Fish Benefits Workbook: Current Applications and Future Development

Mairin Deith, Eric Parkinson, Tom Porteus, Roberto Licandeo, Oliver Murray, Aaron Greenberg, and Murdoch McAllister
The University of British Columbia, Vancouver, Canada
m.deith@oceans.ubc.ca

To help inform proposed improvements to downstream fish passage of juvenile spring Chinook salmon and winter steelhead (*Oncorhynchus tshawytscha* and *O. mykiss*), the Fish Benefit Workbook (FBW) was created in 2014 by the Portland District U.S. Army Corps of Engineers with input from National Oceanic and Atmospheric Administration Fisheries, Oregon Department of Fish and Wildlife, and other agencies. This Excel spreadsheet- and Visual Basic-based workbook models the impacts of changes to water operations and fish passage structures on rates of juvenile fish passage and survival. Designed with the goal of ranking plausible alternative operation and structural changes to 13dams, estimated dam survival and passage efficiency rates from FBW comprise key components of the UBC Team's life cycle models (LCMs). As part of our work towards building LCMs for the Willamette River Basin, we translated FBW into the R statistical programming language (r-project.org) to allow for flexible use and continued development.

The purpose of the conversion to R is two-fold: (1) to allow better integration within LCMs, and (2) to better incorporate and propagate parameter uncertainties within the FBW model and propagate those uncertainties to estimated survival and passage outputs. This translation also allows for further development of FBW to address remaining limitations of the model. The objectives of this talk are to explain (1) the intended use of FBW, including data inputs and modeled processes; (2) limitations in FBW that can be addressed in the R-based framework; and (3) future steps that allow for more transparent ranking of dam passage and operation alternatives.

Objective 1. FBW Operation

FBW models fish passage through each of eight high-head dams in the Willamette River Basin with the goal of informing proposed changes to operational and structural fish passage improvements. It is informed by two main components. First, a reservoir simulation model, RES-SIM, models flow through each dam under different dam operation and structure scenarios. Second, dam-specific run timing information, survival rate estimates, and other parameters are used to estimate what routes juvenile fish will use when passing the dam and their survival through those routes. This second set of parameters was generated from a combination of published and gray literature, and from data gathered during a workshop with the Portland District, U.S. Army Corps of Engineers and agency partners.

Objective 2. Current limitations to the FBW model

The current version of FBW has some shortcomings that limit its applicability. For example, site- and project-specific data are limited, even for current conditions; as such, many parameters were taken from other Willamette Valley Projects or professional opinion. At the same time, RES-SIM only models daily flow patterns although dam operation changes occur hourly. Finally, among the most serious limitation is FBW's inability to express uncertainty in input parameters or outputs. FBW produces dam passage efficiency (DPE) and dam passage survival rate (DPS) rate estimates for several dam structural and operational modifications for which no previous experience exists on a given dam. Expert judgment and studies on similar systems were applied to formulate parameter values for the modelled processes. Yet, FBW does not produce measures of uncertainty in the outputted DPE and DPS. Instead, processes within the FBW model use point estimates or functions of flow. As a result, uncertainty in input parameters is not propagated to FBW's estimates of project survival, rendering such outputs more precise and potentially more or less optimistic than what would be observed if operational or structural fish passage improvements were implemented.

Objective 3. Future development of FBW

Parameterization of FBW can benefit greatly by more in-situ data collection and better understanding of fish behavior at high head dams. While these issues can be addressed within the spreadsheet implementation of FBW, translation to R offers far more flexibility in terms of expression of uncertainty. Even when varying key parameters within the ranges observed in site-specific data, project survival can vary as much as 10% or more (Figure 1). Capturing and reporting such variation and uncertainty is vital to understanding the full range of potential survival rates that might be realized under alternative dam passage operations and structures.

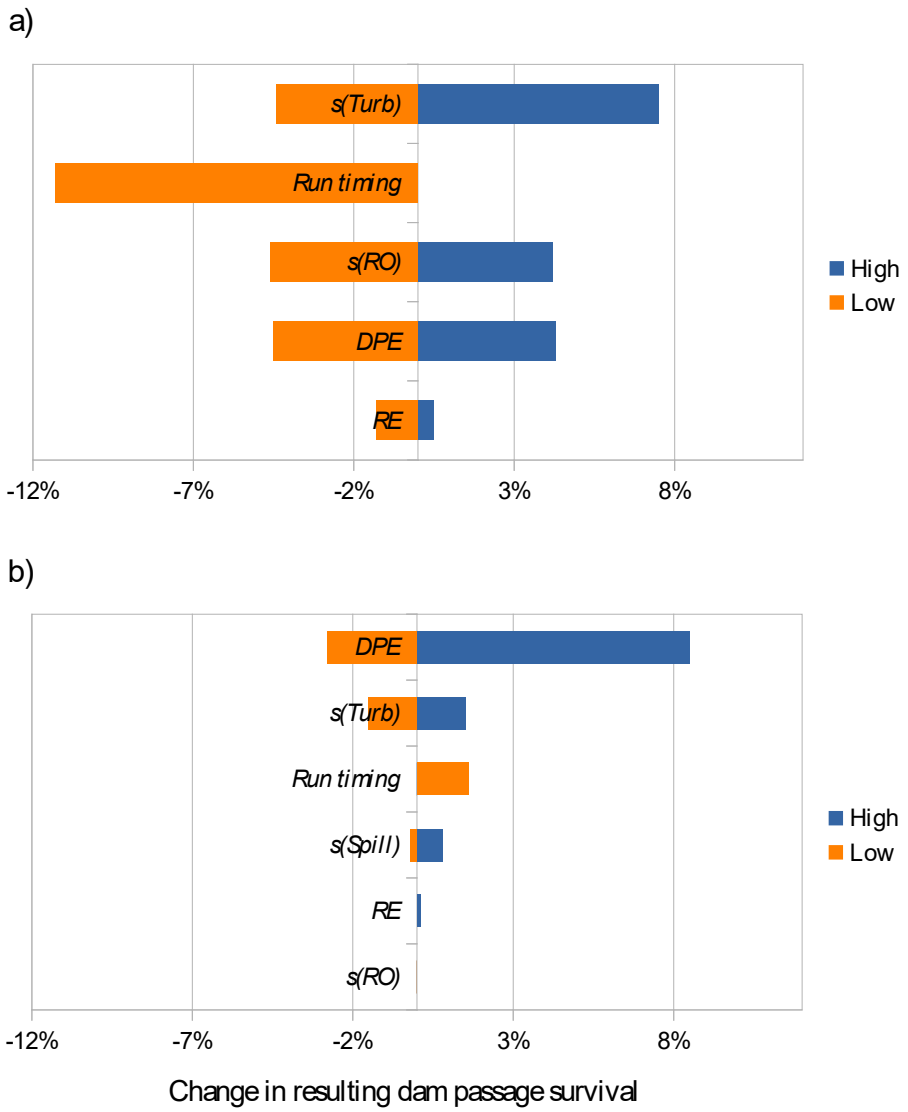

Figure 1. Sensitivity of FBW project survival estimates to high and low parameter values for several key FBW inputs: run timing, survival through the regulating outlets, turbines, and spillway (*s(RO)*, *s(Turb)*, and *s(Spill)*, respectively), dam passage efficiency (*DPE*), and route effectiveness (*RE*). High and low alternative inputs are considered realistic "bookends" of available data for each of Cougar Dam (panel a) and Detroit Dam (panel b). The vertical axis represents baseline survival estimates from an FBW run parameterized with recommended values. Sensitivity results from Tables 2-3 of Alden (2014).