PROBLEMS OF FISHERIES MANAGEMENT: THE PACIFIC COAST EXPERIENCE

by

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I would like to add another perspective to deliberations here regarding salmon management by briefly reviewing the history of fish passage problems on the Columbia River on the American Pacific Coast, the research undertaken to try and find solutions to these problems, and the resulting successful management activities now being carried out.

The Columbia River, once a free-flowing system producing about 50 million pounds of salmon a year, is now a controlled river made up of a series of dams and reservoirs (Figure 1) that yields about 25 million pounds of salmon annually. Salmon and steelhead must negotiate this controlled river for great distances during their migration to and from the spawning grounds--for example, traveling upstream 700-800 miles to reach the spawning grounds in the Salmon River. They must also successfully pass a number of dams: the Columbia mainstem alone has eight dams in a space of 350 miles, and salmon reaching the spawning beds of the Snake River must ascend all of these. Fish moving to or from the productive areas above the Wells Dam on the Columbia River must bypass nine dams.

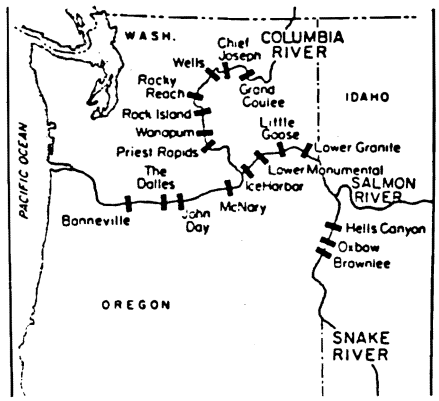

Figure 1. Location of main stem dams in the Columbia River Basin.

The mainstream dams in the Columbia-Snake system are generally around 100 feet tall, with the exception of Grand Coulee and Brownlee Dams. Grand Coulee Dam, 325 feet high from tailrace to forebay, was not the first dam constructed on the Columbia River, but it was the first to cause a serious fish passage problem. In 1939 the agencies involved were not certain the available technology was adequate to build a successful fish passage facility over such a height, and the deci-

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sion was made to transfer the affected fish to downstream locations--primarily hatcheries. The measure was deemed a success (Fish and Hanavan, 1948), but subsequent dam construction downstream negated its positive benefits.

The second major fish passage problem in the Columbia River drainage was posed by the construction of the Brownlee-Oxbow Dam complex. Fish passage was attempted here but subsequently abandoned; thereafter, adults were trapped below Oxbow Dam and transported upstream to Brownlee Dam. A large skimmer net was used in the forebay of Brownlee Dam to attempt to capture young fish migrating downstream; however, the juvenile transfer system was not successful, primarily because insufficient numbers of juveniles made it through the long, deep reservoir behind Brownlee Dam to provide for a sustained run. Again the decision was made to transfer the remaining runs below Oxbow Dam to hatcheries in the Salmon River drainage. This involved stocks of steelhead and spring and fall chinook salmon. The steelhead and spring chinook salmon transfer was successful and continues today. The fall chinook salmon transfer was not successful because of poor water quality at the site selected, and as yet adequate compensation for the loss to the fishery has not been achieved. By 1964, over 50 percent of the natural habitat of the Columbia River drainage was cut off by dams with no passage upstream. In spite of this, the Columbia River still remained very productive downstream of these areas, with hatchery programs helping to compensate for lost natural production. However, in the 1960s, in rapid succession, the John Day Dam on the Columbia River and the Lower Monumental, Little Goose and Lower Granite Dams on the Snake River were constructed, requiring fish migrating in the Snake River to pass four additional dams and reservoirs. On the mid-Columbia River, the Wells, Rocky Reach, Wanapum and Priest Rapids Dams were constructed, adding four dams between the spawning areas of the upper Columbia River and the ocean. As expected, this caused serious problems in maintaining the production of the upriver runs from the Snake and Columbia Rivers.

Prior to the construction of these dams, runs of 100-120 thousand steelhead trout ascended the Snake River annually. In about 1972, when the full effect of these dams began to take effect, a drastic decline occurred (Figure 2). Corrective measures taken since have improved but not restored this run. Similar declines occurred for summer chinook salmon, which dropped from runs of 30-40 thousand fish in the early 1960s to less than 10 thousand fish now and for spring chinook salmon. If the downward trend is examined in terms of percentage return for the numbers of juveniles migrating downstream each year, a more drastic downward trend is indicated. Before the recent dam construction, adult returns of spring and summer chinook salmon smolts migrating out of the Snake River ranged between 3 and 4 percent; adult returns of steelhead ranged between 6 and 7 percent. Subsequently, the percentage return in the low flow yers such as 1973 and 1977 declined to less than 1 percent because all the water flow--and migrating smolts--passed through the turbines at each of the dams.

In the early 1960s, in anticipation of the problems that might arise from the additional construction of the dams, the National Marine Fisheries Service began marking juvenile migrants from various fish stocks in the upper river drainage to measure their migration timing and survival to the lower river areas. Thus, we had good data on migration and survival rates before and after the most recent dam construction program. The data obtained on changes in smolt survival clearly showed that the primary cause of the decline of the adult runs was the decline in downstream survival. In the early 1960s, survival of juvenile migrants ranged between 80 and 90 percent but declined to less than 5 percent in 1973 and 1977, the low flow years. Other concurrent research showed that the main causes of the juvenile losses were turbine mortality, supersaturation of nitrogen or atmospheric gas, delay in migration, and finally, predation.

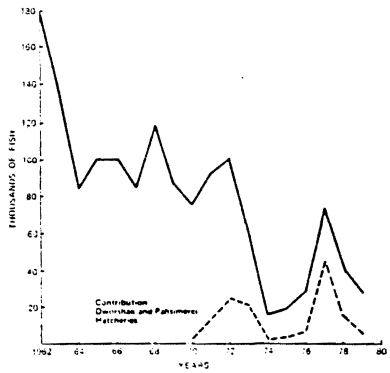

Figure 2. Steelhead trout runs into the Snake River, 1962-80. Yearly totals include catch plus escapement.

Most of the dams on the Columbia River are equipped with between three and sixteen Kaplan turbines, each with a capacity of about 15 to 20 thousand cubic feet per second (kcfs) of water. Our approach to solving turbine mortality was to explore three possibilities: guiding fish around the dams, making the turbines safe, and controlling turbine loads to minimize losses. We found it impossible to make turbines safe without incurring extremely high expenditures. Research showed that controlling turbine loads and operating the turbines at maximum efficiency did reduce smolt mortality, but not enough: direct and indirect mortality of smolts passing through turbines in the Columbia River ranges between 10 and 30 percent.

During the course of our studies we found that 70-85 percent of the juvenile migrants were located in the upper 15 feet of the turbine intake. This knowledge led us to install traveling screens in the intakes to intercept fish in the upper 15 feet and divert them into a gatewell (a large water-filled area utilized at most of the dams on the Columbia River for turbine maintenance). We believed fish could be passed downstream if the gatewell were connected to the ice and trash sluiceway installed at several of these dams. We proceeded with this concept and conducted prototype studies at Ice Harbor Dam as early as 1969 (Figure 3). The traveling screen deflectors have been perfected after several years of testing and modification. Turbines at the Lower Granite, Little Goose, McNary and Bonneville Dams are now completely equipped with these screens and bypass systems. The systems are being used to bypass fish directly or to collect fish for subsequent transportation or bypass.

Our initial experiments in transporting fish were conducted from Little Goose and Lower Granite Dams. Control fish were released below these dams while test fish were transported downstream. The fish were marked with coded wire tags, a brand and an adipose fin clip, permitting their iden- tification both in the fishery and on return to the dam as adults. Our concern was whether transporting the fish downstream, thus eliminating 350 miles of their normal migration route, would seriously affect homing, and whether in fact transportation around several dams would increase their survival.

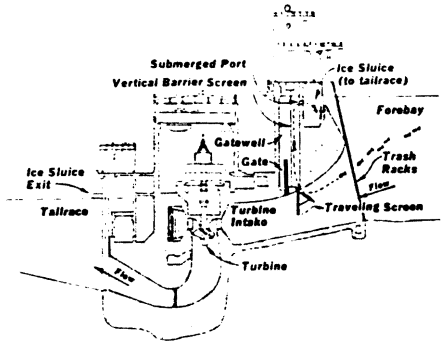

Figure 3. Cross-section of a typical powerhouse used by the U.S. Army Corps of Engineers on the Columbia River, showing fish diversion concept pursued by the National Marine Fisheries Service. Each turbine intake requires 3 screens.

The research showed that the transportation was extremely successful for steelhead and fall chinook and coho salmon but somewhat less successful for spring chinook salmon. Apparently, spring chinook salmon cannot tolerate the stresses of collection and transportation as well as the other species. Figure 4 illustrates the success of steelhead transportation. The bottom trend line indicates the contribution to the run from fish that were not transported but migrated downstream naturally; the top trend line indicates the fish contributed by the transportation effort on the Snake River. These data show that the steelhead run that was down to approximately 10 thousand fish has been restored to a run of 60-70 thousand fish. The projected run for 1983 also looks excellent.

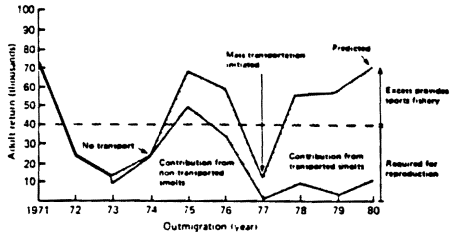

Figure 4. Snake River steelhead adult return from smolt outmigrations, 1971-80, indicating contribution of transported and non-transported smolts.

In the late 1960s, nitrogen supersaturation became a serious problem: fish were observed throughout the river with gas bubble disease symptoms. Research revealed the cause to be the heavy spilling of water into the deep plunge basins at the base of the spillways. This spilling entrained air, plunged it to depths and supersaturated the water. The problem was effectively eliminated by installing spillway deflectors on the spillways of most of the key dams to prevent the water from plunging (Figure 5).

The delay in downstream migration caused by the dams also became a serious problem. Prior to the dams, migrants traveled the distance in about 25 days; after construction about twice the time was required to travel the same distance. Timing also differed with the water flows: in a low flow year, fish required 78 days to travel from the Upper Salmon River to the estuary; in a moderate flow year about 48 days and in high flow years about 28 days. This delay in migration provided increased opportunity for predation and caused an increase in the numbers of "residual" fish which stayed in the reservoirs and failed to migrate to the sea during their normal migration period and therefore did not contribute to the fishery. In low flow years, substantial residualism occurs.

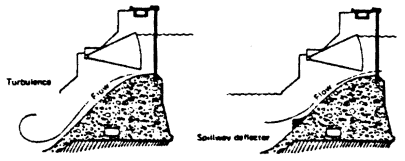

Figure 5. Cross-sections of typical spillways used at dams on the Columbia River, showing the standard spillway (left) and a spillway with flow deflector installed (right).

At John Day Dam, one of the largest on the lower river, the spillway is the only viable means of passing juvenile migrant fish. As this dam is one of the main power producers on the river, the U.S. Army Corps of Engineers requires adequate justification when fishery agencies ask for large volumes of water to be spilled to accommodate fish passage. We began experimenting with scanning sonar at John Day Dam to detect when concentrations of fish were present in the forebay and found that by sequentially shutting down the turbines and opening the spill gates when concentrations of juvenile fish were present, we were able to pass a substantial portion of the migrants in the forebay within about a 2 1/2 hour period in the evening. This practice has been quite successful and has been expanded to include all of the dams where bypass facilities have not yet been constructed.

Work is now underway to refine flow survival and travel time relationships so that we can determine the minimum flow required to get the best survival in any particular flow year. Our data indicate that as the flow increases, the rate of downstream movement of juvenile smolts increases. This relationship has been demonstrated for both the main Columbia and the Snake Rivers. The same relationships holds true for survival: in the Snake River, the optimum flow seems to be about 130 to 140 kcfs; when the flow exceeds 140 kcfs, the spillway deflectors are ineffective, gas bubble disease shows up and survival is reduced. A flow of 130-140 kcfs also appears to be optimum for juvenile steelhead and spring chinook migrants. Eventually, we hope to develop flow/survival curves that will establish minimum flow requirements for several river stretches so that we may recommend these to the power authorities as a guideline to achieve maximum survival of downstream migrants for any type of flow year.

I have not yet spoken about adult migrants or adult passage. There are adult passage problems in the Columbia River; however, the adult passage facilities at most dams are satisfactory, and the problems of adult passage are not as serious as those encountered with downstream migrating smolts. Excessive delays do occur at

some dams, usually from inadequate operation of the passage facilities, and unaccountable losses occur between dams. We also encounter "fallback," where fish ascend the ladders and fall back over the spillway or through the turbines. The usual method for isolating problems and finding solutions has been to use radio tags on the adults to monitor their behavior and record their disposition. Receivers hand-held at shore stations or mounted in aircraft have proved effective in plotting fish movement. For example, in 1972 adult migrants were being delayed at the Dalles Dam. Analysis of the tracking data showed the delay was due to inadequate operation of the powerhouse collection facility; this was corrected and the delay eliminated. At the Bonneville Dam, "fallback" of fish over the spillway was suspected. Radio tagging showed that adult fish ascending the Bradford Island Fishway would swim around the end of the island and across the upstream face of the spillway before proceeding upstream. When spill occurred, those fish traveling near the face of the spillway would fall back over the spill and have to reascend. This problem was solved by the construction of a second powerhouse, which greatly reduced the spill. Another adult passage problem occurred with shad in the fishways. Shad do not prefer the overfall type weir or ladder fishways, especially when submerged orifices are used in the latter. A vertical slot type ladder was examined in the laboratory for use as a possible improvement. Laboratory tests were positive, and vertical slots were installed in fishways at the John Day Dam for testing. These tests were also positive, and the vertical slot fishway is now recommended where shad passage is desired.

Management of the Columbia River fisheries has become complicated and at time seems almost impossible, as several fish runs decline in spite of numerous fish passage activities. Research has led to the development and implementation of several useful management techniques to improve fish production and help predict future run size for fishery management purposes.

As demonstrated earlier, fish survival is related to the level of water flow. In 1977 a unit called Columbia River Fisheries Operations, consisting of fishery agency and power authority representatives, was formed to predict spring flows based on the snow pack, estimate the expected spring river flow and recommend dam operations to achieve maximum survival of smolts without seriously reducing power production. This body has carried out its assigned task each year since 1977, and as of 1982, with passage of the Northwest Power Bill, is mandated by law. Its operational plan consists of achieving the best flow possible for the spring migration period, monitoring fish migrations and operating the dams to achieve maximum survival as fish proceed downstream and upstream.

Collection and mass transportation of juvenile migrants at the Little Goose and Lower Granite Dams on the Snake River and the McNary Dam on the Columbia is now a routine management activity occurring every year. Estimates of survival of various populations migrating downstream and estimates of survival of fish transported are calculated each year and used to predict adult returns for management purposes. Projections based on these estimates have worked extremely well for steelhead and fall chinook salmon but not as

well for spring chinook salmon.

Counts of adult fish at dams are also used to some extent to regulate upstream sport and Indian fisheries. Escapement levels (counts over various dams) are set for maximum production, and the fisheries are regulated accordingly.

The above methods have been used mainly to manage and regulate the river fishery. We are just beginning to use these methods to regulate and manage the ocean fishery--which is a mixed stock fishery of a more complex nature. For example, the fall chinook salmon fishery in the ocean was curtailed last year and again this year to help achieve the appropriate escapement of bright chinook salmon into the mid-Columbia River. This was a difficult task because it meant Alaskan fishermen and Canadian fishermen as well as our own local fishermen had to reduce their catch.

The recent Boldt and Belloni court decisions regarding Indian fishing rights has exacerbated management problems even further. These decisions entitle Indian tribes with early treaty rights to catch 50 percent of the harvestable fish in their usual and accustomed fishing places. Now fish managers not only have to properly manage the fishery, they have to insure that Indian tribes get their 50 percent--and in the area they want to catch them. One approach has been to curtail the traditional fisheries of some stocks further to allow sufficient fish for the Indians' catch and reasonable escapement. Another approach has been to supplement various stocks with hatchery releases. All of the above are working to some extent, but we have a long way to go.

REFERENCES

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