because of our research findings during the fall tests of 1976, all standard traveling screens were equipped with intermediate mesh (72 x 36 x 16 mesh per foot) over 33% perforated plate.

Descaling and injury of fingerlings in the bulkhead slots of Units 2 and 3 were monitored regularly throughout the season. Criteria for determining descaling in 1977 was the same as used in previous years. (Fish with more than 10% of their scales missing were classified as descaled.) The average descaling rate for chinook salmon was 27% in the "B" slots and 24% in the "C" slots. The average descaling rate for steelhead trout was 18% in the "B" slots and 16% in the "C" slots. Total average descaling for the two units was 26% for chinook salmon and 17% for steelhead trout. The "A" slots of units 2 and 3 were not monitored due to releases of post examined fish into the slots.

Descaling of both chinook salmon and steelhead trout was over three times as high as found in previous years (Figure 1). Although high descaling was measured following diversion by traveling screens,

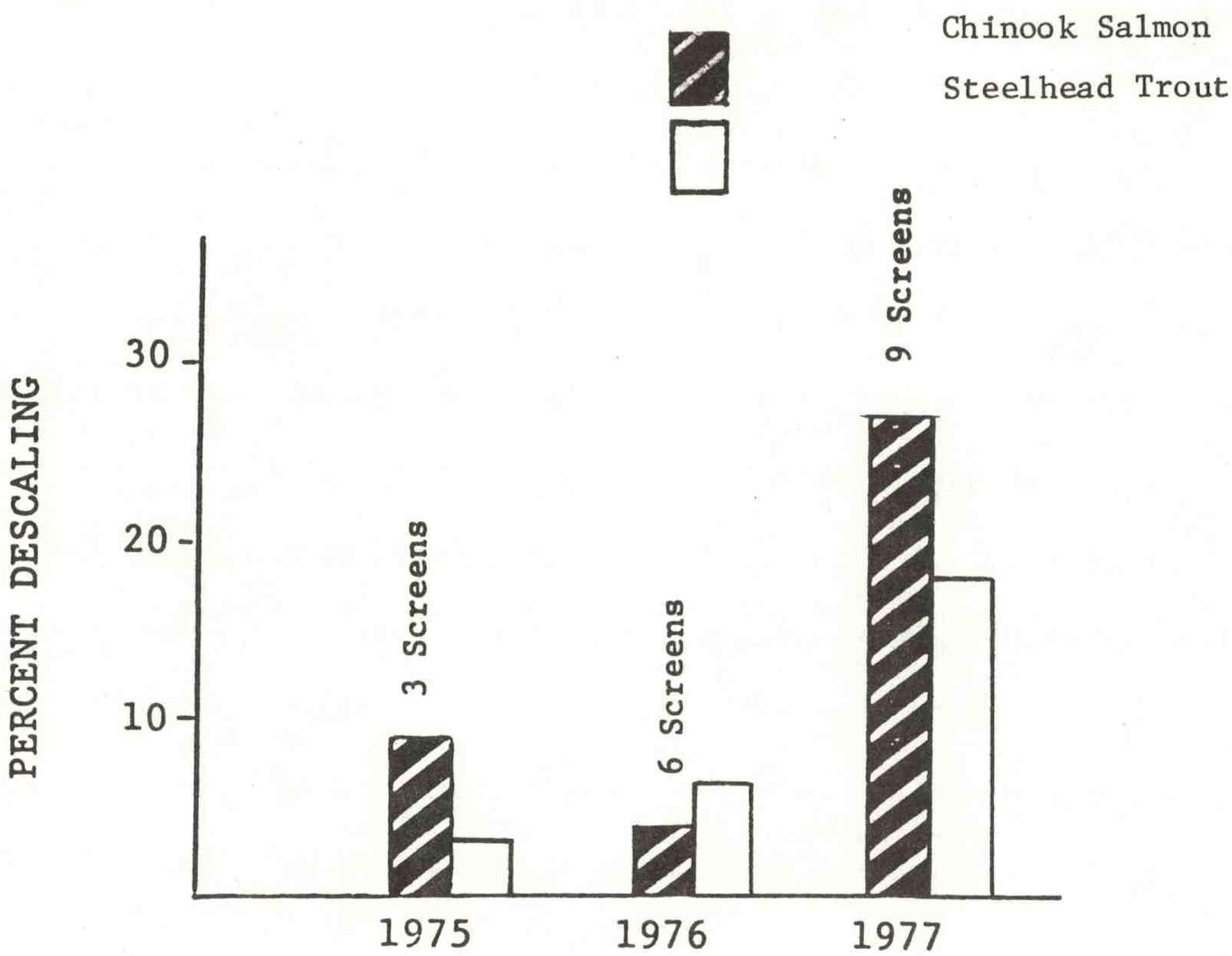

Figure 1.--Descaling of naturally migrating chinook salmon and steelead trout in relation to traveling screen operations 1975-77 at Lower Granite Dam.

other factors such as delay in migration and poor condition of fish may have been contributing to descaling (see section on fish condition).

Testing - Adjustable Angle Traveling Screens

In 1977, operation of the adjustable angle traveling screens was much improved over 1976. In addition to the 1976 prototype screen, two more adjustable angle traveling screens purchased prior to the field season were operated in Unit 1.

Despite problems with low flow, higher water temperature, and crowding of fish, our research objectives were achieved. During the spring and fall testing in 1976, we obtained valuable data on the new screen using pre-smolt hatchery chinook salmon. In 1977, we were able to verify this information using natural migrant fingerlings as test fish.

Procedures

Test fish released through hoses into the turbine intakes and recovered in the gatewells provided data on descaling and guiding during the following test conditions:

1. Adjustable angle traveling screen backed with 33% open area perforated plate; screen angle varied from 50 to 65° in 5° increments; and turbine load (155 megawatts), screen lighting (on), and area of operation (bulkhead slot) held constant.

2. Adjustable angle traveling screen backed with 48% open area perforated plate; screen angle and area of operation (bulkhead or fish screen slot) varied; and screen lighting (on) and turbine load (155 megawatts) held constant.

3. Adjustable angle traveling screen in a nonoperating mode; percentage open area of perforated plate and screen angle varied; and screen lighting (on) and turbine load (155 megawatts) held constant.

4. No traveling screen installed and turbine loads of 135 and 155 megawatts.

Test fish were natural migrant spring chinook salmon collected in the forebay by purse seine and tattooed in lots of 150 fish each. Each release (replicate) was made up of one lot; three replicates totaling 450 fish made up a test group.

Each lot of fish was introduced into the "B" slot of Unit 1 turbine intake through a 4-inch diameter hose placed behind the trash rack and held in place (by cable) about 15 feet upstream from the traveling screen and 4 to 6 feet from the intake ceiling (Figure 2).

Lighting for the adjustable angle screens was provided by an array of twelve 500 watt incandescent bulbs attached to a framework welded to the back side of the screen. Lights were spaced so that the entire screen was illuminated. No illumination was provided at the slot entrance. All tests were conducted with lights on at 155 megawatt turbine loading; the condition found to be optimum in fall tests conducted in 1976.

During tests, the orifices in the test slots (1-B bulkhead or fish screen slot) were closed to prevent egress of fish. Tests were evaluated by dip-netting the slot after each test group (3 lots) was released. The number of fish recovered compared to number of fish

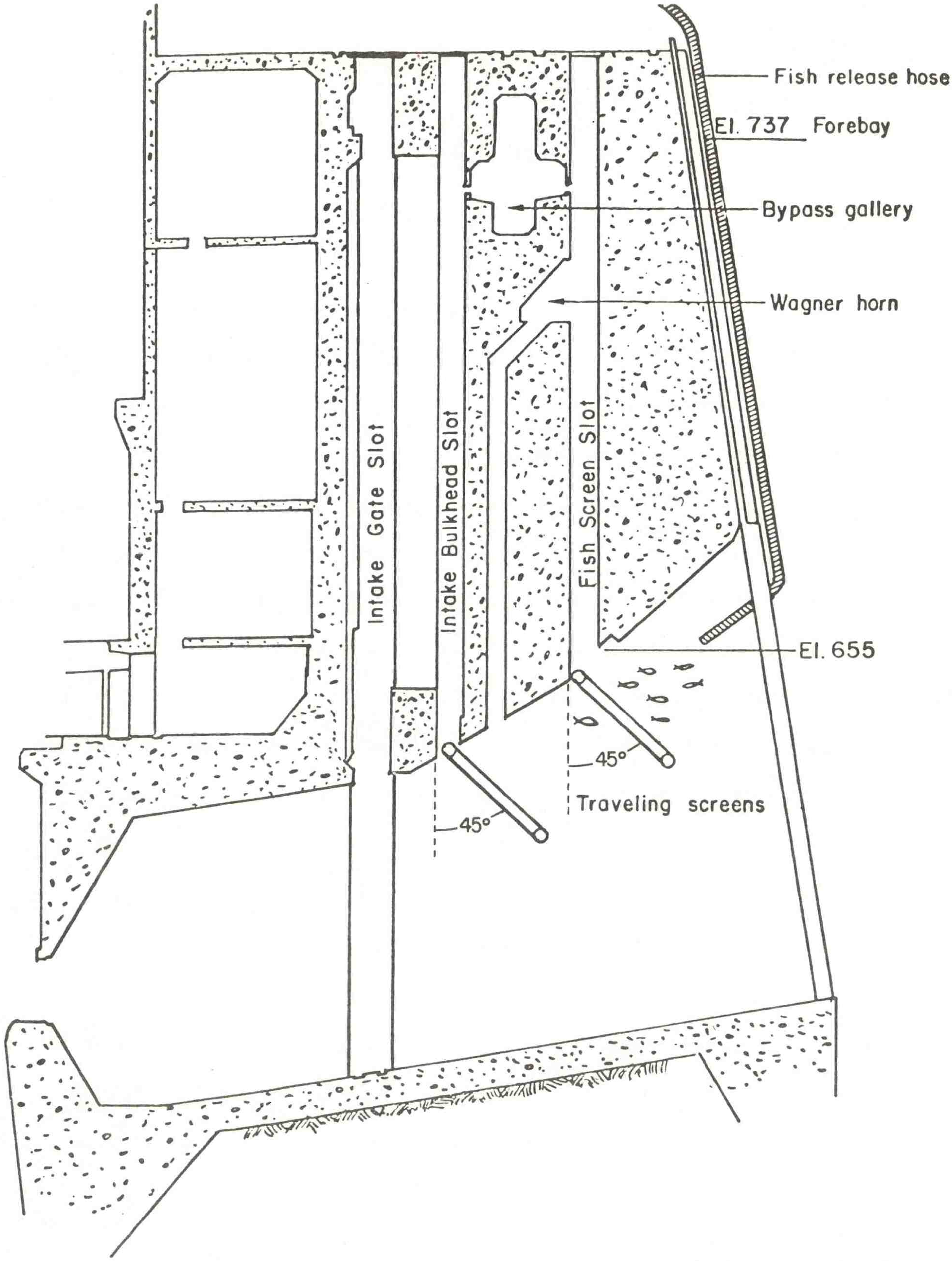

Figure 1.--Schematic drawing of traveling screen placement in the turbine intake at Lower Granite Dam. Traveling screens were tested in either the intake bulkhead slot or the fish screen slot at various angles from vertical (a screen angle of 45° is illustrated).

released provided a measure of guiding efficiency. All fish recovered were examined for descaling and the standard descaling rate was determined.

Results

A composite of 12 test results ranked by average percentage of fish recovered is given in Table 5. Pertinent findings include the following:

(1) Best guidance and lowest rate of descaling occurred with the screen equipped with 33% perforated plate in the bulkhead slot. The average percent recovery for fish during tests with perforated plate at all angles (50 to 65°) in the bulkhead slot was 84%. This compared well with an average recovery of 83% for the same angles tested in 1976. The average descaling of natural migrants in tests with the 33% perforated plate was a low 8% in 1977.

(2) With 48% perforated plate, guidance declined to 64% and rate of descaling increased to an average of 45%.

(3) As in previous years, poorest guidance (55%) occurred with traveling screens in the fish screen slot.

(4) With the screen in a non-traveling mode, recovery of fish was high (70 to 82%) in each test. Descaling was low when tests were made with 33% perforated plate, but increased significantly when 48% plate was used.

Table 5.--Results of tests using modified adjustable angle traveling screens with either a 33% or 48% perforated plate at selected operating conditions. All tests were conducted at turbine loads of 155 megawatts with lights on.

Order of results	Average recovery 1/ (%)	Average descaling 2/ (%)	Screen angle (degrees)	Perforated plate (% open area)	Slot
1	90	9	65	33	BHS
2	84	6	60	33	BHS
3	82	6	50	33	BHS
4	80	12	55	33	BHS
5	75	11	65	48	BHS
6	72	51	60	48	BHS
7	62	54	55	48	BHS
8	57	20	50	48	FSS
9	57	25	65	48	FSS
10	56	20	60	48	FSS
11	48	24	55	48	FSS
12	48	62	50	48	BHS

1/ Percentage of fish released into the turbine intake recovered in the gatewell.

2/ Percentage of fish having 10% or more of their body descaled.

(5) Traveling screens significantly enhanced collection of fingerlings from turbine intakes. Recovery rate without a traveling screen averaged 21%, compared to 84% with a screen installed.

(6) The descaling rates for fish recovered from releases made without a traveling screen were as high or higher (16 to 38%) than the rates measured in the first five-ranked tests in Table 5.

It is obvious that handling fish for marking, coupled with their release through hoses, subsequent recovery, and further handling produced significant descaling. In some cases, as indicated in (6) above, descaling was greater due to handling alone than was due to handling in combination with specific screen tests. What can account for this anomaly? We feel that the primary reasons are that the fish (chinook salmon in particular) were in generally poor condition throughout the season, and their condition varied depending upon the degree of stress that they encountered prior to their arrival at Lower Granite Dam.

CONDITION OF FINGERLINGS IN RELATION TO LOW RIVER FLOWS

Smolts diverted by traveling screens and subsequently hauled from Lower Granite Dam were in very poor condition in 1977. Also, far fewer migrants arrived at Lower Granite Dam than were expected. Fewer fish and their poor condition may be attributed, at least in part, to all-time low tributary and Snake River flows. Smolt condition, as evidenced by descaling, was monitored throughout the season. Descaling rates were extremely high--higher than could logically be attributed to a single incident such as a one time contact with traveling screens.

About 1 May, juveniles entering the gatewell slots and collection system were observed to be more easily descaled. This activity coincided with large numbers of fish (80,000+) entering the system daily. Trash racks were cleaned but high descaling did not subside. It was then decided to purse seine fingerlings from the forebay to determine their general condition and degree of descaling.

Initial purse seining was restricted to a narrow area 50 to 100 yards upstream from the powerhouse intakes. Approximately 2800 chinook salmon were captured. Subsamples indicated that 10 to 14% were descaled depending upon the particular seine set and location. By contrast, fish from sets made between 300 yards and 2 miles upstream were essentially clean (nondescaled). On six different days between 24 May and 14 June, a total of 2530 (nondescaled) chinook salmon were tattooed and released at various locations from 50 yards to 2 miles in front of the powerhouse. Descaling measured after collection of these fish from gatewells ranged from 14 to 33%, approximately the rate measured on other chinook salmon examined from gatewells. From these data it is obvious that descaling must be occurring at the dam and not in the forebay. The fact that significant descaling (10 to 14%) was measured close to the powerhouse suggested that fish may be swimming in and out of the intakes--possibly at times when loads were adjusted, or when insufficient velocity was available to draw fingerlings through the turbines.

In a further effort to assess fish condition, fish captured from the forebay, gatewells, at the fingerling sorter, and various points in the handling process were blood-sampled for electrolyte imbalance and depressed plasma-chloride--known stress indicators. Blood chemistry analysis was designed to show where stresses may occur in the collection and handling processes. Juvenile spring chinook salmon tested appeared outwardly to be in excellent condition. Descaled fish were assumed to be stressed and therefore not tested. The most severe plasma-chloride depression (stress) was noted when fish were dip-netted from the gatewell into holding tanks and then hand brailed into anesthetic troughs for subsequent examination. Similar chloride depression was observed when fingerlings were hand brailed into the sorting trough at the marking facility just prior to marking for transportation studies.

Somewhat surprisingly, fish sampled after purse seine collection, after tattooing at the purse seine, above and below the fingerling grader apparatus, and from the holding box in the marking building, did not show any significant plasma-chloride depression. After sorting in the marking building, fingerlings are cold branded, adipose fin clipped, and coded wire tagged. Although these fish were somewhat stressed by the brailing and sorting process, no further stress was noted due to freeze branding or other marking processes.

It appears that most stresses in our collection-handling processes are due to handling and not collection. If this analysis is correct, mass transported fish should fare far better than marked (handled) fish since mass transported fish are not removed from their environment.

MASS TRANSPORTATION EXPERIMENTS

Mass hauling of juvenile salmonids began in 1976 as a 3-year program. During 1977, the objective of the transport research at Little Goose Dam was the continuance of a mark and release study to evaluate the potential of mass hauling juvenile chinook salmon and steelhead trout to increase their survival.

Experimental Design and Procedures

In 1977, mass transportation research began at Little Goose Dam on 29 April. Collection of fingerlings throughout the migration period was partially limited as Unit 3 had no traveling screens in place for diverting fish into the bypass collection system. Units 1 and 2 had both traveling screens and vertical screens, and Unit 3 contained vertical screens only. Both juvenile chinook salmon and steelhead trout were marked and released in three lots: one lot (a control) was released at Little Goose Dam tailrace (frontroll of turbine), and the other two lots (test) were transported to and released at a site below Bonneville Dam--one lot hauled in fresh water and one lot in 10 ppt salt water. Distinctive wire codes and brands identified time and location of release.

Unmarked fish were transported to and released at our Bonneville site. Handling, marking, and transporting operations were similar to those used at Little Goose Dam in 1976. Fingerlings were transferred either from the raceways into a transport truck (unmarked fish) or into the marking facility via a fish loading hopper. The hopper, containing approximately 175 gallons of water and 3,000 fish, was lifted from the raceway and emptied in 30 seconds.

Rate of descaling (chinook salmon and steelhead trout), incidence of gas bubble disease (chinook salmon), amount of fungus (steelhead trout), and the amount of delayed mortality (chinook salmon and steelhead trout) were criteria used to evaluate the quality of fingerlings hauled from Little Goose Dam.

Numbers and Conditions of Smolts Transported

About 669,000 salmonids were counted at the fingerling facility at Little Goose Dam in 1977--417,740 chinook salmon, 248,189 steelhead trout, and 3,500 sockeye and coho salmon. Of this total counted, 123,357 chinook salmon, 69,392 steelhead trout, 163 sockeye salmon, and 121 coho salmon were marked for the mass transportation experiment (Table 6). (See Appendix Table 7 for more details of marking by test groups.) In addition, a total of 237,381 unmarked chinook salmon, 129,164 unmarked steelhead trout, and about 3,000 unmarked sockeye and coho salmon were transported to release areas below Bonneville Dam (Table 7). Pond holding mortalities totaled approximately 2% of the chinook salmon collected and 4% of the steelhead trout collected. In conjunction with other studies an additional 37,405 chinook salmon and 19,751 steelhead trout were released into the tailrace at Little Goose Dam (backroll of turbine).

Table 6.--Summary of fingerlings collected at Little Goose Dam, marked, and then transported by truck to Bonneville Dam (test) or released at Little Goose Dam (control), 1977.

Release site and transport medium	Chinook Salmon	Steelhead Trout
	(no.)	(no.)
Bonneville Dam		
Salt Water	43,334	22,916
Fresh Water	41,677	24,272
Little Goose Dam - Tailrace	38,346	22,204
Total Marked	123,357	69,392

Table 7.--Summary of fingerlings collected at Little Goose Dam and transported unmarked by truck below Bonneville Dam, 1977.

Release site and transport medium	Chinook Salmon	Steelhead Trout
	(no.)	(no.)
Bonneville Dam		
Salt Water	106,992	59,371
Fresh Water	130,389	69,793
Total Hauled Unmarked	237,381	129,164

During the 1977 fingerling migration, salmonids were subjected to a no-spill year at Little Goose Dam and were in generally poor physical condition. The salmonids collected at Lower Granite Dam had a high incidence of descaling present and generally were in poor physical condition, as previously discussed. Fingerlings arriving at Little Goose Dam had passed through the turbines at Lower Granite Dam and were further stressed by this experience. The average rate of descaling for chinook salmon was 23.9% and ranged from 6.0 to 49.2%, more than twice the rate measured at Little Goose in 1976. The average rate of descaling for steelhead trout was 30.2% with a range of 7.1 to 42.0%--very little descaling was observed in 1976. The high descaling rate among fingerlings in 1977 resulted from the poor physical condition of arriving fish, compounded by the inefficient orifice bypass system and collection facilities at Little Goose Dam. As a result, there were significantly higher mortalities among fish held and transported than in previous years.

Gas bubble disease was minor this season with an average incidence of 11.6% and a range from 0 to 43.0%. Excessive N_2 levels were due to the bypass pipe which allowed air to be entrapped under pressure in the collection system.

Another criteria used for determining fish quality was the presence of fungus (Saphrolegnia) on steelhead. Basically we sampled for fungus from 11 through 31 May, from the onset of Saphrolegnia to the disappearance of the disease. The average incidence of fungus was 24.5% with a range from 1.3 to 44.0%.

Mortality of fish during transport to the Bonneville release site differed between saltwater and freshwater hauls. Average transport mortality for chinook salmon hauled in salt water was 0.48% compared to 1.27% in freshwater hauls. Average transport mortality for steelhead trout was 0.53% for saltwater and 1.08% for freshwater hauls, indicating a greater mortality from the freshwater loads. Mortality observed this year was higher than the 1976 transport mortality, which was: chinook salmon, 0.04% in salt water and 0.56% in fresh water and steelhead trout, 0.06% in salt water and 0.47% in fresh water.

Delayed mortality of fish was compared among the following groups: (1) marked and unmarked chinook salmon, (2) marked and unmarked steelhead trout, and (3) freshwater and saltwater loads. Samples of fish obtained from loads transported to Bonneville Dam were held for 45 hours to determine delayed mortality. Data obtained are summarized in Table 8. The average delayed mortality rates of 21.3 to 42.5% for chinook salmon and 10.5 to 16.1% for steelhead trout are much higher than the average delayed losses for chinook salmon (3 to 6%) and steelhead trout (0.1 to 0.3%) mass hauled last year. Similar data were measured on fingerlings transported from Lower Granite Dam. These data reflect the poor quality of fingerlings mass hauled from both dams in 1977.

NEW ORIFICE CONFIGURATION TESTS

The new orifice system was installed at Little Goose Dam as proposed. Low water and subsequent need of the units for power generation to avoid spilling delayed installation until mid-June--at which

Table 8.--Delayed mortality of marked and unmarked chinook salmon and marked and unmarked steelhead trout held 45 hours at Bonneville Dam after transport from Little Goose Dam in fresh water or salt water (10 ppt).

	Mortality Range (Average)	
	Salt Water (%)	Fresh Water (%)
Marked chinook	10.0 to 54.8 (29.6)	16.7 to 73.8 (42.5)
Unmarked chinook	10.5 to 38.5 (26.0)	12.5 to 41.6 (21.3)
Marked steelhead	0.0 to 40.0 (11.6)	0.0 to 30.2 (11.1)
Unmarked steelhead	5.5 to 20.0 (10.5)	5.0 to 25.0 (16.1)

time smolts were no longer available to test the system. All mechanical operations have been fully checked out, and evaluation has been rescheduled for the spring of 1978.

PRELIMINARY RETURNS OF ADULT CHINOOK SALMON TO LITTLE GOOSE DAM

1975 Outmigration

Returns of 1- and 2-ocean age spring and summer chinook salmon to Little Goose Dam from juveniles marked and released from Lower Granite Dam in 1975 indicate that survival from transported releases was greater than survival from control releases. There is little difference in the transportation benefit between fish wire tagged only (59%) and fish branded and wire tagged (58%) (Table 9).

1976 Outmigration

Very few jack chinook salmon have returned to Little Goose Dam from juvenile releases made in 1976: returns from Little Goose Dam--9 transports and 1 control, from Lower Granite Dam--5 transports and 2 controls.

PRELIMINARY RETURNS OF ADULT STEELHEAD TROUT TO LITTLE GOOSE DAM

1975 Outmigration

Through 30 November 1977, 831 marked 1- and 2-ocean adult steelhead trout from control and transport releases of juveniles from Lower Granite Dam in 1975 have returned to Little Goose Dam. Returns from the Bonneville Dam release site indicate a transport to control benefit of 203% for fish which had been branded and wire tagged and 161% for fish which were wire tagged only (Table 10).

Table 9.--Returns to Little Goose Dam of 1- and 2-ocean chinook salmon from control and transport releases of smolts from Lower Granite Dam in 1975. Recovery period 13 April 1976 to 30 October 1977.

Release site and experimental group	Number of juveniles released 1/	Number of adults recaptured			Adult return in % of juveniles released 2/		Transport benefits 3/ (%)
		1-ocean age	2-ocean age	Total (1 & 2's)	Observed	Estimated	
Lower Granite Dam 4/ (control)	42,915	12	56	68	0.158	0.417	-
Bonneville Dam (transport) Brand & wire tag	30,127	32	43	75	0.249	0.610	58.0
Wire tag only	38,423	30	67	97	0.252	0.640	59.0
TOTAL RECOVERY	111,465	74	166	240			

1/ Adjusted for initial tag loss.

2/ Based on comparison of known recovery of fish with magnetized wire tags at Little Goose Dam and the subsequent recovery of these and other marked fish at Rapid River Hatchery and on spawning ground upstream from Little Goose Dam. Returning fish identified at the dam were marked with jaw tags and released to continue their migration upstream. Numbers of externally-tagged fish arriving at up-river sites were compared with the recovery of other wire tagged fish arriving at up-river sites not previously detected and identified at Little Goose Dam.

3/ Based on observed return.

4/ Adjusted for control fish which were transported from Little Goose Dam.

Table 10.--Returns to Little Goose Dam of 1- and 2-ocean age adult steelhead trout from control and transport releases of smolts from Lower Granite Dam in 1975. Recoveries were made from 1 July 1976 to 30 November 1977.

Release site and experimental group	Number of juveniles released 1/	Number of adults recaptured: 1-ocean age	Number of adults recaptured: 2-ocean age	Number of adults recaptured: Total 1 & 2's	Adult return in % of juveniles released 2/: Observed	Adult return in % of juveniles released 2/: Estimated	Transport Benefits 3/ (%)
Lower Granite Dam 4/ (control)	46,823	57	124	181	0.387	0.511	-
Bonneville Dam Brand & wire tag (transport)	24,078	100	182	282	1.171	1.546	203.0
Wire tag only (transport)	36,397	135	233	368	1.011	1.335	161.0
TOTAL	107,298	292	539	831			

1/ Adjusted for initial tag loss.

2/ Based on comparison of known recovery of fish with magnetized wire tags at Little Goose Dam and the subsequent recovery of these and other marked fish at Dworshak National Hatchery upstream from Little Goose. Returning fish identified at the dam were marked with jaw tags and released to continue their migration upstream. Numbers of externally-tagged fish arriving at Dworshak Hatchery were compared with the recovery of other wire tagged fish arriving at Dworshak Hatchery not previously detected and identified at Little Goose Dam.

3/ Based on observed return.

4/ Adjusted for control fish which were transported from Little Goose Dam.

Contribution of Transportation in 1975 to Adult Steelhead Trout Returning to Dworshak Hatchery in 1976-77

Marking studies to evaluate transportation of smolts from Lower Granite Dam began in late April 1975. Similarly mass transportation began at Little Goose Dam, but without marking for evaluation. Estimates of the contribution of transportation from both Lower Granite and Little Goose Dams based on returns from those marked at Lower Granite Dam are difficult to compute because limited numbers were marked and those marked were not necessarily representative of the total outmigration passing either Lower Granite or Little Goose Dams. For example, much of the migration from Dworshak Hatchery had already passed Lower Granite Dam by the time sampling commenced. (Only 15% of the total number of steelhead trout passing Lower Granite Dam were of Dworshak Hatchery origin as compared to 44% at Little Goose Dam--determined from presence of marked fish in the samples inspected daily at the dams.) However, in the case of returning Dworshak steelhead trout, it is possible to obtain some measure of transportation benefit since 194,000 or 11% of the 1,762,000 fish released from the hatchery in 1975 were marked by coded wire tag and by removal of the adipose fin.

This fall 2,709 Dworshak Hatchery marks were observed by NMFS at the adult facility at Little Goose Dam. Assuming unmarked fish returned at the same rate, the total 2-ocean return of Dworshak Hatchery steelhead trout passing Little Goose Dam would be 24,600 ($2709 \div 0.11$). The assumption is reasonable since 11% of the 1-ocean return were wire tagged as juveniles.

The actual return to the hatchery could vary from the 24,600 estimate depending on (1) fallback rate of adults at the dam (could cause the 2,709 figure to be inflated), (2) trap efficiency (if less than 100%, the 2,709 figure would be low)--and (3) numbers caught in the sport fishery or straying (could reduce the number returning to the hatchery).

It appears that transportation from Little Goose and Lower Granite Dams in 1975 had a significant beneficial impact on the impending excellent return of steelhead trout to Dworshak Hatchery in 1977 (1978 spawning). The best previous return to Dworshak Hatchery was about 0.6% of the total release of smolts. The observed return of marked fish to Little Goose Dam this year is 1.4%. If we assume that the difference is due to transportation then the benefit from transporting Dworshak Hatchery fish in 1975 is 55 to 60% ($1 - \frac{0.6}{1.4} = 1 - 0.43$ or 57%). To support this assumption, we reviewed how many Dworshak Hatchery smolts were transported in 1975, and examined the returns back to Little Goose Dam of 1- and 2-ocean steelhead trout from the control releases at Lower Granite Dam, and related these to returns of 1-ocean steelhead trout to the hatchery.

In 1976, there were 12 marked controls from Lower Granite Dam tests that returned as 1-ocean steelhead trout to Dworshak Hatchery. This is 17.4% of all Lower Granite Dam controls--further confirming our estimate of the Dworshak Hatchery contribution (15%) at the time of outmigration. However, of transported fish returning as adults from smolts transported in 1975, only 27 of 285 1-ocean returns were of Dworshak Hatchery origin. By this analysis about 9.5% of the 60,475 total steelhead trout transported or 5,745 smolts were actually Dworshak Hatchery stock.

Since the previous analysis shows a variation in percent of Dworshak Hatchery smolts in groups marked at Lower Granite Dam from 9.5 to 17.4%, we can indicate a range of transport contributions of adults returning to Dworshak Hatchery.

We estimate the range in contribution of transported fish to the total number of adults returning to Dworshak Hatchery in 1978 to be between 36 and 65% or 8,864 to 15,271 fish (Table 11). The large benefit realized from transporting juveniles of Dworshak Hatchery origin does not necessarily apply to other stocks of steelhead trout in the Snake River. (The return rate of steelhead trout from Dworshak Hatchery has always been significantly lower than the return rate of the overall Snake River run (Raymond 1975).) However, it is apparent that intercepting steelhead trout from Dworshak Hatchery early in their seaward migration and transporting them around dams can bring positive benefits.

The rationale and computations used to estimate the range in transport contribution for adults returning to Dworshak is contained in Appendix A.

1976 Outmigration

In 1976, we used two release sites at Bonneville Dam. From 12 April to 5 May, the release site was on the north shore, 1 mile below Bonneville Dam at the Washington Department of Game's boat ramp (this was our Bonneville Dam release site for the past several years). At the end of April it was discovered that rock fills and roads had been placed across the high water channel downstream from our point of release. This construction destroyed the effectiveness of the release site during high water periods by creating a cul-de-sac.

Table 11. -- Computations for range of transport contribution for adult steelhead trout returning to Dworshak Hatchery in 1977-78 based on smolts marked and subsequently transported from Lower Granite Dam and unmarked smolts transported from Little Goose Dam in 1975.[1/]

	Range	
	Low	High
Percent of Dworshak Hatchery smolts in marked groups at Lower Granite	17.4%	9.5%
Number of Dworshak Hatchery smolts transported from Lower Granite	10,522	5,745
1-ocean age Dworshak Hatchery adults returning from transport group	27	27
Return rate (1-ocean)	0.257%	0.470%
Predicted 2-ocean age Dworshak Hatchery adults returning from transport group[2/]	412	412
Return rate (2-ocean)	3.92%	7.17
Number of Dworshak Hatchery smolts transported (Little Goose and Lower Granite Dams)	226,122	221,345
Predicted total of adults returning to Dworshak Hatchery due to transport	8,864	15,871
Percent of Dworshak Hatchery run contributed by transportation[1/]	36%	65%

1/ Assuming that approximately 24,600 adults will return to Dworshak Hatchery in 1977-78 spawning year.

2/ See Appendix A for computation of predicted 2-ocean adults of Dworshak Hatchery origin returning from transport group.

A new release site was developed at the south side of the Bonneville Dam Powerhouse. Fish were released through a 6-inch diameter aluminum pipe into the outflow from the ice-trash sluice channel. Releases at this site were initiated on 6 May and continued to the end of the season.

Returns to date of 1-ocean steelhead trout indicate considerably higher transport benefit for those hauled from Little Goose Dam as compared to steelhead trout transported from Lower Granite Dam in 1976 (Table 12). Transport to control benefits from the boat ramp releases were 782% for fish transported in fresh water and 613% for fish transported in salt water (10 ppt). The transport benefits from the powerhouse releases were 136% for fish transported in fresh water and 190% for fish transported in salt water. By contrast, returns from those hauled from Lower Granite Dam showed transport to control benefits from the powerhouse releases of 15% for fish hauled in fresh water and 30% for fish hauled in salt water (5 ppt). Returns from the boat ramp releases indicated only a 2% transport benefit for fish hauled in fresh water and a 6% loss for fish hauled in salt water.

The lower return rate for 1-ocean fish from juveniles transported from Lower Granite Dam in 1976 is a concern to NMFS. As a result of these findings, major research objectives for 1978 were shifted to provide a means of determining the cause of the differential return rate for steelhead trout transported from Little Goose and Lower Granite Dams.

Benefits relating to the use of salt water in transport remain unclear at this point. Benefits were inconsistent for hauls from both dams.

Based upon the high return (0.599 to 0.741%) of steelhead trout transported from Little Goose Dam to the Bonneville boat ramp site, it would appear that release site is a more significant element in

Table 12.--Preliminary returns to Little Goose Dam of 1-ocean age adult steelhead trout from control and transport releases of smolts from Lower Granite and Little Goose Dams in 1976. Recoveries were from 28 May 1977 to 30 November 1977.

Release site and experimental groups	Little Goose Dam: Number released 1/	Number	Percent	Transport benefits (%) 2/	Lower Granite Dam: Number released 1/	Number	Percent	Transport benefits (%) 2/
Control 3/	7,135	6	0.084		16,791	27	0.161	
Bonneville Boat Ramp Freshwater (transport)	10,666	79	0.741	782.0	7,304	12	0.164	2.0
Salt water 4/ (transport)	11,677	70	0.599	613.0	16,504	25	0.151	-6.0
Control 3/	22,279	33	0.148		17,114	33	0.193	
Bonneville Powerhouse Freshwater (transport)	32,621	114	0.349	136.0	47,392	105	0.222	15.0
Saltwater 4/ (transport)	42,197	181	0.429	190.0	52,641	132	0.251	30.0
TOTAL	126,575	483			162,707 157,746	334		

1/ Adjusted for initial tag loss.

2/ Based on observed return.

3/ Adjusted for control fish which were transported in the mass transport program at Little Goose and Lower Granite Dams.

4/ 10 ppt salt water at Little Goose Dam and 5 ppt salt water at Lower Granite Dam transport consideration than is the use of salt water during transit. Research aimed at locating optimum sites for releasing transported fish should be continued.

RETURN OF ADULTS TO HATCHERIES, SPAWNING GROUNDS, AND THE INDIAN FISHERY

Enumeration of adults returning to the collection facility at Little Goose Dam is the primary means for evaluation of the collection-transport process. However, adult returns to other sources provide valuable insight regarding reliability of the transport benefit estimates and may indicate whether homing of transported fish is affected by transportation.

RETURN OF ADULTS TO HATCHERIES AND SPAWNING GROUNDS ABOVE LITTLE GOOSE DAM

As of 30 November, 44 marked adult chinook salmon from 1975 transport and control releases were recovered above Little Goose Dam--33 at Rapid River Hatchery (Idaho) and 11 on salmon spawning grounds in Idaho. Of the 44 marked adults, 30 or 68% had escaped detection at Little Goose Dam, indicating that more than twice as many total fish returned to the dam than were observed at the collection facility. In addition, because 30 of the 44 recoveries were transported fish, it does not appear that the homing ability of transported fish was seriously impaired.

Adult steelhead trout from 1975 transport and control releases have been observed at Dworshak and Pahsimeroi Hatcheries. As of 30 November, a total of 55 adults returning after 1 year at sea have been found at the two hatcheries. No effort has been expended on spawning ground surveys because steelhead trout spawn in the spring when stream flows are increasing and other research commitments take priority. The most significant aspect of the returns to the hatcheries is a comparison of total returns of our test fish vs. the number having been intercepted at Little Goose Dam. Forty-two of the 55 adults mentioned above were previously intercepted at Little Goose Dam, indicating a recovery efficiency for steelhead trout at the dam of 76%.

RETURNS TO THE INDIAN FISHERY

In 1977, 41 tagged steelhead trout that had been either transported to Bonneville Dam or released as controls from Little Goose or Lower Granite Dams in 1976 were recovered in the Indian fishery. Admittedly, neither transport benefits to lower river fisheries nor potential adverse homing implications can be drawn from 41 recoveries from 10 different release groups (Table 13). However, in 1978 when 2-ocean returns become available, it will be important to evaluate the rate of returns to the Indian Fishery and to Little Goose Dam.

Table 13.--A comparison between transported and nontransported groups of 1-ocean age steelhead trout based on numbers of transported and nontransported juvenile fish from Little Goose and Lower Granite Dams in 1976 that were recaptured as adults in the Indian Fishery in the lower Columbia River, 25 August to 1 October 1977.

Release site and experimental groups	Transported from Little Goose Dam			Transported from Lower Granite Dam		
	Number Released 1/	Recaptured as Adults		Number Released	Recaptured as Adults	
		Number	Percent		Number	Percent
Control	29,414	2	0.007	33,905	2	0.006
Bonneville Boat Ramp						
Fresh water (transport)	10,666	3	0.028	7,304	3	0.041
Salt water (transport)	11,677	3	0.026	16,504	0	0.0
Bonneville Powerhouse						
Fresh water (transport)	32,621	6	0.018	47,392	9	0.019
Salt water (transport)	42,197	6	0.014	52,641	7	0.013
TOTAL	126,575	20		157,746	21	

1/ Adjusted for initial tag loss.

SUMMARY

1. Because of drought conditions in the Pacific Northwest, flows in the Snake River were at an all time low during the spring migration of juvenile salmonids. As no spilling occurred at the dams, emergency measures were taken to collect and transport the fish from upriver dams to safe release sites in the Columbia River below Bonneville Dam. We estimated that about 7 million juvenile salmonids would reach Lower Granite Dam. However, only about 50% of the expected juveniles arrived, and these arrived later than usual and were in generally poor condition. About 81% of the 3.4 million juvenile salmonids that reached the dam were collected and mass transported downstream--about 2.0 million from Lower Granite Dam and 0.7 million from Little Goose Dam.
2. In trucking operations at Lower Granite Dam, 1.3 million salmonids were transported. Of these, 126,794 chinook salmon and 116,828 steelhead trout were marked for tests comparing the use of salt water vs. fresh water during transport. The relative survival at two release sites below Bonneville Dam was also tested.
3. Based on samples held at Bonneville Dam, delayed mortality of chinook salmon transported by truck was about 30%.
4. The transportation phase of a 2-year air transport study was concluded in 1977. Chinook salmon smolts were air-dropped into the Columbia River near Beacon Rock State Park, Washington (41,092) and near Astoria, Oregon (35,333).
5. To accommodate the large numbers of fish at Lower Granite Dam, barging was instituted for the first time in our transport operations. Over 3.5 million salmonids were barged from various hatcheries and from

Lower Granite Dam. At Lower Granite Dam relatively few fish were barged because the run never fully materialized. However, several hundred thousand smolts were barged including 62,000 marked fish. All barged fish were released about 1.5 miles below Bonneville Dam. First-year operations with the barge were considered extremely successful.

6. Full screening of turbine intakes was accomplished for the first time at Lower Granite Dam; six conventional screens and three new adjustable--angle screens were used. Testing was limited to the adjustable angle screens. Recommendations for future screen acquisitions have been made to the Corps based on the following findings:

   a) Adjustable angle screens should be used in the bulkhead slot.

   b) The 33% perforated plate backing for screens should be used.

   c) Screen angle should be 65°.

   d) Lights should be installed on all screens.

   Traveling screens to be used at Little Goose or Lower Granite Dams should conform to the above criteria to produce maximum guidance while minimizing descaling and injury.

7. Descaling rate for chinook salmon sampled from gatewells at lower Granite Dam was the highest recorded (about 27%). Severe migration conditions brought on by the record low river flows were the likely cause of the high rate of descaling.

8. At Little Goose Dam 669,000 juvenile salmonids were collected; most were mass transported. However, 123,357 chinook salmon, 69,392 steelhead trout, 163 sockeye salmon and 121 coho salmon were marked for transport tests. Tests were designed to compare differences in survival of juveniles transported in salt water (10 ppt) vs. fresh

water. The average mortality after transport varied from 21.3 to 42.5%. for chinook salmon and from 10.5 to 16.1% for steelhead trout.

9. Testing a new orifice configuration to enhance smolt passage from gatewells at Little Goose Dam was planned, and the apparatus for testing was installed. However, testing was deferred until 1978 because of special flow and turbine generation requirements in 1977.

10. Preliminary returns of chinook salmon adults from smolts transported from Lower Granite Dam in 1975 indicate a transport benefit (increase) of about 60%.

11. Return of steelhead trout adults from smolts transported from Lower Granite Dam in 1975 show a benefit of 161 to 203% depending on treatment group. Transport data from these marked fish plus those mass transported as smolts from Little Goose Dam indicate that adult returns from transported smolts accounted for 36 to 65% of the adults returning to Dworshak Hatchery in 1977-78.

12. Very few 1-ocean age chinook salmon returned from fish marked and transported from Lower Granite and Little Goose Dams in 1976. Returns of marked steelhead trout transported from Lower Granite and Little Goose Dams in 1976 indicate that benefits were considerably greater for fish transported from Little Goose Dam than for fish transported from Lower Granite Dam.

13. We have continued to monitor returns of adults to hatcheries and spawning grounds above Lower Granite Dam, and to sport and Indian fisheries. These data are particularly useful for establishing trap efficiencies at the collection dam (Little Goose) and for monitoring homing or straying of various transport groups.

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1975. Snake River runs of salmon and steelhead trout: trends in abundance of adults and downstream survival of juveniles. Northwest Fisheries Center, National Marine Fisheries Service, 2725 Montlake Boulevard E., Seattle, WA 98112, Processed Report, 11 p, 5 fig, 2 tble, Appendix listing 9 tble.

APPENDIX A

The rationale and computations used to estimate the range in contribution of transportation to adults returning to Dworshak Hatchery are illustrated below. The figures used to obtain the high estimate are used as an example. Thus, 9.5% as determined from returning adults of Dworshak Hatchery origin is used for the proportion of smolts of Dworshak Hatchery origin that were marked at Lower Granite Dam. Thus, 9.5% of the 10,475 total steelhead trout transported or 5,745 smolts were Dworshak Hatchery stock. Twenty-seven adults returned from the 5,745 smolts transported, resulting in a return rate of 0.470% $(\frac{27}{5745})$--similar to the return rate of 0.471% $(\frac{285}{60,475})$ of all Lower Granite Dam 1-ocean returns from smolts transported in 1975.

If we assume, then, that a 1-ocean adult return rate of 0.470% can be applied to the 215,600 Dworshak Hatchery smolts transported from Little Goose Dam (44% of the 490,000 steelhead trout transported in 1975) then 215,600 x 0.470% = 1,013 unmarked, unidentified 1-ocean adults returned to Dworshak Hatchery from groups transported; this added to 5,745 x 0.470% = 27 marked identified adults becomes 1,040 or 97% of the 1,075 1-ocean returns at Dworshak Hatchery in 1976.

Assuming the rationale for 1976 (1-ocean returns) is valid, we must have the final return of 2-ocean fish to Dworshak Hatchery this spring to complete the evaluation. Lacking final returns let us make 2 assumptions:

(1) Accept the estimate of 24,600 adult return to Dworshak Hatchery based on the marked population released from the hatchery and recaptured as adults at Little Goose Dam. (Note: the number of adults returning to Dworshak Hatchery as of 20 April 1978 confirms this estimate.)

(2) Accept our estimate of 30,000 total 2-ocean steelhead trout at Little Goose Dam in fall 1977 based on age class composition determined by observations of adults at the fish viewing room at Little Goose Dam. On this premise, 82% $(\frac{24,600}{30,000})$ of the 2-ocean count at Little Goose Dam should be bound for Dworshak Hatchery. This fall there were 503 marked adult 2-ocean steelhead trout that returned to Little Goose Dam from the 5,745 smolts of Dworshak Hatchery origin transported from Lower Granite Dam. Therefore, we might expect 412 (82%) of these to be of Dworshak Hatchery origin.

The 412 marked returns from 5,745 smolts of Dworshak Hatchery origin marked and released at Bonneville Dam produces a return rate of 7% for 2-ocean returns. If a return rate of 7% is assigned to the unmarked smolts transported from Little Goose Dam, the contribution then is

215,600 x 7% = 15,092 and

5,745 x 7% = 402 with a total transport contribution

of 15,494 or 63% of the total 2-ocean adults returning to Dworshak Hatchery in 1977-78. This compares favorably with the 57% transport benefit calculated by comparing the 1.4% return to Little Goose Dam with the best previous hatchery return of 0.6%. Further, the 7% return rate is not too far from Raymond's (1975) estimate of the adult return to the Columbia River from smolts passing The Dalles Dam (5 to 7%).

APPENDIX B

The following tables comprise Appendix B:

1. Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and released as controls above Lower Granite Dam, 1977.

2. Date, brand position, wire tag code, and number of juvenile chinook salmon and steelhead trout marked and transported in 5 ppt salt water by truck from Lower Granite Dam to Dalton Point, 1977.

3. Date, brand position, wire tag code, and number of juvenile chinook salmon and steelhead trout marked and transported in 5 ppt salt water by truck from Lower Granite Dam to Bonneville Dam, 1977.

4. Date, brand position, wire tag code, release location, and number of juvenile chinook salmon marked and transported in 5 ppt salt water by airplane from Lower Granite Dam, 1977.

5. Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and transported by barge from Lower Granite Dam, 1977.

6. Date, transport medium, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout marked and transported by truck from Little Goose Dam (test) or released at Little Goose Dam (control), 1977.

Appendix Table 1.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and released as controls above Lower Granite Dam, 1977.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon (No.)	Steelhead trout (No.)
4/25	LA-K	W-Y-Gr	Clarkston WA	3676	462
4/26	LA-K	W-Y-Gr	Clarkston WA	4405	1315
4/27	LA-K	W-Y-Gr	Clarkston WA	2745	2325
4/30	LA-K	W-Y-Gr	Clarkston WA	742	3612
5/2	LA-K	W-Y-Gr	Clarkston WA	1612	1724
5/6	LA-K	W-Y-Gr	Clarkston WA	2807	1714
			Subtotals	15987	11152
5/10	LA- ⋊	W-Y-Gr	Clarkston WA	3733	2375
5/14	LA- ⋊	W-Y-Gr	Clarkston WA	1403	943
5/14	RA- ⋊	W-Y-Gr	Clarkston WA	28	---
5/16	LA- ⋊	W-Y-Gr	Clarkston WA	4344	1467
5/19	LA- ⋊	W-Y-Gr	Clarkston WA	892	1148
			Subtotals	10400	5933
5/23	LA- ꓘ	W-Y-Gr	Clarkston WA	2939	1671
5/25	LA- ꓘ	W-Y-Gr	Clarkston WA	1485	1802
5/31	LA- ꓘ	W-Y-Gr	Clarkston WA	1229	3461
6/3	LA- ꓘ	W-Y-Gr	Clarkston WA	2110	3444
			Subtotals	7763	10378
6/9	LA- ⋉	W-Y-Gr	Clarkston WA	2193	1582
6/13	LA- ⋉	W-Y-Gr	Clarkston WA	1982	2028
6/15	LA- ⋉	W-Y-Gr	Clarkston WA	--	2079
			Subtotals	4175	5689
			TOTALS	38,325	33,152

1/ LA indicates brand position; left anterior.

2/ Colors of wire tags: W-White; Y -Yellow; Gr-Green

Appendix Table 2.--Date, brand position, wire tag code, and number of juvenile chinook salmon and steelhead trout marked and transported in 5 ppt salt water by truck from Lower Granite Dam to Dalton Point, 1977.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon	Steelhead trout
				(No.)	(No.)
4/25	RA-F	W-O-YOX	Dalton Point	2651	568
4/27	RA-F	W-O-YOX	Dalton Point	6334	---
4/28	RA-F	W-O-YOX	Dalton Point	405	4370
4/29	RA-F	W-O-YOX	Dalton Point	2212	4057
5/3	RA-F	W-O-YOX	Dalton Point	3895	5250
5/10	RA-F	W-O-YOX	Dalton Point	5236	4654
5/13	RA-F	W-O-YOX	Dalton Point	5145	3200
5/16	RA-F	W-O-YOX	Dalton Point	6823	1957
5/19	RA-F	W-O-YOX	Dalton Point	1623	2239
5/25	RA-F	W-O-YOX	Dalton Point	1567	4089
6/6	RA-F	W-O-YOX	Dalton Point	2275	4756
6/9	RA-F	W-O-YOX	Dalton Point	2572	2821
6/15	RA-F	W-O-YOX	Dalton Point	2327	2938
			TOTALS	43,065	40,899

1/ RA indicates brand position; right anterior.

2/ Colors of wire tags; W-White; O-Orange; YOX-Yellow Oxide; Y-Yellow.

Appendix Table 3.--Date, brand position, wire tag code, and number of juvenile chinook salmon and steelhead trout marked and transported in 5 ppt salt water by truck from Lower Granite Dam to Bonneville Dam, 1977.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon	Steelhead trout
				(No.)	(No.)
4/26	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	5986	1634
4/28	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	3101	5480
5/2	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	6281	2218
5/3	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	1535	4104
5/9	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	---	5771
5/11	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	3645	1976
5/14	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	4385	2854
5/17	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	3835	2677
5/23	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	3200	3096
5/31	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	2851	2335
6/8	RA- ⊢⊣	W-Y-LtBl	Bonneville Dam	3096	4328
6/8	RA- ⊢⊣	W-Y-O	Bonneville Dam	119	966
6/13	RA- ⊢⊣	W-Y-O	Bonneville Dam	3678	3563
6/17	RA- ⊢⊣	W-Y-O	Bonneville Dam	3692	1775
			TOTALS	45,404	42,777

1/ RA indicates brand position; right anterior.

2/ Color of wire tags; W-White; Y- Yellow; LtBl-Light Blue; O-Orange.

Appendix Table 4.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon marked and transported in 5 ppt salt water by airplane from Lower Granite Dam, 1977.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon
				(No.)
4/29	RA- Ⅎ	W-YOX-R	Beacon Rock	9900
5/5	RA- Ⅎ	W-YOX-R	"	7248
5/5	RA- Ⅎ	W-O-R	"	2558
5/6	RA- Ⅎ	W-O-R	"	10,537
5/11	RA- Ⅎ	W-O-R	"	4698
5/11	RA- Ⅎ	W-O-W	"	6151
			Sub-total	41,092
4/30	RA- ᖶ	W-Y-R	Tongue Point	10,227
5/7	RA- ᖶ	W-Y-R	"	7856
5/7	RA- ᖶ	W-Y-Bl	"	1821
5/9	RA- ᖶ	W-Y-Bl	"	4640
5/12	RA- ᖶ	W-Y-Bl	"	8455
5/12	RA- ᖶ	W-Y-R	"	2334
			Sub-total	35,333
			TOTAL	76,425

1/ RA indicates brand position; right anterior.

2/ Colors of wire tags; W-White, O-Orange, Y-Yellow, R-Red, Bl-Blue, YOX-Yellow Oxide.

Appendix Table 5.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and transported by barge from Lower Granite Dam, 1977.

Date	Brand position 1/ and symbol	Wire 2/ tag color	Release site	Chinook salmon	Steelhead trout
				(No.)	(No.)
5/4	RA- 3	W-Y-LtGr	Bonneville Dam	10,510	8930
5/5	RA- 3	W-Y-LtGr	Bonneville Dam	---	1185
5/26	RA- ω	W-Y-LtGr	Bonneville Dam	5934	7579
5/27	RA- ω	W-Y-LtGr	Bonneville Dam	4264	2518
6/2	RA- ε	W-Y-LtGr	Bonneville Dam	10,920	6378
6/3	RA- ε	W-Y-LtGr	Bonneville Dam	---	3740
			TOTALS	31,628	30,330

1/ RA indicates brand position; right anterior.

2/ Colors of wire tags: W-White, Y-Yellow, LtGr-Light Green.

Appendix Table 6.--Date, transport medium, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout marked and transported by truck from Little Goose Dam (test) or released at Little Goose Dam (control), 1977.

Date	Transport medium	Brand position and symbol 1/	Wire tag 2/ color	Release site	Chinook salmon	Steelhead trout
					(No.)	(No.)
April 29 - June 16	Salt water 10 ppt	RA-T	W-Y-Y	Bonneville Dam	43,334	22,916
May 2 - June 20	Fresh water	RA-T	W-O-G	Bonneville Dam	41,677	24,272
May 2-11	No transport	LA-Y	W-Y-P	Little Goose Dam	16,535	11,209
May 17 - June 16	No transport	LA-⋉	W-Y-P	Little Goose Dam	21,811	10,995
				TOTALS	123,357	69,392

1/ RA indicates brand position; right anterior
LA indicates brand position; left anterior

2/ Colors on wire tags; W-White, Y-Yellow, O-Orange, G-Green, P-Pink.