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Hydrological connectivity between landscapes and riverscapes: influences on fish migration between different habitats

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Developing the research interface between hydrology and ecology has been identified as a major research frontier in catchment science. Yet, the disciplines still operate somewhat independently with different philosophies, conceptual frameworks, terminology and experimental approaches. Facilitating greater integration is a prerequisite to more holistic understanding of how catchments function as ecohydrological systems, which in turn is needed to inform sustainable river basin management. In this contribution we consider connectivity from the perspective of how hydrological fluxes from the landscape, connect aquatic habitats and the migration of fish within riverscapes. Specifically, we examine catchment scale hydrological connectivity and the migratory movement of adult Atlantic salmon (Salmo salar) into a Scottish river system for spawning. The Girnock is a 30km2 experimental catchment which forms a tributary of the river Dee in the northeast of Scotland. A unique long-term (37 year) fish trap record - which shows the number of female fish entering the stream each day - was analysed along with corresponding flow records during the spawning period (September to November). This showed that fish enter the river in response to hydrological events, with the timing and distribution of entry reflecting the prevailing flows and antecedent conditions. This provided an integrated insight into how hydrological connectivity between the Dee and Girnock facilitated ecological connectivity of different habitats utilized by adult salmon in the river channel network. Additional use of hydrometric and hydrochemical tracer data, in conjunction with GIS analysis, helped elucidate aspects of the spatial structure and dynamics of catchment scale hydrological connectivity that drive the streams hydrological response. This allowed the

migration of salmon into the river network to be explicitly linked to the hydrological connectivity of the catchment landscape. In wetter years, saturated areas are extensive, providing a high degree of connectivity between the hillslope flow paths and channel network and high stream flows. This high connectivity facilitates early fish entry and maintains entry throughout the whole spawning period. This maximises the likelihood of an even distribution of spawners throughout the channel network which optimises subsequent juvenile habitat utilisation. In contrast, when dry antecedent conditions prevail, spawning entry is often late and suboptimal flows are used which minimises likelihood of even distribution of spawning. These differences have major implications for the timing and distribution of juvenile salmon emergence, which in turn affects a wide range of in-stream ecological processes in the following year. Understanding the importance of such connectivity in hydrological and ecological systems is crucial for management given the degree to which such connectivity has been affected by human activities, such as river regulation or water abstraction. It is also a prerequisite to meaningful predictions of the long-term effects of environmental change to aquatic ecosystems.