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FISH-PASSAGE RESEARCH IN THE COLUMBIA RIVER BASIN

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For thousands of years, migrating salmon and steelhead of the Columbia River system have adapted to the conditions prevailing in different parts of the Columbia River Basin. They enter the river, from the sea, at various seasons of the year: in the spring, in the summer, and in the fall. Some migrate only a few miles to spawn, while others swim upstream for more than a thousand miles. Some spawn in large rivers, some in lakes, some in cold mountain streams. Each group in its way has adapted so as to live in harmony with a specific environmental pattern—with a particular sequence of events, all of which have meaning to its existence.

Now, in a few short years, the development of the entire river system for power, irrigation, navigation, and flood control is making sudden, enormous changes in the environments to which the fish have long been adapted. Where swiftly flowing rivers were, a chain of lakes is being created. Freshets and floods that may have played a major role in the transport of fingerlings to the sea are being controlled. Temperature regimes that govern rates of growth and maturation are being modified. In the changed environments, new predator, competitor, and disease relationships are being established that may greatly affect the survival of the migrant fish. Add to these changes the physical barriers to migration created by many dams and the complex nature of fish-passage problems in the Columbia River system is made clear.

The necessity for providing methods for the safe and economical passage of migrating fish over the physical obstructions of dams is an obvious one, and a reality that must be faced. An even greater challenge, however, is the task of anticipating the adaptability of the stocks of fish to migration in the new environments that will be created by dams and developing methods to protect the fish where

environmental changes may be too severe. All of the factors that affect the behavior and survival of anadromous fish on their migrations from the gravel to the sea and from the sea to the spawning nest must be considered if we are to provide safe passage for salmon. The need for information is particularly critical in five major areas:

1. *Effect of Impoundments on Fish Migration.*

A large part of present research effort is directed toward measuring the effect of impoundments upon the migration of salmon. The basic question to be answered is whether the large impoundments that would be created by high dams would be impassable barriers to migratory anadromous fish. The problem is being studied in large and small impoundments in Idaho, Washington, and Oregon with chinook, silver, and sockeye salmon and steelhead trout. The research on downstream migrants includes estimation of recruitment to the impoundment, noting timing, size, and condition of the migrants; distribution and behavior patterns in the impoundment in relation to limnological conditions; estimation of survival and escapement from the impoundment and relation to size, condition, and age of the fish. Orientative behavior of adult salmon released in the reservoir and the ability of adults to pass through the impoundment and successfully reach spawning areas are being measured.

2. *Collection and Transportation of Downstream Migrants.*

In anticipation that certain types of impoundments may be impassable to some species (or races) of migrant fish, an important part of present research is on the development of practical and economical methods of collecting young fish from streams and from the entrance to impoundments. Methods of fish guidance and collection presently in use are only partly successful, or not applicable to large projects, or overly expensive. Research is now exploring the possibilities of more effective combinations of techniques that have shown promise in the past and developing new concepts of fish guidance and collection.

The use of louvers to collect downstream migrants from flowing water is being tested on a large scale at both fixed and floating installations. Further experiments with electrical guiding have been postponed, however, after data from tests indicated that its effectiveness is limited to velocities of less than 0.5 foot per second. New guiding concepts involving the response of fish to changes in water velocity are being developed and will be tested on a prototype scale

at special test facilities now under construction on the Grande Ronde River in Oregon. The possibility of collecting downstream migrants as they first enter an impoundment is being explored at the Brownlee Reservoir in Idaho, attempting to take advantage of the tendency of the young migrants to stay near the surface. Facilities and methods for holding, handling, and transporting the collected fingerlings are to be studied and tested. An investigation of means of controlling the spread of disease in fish concentrated for transportation purposes is in progress.

3. *Passages at Dams.*

The long sequence of river-run dams that fish must pass through in the Columbia River Basin makes protection at river-run dams an important factor in the survival of upper river stocks of salmon. Research is in progress on means of protecting downstream migrants in turbines, attempting to take advantage of the special distribution of fingerlings in turbine intakes and its relation to the cavitation producing areas that are believed to be the major source of injury to fish. Adult studies are planned to determine the effect of spillway operation on the effectiveness of entrance conditions and on fallback of salmon that have already ascended fish ladders. The relation of fishway-exit location to fallback activity will also be studied. Studies at the Fisheries-Engineering Research Laboratory at Bonneville Dam are directed toward the development of design criteria for effective and economical fishways.

High dams, particularly storage dams with fluctuating forebays and intermittent peaking operations, may not have any satisfactory means of exit from the reservoir available to young fish during the time of migration. Information is being sought on effective methods of providing egress for migrants where no spill is available. Facilities proposed for passage of adults at high dams would in some cases subject the fish to unusual stresses. Studies are in progress to measure the ability of salmon to withstand the conditions that would be imposed.

4. *Racial Physiology and Behavior.*

An important phase of fish-passage research is concerned with the adaptability of racial stocks of salmon to environmental changes anticipated with the construction of dams. Increased effort is being put in the prediction of the effects of proposed new dams on water temperature, oxygen, and flow conditions for analysis in terms of salmon passage and production. In order that the ability of anadromous fish to adapt to such changes in environmental patterns can

be predicted, information is being sought on the limits of the inherent capacities of the fish and how these relate to existing and predicted environmental patterns. A study is being made of racial migration rates and timing, and the nature of the homing mechanism of salmon is being investigated for relation to predicted future conditions.

5. *Effect of Temperature Level on Survival and Migration.*

The new fresh-water environment being created will determine the potential for success or failure of the upper river stocks of anadromous fish in the Columbia River Basin. In our frantic attempts to solve each set of problems created by each new dam, we are in danger of neglecting more important opportunities to develop some measure of large-scale environmental control that could be of immense benefit to anadromous fish. It is paradoxical that high storage dams that threaten disaster to anadromous fish runs that they intercept also have the potential capacity to control river temperatures within ranges of extreme importance to fish. Maximum water temperatures now reach into the seventies on the Columbia River and into the eighties on the Snake River. Unfortunately, the planning of the great storage reservoirs on the upper Columbia River includes no attempt to provide downstream temperature control. It would be extremely shortsighted if a similar situation were permitted to develop on the Snake River. Research is needed on the direct effect of water temperature on the migratory behavior and survival of anadromous fish. To fully appraise the benefits to be gained by control of water temperature, however, information is also needed on the effects of water temperature level upon disease and upon warm-water species of fish that compete with and prey upon anadromous fish as they pass through the long sequence of impoundments during their migration.

DISCUSSION

MR. A. T. PRITCHARD [Washington State Game Commission]: My remark is not directed as a question but the matter of a statement which was in the paper. I think particularly our people in the central part of the United States and eastern part of the United States are not aware of some conditions of the high dams which haven't been covered in this paper. On normal dam structures fish migrating upstream seem to get through quite well on the basis of not being handled, but we get into the problem of our higher dams, like the Lewis River and Callas River Dams in Washington where they are using a British-type operation. I think this is something we should be a little more cognizant of in your unprotected stock. At the Lewis River, it took 10 years to kill off a spring run salmon population. This was done again through an elevator-type and a handling operation. We have gone into a similar type of operation in the south again with the Braille, and to cite an example, the Game Department of the State of Washington trailed as carefully as we could some stocked steelhead, which is a very important fish in these streams, and we moved them no greater distance then than they are moving the

fish in California today. We took 60 fish, handling them very very carefully, and in a period of two months, we lost every single fish. This was with extreme care, not in the manner they are doing at the present time on the Callas River, where with the brailling they have a short ladder system. They go into a traveling braille operation, are dumped into a truck and hauled several miles and dumped back in behind the dam. I am afraid that our people are not making progress. It is a point I want to bring out. We should look a little harder at this point.

MR. FISHER: Thank you very much. Mr. Collins mentioned here studies on orientative behavior of adult salmon. I might mention briefly in passing the studies on orientation and celestial navigation of downstream migrants, and I think some downstream migrants, too, being carried out by British Columbia, and I am on the research board. One factor, as I remember, from a summer ago up there is in any positioning of the behavior that they have discovered from their studies on celestial star and sun navigation, and positioned behavior in downstream migrants, that they take up even when experimental leads indicate that it is in total darkness, the point being that here, possibly, is another complex factor in the design of fish passages. It may be of great advantage to design in such a way as to interfere as little as possible with the steelhead in a group orientation behavior.

A VOICE: I'm from Oregon. I would just like to make a little amplification of Dr. Collins' paper. Dr. Collins is aware, as we have discussed it and that is the matter of water quality that we get into on a number of projects. We used to think we could put the fish over any dam merely by building a ladder and the fish would go up. This proved true on our main attempts on Columbia River dams and a lot of other western dams. However, some of the smaller areas where we first started looking matters over, in dams that created stratified reservoirs, we found that in the summer areas, these conditions developed a different type of waterfall in coming down a fish ladder than was issuing from the turbines, with the result that the fish refused to enter fish ladders because the flow was different than that in which they approached the obstruction. This is a factor we are recognizing now on the West Coast and there are ways of getting around it. However, I was a little bit concerned about some of this work being done and proposed for the Susquehanna and some streams on the East Coast because there is every chance that the same thing will happen there, and I see no visions for adding discussions that don't add anything, and I think it is something that could well be taken advantage of and studied in advance before several million dollars are spent for fish ladders that prove utterly unacceptable to fish.

MR. ARNOLD GOLD [Oregon State Game Commission]: I would like to elaborate on one facet here of Dr. Collins' paper. When he speaks of racial stocks, let me point out that in my opinion what he is talking about is the various races of a single species. The spring run of fish, for example, in the Columbia has a great number of racial stocks. In other words, there are those that are going up the Collins about which the gentleman just spoke. There are those who go up the Helena, up the Fuse, and a variety of other streams that connect to the Salmon River in Idaho. You will find those fish are entering the main stem of the Columbia at different times. They have different spawning times. For instance, the Imneha River in Oregon which empties into the Snake River, slightly upstream and across from the Salmon, the fish, the spring chinook—the species is the same —are spawned out a substantial length of time before those in the Salmon River, while the spring chinook that are inhabiting the McKenzie River, a tributary to the Linan, won't be spawned out until summer and mid-September. Those of the Imneha will have spawned and died by the middle of August. The same situation applies to practically every species of salmon using that river. I might point out in the Rogue River, which is completely separate from this, we can at the present time identify seven different races of steelhead alone. There may be more.

MR. FISHER: Thank you very much for finding out your problems. I think perhaps we should move on.