FINAL REPORT ON VERTICAL DISTRIBUTION OF FINGERLING SALMONIDS IN TURBINE INTAKES OF THE BONNEVILLE FIRST POWERHOUSE

This is a final report of research conducted at Bonneville Dam in the spring of 1975 under terms of U.S. Army Corps of Engineers Contract No. DACW-57-75-F-0569.

by Clifford Long

INTRODUCTION

Measurements of how fingerling salmonids are distributed within flows entering the turbine intakes of the Bonneville First Powerhouse is the first step of a research program to develop a more effective and less costly fingerling protection system for the Bonneville Second Powerhouse.[1] The overall research program includes submerged orifice studies, hydraulic model studies and studies to develop new fish-guiding methods. The dimensions and location within turbine intakes of fish-guiding methods depend upon how fish to be guided are distributed within the intake flows.

Previous measurements of the vertical distribution of fingerlings made at The Dalles Dam, McNary Dam and Ice Harbor Dam were not believed applicable to the proposed Bonneville Second Powerhouse primarily because of a difference in head (submergence of the intakes) between the dams and the presence at Bonneville of large numbers of fall chinook fingerlings, a race not found in large numbers upstream of Bonneville Dam. The existing Bonneville First Powerhouse, however, provides turbine intakes of similar design and, because of its location the same availability of fish species as the proposed Bonneville Second Powerhouse.

[1] See "Proposed Research on Fingerling Protection Facilities for the Second Powerhouse", submitted to the U.S. Army Corps of Engineers, November 19, 1974.

The study reported here measured the vertical distribution of seaward-migrating steelhead trout, coho salmon, sockeye salmon and both spring and fall races of chinook salmon in turbine intake 3-B and 5-B of the Bonneville First Powerhouse during the spring outmigration of 1975.

METHODS AND PROCEDURES

The basic equipment used to measure the vertical distribution of fingerlings within turbine intakes and the procedure of operating this equipment was detailed in the National Marine Fisheries Service proposal (op. cit.). A special net frame containing six fyke nets was lowered into the intake via the intake gatewell. The nets strained the center one-third of the flows from the ceiling of the intake to the floor. The turbine was always shut down during installation and removal of the net frame to ensure that fish were captured only at the prescribed depth for each net.

During this study, the net frame was operated in the emergency or downstream slot of the intake gatewell. The resulting opening into the gatewell upstream of the net frame was closed off with a screen to ensure that fish near the ceiling of the intake did not escape the top net by entering the gatewell. The screen was attached with a hinge to the net frame and was lifted to contact the ceiling before beginning each test. In operating position the screen served as an extension of the intake ceiling.

Tests were conducted in unit 3 and in unit 5. In unit 3, twelve successful tests were conducted between May 9 and May 30 while the unit was operating at maximum load; i.e., discharging about 14-15,000 c.f.s. Because of a generator problem, however, the adjacent unit 2 was never operated at more than two-thirds load; i.e., discharging 10-11,000 c.f.s.

Because of the possible influence of adjacent turbines, we conducted two tests in unit 3 while unit 3 and unit 4 were operated at the same load as unit 2; i.e., two-thirds of maximum load. Finally, we moved the net frame to unit 5 and conducted five tests in which units 4, 5 and 6 were all operated at maximum load. These tests were conducted from June 2 - 6.

RESULTS AND DISCUSSION

Table 1 provides the percent of fish by species caught in the two top nets (covering 29 percent of the vertical distance between the ceiling and floor of the turbine intake) in unit 3 at full and at two-thirds turbine load and in unit 5 at full turbine load. For steelhead trout, spring chinook salmon and coho salmon the percent caught in the two top nets did not differ from unit 3 to unit 5 at full turbine load. However, significantly fewer sockeye salmon and fall chinook salmon were caught in the two top nets when the load on unit 3 was reduced to two-thirds load.

Figures 1 to 5 compares the vertical distribution of fingerlings in unit 5 at Bonneville Dam with similar data obtained at The Dalles Dam and McNary Dam in 1960 and 1961, respectively. The data is presented graphically so the percent of fish traveling in any percentage of the flows (below the intake ceiling) can be readily determined.

It is obvious from the graphs that all species are more highly concentrated in the upper 29 percent of the intake flows at Bonneville Dam than at either The Dalles Dam or McNary Dam. Furthermore, the same percentage of steelhead, spring chinook, fall chinook and sockeye could be intercepted at Bonneville Dam with a guiding device projecting 6.5 feet down from the intake ceiling as one at The Dalles Dam projecting 15 feet down from the intake ceiling.

IMPLICATIONS

Results showing that fingerlings are concentrated closer to intake ceilings at Bonneville Dam than at The Dalles Dam and McNary Dam implies that pressure alone is not responsible for the tendency of fish to seek shallower depths; i.e., to swim up towards the intake ceiling as they are drawn deeper in passing through turbine intakes. At Bonneville Dam, the top net was submerged 37.5 feet below normal forebay elevation, but at The Dalles Dam and McNary Dam, the top net was submerged 65 feet and 67 feet, respectively. If pressure were solely responsible for the degree that fish concentrate near intake ceilings, then fish at Bonneville Dam should be less concentrated than fish at the other two dams.

These data imply that factors other than pressure or, in combination with pressure, are responsible for the degree of concentration of fish near intake ceilings. Apparently, the responsible stimuli are more effective at Bonneville Dam than at The Dalles Dam and McNary Dam. Laboratory studies to be proposed may shed additional light on this phenomena. A better understanding may lead to more effective and less costly fish-guiding systems.

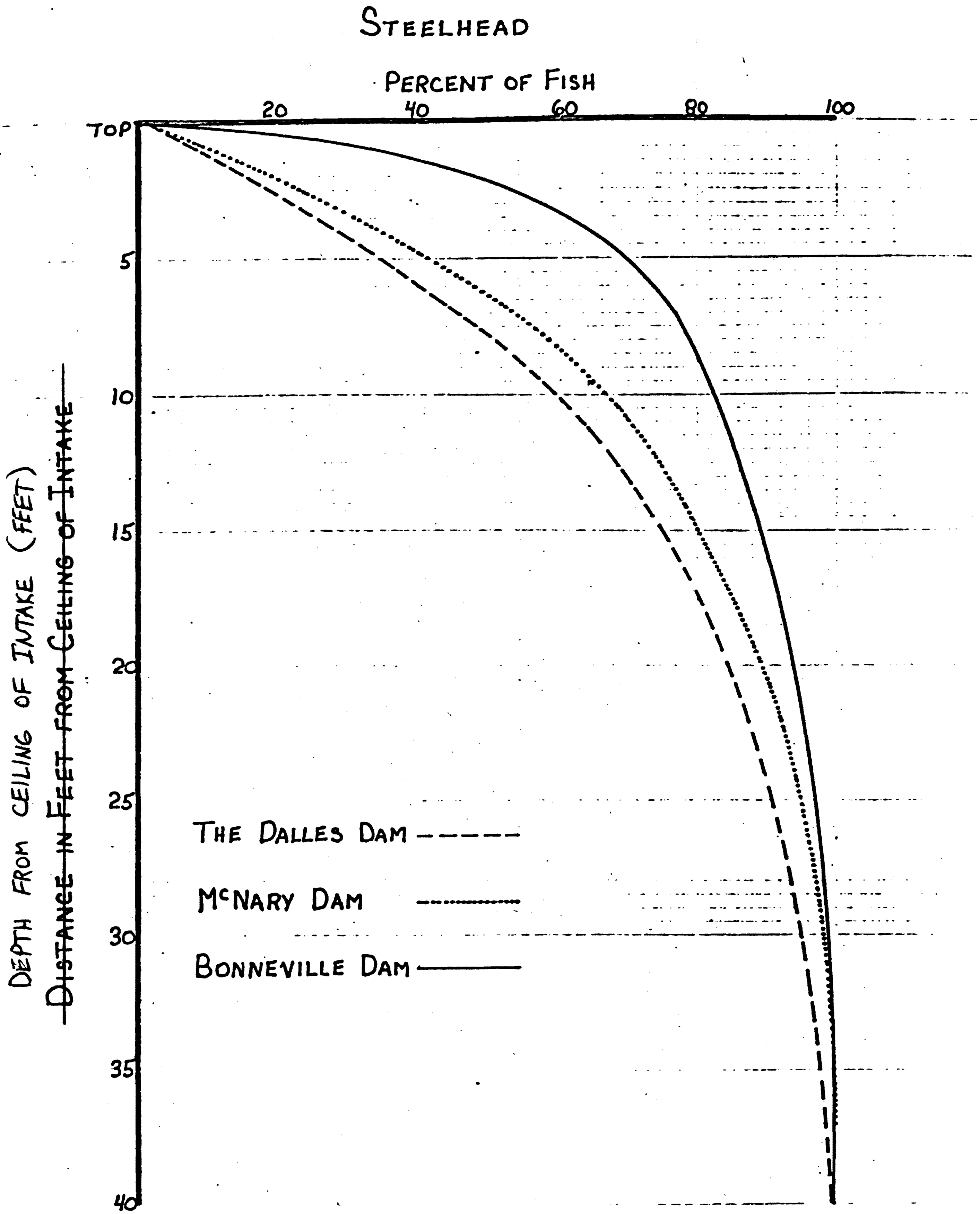

Figure 1.--Vertical distribution of steelhead trout fingerlings in turbine intakes of Bonneville Dam (1975), The Dalles, Dam (1960) and McNary Dam (1961).

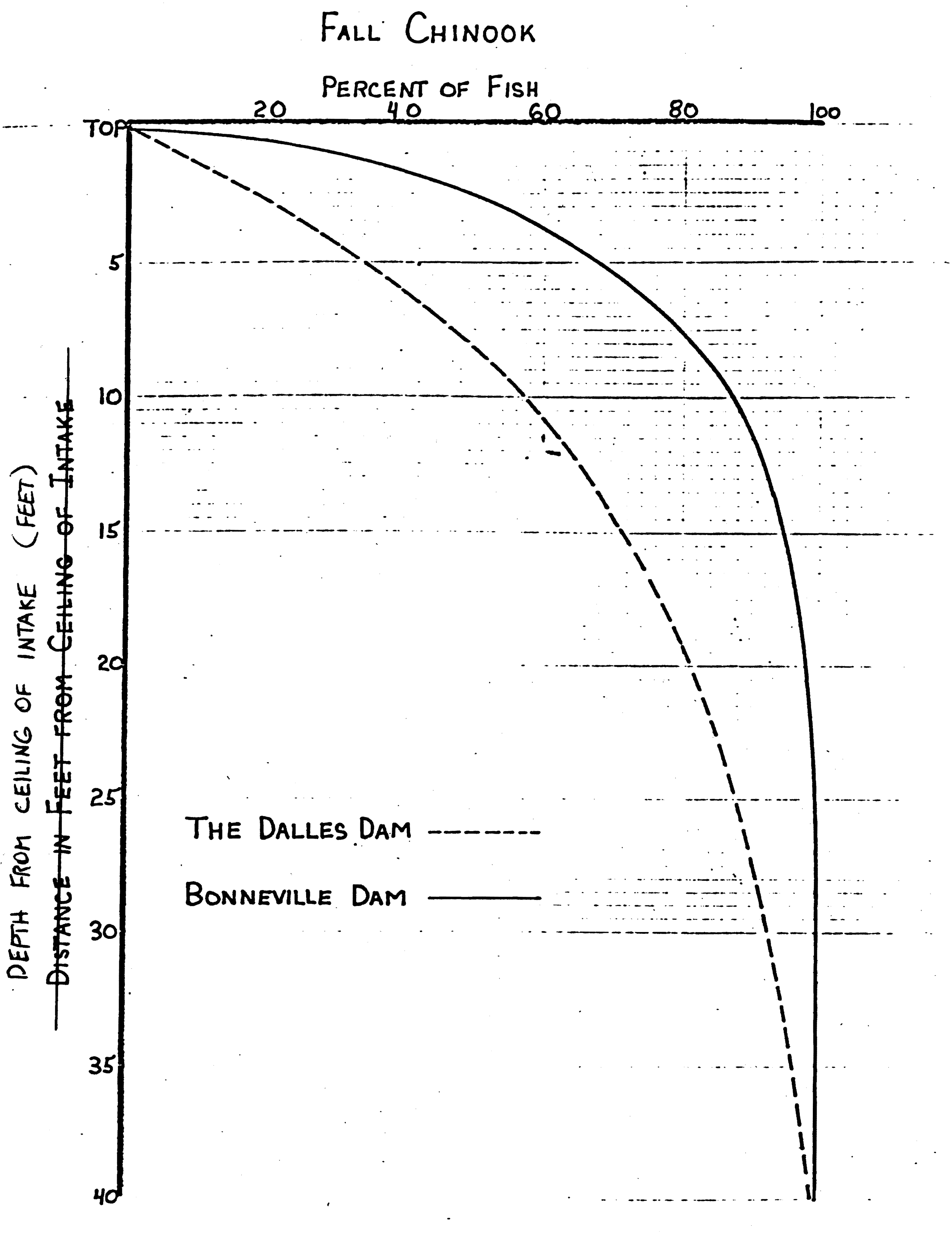

Figure 2.--Vertical distribution of fall chinook salmon fingerlings in turbine intakes of Bonneville Dam (1975) and The Dalles Dam (1960).

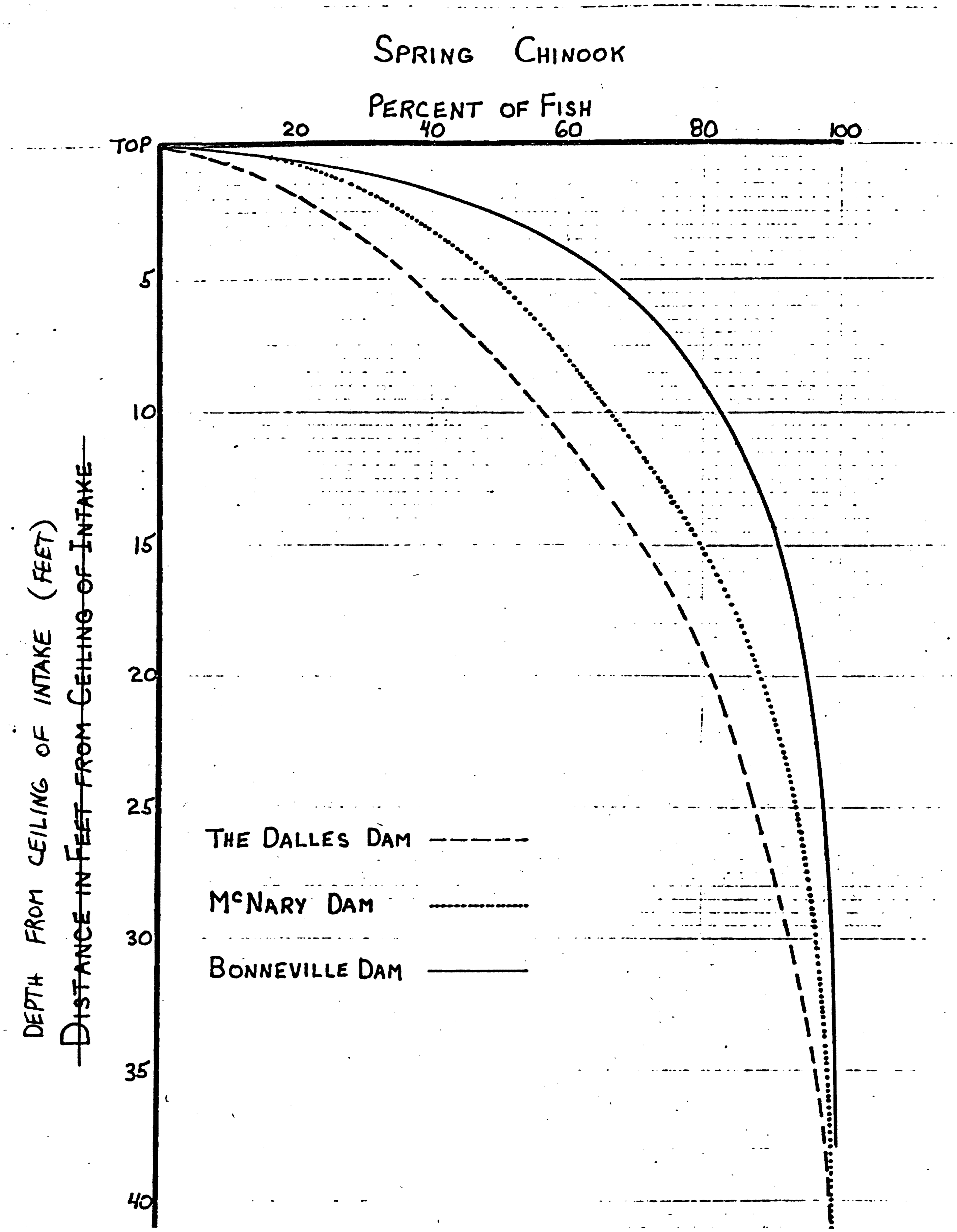

Figure 3.--Vertical distribution of spring chinook salmon fingerlings in turbine intakes at Bonneville Dam (1975), The Dalles Dam (1960) and McNary Dam (1961).

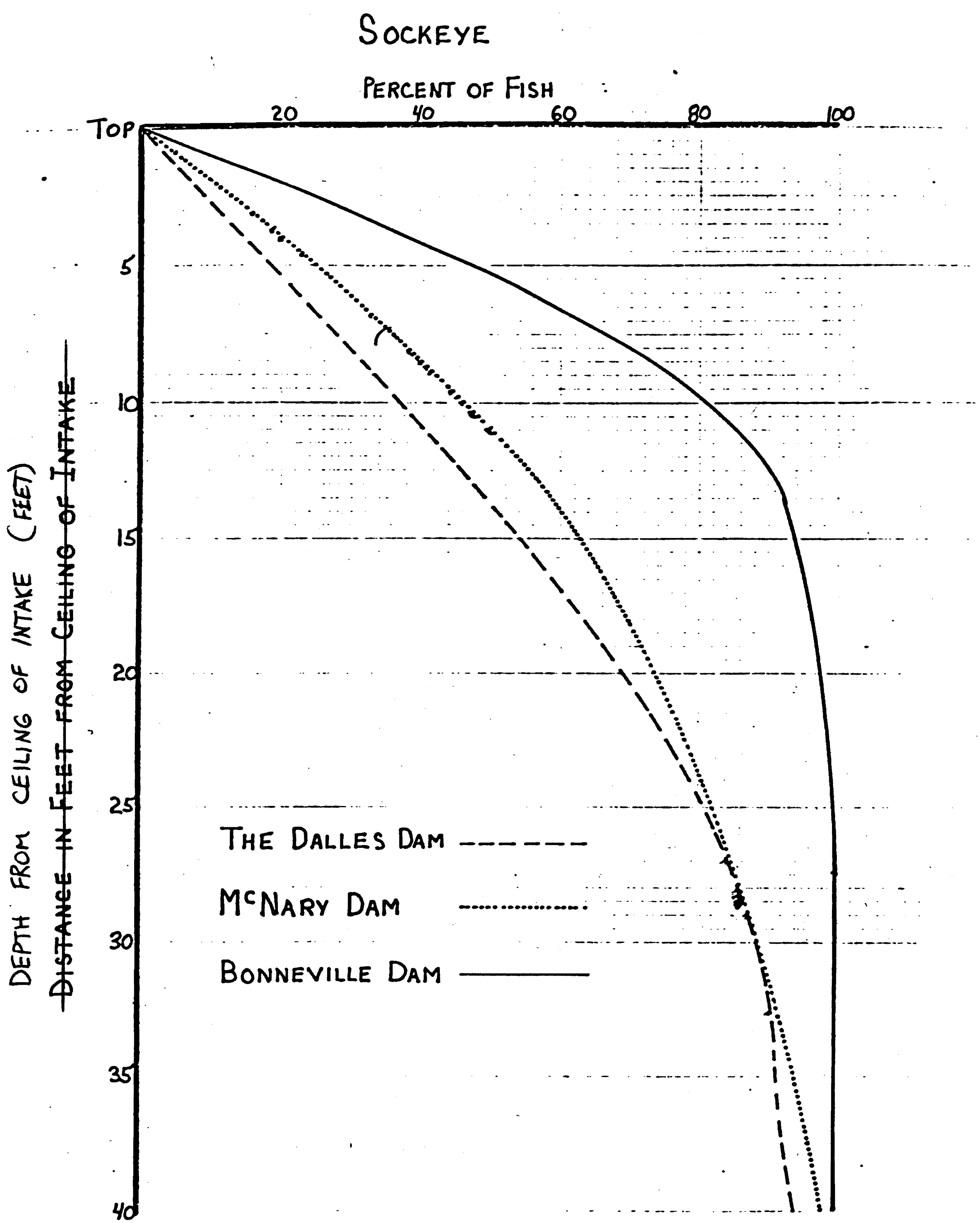

Figure 4.--Vertical distribution of sockeye salmon fingerlings in turbine intakes of Bonneville Dam (1975), The Dalles Dam (1960) and McNary Dam (1961).

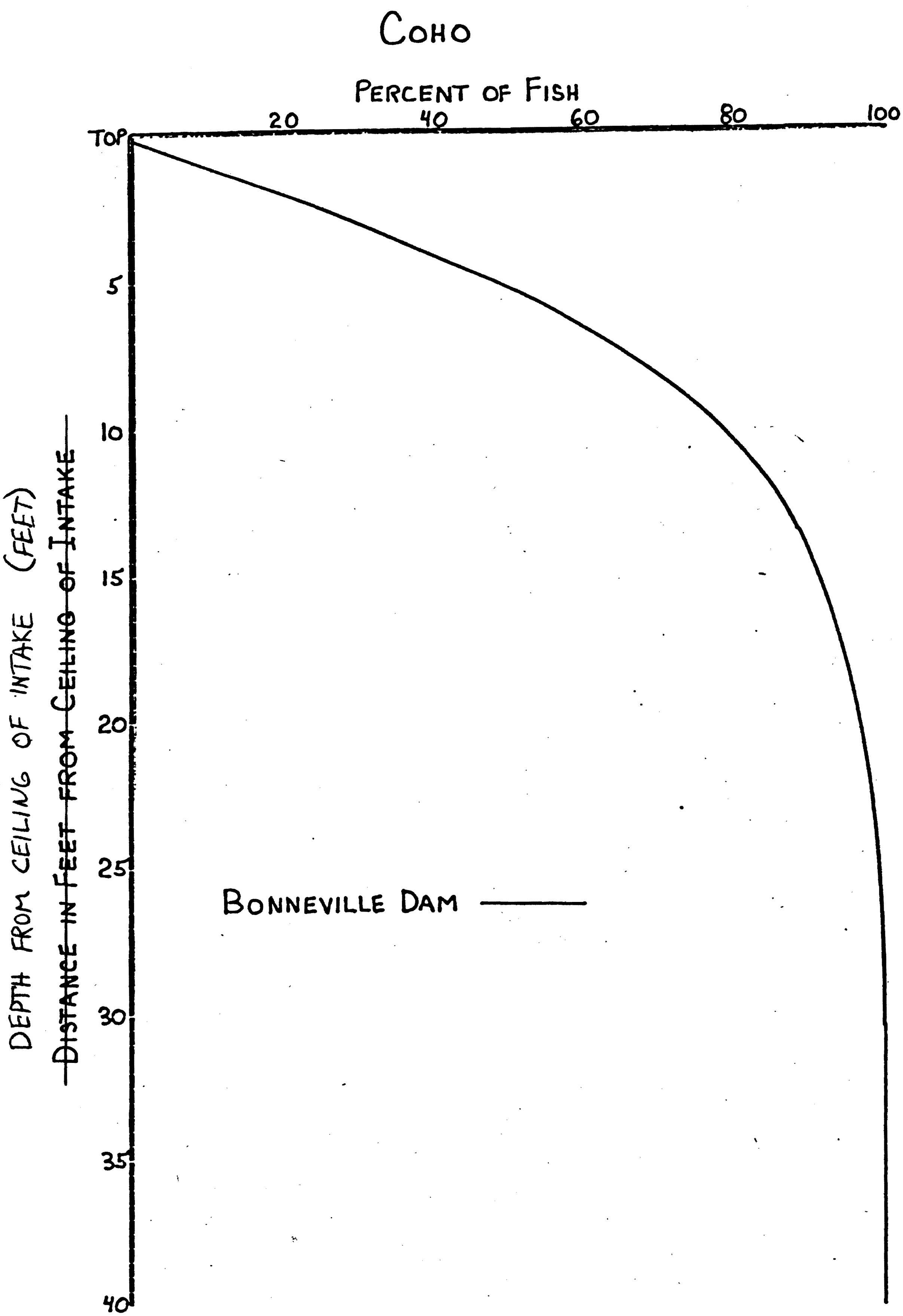

Figure 5.--Vertical distribution of coho salmon fingerlings in turbine intakes of Bonneville Dam (1975).