RESPONSES OF JUVENILE CHINOOK SALMON TO PRESSURE CHANGES

by

Robert M. Tarrant, Jr.

FISH-PASSAGE RESEARCH PROGRAM
U.S. Bureau of Commercial Fisheries
Seattle, Washington

INTRODUCTION

Recent sampling of the gatewells at Ice Harbor Dam indicates that large numbers of juvenile salmon enter these areas of the dam during their downstream migration. It is suspected that response to pressure may be an important factor in the movement of fish into these areas as they are swept past the gatewell openings at a depth of 90 feet. In order to explore this possibility, the effects of pressure changes on vertical movement of juvenile chinook salmon (Oncorhynchus tshawytscha) were investigated.

MATERIALS AND METHODS

A hydraulic chamber (fig. 1) equipped with viewing ports and capable of withstanding pressures up to 275 pounds per square inch was employed. With this device, which has a capacity of 350 gallons of water, groups of fish could be subjected to sudden or gradual pressure changes so that behavior patterns could be observed. Fish distribution was determined by counting the fish in the lower half of the chamber and relating this to the total number of fish used in the test. Twenty counts were made to obtain the average distribution at each pressure level.

In tests of the effect of rapid pressure changes, pressure was increased from 0 to 40 pounds (equivalent to water pressure at a depth of 92 feet) in 2 minutes, and fish distribution was determined before and after the pressure increase. In tests of the effect of gradual pressure changes, pressure was increased from 0 to 7 pounds (equivalent to 16 feet) in 1-pound increments and from 0 to 40 pounds in 5-pound increments. Each of these tests lasted about an hour, and distribution was determined after each pressure increase.

Tests were also conducted to determine the rate of adaptation of juvenile chinook salmon at different pressure levels. Pressure was increased to the desired level, held there for approximately 24 hours, and then decreased slowly. Distribution was determined after each pressure change.

RESULTS AND DISCUSSION

Two tests in which the pressure was increased rapidly from 0 to 40 pounds resulted in an average change in vertical distribution of 28 percent--a rather pronounced change in view of the limited space within which the fish were able to move.

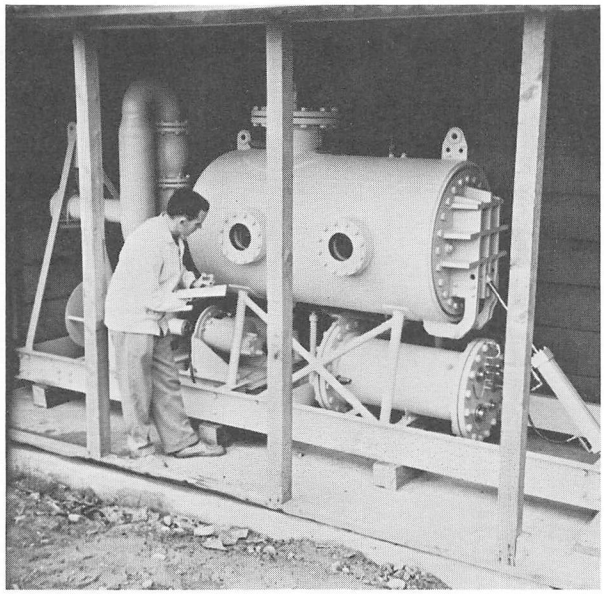

Figure 1.--Hydraulic chamber for studying the effect of pressure changes on fish.

Since the depth of the water was only 3 feet, any tendency toward upward movement was immediately checked at the roof of the chamber, resulting in exploratory movement in other directions.

Three tests were then conducted in which the pressure was increased slowly from 0 to 40 pounds in 5-pound increments (fig. 2). This also resulted in an average change in vertical distribution of 28 percent. Thus the change in vertical distribution for a 40-pound pressure increase was the same whether accomplished in 2 minutes or an hour. In these three tests the most pronounced distribution change occurred within the first 5 pounds of pressure increase.

Three tests were then run in which pressure was increased from 0 to 7 pounds in 1-pound increments (fig. 2) resulting in an average change in vertical distribution of 20 percent. In these tests a 1-pound pressure increase caused a noticeable change in fish distribution indicating pronounced sensitivity to the effects of pressure changes. Pressure sensitivity may be due to loss of hydrostatic equilibrium as determined by visual cues or due to proprioceptors within the body sensitive to contraction and expansion of the swimbladder.

Results of three adaptation tests are shown in figure 3. As pressure increased, more fish were found near the top of the chamber. When the pressure was decreased after approximately 24 hours, distribution returned to that of previous adaptation. However, this distribution now occurred at a higher pressure level. Fish held at 5 pounds (12 feet) had adapted to between 2 and 3 pounds of pressure. Fish held at 15 pounds (35 feet) and 40 pounds had adapted to between 6 and 7 pounds of pressure. This would seem to imply that rate of adaptation is a function of pressure only within certain limits. As the pressure was decreased further, the fish became extremely active, began to give off gas bubbles, and moved to the bottom of the chamber.

Results of these tests seem to indicate a high degree of sensitivity to pressure changes and a strong tendency to compensate for vertical displacement. These factors, together with a slow rate of adaptation, might well account for movement of fish into the gateslot wells as they are swept down past the openings.

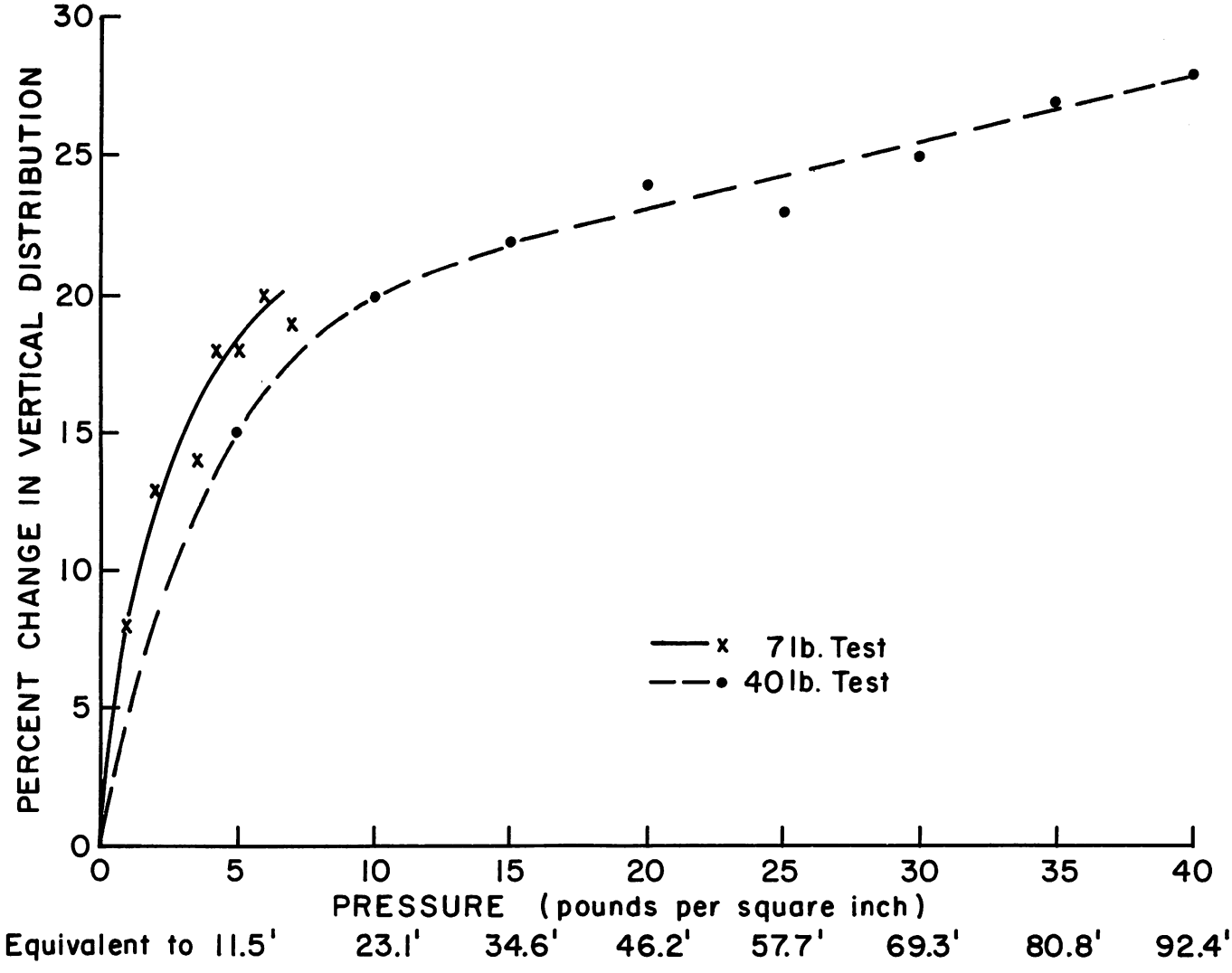

Figure 2.--Relation between vertical distribution of juvenile chinook salmon and pressure change in 3 feet of water. Each curve is based on an average of three tests, each of which lasted approximately 1 hour.

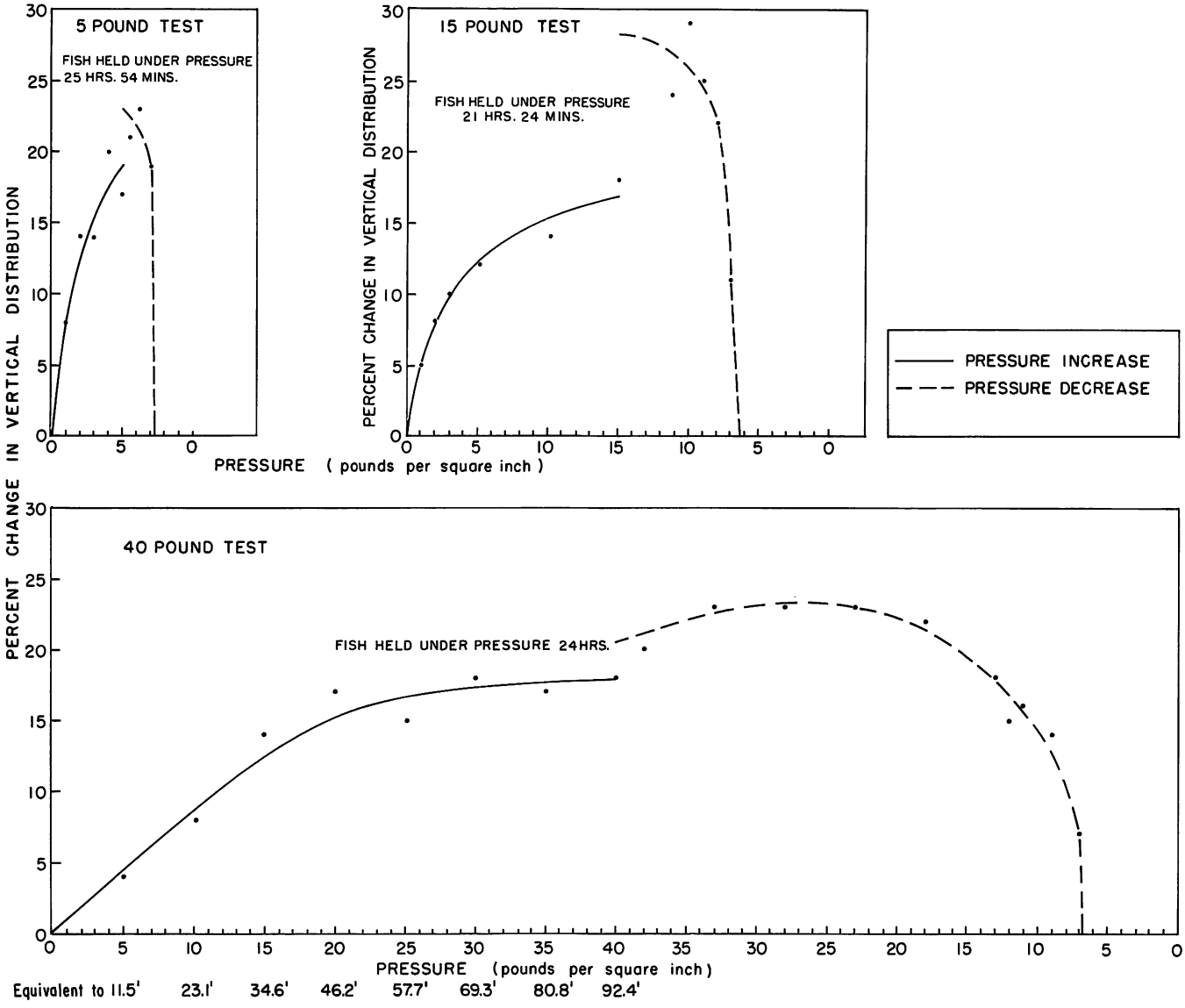

Figure 3.--Adaptation of juvenile chinook salmon to three different pressure levels. For the 5-pound test, the periods of pressure increase and decrease were approximately 1 hour each. For the 15-pound test, these periods were 1 hour and 36 minutes each. The 40-pound test pressure was reached in approximately 3 hours; the decrease required 2 hours, 12 minutes.