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Long-term integrated data reveals the importance of water quality for fish productivity and performance

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The United Kingdom Acid Waters Monitoring Network (UKAWMN), funded by the Department for Environment, Food and Rural Affairs was established in 1988 to monitor the ecological impact of acid deposition in areas of the UK believed to be sensitive to acidification. Nineteen years on, its data-base provides a long-term record of water chemistry and biology, which is unique for upland freshwater systems in the UK.

The Network consists of 11 lakes and 11 streams, across an acidity gradient, for which there is integrated chemical and biological data. At all sites, regular spot samples are taken for laboratory analysis of an extensive range of chemical determinands, including pH, conductivity, alkalinity, nutrients, dissolved organic carbon and a standard suite of base cations, anions and metals. Epilithic diatoms, aquatic macrophytes and benthic invertebrates are sampled annually in the spring/summer and fish surveys for stream sites and the outflow streams of lakes are conducted each autumn. The headline findings of the UKAWMN have been extensively documented. However, until now there has been no attempt to investigate potential links between fish performance/productivity and changing water chemistry.

In this study, the long-term water chemistry and fish data-sets were examined to establish the relationship between water quality and recovery from acidification, and fish performance and productivity. At a gross level, acid neutralising capacity (ANC) and labile aluminium were shown to have a strong influence on fish density. More subtle effects on performance and age structure were investigated using Principle components analysis. Preliminary investigation of the water chemistry data showed that the

majority of inter-site variability could be explained by the first 3 principle components, which related to acidity (component 1), dissolved organic carbon (component 2) and nitrate (component 3). PCA undertaken on the fish data (fish density, mean length, standard deviation, skewness, min and max) of 0+, 1+, 2+ and 3+ aged brown trout (*Salmo trutta*) revealed contrasting age and size structure between sites. The AWMN data showed potentially explanatory inter-relationships between fish size, density, age structure and water quality. However, these relationships are confounded by a lack of adequate site specific temperature data, which is known to have a substantial influence on fish performance and is known to have changed over a similar time period to changes in water quality associated with reduced acid deposition.