PERFORMANCE MEASURE INFORMATION SHEET #29

LOWER COLUMBIA RIVER: MOUNTAIN WHITEFISH EGG LOSS

Objective / Location	Performance Measure	Units	Description	MSCI
Mountain Whitefish / Lower Columbia River	Estimated Egg Loss	%	Reports on results of the Whitefish Egg Loss model, which predicts estimated egg mortality caused by daily variability in river flows in the lower Columbia River	10%

Background

Flows in the lower Columbia River are a function of both flows out of Arrow Lakes Reservoir past Hugh Keenleyside Dam (HLK) and ALGS (Arrow Lakes Generating Station) and the Kootenay system past Brilliant and Brilliant Expansion Dams (BRD/X). During the winter period (November through March), flows from both systems are variable and depend on numerous factors including Columbia River Treaty requirements, energy demands, inflows, etc. From early November to February, mountain whitefish are known to spawn in the lower Columbia and Kootenay rivers (Golder 2010). Hatching of the eggs is assumed to start in January and potentially extend until May (R.L.&L. 2001, Golder 2010). During the spawning and egg incubation period, variability in river flows is assumed to cause mountain whitefish egg mortalities (losses) as a result of stranding and dewatering.

Since 1994, BC Hydro has entered into negotiations with the U.S. for provision of spawning and incubation flows to protect whitefish populations in the lower Columbia River. The Whitefish Operating agreement allows for the storage of additional water in Arrow and Kinbasket reservoirs during the peak spawning period (1-20 January) to reduce Arrow outflows by 20 kcfs. After this, efforts are made to maintain stable minimum flows to minimize dewatering of eggs until the end of March. A predictive mountain whitefish egg loss model (ELM) has been developed to better understand the extent to which operations affect spawning/incubation success. The ELM represents our best prediction of the physical effects of daily flow changes and biological timing of whitefish reproduction on egg loss.

The mountain whitefish ELM was originally developed in 2003 by R.L.&L. and was recently updated by Golder Associates Ltd. in 2008. The ELM is based on hourly flows from both HLK and BRD/X, daily average water temperatures (Columbia and Kootenay) and transects derived from a lower Columbia and Kootenay River hydraulic analyses. The biological considerations of the ELM include MW egg deposition probabilities (based on previous field studies), a fish hatching determination (based on previous literature and field studies), and egg dewatering thresholds for mortality (based on previous *in situ* investigations (Golder 2008). Based on historic spawning locations and representative hydraulic information, four sites were selected for incorporation into the model: Upper Tin-Cup Rapids, Lower Tin-Cup Rapids, Lower Kootenay River, Kinnaird Bridge Area. The ELM can forecast future egg stranding mortalities by projecting hourly flow data into the future along with forecasting mean daily temperatures for the spawning and incubation period based on multiple-year daily average data (Golder 2008).

Performance Measure

The ELM tracks the survival of an individual egg over time. Each of the four sites, representing known spawning areas, is represented by a single transect that is part of a hydraulic model used to estimate water levels at various 2 000 cfs increments of discharge from the Columbia and Kootenay rivers. The model uses observations from egg mats to determine probability of deposition of an egg on any given day (based on spawning time data) and at any given depth zone (based on historical egg deposition rates at depth). For each day following the day of egg deposition, the model determines if the egg deposited in a particular depth zone has accumulated enough thermal units (ATUs) to hatch without being dewatered for a "set" number of hours prior to the day of hatching. Hatched eggs are assumed to no longer be vulnerable to mortality and are not included in egg loss estimates. An egg deposited in depth zones that dewater for this "set" number of hours are assumed to not survive. The overall survival of an egg is determined by summing the probabilities of deposition of all depth zones and all spawning days for those depths and days where eggs would have hatched prior to mortality from dewatering.

Calculations

For each scenario:

1. Hourly data are interpolated for 1 November to 30 April for Arrow and Brilliant discharges.
2. These data are entered into a model that estimates flow impacts on mountain whitefish egg stranding averaged over four locations. Values are stranded eggs as a percentage of assumed total egg deposition over the year.
3. The model uses number of hours stranded before mortality as a variable. Estimates provided are based on minimum flow over a consecutive 8-hour period.
4. Summarize all statistics (Figure 1).

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).
- For the purposes of the NTS analysis, average water temperature data over the past 10 years was used in the modeling.
- Biological assumptions of the seasonal timing of spawning, development rates of ova and the vertical distribution of deposited eggs in the river channel are incorporated into the model to estimate daily egg losses.
- Assumes that the four channel cross-sections utilized in the ELM are representative whitefish spawning areas in the lower Columbia River in any given year.
- Limited availability of relevant topographic data to predict flow dependent changes in river stage and areas of channel dewatering was identified as a key data gap during the Columbia WUP. To reduce this uncertainty and increase the reliability of the egg loss estimates, there are WLR monitoring programs being implemented to: a) document topographic characteristics of representative whitefish spawning locations; and b) update the existing whitefish ELM to include new topographic and biological data.

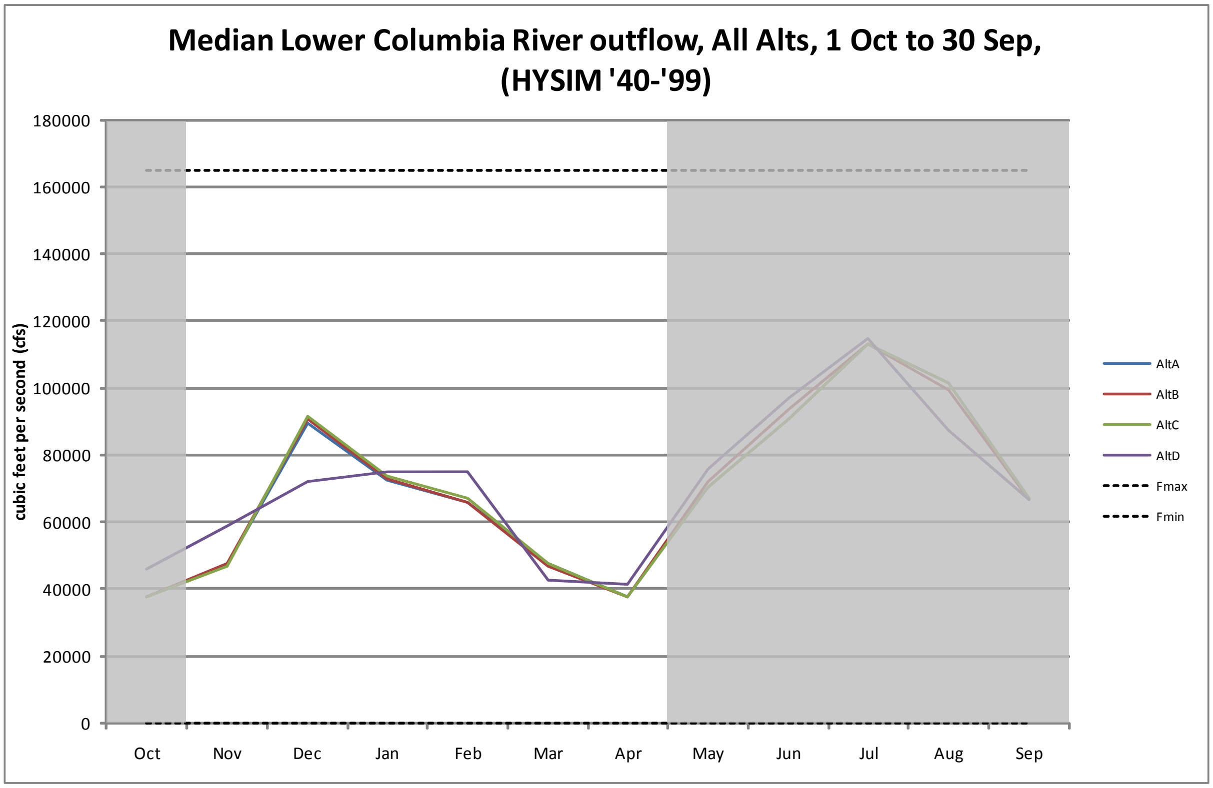


Figure 1. HYSIM Simulated Lower Columbia River Flows. Median over 60 years showing peak spawning and incubation period for mountain whitefish.

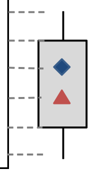
Results

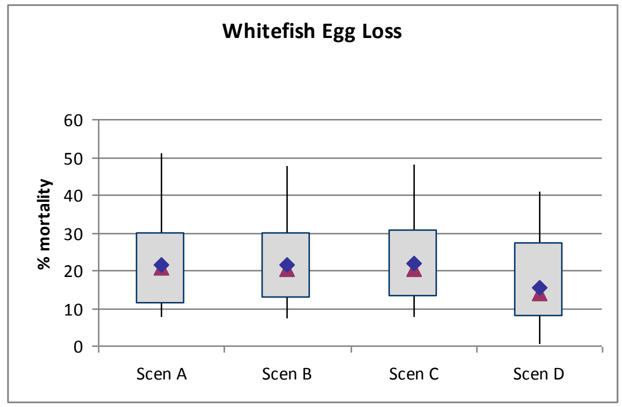
Regardless of the statistic considered, Scenario D (no NTSA) performs better for protection of mountain whitefish (i.e., reduced proportion of egg losses/mortalities) in the lower Columbia River. All of the “with NTS” scenarios perform the same.

Under all of the four scenarios, estimated whitefish egg losses are predicted to be within the ranges as agreed to with DFO during the WUP process. That is, on average, egg losses would be within the 0-40% range for the majority of the simulated 60-year period. However, predicted egg losses could exceed 40% mortality in rare occurrences (max statistic: 41-51%).

Figure 2. Whitefish Egg Loss – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	51%	47%	48%	41%
90th	30%	30%	31%	27%
Mean	22%	22%	22%	16%
Med	21%	20%	20%	14%
10th	11%	12%	13%	8%
Min	7%	7%	7%	0%





References

Golder Associates Ltd. 2008. Estimates of Mountain Whitefish Egg Stranding Mortality from Kootenay and Columbia River Flow Reductions, 1994-95 to 2007-08. Report prepared for BC Hydro. 14 p.

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