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Longer-term, continuous monitoring of the hyporheic environment: the ecological significance of inter-annual variability.

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Within the past few years, the development of continuous logging optopes has facilitated fine temporal resolution of the water quality dynamics of the hyporheic zone, which - in many cases - primarily reflects groundwater-surface water interactions. In this contribution, we report the insights from longer-term, continuous monitoring of surface waters and the hyporheic zone of a riffle in a montane stream where Atlantic salmon spawn. Throughout this period, DO in surface waters remained close to 100% saturation, but exhibited daily variations related to CO2 cycling driven by diurnal patterns of respiration and photosynthesis. However, in the hyporheic zone, variations were much more dynamic over storm event, seasonal and inter-annual timescales. At 300mm depth, DO saturation was generally close to 100% during summer low flows, though levels occasionally fell during warm periods which appeared to be related to diffusion gradients caused by benthic respiration. Such DO decreases at low flows were much more common and marked at 150mm depths. During wetter conditions, DO saturation at 300mm fell to zero for prolonged periods; this is consistent with increased fluxes of reduced groundwater discharging through the hyporheic zone. At such times, stream and hyporheic temperatures were clearly de-coupled reflecting different water sources. During the wettest periods, this also affects DO saturation and temperatures at 150mm. However, during individual hydrological events, hyporheic water quality is “re-set” as head reversals cause stream water ingress which results in transient periods of re-oxygenation, which end during the hydrograph recession. This is consistent with stream-ward hydraulic gradients being re-established in riparian ground water as the stream stage falls. The connectivity between groundwater and streamwater through the hyporheic zone is driven by climatic conditions and is reflected in marked inter-annual variability in water quality characteristics. This variability has profound implications for the ecology of the hyporheic environment. For example, in wet years when the hyporheic zone is dominated by marked discharge of reduced groundwater, the probability of salmon embryo survival in the time period between spawning (November) and hatch (April) is low. However in drier winters, with poor groundwater connectivity, the hyporheic environment may be dominated by well-oxygenated surface water and 100% embryo survival. Longer-term continuous monitoring reveals the dynamics of groundwater – surface water exchange in the hyporheic zone and the way in which this can exhibit marked inter-annual variability. These results emphasise how the findings of most of hyporheic studies – which are usually short term, with infrequent sampling – must be treated with extreme caution.