Geophysical Research Abstracts, Vol. 9, 05285, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05285


# The importance of scale in hydro-ecological studies of groundwater – surface water interactions in the hyporheic zone

**I.A. Malcolm** (1), C. Soulsby (2), A.F. Youngson (1) and D. Tetzlaff (2)

(1) FRS Freshwater Laboratory, Faskally, Pitlochry, UK (i.a.malcolm@marlab.ac.uk / Fax: +44 (0)1796 473523 / Phone: +44 (0)1224 294419) (2) Department of Geography and Environment, School of Geosciences, University of Aberdeen, UK

The hyporheic zone is a spatially and temporally dynamic mixing zone at the interface between groundwater (GW) and surface water (SW). In recent years its importance to the hydrological and ecological functioning of rivers has become increasingly apparant. This has been associated with increasing research efforts; major advances in methodologies; and thus, an increased understanding of processes. The physical and chemical characteristics of the hyporheic zone can affect a wide range of hydro-ecological interactions including nutrient proce and invertebrate community structure. One area of research which has received particular attention is the influence of hyporheic water quality on gravel spawning fish, particularly salmonids. Species, such as Atlantic salmon, burry their eggs beneath the streambed at depths of up to 0.3m. Consequently the survival and performance of salmonid embryos is acutely dependant on hyporheic processes and water quality and in particular the availability of dissolved oxygen. Many studies of the hyporheic zone have failed to adequately characterise hyporheic processes at the spatial and temporal scales appropriate to understanding ecological responses. In particular, there has been a lack of understanding of how GW-SW interactions scale in relation to their influence on the hyporheic environment.

In this paper we investigate the influence of GW-SW interactions on hyporheic water quality of salmon spawning sites at a range of nested spatial and temporal scales. Spatial scales ranged from catchment (ca. 30km$^2$) to reach (ca. 300 m$^2$) to redd ($<$1m$^2$) to the scale associated with individual egg pockets (ca. 5cm). Investigations at the catchment scale using geochemical tracers revealed a continuum of potential reach

scale GW-SW interactions from groundwater-dominated to surface-water dominated hyporheic zones, with a range of intermediate sites characterised by transient groundwater connectivity. At the reach scale, geochemical tracers combined with temperature and hydraulic head data facilitated more detailed process-based understanding which revealed the importance of local sedimentary structure and channel geomorphology in controlling GW-SW interactions. At the finest spatial scales ($<$1m) stream and hyporheic hydrochemistry were used to infer GW-SW interactions using a combination of small volume sampling and in-situ continuous DO measurement techniques. At these smallest scales, compressed hydrochemical gradients suggested a temporally shifting GW-SW boundary, rather than an extensive mixing zone. Temporal scales investigated ranged from inter-annual to the scale of individual hydrological events. Hyporheic water quality was found to vary temporally depending on variability in the relative contribution of GW and SW, which in turn depended on local water table elevation and stream stage.

Embryo performance is known to be influenced by complex interactions between temperature, interstitial velocity and dissolved oxygen concentrations. However, in broad terms performance scaled with mean hyporheic dissolved oxygen concentrations. Impacts ranged from outright mortality to sub-lethal effects such as delayed hatch and reduced body size. This study demonstrates the importance of GW-SW interactions for salmonids at a range of spatial and temporal scales. It is suggested that future hydroecological studies explicitly consider the importance of scale when matching hydrological observations with ecological data.