EFFECTS OF WATER TEMPERATURE ON SWIMMING PERFORMANCE OF ADULT CHINOOK SALMON (SUMMARY)

by

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INTRODUCTION

It is known that swimming performance abilities of adult salmon may vary during migration. Paulik and DeLacy (1958) noted a decline in swimming capacities of sockeye measured at successive upstream points in the Columbia River which they related to effects of sexual maturity. Fishway swimming tests at Bonneville (Collins et al 1963) suggested that at this period in their migration salmon could climb extremely high ladders without becoming exhausted. In the Bonneville tests the performance ability was rated on the basis of the willingness or volitional tendency of fish to ascend the test fishways--a paced type of performance. The measures of Paulik and DeLacy were different. They evaluated the maximal or absolute abilities of fish by forcing them to swim against strong water velocities.

While such measures each apply to aspects of fish passage performance, additional information is needed to relate them. For example, do the absolute capacity measures apply directly as an index of fish passage capabilities? How may the results from the apparently tireless volitional performances observed in the tests at Bonneville be extrapolated to situations where sexual maturity is a factor? Also, how may water temperature variation pertain to these performance abilities?

To attempt to examine such relationships, tests of adult chinook swimming performances have been conducted on the lower Columbia River near Bonneville Dam. This has entailed measurements of absolute and volitional swimming performances of spring-run and fall-run fish at varied water temperatures.

MATERIALS AND METHODS

The Facility

The testing facility, installed at North Bonneville, Washington, was a self-contained recirculating hydraulic system designed especially to examine effects of water temperature variation on adult salmon swimming abilities. Actual testing components were a straight velocity flume, the same one used by Paulik and DeLacy, where absolute performances were measured (figs. 1 and 2); and a circular four-pool endless fishway, where volitional performances were evaluated (figs. 3 and 4). Each testing component could be supplied with water recirculated from either of two reservoirs maintained at different temperature levels. These also supplied the tanks in which the fish were held. The volume of each water mass was about 12,000 gallons.

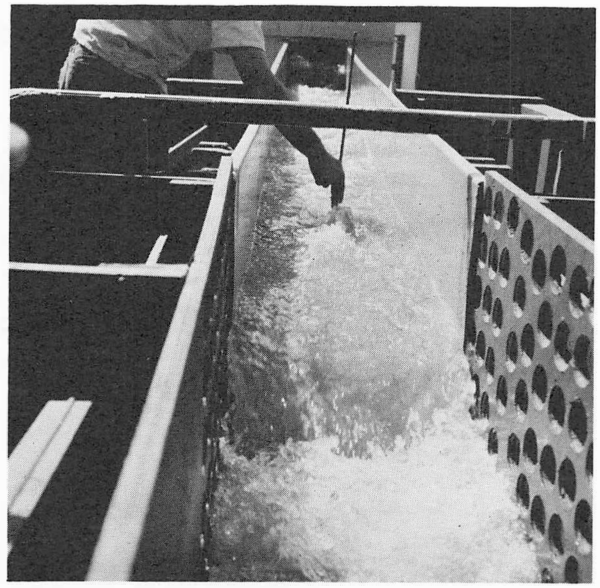

Figure 1.--View of swimming flume from the lower end. The channel is 20 feet long and 18 inches wide with a U-shaped bottom. In all testing the velocity was 7 feet per second.

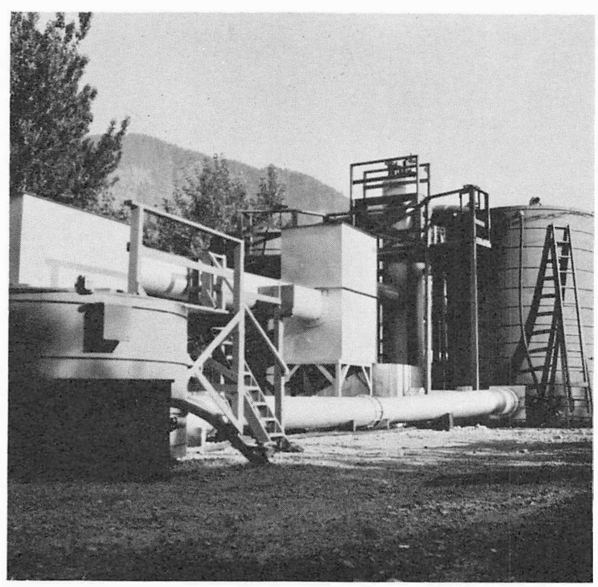

Figure 2.--Side view of test flume and related structures. One of two controlled temperature reservoirs stands at far right.

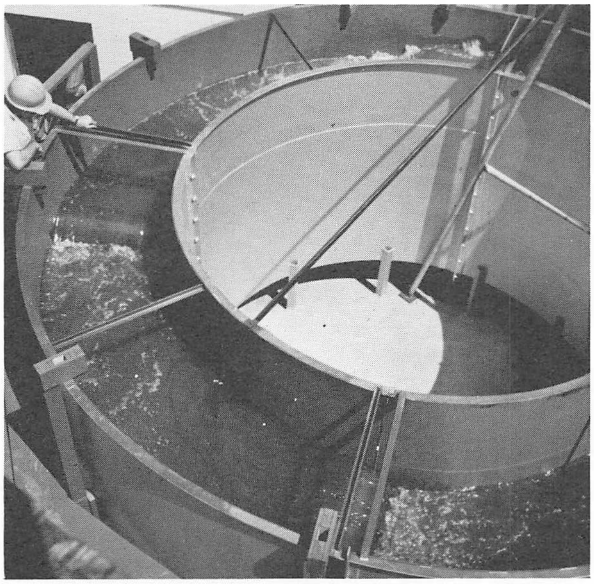

Figure 3.--Overhead view of the endless fishway swimming apparatus. Recirculating water enters at the upper right and drops counterclockwise over weirs that equally divide the 3-foot-wide circular channel into four pools, each 4 feet deep. The lowest pool, from which the water passes out, is 2 feet below the crest of the flow introduction weir.

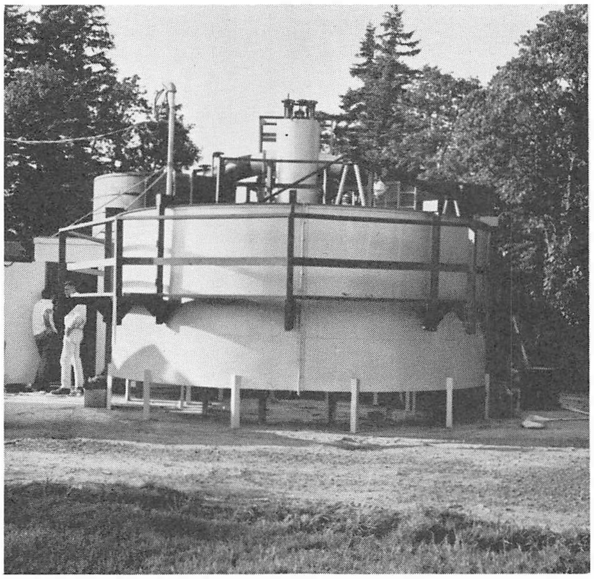

Figure 4.--Side view of circular endless fishway. Tower in center rear is standpipe used to provide constant head for water drawn from either reservoir at right and left.

Test Fish

Fish tested were spring- and fall-run chinook salmon obtained at Bonneville Dam, and a sample of male fall-run chinook from the Spring Creek hatchery upriver from Bonneville. After testing, the river fish were released at Stevenson, and the Spring Creek fish were returned to the hatchery.

Procedure

A test series consisted of successive performance trials of separate fish groups held and tested in changing or changed water temperature. During the same interval, control observations were made by conducting similar performance tests with fish held at constant temperatures--maintained equivalent to those temperatures at locations from which the groups were obtained.

Spring tests.--From April 28 through May 10, 1964, a total of 54 adult spring-run chinook, all presumably immature fish, were tested in two separate series. For each series, absolute and volitional performances were observed at the prevailing river temperature (52° F.) and in rising temperatures (52° to 64° F.).

Fall tests.--From September 14 through 28, 1963, a total of 52 fall-run chinook were tested. These fish were tested in two categories. The first tests were of fish from the river at Bonneville. While these showed secondary sexual characteristics they were not in spawning condition. Absolute and volitional performances of these fish were measured at the river temperature (69° F.) and in declining temperatures (69° F. to 52° F.).

The second series tested fish from the Spring Creek hatchery. These were all males considered surplus to the hatchery operation and mostly in spawning condition. Performances were measured at the hatchery water temperature (46° F.) and at the river temperature (69° F.).

Performance Measures

Absolute performance ratings were based on the maximal time that fish could be forced to make headway or maintain themselves against a fixed velocity. Volitional performances were scored on the number of endless fishway circuits completed in relation to the number of voluntary weir ascents. This latter value expressed performances resulting in direct passage through the fishway. The volitional performance measure differed from volitional activity, an index of general responsiveness which was determined from the total count of weir ascents, a value not necessarily related to passage through the fishway.

RESULTS AND DISCUSSION

Sample sizes were relatively small because of the capacity limits of the test facilities and the restricted seasonal interval that test fish are available. However, a summary (fig. 5) of the results offers certain tentative suggestions.

The performance capacities as measured did not appear to be related. High performances in one measurement were not necessarily reflected in another. The separation of these capacities also was indicated by the differing effects of temperature on the measured performances.

A decline in absolute performances probably related to maturity was indicated in these tests. The values for presumably immature spring-run fish were notably higher than those for the maturing fall fish. Such maturity effects were not shown, however, for fishway-type performance since the volitional performances were highest for fall fish at river temperatures with the next highest values noted for the sexually ripe hatchery fish tested at river temperatures.

Volitional activity measures indicated a pattern of responsiveness consistent with many observations of seasonal variation in behavior of chinook salmon. The spring-run fish were less active than the fall-run fish which in turn were highly active when they were in spawning condition. This did not appear to be related to temperature.

The observed effect of lowered water temperature on the volitional performance of fall-run river fish is of interest in view of thoughts of supplying cooler water to fishways in some areas where river temperatures are high. As indicated, an initial effect may be to lower the rate of progressive upstream passage.

While more field data is needed to confirm these indicated performance patterns and investigate the nature and range of temperature effects, a tentative conclusion appears to be that maturity may have less effect on fishway-type performance than water temperature changes. The limited information further suggests that mature chinook would not experience difficulty in negotiating standard fishways at routinely prevailing river temperatures.

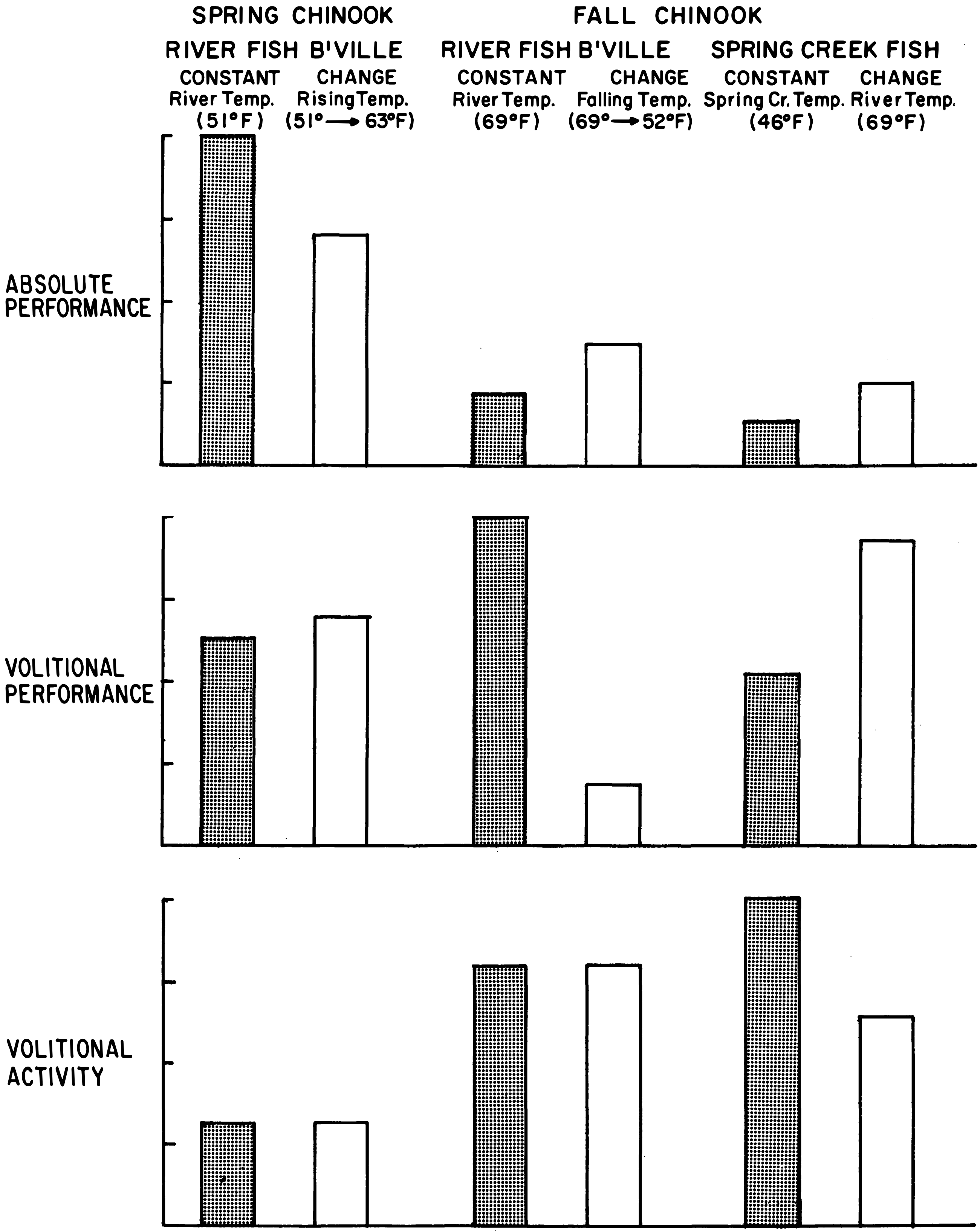

Figure 5.--Effects of water temperature on swimming performance of adult chinook. Bars depict the total measured performance in each test category. Obtained values are adjusted and shown on a common scale.

LITERATURE CITED

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1958. Changes in the swimming ability of Columbia River sockeye salmon during upstream migration. University of Washington, College of Fisheries Technical Report No. 46, 67 p.

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