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Spatial and temporal variability of groundwater - surface water interactions in salmon spawning streams: implications for egg survival

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Atlantic salmon bury their eggs in open gravel structures known as redds to depths of between 0.1 and 0.3m beneath the streambed. Eggs are deposited in autumn and early winter with hatch in spring of the following year. Survival and performance between spawning and hatch is dependent on the delivery of oxygen and removal of metabolites from the redd environment, which in turn is dependent on the relative contribution of groundwater and surface water and the hydrochemical characteristics of these source waters. Long residence groundwater differs characteristically from surface water, both physically and chemically. Critically, long residence groundwater is often chemically reduced and as such exhibits low DO concentrations that are below those tolerated by developing salmonid embryos. This paper summarises the findings of recent inter-disciplinary investigations of groundwater-surface water interactions in the hyporheic zone of a semi-pristine upland spawning stream in the Cairngorms, north-east Scotland. Conservative hydrochemical tracers were combined with continuous water quality (Dissolved Oxygen, Temperature) and hydraulic head data to characterise hyporheic water quality and infer the nature of GW-SW interactions at nested spatial and temporal scales. At the catchment scale, geology and geomorphology controlled groundwater inputs. At the reach scale, local geomorphology and sedimentary stratigraphy of streambed materials were substantial influences. Temporal variability occurred in response to changing stream stage and water table elevation. At sites characterised by strong groundwater upwelling, hyporheic DO levels were consistently low and embryo survival correspondingly poor. At intermediate sites, characterised by transient groundwater intrusion, oxygen levels were often sufficient to permit survival

to hatch, but low enough to cause marked sub-lethal effects on embryo performance with potential to effect post-emergent fitness. This study emphasises the importance of inter-disciplinary approaches in understanding the links between hydrology, hydro-chemistry and freshwater ecology.