PERFORMANCE MEASURE INFORMATION SHEET #8

MCA-REV PROPORTION OF FISH POPULATION ENTRAINED

Objective / Location	Performance Measure	Units	Description	MSIC
Fish/ Mica and Revelstoke Facilities	Proportion of fish population entrained	%	Proportion of fish population entrained for each species' life history for kokanee, bull trout, burbot at Mica, and kokanee at Revelstoke	10%

Description

Fish entrainment is the process whereby fish upstream of flow management structures are swept downstream as a function of operations and/or fish behaviour. Fish entrainment can have impacts on upstream populations and can influence downstream populations through species introduction, supplementation or fish food. Fish entrainment in the Columbia Basin was identified as a significant issue during the Columbia Water Use Plan (WUP) process, and the issue was deferred to BC Hydro's Fish Entrainment Strategy (BC Hydro 2006).

As a result of commitments made in the WUP process, the Revelstoke Unit 5 Project and the BCH-DFO Alternative Measures Agreement, the Strategy was implemented and the MCA-REV Fish Entrainment Strategy Action Plan (MCA-REV FESTC 2009) was initiated. The Action Plan process employed a Structured Decision Making (SDM) approach that elicited a trade-off between different interests affected by entrainment at the Revelstoke and Mica facilities. The approach required the development of several performance measures (PMs) to evaluate different alternatives, including "proportion of fish population entrained".

Performance Measure

The "proportion of fish population entrained" PM describes the number of fish from the reservoir population entrained through the regulating facility as a proportion of the population in the reservoir. Since we do not know the instantaneous population levels in either reservoir at any one time, this metric provides a quantitative output independent of population sizes. The PM model is theoretical, but is based on strong habitat, hydraulic response and flow routing models that were approved by the MCA-REV Fish Entrainment Strategy Technical Committee (FESTC):

- Habitat model: habitat use for each species and life history stage was delineated between stream, pelagic and littoral use. Time of day and time of year (season) were considered to help integrate effects of within-day operational changes. Information was provided by Water License Requirements (WLR) program studies, compensation program initiatives, general habitat use information and professional opinion.
- Hydraulic response model: a computational fluid dynamics (CFD) model was created for a range of reservoir elevations and operations at each facility to characterize typical operations. These models described average velocities for the entire width at a variety of depths in front of the dam. The result is an estimate of "risky" volumes at each depth in relation to operations. Fish deemed to be using the volume from the habitat model, are assumed to be entrained.
- Flow routing model: BC Hydro developed a generation optimization model (GOM) to predict operations at Mica-Revelstoke-Hugh Keenleyside under various MCA-REV project upgrade stages. The model outputs 2-hr flows for the entire facility, including

Arrow Lakes Hydro (ALH) generation and HLK releases. All other release attributes (e.g., unit or outlet specific discharges) are defined by generation operating orders for the respective facilities.

The modeling concluded that, for the operating alternatives evaluated for the Action Plan, kokanee were at a moderate-high risk of entrainment from Revelstoke, and that kokanee, bull trout and burbot were a low-moderate risk of entrainment from Mica. The Action Planning process identified several uncertainties with respect to entrainment and population responses. A Detailed Assessment Program (DAP) has been implemented to address uncertainties and develop a compensation-mitigation package as warranted by DAP results. The DAP includes multi-year monitoring programs to assess entrainment rates of kokanee at Revelstoke and burbot and bull trout at Mica; the results will be used to recalibrate the entrainment model.

For the NTS review, the model assumptions were re-evaluated, including updating thermocline measurements and incorporating the four NTS scenarios. The species groups highlighted in the MCA-REV Action Plan (Mica: kokanee, bull trout and burbot; Revelstoke: kokanee) are presented here. Modeling was completed for all species and the results are available on request.

Calculations

The following steps are taken in calculating the “proportion of fish population entrained” for each species’ life history for each 2-hour time step, and for each depth bin from surface to bottom:

1. Hydraulic response volumes for the respective depth bin and operating scenario are interpolated from existing models.
2. Population index (0-1), Habitat use (0-1), distribution (0-1) and avoidance factors (0-1) for the species life history stage being evaluated are combined for each depth bin’s risky volume.
3. The “weighted volumes” are added across the depth range and divided by the total upstream volume to describe the proportion of population entrained in the 2-hour event.
4. The 2-hour entrainment is subtracted from the upstream population, which then becomes the re-calculated population index.
5. For the proceeding time steps, the above steps are re-calculated using the update population index numbers as the population base from which fish are entrained.

Key Assumptions and Uncertainties

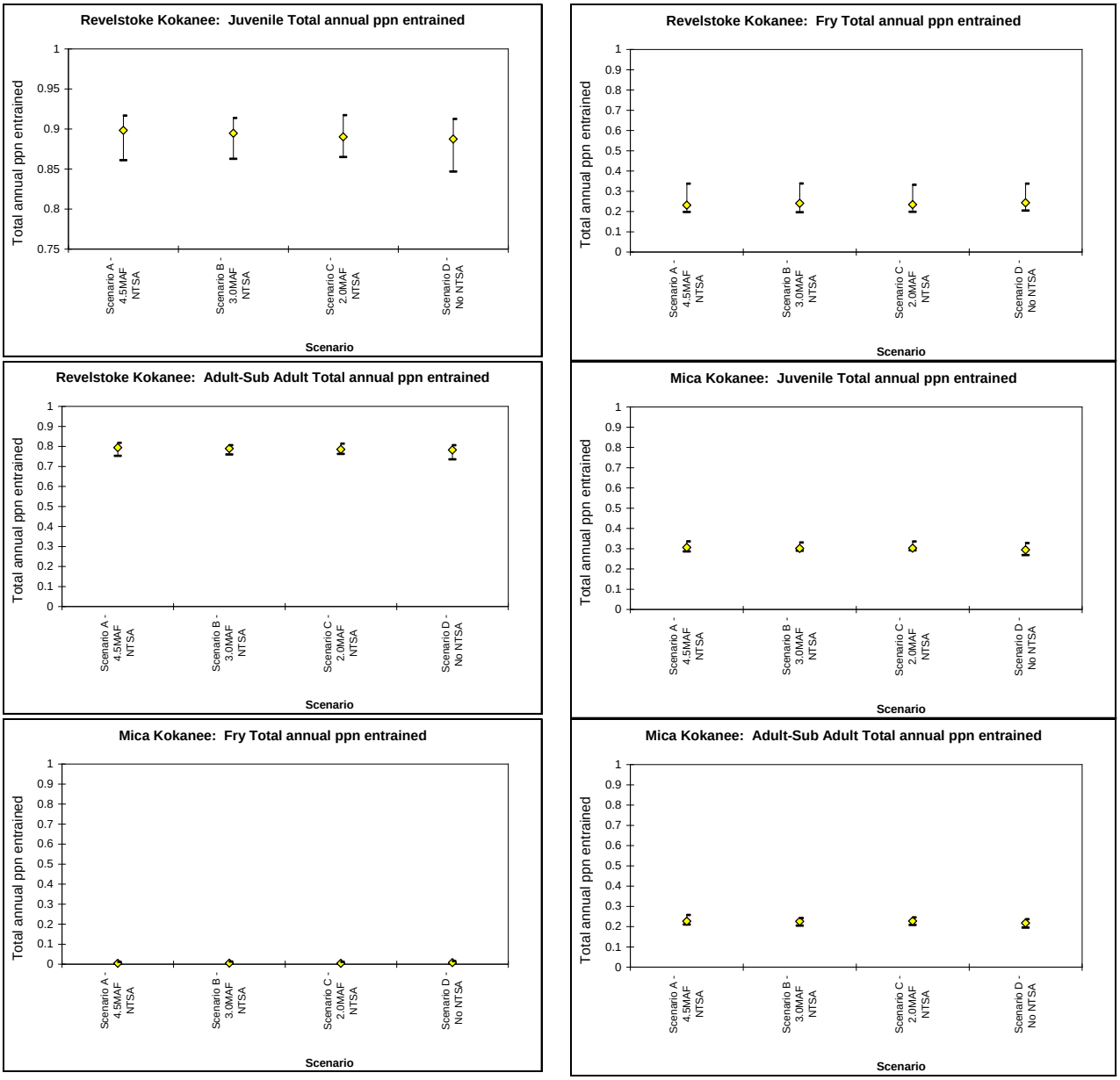
- Each scenario is simulated using the same set of system constraints, input assumptions (e.g., load forecasts) and historic basin inflows (1940 – 2000).
- Assumes life history timing does not vary from year to year either naturally or as a function of reservoir elevations and inflows.
- Assumes that fish are passively distributed in the reservoir based on observations in WLR and FWCP studies – the result is that fish entrained from risky volumes are replaced at the same density (proportional to the upstream population).
- Avoidance factors and habitat use assumptions are being evaluated in the Detailed Assessment Phase of the MCA-REV Fish Entrainment Strategy Action Plan – see MCA-REV FESTC (2009) for more details.

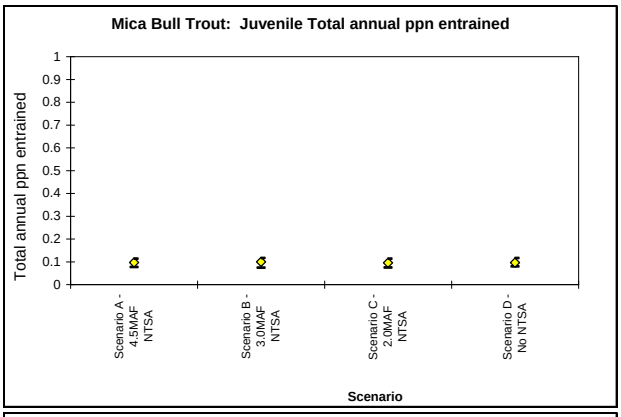
Results

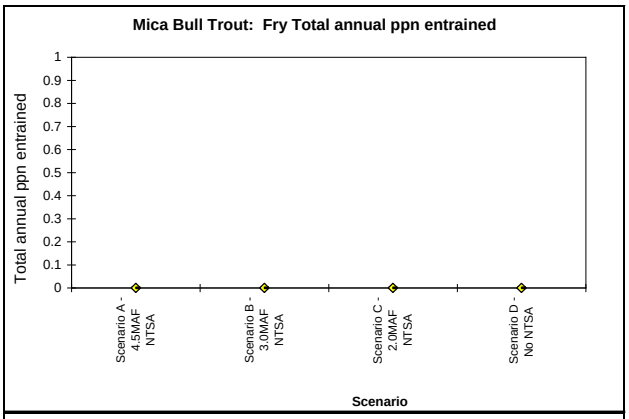
For each of the NTS scenarios, results for proportion of fish population entrained are presented for the full-year analysis for each life history of interest. As stated above, the modeling focussed on kokanee for the Revelstoke facility, and kokanee, bull trout and burbot for the Mica facility.

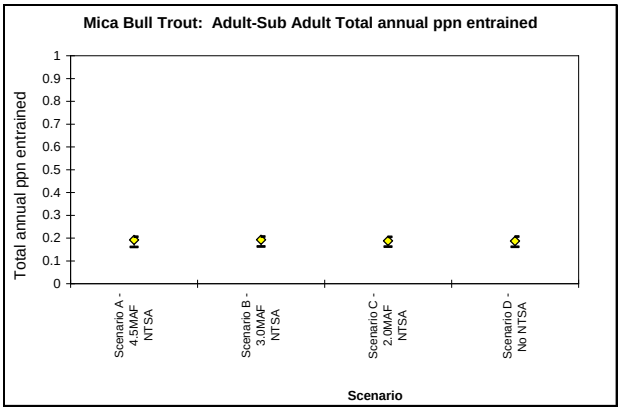
The results show a lack of variation across the scenarios. The only result of note relates to entrainment for Revelstoke kokanee juveniles, which is highest in winter (not shown) and which drives the total annual results shown here. Lower entrainment rates are observed within the 10th and 90th percentile values in Scenario D (no NTSA) but the median value (0.88) is not different from the "with NTS" scenarios (0.89-0.90).

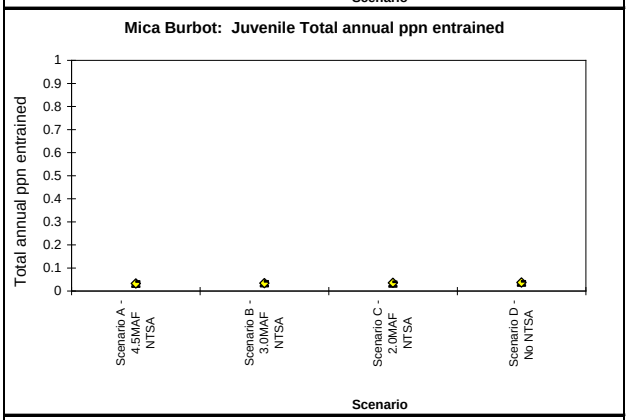
Figure 1. Proportion of Fish Entrained, Mica and Revelstoke Facilities - Results for all NTS scenarios

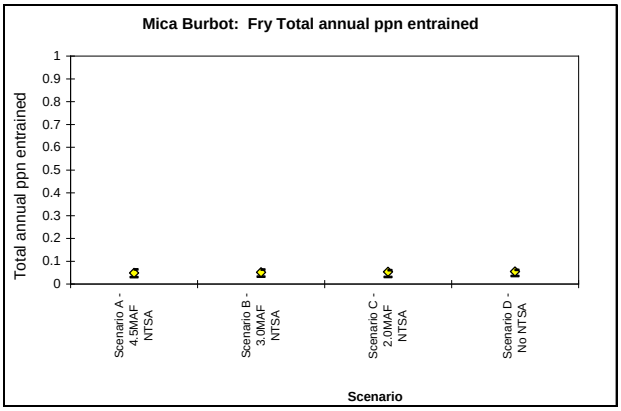


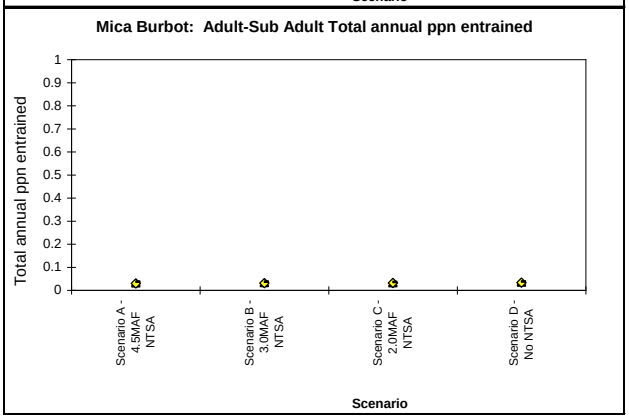












References

BC Hydro. 2006. BC Hydro Fish Entrainment Strategy. Prepared for BC Hydro Generation Operations, Burnaby, BC.

MCA-REV FESTC. 2009. Mica-Revelstoke Fish Entrainment Strategy Action Plan. Prepared by the Fish Entrainment Strategy Technical Committee for the Revelstoke Unit 5 Project, Revelstoke BC.