Elements of Fish Passage through Culverts: Need for Practical Assessment for Replacement

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Problem Statement

Restoration of fish passage through culverts is becoming a key component of road maintenance plans required of forest landowners in Washington. The Forests and Fish Report (USFWS et al. 1999) is the basis for changes in the states forest practice rules to address salmonid Endangered Species Act issues. The report states that one policy objective for the management of forest roads will be "… to maintain or provide passage for fish in all life stages…". To achieve these policy objectives, "..the rules and Forest Practice Board Manual will be amended to provide for….removing artificial barriers to passage of fish at all life stages." Repair or maintenance work to improve fish passage is listed as a priority action for implementation of the plans under revised state forest practice rules.

Inventories of culverts in Washington have revealed that the majority of culverts situated along forest road networks are technically considered barriers according to Washington Administrative Code passage criteria. The Washington Administrative Code 220-110-770 (Water Crossing Structures) provides specific guidelines for water crossing structures to ensure free and unimpeded passage for adult and juvenile fishes in order to preserve access to spawning and rearing habitat. It includes fish passage design criteria consisting of maximum water velocity, maximum hydraulic drop, and minimum flow depths, for all crossing structures. These criteria are used as the technical definition of a fish passage barrier in the regulatory arena and they form the basis for fish passage design. Some type of barrier is assumed to be present when these criteria are not achieved.

It is recognized that fish passage through artificial structures cannot practically be provided at all flows. In many situations, assumptions are made to define the period of year during which fish passage is required, based upon the species that are expected to inhabit the stream (i.e. spawning runs of adult coho in the late fall or upstream redistribution of juvenile salmon from overwintering mainstem habitat). A high flow design discharge is selected to be the upper limit of the range through which upstream fish passage criteria are satisfied. WAC 220-110-770 requires that the high flow design discharge be the flow that is not exceeded more than 10 percent of the time during the months of migration. If, at high flow design discharge, the culvert velocities are less than or equal to the allowable velocity 90 percent of the time, the WAC criteria is met. If not, the culvert is considered a barrier.

Many culverts present only a temporary, or "flow-dependent", barrier to fish passage or are barriers to juvenile and resident fish only. These temporary and partial barriers are omnipresent because of the preponderance of culverts that exceed WAC maximum velocity criteria at the high flow design discharge.

Barrier determinations made by physical and hydraulic measurements, as described in the Washington Administrative Code, may not accurately represent the influence a culvert has on fish movement. In order to document the actual effect of a culvert on fish movement it is necessary to collect information on the behavior of the fish in response to the culvert.

Some culverts that are determined as barriers based on WAC criteria are not barriers to upstream movement during most flows. In some situations, culverts are expected to be impassable for only brief periods based on hydraulic conditions. The significance of such barriers on fish movement in field situations has not been thoroughly investigated, especially where the oc-

currence and timing of fish movement is poorly understood. Also, there are gaps in knowledge about the movement patterns of various salmonid species and life history stages (particularly of resident and juvenile anadromous salmonids) in small stream channels. It is known that the volitional (voluntary) movement of fish can vary greatly among species, lifestages, habitats, seasons, and years (Gowan et al. 1994, Kahler and Quinn 1998).

Considering the high cost of culvert retrofits, forest managers and landowners recognize the need to identify culverts that have the greatest influence on fish movement in order to prioritize the order in which "fixes" are made. Furthermore, once culverts have been brought up to standards, managers need a means to verify the effectiveness of various culvert designs in maintaining or restoring fish passage.

Suggested Study Approach

The TFW Monitoring Program provides a monitoring approach and procedures guide to evaluate the effectiveness of culverts in providing for upstream passage of salmonids (Cupp et al. 1999). The passage validation component of the study plan proposes methods to investigate to what extent fish movement occurs in different types of stream channels and how culverts actually affect fish movement in a variety of situations. Procedures to investigate the influence of culverts on movement of both adult and juvenile resident and anadromous fish are provided.

The study plan provides monitoring questions / hypotheses, sampling methods and an approach for hypothesis testing. Questions to be answered and hypotheses to be tested address 1) volitional upstream movement of fish, 2) culvert influence on upstream and downstream fish movement, and 3) the correspondence between fish movement and culvert barrier status based on physical and hydraulic features. Measures of fish movement to be tested in the hypothesis evaluation, such as proportional daily movement and fish passage efficiency are described. The study incorporates comparison of fish movement measures across natural reaches with movement through culverts.

In order to effectively investigate the influence of culverts on fish movement, the study plan attempts to control for several key factors that may influence fish movement independent of the culvert. A stratified sampling design is used to group the factors that are predicted to influence fish movement. The basic unit for grouping sites (site situations) is based on a combination of position in the drainage network, channel gradient class, ecoregion, and life-history forms present in the watershed. Position in the drainage network accounts for species and potential for certain life history forms to inhabit a given site. Channel gradient class serves to control for the variety of habitat conditions that may influence fish movement during certain seasons and flow conditions. Ecoregion classification effectively separate the forest lands into climatic zones which influence stream temperature regimes and run-off patterns, which in turn may influence fish movement. These groups are further categorized based on the presence of stream crossing structures and their barrier status.

Practical Considerations

I envision this study program being established as a regional, watershed-based monitoring program conducted by various TFW Cooperators and coordinated by TFW CMER and the Monitoring Advisory Group. A coordinated monitoring plan will decrease logistical and personnel constraints and enhance understanding of fish movement and passage needs in a variety of watershed settings in different regions of the state. Ideally, the study period should cover more than one year at each study site, and cover a range of flows during the known migration season. Effort should also be allocated to document conditions on a seasonal basis (or, alternatively, during or following specific flow conditions).

Evaluation of fish passage by site-situation category and structure conditions, combined with culvert inventory procedures, will simplify the task of targeting specific sites where there is a high likelihood for fish to move, culverts that inhibit passage are common, and the potential for watershed-scale biological impacts from passage inhibition is greatest. Analogously, this information will help managers realize which combinations are least likely to cause biological impacts, and where further detailed efforts may not be warranted. Depending upon relationships discovered, this analysis may form a basis for refinement of road restoration and maintenance needs.

References

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