NORTHWEST FISHERIES CENTER PROCESSED REPORT

February 1976

EVALUATION OF FISH PROTECTIVE FACILITIES
AT LITTLE GOOSE AND LOWER GRANITE DAMS

AND

REVIEW OF OTHER STUDIES RELATING TO PROTECTION
OF JUVENILE SALMONIDS
IN THE COLUMBIA AND SNAKE RIVERS, 1975

by

Donn L. Park, Earl M. Dawley, Richard F. Krcma
Clifford W. Long, Emil Slatick, Jim Ross Smith
and George A. Swan

Prepared by:
Northwest Fisheries Center
National Marine Fisheries Service
2725 Montlake Boulevard E.
Seattle, Washington 98112

EVALUATION OF FISH PROTECTIVE FACILITIES AT LITTLE GOOSE AND LOWER GRANITE DAMS

AND

REVIEW OF OTHER STUDIES RELATING TO PROTECTION OF JUVENILE SALMONIDS IN THE COLUMBIA AND SNAKE RIVERS, 1975

by

Donn L. Park, Earl M. Dawley, Richard F. Krcma
Clifford W. Long, Emil Slatick, Jim Ross Smith
and George A. Swan

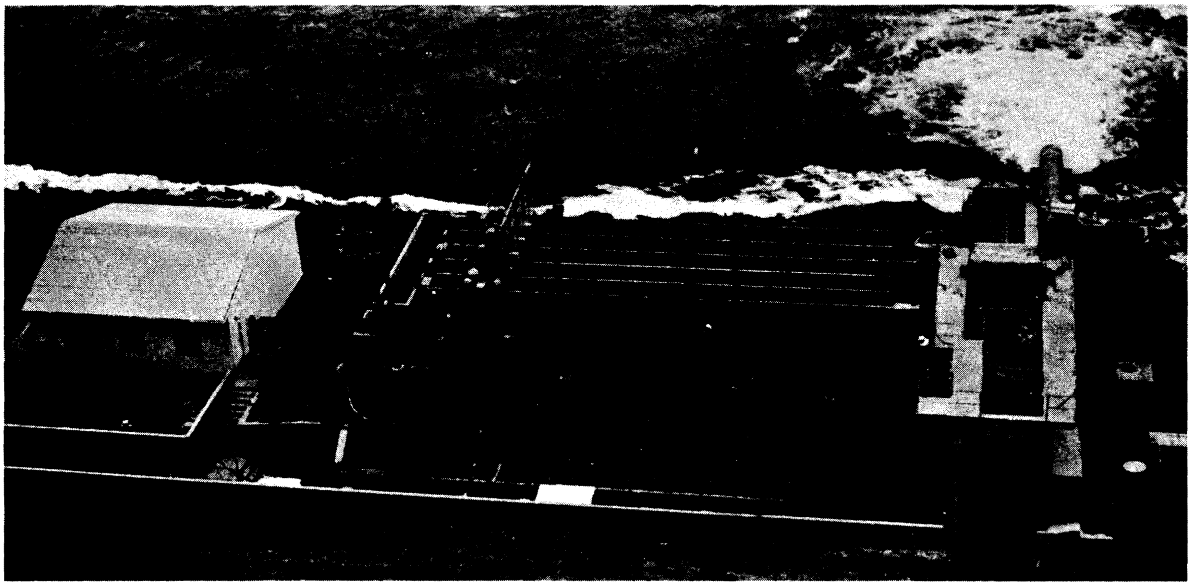
Report of Research
Financed By
U.S. Army Corps of Engineers
Under Contract No. DACW68-75-C-0111

and

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

February 1976

Research started on fish protective facilities at Lower Granite Dam (above) when the first turbine became operational in mid-April, 1975. The fingerling collector system (below) where fish are screened from the by-pass water mass, graded and marked for transportation studies is a principal feature of the protective facilities.



CONTENTS

INTRODUCTION

During 1975, the National Marine Fisheries Service (NMFS) under contract to the U.S. Army Corps of Engineers continued, for a fifth year, an evaluation of fish protective facilities for juvenile salmonids at Little Goose Dam. A similar evaluation was also started at Lower Granite Dam. This year, emphasis was placed on observing the operational features of facilities at Lower Granite Dam, including traveling screens placed in the bulkhead and fish screen slots, orifice passage from gatewells, the fingerling separator at the terminal end of the by-pass system, and the adult tag detector and trapping facility in the fishway.

At Little Goose Dam emphasis was placed on the emergency transportation of unmarked steelhead trout smolts to Bonneville Dam. In addition, recovery efforts continued on adult salmonids returning upriver from juvenile migrations marked and transported in 1972 and 1973. Recoveries included over 500 marked adult steelhead trout and nearly 300 spring and summer chinook salmon. Additional recoveries were made in the Indian Fishery and at hatcheries upstream. These preliminary data are summarized and effects of transport on survival and homing are indicated.

Further research was done on the use of salt (NaCl) for reducing the effects of stress on chinook salmon in transport systems, timing and survival of fingerlings, and on levels of dissolved gases in the Columbia and Snake Rivers in relation to river discharge and operation of spillway flow deflectors. This report summarizes progress on these studies in 1975.

TRANSPORTATION AND HOMING - LOWER GRANITE DAM

Research began at Lower Granite Dam when the first turbine became operational on April 18, 1975. Collection and subsequent marking of fingerlings was limited throughout the migration because only one unit had traveling screens placed in it for diverting fish into the by-pass system and units 2 and 3 were not fully operational until the migration had passed.

At Lower Granite Dam once fingerlings are diverted from the turbine intake into gatewells, they may enter the by-pass system by passing through one of two 8-inch orifices placed at either end of the standard gatewell. After passing through the orifice, fingerlings are in a flume-like channel (gallery) which traverses the length of the powerhouse. Upon reaching the south end of the powerhouse fingerlings pass over a stop-log weir, descend to the tailrace level (about 60 feet vertical) and to the collection facility (a distance of 400 yards) through a 42-inch pipe. Under operating conditions this year, the 42-inch pipe carried about 250 cfs of water at a velocity of approximately 25 fps.

The collection facility is the terminal end of the by-pass system where fingerlings emerge from an upwell, pass over an inclined screen that eliminates most of the water, then over a perforated plate further reducing the amount of water, and onto grading bars before entering four water-filled bins where they must pass through an electronic fish counter before entering one of five raceways.

One phase of the research at Lower Granite Dam was centered on monitoring closely the condition of fingerlings at various locations in the by-pass collection and transport system. Stress areas in the system could thus be isolated and corrections needed in mechanical or operational systems could be identified. A final assessment of the by-pass, collection system, and transport concept will be made as data on returning adults are analyzed. The ultimate goal is to determine whether large numbers of naturally migrating wild and hatchery reared stocks of juvenile salmonids can be collected and transported to downstream locations without excessive mortality or loss of homing ability; thus increasing survival and subsequent returns to parent streams. It is deemed especially important to test the transport concept at Lower Granite Dam because of its proximity to nearby rearing areas. If smolts are collected and transported too soon after they begin their seaward migration, it is conceivable that homing could be destroyed or impaired, resulting in increased straying as adults.

EXPERIMENTAL DESIGN

To test the transport concept, juvenile chinook salmon and steelhead trout were marked distinctively in three groups--one control and two test or transport groups. The control group was released about 8 miles below Clarkston, Washington on the south shore of the Snake River. Both test groups were released from the Washington State boat launching site about 1 mile downstream from the spillway at Bonneville Dam on the Washington shore.

Evaluation of the survival and homing ability of each group will be based on adult returns to the commercial, Indian, and sports fisheries and to the adult separator at Little Goose or Lower Granite Dams. Additional returns are expected at hatcheries and native spawning grounds upstream.

COLLECTION, MARKING AND TRANSPORTATION PROCEDURES

Fish accumulated in the raceways were crowded to the lower end and gravity fed into the holding tank inside the marking building. Fish were hand dipped from the holding tank into sorting troughs containing a temperature controlled solution of MS222. Previously marked fish such as fin-clipped fingerlings from hatcheries were returned to the river. Most fish were cold-branded with liquid nitrogen and a wire tag was inserted into their snouts. After tagging, the fish passed through a detection coil that contained a magnetic field. Non-tagged fish were automatically rejected and returned to the marker for retagging. Before the fish left the marking facility they were subjected to a disinfectant bath of Malachite Green.

Separate wire tag codes were designated for each experimental group. One test group was wire-tagged only. The other test group was marked by wire tag and by distinctive brand. The control group was also wire-tagged and branded. On those groups branded, the brand or brand rotation (orientation) was changed weekly.

Descaling was the criterion used to evaluate degree of injury of smolts passing through the by-pass-collection system. Any fish with over 10% visible descaling was recorded as a descaled fish. Descaling was measured at the gatewell (before entry into the by-pass) and in the marking building. Descaling rate in the marking building provided a total injury factor, and an injury factor for the by-pass and collection facility (established by subtracting the amount of descaling observed at the gatewell from the total injury factor).

Steelhead trout and chinook salmon were hauled simultaneously but in separate compartments in both the 3,500 and 5,000-gallon tankers. Both trucks were equipped with refrigeration, aeration, and filtration systems. Water temperature and chemical measurements for dissolved oxygen, carbon dioxide, and pH were made from water samples taken from the transportation truck prior to releasing salmonids in each load. Hauling mortalities were recorded during release, and sample fish were held 45 hours to determine delayed mortality.

TRANSPORTATION AND DELAYED MORTALITY

A total of 307,083 salmonids were counted at the fingerling facility at Lower Granite Dam in 1975; 150,160 chinook salmon, 153,437 steelhead trout, 2,333 coho salmon, and 1,153 sockeye salmon. Of these, 112,452 chinook salmon and 110,076 steelhead trout were marked for the transportation experiment (Tables 1 and 2). See Appendix Tables 1 and 2 for more detail of marking by test group. No unmarked fingerlings were hauled to Bonneville Dam in 1975.

Stresses (including minor descaling, collection, marking, and transport) placed upon juvenile chinook salmon were assessed in terms of delayed mortality after transport to Bonneville Dam. Samples of fish were taken from each load and held 45 hours for observation near Bonneville Dam. Delayed mortality of chinook salmon ranged from 0.5 to 34.0%. The weighted average delayed mortality for chinook was 11.5%, which is similar to the delayed mortality we reported for chinook hauled during experiments at Little Goose Dam. Delayed mortality of transported steelhead ranged from 0 to 1.8% with a weighted average of 0.38%. (Delayed mortality of steelhead was also similar to that observed in the Little Goose experiments.)

Table 1.--Marking summary for juvenile chinook salmon and steelhead trout transported to Bonneville Dam from Lower Granite Dam--1975.

Marking period	Position and brand [1/]	Wire tag color	Chinook salmon	Steelhead trout
4-23 to 5-6	RA-T	W-Y-YOX-R	9915	8814
5-9 to 5-13	RA-T	W-Y-YOX-G	11167	4765
5-17 to 6-2	RA-N	W-O-ROX	9045	10499
	SUB-TOTAL		30127	24078
4-25 to 5-16	No Brand	W-Y-YOX-LG	21417	16383
5-17 to 6-17	No Brand	W-O-BR	17006	20014
	SUB-TOTAL		38423	36397
	GRAND TOTAL		68550	60475

1/ RA indicates brand position - Right Anterior

Table 2.--Marking summary for juvenile chinook salmon and steelhead trout released as controls at Lower Granite Dam--1975.

Marking period	Position [1] and brand	Wire tag color	Chinook salmon	Steelhead trout
4-22 to 5-15	LA-F	W-Y-B-L	31940	27201
5-20 to 6-13	LA-K	W-Y-YOX-P	11962	22400
GRAND TOTAL			43902	49601

1/ LA indicates brand position--Left Anterior

Direct transport mortality, (mortality observed at time of release) was 1.4% for chinook salmon and 0.43% for steelhead trout.

We are concerned that delayed mortalities related to transportation remain relatively high among chinook salmon. We are investigating ways to reduce this factor and a particularly encouraging means appears to be hauling fingerlings in a moderately saline solution. This system will be discussed in detail in a subsequent section.

DESCALING IN THE COLLECTION SYSTEM

Data obtained from earlier studies at Little Goose Dam indicated that descaling was the main injury factor causing excessive stress and delayed mortality of juvenile chinook. We therefore limited out measurements of stress in the system to this parameter. Descaling, injury, and stress to steelhead has not been a problem.

Descaling rate was measured throughout the season in two locations: (1) in the gatewell after diversion from the intake by traveling screens and (2) in the marking building after travel through the by-pass pipe, fingerling sorter, and raceway system. The descaling rate in the gatewell, which included naturally-caused descaling as well as that which might have occurred because of contact with traveling screens, was 6.4%. The average descaling rate measured in the marking building was 13%. Thus an additional 6.6% descaling occurred as fish passed from the gatewells to the marking building. We believe much of the latter occurred before several mechanical failures in the system were eliminated. Descaling rate will again be monitored in 1976 to isolate and correct failures if they occur.

GENERAL COMMENTS ON COLLECTION SYSTEM OPERATIONS

In 1975, smolt collection was underway simultaneously with completion of the fingerling sorter assembly and marking facility. Therefore, "debugging" of mechanical problems occurred concurrently with the fingerling migrations. There were several problems that were never resolved during the smolt migration:

(1) The volume of water emerging from the 42-inch pipe fluctuated so much that manual control at the sorter was needed to assure adequate water to carry fingerlings over the inclined screen and perforated plate and onto the sorter area.

(2) Electro-mechanical failures were numerous at the sorter which precluded normal debris sweep operations.

(3) The sorter was inadequately designed; consequently, no useful size grading was achieved.

We believe that all deficiencies noted above can be resolved before the 1976 smolt outmigration.

TRANSPORTATION AND HOMING - LITTLE GOOSE DAM

Research at Little Goose Dam focused on operation of the adult tag detector and fish separator in the fishway during spring, summer, and fall salmon and steelhead runs. These data are summarized for operations through November 10, 1975.

In addition, mass-transportation of unmarked steelhead smolts from Little Goose Dam to a release site below Bonneville Dam was initiated. Because of an all-time low adult steelhead run returning to the Snake River in 1974, the fisheries agencies of the Pacific Northwest made a decision to mass-transport steelhead smolts as an emergency measure in the spring of 1975. It was a cooperative venture and personnel were provided by NMFS, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, and Washington Department of Game.

PRELIMINARY RETURNS OF ADULT CHINOOK SALMON TO LITTLE GOOSE DAM

1972 Outmigration

The combined returns of 2 and 3-ocean spring and summer chinook salmon to Little Goose Dam from juveniles marked in 1972 indicate that survival from transported releases were greater than from control releases. Returns from the Bonneville Dam release site indicated a transport to control benefit of 14%; returns from the Dalton Point release site indicated a 22% benefit (Table 3).

Returns of chinook to Little Goose Dam were also compared by spring and summer races (Table 4). Returns from the Bonneville Dam release were 12.5% less than returns from controls for spring chinook but showed a transportation benefit of 167% for summer chinook. Returns from the Dalton Point releases had a transportation benefit of 11% for spring chinook and 67% for summer chinook.

Table 3.--Adult recaptures of chinook salmon at Little Goose Dam from transport (test) and control releases of juveniles in 1972. Recovery period - April 10, 1974 to August 14, 1975.

Release site and (in parenthesis) experimental group of fish	Number of juveniles released 1/	Number recaptured as adults	Percentage return as 2- and 3-ocean adults		Transport to control benefit (%)
			Observed	Estm. 2/	
Little Goose Dam (control)	32,836	21	0.064	0.078	
Bonneville Dam (transported)	54,906	40	0.073	0.091	14.0
Dalton Point (transported)	51,499	40	0.078	0.095	22.0
TOTAL RECOVERY		101			17.0

1/ Adjusted for initial tag loss.

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

Table 4.--A comparison by seasonal race (spring and summer chinook) of transported (test) and non-transported (control) groups of chinook salmon returning to Little Goose Dam as adults in 1974-75 from releases of juveniles at Bonneville Dam and Dalton Point in 1972.

Release site (of juveniles) and seasonal race of salmon 1/	Number of salmon recaptured as adults at Little Goose Dam 2/		Transport to control benefit (&)
	Transported	Non-transported (control)	
Below Bonneville Dam			
Spring Chinook Salmon	16	18	-12.5
Summer Chinook Salmon	8	3	167.0
Dalton Point			
Spring Chinook Salmon	20	18	11.0
Summer Chinook Salmon	5	3	67.0

1/ Seasonal races of chinook salmon in the Columbia system are classified as spring, summer, or fall chinook depending on the time of year adults enter the river to spawn.

2/ Numbers recaptured adjusted in relation to numbers released.

1973 Outmigration

Returns of 2-ocean spring and summer chinook salmon to Little Goose Dam from juveniles marked and released in 1973 indicated a much higher survival from transported releases than from control releases. Returns from the Bonneville release site indicated a transport to control benefit of 1283% (ratio 13.83 to 1); returns from the Dalton Point release site indicated a 1750% (ratio 18.5 to 1 benefit) (Table 5). When the returns are separated by seasonal races, the transportation benefit from the Bonneville releases were 1817% for spring chinook and 540% for summer chinook. Similarly, returns from the Dalton Point releases had a transportation benefit of 2317% for spring chinook and 980% for summer chinook (Table 6).

To date, four adult fall chinook have returned to Little Goose Dam from smolts released in 1973. (At time of outmigration fall chinook could not be separated from spring or summer chinook and so were reported as spring chinook transported.) All four are from transport groups indicating that transportation of this endangered race may be instrumental in its ultimate survival.

PRELIMINARY RETURNS OF ADULT STEELHEAD TROUT TO LITTLE GOOSE DAM

1972 Outmigration

Returns to Little Goose Dam of 1-, 2-, and 3-ocean age adult steelhead from control and transport releases of smolts in 1972 are reported through November 10, 1975. To date, 794 have been identified. Benefits derived from transporting young steelhead (Table 7) were 210% from the Bonneville release and 243% from the Dalton Point release.

Table 5.--Adult recaptures of chinook salmon at Little Goose Dam from transport (test) and non-transport (control) releases of juveniles in 1973. Recovery period - April 20, 1975 to September 30, 1975.

Release site and (in parenthesis) experimental group of fish	Number of juveniles released 1/	Number recaptured as adults	Percentage return as 2-ocean adults		Transport to control benefit (%)
			Observed	Estimated	
Little Goose Dam (control)	88,170	11	0.012	0.014	
Bonneville Dam (transported)	83,606	139	0.166	0.193	1283.0
Dalton Point (transported)	57,758	128	0.222	0.258	1750.0
TOTAL RECOVERY		278			1575.0

1/ Adjusted for initial tag loss.

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

Table 6.--A comparison by seasonal race (spring and summer chinook) of transported and non-transported (control) groups of chinook salmon returning to Little Goose Dam as adults in 1975 from releases of juveniles at Bonneville Dam and Dalton Point in 1973.

Release site (of juveniles) and seasonal race of salmon 1/	Number of salmon recaptured as adults at Little Goose Dam 2/		Transport to control benefit (%)
	Transported	Non-Transported (control)	
Below Bonneville Dam			
Spring chinook salmon	115	6	1817.0
Summer chinook salmon	32	5	540.0
Dalton Point			
Spring chinook salmon	145	6	2317.0
Summer chinook salmon	54	5	980.0

1/ Seasonal races of chinook salmon in the Columbia system are classified as spring, summer, or fall chinook depending on the time of year adults enter the river to spawn.

2/ Numbers recaptured adjusted in relation to numbers released.

Table 7.--Returns to Little Goose Dam of 1-, 2-, and 3-ocean age steelhead trout from control and transport releases of smolts in 1972. Recoveries were made from June 17, 1973 to November 10, 1975.

Release site and experimental groups (in parenthesis)	Number of juveniles released 1/	Number of adults recaptured				Adult return in % of juveniles released		Transport benefits 3/ (%)
		1-ocean age	2-ocean age	3-ocean age	Total (1+2+3's)	Observed	Estimated 2/	
Little Goose Dam (control)	32,488	75	57	0	132	0.406	0.564	
Bonneville Dam (transport)	27,326	202	139	3	344	1.259	1.750	210.0
Dalton Point (transport)	22,831	187	130	1	318	1.393	1.936	243.0
TOTAL	82,645	464	326	4	794			

1/ Adjusted for initial tag loss.

2/ Based on comparison of the 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 dart and 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 not previously detected and identified at Little Goose Dam.

3/ Based on observed return.

1973 Outmigration

Returns (to November 10, 1975) of 1,195 1- and 2-ocean age steelhead from the 1973 juvenile releases indicate much greater benefits than accrued from the 1972 releases; returns from 1973 releases showed transportation benefits of 1380%, or about 15.0 to 1 ratio, for the Bonneville releases and 1388% or about 15.0 to 1 ratio for the Dalton Point releases (Table 8).

Recent data on adult returns from steelhead smolts transported in 1973 clearly indicate the positive benefits of transporting smolts to enhance survival and thereby contribute significantly to the Snake River steelhead run. About 3.5% (177,000) of the total steelhead smolt outmigration was transported in 1973. There were approximately 11,000 adult steelhead returning in 1974-75 runs from the total smolt outmigration in 1973. The transport contribution for steelhead hauled in 1973 was 4,375 or about 40% of the total returns. If no transportation had taken place, only 6,600 adults would have returned from that outmigration. Unfortunately, there was no authorization to mass-transport in 1973 and we returned 695,000 steelhead smolts to the river at Little Goose Dam; our return data indicate that, had these smolts been transported along with experimental fish, the total adult return from 1973 would have been 29,000 rather than the actual 11,000.

GENERAL COMMENTS ON ADULT RETURNS

In general, the current transport to control ratios for adult steelhead and chinook are very encouraging. The one exception is the poor return of adult chinook released as smolts in 1972. A possible

Table 8.--Returns to Little Goose Dam of 1- and 2-ocean age adult steelhead from control and transport releases of smolts in 1973. Recoveries were made from June 17, 1974 to November 10, 1975.

Release site and experimental groups (in parenthesis)	Number of juveniles released 1/	Number of adults recaptured			Adult return in % of juveniles released		Transport benefits 3/ (%)
		1-ocean age	2-ocean age	Total	Observed	Estimated 2/	
Little Goose Dam (control)	42,461	20	31	59	0.139	0.167	
Bonneville Dam (transport)	36,802	352	211	654	1.78	2.5187	1380
Dalton Point (transport)	26,650	276	133	482	1.809	2.559	1388
TOTAL	105,913	648	375	1195			

1/ Adjusted for initial tag loss.

2/ Based on comparison of the 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 dart and 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.

explanation for the poor returns is that there was a high incidence of kidney disease in the hatchery chinook smolts that year. The stress of collection and crowding of these infected fish in raceways and in transport trucks may tend to nullify any benefit derived from transportation.

RECOVERY OF ADULT STEELHEAD TROUT IN THE INDIAN FISHERY

Thirty-nine wire tagged adult steelhead (released as juveniles in 1973) were recovered in the fall Indian gill-net fishery in the Lower Columbia River. Although transport to control benefit ratios were highly favorable, they differed considerably from the ratios observed at Little Goose Dam. Benefit ratios observed at Little Goose Dam for Bonneville and Dalton Point releases were nearly identical--about 15.0 to 1. Benefit ratios observed from the Indian Fishery recoveries were 24.5 to 1 for the Bonneville release and 34.5 to 1 for the Dalton Point release. However, the relatively small number of returns from the Indian Fishery does not provide significant data to give actual transport-to-control ratios from either release site. A more intensive sampling program in future years should clarify this discrepancy.

EMERGENCY MASS TRANSPORT OF JUVENILE STEELHEAD

A total of 489,357 juvenile steelhead and an incidental catch of 344,825 juvenile chinook salmon were transported from Little Goose Dam to below Bonneville Dam. Juveniles were diverted from the turbine intake by 6 traveling screens operated and maintained by the Corps. Upon exiting from the gatewells the juvenile trout and salmon were gathered in the juvenile collection facility. Fingerlings were transported using the same procedures as described in previous reports. Pertinent data on juvenile mortalities and water quality were recorded for each transport load.

Transport and delayed mortality for steelhead trout was 1.1% and 0.6% respectively. For chinook salmon, mortalities were 4.7%--transport and 14.4%--delayed. These mortality figures are essentially the same as we reported for experiments conducted at Little Goose Dam in 1973.

Approximately 3,000 fish or 10% of the juvenile salmon and trout collected at Little Goose Dam were sampled for marks, symptoms of gas bubble disease (GBD), descaling, and species.

A high incidence of GBD was present throughout the season among juvenile chinook and to a lesser degree among juvenile steelhead (Table 9). The stress from gas bubble disease no doubt contributed to the delayed mortality figure (14.4%) measured for chinook mass transported. Availability of additional turbine capacity at Lower Granite Dam should eliminate this problem in 1976.

USE OF SALT (NaCl) TO REDUCE MORTALITY OF CHINOOK SALMON SMOLTS DUE TO HANDLING AND HAULING

Throughout our transportation studies, survival of transported steelhead has been consistently higher than that of transported chinook. One measurable difference in survival has been delayed mortality following transportation of the smolts. For the past several years, delayed mortality of steelhead has averaged less than 1 percent while that of chinook has averaged 10-20 percent. Both disease and stress are suspected of causing the delayed mortality of chinook smolts.

To minimize stress on the fish, NMFS researchers have streamlined methods of handling the fish and have made several improvements in the truck transport design. In spite of these improvements, excessive delayed mortality of chinook continues to occur in some loads.

Table 9.-- Percent of juvenile chinook salmon and steelhead trout sampled from raceways at Little Goose Dam with visible N_2 symptoms - April-June 1975

Month	Chinook with N_2 symptoms	Steelhead with N_2 symptoms
April	62%	28%
May	21%	4%
June	32%	30%

There is evidence from the literature that stress due to handling and hauling can be alleviated by adding salt (NaCl) to the water containing the fish. The Washington State Department of Fisheries has been transporting chinook salmon smolts in salt water, but no data have been generated to quantify benefits.[1/]

Besides alleviating the effects of stress, salt water has therapeutic value and can aid in preventing disease transmission from one fish to another. Salt water is fairly effective against disease organisms such as protozoa and fungi. Chondrococcus columnaris, a highly transmissable disease, is destroyed when suspended in water having a salinity of 8.5 ppt.[2/] It was clear from the literature that salt water could provide dual benefits in our fish handling and hauling activities.

The exploratory research reported here indicates the use of salt water will significantly increase survival of chinook salmon smolts over that now being experienced in current transportation studies. If, in practice, similar results are obtained, this technique will be the major breakthrough we have been seeking.

EXPLORATORY STUDIES WITH SALT (NaCl)

Attempts to increase survival of chinook salmon smolts by adding salt to the water were conducted at Bonneville Dam where delayed mortality studies of transported fish were underway. For these studies, we set up 20 test tanks; 16 with 60-gallon capacities and four with 150-gallon capacities. Test and control fish were obtained from the transport trucks which arrived every other day.

1/ Personal communication. James Woods, Washington Dept. Fisheries

2/ Personal communication. Paul Fujihara, Battelle Northwest, Richland, WA

Three experiments were conducted. In the first two experiments, we compared survival in fresh water with survival in salinities of 1, 3, 5, 10, and 15-20 ppt. We also tested three different levels of stress (Figure 1); a 10-count, a 15-count, and a 20-count stress. The stress was applied every 2 hours for the first 8 hours of the 24-hour test.

In the third experiment, we transported three different loads of fish from Little Goose Dam in water having a salinity of 5 ppt. Samples of these fish and fish obtained from transport trucks using fresh water were placed in test tanks for periods of 72 to 114 hours. Half of the test tanks were filled with fresh water and the other half with salt water at a salinity of 5 ppt. We also imposed a controlled stress on half of the groups of fish in both the fresh and salt water.

BENEFITS OF SALT (NaCl)

Figure 2 presents data comparing survival of chinook smolts in fresh water and in salt water at salinities of 5, 10, and 15-20 ppt at three different levels of stress. Survival of fish in all salinities tested and for all levels of stress was nearly 100 percent; only one mortality occurred in 225 fish tested. On the other hand, mortality of fish in fresh water was 20 percent for the 10-count stress and increased to 84 percent for the 20-count stress.

Figure 3 presents data comparing survival of chinook smolts in fresh water and in salt water at salinities of 1, 3, and 5 ppt. Again, survival of fish in all salinities tested was significantly higher than survival of fish in fresh water. The data imply, however, that survival at 1 ppt salt was not as great as at 3 and 5 ppt. Additional tests must be conducted to determine whether this difference is significant.

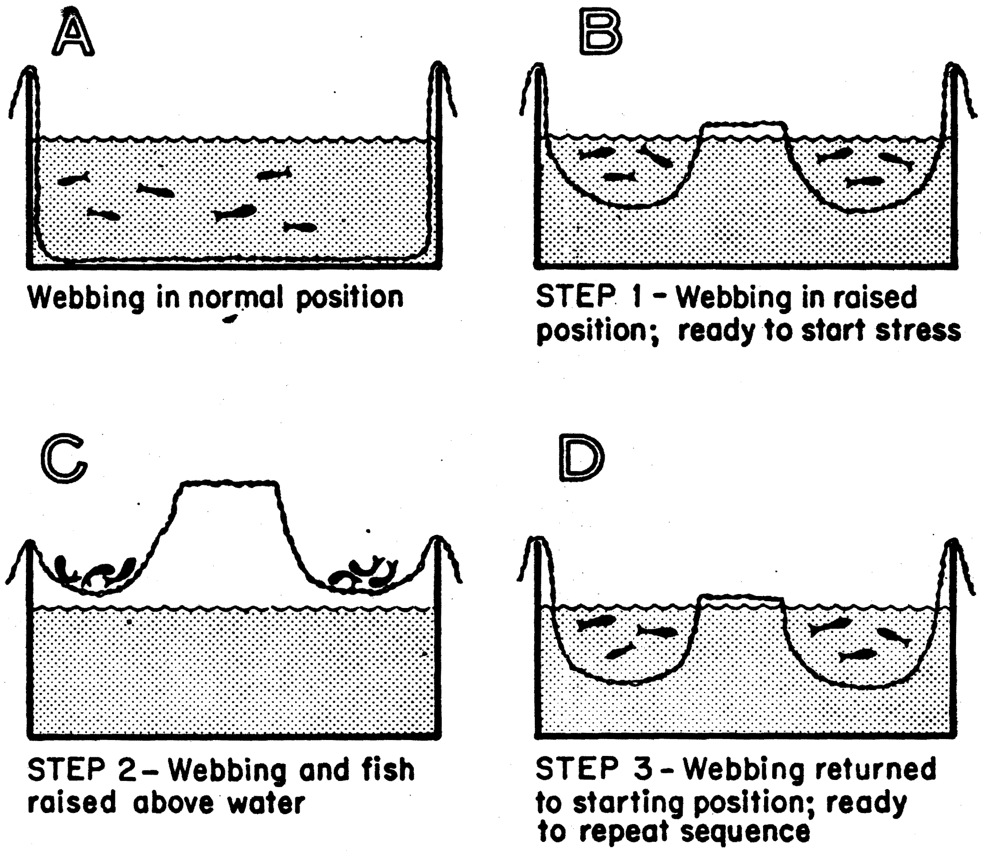


Figure 1.--Procedure for imposing a controlled stress on fish in test tanks. Raising the webbing and fish out of the water ten times (steps 1, 2, and 3 repeated ten times rapidly) is referred to as a 10-count stress.

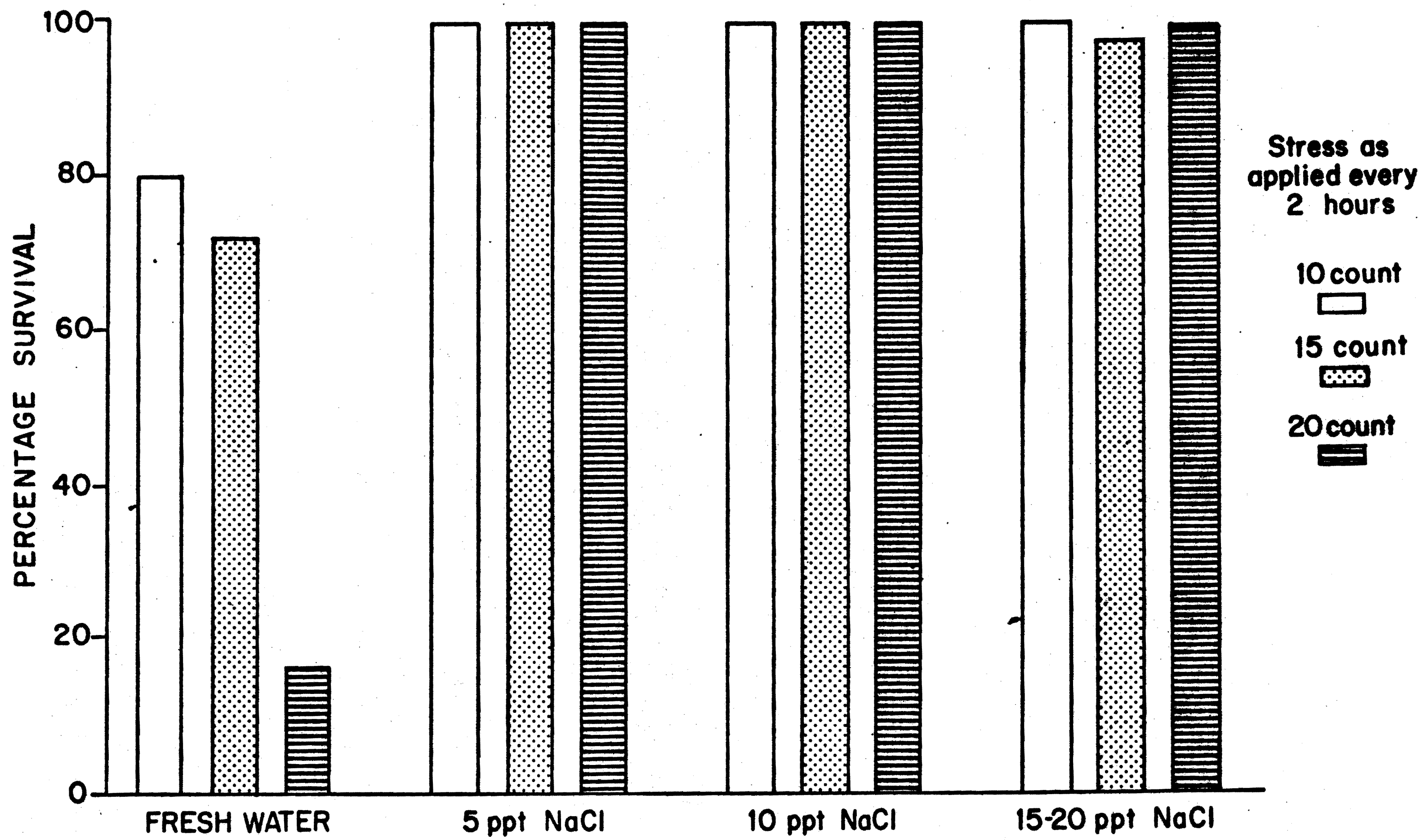


Figure 2.--Results of a 24-hour test at three different stress levels showing enhanced survival of chinook smolts held in salt water by comparison with smolts held in fresh water.

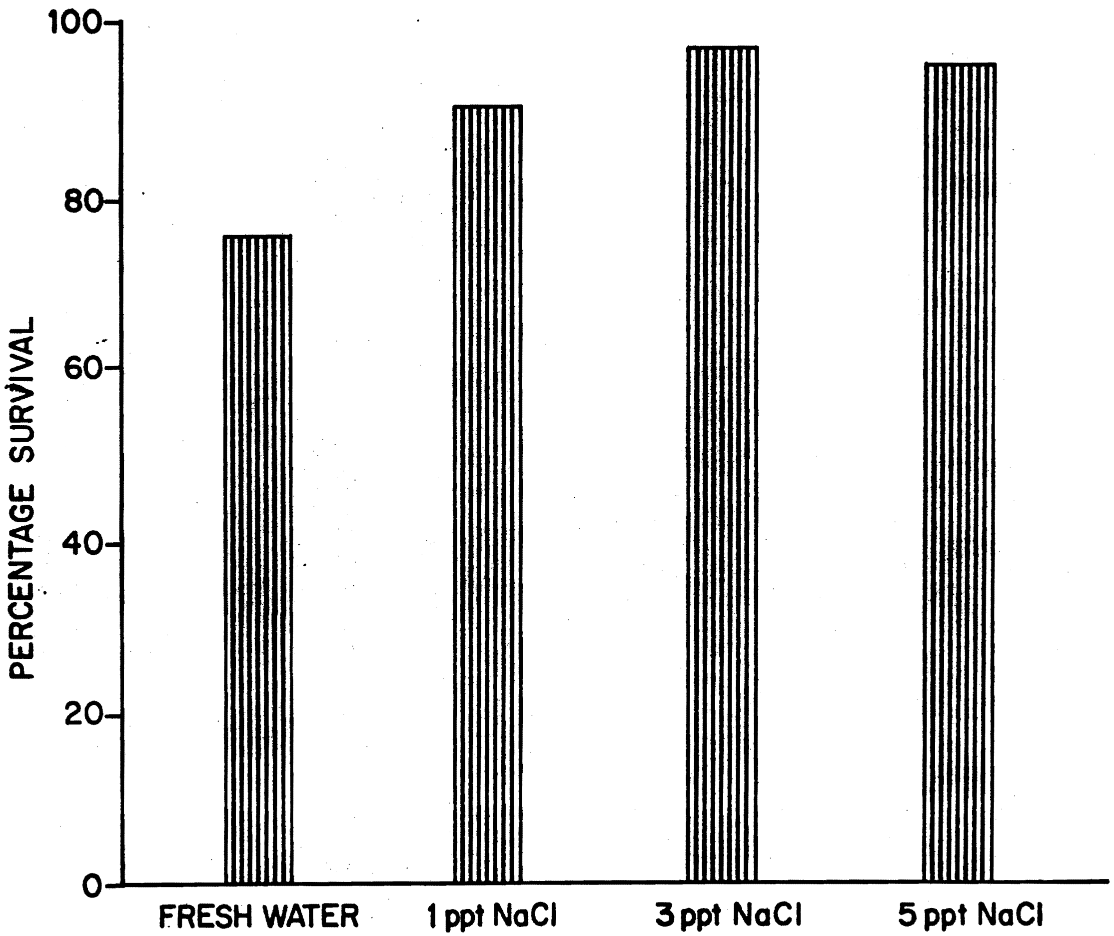


Figure 3.--Results of 24-hour test comparing survival of chinook smolts held in fresh and salt water. All groups were given a 10-count stress every two hours for the first 12 hours of the test.

Figure 4 compares survival of chinook smolts in test tanks of fresh water and salt water after having been transported either in fresh water or salt water. Again, the benefits of salt are obvious. Fish hauled and held in salt water had a survival of 98.2 percent whether they received the controlled stress or not. Fish hauled in salt water and held in fresh water without stress had a survival of 97.3 percent--not significantly different from those groups hauled in salt water and held in salt water. Although the stressed group held in fresh water had a significantly lower survival (93.3 percent) than the unstressed group (97.3 percent), having been hauled in salt water obviously benefited the fish even after they were placed in fresh water; their counterpart (stressed) group hauled in fresh water had a survival of only 60.5 percent.

IMPLICATIONS

These exploratory studies show clearly that adding NaCl to water dramatically increases the survival of 1+age chinook salmon smolts subjected to stressful conditions associated with handling and hauling.

We believe the benefits to be gained by using salt water during future transportation studies will be even greater than is indicated by these exploratory studies because the test fish we used were the survivors of fish that had already undergone the stresses of the handling system at Little Goose Dam or Lower Granite Dam prior to hauling. The addition of salt to the water used to hold, anesthetize, and mark the fish prior to hauling should yield greater benefits over merely hauling the fish in salt water.

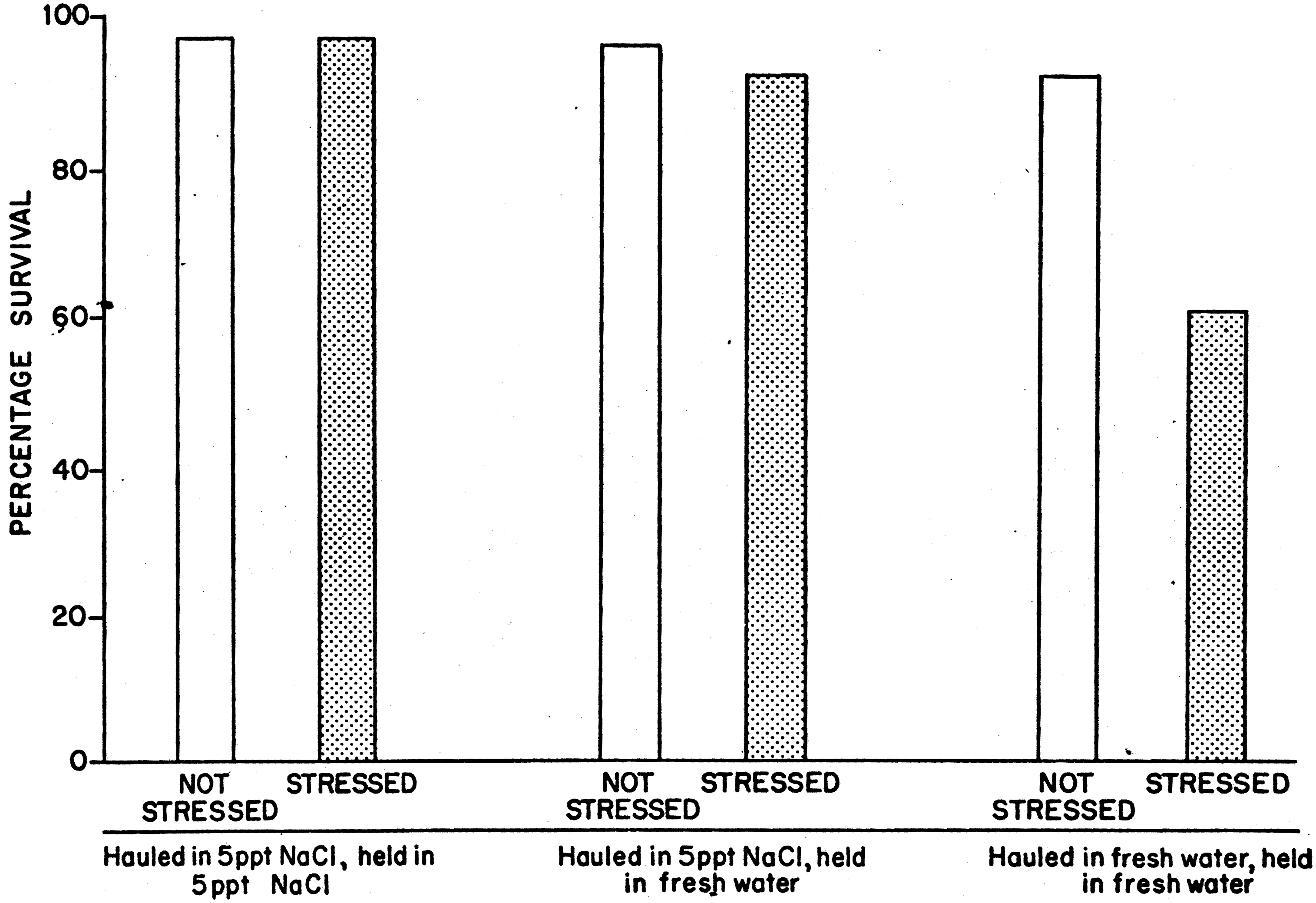


Figure 4.--Survival of chinook salmon smolts hauled in 5 ppt salt water or fresh water when held and stressed in salt water or fresh water. All stressed groups were given a 10-count stress every two hours for the first 16 to 24 hours.

Additional studies will be necessary to determine the best concentration of salt for optimum benefits for both stress and disease problems. Logically, a higher salinity level should yield more rapid and effective benefits against diseases.

SURVIVAL OF JUVENILE CHINOOK SALMON AND STEELHEAD TROUT MIGRATING IN THE SNAKE RIVER

METHOD

Survival measurements of juvenile chinook (as in previous years) were based on fish that were collected, marked, and released at Riggins, Idaho on the Salmon River and recovered at Lower Granite, Ice Harbor, and The Dalles Dams. Additional data were available from releases of marked fish at Rapid River and Dworshak Hatcheries in Idaho and from releases in the forebay of Ice Harbor and Lower Granite Dams.

Estimates of survival were based on the comparative recovery of up-river marks and Lower Granite and Ice Harbor forebay marks at sampling points downstream (i.e., Ice Harbor and The Dalles Dams).

DOWNSTREAM SURVIVAL OF JUVENILES

Survival of juvenile chinook and steelhead to The Dalles Dam in 1975 was 25% and 42%, respectively. Steelhead survival was the highest measured since 1969 (Figure 5). The low survival of chinook was attributed to dominance (60%) of the 1975 outmigration by hatchery fish (mostly Rapid River) which survived at a lower rate (17%) than native stocks (38%). In previous years, less than 30% of the outmigration was of hatchery origin and the impact on overall survival was not significant. The 38% survival of native chinook was nearly as high as

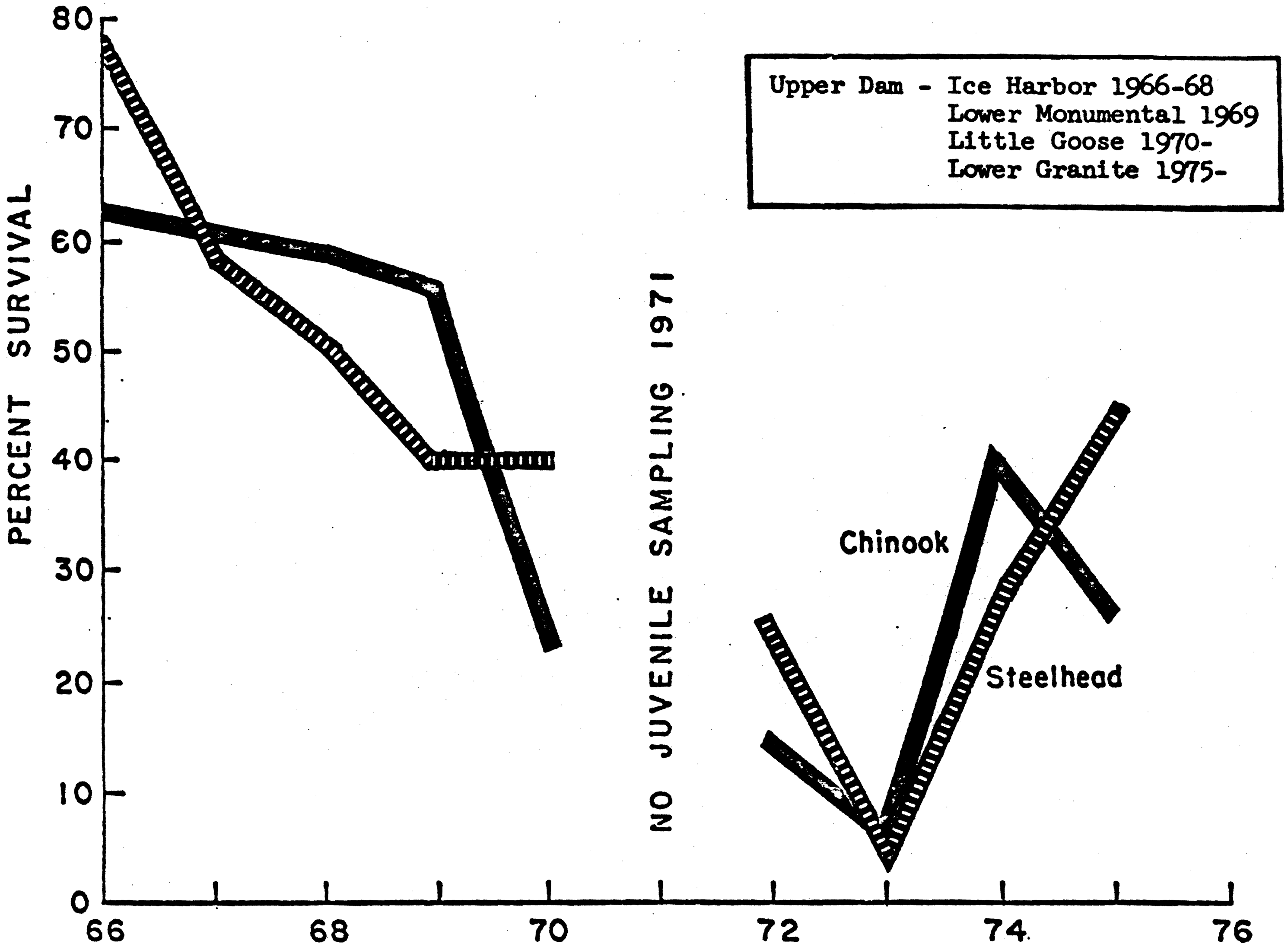


Figure 5.--Survival of Snake River juvenile chinook salmon & steelhead from the upper dam to The Dalles Dam 1966-75.

that measured for steelhead. Major factors resulting in higher survival of steelhead and native chinook in 1975 included reduced N_2 supersaturation from fliplips in operation at Lower Granite and Lower Monumental Dams, favorable runoff conditions resulting in timely spill and lower turbine mortalities, and higher quality steelhead smolts released from Dworshak Hatchery than in 1974. However, in spite of the improvements in environmental conditions, lack of native chinook migrants and a smaller release of steelhead from Dworshak Hatchery resulted in a lower than average number of migrants arriving at The Dalles Dam (0.9 million chinook and 1.1 million steelhead). Details with respect to numbers and survival of wild and hatchery fish to each dam in 1975 are given in Tables 10 and 11.

DISSOLVED GAS (N_2) STUDIES - 1975

MONITORING OF NITROGEN SUPERSATURATION

This year, concentrations of dissolved atmospheric gas in the Columbia and Snake Rivers were again measured every two weeks during spring freshet conditions (April 8 - July 29). The same sampling sites monitored in 1974 (forebays from Little Goose to Bonneville Dam, including two sites in the lower river) were monitored with the addition of sites at the forebay and tailrace of Lower Granite Dam and the deletion of the site above the mouth of the Snake River on the Columbia River. Samples from a cross section of the river (6 separate sampling sites) at the tailrace of the Bonneville spillway were also taken during specific flow levels.

Table 10.--Estimated number of Snake River chinook and steelhead smolts passing Lower Granite, Ice Harbor, and The Dalles Dam, 1975.

	Millions of Fingerlings				
	Lower Granite (A)	Transported (B)	[1] (A-B)	Ice Harbor	The Dalles
Chinook					
Rapid River (3.70)[2]	2.50	.26	2.24	0.55	0.38
Native & other hatcheries	1.50	.14	1.36	0.75	0.52
TOTAL	4.00	0.40	3.60	1.30	0.90
Steelhead					
Dworshak (1.75)	1.30	0.21	1.09	0.70	0.45
Pahsimeroi (1.50)	1.00	0.17	0.83	0.55	0.35
Native	0.90	0.17	0.73	0.46	0.30
TOTAL	3.20	0.55	2.65	1.71	1.10

1/ Numbers of fingerlings remaining to migrate downstream from Lower Granite and Little Goose Dams after subtracting number transported from these dams.

2/ Numbers released from hatchery.

Table 11.--Survival (percentage) of populations of Snake River chinook and steelhead smolts to The Dalles Dam, 1975.

Stretch of River	CHINOOK Rapid River Hatchery	CHINOOK Native & other Hatchery	CHINOOK Overall[1] Survival	STEELHEAD Dworshak Hatchery	STEELHEAD Overall[2] Survival
From:					
Salmon River and hatcheries to Lower Granite Dam	65%	85%		70%	
Lower Granite Dam to Ice Harbor Dam	24%	50%	36%	64%	64%
Ice Harbor Dam to The Dalles Dam	69%	69%	69%	65%	65%
Lower Granite Dam to The Dalles Dam	17%	38%	25%	42%	42%

1/ Overall survival based on recoveries from Rapid River, other hatcheries, and native stocks marked in the Salmon River.

2/ Overall survival based on recoveries from Dworshak and Pahsimeroi Hatcheries and native stocks marked in the Salmon River.

Throughout the sampling period, spillway discharges were moderate (maximum regulated flow about 185 and 408 kcfs for the Snake and Columbia rivers, respectively); and with the exception of the Lower Monumental forebay and the Bonneville tailrace, the dissolved gas levels were below those of 1971, 1972, and 1974. Saturation values at all sampling sites did not drop below the 110% level of total dissolved gas until July 29 (Appendix Table 3). During the period of major migration of juvenile chinook and steelhead (April 15 - May 20), nitrogen values ranged from 115.8 to 137.7% of saturation in Lower Monumental forebay and from 120.2 to 135.9% in the spillway tailrace at Bonneville Dam.

SPILL DEFLECTORS AND NITROGEN SUPERSATURATION AT LOWER GRANITE & LOWER MONUMENTAL DAMS

In 1974, tests of multiple spill deflectors at Lower Monumental Dam indicated less benefit (decrease in supersaturation) than anticipated by extrapolation from single bay deflector tests in 1972 and 73. On the 25th and 27th of March of 1975, we collected water samples at Lower Monumental Dam to measure gas content of water discharged over multiple spill deflectors. Samples were taken during 5 separate tests; with Bay 4 spilling at 15.0 kcfs (Test 1) and with all six deflector bays spilling at 4.6, 9.7, 14.9, and 20 kcfs per bay (Tests 2-5). During these tests the water temperature remained at 6.0°C and the nitrogen saturation in the forebay averaged 108.7%. Dissolved gas saturation in the tailrace during the multiple bay tests ranged from 112.3% to 123.7% N_2 at the various flows (Appendix Table 4).

The average saturation for the single bay test was 115.3% N_2, while the average saturation for the multiple bay test with comparative spill discharges per bay (14.9 kcfs) was 121.4% N_2. This difference, together with differences observed in tests conducted during previous years, confirm that saturation values resulting from single bay deflector discharges are indeed lower than values from multiple bay deflector discharges at Lower Monumental Dam when spill volumes per bay are equal.

As in 1974, there was a decrease in saturation between the forebays of Lower Monumental and Ice Harbor Dams. The data show that this difference ranged from 0 to 20% N_2, depending on the spill discharge and the saturation level in the Lower Monumental forebay. Although a slight decrease existed before the installation of deflectors, data from 1974 to 1975 show that the deflectors are substantially degassing supersaturated water as it passes through the spillway at Lower Monumental Dam.

On April 17, water samples were taken below the 6 spill deflectors at Lower Granite Dam to test their effectiveness . During the test, forebay saturation levels averaged 102.7% N_2 and the water temperature remained at 8.7°C. Water samples were collected at spillway flows of 5, 10, 15, and 20 kcfs per bay. At these flows, the saturation values ranged from 112.2% to 123.4% N_2 (Appendix Table 5). These values compare well with values obtained at Lower Monumental Dam after the spill deflectors were installed in all six bays. Thus, without the spill deflectors, saturation levels below Lower Granite spillway would have been much greater (10 to 20%) and would have been comparable to levels observed below Lower Monumental in 1969 before the spill deflectors were installed.

TRAVELING SCREEN AND ORIFICE BY-PASS STUDIES AT LOWER GRANITE DAM

Turbine intake traveling screens were tested in unit one at Lower Granite Dam in 1975. Through most of the spring season, there was only one unit in service and it generally was operated at maximum power output of 155 mw. Research objectives were: (1) determine workability of the traveling screens in the bulkhead slot (BHS) (traditional placement of screen) and the newly designed fish screen slot (FSS) and (2) after fingerlings were guided into the gatewells, determine how rapidly fingerlings exited through the orifices. Preliminary tests in the spring indicated further testing was required to quantify guidance and descaling rates for specific screen mesh-perforated plate combinations. During October 1975, a special test was designed to determine which combination(s) might be best suited for use at Lower Granite Dam.

TRAVELING SCREEN TESTS - SPRING 1975

Tests conducted at Little Goose Dam in the fall of 1974 indicated a 48% open area perforated plate placed between the conveyor belt screen of either regular mesh (42 x 36 x 16 mesh per foot) or intermediate mesh (72 x 36 x 16 mesh per foot) might be satisfactory for use at Lower Granite Dam. Therefore, we used three screens all with 48% open area plate, two of which were equipped with regular mesh and one with intermediate mesh. Screens were tested in unit one where vertical barrier screens had been installed. The upper 36 feet of the barrier screens were covered with solid plate, similar to the conditions tested at Little Goose Dam.

Lower Granite Dam is the first dam where special accomodations have been made for use of traveling screens. That is, special fish screen slots (FSS) were constructed in the dam upstream of the bulkhead slot (BHS) specifically for the placement of the traveling screens. (See Figure 6.) A traveling screen could be operated in either slot without modification.

Some features, however, made the FSS different from the BHS:

1. The FSS is closer to the entrance of the intake where the cross sectional area is larger and the approach velocity less.

2. The angle of flow approaching the screen is more acute because the intake ceiling is steeper at this point.

3. There is no vertical barrier screen, but the slot is much narrower (from front to back). A screened opening (10' x 20'), generally referred to as the Wagoner Horn, is located approximately 15 feet below the water surface.

4. The ceiling of the intake on the upstream side of the FSS is cut off horizontally allowing a larger opening into the FSS than in the BHS when a traveling screen is installed.

Tests of the traveling screens were divided into four separate time periods, each with different screen arrangements. Constant turbine loading of 155 megawatts generally prevailed. The four test periods are as follows:

1. Regular mesh in the BHS of 1A and 1B and intermediate mesh in BHS of 1C (May 7-May 11). (The terms 1A, 1B, and 1C refer to gatewell slots of unit one.)

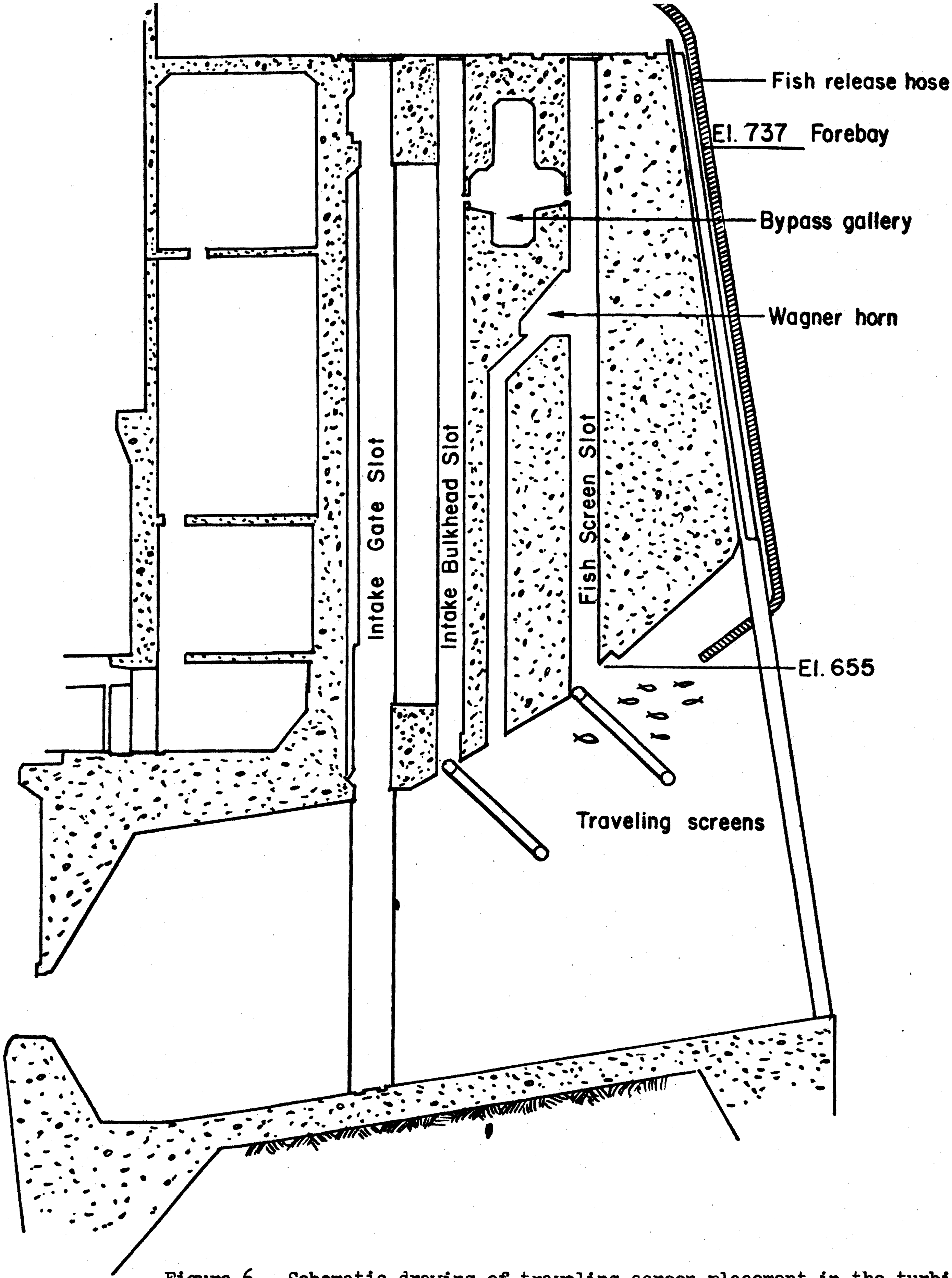


Figure 6.--Schematic drawing of traveling screen placement in the turbine intake at Lower Granite Dam. Traveling screens were tested in either the intake bulkhead slot or the fish screen slot.

2. Regular mesh in the FSS of 1A and the BHS of 1B, and intermediate mesh in the BHS of 1C (May 11-13).

3. Intermediate mesh in the BHS of 1A, regular mesh in the BHS of 1B and 1C (May 14-June 4).

4. Same as number three except the 1B screen was removed (June 4-June 12).

Descaling Measurements

Descaling tests were conducted with both mesh sizes of screen in the BHS. Tests in the FSS were done only with the regular mesh. Descaling and injury were measured by examining a sample of the fingerlings taken from the gatewells with a gatewell dipnet. Fish with more than 10% of the scales missing were classified as descaled.

The positive benefit of perforated plate backing was confirmed at Lower Granite Dam in 1975. Overall average percent descaling (APD) for salmon in the BHS's was 6.4%, reduced from the 21% rate recorded in previous years when there was no perforated plate backing behind the screen. A comparison of the descaling rates between the two mesh sizes (intermediate and regular) indicated that the intermediate mesh was best. Descaling during the May 6-10 test was considerably less in 1C (intermediate mesh) than in 1A (regular mesh); APD = 2.5 vs 10% respectively. When the screens in 1A and 1C were exchanged, descaling in 1A (now intermediate mesh) was reduced from 10% to 5%; descaling rate increased from 2.5% to 5% in 1C with regular mesh (Figure 7).

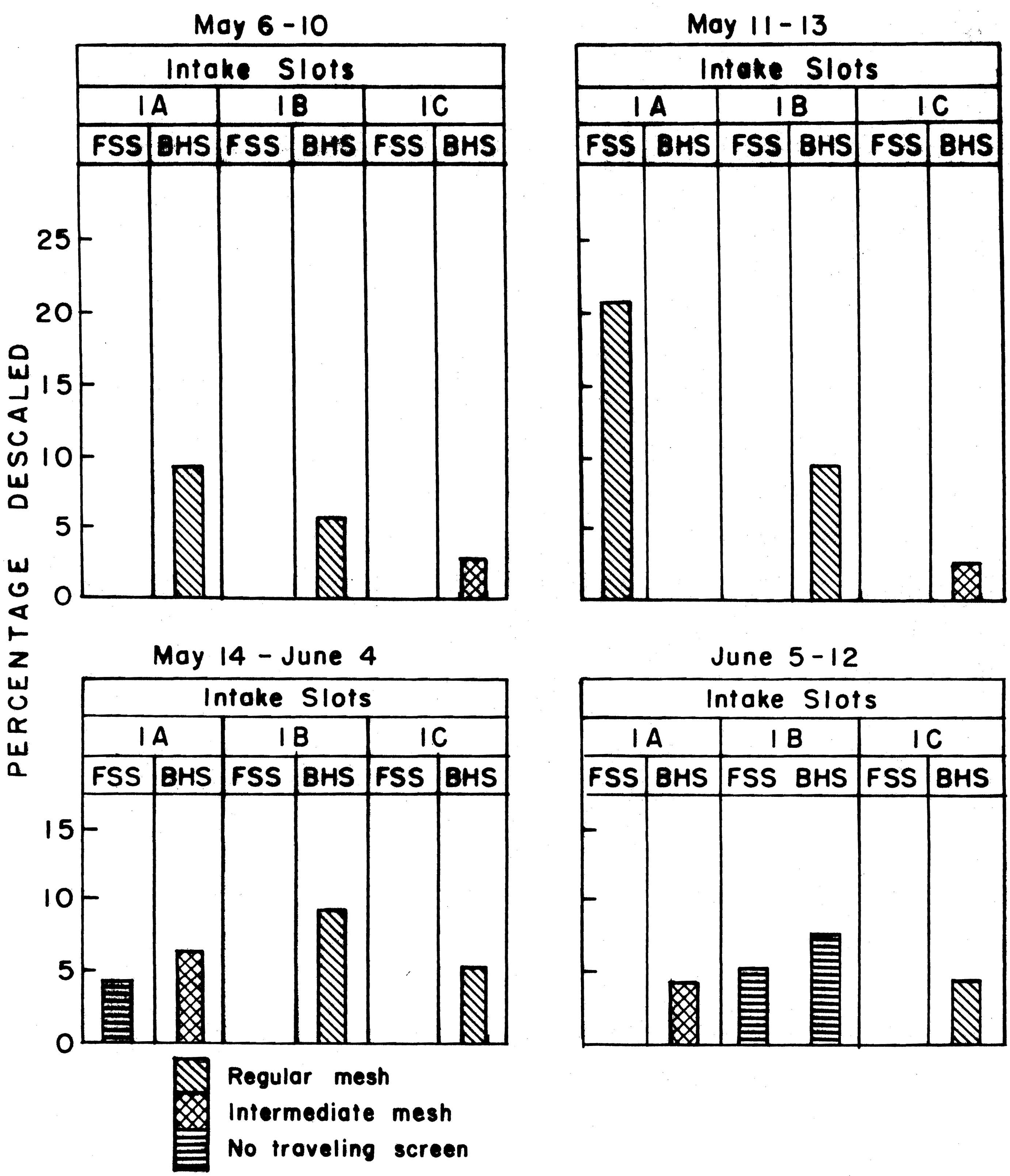


Figure 7.--The percent descaling of naturally migrating fingerling chinook salmon taken from the intake slots at Lower Granite Dam during four different time periods with different traveling screen arrangements.

With regular mesh in the FSS during the May 11-13 test, descaling of salmon was 20.4% (Figure 7). Because this period coincided with the peak of the fingerling outmigration and the amount of descaling was excessive, further testing of traveling screens in the FSS was postponed until after the major outmigration of juveniles had passed.

Highest descaling rates occurred during May when hatchery chinook dominated the catch. Lowest rates occurred in June when nearly all fingerlings were of native origin. The low rate measured in June was consistent between both screened and unscreened intake slots. In fact, APD in 1B (unscreened) was slightly higher (8.0) than for either of the screened intakes (4.6 for 1A and 4.9 for 1C).

The pattern of descaling in steelhead was similar to that of chinook except APD was much lower.

Fish Guidance

Only one test to measure variation in fish guidance was possible with natural migrants during the spring period. Most tests were conducted in the fall with hatchery stocks which were released through hoses (Figure 6) placed in turbine intakes. The test with natural migrants was conducted during a 4-day period toward the end of the outmigration to avoid handling excessive numbers of fish. Conditions tested were: traveling screen with regular mesh in BHS of 1C; traveling screen with intermediate mesh in BHS of 1A; and, no screen in 1B. The number of fish dipnetted from the bulkhead and fish screen slots with orifices closed formed the basis for determining differences in fish guidance. Since testing was of an exploratory nature, results should be considered preliminary at this time. Two obvious differences in guidance were apparent:

1. Less than 4% of the salmon and 15% of the steelhead collected in both slots of 1A and 1B entered FSS slots when traveling screens were operating in the BHS's. In the unscreened intake (1B) nearly 20% of the salmon and 40% of the steelhead collected in 1B gatewells were taken from the FSS. The overall total collected in 1B, however, was not as great as that collected in 1A.

2. More steelhead than salmon entered the FSS's; the reverse was true for the BHS's.

TRAVELING SCREEN TESTS - FALL 1975

Traveling screens were tested during October, 1975 at Lower Granite Dam. Fall testing is desirable because flows through turbines can be more closely controlled without interfering with power production and water is generally clear enough to use underwater television to study fingerling behavior at the traveling screen during operating conditions. On the other hand, naturally-migrating fingerlings are not abundant and hatchery-reared fish must be used as test animals.

Our test objectives were: (1) determine guiding efficiency and descaling rate for fish at various mesh and perforated plate combinations, (2) make video observations of fingerlings as they were actually being guided by the screen and, (3) determine ability to attract fish into bulkhead or fish screen slots by use of lights.

Procedures

Test fish were primarily hatchery-reared pre-smolt coho salmon. Some naturally-migrating chinook salmon were collected during test operations. These were accumulated and used for companion releases with coho salmon in some tests. Test fish were tattooed in lots of 300. Each release was made up of one lot; three replicates or lots made up a test group.

Each replicate was introduced into the turbine intake through a 3-inch hose placed behind the trash rack and held in place (by cable) about 20 feet upstream from the traveling screen and 4-6 feet from the intake ceiling. (Figure 6) Video observations were made by placing the camera and its light source near the center of the screen. Direct observations were made on the intake deck via a monitor, and observations were recorded on tape for later analysis. Video observations were made on only two of three replicates, so that the TV light source would not influence fish behavior during the 3rd (dark) replicate.

Five combinations of mesh size, perforated plate, or solid plate over screen were tested:

1. 42 x 36 x 16 mesh (regular) and 48% perforated plate.
2. 42 x 36 x 16 mesh and 33% perforated plate.
3. 72 x 36 x 16 mesh (intermediate) and 48% perforated plate.
4. 72 x 36 x 16 mesh and 33% perforated plate.
5. Solid plate (plywood) over upper 3/5 of screen area.

All combinations were tested during turbine loads of 155 and 125 megawatts with the traveling screen operating in the bulkhead slot. Only the number 2 combination above was tested in the fish screen slot of 1A for reasons described later.

All tests were repeated with lights placed at the entrance to the fish screen slot. Illumination was provided by installing three 500 watt incandescent lamps on a frame lowered into the slot to the desired depth.

During tests, orifices of both slots were closed to prevent egress. Tests were evaluated by dipnetting both slots (BHS and FSS) after each replicate. The number recovered compared to number released provided the guiding efficiency. All fish recovered were examined for descaling. A fish was considered to be descaled if 10% of its scales were missing. The number descaled was compared to the number not descaled for the descaling rate.

Results

Midway through the test program it became apparent that the coho salmon being tested were not good test animals. Regardless of screen combination or turbine operating condition tested, recoveries were lower and descaling rate higher than expected. Companion releases of wild chinook salmon coupled with video observations on behavior of both species confirmed our belief. For example, the recovery (guiding efficiency) of the relatively small number of chinook released was about twice that of coho released. Further, it was apparent the coho were poor swimmers as evidenced by the high degree of impingement we observed by underwater television. We concluded, therefore, that actual percentage guidance could not be obtained with this group of hatchery fish. Sufficient data were obtained, however, on relative differences in descaling and guidance between test situations. In general, the intermediate mesh over 48% open plate provided the lowest descaling, but was only fair in terms of guidance. On the other hand, regular mesh over either plate provided good guidance, but descaling was higher. It would appear that for screen mesh and plate now on hand, regular mesh should be used with 33% plate and intermediate mesh should be used with 48% plate.

Regardless of screen mesh-plate combinations tested, turbine load reduction to 125 megawatts reduced descaling. Adding light in the fish screen slot increased guiding efficiency at both 155 and 125 megawatt loads.

When solid plate was tested on the upper 3/5 of the screen area, recovery was nil (4 fish recovered from 12 replicates of 300 fish each) and obviously descaling was not a factor to be considered. We are not considering further tests with solid plate.

Regular mesh with 33% plate was the only combination tested in the fish screen slot. To get the best possible tests, only wild chinook were used. Recovery was poor and descaling was high (similar to findings in the single spring test). Fingerling behavior was monitored closely by Corps of Engineers and NMFS personnel during releases. Approach velocity to the screen was low to moderate when compared to approach velocities measured in the BHS. We observed fish swimming from the screen (near the entrance to the slot) toward the camera, indicating that the fish can swim at random in the vicinity of the screen. This probably accounts for the poor recovery since the fish were fully capable of avoiding the screen altogether by swimming back upstream and subsequently under the screen. High descaling is probably caused by repeated contacts with the screen since no positive directional guidance was provided.

We believe the high descaling and poor guidance shown by the FSS test data were due to two main factors: approach velocity and angle of screen in relation to water flow. The current screen is placed 45° from vertical which results in the screen being nearly perpendicular to the flow of water entering the intake when the screen is placed in the FSS. A change in the screen angle from 45° to some greater angle appears to be the most logical solution to the problem at this time.

A new screen design is now being manufactured which should compensate for hydraulic conditions that apparently are unique in the area of the fish screen slot. Its salient feature is an adjustable screen angle which can be tested at 45° (the traditional screen design angle), 55°, or 65°. It is planned to test the new screen in the fish screen and bulkhead slots at Lower Granite Dam in 1976.

ORIFICE PASSAGE AND DIURNAL MOVEMENT OF FINGERLINGS

At Lower Granite Dam, the bulkhead and fish screen slots were both equipped with a pair of submerged orifices for the passage of fingerlings from the gatewells to an open by-pass channel within the powerhouse. The submerged orifices were 8-inch diameter openings that could be easily converted to 6-inch diameter openings by installing inserts from the downstream side of the orifice (from the by-pass gallery).

Preliminary data indicated that fingerling passage or exit from gatewells was excellent when two 8-inch orifices were open. Passage when two 6-inch orifices were open was still acceptable, but about twice as many fingerlings stayed in the gatewell compared to residual counts when two 8-inch orifices were open. Exploratory tests indicated there was no preference for egress through the south vs. the north orifice. Further testing is required to determine if a single 8-inch orifice would be adequate for optimum passage--a condition that would save considerable water when all 6 turbine units are operating.

During two 24-hour periods during the season, gatewells (bulkhead slots) in unit one were dipnetted every two hours to establish a diurnal pattern for entry of chinook and steelhead smolts in to the gatewell when traveling screens were operating. The data, summarized in Figure 8, indicated that steelhead entered mainly during day light hours. Chinook, on the other hand, entered during dark hours with the peak movement about 4:00 A.M. when 23% of the total entry was recorded.

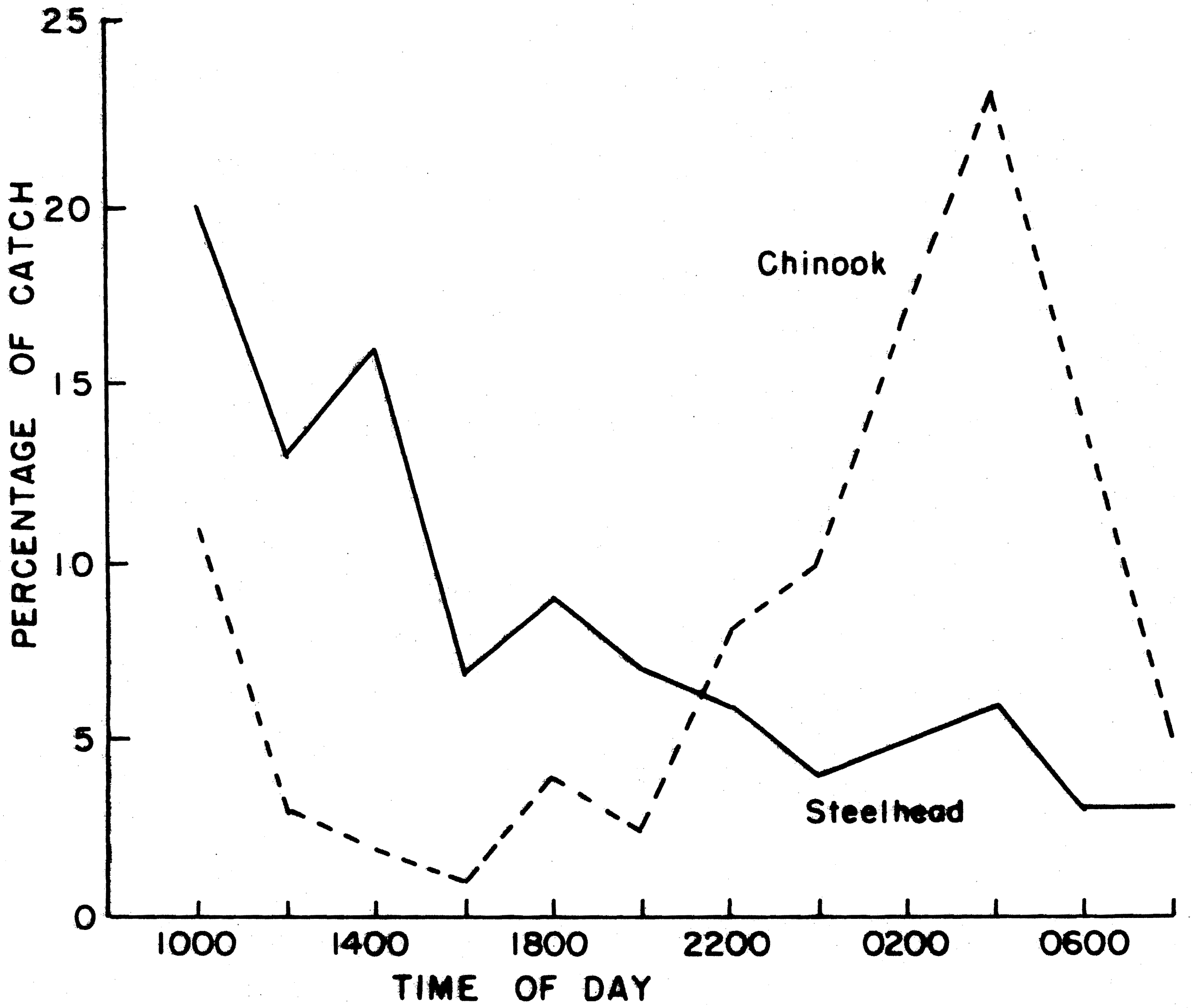


Figure 8.--Diurnal collection of chinook salmon and streelhead trout smolts from gatewells with traveling screens operating.

SUMMARY

1. Over 220,000 fingerling chinook salmon and steelhead trout were marked at Lower Granite Dam for release near Clarkston, Washington (controls) and Bonneville Dam (test) to test the transportation concept.

2. Adult returns to Little Goose Dam for fingerlings transported in 1971-73 are essentially complete (except for 3-ocean chinook salmon hauled in 1973). To date benefit ratios for chinook salmon are 1.6:1, 1.1:1, and 15.6:1 for 1971, 72 and 73 respectively. Benefit ratios for steelhead trout are 1.7:1, 3.25:1, and 15.0:1 for 1971, 72 and 73 respectively. Transportation of juvenile salmonids continues to show a positive means of enhancing survival of Snake River outmigrants.

3. Mass transportation of steelhead trout and chinook salmon was begun at Little Goose Dam in 1975. About 500,000 steelhead and 350,000 chinook were hauled (unmarked) to Bonneville.

4. Fingerling chinook salmon hauled in salt (5 ppt) water showed a delayed mortality of about 2 percent. Chinook hauled in fresh water showed a delayed mortality of about 12 percent, indicating a significant benefit in survival for hauling smolts in salt water.

5. Survival of juvenile chinook and steelhead emigrating from the Snake River was 25% and 42% respectively to The Dalles Dam in 1975. Steelhead survival was the highest measured since 1969. The chinook outmigration was dominated by hatchery stocks (60%--primarily from Rapid River) for the first time.

6. Major factors resulting in higher survival of steelhead and native chinook in 1975 included reduced N_2 supersaturation from flip-lips in operation at Lower Granite and Lower Monumental Dams, favorable runoff conditions which allowed timely spill and lower turbine mortalities, and higher quality steelhead smolts released from Dworshak Hatchery than in 1974.

7. During the period of major migration of juvenile chinook and steelhead (April 15-May 20), nitrogen values ranged from 115.8 to 137.7% of saturation in Lower Monumental forebay and from 120.2 to 135.9% in the spillway tailrace at Bonneville Dam.

8. Spillway deflectors at Lower Monumental Dam were shown to be instrumental in degassing water.

9. In the spring of 1975, traveling screen tests at Lower Granite Dam revealed that an excessively high descaling rate occurred when a screen was operated in the newly designed fish screen slot (about 20%). Screens operated in the traditional bulkhead slots had an average descaling rate of 6.4%.

10. Traveling screen tests in the fall of 1975 indicated that the present screen design could not be made safe for fingerlings when the screen was used in the fish screen slot. From underwater TV observations it was determined that a new design incorporating an adjustable screen angle should be tested. Tests using a single screen of the new design will be accomplished in the spring of 1976.

11. Conventional screens tested at Lower Granite in the fall of 1975 indicate that regular mesh with 33% perforated plate and intermediate mesh with 48% perforated plate should be used whenever possible to make the most efficient use of screens now on hand.

12. Fingerling passage from gatewells was excellent when two 8-inch orifices were open. Eight inch orifices were nearly twice as effective in reducing residualism in gatewells as 6-inch orifices.

Appendix Table 1.--Date, brand position, wire tag code, release location and number of juvenile chinook salmon and steelhead trout marked and transported (test groups) - Lower Granite Dam 1975.

Date	Brand Position[1] and symbol	Wire[2] Tag color	Release Site	Chinook Salmon	Steelhead Trout
4-23	RA-T	W-Y-YOX-R	Bonneville boat Launch	1103	640
4-25	None	W-Y-YOX-LG	"	4146	945
4-28	RA-⊢∃	W-Y-YOX-R	"	3975	2635
4-29	None	W-Y-YOX-LG	"	2186	3923
5-1	RA-⊢∃	W-Y-YOX-R	"	1325	3148
5-5	None	W-Y-YOX-LG	"	4945	2957
5-6	RA-ıL	W-Y-YOX-R	"	3512	2391
5-7	None	W-Y-YOX-LG	"	2581	3055
5-9	FA-E⊣	W-Y-YOX-GR	"	3787	2638
5-12	None	W-Y-YOX-LG	"	2825	3398
5-13	RA-E⊣	W-Y-YOX-GR	"	7380	2127
5-16	None	W-Y-YOX-LG	"	4734	2105
5-17	RA-N	W-O-ROX	"	3653	2164
5-19	None	W-O-BR	"	4593	4100
5-20	RA-N	W-O-ROX	"	1796	2308
5-21	None	W-O-BR	"	2389	4423
5-22	RA-N	W-O-ROX	"	2396	2766
5-27	None	W-O-BR	"	3445	2988
6-2	RA-Z	W-O-ROX	"	1200	3261
6-5	None	W-O-BR	"	1943	2218

Appendix Table 1 (Continued)

Date	Brand Position 1/ and symbol	Wire 2/ Tag Color	Release Site	Chinook Salmon	Steelhead Trout
6-9	None	W-O-BR	Bonneville Boat Launch	1985	2275
6-11	None	W-O-BR	"	1342	1928
6-17	None	W-O-BR	"	1309	2082

1/ LA-RA indicate brand position; i.e. left anterior, right anterior

2/ Colors on Tags W-White, Y-Yellow, R-Red, LG-Light Green, GR-Green, O-Orange, BR-Brown, OX-Oxide

Appendix Table 2.--Date, brand position, wire tag code, release location and number of chinook and steelhead trout released as controls at Lower Granite Dam 1975.

Date	Brand Position and symbol[1]	Wire Tag Color[2]	Release Site	Chinook Salmon	Steelhead Trout
4-22	LA-F	W-Y-B-L	Clarkston, WA	858	1165
4-24	LA-F	W-Y-B-L	"	1443	663
4-25	LA-F	W-Y-B-L	"	453	397
4-28	LA-ꟻ	W-Y-B-L	"	751	1831
4-29	LA-ꟻ	W-Y-B-L	"	285	1543
4-30	LA-ꟻ	W-Y-B-L	"	2588	2927
5-2	LA-ꟻ	W-Y-B-L	"	2865	2916
5-3	LA-ꟻ	W-Y-B-L	"	3017	2265
5-5	LA-Ⅎ	W-Y-B-L	"	2661	423
5-6	LA-Ⅎ	W-Y-B-L	"	545	989
5-8	LA-Ⅎ	W-Y-B-L	"	3223	2258
5-10	LA-Ⅎ	W-Y-B-L	"	2262	2108
5-12	LA-Ⅎ	W-Y-B-L	"	2287	1486
5-13	LA-Ⅎ	W-Y-B-L	"	1374	1092
5-14	LA-Ⅎ	W-Y-B-L	"	3650	2656
5-15	LA-Ⅎ	W-Y-B-L	"	3678	2482
5-20	LA-K	W-Y-YOX-P	"	1647	2427
5-21	LA-K	W-Y-YOX-P	"	691	2948
5-23	LA-K	W-Y-YOX-P	"	1754	2018
5-24	LA-K	W-Y-YOX-P	"	1729	2563
5-27	LA-K	W-Y-YOX-P	"	812	2949

Appendix Table 2 (Continued)

Date	Brand Position[1] and symbol	Wire[2] Tag Color	Release Site	Chinook Salmon	Steelhead Trout
5-28	LA-	W-Y-YOX-P	Clarkston, WA	1433	1801
5-29	LA-	W-Y-YOX-P	"	180	2064
5-30	LA-	W-Y-YOX-P	"	692	1976
6-3	LA-	W-Y-YOX-P	"	1016	724
6-6	LA-	W-Y-YOX-P	"	1226	1488
6-13	LA-	W-Y-YOX-P	"	782	1442
			TOTALS	43,902	49,601

1/ LA-RA indicate brand position; i.e. left anterior, right anterior

2/ Colors on Tags W-White, Y-Yellow, B-Blue, L-Lavender, P-Pink, OX-Oxide

Appendix Table 3.--Dissolved gas saturation data for Columbia and Snake Rivers, April-July, 1975.

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE APRIL 8,1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1000	33	7.2	12.32	104.8	15.51	100.4	749.9	101.2	8	0.0	0.0	740	0	0
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1000	0	7.6	12.40	106.5	15.55	101.6	759.4	102.5	8	0.0	0.0	740	0	0
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1005	0	7.6	13.68	117.1	18.05	117.5	871.1	117.2	8	0.0	0.0	640	0	0
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1045	33	7.6	13.99	119.8	17.61	114.6	858.2	115.5	8	0.0	0.0	638	0	0
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1045	0	7.6	14.19	121.5	17.47	113.7	855.8	115.1	8	0.0	0.0	638	0	0
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1110	33	7.2	13.90	117.4	17.22	110.7	834.7	111.9	0	0.0	0.0	540	0	0
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1110	0	7.6	14.32	122.2	17.05	110.6	841.7	112.8	0	0.0	0.0	540	0	0
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1130	33	7.6	13.93	118.5	16.55	107.0	817.6	109.2	10	0.0	0.0	440	0	0
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1130	0	8.1	14.06	121.1	16.46	107.4	825.5	110.3	10	0.0	0.0	440	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1158	33	7.2	14.45	121.2	17.89	114.2	866.9	115.4	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1156	0	7.2	14.58	122.3	17.63	112.6	859.2	114.4	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE CR.	1200	33	7.2	14.19	119.1	16.97	108.3	829.1	110.4	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE CR.	1200	0	7.2	14.45	121.2	17.05	108.6	835.6	111.2	0	0.0	0.0	340	0	0
JOHN DAY FOREBAY 1/4 MI UP CNTR	1339	33	7.2	13.55	113.4	16.72	106.4	811.4	107.7	0	0.0	0.0	265	0	0
JOHN DAY FOREBAY 1/4 MI UP CNTR	1339	0	7.2	13.55	113.4	16.55	105.3	805.1	106.9	0	0.0	0.0	265	0	0
THE DALLES FOREBAY 1/4 MI UP CENTER	1400	33	7.2	12.91	107.6	16.30	103.4	787.3	104.1	0	0.0	0.0	160	0	0
THE DALLES FOREBAY 1/4 MI UP CENTER	1400	0	7.2	13.04	108.7	16.30	103.4	789.0	104.4	0	0.0	0.0	160	0	0
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1445	33	7.2	13.16	109.4	16.53	104.5	799.2	105.4	10	0.0	0.0	74	0	0
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1445	0	7.2	12.93	107.4	16.13	102.0	781.3	103.0	10	0.0	0.0	74	0	0
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1500	0	7.2	15.12	125.4	19.99	126.2	954.4	125.7	10	0.0	0.0	29	0	0
COLUMBIA RIVER PRESCOTT CENTER	1545	0	7.6	12.94	108.3	16.30	103.0	795.0	104.6	10	0.0	0.0	14	0	0

NATIONAL MARINE FISHERIES SERVICE COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE APRIL 22,1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1508	0	9.4	12.52	112.4	15.77	107.3	801.5	106.2	6	0.0	0.0	740	0	0
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1512	33	8.7	11.95	105.4	15.88	106.3	765.2	106.0	6	0.0	0.0	740	0	0
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1530	0	8.7	13.49	118.6	16.24	121.7	897.5	120.6	6	0.0	0.0	640	0	0
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1435	0	9.9	14.18	126.4	17.22	118.0	891.0	119.9	8	0.0	0.0	638	0	0
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1454	33	8.9	13.08	115.6	17.50	117.3	867.2	116.7	8	0.0	0.0	638	0	0
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1415	0	9.6	13.41	120.1	16.68	114.5	860.9	115.4	8	0.0	0.0	540	0	0
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1420	33	9.2	13.19	117.0	17.22	115.6	863.8	115.8	8	0.0	0.0	540	0	0
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1345	0	9.5	13.85	123.3	16.61	113.4	862.4	115.2	10	0.0	0.0	440	0	0
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1400	33	9.4	13.41	119.1	17.01	114.5	862.5	115.2	10	0.0	0.0	440	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1155	0	9.1	13.96	122.7	16.81	112.0	856.3	114.0	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1200	33	9.0	13.55	116.7	16.68	112.2	851.4	113.3	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1205	0	9.4	13.74	121.6	16.60	111.3	850.8	113.3	0	0.0	0.0	340	0	0
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1210	33	9.0	13.34	116.9	16.67	110.8	840.5	111.9	0	0.0	0.0	340	0	0
JOHN DAY FOREBAY 1/4 MI UP CNTR	1120	0	8.7	12.63	109.7	15.84	104.3	793.3	105.3	0	0.0	0.0	265	0	0
JOHN DAY FOREBAY 1/4 MI UP CNTR	1125	33	8.9	12.52	109.2	15.95	105.5	799.4	106.1	0	0.0	0.0	265	0	0
THE DALLES FOREBAY 1/4 MI UP CENTER	1100	0	8.9	12.52	108.8	15.91	104.8	798.0	105.6	0	0.0	0.0	160	0	0
THE DALLES FOREBAY 1/4 MI UP CENTER	1105	33	9.2	12.63	110.6	15.98	106.0	807.6	106.6	0	0.0	0.0	160	0	0
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1014	0	8.7	12.74	109.9	15.98	104.5	800.1	105.5	8	0.0	0.0	74	0	0
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1025	33	8.7	12.82	110.5	15.98	104.5	801.1	105.6	8	0.0	0.0	74	0	0
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1030	0	9.0	13.74	119.1	16.28	120.1	908.6	119.6	8	0.0	0.0	29	0	0
COLUMBIA RIVER PRESCOTT CENTER	945	0	9.4	13.23	115.7	16.32	106.2	832.9	109.6	0	0.0	0.0	14	0	0

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE MAY 6, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1510	0	10.0	11.13	101.3	14.98	103.3	761.3	102.8	7	52.0	74.0	740	69	90
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1515	33	10.0	11.17	101.7	15.11	104.1	766.7	103.5	7	52.0	74.0	740	69	90
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1525	0	10.0	13.10	118.8	17.68	121.4	896.0	120.5	7	52.0	74.0	640	69	90
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1435	0	10.9	12.10	112.2	15.91	111.4	827.7	111.4	2	19.0	85.0	638	33	98
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1440	33	10.9	12.23	113.3	16.22	113.5	842.0	113.3	2	19.0	85.0	638	33	98
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1409	0	10.5	13.57	124.2	18.07	125.0	928.3	124.5	8	42.0	85.0	540	57	94
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1415	33	10.4	13.57	123.9	18.45	127.4	941.7	126.3	8	42.0	85.0	540	57	94
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1345	0	10.7	13.21	120.9	17.07	118.1	866.5	118.4	9	39.0	84.0	440	49	94
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1350	33	10.3	12.87	116.7	17.14	117.6	877.2	117.2	9	39.0	84.0	440	49	94
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1140	0	10.3	13.57	122.7	16.14	110.4	846.9	112.7	2	21.0	257.0	340	25	231
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1145	33	9.8	12.91	115.3	16.14	109.1	828.3	110.3	2	21.0	257.0	340	25	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1155	0	10.0	13.21	118.5	16.53	112.3	851.7	113.4	2	21.0	257.0	340	25	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1200	33	9.6	12.84	114.2	16.53	111.3	839.1	111.7	2	21.0	257.0	340	25	231
JOHN DAY FOREBAY 1/4 MI UP CNTR	1115	0	10.3	12.59	113.6	15.52	105.9	868.4	107.3	0	0.0	283.0	265	8	248
JOHN DAY FOREBAY 1/4 MI UP CNTR	1120	33	10.3	12.35	111.3	15.52	105.9	805.0	106.9	0	0.0	283.0	265	8	248
THE DALLES FOREBAY 1/4 MI UP CENTER	1055	0	10.2	12.10	108.5	15.29	103.7	790.6	104.6	0	0.0	255.0	160	0	258
THE DALLES FOREBAY 1/4 MI UP CENTER	1100	33	10.3	12.10	108.7	15.29	103.9	792.3	104.8	0	0.0	255.0	160	0	258
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1035	0	10.3	12.47	111.7	15.75	106.7	816.0	107.6	18	139.0	270.0	74	137	267
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1040	33	10.3	12.44	111.4	15.63	107.2	818.6	107.9	18	139.0	270.0	74	137	267
BONVILL SPIL 1/4 MI.DS N.SIDE BAY1-3+5-18	1005	0	10.3	13.82	123.5	16.69	126.4	952.4	125.4	18	139.0	270.0	25	137	267
BONVILL SPIL 1/4 MI.DS N-MID. BAY1-3+5-18	1008	0	10.3	14.06	125.7	18.99	128.5	968.2	127.5	18	139.0	270.0	25	137	267
BONVILL SPIL 1/4 MI.DS N-MID. BAY1-3+5-18	1011	10	10.3	14.18	126.8	19.23	130.0	979.2	128.9	18	139.0	270.0	25	137	267
BONVILL SPIL 1/4 MI.DS S-MID. BAY1-3+5-18	1014	0	10.3	13.94	124.6	18.76	126.9	957.2	126.0	18	139.0	270.0	25	137	267
BONVILL SPIL 1/4 MI.DS S-MID. BAY1-3+5-18	1017	10	10.3	14.43	129.0	19.38	131.1	968.8	130.2	18	139.0	270.0	25	137	267
BONVILL SPIL 1/4 MI.DS S.SIDE BAY1-3+5-18	1020	0	10.3	13.59	121.5	18.46	124.8	939.9	123.7	18	139.0	270.0	25	137	267
COLUMBIA RIVER PRESCOTT CENTER	908	0	9.8	12.60	111.3	16.60	111.0	842.5	110.9	0	0.0	0.0	14	0	0

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE MAY 20, 1975

				---OXYGEN---		ATMOSPHERIC --NITROGEN--		-TOTAL PRESSURE	GAS-	NO. GATE	HOURLY ----KCFS----	FLOW	SAMPLE ELEV	PEAK DAILY FLOW--KCFS	
LOCATION	TIME	DEPT FT	TEMP C	MG/L	SAT	ML/L	SAT	MM HG	SAT	OPEN	SPILL	TOTAL	FEET	SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1500	0	11.2	10.85	101.6	14.92	105.5	774.6	104.6	8	113.0	168.0	740	115	153
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1510	33	10.5	10.80	99.5	14.65	103.4	759.4	102.5	8	113.0	168.0	740	115	153
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1530	0	10.7	13.02	120.1	17.92	124.9	918.2	123.5	8	113.0	168.0	640	115	153
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1430	0	13.4	12.72	124.7	17.09	126.1	931.9	125.4	8	136.0	181.0	638	104	167
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1440	33	11.2	12.29	114.6	17.09	120.4	883.9	116.9	8	136.0	181.0	638	104	167
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1400	0	12.7	14.16	136.2	19.26	139.5	1031.3	138.3	8	119.0	164.0	540	121	162
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1405	33	11.4	14.16	132.2	19.52	137.7	1014.4	136.0	8	119.0	164.0	540	121	162
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1325	0	12.1	12.86	121.7	17.35	123.7	920.1	122.9	9	119.0	165.0	440	120	166
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1330	33	11.9	12.72	119.7	17.35	123.2	914.2	122.1	9	119.0	165.0	440	120	166
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1155	0	12.5	12.00	114.1	15.70	112.5	846.0	112.6	19	114.0	358.0	340	128	341
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1200	33	11.7	11.57	108.0	15.35	108.2	811.2	108.0	19	114.0	358.0	340	128	341
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1145	0	12.5	12.57	119.6	16.31	116.8	880.0	117.1	19	114.0	358.0	340	128	341
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1150	33	11.9	12.29	115.3	16.74	118.5	862.7	117.5	19	114.0	358.0	340	128	341
JOHN DAY FOREBAY 1/4 MI UP CNTR	1050	0	12.5	11.57	109.7	15.70	112.2	839.6	111.5	20	58.0	352.0	265	74	354
JOHN DAY FOREBAY 1/4 MI UP CNTR	1055	33	12.5	11.42	108.4	15.70	112.2	837.5	111.2	20	58.0	352.0	265	74	354
THE DALLES FOREBAY 1/4 MI UP CENTER	1030	0	12.3	11.71	110.2	15.96	113.2	849.1	112.3	22	96.0	337.0	160	104	350
THE DALLES FOREBAY 1/4 MI UP CENTER	1035	33	12.3	11.71	110.2	16.13	114.4	856.3	113.3	22	96.0	337.0	160	104	350
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1005	0	12.2	11.71	109.6	15.79	111.4	640.0	110.8	18	219.0	349.0	74	218	349
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1010	33	12.2	11.71	109.6	15.96	112.6	847.3	111.7	16	219.0	349.0	74	218	349
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	950	0	12.2	13.82	129.1	19.30	135.9	1017.0	133.9	18	219.0	349.0	27	218	349
COLUMBIA RIVER PRESCOTT CENTER	859	0	12.8	11.82	111.8	16.57	118.1	865.1	116.5	0	0.0	0.0	14	0	0

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JUNE 3, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1506	0	12.1	10.46	100.0	14.78	106.5	777.9	105.0	8	143.0	184.0	740	127	17[illegible]
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1510	33	11.5	10.41	98.1	14.58	103.7	75[illegible].2	102.5	8	143.0	184.0	740	127	17[illegible]
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1515	0	11.8	13.09	123.8	16.22	130.0	95[illegible].3	126.3	8	143.0	184.0	640	127	17[illegible]
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1442	0	13.2	11.57	112.9	16.13	118.5	870.0	117.0	8	119.0	186.0	638	109	17[illegible]
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1440	33	13.1	11.70	114.0	16.30	119.5	877.5	118.1	8	119.0	186.0	638	109	17[illegible]
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1415	0	14.0	12.95	128.3	18.08	134.5	989.5	132.7	8	108.0	174.0	540	102	1[illegible]
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1420	33	13.6	13.09	128.5	18.50	136.5	1001.6	134.3	8	108.0	174.0	540	102	1[illegible]
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1350	0	13.8	11.98	117.7	16.64	122.9	908.9	121.4	9	64.0	110.0	440	121	1[illegible]
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1355	33	13.6	12.12	118.6	16.72	123.0	910.9	121.7	9	64.0	110.0	440	121	1[illegible]
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1208	0	14.3	11.98	118.6	16.47	122.4	910.7	121.2	22	134.0	373.0	340	16[illegible]	37[illegible]
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1210	33	14.0	11.98	117.8	16.64	122.9	912.6	121.5	22	134.0	37.0	340	[illegible]	[illegible]37
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1212	0	14.7	12.12	121.0	15.62	117.1	883.1	117.6	22	134.0	373.0	340	16[illegible]	[illegible]
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1214	33	14.1	12.00	118.2	15.71	116.3	874.3	116.4	22	134.0	373.0	340	16[illegible]	[illegible]37
JOHN DAY FOREBAY 1/4 MI UP CNTR	1130	0	15.0	11.70	117.3	15.71	118.1	885.8	117.6	20	89.0	382.0	265	12[illegible]	37[illegible]
JOHN DAY FOREBAY 1/4 MI UP CNTR	1125	33	14.4	12.12	119.9	16.05	119.2	896.3	119.0	20	89.0	382.0	265	12[illegible]	37[illegible]
THE DALLES FOREBAY 1/4 MI UP CENTER	1100	0	14.2	12.54	123.0	17.15	126.4	946.7	125.2	22	47.0	369.0	160	117	3[illegible]
THE DALLES FOREBAY 1/4 MI UP CENTER	1105	33	14.2	12.81	125.8	17.40	128.3	961.9	127.2	22	47.0	369.0	160	117	3[illegible]
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1045	0	14.0	11.98	116.7	16.21	118.7	894.4	117.9	18	229.0	359.0	74	23[illegible]	3[illegible]
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1047	33	14.0	11.98	116.7	16.21	118.7	894.4	117.9	18	229.0	359.0	74	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1010	0	14.0	12.95	126.0	17.82	130.2	978.5	128.8	18	229.0	359.0	27	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1013	10	14.0	13.37	130.0	18.42	134.6	1010.4	133.0	18	229.0	359.0	27	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1016	0	14.0	13.23	128.7	18.25	133.3	1001.0	131.8	18	229.0	359.0	27	23[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1020	10	14.0	13.95	135.6	19.16	140.0	1051.1	138.4	18	229.0	359.0	27	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY6	1025	0	14.0	13.92	135.4	19.18	140.1	1051.7	138.5	18	229.0	359.0	27	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY6	1027	10	14.0	13.73	133.5	19.01	138.9	1041.4	137.1	18	229.0	359.0	27	[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1029	0	14.0	13.64	132.7	18.75	137.0	1029.2	135.5	18	229.0	359.0	27	23[illegible]	3[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1032	10	14.0	13.64	132.7	18.64	137.7	1032.9	136.0	18	229.0	359.0	27	[illegible]	3[illegible]
COLUMBIA RIVER WASHOUGAL CNTR	944	0	14.2	12.54	122.5	17.23	126.4	950.3	125.1	0	0.0	0.0	26	[illegible]	[illegible]
COLUMBIA RIVER PRESCOTT CENTER	913	0	14.7	12.20	120.4	16.55	122.6	92[illegible].0	12[illegible].7	0	0.0	0.0	14	[illegible]	

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JUNE 17, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL GAS- PRESSURE MM HG	SAT	NO. GATE OPEN	HOURLY FLOW ----KCFS---- SPILL	TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
COLUMBIA RIVER PRESCOTT CENTER	900	0	15.5	11.06	111.1	15.52	116.8	876.0	115.3	0	0.0	0.0	14	0	0
COLUMBIA RIVER WASHOUGAL CNTR	915	0	14.5	11.56	113.6	15.94	117.6	884.8	116.5	0	0.0	0.0	26	0	0
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY17	1015	0	14.6	12.02	118.4	17.29	127.8	952.5	125.4	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY17	1018	10	14.6	12.13	119.6	17.29	127.8	954.3	125.6	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY13	1021	0	14.6	12.49	123.1	17.71	131.0	978.1	128.8	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY13	1024	10	14.6	12.60	124.2	17.92	132.5	988.9	130.2	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1027	0	14.6	12.72	125.4	18.05	133.5	996.4	131.2	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1030	10	14.6	12.84	126.5	18.38	135.9	1013.0	133.4	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1033	0	14.6	12.37	121.9	17.71	131.0	976.3	128.5	18	165.0	301.0	24	158	301
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1036	10	14.6	12.60	124.2	17.71	131.0	979.9	129.0	18	165.0	301.0	24	158	301
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1045	0	14.7	10.96	108.2	14.93	110.6	834.9	109.9	18	165.0	301.0	24	158	301
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1050	33	14.6	10.96	108.0	14.93	110.4	833.2	109.7	18	165.0	301.0	24	158	301
THE DALLES FOREBAY 1/4 MI UP CENTER	1115	0	15.0	10.96	109.5	14.93	111.8	839.9	111.1	2	3.0	292.0	160	94	291
THE DALLES FOREBAY 1/4 MI UP CENTER	1120	33	14.9	10.84	108.1	14.92	111.5	835.8	110.5	2	3.0	292.0	160	94	291
JOHN DAY FOREBAY 1/4 MI UP CNTR	1145	0	15.3	11.08	111.8	15.01	113.5	850.4	112.9	0	0.0	302.0	265	51	300
JOHN DAY FOREBAY 1/4 MI UP CNTR	1150	33	15.0	10.96	109.9	15.10	113.5	847.4	112.5	0	0.0	302.0	265	51	303
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1210	0	14.8	11.31	113.2	15.18	114.0	853.1	113.6	15	151.0	388.0	340	110	347
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1215	33	14.3	11.26	111.4	15.43	114.7	854.7	113.8	15	151.0	388.0	340	110	347
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1225	0	14.6	11.55	115.1	15.69	117.3	875.4	116.5	15	151.0	388.0	340	110	347
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1230	33	14.1	11.55	113.8	16.02	118.6	881.2	117.3	15	151.0	388.0	340	110	347
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1330	0	13.6	12.13	118.7	16.95	124.7	920.9	123.0	9	51.0	97.0	440	102	15[illegible]
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1335	33	13.2	12.04	116.7	16.61	121.3	897.2	119.9	9	51.0	97.0	440	102	15[illegible]
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1350	0	13.9	13.19	130.4	18.97	140.9	1029.6	138.0	8	63.0	130.0	540	79	148
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1355	33	13.5	13.24	129.7	19.31	142.2	1036.5	139.0	8	63.0	130.0	540	79	148
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1425	0	12.8	11.78	114.0	16.61	121.1	866.5	119.3	8	101.0	166.0	638	91	156
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1430	33	12.5	11.78	113.3	16.61	120.3	861.1	118.5	8	101.0	166.0	638	91	156
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1550	0	12.3	12.17	116.4	17.03	122.5	920.5	121.2	8	108.0	155.0	640	101	148
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1555	0	12.1	10.61	101.4	14.76	106.4	779.4	105.2	8	108.0	155.0	740	101	148
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1610	33	12.1	10.47	100.1	14.75	106.3	776.7	104.9	8	108.0	155.0	740	101	148

NATIONAL MARINE FISHERIES SERVICE COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JULY 1, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL GAS- PRESSURE MM HG	SAT	NO. GATE OPEN	HOURLY FLOW ----KCFS---- SPILL	TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
COLUMBIA RIVER WASHOUGAL CNTR	1955	0	15.3	11.77	117.8	16.01	120.0	905.1	119.2	0	0.0	0.0	26	0	[illegible]
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1900	0	15.1	11.42	113.8	15.76	117.7	885.5	116.6	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1905	10	15.1	11.54	114.9	15.69	117.2	884.2	116.4	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1910	0	15.1	11.54	114.9	15.69	117.2	884.2	116.4	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1915	10	15.1	11.54	114.9	15.64	118.3	890.5	117.2	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1918	0	15.1	11.89	118.4	16.05	119.9	905.5	119.2	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1920	10	15.1	11.37	113.2	16.27	121.5	907.0	119.4	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1923	0	15.1	11.89	118.4	16.05	119.9	905.5	119.2	16	80.0	225.0	20	99	246
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1925	10	15.1	11.65	116.1	16.05	119.9	901.9	118.7	16	80.0	225.0	20	99	246
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1820	0	15.1	11.31	112.6	15.55	116.3	874.2	115.3	16	80.0	225.0	74	99	246
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1825	33	15.2	11.62	116.2	15.40	115.5	874.3	115.3	16	80.0	225.0	74	99	246
THE DALLES FOREBAY 1/4 MI UP CENTER	1710	0	15.1	11.07	110.8	15.11	113.4	851.4	112.6	0	0.0	258.0	160	[illegible]	[illegible]
THE DALLES FOREBAY 1/4 MI UP CENTER	1715	33	15.1	10.96	109.7	14.97	112.3	843.2	111.5	0	0.0	258.0	160	20	[illegible]
JOHN DAY FOREBAY 1/4 MI UP CNTR	1640	0	14.7	10.49	104.5	14.46	108.1	807.3	107.2	0	0.0	225.0	265	30	227
JOHN DAY FOREBAY 1/4 MI UP CNTR	1645	33	14.7	10.49	104.5	14.53	108.6	810.4	107.6	0	0.0	225.0	265	30	227
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1440	0	17.9	11.89	127.0	15.04	119.9	908.6	120.9	3	14.0	228.0	340	47	236
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1445	33	15.0	11.42	114.8	15.91	119.9	890.2	116.5	3	14.0	228.0	340	47	236
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1420	0	17.2	11.65	122.8	14.97	117.8	869.6	116.4	3	14.0	228.0	340	47	236
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1423	33	15.1	11.49	115.7	15.40	116.3	870.6	115.9	3	14.0	228.0	340	47	236
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1220	0	13.6	12.00	117.4	16.70	122.9	906.3	121.3	10	69.0	113.0	440	62	[illegible]
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1227	33	13.6	12.19	119.2	16.56	121.8	904.9	120.9	10	69.0	113.0	440	62	[illegible]
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1147	0	14.1	13.86	137.6	19.24	143.4	1055.4	141.5	8	46.0	112.0	540	[illegible]	111
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1150	33	12.6	14.08	135.1	19.42	140.4	1034.3	138.7	8	46.0	112.0	540	45	111
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1120	0	13.5	11.89	116.8	16.49	121.9	895.5	120.5	8	56.0	121.0	635	49	117
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1122	33	12.2	11.89	113.5	16.78	120.7	883.8	118.9	8	56.0	121.0	638	49	117
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1045	0	12.6	11.89	114.5	16.49	119.6	879.1	118.3	7	50.0	118.0	640	50	117
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1020	0	12.4	10.03	96.5	14.39	104.4	760.3	102.7	7	50.0	118.0	740	50	117
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1025	33	12.4	10.48	100.8	14.77	107.1	762.6	105.7	7	50.0	118.0	740	50	117

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JULY 15, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
COLUMBIA RIVER PRESCOTT CENTER	932	0	18.8	9.57	103.0	13.91	111.5	831.7	109.4	0	0.0	0.0	14	0	0
COLUMBIA RIVER WASHOUGAL CNTR	1030	0	17.6	10.02	105.3	14.60	116.0	861.6	113.4	0	0.0	0.0	26	0	0
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1045	0	18.6	9.52	102.3	13.91	111.3	827.8	109.2	18	85.0	230.0	74	85	231
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1047	33	18.1	9.61	102.1	13.51	107.1	803.2	105.9	18	85.0	230.0	74	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1100	0	18.6	10.22	109.6	15.18	121.2	899.2	118.4	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1102	10	18.6	10.22	109.6	15.18	121.2	899.2	118.4	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1106	0	18.3	10.12	107.9	15.18	120.6	892.5	117.5	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1111	10	18.1	10.22	106.5	15.34	121.4	898.3	118.2	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1115	0	18.3	10.32	110.0	15.18	120.6	895.9	117.9	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1118	10	18.1	10.42	110.6	15.59	123.3	913.1	120.2	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1120	0	18.3	10.22	108.9	15.18	120.6	894.2	117.7	18	85.0	230.0	20	85	231
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1122	10	18.1	10.22	108.5	15.10	119.5	887.2	116.8	18	85.0	230.0	20	85	231
THE DALLES FOREBAY 1/4 MI UP CENTER	1215	0	19.1	9.52	103.6	13.99	113.3	839.3	111.0	0	0.0	255.0	160	0	224
THE DALLES FOREBAY 1/4 MI UP CENTER	1218	33	19.1	9.52	103.6	13.99	113.3	839.3	111.0	0	0.0	255.0	160	0	224
JOHN DAY FOREBAY 1/4 MI UP CNTR	1300	0	19.6	9.72	107.3	14.23	116.7	861.7	114.4	0	0.0	280.0	265	0	225
JOHN DAY FOREBAY 1/4 MI UP CNTR	1303	33	19.1	9.72	106.1	14.54	118.3	868.9	115.4	0	0.0	280.0	265	0	225
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1330	0	19.6	9.92	109.8	13.67	112.5	838.6	111.6	4	12.0	210.0	340	16	231
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1333	33	19.6	9.82	108.7	13.83	113.8	844.5	112.4	4	12.0	210.0	340	16	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1339	0	19.6	9.62	106.4	13.91	114.4	844.9	112.5	4	12.0	210.0	340	16	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1340	33	19.1	9.78	107.1	14.07	114.7	847.3	112.6	4	12.0	210.0	340	16	231
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1500	0	18.6	9.72	105.8	14.94	121.1	879.6	117.5	0	12.0	57.0	440	26	70
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1503	33	18.3	9.82	106.2	14.76	119.2	869.0	116.1	0	12.0	57.0	440	26	70
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1530	0	19.1	9.52	105.0	14.38	118.1	85[illegible].0	115.0	6	7.0	71.0	540	5	73
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1532	33	19.0	9.92	109.2	14.88	121.9	8[illegible].5	118.6	6	7.0	71.0	540	5	73
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1600	0	19.6	9.12	102.0	13.75	114.3	828.7	111.5	4	7.0	72.0	638	13	78
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1603	33	19.1	9.10	100.7	13.99	115.3	832.1	111.9	4	7.0	72.0	638	13	78
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1630	0	19.6	8.61	96.7	13.04	108.8	786.1	106.1	0	0.0	65.0	740	6	72
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1632	33	19.1	8.72	96.8	13.48	111.4	801.4	108.2	0	0.0	65.0	740	6	72
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1645	0	19.1	8.51	94.3	13.19	108.7	764.8	105.6	0	0.0	65.0	640	6	72
LWR GRANITE TAILRACE N 1/4 MI DN SPILL SIDE	1648	33	18.6	8.66	94.9	13.35	109.0	767.4	105.9	0	0.0	0.0	640	0	[illegible]

NATIONAL MARINE FISHERIES SERVICE COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JULY 29, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY FLOW ----KCFS---- SPILL	TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
COLUMBIA RIVER PRESCOTT CENTER	945	0	20.6	9.00	100.4	12.30	101.9	771.2	101.5	0	0.0	0.0	14	0	0
COLUMBIA RIVER WASHOUGAL CNTR	1015	0	19.6	9.27	101.4	12.37	100.6	765.1	100.7	0	0.0	0.0	26	0	0
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1110	0	19.7	9.42	103.2	12.85	104.7	792.1	104.2	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY15	1114	10	19.7	9.52	104.4	12.85	104.7	793.9	104.5	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1117	0	19.7	9.52	104.4	13.08	106.6	805.1	105.9	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY11	1119	10	19.7	9.42	103.2	13.24	107.9	810.8	106.7	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1123	0	19.7	9.52	104.4	13.24	107.9	812.5	106.9	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY8	1125	10	19.7	9.62	105.5	13.55	110.4	829.3	109.1	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1130	0	19.7	9.52	104.4	13.39	109.2	820.1	107.9	0	16.0	153.0	14	10	134
BONVILL SPIL 1/4 MI.DS BAY 1-18 CTR BAY4	1135	10	19.7	9.52	104.4	13.24	107.9	812.6	106.9	0	16.0	153.0	14	10	134
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1145	0	19.7	8.89	97.5	11.63	96.4	734.5	96.6	0	16.0	153.0	14	10	134
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1147	33	19.6	8.89	97.5	11.83	96.4	733.1	96.7	0	16.0	153.0	74	10	134
THE DALLES FOREBAY 1/4 MI UP CENTER	1210	0	19.9	8.69	96.1	12.14	99.8	748.6	99.0	0	0.0	197.0	160	0	137
THE DALLES FOREBAY 1/4 MI UP CENTER	1215	33	19.8	8.67	95.7	12.14	99.6	746.9	98.8	0	0.0	197.0	160	0	137
JOHN DAY FOREBAY 1/4 MI UP CNTR	1235	0	20.3	8.58	96.0	12.14	100.9	752.3	99.9	0	0.0	220.0	265	0	138
JOHN DAY FOREBAY 1/4 MI UP CNTR	1237	33	20.3	8.69	97.2	12.14	100.9	754.1	100.1	0	0.0	220.0	265	0	138
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1300	0	21.0	9.52	108.3	12.30	103.8	785.9	104.6	1	0.0	179.0	340	0	123
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1304	33	20.8	9.52	107.9	12.45	104.7	790.6	105.2	1	0.0	179.0	340	0	123
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1310	0	20.9	9.42	106.9	12.30	103.6	782.6	104.2	1	0.0	179.0	340	0	123
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1315	33	19.9	8.73	97.1	12.77	105.6	779.4	103.7	1	0.0	179.0	340	0	123
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1505	0	21.4	8.37	96.4	11.63	100.9	748.1	99.9	0	0.0	44.0	440	0	42
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1507	33	21.0	8.17	93.2	11.98	101.5	747.0	99.8	0	0.0	44.0	440	0	42
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1530	0	20.6	8.06	91.6	11.91	100.5	735.9	98.7	0	0.0	65.0	540	0	43
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1535	33	20.4	8.09	91.6	11.83	99.4	729.9	97.8	0	0.0	65.0	540	0	43
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1550	0	20.7	7.95	90.9	12.60	101.8	739.8	99.5	0	0.0	68.0	638	0	42
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1553	33	20.7	8.58	98.1	12.22	103.7	761.5	102.4	0	0.0	68.0	638	0	42
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1625	0	21.5	8.89	103.7	12.14	104.9	774.1	104.5	0	0.0	42.0	740	0	36
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1628	33	21.4	8.69	101.0	12.30	106.0	776.7	104.9	0	0.0	42.0	740	0	36
LWR GRANITE TAILRACE W 1/4 MI DN SPILL SIDE	1635	0	20.5	8.16	93.0	11.85	100.1	733.6	98.7	0	0.0	42.0	640	0	36

Appendix Table 4.--Dissolved saturation data for Lower Monumental Spillway deflector test March 25-March 27, 1975.

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE MARCH 25, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR MONUMENT FOREBAY SPILL SIDE	940	50	5.8	12.80	104.4	17.44	108.5	802.1	107.5	0	0.0	0.0	539	0	0
LWR MONUMENT FOREBAY SPILL SIDE	1307	50	5.9	12.69	103.7	17.53	109.3	805.6	108.0	0	0.0	0.0	537	0	0
LWR MONUMENT FOREBAY POWER SIDE	930	50	5.8	12.74	103.9	17.51	108.9	803.6	107.7	0	0.0	0.0	539	0	0
LWR MONUMENT FOREBAY POWER SIDE	1320	50	5.9	12.92	105.6	17.44	108.8	805.6	108.0	0	0.0	0.0	537	0	0
LITTLE GOOSE FOREBAY POWERHOUSE SIDE	1540	50	6.5	13.38	111.5	17.94	113.9	841.2	113.2	0	0.0	0.0	638	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1340	0	6.1	13.61	111.5	18.92	118.2	872.4	116.5	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1330	0	6.1	13.72	112.4	16.92	118.2	873.8	116.7	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1320	0	6.1	13.84	113.4	19.01	118.7	878.3	117.3	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1335	0	6.1	14.30	117.1	19.58	122.3	905.2	120.9	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1325	0	6.2	14.19	116.5	19.67	123.1	908.9	121.4	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1315	0	6.2	14.26	117.1	16.91	118.3	881.9	117.8	6	89.0	155.0	442	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1130	0	6.0	12.92	105.5	18.02	112.3	828.5	110.7	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1120	0	6.0	13.03	106.5	16.02	112.3	830.0	110.9	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1110	0	6.0	13.26	108.3	18.18	113.3	838.9	112.1	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1125	0	6.0	14.19	115.9	19.34	120.5	892.7	119.3	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1115	0	6.0	14.07	114.9	19.34	120.5	891.2	119.1	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1105	0	6.0	13.30	108.6	19.21	119.6	876.6	117.1	6	58.0	123.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1045	0	6.0	12.80	104.6	18.27	113.8	836.1	111.7	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1035	0	6.0	12.80	104.6	17.95	111.8	824.5	110.1	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1025	0	6.0	13.09	106.9	17.88	111.4	825.4	110.3	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1040	0	6.0	13.02	106.4	18.03	112.3	830.1	110.9	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1030	0	6.0	13.02	106.4	18.03	112.3	830.1	110.9	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	1020	0	6.0	13.13	107.2	18.27	113.8	840.2	112.2	6	28.0	92.0	440	0	0
LWR MONUMENT TAILRACE DEFL BAY 4	950	0	6.0	13.38	109.3	16.43	114.8	849.4	113.5	1	15.0	77.0	439	0	0
LWR MONUMENT TAILRACE DEFL BAY 4	945	0	6.0	13.38	109.3	18.51	115.3	852.4	113.9	1	15.0	77.0	439	0	0
LWR MONUMENT TAILRACE DEFL BAY 4	940	0	6.0	13.49	110.2	18.51	115.3	853.9	114.1	1	15.0	77.0	439	0	0

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE MARCH 27, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR MONUMENT FOREBAY POWER SIDE	900	50	6.0	13.90	113.9	17.24	107.7	812.3	108.9	0	0.0	0.0	538	0	0
LWR MONUMENT FOREBAY SPILL SIDE	920	50	6.0	13.74	112.6	17.14	107.1	806.8	108.1	0	0.0	0.0	538	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	1000	0	6.0	14.60	119.3	18.17	113.2	855.2	114.3	6	120.0	188.0	444	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	951	0	6.0	14.48	118.3	17.83	111.1	841.2	112.4	6	120.0	188.0	444	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 6	948	0	6.0	14.46	118.1	18.07	112.6	850.0	113.6	6	120.0	188.0	444	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	943	0	6.0	15.74	128.6	19.27	120.0	909.8	121.6	6	120.0	188.0	444	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	940	0	6.0	15.74	128.6	19.29	120.2	910.8	121.7	6	120.0	188.0	444	0	0
LWR MONUMENT TAILRACE DEFL 2-7 CTR BAY 2	935	0	6.0	15.72	128.4	19.85	123.7	930.9	124.4	6	120.0	188.0	444	0	0

Note:

1) Samples taken from the north side of the spillway discharge (centerline bay 6) were lower in gas concentration (most cases) than those taken from the south side (centerline bay 2). We believe that this anomaly was a consequence of turbine water discharge mixing with the water from the spillway, therefore, we intend to use only the centerline bay 2 samples for analysis of the spillway deflectors.

2) Oxygen concentrations measure March 27 appear much higher than is normally expected for these conditions. We suspect that there may be a systematic error in these data (an after-the-fact, subjective analysis).

Appendix Table 5.--Dissolved gas saturation data for Lower Granite Spillway deflector test April 17, 1975.

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE APRIL 17, 1975

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS- SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LWR GRANITE FOREBAY SPILL SIDE	930	50	8.2	11.64	101.5	15.59	103.2	761.2	102.8	6	0.0	0.0	740	0	0
LWR GRANITE FOREBAY SPILL SIDE	1545	50	8.1	11.64	101.2	15.44	102.1	754.1	101.8	6	0.0	0.0	740	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1101	0	8.2	12.79	111.1	17.25	113.8	840.2	113.0	6	35.0	57.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1106	0	8.2	12.95	112.5	17.56	116.0	855.1	115.0	6	35.0	0.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1109	0	8.2	12.73	110.6	17.41	114.9	845.8	113.8	6	35.0	0.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1112	0	8.2	12.61	109.6	17.00	112.2	828.6	111.5	6	35.0	0.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1115	0	8.2	12.61	109.6	17.25	113.8	838.0	112.7	6	35.0	0.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1117	0	8.2	12.61	109.6	17.00	112.2	828.6	111.5	6	35.0	0.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1241	0	8.2	13.06	113.5	17.74	117.1	862.9	116.1	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1244	0	8.2	13.00	112.9	17.71	116.8	860.6	115.8	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1246	0	8.2	12.84	111.6	17.49	115.4	850.5	114.4	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1248	0	8.2	13.06	113.5	17.66	116.5	859.8	115.7	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1251	0	8.2	13.06	113.5	17.74	117.1	862.9	116.1	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1254	0	8.2	13.06	113.5	17.62	117.6	866.1	116.5	6	60.0	81.0	634	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1404	0	8.2	13.29	115.5	18.31	120.8	867.9	119.4	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1405	0	8.2	13.18	114.5	17.99	118.7	873.8	117.6	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1407	0	8.2	13.51	117.3	18.15	119.8	864.5	119.0	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1410	0	8.2	13.40	116.4	18.15	119.8	883.1	118.8	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1412	0	8.2	13.40	116.4	18.07	119.2	880.0	118.4	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1414	0	8.2	13.51	117.4	18.31	120.8	890.9	119.9	6	90.0	112.0	635	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1512	0	8.2	13.51	117.4	18.40	121.4	894.1	120.3	6	120.0	141.0	636	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1514	0	8.2	13.85	120.4	18.64	123.0	908.0	122.2	6	120.0	141.0	636	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1516	0	8.2	13.40	116.5	18.48	121.9	895.7	120.5	6	120.0	141.0	636	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1516	0	8.2	13.81	120.0	18.70	123.4	909.4	122.3	6	120.0	141.0	636	0	0
LWR GRANITE TAILRACE S BAYS 1-8 SPILL DEFLECTOR	1520	0	8.2	13.40	116.5	18.31	120.8	889.4	119.7	6	120.0	141.0	636	0	0
LWR GRANITE TAILRACE N BAYS 1-8 SPILL DEFLECTOR	1522	0	8.2	13.85	120.4	18.64	123.0	908.0	122.2	6	120.0	141.0	636	0	0
LITTLE GOOSE FOREBAY POWERHOUSE SIDE	1810	50	8.3	13.18	114.8	16.92	111.9	834.9	112.3	6	0.0	0.0	638	0	0