Panel 2: Fish Passage Problems and Solutions

Major Passage Problems

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We have heard today that the Columbia and Snake River systems, once free-flowing drainages, have been reduced to a series of pools and dams. Today I'm going to talk principally about the Snake River runs, not only because we have the best data on these runs, but also because Dick Allen has pretty well covered the data on the Columbia River stocks.

Since 1968, four new dams have been completed in the Snake and Columbia Rivers: John Day Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. These dams have had a drastic effect on the survival of both the steelhead trout and chinook salmon stocks in the upper Snake River. Population and survival estimates of juvenile salmon and steelhead trout migrating from upriver rearing areas to lower-river dams have been made each year since 1966. Initially survival of juvenile salmonids was between 60 and 80% from the upper Snake River to The Dalles Dam. As more dams were constructed, the survival declined with a low of less than 10% being recorded in 1973. However, it must be understood that 1973 was a low-flow year; thus, all the downstream migrants had to pass through turbines because of the lack of excess water that is normally spilled. The water passing over spillways in a normal-flow year provides an alternate, and usually safer, passage route. Obviously, these smolts migrated under the worst conditions. In 1974, there was an increase in the survival of both steelhead trout and chinook salmon stocks over that recorded in 1973 but the survival of chinook salmon declined again in 1975, while the steelhead trout populations remained at the 1974 level.

A superficial examination of available data indicates there was no serious decline in adult chinook salmon and steelhead trout runs to the Snake River until 1974. However, an analysis of adult returns by year of outmigration shows Snake River runs have been declining since 1969. Greatly increased release of chinook salmon and steelhead fingerlings from hatcheries, combined with an above-average survival in the ocean of chinook salmon migrating downriver in 1970, have masked the real effect of new dams and impoundments on survival of juveniles migrating downriver. The adult run of spring chinook salmon and steelhead migrating up the Columbia River each year consists of survivors from 3 separate years of juvenile downstream migrations; therefore, one very successful juvenile outmigration in any given year can result in that year class dominating the adult run for several years. Returns in 1974, not influenced by the fish that migrated in 1970, are dangerously low.

The percentage of adults returning from known populations of juvenile chinook salmon and steelhead migrating downriver each year reflects the status of fish passage conditions in the Snake and Columbia Rivers. While total numbers of both chinook salmon and steelhead smolts increased significantly starting in 1970, adult return percentages of both species have declined at an alarming rate since 1969. Prior to installation of recent dams and resulting reservoirs in the Snake

River (1964 to 1968), returns of chinook averaged about 4%. In 1969, with the completion of Lower Monumental Dam, adult returns from that year's juvenile population dropped to 3.5%, and to 3.2% in 1970, after the completion of Little Goose Dam. Since that time, adult returns from juvenile populations migrating downstream have declined sharply to 2.2% from juveniles migrating downstream in 1971 to 0.8% from those migrating downstream in 1972. We estimate that only 0.3 to 0.4% will return from those migrating downstream in 1973. Steelhead runs show a similar decline from 5 to 6% through 1966 to 2.5% in 1969, 2.1% in 1970, 1.4% in 1971, 1.0% in 1972, and an estimated 0.2 to 0.3% in 1973.

The drop in adult return percentages reflects losses of juveniles due to fish passage problems in the Snake River—not to adult losses at dams, nor to ocean mortality, nor to increased fishing pressure in the ocean, nor even to the river gillnet fishery.

If the declines in fish populations since 1969 were due to increased fishing pressure in the ocean, then chinook salmon should be the only species showing a drop, since there is no significant harvest of steelhead in the ocean. If the decline were due to the river fishery, then it would have to be due to unreported catches since both sport and commercial fisheries are included in adult return calculations. The decline is not due to losses of adults at dams. Data from the Fish Commission of Oregon[1] show that losses of adult salmon and steelhead in recent years (1970 to 1973) were no higher than losses in 1968 or 1969.

What are the major causes?

The major losses of the juvenile stocks are now attributed to the turbines, supersaturation of the water with nitrogen, the delay in migration caused by the impoundments, and an increase in predation.

Several studies have been conducted on turbine mortalities; the average turbine mortality among migrating smolts lies somewhere between 10% and 15%. However, at some dams where there are considerable numbers of bird and fish predators, the mortality among downstream migrants can be as high as 30%, particularly among those fish that become trapped in the backroll of the turbine discharge, become badly injured or stunned, and are diverted into backwaters where there are concentrations of predators. The main point of these studies lies in the fact that smolt mortality is not always 10% or 15%, but in some cases can rise to as much as 30% just in passage through a single dam and its complex of turbines. Such mortality rates can explain why our smolt migrations were so terribly decimated in 1973.

Considerable data are available to demonstrate the effect of the dams on the chronology of the juvenile migrations. Before the dams were in place, the migrating smolts took about 22 days to get from the Salmon River to the lower Columbia below Bonneville Dam. Since these impoundments were filled, it takes a smolt about 54 days to reach the lower river. Such delays have had a rather drastic effect on the juveniles by exposing them for almost three times their original availability to predators. The series of dams and reservoirs also results in a multiplication of their exposure to nitrogen supersaturation and a radically increased period of exposure to disease organisms, parasites, and several other hazards. During low-flow years, the delay caused by the impoundments can result in a significant portion of the juvenile population residualizing, i.e., losing its migratory urge, staying in the lacustrine flowages and not attempting to reach the sea.

The following examples are typical of the predation that is encountered. Dolly Varden with as many as six juvenile chinook salmon in their stomach have been captured. Squawfish and other coarse fish take a heavy toll as well. Fish-eating birds are also serious culprits, particularly on migrating smolts that are partially injured or stunned passing through the turbines.

The other serious factor in smolt mortality is the supersaturation of the river water with atmospheric gas which is primarily (78%) nitrogen. Our research has shown that the major cause of such nitrogen concentrations is the spilling from dams. Fish mortality is related to the level of supersaturation, the depth the fish are migrating, and the exposure time to the nitrogen levels below the dams.

Extensive research on the number of days that it takes juvenile migrants to reach the lower dams has been conducted on the Snake and Columbia Rivers. Generally, these data show that migration rate is proportional to flow; i.e., the higher the flow the faster the rate and vice versa.

Our research has been able to relate the timing of such juvenile migration to the ambient levels of nitrogen, and actually make some calculations concerning the percentage of the population killed by exposure to supersaturation below the dams. Our calculations are based on juvenile stocks of fish from the Snake River, and we calculated that nitrogen supersaturation in 1970, 1972, and 1974 caused about 40% of the mortality. Remaining mortality came from passage through turbines, and other factors such as increased exposure to predation. In 1973 the loss was due to the other factors because there was no spillage at the reservoirs. Mortality caused by supersaturation of nitrogen was not estimated in 1975.

What are some of the solutions?

The partial solution to supersaturation of nitrogen below the impoundments lies in the installation of spillway deflectors. These deflectors were first developed by the Corps of Engineers and tested extensively by the National Marine Fisheries Service. Most biologists and responsible fishery agencies on the Columbia presently believe that such structures are the best solution. There has been excellent progress in the installation of these spillway deflectors. Later this spring, we will have completed a complement of spillway deflectors on the dams in the Snake River, with the exception of Ice Harbor Dam, and made a good start on the spillway deflectors at the McNary Dam on the Columbia River. Some biologists feel at this point that the nitrogen problem, as far as Snake River stocks are concerned, is perhaps essentially solved, and the fish will not experience serious losses from nitrogen in future years.

What about the turbine mortality?

The National Marine Fisheries Service has conducted several studies to determine the distribution of the juvenile fish passing through the turbine intakes and into the turbines themselves. In our earlier studies we attempted to find ways of passing the fish through the turbines safely or at least ways of reducing the mortality rates. However, we discovered that even though we could get high percentages through the turbines, a substantial percentage was diverted into the backrolls and excessive mortality from predation would occur anyway. Consequently, we began experimenting with methods of diverting the fish from the turbine intakes into bypass systems. Later research determined that about 85% to 90% of fish that enter a turbine are in the upper 15 feet of the water. It seemed that a structure which screened only about that volume of the intake water could

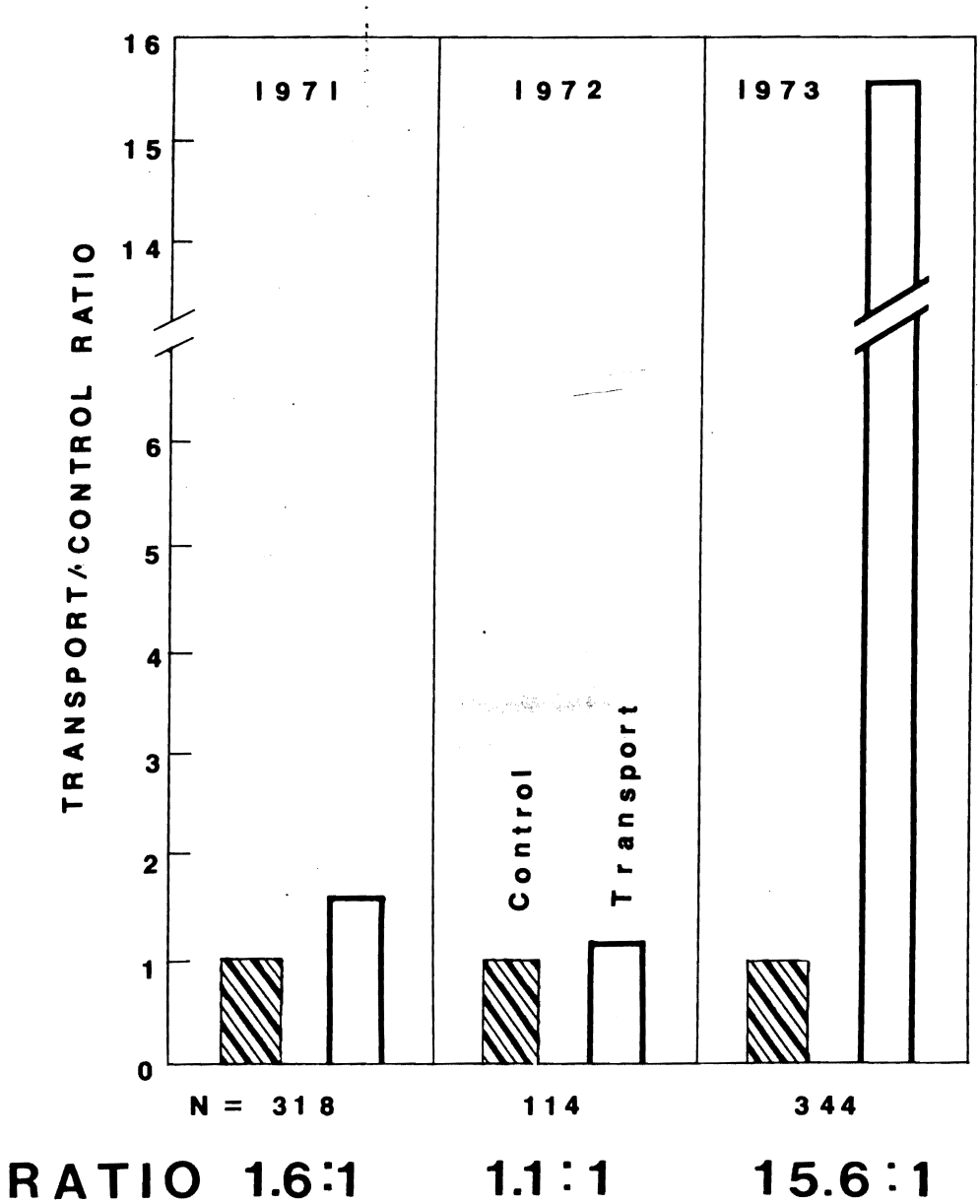

Figure 1. Comparisons of adult returns from control and transported releases of juvenile chinook salmon from Little Goose Dam.

protect and divert 85% to 95% of the fish, so we pursued this area of research intensively and diversion screens were developed. Current research on the screens is centered on development of diversion systems which can divert fish, mainly chinook salmon fingerlings, without injury or excessive exposure to predation. Considerable effort has been expended on this research, and we feel that at this time, we have refined the screen to the point where it is workable and can be applied to divert fish from the turbine intake without causing excessive percentages of injury. However, we believe several improvements in the screen design

and diversion system can be made, and future research will be centered on obtaining an optimum system. We will be testing a screen, designed by the U.S. Army Corps of Engineers, which allows the research team to change the screen angle in the intake flow. We believe this concept will improve the diversion capabilities, and we plan to have a major research effort on this aspect of intake screen deisgn later this spring.

Our data on screen design were largely obtained at Little Goose and Lower Granite Dams. The studies attempted to determine the optimal mesh size, and the best perforated plate design behind the mesh that will reduce the velocities of flow so as to keep the fish from impinging on the screen mesh. Some critical measurements that we made to evaluate our screen design involved the problem of descaling the migrant fish. Without the perforated plate to reduce the rate of flow, the rate of descaling among smolts reached an incidence of 20%. With the perforated plate, we were able to reduce fish descaling to somewhere between 5% and 8%, which is perhaps as low as we can reduce the problem. Even without any screens, it is possible to measure similar percentages of descaling on fish migrating downstream. One concept implicit in such a screening system is to divert the fish around the dam, induce them into some kind of a bypass system, and return the fish to the river below the impoundment. Such concepts are still being pursued, but display some problems in that the fish are only transported into the reservoir of the next dam downstream. Such fish are still subjected to concentration of predators waiting below. They also are still subjected to a considerable delay, particularly when migrating in a low-flow year. In addition, several of the dams lack an ice-and-trash sluiceway that can be used as a passageway after diverting the fish from the turbines and spillways to pass them around the dam. Some of the dams have an enclosed conduit which becomes plugged with debris. Such conduits not only get plugged with debris, but also prevent the fish from escaping collection areas as fast as they should when they are not designed for sufficient flow capacity. Obviously, the problem is not as simple as merely placing screens.

One practical way to reduce losses of juveniles during their down stream migration is by a collection and transportation system whereby fish are collected at an upstream dam and transported to the estuary around many dams. This would eliminate losses of juveniles from turbines, nitrogen supersaturation, pollution, and delay at a large number of dams. We have been experimenting with a collection-and-transport system at Little Goose Dam since 1971. This dam was provided with raceways where the fish can be collected after being diverted from the turbine intakes. They can either be held in those raceways or placed back into the tail-race. There is a pressure conduit that carries the fish from the gatewells after they have been diverted by the screens. Once the fish are collected, we employ large trucks to transport the fish, vehicles having a 5,000-gallon capacity.

The transport experiment was designed to determine effects of transportation on homing and survival of juveniles. The data, summarized in Figures 1 (chinook) and 2 (steelhead) indicate that survival of both chinook and steelhead was increased in most years (1971–1973) by collection and transportation. The percentage increase in survival varies from year to year depending on river conditions. During years when survival of natural migrants was very low, we had correspondingly low survival of our control release and the percentage benefit from

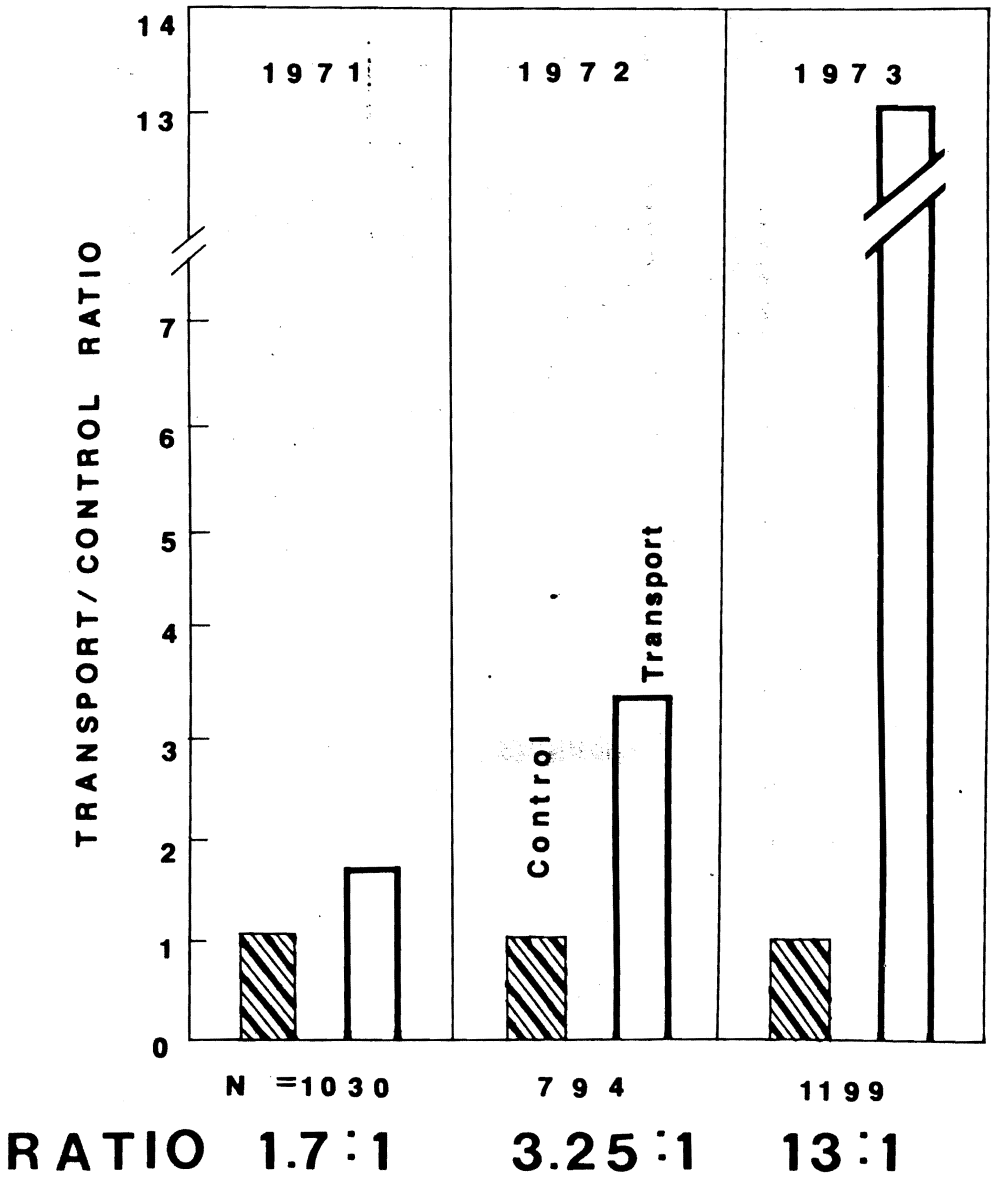

Figure 2. Comparisons of adult returns from control and transported releases of juvenile steelhead from Little Goose Dam.

transport was greatest. For example, in 1973, survival estimates indicated an all-time low survival rate for both juvenile chinook salmon and steelhead trout migrants; transport benefit ratios were the highest (16:1 for chinook, 13:1 for steelhead). (Adult return data through November 10, 1975.) The only exception was the poor return of chinook salmon transported in 1972. Adult returns of chinook salmon to Rapid River hatchery from the 1972 release were also unusually low. Since kidney disease may have been a complicating factor contributing to their poor return, disease among our transported fish could have offset a potential benefit of transportation.

The general concept of transportation is quite encouraging, and we believe that in managing the steelhead trout runs, we might begin immediately with a mass transport program to increase the adult returns of these migratory trout.

One breakthrough that we encountered this year was the discovery that hauling chinook salmon in a mild saline solution resulted in a dramatic increase in their survival after release downstream. We had been plagued with a rather high delayed mortality of juvenile chinook salmon after their subsequent release. We had typically encountered approximately a 15% delayed mortality with chinook salmon in freshwater tanks, but when we hauled them in saltwater mixtures, the fish suffered surprisingly little mortality. We believe hauling in salt water may prove to be the solution to the chinook salmon survival problems experienced in the past, and this year we are implementing a full-scale transportation effort using salt water with juvenile chinook salmon.

Our experience with these adult returns has made us believe we can work wonders with this transportation system, particularly with the steelhead trout ascending the Snake. We are convinced that termination of this effort at this time would result in the oblivion of these steelhead trout and salmon. We believe that if things proceed as they are now, combining the traveling screens and placing them in operation on schedule, expanding the transportation effort on schedule, and adding the spillway deflectors at the dams to reduce the nitrogen concentrations, we can restore the adult steelhead trout runs to their former levels within two to three years. After the Snake River Mitigation Plan is approved by Congress, it seems possible that we can establish adult runs of both steelhead trout and salmon in far greater numbers than existed before.

Both biologists and engineers believe we can maintain those runs in the upper Snake River if the proper measures are taken. We believe they ought to be taken, because the steelhead trout and salmon are worth saving, and because the people in the upper Snake country want them preserved.

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Footnote

[1] Data compiled from commercial and sport fisheries statistics by Burnie Bohn, Oregon Fish Commission, Clackamas, Oregon.