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Developing New Modelling Tools for Environmental Flow Assessment in Regulated Salmon Rivers

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There is a strong political drive in Scotland to meet all electricity demands from renewable sources by 2020. In Scotland, hydropower generation has a long history and is a key component of this strategy. However, many rivers sustain freshwater communities that have both high conservation status and support economically important Atlantic salmon fisheries. Both new and existing hydropower schemes must be managed in accordance with the European Union's Water Framework Directive (WFD), which requires that all surface water bodies achieve good ecological status or maintain good ecological potential. Unfortunately, long-term river flow monitoring is sparse in the Scottish Highlands and there are limited data for defining environmental flows.

The River Tay is the most heavily regulated catchment in the UK. To support hydropower generation, it has an extensive network of inter- and intra- catchment transfers, in addition to a large number of regulating reservoirs for which abstraction legislation often only requires minimum compensation flows. The Tay is also considered as one of Scotland's most important rivers for Atlantic salmon (Salmo salar), and there is considerable uncertainty as to how best change reservoir operations to improve the ecological potential of the river system. It is now usually considered that environmental flows require more than a minimum compensation flow, and instead should cover a range of hydrological flow aspects that represent ecologically relevant streamflow attributes, including magnitude, timing, duration, frequency and rate of change. For salmon, these hydrological indices are of particular interest, with requirements varying at different stages of their life cycle. To meet the WFD requirements, rationally alter current abstraction licences and provide an evidence base for regulating new hydropower schemes, advanced definitions for abstraction limits and ecologically appropriate flow releases are desirable. However, a good understanding of the natural flow variability and the hydrological impacts of the regulation is unavailable, partly because pre-regulation data of existing hydropower schemes are lacking.

Here we develop a novel modelling approach for characterising natural flow regimes and defining hydrological flow indices. This allows us to quantitatively assess the impacts of hydropower to better inform environmental flow requirements for the Atlantic salmon river ecosystem. Results are presented for the River Lyon (390 km2), a regulated headwater catchment of the River Tay. The HBV hydrological rainfall-runoff model is used to simulate flows, based on calibrated parameters from regulated flow data, with the current hydropower scheme active. For this, the HBV model is adapted to be able to incorporate water transfers and regulated flows. The natural hydrological indices are derived from the simulated pre-regulation data, and compared with those of the regulated data to investigate the impact of the regulation on these at different critical times for Atlantic salmon. The sensitivity of the system to change is also investigated to explore the extent to which flow variables can be modified without major degradation to the river's ecosystem, while still maintaining viable hydropower generation. The modelling approach presented will provide the basis for assessing impacts on hydrological flow indices and informing environmental flows in regions with similar heavily regulated mountain river ecosystems.