

**UNIVERSITY OF BIRMINGHAM, SCHOOL OF GEOGRAPHY, EARTH & ENVIRONMENTAL SCIENCES
CASE PhD studentship with Marine Scotland Sciences (MSS)**

River temperature: understanding controls, predicting change and management options for thermal extremes across Scotland

Supervisors:

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Project Description:

There has been a recent upsurge in river and stream temperature research driven by widening recognition of the critical importance of temperature for physical, chemical, and biological processes in flowing waters. For salmonid fish, water temperature influences growth, smolt age, mortality, productivity and demographic structure. At the national level, UK environmental organisations are tasked with providing thermal standards for water bodies as part of the EU Water Framework Directive. However, most studies of river thermal variability are conducted at the sub-basin scale; and there is a paucity of large-scale perspectives on river temperature variation.



Climate change will alter river thermal regimes; but this is an under-researched topic. Restoration of riparian vegetation is often advocated to reduce anticipated rising water temperature under climate warming; however, the UK evidence base for this mitigation option is weak. Thus, there is a pressing need to assess the moderation of climate influences on river temperature by hydrology and basin/ site properties to improve process knowledge and predictions.

For Scotland, there is a particular imperative for such research because (unlike England and Wales) there has been no national-level analysis of stream temperature; yet Scotland hosts a large proportion of Europe's temperature-sensitive Atlantic salmon population.

This studentship will address these critical research gaps as it *aims*: (1) to characterise spatial and temporal variability in river thermal regimes for important salmon rivers across Scotland; (2) to identify the most climatically sensitive locations and time-periods; (3) to use information from 1 and 2 to elucidate hydrological, climatological and basin/ site controls and so assess buffering of water temperature by non-climatic factors; (4) to develop models to predict future river temperature changes; and (5) to use information from 3 and 4 to assess climate change mitigation options for high temperature.

Training:

The research programme will provide the student with training in research design, field data collection, hydrology, climatology, database management, statistical analysis, GIS and modelling of environmental data. S/he will benefit from being part of the large, active graduate research community within the School of Geography, Earth and Environmental Sciences (GEES) and also the applied Government setting of the MSS Freshwater Laboratory (FL). The University of Birmingham and GEES provide formal training for PhD students. In addition, the student will attend relevant courses from the MScs in River Environmental Management and Applied Meteorology & Climatology. The student will gain GIS training and advice from MSS. During time at MSS-FL, s/he will develop an understanding of the importance and application of scientific research in policy and management contexts.

Some Relevant Papers by Supervisors:

- Brown L.E. and Hannah D.M. (2008), Spatial heterogeneity of water temperature across an alpine river basin, *Hydrological Processes*, 22, 954-967 DOI: 10.1002/hyp.6982
- Hannah D.M., Malcolm I.A. and Bradley C. (2009), Seasonal hyporheic temperature dynamics over riffle bedforms, *Hydrological Processes*, 23 2178-2194 DOI: 10.1002/hyp.7256
- Hannah D.M., Malcolm I.A., Soulsby C. and Youngson A.F. (2004), Heat exchanges and temperatures within a salmon spawning stream in the Cairngorms, Scotland: Seasonal and sub-seasonal dynamics, *River Research and Applications*, 20, 635-652
- Hannah D.M., Malcolm I.A., Soulsby C. and Youngson A.F. (2008), A comparison of forest and moorland stream microclimate, heat exchanges and thermal dynamics, *Hydrological Processes*, 22, 919-940 DOI: 10.1002/hyp.7003
- Hrachowitz M., Soulsby C., Imholt C., Malcolm I.A. and Tetzlaff D. (2010) Thermal regimes in a large upland salmon river: a simple model to identify the influence of landscape controls and climate change on maximum temperatures. *Hydrological Processes*, 24, 3374-3391
- Imholt C., Gibbins C.N., Malcolm I.A., and Soulsby C. (2011) Effects of riparian tree cover on stream temperatures and invertebrate growth. *Aquatic Ecology*, DOI: 10.1007/s16452-009-9305-0.
- Imholt C., Malcolm I.A., Gibbins C., Bacon P.J. and Soulsby C. (2011) Does diurnal temperature variability affect growth in juvenile Atlantic salmon? *Journal of Fish Biology*. doi:10.1111/j.1095-8649.2010.02838.x
- Imholt C., Soulsby C., Malcolm I.A., Hrachowitz M., Gibbins C.N., Langan S., and Tetzlaff, D. (in press) Influence of scale on thermal characteristics in a large montane river basin. *Hydrological Processes*
- Webb B.W., Hannah D.M., Moore R.D., Brown L.E. and Nobilis F. (2008), Recent advances in stream and river temperature research, *Hydrological Processes*, 22, 902-918 DOI: 10.1002/hyp.6994
- Wilby R.L. and 17 others (2010), Evidence needed to manage freshwater ecosystems in a changing climate: turning adaptation principles into practice, *Science of the Total Environment*, 408, 4150-4164 DOI: 10.1016/j.scitotenv.2010.05.014

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