Abilities of trout to swim through highway culverts

by David Andrew Belford

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Seven culverts in Montana were studied from 1984 -1986 to determine conditions that allowed and prohibited the passage of rainbow trout, brown trout, cutthroat trout and brook trout. A curve was fitted to the most stringent combinations of distances and average bottom water velocities between rest sites in culverts trout swam through. This curve indicated that for distances between rest sites of 0 - 20 m, average bottom velocities of near or below 1.67 - 0.83 m/s, respectively, permitted passage. For distances of 20 - 100 m, average bottom velocities of near or below 0.83 - 0.64 m/s, respectively, permitted passage. Trout 185 - 470 mm in total length passed through culverts with these maximum conditions. No differences in swimming ability were noted among the four trout species studied in the field. Laboratory swimming stamina tests indicated that brown trout, rainbow trout and cutthroat trout had similar staminas. All three types of culvert modifications studied created conditions that permitted trout passage.

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Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 1986

APPROVAL

of a thesis submitted by

David Andrew Belford

This thesis has been read by each of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date July 26, 1986

ACKNOWLEDGEMENT

I sincerely thank the following people for help throughout this study. Dr. William Gould directed the study and assisted with the field work and preparation of the manuscript. Drs. Ray White, Lynn Irby, John Priscu and Tad Weaver critically reviewed the manuscript. Charlie Smith, Pat Dwyer and Arthur Viola at the Fish Cultural Development Center provided space and assistance at the Center. Ralph Boland and Chris Clancey, Montana Department of Fish, Wildlife and Parks, critically reviewed the study proposal and provided field assistance, respectively. Dan Gustafson provided statistical and computer assistance. Mike Hensler and other fellow students assisted me in the field. My sincere appreciation also goes to my wife, Susan, and family for encouragement throughout this study.

This study was funded by a Federal Highway Administration grant to the Montana Department of Highways (Project 8093). Special thanks are given to Les Reichelt, Paul Garrett, Donald Harriott, Stephen Kologi and Robert Garber of the above agencies for their interest and support of this study.

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ABSTRACT

Seven culverts in Montana were studied from 1984 - 1986 to determine conditions that allowed and prohibited the passage of rainbow trout, brown trout, cutthroat trout and brook trout. A curve was fitted to the most stringent combinations of distances and average bottom water velocities between rest sites in culverts trout swam through. This curve indicated that for distances between rest sites of 0 - 20 m, average bottom velocities of near or below 1.67 - 0.83 m/s, respectively, permitted passage. For distances of 20 - 100 m, average bottom velocities of near or below 0.83 - 0.64 m/s, respectively, permitted passage. Trout 185 - 470 mm in total length passed through culverts with these maximum conditions. No differences in swimming ability were noted among the four trout species studied in the field. Laboratory swimming stamina tests indicated that brown trout, rainbow trout and cutthroat trout had similar staminas. All three types of culvert modifications studied created conditions that permitted trout passage.

INTRODUCTION

In many instances, conditions permit highway management agencies to design either culverts or bridges when crossing streams. In these situations, the highway management agencies often prefer to install culverts rather than bridges because of reduced costs. In contrast, conservation agencies often prefer that bridges be used because the literature contains documentation of culverts impeding or preventing fish movements.

Culvert installations often cause high water velocities which impede or block fish movements. High velocities in culverts have been found to prevent the passage of Arctic grayling (Thymallus arcticus), longnose suckers (Catostomus catostomus), northern pike (Esox lucius) (Derksen 1980), steelhead (Salmo gairdneri), coho salmon (Onocorhynchus kisutch), chinook salmon (O. tshawytcha) (Kay and Lewis 1970) and cutthroat trout (S. clarki) (Huston 1964). Higher velocities can develop in culverts than in natural streams because culverts have lower roughness coefficients or steeper slopes. Agencies have tried to mitigate this passage problem by installing velocity reducing structures in some culverts. Fish passage may also be prohibited because of high velocities in adjacent stream sections caused by culvert hydraulics which can prevent fish from either entering or leaving the culverts (Evans and Johnston 1977).

Oversized culverts or culverts with steep gradients have produced shallow water conditions which can block fish passage (Bryant 1981). Shallow water can block fish movements because it reduces the fish's swimming ability. (Webb 1975). Evans and Johnston (1977) have recommended that minimum water depths for passage in culverts be 15 and 30 centimeters (cm) for resident trout and anadromous salmonids, respectively.

Elevated culvert outlets also can prevent fish passage. Evans and Johnston (1977) recommended that single jumps not exceed 30 cm in height for resident trout and 61-91 cm for anadromous salmonids. A jumping pool depth of 1.25 times the jump height is also recommended for these situations (Gebhards and Fisher 1972).

Light levels within culverts were once thought to influence fish passage (Metsker 1970). However, it is now generally regarded as an insignificant factor (Bell 1973; Lauman 1976).

The study of fish passage through culverts or steep pass fishways has largely focused on the abilities of anadromous salmonids (Gauley 1960, 1967; Kay and Lewis 1970; Slatick 1971). It has been assumed that anadromous salmonids have greater passage abilities than nonanadromous salmonids, but the actual capabilities of the latter have largely been unmeasured.

The goal of this study was to relate the physical conditions in and around selected highway culverts in Montana to salmonid passage. The specific objectives were to measure the velocities, distances between rest sites and water depths in culverts and determine if the brown trout (_S. trutta_), rainbow trout (_S. gairdneri_), brook trout (_Salvelinus frontinalis_) and/or cutthroat trout present could pass through them. In addition, evaluations of the effectiveness of the fish passage stuctures present in three culverts and the relative swimming abilities of brown trout, rainbow trout and cutthroat trout were made. The findings of this study can be used to help determine if planned and existing highway culverts will prevent or allow nonanadromous salmonid passage.

DISCRIPTION OF STUDY AREAS

Culverts at five sites in Montana were chosen for study (Figure 1). The characteristics of the seven culverts at these sites havebeen given in Table 1. Cedar Creek, tributary to the Yellowstone River, was located in Park County approximately 44 air kilometers (km) south of Livingston. It flowed under U.S. Highway 89 through two culverts lying side by side.

Discharges in Cedar Creek were estimated to have been 0.02 - 1.22 cubic meters per second (m^3/s) during the study periods. The creek has resident brown trout, cutthroat trout and brook trout. It was also a spawning site for migrating cutthroat trout from the Yellowstone River.

The north culvert was fitted with a ladder - like structure on the bottom. The ladder rungs were spaced at mean (range) distances of 1.22 m (1.13 - 1.45 m) apart and held bedload which provided rest sites for trout. The structure was approximately 1.1 m wide and extended the full length of the culvert. The south culvert contained no structures. Prior to the installation of the ladder both culverts blocked migratory cutthroat trout movement (Berg 1975).