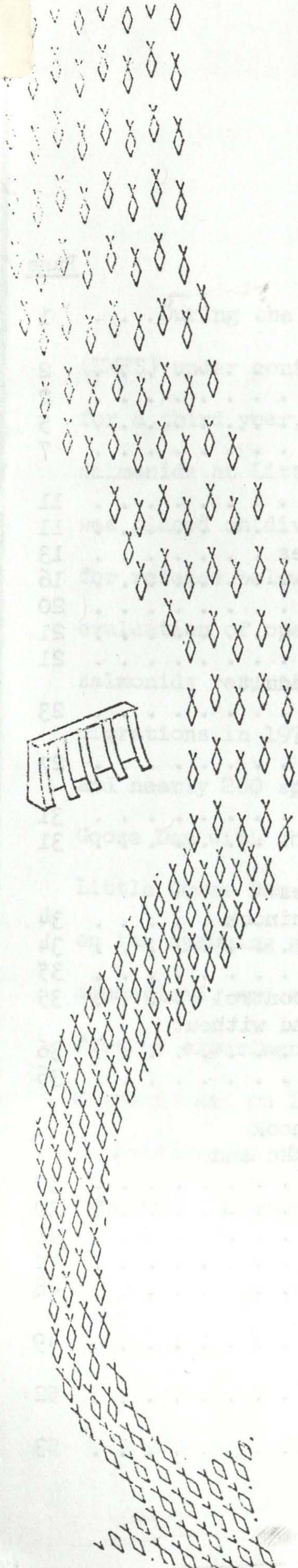

PROGRESS REPORT

Evaluation of Fish Protective Facilities at Little Goose Dam and Review of Other Studies Relating to Protection of Juvenile Salmonids in the Columbia & Snake Rivers, 1973

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INTRODUCTION

During the spring of 1973, the National Marine Fisheries Service (NMFS) under contract of the U.S. Army Corps of Engineers continued, for a third year, an evaluation of fish protective facilities for juvenile salmonids at Little Goose Dam on the Snake River. As in 1972, emphasis was placed on diverting, collecting, marking and transporting young salmonids for release below Bonneville Dam with appropriate control releases for evaluation of operations. In addition, recovery efforts continued on adult salmonids returning upriver after marking and transport during juvenile migrations in 1971 and 72. More than 1000 marked adult steelhead trout and nearly 200 spring and summer chinook salmon were recovered at Little Goose Dam with the tag detector and fish trap operated in the ladder at Little Goose Dam. Additional recoveries were also made in the fisheries and on the spawning grounds. Preliminary analysis of data from these returns are summarized, and effects of transport on survival and homing are indicated. Further experimentation was made on rates, timing and survival of young migrants and on levels of dissolved gases in the Columbia and Snake Rivers in relation to river discharge and operational procedures. This report summarizes progress on these actions in 1973.

TRAVELING SCREEN AND ORIFICE BYPASS STUDIES

Nine traveling screens were operative during the 1973 fingerling salmon and steelhead migration. Vertical barrier screens in the gatewells were modified according to recommendations made in the previous year; the upper 36 feet of each screen was covered with solid baffles. Fingerling passage from the gatewells was monitored with electronic counters. An air bubble device designed to divert fingerlings from a turbine intake was also tested.

Traveling Screens

Intake traveling screen installations commenced March 30. All nine screens were installed and operating by April 21. Mechanical aspects of the traveling screens were satisfactory. No major operational problems were encountered with the three original prototypes developed by NMFS. A gear box seal problem developed in some of the new models recently installed by Corps contractors, but this problem is being corrected.

By the first week of May, more fish were being collected than were required for the transportation experiment. This, along with the rising incidence of descaling, prompted the decision to take six of the traveling screens out of service on May 11. Three of the traveling screens were left in operation and used for experiments attempting to pin down the causes of descaling. On occasion when greater numbers of fish were needed for the transportation experiments, additional traveling screens were put into operation. The number of traveling screens in operation and the daily counts of fingerlings entering the fingerling collection facility are shown in Figure 1. Samples of fish taken from the gatewells and collection facility indicated descaling at times approached unacceptable levels. Subsequently, detailed descaling examinations were conducted.

Results of these examinations indicated that the percentage of descaled chinook fingerlings from the gatewells associated with traveling screens ranged from a low of 1.3% to a high of 52.8% and averaged 13.9%. Descaling checks made on fish from gatewells without traveling screens ranged from 0 to 9.2% and averaged 4.1%. Sample size usually ranged from about 300-400 fish. A total of 48,730 chinook fingerlings was examined during these detailed observations.

Initially, the cause of descaling was assumed to be related to the vertical barrier screen dividing the gatewell. The basis for this hypothesis was derived from last year's data which indicated a direct relationship between length of time fingerlings remained in the gatewells and degree of descaling. Prior to the 1973 field season, vertical barrier screen modifications were made to reduce the turbulent condition on the surface of the gatewells where descaling appeared to occur. Various arrangements of screens and panels on the vertical barrier screen were tested, including the covering of the rough galvanized hardware cloth portion of the screen with a smooth covering of perforated aluminum plate.

In the event that descaling was being caused by fish impingement on the traveling screen, mesh size on one of the traveling screens was reduced (less open area, hence reduced approach velocity) and tested. Attraction of fingerlings from lower regions of the gatewells to the bypass ports by use of submerged lights was also tested.

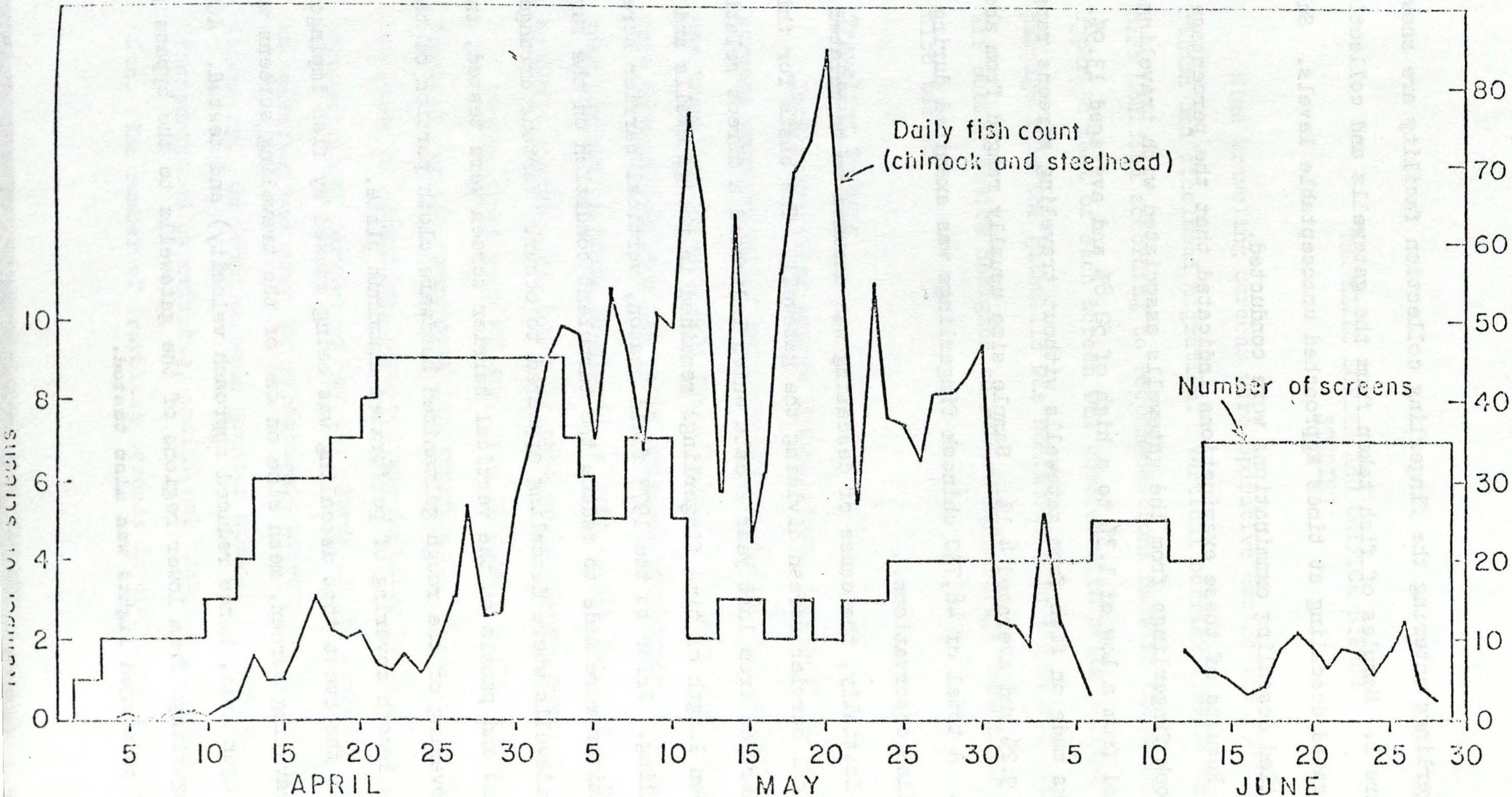

Figure 1--Number of traveling screens in operation and daily counts of fingerlings entering the fingerling collection facility at Little Goose Dam.

Effects of most of the foregoing modifications on incidence of descaling proved difficult to isolate and, as a result, little conclusive evidence of a consistent reduction in descaling was found. We did find, however, a relationship between turbine load and incidence of descaling. When turbine operation was maintained at a low level (less than 120 MGW), descaling was appreciably reduced. Results from use of the fine-mesh traveling screen also appeared to reduce descaling. A comparison of percentage descaling in these tests is shown in Table 1.

To thoroughly examine the descaling problem, a much more sophisticated test program will be required--one that will enable inspections of the condition of natural migrants at various locations before and after they enter the turbine intake as well as after they are in the gatewell. Plans are underway to conduct such a program in the spring of 1974. Tests using marked hatchery fish will be conducted this fall in an attempt to isolate some of the areas of descaling so corrective actions can be taken prior to the migration next spring.

Fish Passage From Gatewell Orifices

Lighted orifice inserts similar to those used last year were employed. In addition seven of nine orifices were equipped with electronic fish counting devices.

Prior to the field season all of the orifices were back-flushed when the gatewells were unwatered for vertical barrier screen modifications. To determine the amount of descaling occurring in the fingerling bypass, test fish were released directly into the orifices and recovered as they entered the raceways of the fingerling collection system. Six percent of those

1.--Effects of turbine load and screen mesh size on incidence of descaled juvenile chinook, Little Goose Dam, 1973.

	Proportion of descaled fish and number of replicates ( ) by screen condition		
	Screen mesh-- Course (36 meshes per foot)	Screen mesh-- Fine (48 meshes per foot)	No Screen
	Percent	Percent	Percent
	18.4 (21)	11.1 (24)	3.8 (18)
	11.4 (15)	2.7 (2)	5.3 (4)

fish were descaled. The severity of descaling in these tests was minor--slightly over 10% of the body area.

Overall, movement of juveniles through the gatewell orifices appeared to be much improved over that of the previous year based on visual observations of fish concentrations (much reduced in 1973) in surface areas of the gatewells. Scuba observations at depth in the gatewells, however, indicated that many fish were concentrated below solid panels on the vertical barrier screens (36 feet+). Additional tests are planned, therefore, to devise means of rapidly attracting the fish upward toward the orifices.

Bubble Screen Evaluation

Tests to determine whether an air bubble screen would prevent fingerling salmon and steelhead from entering a turbine intake were conducted during two periods of the fish migration. These tests were undertaken to determine whether such a screen might be useful in diverting downstream migrants away from slotted gates that have been constructed for use in skeleton bays at dams in the lower Snake River. Although the slotted gates have been effective in alleviating the problem of supersaturation of nitrogen, mechanical injuries to fish passing through the gates have been excessive.

A "V" shaped bubble screen was placed about 50 feet deep and immediately in front of turbine intake slots 2A, B, and C with the tip of the "V" extending approximately 150 feet upstream. Automatic fish counters were installed in the orifices of these three intakes as well as in adjoining orifices of units 1C and 3A. Theoretically, an effective screen would then logically divert fish from 2A, B, and C into 1C and 3A. Counts through the orifices of fish leaving the gatewells would be expected to reflect this trend

Table 2 shows the results of a test conducted during a period when large numbers of fish were available. A total of 205,768 fish were counted through the five gatewell orifice counters during the 7-day test period (about 30,000 fish per day).

Table 3 shows the results of a later test conducted by dipnetting all of the fish from the gatewells so that a species identification, as well as a total count could be made. In both tests the gatewells were dipped clean prior to the testing.

From the results of these tests, it would appear that the existing air bubble screen was an ineffective device for diverting fingerling salmon and steelhead from turbine intakes. Had there been a diverting effect, one would have expected a marked increase in the proportion of fish entering (and leaving) units 3A and 1C during the first test. Actually a reduced proportion of fish passed from these gatewells during this test period. Likewise, during the second test, gatewell dipping should have indicated more fish in 1A and 1B. Instead, numbers of chinook and steelhead entering these areas were considerably less than those entering the section downstream from the bubble screen. Normally gatewells 1A and 1B have the highest concentrations of fish during the juvenile migration period. Ideally, the second test would have again utilized gatewells 1C and 3A for the comparison (as in first test), but these areas were inaccessible at the time of the test.

In retrospect, results of the tests with the air bubble screen were not too surprising in view of previous findings. Bates and Vanderwalker (1964) found that the efficiency of an air bubble screen is a function of the fish's

Table 2.--Effects of the air bubble screen on fingerling guidance. Bubble screen installed upstream from unit 2 (A, B & C).

Gatewell	Average percent of total daily count by gatewell				
	1C	2A	2B	2C	3A
Bubble Screen off 1/	20.3	26.2	23.0	14.7	30.5
Bubble Screen on 2/	19.4	27.9	22.4	23.6	9.7

1/ The "off" period covers 2 days before the 2 days after the "on" period.

2/ The "on" period is for three consecutive days.

Table 3.--Effects of the bubble screen on guidance of chinook and steelhead fingerlings. Figures represent a physical count by species for a 48-hour period.

Species	Total numbers captured per gatewell			
	No Bubble Screen		Bubble Screen	
	1A	1B	2A	2B
Chinook	608	919	1448	1628
Steelhead	212	53	571	101
TOTAL	820	972	2019	1927

ability to see it; i.e., guiding efficiency at night was markedly lower than in the day. An increase in approach velocity also tended to reduce guiding efficiency. Thus, in the recent Snake River application, limited visibility and increasing approach velocities in the area of the turbine intake may well have negated potential fish guilding capabilities that might have prevailed under more favorable conditions.

TRANSPORTATION AND HOMING

Progress in the transportation studies at Little Goose Dam during 1973 is summarized in this section of the report.

Objectives of the transportation research were: (1) continue evaluation of the transportation system by marking and releasing 50,000 juvenile chinook as controls at Little Goose Dam and 50,000 as test (transported) fish below Bonneville Dam, (2) mark and release 50,000 steelhead at Little Goose (controls) and 50,000 for release below Bonneville (test) to evaluate the effect of transporting juvenile steelhead, (3) continue to test and evaluate fish facilities used at Little Goose Dam for diverting, collecting, marking, and transferring fish to transport trucks, (4) continue studies to determine levels of stress in fish at various stages of handling and transporting, and (5) begin preliminary evaluation of the study by examination of marks on returning adult chinook and steelhead.

General experimental design

Juvenile steelhead and chinook used for the transportation experiment in 1973, were divided into five groups--three control and two test or transported groups. One control group was marked and released about 21 km upstream from Little Goose Dam at Central Ferry on the south shore of the river; a second control was marked and released on the north shore, and a third control group was marked and released directly into the tailrace about 1 km downstream from the power house.

The test groups were hauled in tank trucks to two release sites downstream from Bonneville Dam; one was at Dalton Pt., 17 km from Bonneville on the Oregon shore and the other was at the Washington State boat launching site about 2 km downstream from the spillway at Bonneville Dam on the Washington shore. As in 1972, 1-3 ppm quinaldine was used in the transport truck to partially anesthetize fish destined for release at Dalton Pt.; fish released on the Washington shore were not anesthetized. The two conditions provided a basis for comparing mortalities occurring during and after transport. Separate magnetic tag codes and brands were designated for each experimental group. Codes on the tags were changed twice during the marking periods; the brands were changed weekly.

Evaluation of the survival and homing ability of these groups will be based on adult returns to the commercial (including Indian fishery) and sport fishery, Little Goose Dam, and the spawning grounds. A magnetic tag detector and fish separator, similar to that used at Ice Harbor Dam, was installed at Little Goose Dam for evaluation of adults returning to the dam.

Blood glucose and urea levels were again analyzed from several groups of juvenile chinook salmon during the migration period. Fish were obtained from the following locations: (1) gatewell with traveling screen, (2) gatewell without traveling screen, (3) counter tunnels (after passage through the bypass pipe and sorter), (4) holding box in marking facility after passage through pump, (5) exit of marking building (before entering transport truck), and (6) release site. We sampled at these locations again this year because we wished to compare stress levels measured last year when only three traveling screens operated with stresses prevailing in the current year when up to 9 screens were operating. In addition, we took samples after each stage of marking (fin-clipping, branding, and wire-tagging) to determine whether any particular marking operation produced excessive stress. Delayed mortality was also compared among fish taken at locations 3 and 4.

Mortality during transport and delayed mortality measurements were compared among all groups transported downstream. These comparisons included high vs low density loads, anesthetized vs loads not anesthetized, and marked vs unmarked. In these comparisons, a high density load was 1.0 pound or more fish/gallon of water; low density was usually 1/2-pound fish or less/gallon of water.

Collection, marking, and transport procedures

Juvenile salmon entering the gatewells were all collected at the end of the orifice bypass system; fish dipped from the gatewells were not used this year as experimental fish for the transportation studies. Fish obtained with the gatewell net were used only in determining stress levels at that point in the system. Fish entering the orifices from gatewells continued on through the bypass pipe (Figure 2) to the holding area downstream from the tailrace deck. Before entering the holding area, the fish passed through a grader and were sorted by size. We adjusted the grades so that

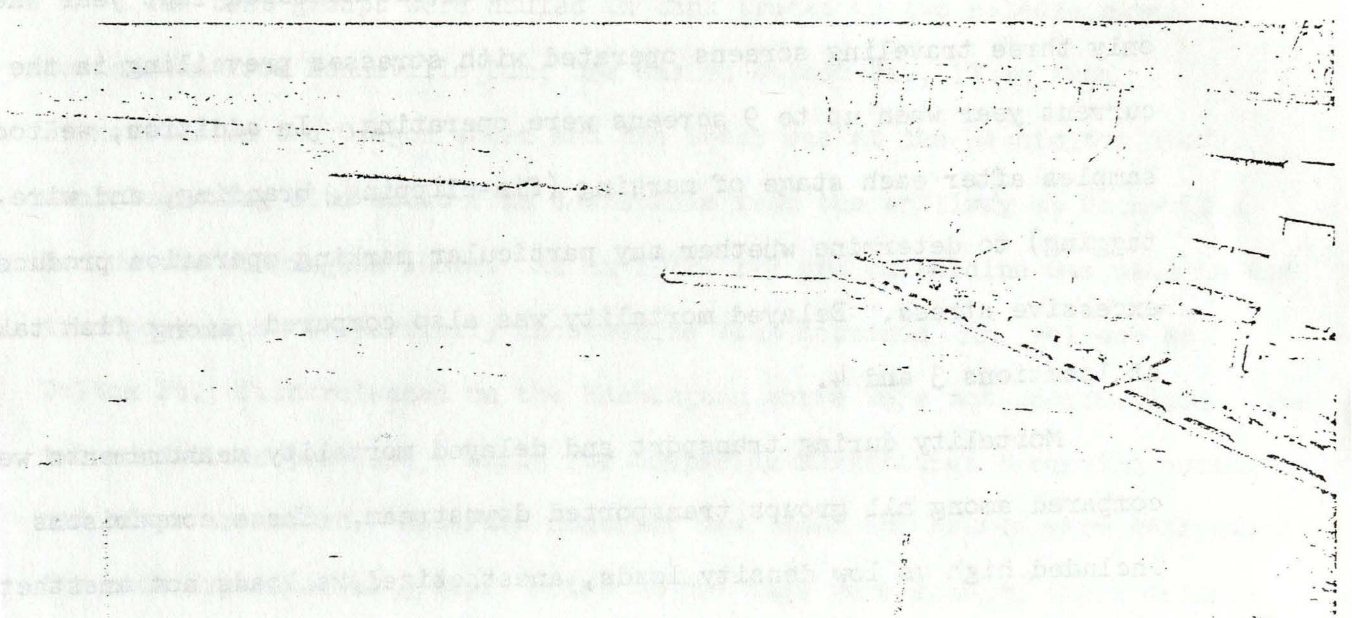

Figure 2.--Fingerling bypass transport pipe (arrow) and raceways for holding juvenile salmon and steelhead at Little Goose Dam.

most of the juvenile chinook would be separated from the steelhead before entering the holding ponds.

Fingerling chinook salmon and steelhead trout were pumped with a 5-inch Paco model fish pump into a tank in the marking building. Here they were dipped from the tank, anesthetized and sorted. Previously marked or injured and descaled fish were returned to the river in the tailrace of the turbine discharge. Each of the remaining fish was cold-branded with liquid nitrogen (Mighell, 1969), the adipose fin was excised, and a magnetic wire tag (Jefferts, et al., 1963) was inserted in the snout. Before discharge into the transport truck, the fish passed through a magnetic field and detection coil. Improperly tagged fish were automatically rejected and returned to the marker for retagging. When steelhead and chinook were hauled simultaneously, they were kept in separate compartments in the tank truck whenever possible. Load densities were governed by the size of the daily catch and ranged as high as 1.5 pounds of fish per gallon. All fish were transported in a 5,000-gal capacity truck with aeration, refrigeration, and filtration.

Water chemistry measurements were made at the time of release for each load of fish transported. Concentrations of ammonia, nitrogen, dissolved oxygen, carbon dioxide, pH, and total alkalinity were recorded. Most releases were made at dusk. Records of mortality of transported groups were also determined by holding samples of fish from each load in cages for 48 or more hours at the Bonneville hatchery.

Blood samples were obtained from fish taken in gatewells (with and without traveling screens) and in the holding area below the dam; blood glucose and urea values were determined by Scientia Labs using a technicon SMA 1260 AutoAnalyzer.

Percentage descaling among groups of fish obtained in the gatewells and the holding area was determined during the marking process. Any fish with over 10% visible descaling was recorded as a descaled fish. No further refinement of descaling categories was made.

Marking and transport

A total of 253,411 chinook (110,849 controls, 142,562 test) and 120,762 steelhead (57,310 controls, 63,452 test) were marked as experimental groups for the transportation studies (Table 4). Approximately 106,000 chinook and 113,000 steelhead were transported unmarked (Table 5). The grand total of fish enumerated at Little Goose in 1973 was over 1,750,000; about 500,000 fish were examined for previous marks or injuries. Of the total number enumerated, about 1,000,000 fish were returned to the river in the tailrace area without examination or handling.

More chinook salmon (about 100,000) were marked than originally planned due to the long, drawn out migratory period brought about by extreme low river flows. The number of steelhead marked barely exceeded the research objective. Relatively small numbers of unmarked fish were hauled when available to determine if there was a differential delayed mortality between marked and unmarked groups. Many more unmarked fish were returned to the river at Little Goose Dam during the past spring than in the previous 2 years because of the high collection efficiencies due to increased screening, and the discharge of virtually all river flows through the turbines. Also, because of the absence of a gas supersaturation problem in 1973, the urgency to transport large number of migrants enmasse (to avoid losses from gas bubble disease) did not develop as in 1971 and 72.

Table 4.--Summary of marked juvenile chinook and steelhead by release group, Little Goose Dam--Spring 1973.

Marking period	Release site	Brand position[1]/ and symbol	Chinook	Steelhead
April 2-19	Central Ferry North	LA-K	10,261	1,478
April 23-May 4	" " "	LA-⋈	14,579	7,187
May 8-17	" " "	LA-ꓘ	10,695	6,350
May 23-31	" " "	LA-⋈	5,642	6,782
		Subtotal	41,177	21,797
April 13-21	Central Ferry South	LA-F	11,373	1,431
April 25-May 3	" " "	LA-Ⅎ	8,034	5,852
May 7-18	" " "	LA-Ⅎ	9,196	8,877
May 24-30	" " "	LA-Ⅎ	6,804	4,504
June 14-26	" " "	LA-N	12,333 fails--?	
		Subtotal	47,740	20,664
April 4	Tailrace-Little Goose	LA-W	31	265
April 18-21	" " "	LA-Ш	4,063	833
April 25-26	" " "	LA-M	2,993	1,446
May 2-5	" " "	LA-Ш	6,864	4,439
May 9	" " "	LA-S	2,405	1,545
May 16	" " "	LA-ᔕ	3,302	4,299
May 25	" " "	LA-Z	2,274	2,022
		Subtotal	21,932	14,849

1/ LA and RA indicate brand positions, i.e., left anterior and right anterior.

Table 4.--Continued.

Marking period	Release site	Brand position[1/] and symbol	Chinook	Steelhead
April 11	Dalton Pt.	RA-J	923	574
April 18	" "	RA-ᓄ	5,389	169
April 23-26	" "	RA-ſ	7,688	2,591
April 30-May 4	" "	RA-ᓑ	14,964	5,549
May 7-11	" "	RA-P	9,710	7,029
May 15-17	" "	RA-ᓂ	10,543	4,031
May 21-25	" "	RA-ᑯ	9,030	6,707
		Subtotal	58,247	26,650
April 9	Bonneville Boat Launch	RA-H	345	837
April 16-19	" " "	RA-ᕼ	10,059	968
April 24-27	" " "	RA-T	8,364	3,449
May 1-5	" " "	RA-ᕼ	16,506	6,130
May 8-10	" " "	RA-⅃	7,192	4,597
May 14-18	" " "	RA-ᕼ	13,482	7,091
May 22-24	" " "	RA-L	2,629	5,137
May 29-June 1	" " "	RA-ᒷ	9,410	8,593
June 13-25	" " "	RA-T	13,052	--
July 13	" " "	RA-ᒻ	3,276	--
		Subtotal	84,315	36,802
		Grand total	253,411	120,762

1/ LA and RA indicate brand positions, i.e., left anterior and right anterior.

Table 5.--Numbers of unmarked juvenile chinook and steelhead collected at Little Goose Dam and transported to release locations downstream from Bonneville Dam--Spring 1973.

Date	Release site	Chinook	Steelhead
April 27-May 5	Bonneville boat launch	18,400	24,887
May 8	" " "	13,570	480
May 14-18	" " "	11,380	8,620
May 22-24	" " "	11,660	15,840
May 29-30	" " "	2,500	15,500
	Subtotal	57,510	65,327
April 30-May 4	Dalton Pt.	6,000	10,000
May 7-11	" "	28,067	11,176
May 15-17	" "	12,130	15,870
May 23-25	" "	2,960	11,040
	Subtotal	49,157	48,086
	Grand total	106,667	113,413

Transport and delayed mortality

A successful transport operation requires a collection system that delivers fingerlings in good condition. Once collected in good condition, fingerlings can be hauled long distances with reasonable assurance that survival will be high and transport benefits will be realized. At Little Goose in 1973, descaling and subsequent stresses placed upon juveniles in the collection system continued to be a problem. We assessed the problem in terms of delayed mortality at Little Goose and at Bonneville Dam after transport.

Mortality observed at the time of release of the transported groups (transport mortality) indicated an overall average of 0.70% for chinook and 0.51% for steelhead. This is slightly higher than the 0.57% and 0.47% mortality observed last year for chinook and steelhead respectively. Samples of fish from each load were held for 48 hours at Bonneville Dam to determine delayed mortality. A comparison of delayed mortality of fish treated differently in the system included (1) marked and unmarked chinook, (2) marked and unmarked steelhead, and (3) partially anesthetized vs non-anesthetized chinook and steelhead.

Delayed mortality of marked chinook ranged from 2.9 to 43.0% with an overall weighted average of 17.2%; delayed losses in marked steelhead ranged from 0 to 16.6% with an overall average of 4.5%. Average delayed mortality of unmarked chinook was 15.3% while losses of unmarked steelhead were 4.4%. Among both species, unmarked losses were slightly less than marked losses. These small differences are probably significant since unmarked fish were pumped from raceways without inspection and probably included substantial numbers of descaled fish whereas the marked groups were inspected individually and descaled fish were removed.

Average weighted delayed mortality of 12 loads of marked chinook not anesthetized was 22.4%; mortality in 12 loads of partially anesthetized fish was 11.9%. Delayed losses among marked steelhead were 5.8% for those not anesthetized vs 2.9% in anesthetized loads. These data confirm our findings in 1972 and definitely indicate partial anesthesia is beneficial.

Delayed mortality tests at Little Goose

Samples of chinook were held in live cars in the raceways at Little Goose Dam to establish a relationship between known descaling (with associated stresses) and the true mortality that may eventually be experienced. Three groups of chinook were held in live cars 72 hours (Table 6). Mortality was observed among (1) fish that were descaled but not marked, (2) fish that appeared to be healthy but were marked as if to be transported, and (3) fish that were not handled in any way. The first two groups were subjected to the pumping operation, the third was not. Delayed mortality in the first two groups was 17.6 and 21.8% which is similar to losses noted in the Bonneville post-transport tests (17.2%). Somewhat surprisingly the mortality of the non-handled groups was less than 1% even though about 20% of these fish had some measure of descaling. The latter results would appear to indicate that substantial losses may be avoided if fingerlings were gravity-fed into the transport tank rather than pumped as we are now doing.

Blood Chemistry Measurements of stress

Urea and glucose concentrations in the blood of juvenile chinook were again measured to compare stress levels this year with those recorded last year. In addition, stress levels at the various stages of marking also were measured.

Table 6.--Holding tests to determine delayed mortality among different lots of fingerling chinook obtained from the fingerling collector at Little Goose Dam--1973.

Test	Number in test	Number of replicates	Delayed mortality--Percent at 72 hours Range	Average
All fish 10% or more descaled, pumped but not marked	50-100	11	6-30	17.6
All fish apparently healthy, pumped and marked	50	10	2-58	21.8
Non-handled fish (No marking or pumping but including descaled fish)	50-212	17	0.5	<1

The general pattern of glucose and urea concentrations measured sequentially at four locations (Fig. 3) in the diversion, bypass and marking operation was similar to that noted last year, i.e., concentrations increased as fish proceeded through the system. However, the condition of fish taken on entry to the system--as evidenced by the concentrations of glucose in the blood of fish taken from a gatewell without a traveling screen--was not as good as last year. Higher levels of glucose indicate that juvenile fish arriving at Little Goose Dam were in a more stressed condition than last year.

Glucose levels measured at various stages of marking (Fig. 4) indicated that the stress was cumulative; fish receiving three marks (fin clip, cold brand and wire tag) were in a more stressed condition than those receiving only one mark. Blood glucose measurements taken from each marking operation, when only one of the operations was done, indicated that cold branding is less stressful to juvenile chinook salmon than fin-clipping or wire-tagging (Fig. 5). The one-mark glucose measurements should be repeated next season as the differences observed in the recent tests could also be attributed to individual marking technique or variability within a single raceway of fish.

<u>Preliminary returns to Little Goose Dam of adult spring and summer chinook salmon</u>

Table 7 lists the number of adult (2-ocean) salmon successfully detect[ed] separated and indentified at the automatic separator in the ladder at Little Goose Dam. It should be stressed that the current observed return represent[s] only part of the expected total return to Little Goose Dam of fish marked in 1971. The observed tally is low for the following reasons: (1) approximat[ely]

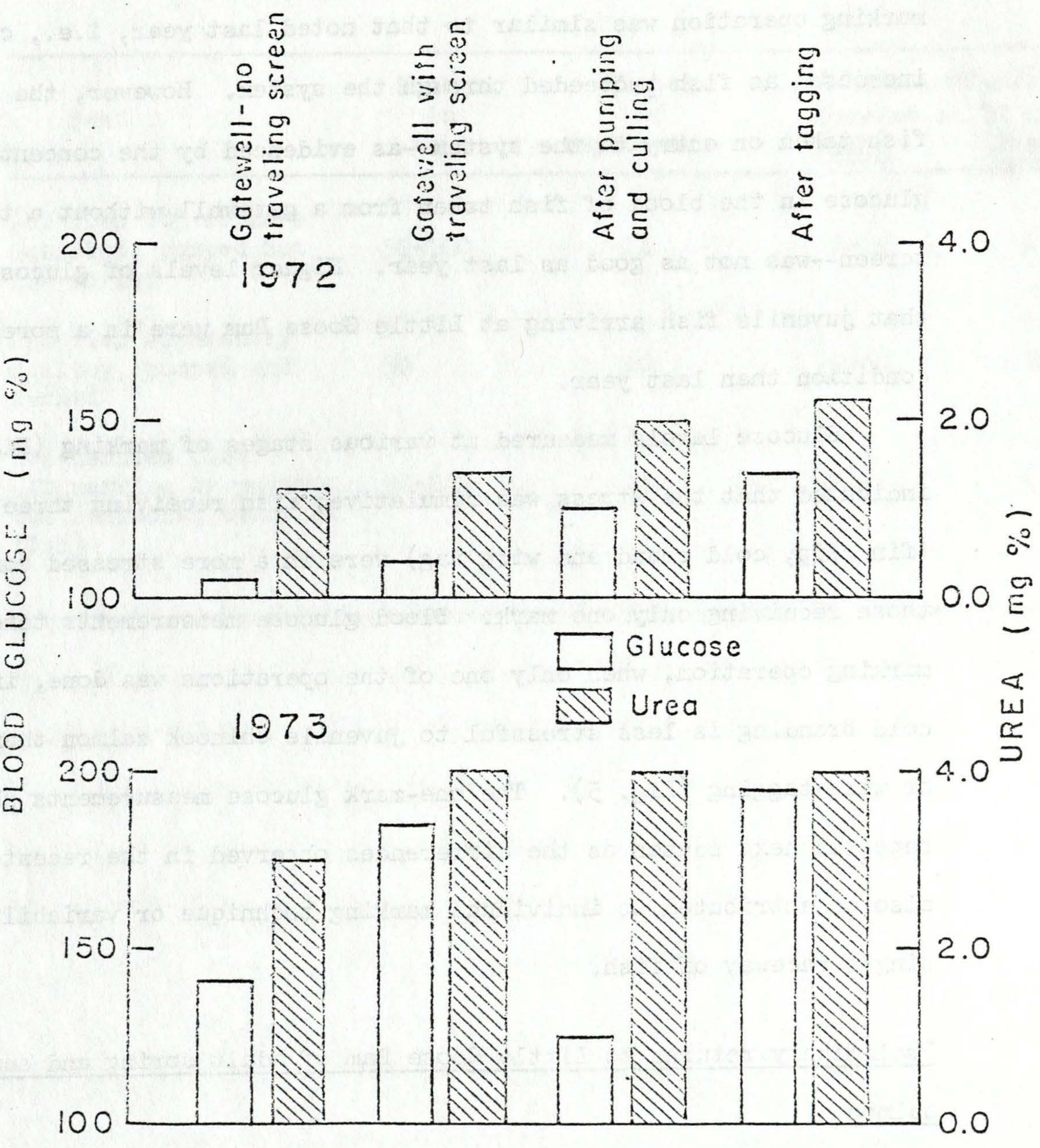

Figure 3--General pattern of glucose and urea concentrations in juvenile chinook salmon, measured sequentially at four locations in the diversion, bypass, and marking operation.

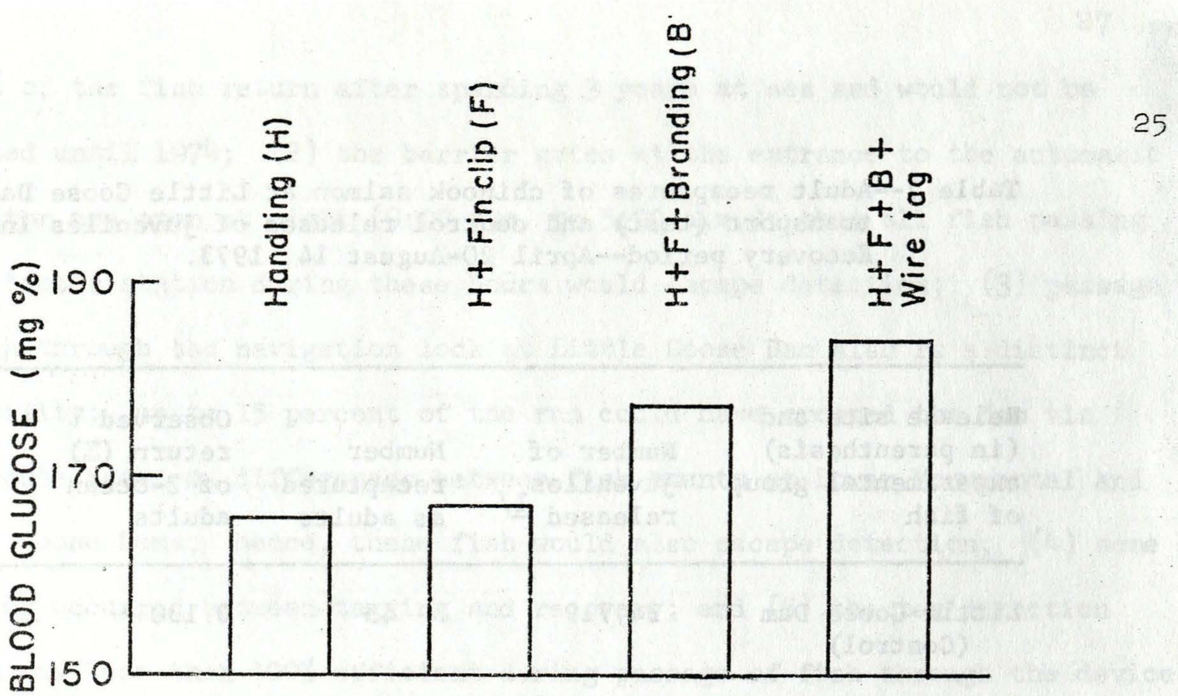

Figure 4--Serum glucose levels of juvenile chinook after various stages in the marking process.

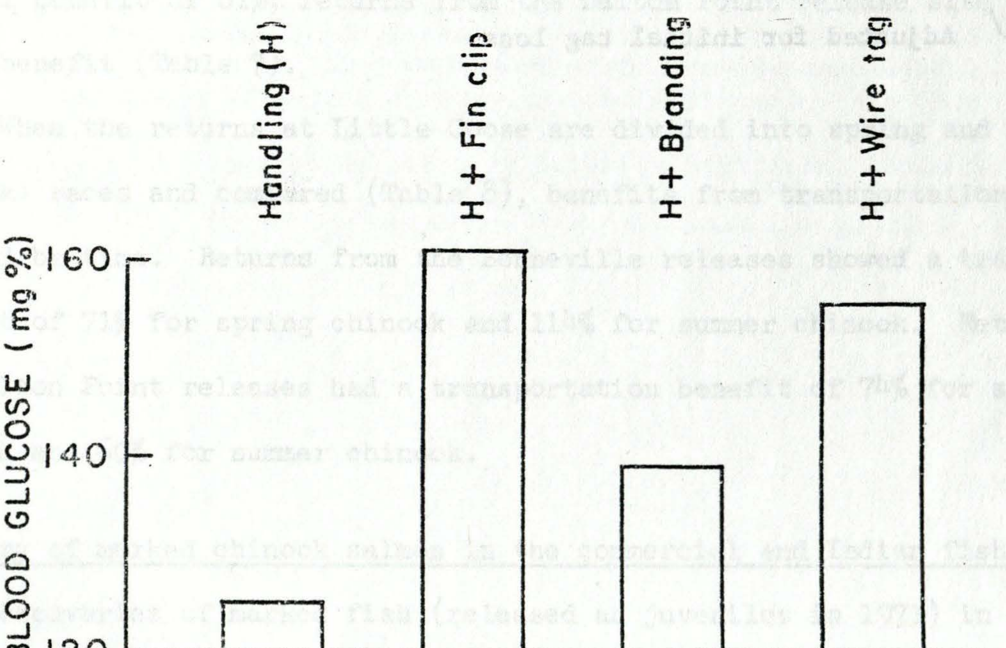

Figure 5--Serum glucose levels of juvenile chinook in relation to type of mark applied.

Table 7--Adult recaptures of chinook salmon at Little Goose Dam from transport (test) and control releases of juveniles in 1971. Recovery period--April 20-August 14, 1973.

Release site and (in parenthesis) experimental group of fish	Number of juveniles released 1/	Number recaptured as adults	Observed return (%) of 2-ocean adults	Transport to control benefit (%)
Little Goose Dam (Control)	34,719	45	0.130	---
Bonneville Dam (Transported)	35,252	83	0.235	81.0
Dalton Point (Transported)	30,637	70	0.228	75.0
Total recovery:		198	---	78.0

1/ Adjusted for initial tag loss.

30-50% of the fish return after spending 3 years at sea and would not be expected until 1974; (2) the barrier gates at the entrance to the automatic separator are open at night (9:00 p.m. to 5:00 a.m.); thus all fish passing the detector station during these hours would escape detection; (3) passage of fish through the navigation lock at Little Goose Dam also is a distinct possibility; up to 15 percent of the run could have crossed the dam via this route based on differences between fish counts at Lower Monumental and Little Goose Dams; hence, these fish would also escape detection; (4) some tag loss occurred between tagging and recovery; and (5) the tag detection system was less than 100% efficient during passage of fish through the device.

The combined returns of 2-ocean spring and summer chinook salmon at Little Goose Dam to August 14, 1973, from juveniles marked in 1971 indicate that survival from transported releases was greater than from the control releases. Returns from the Bonneville release site indicated a transport to control benefit of 81%; returns from the Dalton Point release site indicated a 75% benefit (Table 7).

When the returns at Little Goose are divided into spring and summer seasonal races and compared (Table 8), benefits from transportation are defined by time. Returns from the Bonneville releases showed a transportation benefit of 71% for spring chinook and 114% for summer chinook. Returns from the Dalton Point releases had a transportation benefit of 74% for spring chinook and 60% for summer chinook.

Recovery of marked chinook salmon in the commercial and Indian fisheries

Recoveries of marked fish (released as juveniles in 1971) in the commercial gill net fisheries in the lower Columbia River (Table 9) are based on the spring fishery only and again show a favorable transport to

Table 8--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 1973 from releases of juveniles at Bonneville Dam and the Dalton Point in 1971.

Release site (of juveniles) and seasonal race of salmon 1/	Number of salmon recaptured as 2/ adults at Little Goose Dam		Transport to control benefit (%)
	Transported	Non-transported (Control)	
Below Bonneville Dam			
Spring chinook salmon	60	35	71.0
Summer chinook salmon	22	10	114.0
Dalton Point			
Spring chinook salmon	61	35	74.0
Summer chinook salmon	16	10	60.0

1/ Seasonal races of chinook salmon in the Columbia River system are classified as spring, summer, or fall chinook depending on the time of year that the adults enter the river to spawn. We classified adult salmon captured at Little Goose Dam prior to June 17 as spring chinook and those taken from June 17 through August 14 as summer chinook.

2/ Numbers recaptured adjusted in relation to numbers released (Table 7).

Table 9--A comparison between transported and non-transported groups of chinook salmon based on numbers of transported and non-transported juvenile fish (tagged in 1971) that were recaptured as adults by Commercial and Indian Fisheries in the lower Columbia River, spring, 1973.

	Number of salmon recaptured as adults from releases at --		
Location of fisheries	Bonneville (Transported)	Dalton Point (Transported)	Little Goose (Control)
	Number of Tags	Number of Tags	Number of Tags
Upstream from Bonneville Dam (Indian Fishery)	10	12	1
Downstream from Bonneville Dam	13	14	3
TOTAL	23	26	4
% Transport benefit	491	518	

control ratio. In this instance, however, for the Dalton Point releases, the return benefit for transported fish was slightly greater than that for the Bonneville releases which is the reverse of that shown for recoveries at Little Goose Dam.

Although the differences between returns from releases at Dalton Point and Bonneville are slight and not significant statistically, some consideration should be given to the differences in treatment of the two test groups and the possible effects of that treatment on eventual returns. Possibly some loss of homing occurs when chinook are released at Dalton Point which results in milling and hence longer availability for capture in the nets. Timing of return of the two groups could also be involved. If the fish released near Bonneville Dam tend to return earlier in the season than those released at Dalton Point, possibly more of the Bonneville returns would pass through the lower river before the start of commercial fishery. Further examination of returns by time will determine whether this, in fact, does occur. Another factor that may have possible bearing on returns from the two release sites is the effect of using anesthetic during transport of the juveniles. It may be recalled that only those groups transported to Dalton Point were treated with a mild solution of quinaldine, those transported to the Bonneville release site were not treated. Further tests should, therefore, be made to determine whether use of anesthetic may in any way affect homing ability.

Overall, recoveries of marked fish in the commercial fishery were limited and should be augmented by additional recoveries in 1974 before any final conclusions can be made concerning returns from the 1971 experiment.

Preliminary returns of adult steelhead trout to Little Goose Dam

The first steelhead adults returning from control and transport releases in 1971 appeared at Little Goose Dam in the summer and fall of 1972 after 1 year at sea. Additional 1-ocean fish from the 1971 outmigration also continued to pass the dam in the following spring (1973), apparently having spent the winter below the dam. Beginning in the summer of 1973, 2-ocean adults from 1971 releases and 1-ocean adults from 1972 releases began appearing at Little Goose. To date, (October 24, 1973) 973 adult steelhead have been identified from releases in 1971. Benefits derived from transported steelhead (Table 10) were 43% from the Bonneville release, 44% for the Dalton Point release.

Preliminary returns of 409 1-ocean adults from the 1972 release indicate a much greater benefit than those from the 1971 releases; 206% for the Bonneville release, 252% for the Dalton Point release. The ratio of transport to control on these fish therefore ranges between 3 to 3.5:1.

General comments on adult returns

In general, the current transport to control ratios of adult steelhead and chinook are encouraging. In addition, the estimated return (Table 10) of only the 1-ocean steelhead transported to Bonneville and Dalton Point already exceeds the average estimated percent return of steelhead to Dworshak Hatchery from all ocean age groups of a brood year. The observed percentage return (about 0.2) of 2-ocean chinook from the transported releases does not yet exceed the percentage return of Rapid River Hatchery, but when the 3-ocean chinook returns are added next year, the average percentage return (0.35%) achieved at Rapid River in 1973 should be exceeded. If the problem of excess stress incurred during diversion, collection and marking of chinook

Table 10.--Returns to Little Goose Dam of 1- and 2-ocean age adult steelhead from control and transport releases of smolts in 1971. Recoveries made from July 20, 1972 to October 24, 1973.

Release site and experimental groups (in paren.)	Number of juveniles released1/	Number of adults recaptured 1-ocean age	2-ocean age	Total (1+2's)	Adult return in percent of juveniles released Observed	Estimated2/	Transport benefit3/ --percent
Little Goose Dam (control)	55,293	111	203	314	0.567	0.945	--
Bonneville Dam (transport)	44,939	166	199	365	0.812	1.353	47.0
Dalton Point (transport)	35,967	124	170	294	0.817	1.361	62.0
Total	136,199	401	572	973	--	--	Ave. 44

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.

can be eliminated, the percentage return shown now for both transported and control lots of chinook could double. We will therefore concentrate most of our effort next year on this problem.

Data from recovery of tagged chinook and steelhead on the spawning grounds is incomplete at this time and will be reported on later.

DISSOLVED NITROGEN IN THE COLUMBIA AND SNAKE RIVERS WITH OBSERVATIONS OF EFFECT ON STEELHEAD AND CHINOOK

Dissolved gas levels in the Columbia and Snake Rivers were again monitored in 1973 to (1) determine the effect of an expected low flow year on nitrogen levels (2) test effects on gas saturation levels of prototype spillway deflectors (with and without dentates), (3) assess effect of flow and load control on nitrogen levels below Bonneville Dam, and (4) compare survival of juvenile and adult steelhead and chinook migrants under prevailing saturation levels.

Methods

Methods used for collection and analysis of nitrogen samples in 1973 were nearly identical to those reported by NMFS in 1972 except that tailrace stations were discontinued at all dams except McNary and Bonneville. Additional stations in the Columbia River at Washougal and Vancouver were taken along with a station in the mouth of the Willamette River at Portland. The dissolved gas data are listed in Appendix Table 1. Dissolved gas measurements to determine the effect of the prototype spillway deflector without dentates were made at Lower Monumental Dam. These measurements were made below both the deflector with dentates and the deflector without dentates under identical conditions to ensure direct comparison between the two deflectors and with other data previously obtained.

Effects of nitrogen saturation levels on fish were based on techniques similar to those used in 1972. One fish holding test was conducted even though gas levels were low, to establish mortality rates under a control situation with normal gas levels. Examination of the condition of juvenile steelhead and chinook arriving at Ice Harbor Dam was occasionally made again to establish a condition factor under a "control" situation where low gas saturations prevail. Survival estimates based on recapture of marked juveniles from upstream locations were continued. These are discussed in another section of this report.

Information on condition of mature adults was based on data from Rapid River hatchery and spawning ground surveys made by NMFS and Idaho Fish and Game.

Results

Nitrogen concentrations and effect of flow control

Concentrations of dissolved gases (Appendix Table 1) were the lowest recorded for any spring season that dissolved gases (primarily nitrogen) have been monitored. Concentration rarely exceeded 110% saturation except in the tailrace of the spillways at Bonneville and McNary Dams when occasional spilling did occur. The mixed value downstream, however, remained below 110% saturation. Low flow in the Columbia and Snake Rivers was, of course, the main factor in returning the gas levels to normal. Peak flows were less than 300,000 cfs in the Columbia at Bonneville and remained below 100,000 cfs in the Snake at Ice Harbor Dam.

The low flow of the Columbia enabled the Corps of Engineers to reduce spilling at Bonneville Dam from mid-April until about mid-May, which resulted in tailrace concentrations below 118% downstream from the spillway. The mixed value at Washougal thus remained below 105% saturation. The low concentrations of dissolved gases should have benefited downstream migrants as well as adults migrating upstream. Counts of adult spring and summer chinook over John Day Dam suggest that survival of upstream migrants was improved. More fish passed over John Day this year than last year (72) in spite of the fact that less fish were available as evidenced by lower counts over Bonneville Dam.

Effect of prototype flow deflectors, with and without dentates, on nitrogen concentrations

On March 29 nitrogen concentrations produced by spillway [illegible] with and without dentates were compared with a control spillway at [illegible] volumes--4,600, 9,700, and 14,900 cfs (Fig. 6). The most marked [illegible] of gas saturation levels occurred at 4,600 cfs. In 1972, when only the deflector with dentates was tested, maximum control of gas levels also occurred at 4,600 cfs. The spillway deflector without dentates appeared to produce slightly less gas entrainment than the deflector with dentates at all three discharges. Based on these observations (and fish survival [illegible] of fish passing through the modified spillways) it would appear that the deflector without dentates would be the preferred modification.

Effect of nitrogen supersaturation on fish

Because supersaturation of nitrogen rarely occurred in 1973, evidence of gas bubble disease in juveniles and adults was nil. Condition of juveniles arriving at Ice Harbor was generally better than that noted in other years.

Condition of adults arriving at Little Goose Dam, Rapid River Hatchery, and on the spawning grounds was generally excellent. A higher than normal incidence of kidney disease was noted, however, at Rapid River Hatchery. Record numbers of adult chinook arrived at Rapid River Hatchery this year, but percentage return--based on number released--was about 0.39%, less than in 1971 and 72.

A live cage study was begun at Ice Harbor Dam on May 29 and terminated on June 5. This study was done to compare mortalities that occur during periods of normal saturation with past mortality data obtained during years of high supersaturation. Three cages were used: one held at the surface, a

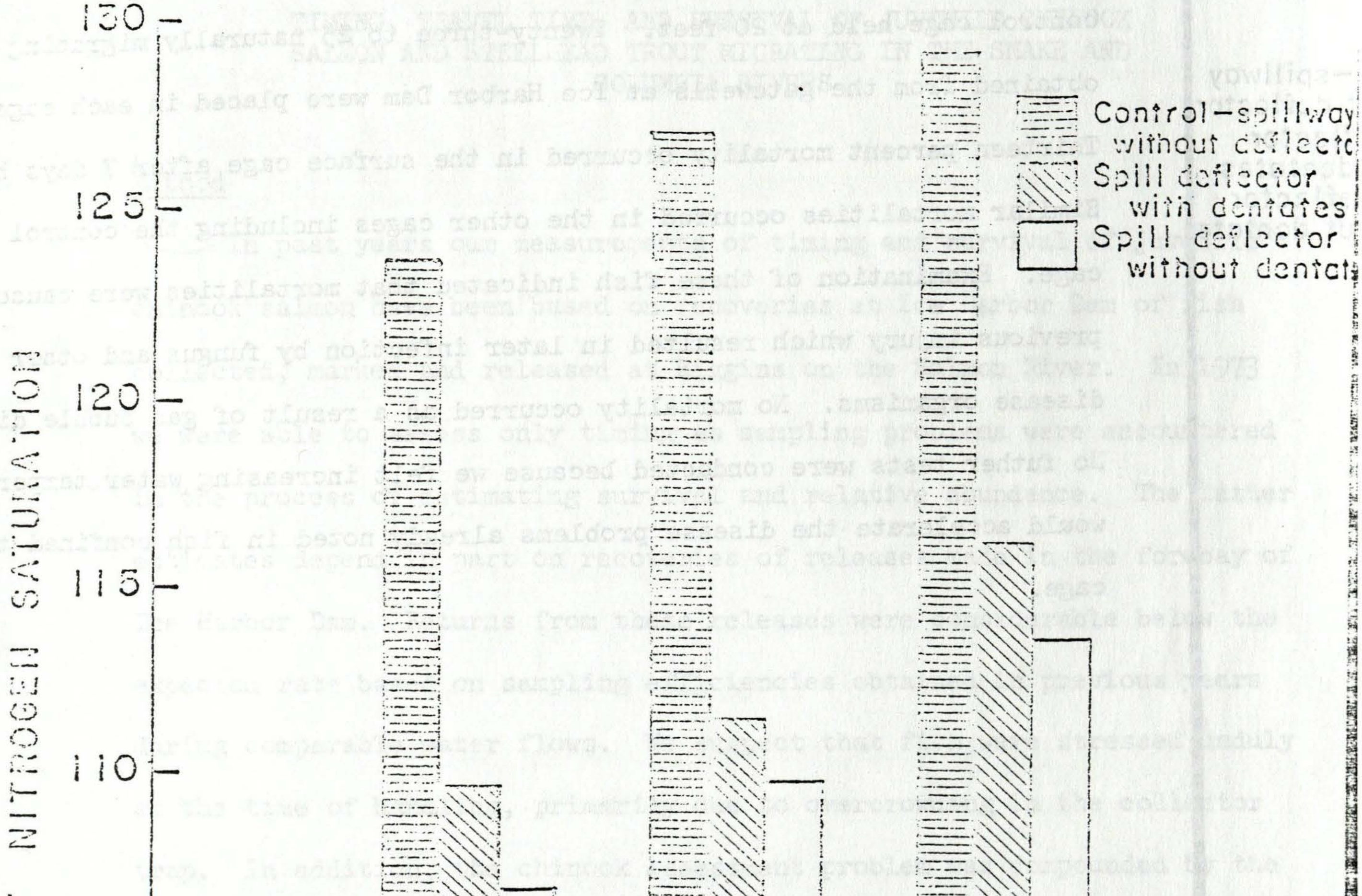

Figure 6--Average nitrogen concentration measured at Lower Monumental Dam in forebay, below spillway deflectors with and without dentates, and control spillway bay at three flows; March 29, 1973.

volitional cage allowing the fish to sound to 15 feet of depth, and a control cage held at 20 feet. Twenty-three to 25 naturally migrating chinook obtained from the gatewells at Ice Harbor Dam were placed in each cage. Thirteen percent mortality occurred in the surface cage after 7 days holding. Similar mortalities occurred in the other cages including the control (deep) cage. Examination of these fish indicated that mortalities were caused by previous injury which resulted in later infection by fungus and other disease organisms. No mortality occurred as a result of gas bubble disease. No futher tests were conducted because we felt increasing water temperature would accelerate the disease problems already noted in fish confined to the cage.

TIMING, TRAVEL TIME, AND SURVIVAL OF JUVENILE CHINOOK SALMON AND STEELHEAD TROUT MIGRATING IN THE SNAKE AND COLUMBIA RIVERS

Method

In past years our measurements of timing and survival of juvenile chinook salmon have been based on recoveries at Ice Harbor Dam of fish collected, marked and released at Riggins on the Salmon River. In 1973 we were able to assess only timing as sampling problems were encountered in the process of estimating survival and relative abundance. The latter estimates depend in part on recoveries of releases made in the forebay of Ice Harbor Dam. Returns from these releases were considerable below the expected rate based on sampling efficiencies obtained in previous years during comparable water flows. We suspect that fish were stressed unduly at the time of handling, primarily due to overcrowding in the collector trap. In addition, the chinook assessment problem was compounded by the necessity of sorting out some 33,000 marked coho recovered from releases made upstream at Lower Monumental Dam to evaluate bulkhead and flow deflector structures. To summarize, handling facilities at Ice Harbor Dam in 1973 simp would not permit rapid processing of juvenile chinook needed for the sampling efficiency tests. As similar problems are expected in conjunction with additional proposed tests at Lower Monumental Dam in 1974, we plan to overcom the fish handling aspect by closing off the orifices at Ice Harbor and dipnetting the fish directly from the gatewells rather than concentrate all the fish in the collector trap.

During the past season, we did, however, sample the juvenile outmigrati at The Dalles Dam as a part of the peaking effects study program sponsored by Corps of Engineers. No spilling occurred at The Dalles in 1973. Consequentl the sampling efficiency remained between 3-5% as predicted--a recovery adequate to obtain measures of timing and survival to that dam. Therefore, in 1973 we shifted our assessment of survival to encompass the reach from the Salmon River to The Dalles Dam rather than only to Ice Harbor Dam. Using this approach, we were able to obtain a measure of survival in 1973 relative to pre-dam survival (before John Day, Lower Monumental and Little Goose Dams) and to compare this with survival during years of comparable river flows in 1966 and 1967. We also were able to compare the above results with data from 1968, the year in which John Day Dam was completed (no turbines operating). Additional data were available from releases of marked fish at hatcheries and in the forebay and tailrace of Little Goose Dam. Numbers of fish marked at individual locations and subsequently recovered at Little Goose, Ice Harbor, McNary and The Dalles Dam are given in Table 11.

Assessment of steelhead migrations from the Salmon River have never been possible due to the low capture efficiency of this species at Riggins. Other detail on timing of steelhead at various dams and on population estimates at Little Goose Dam was obtained from sampling and marking programs at these sites. As with chinook, no population estimates could be made at Ice Harbor Dam.

Timing and travel time--chinook

The 1973 outmigration of chinook from the Snake River was the latest since sampling started at Ice Harbor Dam in 1964. Very few chinook migrants were collected at Ice Harbor Dam until early May; the peak of migration occurred on May 21. By contrast, during comparable low river flows in 1966-68

Table 11--Number of fish marked and subsequently recovered at Little Goose, Ice Harbor, McNary, and The Dalles Dams.

Release area and stock[1/]	Species	No. marked	Number recovered: Little Goose	Ice Harbor	McNary	The Dalles
Riggins (wild)	Ch	79,000	7,534	322	164	147
Rapid River (hatch.)	Ch	200,000	14,401	129	438	525
Whitebird (wild and hatch.)	Ch	45,000	5,576	204	197	105
Kooski (hatch.)	Ch	100,000	4,505	72	39	6
Dworshak (hatch.)	(Sthd)	158,000	17,565	1,293	*	592
Little Goose (forebay)	Ch	64,000	8,862	601	689	316
" " "	(Sthd)	31,000	8,425	1,226	*	115
" " (tailrace)	Ch	22,000	--	395	440	129
" " "	(Sthd)	15,000	--	616	*	44
Ice Harbor (forebay)	Ch	12,000	--	1,102	115	32
" " "	(Sthd)	12,000	--	84	*	28
" " (tailrace)	Ch	10,000	--	--	165	40
" " "	(Stld)		--	--	*	30
McNary (tailrace)	Ch	31,000	--	--	--	269
" "	(Sthd)	12,000	--	--	*	109
The Dalles (forebay)	Ch	17,000	--	--	--	517
" " "	(Sthd)	8,000	--	--	*	392

1/ All fish marked at locations from Little Goose Dam and downstream are presumed to be a mix of hatchery and wild stocks from upriver sources.

* Steelhead marks not recorded at McNary Dam.

chinook migrations peaked in late April (Table 12). Travel time from the Salmon River to Ice Harbor in 1973 averaged 23 days, comparable to that in 1970 but much slower than the 14 days measured in 1966 and 15 days in 1967 and 1968.

Timing and travel time were also compared as far downstream as The Dalles Dam in the 1966-73 period (Table 13). Migrations in 1966-67 through three dams and reservoirs (Ice Harbor, McNary and The Dalles) were compared with passage through four projects in 1968 (John Day Dam added) and six projects in 1973 (Lower Monumental and Little Goose Dams added). River flows during the period when migration rates were measured in each of the 4 years (1966, 67, 68, and 73) were generally comparable (Table 14). During 1966-67, fish took 24 days to travel from the Salmon River to The Dalles compared to 32 days (8 additional days) in 1968 when John Day was added and 41 days (17 additional days) in 1973 when two additional dams were operating. The data substantially agree with those previously documented by Raymond (1968 and 69); i.e., chinook move only about one-third as fast through the reservoirs as through free-flowing stretches of river. As would be expected, arrival time in 1973 was correspondingly later than in the earlier years. (June 5 vs early and mid-May). The slower migration may have contributed to the apparent loss or holdover of fish from the Salmon River to The Dalles Dam in 1973, which is discussed next.

Survival--chinook

Relative survival to The Dalles Dam (Table 15) of chinook released at Whitebird on the Salmon River in 1973 was approximately 1/12th that measured during comparable flows and sampling effort in 1966 and 67 (5% vs 60%). Only

Table 12--Average travel time to Ice Harbor Dam and dates of peak migration of juvenile chinook salmon from the Salmon River, 1966-73.

Year	Travel time (days)	Peak of migration	Water flow[2] (cfs) at peak of migration
1966	14	4/27	48,000
1967	17	5/3	42,000
1968	16	4/26	37,000
1969[1]	--	4/25	129,000
1970	25	5/13	88,000
1971	17	5/4	188,000
1972	16	5/12	125,000
1973	23	5/21	87,000

1/ Trap on Salmon River not operated in 1969.

2/ Snake River discharge at Ice Harbor Dam.

Table 13--Timing and travel time of yearling chinook from the Salmon River (Whitebird) to Ice Harbor and The Dalles Dams for comparable water years of 1966-68 and 1973.

	1966		1967		1968		1973	
Stretch of river	Timing	Travel time	Timing	Travel time	Timing	Travel time	Timing	Travel time
Salmon River to Ice Harbor Dam	4/5 4/19	14 days	4/15 5/1	16 days	4/15 5/1	15 days	4/25 5/18	23 days
Ice Harbor to The Dalles Dam	4/19 4/29	10 days	5/1 5/11	9 days	5/1 5/17	17 days	5/18 6/5	18 days
Total (To The Dalles)	(4/29)	24 days	(5/11)	25 days	(5/17)	32 days	(6/5)	41 days

1966-67 Ice Harbor and McNary Dams only.

1968 John Day Dam added.

After 1969 Lower Monumental and Little Goose Dams added.

Table 14--River flows (thousands of cfs) of the Snake and Columbia Rivers in 1966--68 and 1973 during periods of downstream migration assessments of juvenile spring chinook salmon.

Year	River flow (thousands of cfs)	
	Snake River	Columbia River
1966	33 - 65	123 - 210
1967	40 - 45	120 - 150
1968	32 - 60	96 - 200
1973	41 - 89	113 - 168

Table 15--Relative survival of yearling chinook salmon from the Salmon River (Whitebird) to The Dalles Dam--1966-68, and 1973.

Year	Recoveries from releases in Salmon River		Recoveries from releases in The Dalles forebay		Estimated survival
	N	Percent	N	Percent	Percent
1966	186	1.8	142	2.9	62
1967	194	2.4	177	4.0	60
1968	303	2.3	996	4.5	51
1973	105	0.2	320	3.8	05

a slight decline in survival could be attributed to the addition of John Day Dam in 1968 (61-51%) when no turbines were operating at that project. Sampling efficiency in the four years at The Dalles was comparable (2.9-4.5%). Recoveries at The Dalles (1.8 to 2.4%) from Whitebird releases were also comparable during the 1966-68 period, but dropped one order of magnitude to 0.2% in 1973.

What accounted for the apparent low survival of fingerlings in 1973? Some possible hypotheses are listed below:

(1) Low river flows prevailed throughout most of the chinook outmigration. Only minimal spilling occurred at Snake River dams and none at Columbia River dams. As a consequence most of the migration was confined to passage through the powerhouses and was subjected to turbine-related losses which, at times can be significant. For example, the differential in recovery rate at Ice Harbor, McNary and The Dalles Dams of forebay and tailrace releases of chinook at Little Goose Dam indicated that migrants passing this dam suffered a 50% loss. Long (1968) showed a 30% turbine related loss at Ice Harbor Dam in 1969. If similar losses prevailed at Lower Monumental, McNary, and John Day Dams and the estimated loss of 20-30% in the area from the Salmon River to Little Goose Dam is added to the total, we would arrive at a net survival of 12% to The Dalles which is within limits of our measured survival (5%).

(2) The apparent low survival may not all be related to mortality. Increased holdover (residualism) may have occurred in reservoirs due to the delaying action of low river flows and reduced velocities in the impoundments. As indicated previously, travel time nearly doubled over that in the 1966-68 period.

(3) Owing to low runoff, water clarity was much higher in 1973 than in a normal flow year. Conceivably, then, the migrants were afforded less protection from predator fish and birds than would have occurred in years of turbid flow. Purse seining in the Snake River during the recent summer and fall has revealed a large population of squawfish is present in this area.

Thus, a combination of the above mentioned factors might well account for the marked reduction in the measured survival of juvenile spring chinook in 1973. Future studies currently being developed in relation to effects of power peaking in the Snake and Columbia Rivers should result in additional data that will enable a more precise determination of losses associated with the aforementioned factors. Such information could then be used in subsequent decision-making processes concerning uses and applications of turbine intake screens and fingerling bypass and transportation systems.

Steelhead trout

The outmigration of steelhead trout passing Ice Harbor Dam peaked on May 24, 3 days later than the peak of the chinook outmigration. In past years steelhead have peaked about 10 days later than chinook. Recently, however, large early releases from Dworshak Hatchery ~~were~~ [illegible] moved the peak ahead. Timing and migration rate from Ice Harbor Dam to The Dalles Dam approximated that of chinook. As with chinook, no population estimate could be made at Ice Harbor Dam.

SUMMARY AND CONCLUSIONS

1. Mechanical operation of 9 traveling screens installed at Little Goose Dam was satisfactory, but during certain periods, excessive descaling of collected fish was noted.
2. A thorough examination of the descaling problem was not possible, but a definite relationship between turbine load and descaling was noted. At turbine loads less than 120 mgw, descaling was appreciably reduced. Use of the fine mesh traveling screen also appeared to reduce descaling.
3. Modification to the vertical barrier screens (placement of solid panels in the upper 36 feet) and installation of permanent-type lighted orifice inserts greatly improved passage of juveniles through the orifices.
4. Tests to determine whether an air bubble screen would divert fingerling salmon and steelhead from a turbine intake indicated that the device, as installed at Little Goose Dam, was ineffective. Fish readily passed through the bubble screen and entered the turbine intakes.
5. About 1,750,000 juvenile chinook and steelhead were enumerated at Little Goose Dam during the past spring migration in conjunction with the evaluation studies. Overall, 425,000 (250,000 chinook and 175,000 steelhead) were transported downstream and released below Bonneville Dam. About 253,000 chinook (111,000 controls, 142,000 transport) and 121,000 steelhead (57,000 controls, 64,000 transport) were marked for evaluation of the bypass and transportation system.
6. Mortality during transport was again low--less than 1 percent for chinook about .5 percent for steelhead. Delayed mortality (determined by holding after transport) was higher than last year (17.2% for chinook and 4.5% for steelhead). Delayed mortality of anesthetized loads of steelhead and chinook was significantly lower than loads not anethetized. Descaling

from passage through the bypass system (from turbine intakes [illegible] holding area) and stress incurred during the pumping and marking [illegible] appeared to be the primary cause of the high post-release mortality [illegible] chinook.

7. Delayed mortality tests conducted at Little Goose Dam with migrant juvenile chinook indicated that mortality of non-handled groups (fish that had not been pumped or marked) was less than 1 percent even though 20 percent of these fish had some measure of descaling. This indicates that substantial losses may be avoided if fingerlings were not marked and gravity-fed into the transport truck rather than pumped and marked as we are now doing. Blood glucose measurements (indicators of stress) from fish sampled at various points in the bypass system and during various stages of handling and marking also seem to verify this conclusion.

8. Returns of adult (1- and 2-ocean) steelhead from those released as controls and transports in 1971 and 72 are excellent. The ratio of transport to controls varied from about 1.7:1 from those released in 1971 to 3:1 for those released in 1972. Return ratios of adult (2-ocean) chinook are also encouraging. The average ratio of transport to control was 1.6:1. A total of 1382 adult steelhead and 198 chinook have been recovered at Little Goose Dam to date (November 22, 1973).

9. Concentrations of dissolved gases were the lowest recorded in any spring season since dissolved gases have been monitored. Thus, adverse effects of supersaturation on fish were nil.

10. Evaluation of the spillway deflectors, with and without dentates, indicated that the spillway deflector without dentates was superior to that with dentates. Survival of fish passing through the modified spillway without dentates was higher than the survival recorded from fish passing through

the spillway with dentates and gas entrainment appeared to be lower below the spillway deflector without dentates.

11. The peak of outmigration of chinook from the Snake River occurred on May 21, the latest timing of downstream movement since sampling started in 1964. Travel time from the Salmon River to Ice Harbor Dam in 1973 averaged 23 days compared to 14 days in 1966 and 16 days in 1965. During the 1966-67 period chinook from the Salmon River took 24 days to travel to The Dalles Dam arriving in early May; in 1973, they took 41 days, arriving in early June.

12. Relative survival to The Dalles Dam of chinook from the Salmon River in 1973 was 1/12th that measured during comparable river flows in 1966-68. Possible causes include turbine losses, residualism, and predation.

13. The outmigration of steelhead trout passing Ice Harbor Dam peaked on May 24, 3 days later than the chinook.

14. Based on data obtained in 1973, it would appear that there is more to protecting downstream migrants than simple N_2 abatement alone. If these data prove out, it may be more imperative to transport fingerlings during low flow (no spill) years than during high flow (high spill and N_2) years.

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Appendix Table 1.--Dissolved gas saturation data for Columbia River and tributaries, April - July 1973.

NATIONAL MARINE FISHERIES SERVICE   COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE---APRIL 3,1973

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
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	935	0	9.3	11.14	99.4	15.27	103.3	761.1	102.4	0	0.0	28.0	638	0	29
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	935	33	9.2	10.66	94.9	15.14	102.1	747.5	100.6	0	0.0	28.0	638	0	29
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1003	0	9.2	11.50	102.0	15.40	103.6	769.5	103.2	0	0.0	64.0	540	0	32
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1003	33	8.8	11.26	98.9	15.40	102.7	759.4	101.8	0	0.0	64.0	540	0	32
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1025	0	9.2	11.74	103.8	15.74	105.4	765.8	105.0	0	0.0	45.0	440	0	33
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1025	33	8.5	11.38	98.9	15.54	102.5	761.1	101.7	0	0.0	45.0	440	0	33
COLUMBIA RIVER ABOVE MOUTH SNAKE	1040	0	6.3	13.15	107.8	17.43	108.9	815.4	108.5	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SI	1056	0	8.2	12.82	110.2	16.67	106.8	818.5	109.0	0	0.0	214.0	340	0	166
MCNARY DAM FOREBAY 1/4 MI UP SPILL SI	1056	33	7.1	12.70	106.3	16.67	106.1	796.6	106.0	0	0.0	214.0	340	0	166
MCNARY DAM FOREBAY 1/4 MI UP POWER SI	1105	0	7.6	12.70	107.6	16.67	107.4	805.8	107.3	0	0.0	214.0	340	0	166
MCNARY DAM FOREBAY 1/4 MI UP POWER SI	1105	33	7.0	12.34	103.0	16.47	104.6	782.7	104.2	0	0.0	214.0	340	0	166
MCNARY TAILRACE 1/4 MI DN SPILL SI	1115	0	7.2	12.70	106.3	16.60	105.7	796.0	105.7	0	0.0	214.0	270	0	166
MCNARY TAILRACE 1/4 MI DN POWER SI	1120	0	7.2	12.46	104.3	16.47	104.8	787.8	104.6	0	0.0	214.0	270	0	166
JOHN DAY FOREBAY 1/4 MI UP CNTR	1322	0	8.5	12.46	107.6	16.14	105.8	798.8	106.0	0	0.0	272.0	265	0	196
JOHN DAY FOREBAY 1/4 MI UP CNTR	1322	33	7.5	12.34	104.0	16.37	104.9	787.9	104.6	0	0.0	272.0	265	0	196
THE DALLES FOREBAY 1/4 MI UP CENTER	1349	0	7.5	12.10	101.6	16.00	102.2	771.0	102.0	0	0.0	260.0	160	0	206
THE DALLES FOREBAY 1/4 MI UP CENTER	1349	33	7.5	12.34	103.6	16.14	103.0	779.2	103.1	0	0.0	260.0	160	0	206
BONNEVILLE FOREBAY 1/2 MI UP SPILL SI	1417	0	7.8	12.10	102.1	15.87	101.7	771.3	101.7	9	94.0	240.0	74	65	210
BONNEVILLE FOREBAY 1/2 MI UP SPILL SI	1417	33	7.8	12.42	104.7	15.94	102.1	778.0	102.6	9	94.0	240.0	74	65	210
BONNEVILLE TAILRACE 1/4 MI DN SPILL SI	1438	0	7.9	14.96	126.3	19.33	124.0	942.5	124.1	9	94.0	240.0	29	65	210
COLUMBIA RIVER WASHOUGAL CNTR	1445	0	8.1	12.82	108.8	16.87	107.4	816.7	107.5	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-IS	1500	0	8.5	12.46	106.7	16.14	104.9	798.8	105.2	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1521	0	8.9	12.10	104.6	15.75	103.2	785.8	103.4	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 APRIL 17, 1973

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
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1340	0	10.6	10.84	99.8	14.45	100.5	745.6	100.3	0	0.0	42.0	638	0	40
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1340	33	10.6	10.75	98.9	14.41	100.2	742.5	99.9	0	0.0	42.0	638	0	40
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1400	0	10.3	10.84	98.7	14.63	102.2	756.3	101.4	0	0.0	42.0	540	0	41
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1400	33	10.3	10.62	96.7	14.45	99.5	737.6	98.9	0	0.0	42.0	540	0	41
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1313	0	10.4	10.50	95.5	14.45	99.4	737.6	98.5	0	0.0	44.0	440	0	41
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1313	33	10.4	10.39	94.5	14.52	99.9	739.1	98.7	0	0.0	44.0	440	0	41
COLUMBIA RIVER ABOVE MOUTH SNAKE	1308	0	8.7	12.54	109.1	16.08	106.1	801.1	106.6	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1113	0	9.3	12.20	107.7	15.69	105.0	792.0	105.4	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1113	33	9.1	11.63	102.2	15.15	100.9	759.5	101.1	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1123	0	9.1	12.08	106.2	15.77	105.0	790.0	105.2	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1123	33	9.2	12.08	106.4	15.69	104.7	788.7	105.0	0	0.0	211.0	340	0	158
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1130	0	9.5	12.13	107.3	15.46	103.6	785.4	104.3	0	0.0	211.0	270	0	158
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1140	0	9.2	12.24	107.5	15.78	105.1	794.1	105.4	0	0.0	211.0	270	0	158
JOHN DAY FOREBAY 1/4 MI UP CNTR	1040	0	9.1	12.20	106.9	15.53	103.2	782.4	103.9	0	0.0	178.0	265	0	159
THE DALLES FOREBAY 1/4 MI UP CENTER	1020	0	9.1	11.86	103.5	15.46	102.3	774.7	102.5	0	0.0	165.0	160	0	165
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	956	0	9.4	11.52	101.0	15.22	101.1	766.1	101.0	0	9.0	153.0	74	33	176
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	956	33	9.3	12.42	108.7	15.84	105.0	801.2	105.6	0	9.0	153.0	74	33	176
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	950	0	9.5	13.24	116.1	17.66	118.7	895.5	117.9	0	9.0	153.0	29	33	176
COLUMBIA RIVER WASHOUGAL CNTR	933	0	9.3	11.75	102.6	15.30	101.2	770.6	101.4	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-I5	918	0	9.6	11.75	103.3	15.22	101.4	772.6	101.7	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	850	0	10.0	11.41	101.2	15.22	102.2	774.8	101.9	0	0.0	0.0	14	0	0
WILLAMETTE R PORTLAND	913	0	12.0	10.05	93.5	14.64	102.6	764.6	100.6	0	0.0	0.0	26	0	0

WILLAMETTE R PORTLAND	913	0	12.0	10.05	93.5	14.64	102.6	764.6	100.6	0	0.0	0.0	26	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 1, 1973

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
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1633	0	14.9	14.06	142.5	14.10	107.8	853.2	114.8	0	0.0	65.0	638	0	41
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1633	33	12.2	10.73	102.4	14.28	102.7	762.6	102.6	0	0.0	65.0	638	0	41
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1607	0	13.7	11.30	111.2	14.39	106.4	800.2	107.3	1	3.0	54.0	540	1	42
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1607	33	11.5	10.67	99.9	14.60	103.2	764.1	102.4	1	3.0	54.0	540	1	42
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1544	0	13.9	10.17	100.2	14.32	105.9	783.3	104.6	0	0.0	45.0	440	0	42
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1544	33	11.6	9.92	92.7	14.23	100.4	739.2	98.7	0	0.0	45.0	440	0	42
COLUMBIA RIVER ABOVE MOUTH SNAKE	1530	0	11.0	12.44	114.3	15.17	105.3	804.1	107.0	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1511	0	11.9	12.30	115.4	14.74	104.3	800.1	106.5	0	0.0	155.0	340	0	137
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1511	33	11.3	12.18	112.7	14.88	104.0	794.0	105.7	0	0.0	155.0	340	0	137
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1504	0	11.8	11.80	110.5	14.81	104.6	794.1	105.7	0	0.0	155.0	340	0	137
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1504	33	11.0	11.42	105.0	14.88	103.3	778.2	103.6	0	0.0	155.0	340	0	137
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1423	0	12.3	12.55	118.6	14.88	105.9	816.5	108.4	0	0.0	155.0	270	0	137
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1430	0	11.4	11.80	109.2	15.03	104.9	796.1	105.7	0	0.0	155.0	270	0	137
JOHN DAY FOREBAY 1/4 MI UP CNTR	1341	0	13.7	10.80	105.2	14.03	102.8	777.4	103.2	0	0.0	165.0	265	0	129
JOHN DAY FOREBAY 1/4 MI UP CNTR	1341	33	11.3	11.25	103.8	14.88	103.6	780.2	103.6	0	0.0	165.0	265	0	129
THE DALLES FOREBAY 1/4 MI UP CENTER	1315	0	11.4	11.05	101.8	14.53	101.1	764.9	101.2	0	0.0	119.0	160	0	130
THE DALLES FOREBAY 1/4 MI UP CENTER	1315	33	11.5	11.17	103.2	14.67	102.3	774.2	102.4	0	0.0	119.0	160	0	130
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1128	0	11.0	11.42	104.0	14.60	100.4	766.7	101.1	2	2.0	143.0	74	2	141
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1128	33	11.0	11.42	104.0	14.53	99.9	763.8	100.7	2	2.0	143.0	74	2	141
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1103	0	11.6	11.80	108.8	15.38	107.0	814.0	107.2	2	2.0	143.0	29	2	141
COLUMBIA RIVER WASHOUGAL CNTR	1045	0	11.0	11.55	105.0	14.68	102.2	780.0	102.7	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-15	1030	0	11.3	11.42	104.6	14.46	99.9	765.8	100.8	0	0.0	0.0	26	0	0
WILLAMETTE R PORTLAND	1023	0	13.4	9.92	95.2	14.32	103.3	771.5	101.6	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1000	0	11.5	11.30	103.8	14.74	102.3	779.0	102.5	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 MAY 14, 1973

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	SAT	ATMOSPHERIC --NITROGEN-- ML/L	SAT	-TOTAL PRESSURE MM HG	GAS-SATURE SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	942	0	16.5	12.38	129.8					0	0.0	66.0	638	0	58
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	942	33	13.6	10.72	105.6	14.66	108.5	801.2	107.8	0	0.0	66.0	638	0	58
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1004	0	15.7	11.14	114.5	14.28	109.9	825.5	110.7	0	0.0	65.0	540	1	58
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1004	33	13.6	9.78	96.0	14.14	104.4	765.1	102.6	0	0.0	65.0	540	1	58
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1025	0	15.5	10.61	108.2	14.18	108.3	809.4	108.1	0	0.0	44.0	440	13	58
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1025	33	14.0	9.78	96.5	14.14	104.9	771.5	103.1	0	0.0	44.0	440	13	53
COLUMBIA RIVER ABOVE MOUTH SNAKE	1027	0	13.7	13.12	128.1					0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1053	0	14.8	12.39	124.0	14.63	109.8	845.5	112.5	0	0.0	159.0	340	0	154
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1053	33	14.2	11.60	114.5	14.70	109.0	826.3	110.0	0	0.0	159.0	340	0	154
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1100	0	15.5	12.28	124.8	14.70	111.9	858.8	114.3	0	0.0	159.0	340	0	154
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1100	33	13.2	11.14	107.6	14.77	107.3	805.7	107.2	0	0.0	159.0	340	0	154
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1110	0	14.1	11.76	115.7	14.77	109.0	830.1	110.2	0	0.0	159.0	270	0	154
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1115	0	13.8	11.45	111.8	14.63	107.4	814.4	108.1	0	0.0	159.0	270	0	154
JOHN DAY FOREBAY 1/4 MI UP CNTR	1317	0	15.1	11.24	112.9	14.14	106.5	811.3	107.7	0	0.0	185.0	265	0	129
JOHN DAY FOREBAY 1/4 MI UP CNTR	1317	33	14.2	11.31	111.4	14.28	105.7	803.8	106.7	0	0.0	185.0	265	0	129
THE DALLES FOREBAY 1/4 MI UP CENTER	1328	0	14.5	10.82	106.9	14.35	106.4	804.4	106.4	0	0.0	182.0	160	0	138
THE DALLES FOREBAY 1/4 MI UP CENTER	1328	33	15.4	10.72	108.0	14.21	107.3	811.1	107.3	0	0.0	182.0	160	0	138
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1410	0	14.9	10.82	107.6	14.21	105.9	804.7	106.1	2	2.0	141.0	74	2	142
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1410	33	14.4	10.61	104.3	14.07	103.8	787.4	103.8	2	2.0	141.0	74	2	142
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1418	0	14.7	11.10	109.6					2	0.0	0.0	29	0	0
COLUMBIA RIVER WASHOUGAL CNTR	1434	0	14.7	10.95	108.1	14.37	106.4	810.0	106.6	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-I5	1519	0	14.9	11.35	112.5	14.56	108.3	828.0	109.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1543	0	15.3	11.14	111.4	14.63	109.7	834.4	109.8	0	0.0	0.0	14	0	0
WILLAMETTE R. PORTLAND	1824	0	17.1	9.37	97.4					0	0.0	0.0	26	0	0

NATIONAL MARINE FISHERIES SERVICE COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE

COLUMBIA RIVER	[illegible]	0	14.9	11.55	112.5	14.56	108.3	828.0	109.0	0	0.0	0.0	26	0	0
PRESCOTT CENTER	1543	0	15.3	11.14	111.4	14.63	109.7	834.4	109.8	0	0.0	0.0	14	0	0
WILLAMETTE R PORTLAND	1524	0	17.1	9.37	97.4	[illegible]	[illegible]	[illegible]	[illegible]	0	0.0	0.0	26	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 29, 1973

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 ---KCFS--- SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	TOTAL
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1542	0	14.1	9.76	97.2	13.70	102.5	753.4	101.4	0	0.0	61.0	638	0	66
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1542	33	13.5	9.65	96.8	13.77	101.7	748.4	100.7	0	0.0	61.0	638	0	66
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1518	0	14.0	10.01	99.1	14.05	104.5	770.9	103.3	0	0.0	64.0	540	0	64
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1518	33	14.0	10.13	100.4	14.19	105.6	778.9	104.4	0	0.0	64.0	540	0	64
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1450	0	15.4	10.51	106.9	14.82	113.0	834.8	111.5	6	17.0	62.0	440	17	61
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1450	33	13.6	10.50	102.7	14.75	108.5	802.1	107.1	6	17.0	62.0	440	17	61
COLUMBIA RIVER ABOVE MOUTH SNAKE	1445	0	16.6	10.26	106.7	13.84	107.6	805.9	107.3	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1415	0	17.0	12.38	129.9	13.91	109.0	849.7	113.1	0	0.0	173.0	340	0	124
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1415	33	15.0	11.38	114.4	14.43	108.7	824.3	109.7	0	0.0	173.0	340	0	124
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1415	0	17.8	12.25	130.7	13.91	110.7	860.6	114.6	0	0.0	173.0	340	0	124
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1415	33	14.0	10.13	99.7	14.19	104.8	778.9	103.7	0	0.0	173.0	340	0	124
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1415	0	15.1	11.38	114.4	14.19	106.9	815.6	108.3	0	0.0	173.0	270	0	124
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1415	0	14.7	10.63	105.9	13.91	104.0	785.3	104.3	0	0.0	173.0	270	0	124
JOHN DAY FOREBAY 1/4 MI UP CNTR	1300	0	17.4	11.01	116.1	13.56	106.8	817.6	108.5	0	0.0	186.0	265	0	155
JOHN DAY FOREBAY 1/4 MI UP CNTR	1300	33	15.7	10.63	108.2	13.56	103.3	785.3	104.3	0	0.0	186.0	265	0	155
THE DALLES FOREBAY 1/4 MI UP CENTER	1140	0	15.7	10.38	105.3	13.70	104.0	787.6	104.2	0	0.0	176.0	160	0	153
THE DALLES FOREBAY 1/4 MI UP CENTER	1140	33	15.7	10.51	106.5	13.63	103.5	786.5	104.0	0	0.0	176.0	160	0	153
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1050	0	15.2	10.38	103.8	13.49	101.1	770.6	101.6	6	21.0	163.0	74	10	151
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1050	33	15.2	10.38	103.8	13.49	101.1	770.6	101.6	6	21.0	163.0	74	10	151
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1050	0	15.3	12.18	121.8	16.10	120.7	915.5	120.5	6	21.0	163.0	29	10	151
COLUMBIA RIVER WASHOUGAL CNTR	1028	0	15.3	10.38	103.9	13.63	102.2	778.3	102.5	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-15	958	0	15.5	10.63	106.8	13.77	103.7	791.7	104.2	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	900	0	15.6	10.13	102.0	13.56	102.2	775.9	102.1	0	0.0	0.0	14	0	0
WILLAMETTE R PORTLAND	1008	0	17.2	8.77	91.3	13.49	104.9	774.9	102.0	0	0.0	0.0	26	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 12, 1973

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
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1015	0	17.6	9.75	104.6	13.24	106.1	785.3	105.6	0	0.0	53.0	638	0	67
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1015	33	16.6	9.24	97.1	13.45	105.7	771.6	103.8	0	0.0	53.0	638	0	67
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1055	0	16.9	10.36	109.2	13.64	107.4	802.9	107.6	0	0.0	51.0	540	0	48
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1055	33	15.4	9.38	95.8	13.71	104.9	767.9	102.9	0	0.0	51.0	540	0	48
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1121	0	17.3	9.75	103.3	13.56	107.2	795.4	106.3	0	0.0	44.0	440	2	46
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1121	33	15.8	9.38	96.2	13.56	104.2	766.9	102.4	0	0.0	44.0	440	2	46
COLUMBIA RIVER ABOVE MOUTH SNAKE	1142	0	16.3	11.31	116.9	13.71	106.0	812.3	108.1	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1205	0	17.2	11.47	120.8	13.80	108.5	832.9	110.9	0	0.0	204.0	340	0	148
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1205	33	16.0	10.61	109.0	13.87	106.7	803.8	107.0	0	0.0	204.0	340	0	148
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1205	0	17.1	10.98	115.4	13.71	107.7	819.6	109.1	0	0.0	204.0	340	0	148
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1205	33	15.4	8.64	87.6	13.87	105.4	763.4	101.6	0	0.0	204.0	340	0	148
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1205	0	16.0	10.48	107.4	13.87	106.4	801.8	106.5	0	0.0	204.0	270	0	148
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1205	0	15.8	10.24	104.5	13.87	106.0	794.7	105.5	0	0.0	204.0	270	0	148
JOHN DAY FOREBAY 1/4 MI UP CNTR	0	0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0	0.0	203.0	265	0	147
JOHN DAY FOREBAY 1/4 MI UP CNTR	0	33	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0	0.0	203.0	265	0	147
THE DALLES FOREBAY 1/4 MI UP CENTER	1430	0	16.8	9.99	103.7	13.48	104.5	788.2	104.3	0	0.0	198.0	160	0	150
THE DALLES FOREBAY 1/4 MI UP CENTER	1430	33	16.8	9.99	103.7	13.56	105.2	791.8	104.7	0	0.0	198.0	160	0	150
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1507	0	16.5	10.12	104.0	13.40	103.0	782.1	103.1	8	22.0	149.0	74	16	149
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1507	33	16.5	10.12	104.0	13.40	103.0	782.1	103.1	8	22.0	149.0	74	16	149
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1507	0	16.5	11.74	120.5	16.48	126.5	947.3	124.7	8	22.0	149.0	29	16	149
COLUMBIA RIVER WASHOUGAL CNTR	1540	0	16.5	10.24	105.1	13.48	103.5	787.7	103.7	8	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-I5	1540	0	16.8	10.36	107.1	13.71	105.9	805.0	106.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1625	0	17.0	9.75	101.1	13.16	101.9	772.9	101.7	0	0.0	0.0	14	0	0

WILLAMETTE R

LOCATION	TIME	DEPT FT	TEMP C	OXYGEN MG/L	OXYGEN SAT	NITROGEN ML/L	NITROGEN SAT	TOTAL PRESSURE MM HG	GAS-SAT	NO. GATE OPEN	HOURLY SPILL	FLOW TOTAL	SAMPLE ELEV FEET	MEAN DAILY SPILL	MEAN DAILY TOTAL
WASHOUGAL CNTR	1540	0	18.5	10.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COLUMBIA RIVER VANCOUVER-I5	1540	0	16.8	10.36	107.1	13.71	105.9	805.0	106.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1625	0	17.0	9.75	101.1	13.16	101.9	772.9	101.7	0	0.0	0.0	14	0	0
WILLAMETTE R															

NATIONAL MARINE FISHERIES SERVICE COASTAL ZONE AND ESTUARINE STUDIES
COLUMBIA RIVER AND TRIBUTARIES GAS SATURATION DATA---COMPENSATED FOR TEMPERATURE AND ALTITUDE
SURVEY DATE JUNE 27, 1973

LOCATION	TIME	DEPT FT	TEMP C	---OXYGEN--- MG/L	---OXYGEN--- SAT	ATMOSPHERIC --NITROGEN-- ML/L	ATMOSPHERIC --NITROGEN-- SAT	-TOTAL PRESSURE MM HG	GAS-SAT	NO. GATE OPEN	HOURLY ----KCFS---- SPILL	FLOW ----KCFS---- TOTAL	SAMPLE ELEV FEET	MEAN DAILY FLOW--KCFS SPILL	MEAN DAILY FLOW--KCFS TOTAL
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	944	0	18.4	9.72	106.1	12.92	105.1	781.8	105.2	0	0.0	45.0	638	0	51
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	944	33	17.8	8.72	94.0	13.10	105.3	764.7	102.9	0	0.0	45.0	638	0	51
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1006	0	17.4	9.84	104.9	13.27	105.6	765.6	105.3	0	0.0	48.0	540	0	50
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1006	33	16.4	9.22	96.2	13.36	104.3	764.7	102.5	0	0.0	48.0	540	0	50
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1033	0	18.5	9.60	104.2	13.10	106.0	769.6	105.5	0	0.0	45.0	440	0	44
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1033	33	17.0	8.85	93.1	13.10	103.0	755.4	100.9	0	0.0	45.0	440	0	44
COLUMBIA RIVER ABOVE MOUTH SNAKE	1049	0	16.9	10.74	112.4	13.63	106.6	808.8	107.7	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1108	0	20.5	10.47	117.9	13.01	108.8	829.7	110.4	0	0.0	173.0	340	0	140
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1108	33	17.8	9.60	102.3	13.10	104.2	779.2	103.7	0	0.0	173.0	340	0	140
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1108	0	21.0	10.47	119.1	13.28	112.0	850.2	113.2	0	0.0	173.0	340	0	140
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1108	33	17.0	10.09	105.9	13.18	103.3	779.7	103.8	0	0.0	173.0	340	0	140
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1123	0	17.7	9.47	100.6	13.18	104.5	779.8	103.5	0	0.0	173.0	270	0	140
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1123	0	17.7	9.47	100.6	12.92	102.3	767.5	101.9	0	0.0	173.0	270	0	140
JOHN DAY FOREBAY 1/4 MI UP CNTR	1327	0	19.0	9.84	107.3	13.01	105.6	796.9	105.8	0	0.0	187.0	265	0	146
JOHN DAY FOREBAY 1/4 MI UP CNTR	1327	33	17.8	9.35	99.4	13.18	104.6	779.2	103.4	0	0.0	187.0	265	0	146
THE DALLES FOREBAY 1/4 MI UP CENTER	1346	0	17.7	9.47	100.2	13.18	104.1	779.8	103.1	0	0.0	218.0	160	0	142
THE DALLES FOREBAY 1/4 MI UP CENTER	1346	33	17.8	9.22	97.7	13.01	102.8	768.9	101.7	0	0.0	218.0	160	0	142
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1420	0	17.7	9.47	99.9	13.18	103.7	779.8	102.8	0	2.0	142.0	74	3	142
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1420	33	17.9	9.35	99.0	13.18	104.1	780.7	102.9	0	2.0	142.0	74	3	142
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1420	0	18.2	10.20	108.5	14.35	113.8	853.3	112.3	0	2.0	142.0	29	3	142
COLUMBIA RIVER WASHOUGAL CNTR	1448	0	17.9	9.47	100.1	13.10	103.3	778.6	102.5	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-I5	1500	0	18.2	9.47	100.7	13.18	104.5	787.2	103.6	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1533	0	18.1	9.10	96.5	13.18	104.3	779.5	102.6	0	0.0	0.0	14	0	0
WILLAMETTE R PORTLAND	1513	0	18.9	8.74	94.3	13.18	105.9	785.1	103.4	0	0.0	0.0	26	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 JULY 10, 1973

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
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	930	0	22.3	9.08	107.1	12.02	104.9	782.4	105.3	0	0.0	19.0	638	0	30
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	930	33	20.0	8.57	96.6	12.31	103.1	755.9	101.7	0	0.0	19.0	638	0	30
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	957	0	20.0	9.40	105.6	12.17	101.6	763.7	102.4	0	0.0	54.0	540	0	32
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	957	33	20.0	9.08	102.0	12.24	102.2	761.9	102.1	0	0.0	54.0	540	0	32
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1022	0	20.4	9.50	107.2	12.32	103.2	778.1	103.9	0	0.0	43.0	440	0	38
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1022	33	19.6	9.26	102.8	12.54	103.6	773.4	103.3	0	0.0	43.0	440	0	38
COLUMBIA RIVER ABOVE MOUTH SNAKE	1037	0	18.2	10.24	110.1	13.41	107.5	810.1	107.8	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1056	0	21.2	10.03	114.5	12.62	106.8	813.1	108.2	0	0.0	216.0	340	0	155
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1056	33	19.3	9.92	109.1	12.99	106.3	801.6	106.7	0	0.0	216.0	340	0	155
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1105	0	22.1	9.19	106.8	12.99	111.8	829.5	110.4	0	0.0	216.0	340	0	155
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1105	33	18.2	9.08	97.7	13.28	106.5	785.3	104.5	0	0.0	0.0	340	0	155
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1116	0	19.5	9.61	105.8	12.76	104.6	788.7	104.7	0	0.0	0.0	270	0	155
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1120	0	19.5	9.61	105.8	12.91	105.8	795.7	105.7	0	0.0	0.0	270	0	155
JOHN DAY FOREBAY 1/4 MI UP CNTR	1340	0	20.0	9.19	102.2	12.69	104.9	785.1	104.2	0	0.0	199.0	265	0	162
JOHN DAY FOREBAY 1/4 MI UP CNTR	1340	33	19.8	9.08	100.6	12.43	102.3	767.7	101.9	0	0.0	199.0	265	0	162
THE DALLES FOREBAY 1/4 MI UP CENTER	0	0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0	0.0	184.0	160	0	159
THE DALLES FOREBAY 1/4 MI UP CENTER	0	33	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0	0.0	184.0	160	0	159
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1437	0	19.3	9.08	99.0	12.69	102.9	773.3	102.0	5	39.0	182.0	74	21	162
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1437	33	19.2	9.19	99.9	12.84	103.9	780.6	102.9	5	39.0	182.0	74	21	162
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1450	0	19.1	11.81	128.0	16.70	134.6	1006.1	132.5	5	39.0	182.0	29	21	162
COLUMBIA RIVER WASHOUGAL CNTR	1510	0	19.1	9.22	99.8	13.21	106.5	797.2	105.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-I5	1540	0	19.5	9.08	99.2	12.99	105.5	790.3	104.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1615	0	19.5	8.87	96.9	12.85	104.3	780.0	102.6	0	0.0	0.0	14	0	0
WILLAMETTE R															

COLUMBIA RIVER VANCOUVER-15	1540	0	19.5	9.08	99.2	12.99	105.5	790.3	104.0	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1615	0	19.5	8.87	96.9	12.85	104.3	780.0	102.6	0	0.0	0.0	14	0	0
WILLAMETTE R															

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
GRAND COULEE FOREBAY POWER SIDE	900	0	18.5	8.56	92.6	11.80	95.1	711.8	94.7	11	14.0	101.0	1320	16	103
GRAND COULEE FOREBAY POWER SIDE	900	33	17.2	8.68	91.4	12.40	97.5	723.8	96.3	11	14.0	101.0	1320	16	103
GRAND COULEE TAILRACE SPILL SIDE	915	0	13.6	9.53	92.8	14.12	103.4	760.5	101.2	11	14.0	101.0	1320	16	103
CHIEF JOSEPH FOREBAY POWER SIDE	940	33	13.7	9.65	96.3	14.20	106.5	766.9	104.3	0	0.0	114.0	943	0	113
WELLS FOREBAY 1/2 MI UP CENTER	958	33	14.1	9.92	99.5	14.20	107.0	777.4	105.3	0	0.0	135.0	640	0	116
ROCKY REACH FOREBAY 1/2 MI UP CENTER	1040	0	14.5	9.65	97.5	13.83	104.8	763.4	103.2	0	0.0	173.0	775	0	117
ROCKY REACH FOREBAY 1/2 MI UP CENTER	1040	33	14.5	9.77	98.6	14.05	106.5	775.0	104.8	0	0.0	173.0	775	0	117
ROCK ISLAND FOREBAY 1/2 MI UP CENTER	1058	33	14.4	9.77	98.1	14.05	105.9	773.4	104.2	6	78.0	157.0	680	44	121
WANAPUM FOREBAY 1/2 MI UP CENTER	1123	33	14.5	9.89	99.5	13.83	104.3	767.1	103.2	0	0.0	175.0	650	0	139
PRIEST RAPIDS FOREBAY 1/4 MI UP CENTER	1135	33	14.6	9.77	98.1	13.60	102.5	756.9	101.5	0	0.0	156.0	560	0	145
SNAKE RIVER-MOUTH MOUTH	1300	0	19.4	7.49	82.5	12.03	98.6	716.1	95.3	0	0.0	0.0	341	0	0
COLUMBIA RIVER ABOVE MOUTH SNAKE	1258	0	15.7	9.77	99.7	13.23	101.1	756.9	100.8	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1320	0	18.4	9.65	104.2	12.63	101.6	767.0	102.1	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1320	33	16.8	9.17	95.7	12.93	100.9	749.8	99.8	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1330	0	18.7	9.41	102.2	12.48	101.0	760.2	101.2	0	0.0	211.0	340	0	158
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1330	33	16.5	8.68	90.1	12.78	99.2	731.1	97.3	0	0.0	211.0	340	0	158
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1345	0	17.0	9.04	94.6	12.85	100.5	747.5	99.3	0	0.0	211.0	270	0	158
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1350	0	16.8	8.92	93.0	12.78	99.5	739.2	98.1	0	0.0	211.0	270	0	158
JOHN DAY FOREBAY 1/4 MI UP CNTR	1450	33	18.1	8.19	87.6	12.29	98.1	722.6	95.9	0	0.0	170.0	265	0	126
THE DALLES FOREBAY 1/4 MI UP CENTER	1510	33	17.9	8.32	88.3	12.33	97.7	724.0	95.8	0	0.0	178.0	160	0	136
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1544	0	17.5	8.68	91.2	12.25	96.0	721.1	95.1	2	2.0	143.0	74	2	134
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1544	33	17.6	8.92	93.9	12.48	98.0	736.8	97.1	2	2.0	143.0	74	2	134
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1555	0	17.6	9.77	102.8	13.90	109.2	816.3	107.6	2	2.0	143.0	74	2	134
COLUMBIA RIVER WASHOUGAL CNTR	1613	0	17.7	9.03	95.0	12.48	98.0	739.8	97.4	0	0.0	0.0	26	0	0
COLUMBIA RIVER VANCOUVER-15	1628	0	17.7	8.92	93.9	12.48	98.0	738.1	97.2	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1700	0	17.7	8.44	88.8	12.53	98.3	732.4	96.4	0	0.0	0.0	14	0	0
WILLAMETTE R															

Ebel, Wesley
Evaluation of fish protective facilities at Little Goose Dam and Review of other studies ... 1973