

## **SFG100th Meeting Poster Abstracts**

### **The geomorphic and hydrological responses of flood embankment removal on the upper River Dee, Aberdeenshire.**

*Stephen Addy & Mark Wilkinson*  
*The James Hutton Institute*

Floodplain restoration has been highlighted as a technique that could help improve the natural functioning of river corridors and potentially reduce flood peaks. However, empirical evidence of its effectiveness is limited. In October 2015 an artificial embankment was partially removed on the upper River Dee, Aberdeenshire to reconnect its floodplain and a relict channel. Comparison of 4 years pre- and post-restoration geomorphic and hydrological monitoring data shows the lowering and several large floods soon after have altered geomorphic and hydrological dynamics appreciably. Channel widening, riverbed aggradation of up to 1 m and the movement of gravel into the floodplain were the dominant geomorphic responses. The floodplain hydrology has changed with surface water connection to the river occurring during moderate flows of approximately  $40 \text{ m}^3 \text{ s}^{-1}$  (previously approximately  $70 \text{ m}^3 \text{ s}^{-1}$ ) and a higher water table. The monitoring demonstrates that significant hydro-geomorphic responses can result from targeted embankment lowering.

### **Impacts of onshore wind farm developments on fish populations in Scotland.**

*Emily E. Bridcut*  
*Marine Scotland Science*

Marine Scotland Science (MSS) provides advice related to fish populations of economic and conservation value to Scottish Government during the consenting process for onshore wind farm developments. Various construction activities can have direct and indirect impacts on fish populations. MSS assesses the risks posed by developments in relation to the distribution and density of fish and advises on vulnerable populations and appropriate mitigation.

MSS has recently started assembling material for a meta-analysis of fish density and water quality data which have been collected in the monitoring programmes stipulated in planning conditions for consented wind farms. In addition to underpinning the advice we provide, findings from this research will be able to feed back into site management thereby helping to ensure that renewable energy continues to meet Scottish Government targets without jeopardising Scotland's valuable fish stocks.

## **Examining the response of Freshwater Pearl Mussels, *M. margaritifera*, to changes in the hydrological environment**

***Edward A.M. Curley, Rhian Thomas, Colin Adams & Alastair Stephen***  
***University of Glasgow***

Whilst there is encouragement to be taken from the fact that Scotland remains a stronghold for *M. margaritifera* populations, a trend of continued population decline persists. Our understanding of the hydrological characteristics associated with successful *M. margaritifera* proliferation in the wild is poor. Additionally, evidence to suggest how *M. margaritifera* respond to variation in the associated parameters, is limited.

The primary motif of this research project was to address that knowledge gap. Initial experimental analysis has sought to establish a non-invasive method of quantifying acute mussel stress; using behavioural response indicators, coupled with measures of physiological condition. Further research - utilising a laboratory-based flume system with live mussels – has since commenced, with the aim of monitoring the behavioural response of *M. margaritifera* to alterations in water depth and flow regime, in accordance with changes to substrate type and population density. The preliminary results from the project are presented here.

## **A 50 year change of the distributions of macroinvertebrates in the River Endrick**

*Jennifer Dodd, Peter Maitland & Colin Adams*  
**Veritas Ecology/University of Glasgow**

The impacts of human endeavour on the distribution of biological diversity, is particularly evident in freshwaters. Quantifying this change over long periods is important to provide insight into population and community change which can inform a host of practical management applications (e.g. improved accuracy of environmental monitoring). Long-term studies from freshwaters are however, scarce. We present the results of a long-term (50-year) study of the distribution of macroinvertebrates from the River Endrick.

## **Salmon smolt coastal netting survey work**

*Ross Gardiner, Robert Main, Ian Davies & John Gilbey*  
**Marine Scotland**

Losses of salmon smolts are not compensated for by density dependent survival effects and their small size makes them physically less able to take avoiding action than adult salmon. Information on their distribution in space and time in the vicinity of marine renewable development areas and which rivers they are associated with is needed to assess fully the risks posed by the developments. A short but informative campaign of surface trawling was successfully carried out in 2017 over different parts of the Moray Firth to catch smolts for investigation and where possible genetically assign them to rivers of origin. Other species including adult sea trout were also caught. The gear also included video cameras and PIT detection so that the net can also be operated open ended. The 2017 results will be described and discussed.

## **Detailed long-term study of a Scottish Atlantic salmon population across multiple life-stages suggests no discernible benefit of conservation stocking**

*Ross Glover, RJ Fryer, C Soulsby, PJ Bacon & IA Malcolm*  
**Marine Scotland Science**

There are increasing calls for “conservation stocking” to counter declines in Atlantic salmon populations. However, there are too few quantitative studies to assess its efficacy within the broader context of natural population variation and regulation. The Girnock Burn is a valuable long term monitoring site where adult and juvenile salmon abundance has been assessed for over 50 years. Conservation stocking was undertaken over 11 years and aimed to reduce both density-independent and density-dependent mortality of fry (0+) and parr ( $\geq 1+$ ). Catchment-scale juvenile production estimates were modelled from an extensive electrofishing dataset using a novel spatial statistical river network model, incorporating the effects of capture probability, habitat and stock level. Survival from ova to fry was density-independent and higher under stocking than natural spawning. However, increased fry production did not translate to increased parr production, which was strongly density-

dependent. This study demonstrates the importance of quantitative assessments of management actions.

## **Statistical methods for analysing the remote-sensing lake data**

**Mengyi Gong, Craig Wilkie, Anna Sehn, Ruth O'Donnell, Claire Miller & Marian Scott**  
**University of Glasgow**

Remote-sensing technology is widely used in Earth observation. The remarkable coverage and resolution of the data are extremely beneficial to the investigation of environmental problems, such as the state and function of lakes under climate change. However, some of the features of remote-sensing data bring new challenges to statistical analysis. These include dimensionality, missing observations and data uncertainties. This poster presents some of the statistical methods developed by the environmental statistics group in the University of Glasgow to deal with these challenges. The methods include non-parametric fusing of remote-sensing and in-situ lake Chlorophyll data, the imputation of missing observations in lake temperature images through spatio-temporal smoothing and the investigation of satellite reflectance data associated with lake measurements using functional data approaches, etc. We show the benefits which these methods bring to our understanding of changes over time in lake ecological status.

## **Patterns of freshwater habitat use by a rare breeding duck, the common scoter, and implications for scoter conservation**

**Alison Maclennan, Hannah Robson, Mark Hancock, Trevor Smith & Andy Douse**  
**RSPB**

The diving duck, the common scoter *Melanitta nigra*, is one of the rarest breeding birds in Britain, confined to upland Scottish lakes. We investigated patterns of lake use by breeding scoters in Scotland, in relation to habitat correlates like water depth, food abundance and fish populations. Breeding scoters occurred most often at lakes having relatively more extensive shallow water and abundant large invertebrates. Similarly, within breeding lakes, areas with shallow water were preferred by foraging scoters. Large invertebrates tended to be more abundant where there were fewer brown trout *Salmo trutta*, suggesting that scoters and trout may compete for the same prey. We are now testing this idea at four lakes within Forsinard Flows RSPB reserve in the north Highlands. Small exclosures and the re-introduction of regular angling are being used to reduce trout numbers, while we measure responses by invertebrates and the waterbirds – like scoters – that feed on them.

## **Using ecosystem engineers as tools in habitat restoration and rewilding: beaver and wetlands**

**Alan Law**, Martin J. Gaywood, Kevin C. Jones, Paul Ramsay & Nigel J. Willby  
*University of Stirling*

Potential for habitat restoration is increasingly used as an argument for reintroducing ecosystem engineers. Beaver have well known effects on hydromorphology through dam construction, but their scope to restore wetland biodiversity in areas degraded by agriculture is largely inferred.

After 12 years of beaver presence mean plant species richness had increased on average by 46% per plot, whilst the cumulative number of species increased on average by 148%. Heterogeneity, measured by dissimilarity of plot composition, increased on average by 71%. Plants associated with high moisture and light conditions increased significantly in coverage, whereas species indicative of high nitrogen decreased.

Our study illustrates that a well-known ecosystem engineer, the beaver, can with time transform agricultural land into a comparatively species-rich and heterogeneous wetland environment, thus meeting common restoration objectives. The use of such species may yet emerge as the missing ingredient in successful restoration.

## **Assessing recent responses of freshwater Scottish lochs to changes in nutrient loading**

*Lucia Lencioni, Helen Bennion, Carl Sayer & Nadia Solovieva*  
**University College London**

Nutrient reduction measures have been introduced at a number of Scottish lochs yet the effectiveness of these has not been fully assessed. Multiple stressors such as eutrophication, climate change and invasive species continue to exert pressure on Scottish freshwaters, making recovery trajectories difficult to predict. The lake sediment record potentially offers a unique opportunity to track the degree to, and rate at which, lakes return to pre-impact conditions and thereby to judge whether lake restoration targets are achievable or even desirable. This study explores this potential at a set of Scottish lochs, originally cored in the late 1990s (Bennion et al. 2004) and cored again in 2015/16, based on analysis of the sub-fossil diatom assemblages with a focus on the last few decades. We explore whether early responses to changes in nutrient loading can be detected and consider the implications for freshwater monitoring and assessment.

References: Bennion, H., Fluin, J. & Simpson, G. (2004). Assessing eutrophication and reference conditions for Scottish freshwater lochs using sub-fossil diatoms. *Journal of Applied Ecology*, 41, 124-138.

## **Thinking wet and dry: on the criticality of water in the Scottish economy**

*Scott J. McGrane, Grant Allan & Graeme Roy*  
**University of Strathclyde**

Competing demands for water have resulted in an intensification of pressure on our freshwater resources. Population growth has necessitated continual upgrades to existing freshwater supply infrastructure and has also resulted in increasing demand from service provisioning industries such as energy generation and food production. Scotland benefits from being a nation that has considerable access to freshwater resources, and as a result, water is a critical component of many industries within the Scottish economy (e.g., the food and drink industry, which contributes £5 billion per annum). Furthermore, despite being water-rich, Scotland remains a net importer of water via virtual water transfers embedded in resources such as food and raw materials. Here, we explore the critical value of water in the Scottish economy over the past 50 years, and present a discussion of the critical threats that face water resources, and concomitantly, our economic development, over the next 50 years.

## **Understanding and assessing the effects of river regulation on Atlantic salmon fry**

*Karen Millidine, Rob Fryer, Iain Malcolm*  
**Marine Scotland Science**

Hydropower infrastructure has a major effect on the hydrological regime of affected rivers. There is increasing interest in modifying flows to improve ecological status and fisheries productivity.

However, the evidence base for decision making is constrained and different species and lifestages have contrasting flow requirements. This study investigated the effects of an atypical seasonal hydrological regime and a spring high flow “freshet” (designed to facilitate downstream migration of smolts) downstream of a dam. Saturation stocking and electrofishing were combined with hydraulic and habitat models to understand the effects of discharge on habitat quality and salmon production. The discharge at which the highest habitat quality was predicted varied depending on reach morphology and channel roughness. Low fry survival was consistent with predictions of low habitat quality during the spring freshet. The combination of saturation stocking, hydraulic and habitat models provides a valuable approach for assessing the effects of regulation.

## **Ponding in intermittent streams: biodiversity hotspots**

*Tory Milner & Matthew Hill*  
*University of Worcester*

Intermittent rivers are spatio-temporally dynamic habitats, transitioning between flowing, pool and dry states. During flowing phases, aquatic macroinvertebrate diversity is typically lower at intermittent than perennial sites. However, instream ponds that form during streambed drying may have very high abundances and taxonomic richness of macroinvertebrates. Few intermittency studies have included macroinvertebrate diversity from instream ponds. Therefore, aquatic taxonomic richness may have been historically underestimated. Our study examined the diversity and community composition of macroinvertebrates from perennial, intermittent sites and instream ponds in the R. Hamps and R. Manifold, catchment, in the Peak District, UK. We found instream ponds supported lower alpha diversity but possessed a different community composition from perennial and intermittent sites. Our findings indicate instream ponds provide a refuge for macroinvertebrates and a habitat for newly colonising taxa. As intermittent rivers are predicted to increase, information regarding their ecological diversity is important for effective freshwater conservation and management.

## **Spatial and temporal trends in historic sea trout population fluctuations across Scotland**

*Isabel Moore, Jennifer Dodd & Colin Adams*  
**University of Glasgow**

Salmonid populations in Scotland are thought to have been in decline for several decades. Although the decline in Atlantic salmon in Scotland has been examined, no similar study has been carried out for sea trout populations. Using a national historic dataset of catch records collected for river systems around Scotland, the decline of sea trout in different regions was examined and potential environmental and anthropogenic drivers that could be influencing observed trends was modelled.

## **Water Quality Outcomes of a Constructed Wetland**

*Ewan Lawrie, Fiona Napier & Richard Humpidge*  
**Scottish Natural Heritage**

The Loch of Strathbeg is the UK's largest dune loch. The loch itself and the surrounding vegetation is a Ramsar site and SSSI. It is also a SPA for its wildfowl interest and a large part is an RSPB reserve.

There have been long standing concerns over nutrient enrichment and in 2008 RSPB, with support from European Structural Funds and in partnership with SNH and SEPA, carried out large scale engineering works on a major inflow the Burn of Savoch, re-establishing a more natural meandering watercourse, removing the artificially high banks and returning a large area to wetland.

SEPA is carrying out monitoring to assess the impact of the new wetland on water quality in the burn. Some of the results have shown some negative impacts on water quality. Such long term post-construction monitoring is unusual and the results raise issues regarding the aims and management of constructed wetlands.

## **Understanding migration in highly managed species: New insights from emerging technology**

*Mathew Newton, Rob Main, Hannele Honkanen, Isabel Moore, Ross Gardiner, Ian Davis & Colin Adams*  
**Atlantic Salmon Trust/University of Glasgow/Marine Scotland**

The rapid emergence of new technologies for tracking aquatic animals has opened the possibilities to address questions that have, until recently never before been possible. IN this poster we will explore some of the emerging insights into fundamental ecological questions, that this technology is providing for migratory anadromous salmonids in Scotland.



## **Patterns of habitat modification in priority freshwater pearl mussel catchments**

*Karen O'Neill, J.S. Rowan, J.A. Finn, P. Phelan & D. Ó hUallacháin*  
**University of Dundee/Teagasc, Ireland/KerryLIFE**

The freshwater pearl mussel (FPM) is a long-lived invertebrate which is Critically Endangered (IUCN) across its range. European populations have declined by >90% over the last century, with Ireland and Scotland constituting strongholds for the species. River channel modifications are thought to have contributed to the species' decline. River Habitat Survey was applied in three priority FPM catchments in south-west Ireland to investigate habitat modification scores (HMS), along with the potential for modifications to disrupt sediment pathways. Initial RHS results suggest that there are significant levels of modifications in these priority habitats, which may have contributed to loss of function; a catchment with a small remnant adult population achieved highest overall HMS, while a catchment with recent recruitment recorded the lowest levels of modification. Findings will be combined with the outcomes of sediment source and yield studies, and will contribute to sustainable land management for priority aquatic species.

## **The effects of invasive riparian cover on the diversity and turnover of river invertebrate communities.**

*Alex Seeney*  
**University of Stirling**

Invasion of the riparian zone by non-native flora is commonly perceived as a negative occurrence for river management, but the nature of the changes induced by invasive flora remain largely undetermined. The effects of invasive riparian flora on river ecology may manifest through changes to sediment delivery, allochthonous material input and channel shading, eliciting responses in river invertebrate communities which provide essential ecological processing and forage for salmonid fish in Scottish rivers. This study examines how river invertebrate diversity, in addition to spatial and temporal turnover in invertebrate composition, respond to invasive riparian flora. Invertebrate samples collected from 24 field sites across central Scotland during 2015 were combined with vegetation surveys and physical and chemical measurements to show that whilst invasive cover is a significant and strong driver of aquatic invertebrate diversity at the local scale, it does not have a significant effect on spatial or seasonal turnover.

## **Forests, fish and freshwater pearl mussels – the effects of peatland restoration on water quality.**

*Nadeem Wasif Shah & Thomas R. Nisbet*

*Forest Research*

Increasing attention is being given to forest removal on peatland for habitat restoration and protection of carbon stocks. Large-scale deforestation is underway at a number of sites in Scotland with concerns raised about the impact of such a rapid change in forest cover on water quality, particularly in terms of phosphate and carbon losses.

Sensitive species such as the freshwater pearl mussel and salmonids are especially vulnerable to changes in water quality. The mussel is slipping to extinction throughout its Holarctic range, placing even greater importance on the need to protect remaining viable populations.

We present results from over 7 years of pre and post-restoration monitoring at a large raised bog straddling the River Forth; the 400 ha site was planted with non-native conifers and is being cleared to restore peatland habitat. Data are available for three separate catchments yielding information on the effects of the deforestation on water quality.

## **Fussy freshwater pearl mussels – what we've learned about how to reintroduce them, and their choosy fish hosts.**

*Iain Sime, Diane Baum, Peter Cosgrove, Jon Watt, Lee Hastie, Chris Daphne & Brian Shaw*  
**Scottish Natural Heritage**

Freshwater pearl mussels are amongst the most endangered molluscs in the world, with Scotland continuing to support many of the largest remaining populations. Over the past decade and more there has been a lot of work to improve their conservation. This has included reintroductions to rivers from which they had become extinct. A decade on we have returned to those rivers and found mixed results. We have also discovered that the pearl mussel, which relies on a salmonid host to complete its lifecycle, uses different hosts in different rivers. We report on the variation in fish hosts following a wide range of surveys across Scotland. And how knowledge of host specificity can help inform and guide potential future reintroductions.

## **Scotland's rivers: A review of geomorphological response to flow, sediment and ecological regimes**

*Rhian Thomas, Trevor Hoey & Richard Williams*  
**University of Glasgow**

Scotland's rivers are diverse, dynamic systems, that respond to regional climate, geology, vegetation, soil type and topography. They exhibit episodic, spatially variable change in response to flow, sediment and ecological regimes and are influenced by natural and anthropogenic factors. We discuss recent Scottish research on these interlinked areas, reviewing progress made over recent decades and highlighting ongoing issues. Recent research on the endangered freshwater pearl mussel illustrates complex ecological responses to flow regimes. Flow and sediment regimes control channel change over a range of scales, and responses to engineering show long-term impacts of river management. We review relationships between river restoration, ecology and hydrological and geomorphological regimes, and demonstrate changes to policy and practice, using examples such as beaver re-introductions. A consistent theme of the research is the importance of catchment-scale approaches to inform river management, encompassing hydrology, geomorphology and ecology.

## **IUCN NCUK river restoration and biodiversity project**

*Angus Tree, Members of the IUCN NCUK river restoration and biodiversity project steering group*  
**Scottish Natural Heritage**

Despite increasing interest in river restoration there remains only limited information about the value of it for aquatic biota. The aim of the river restoration and biodiversity project is to provide compelling evidence of the benefits for biodiversity of restoring rivers and so attract more funding for restoration schemes. The project is led by SNH under the auspices of the IUCN's UK National Committee and has a steering group comprising representatives of the UK and Ireland's nature conservation and environment protection agencies, and the River Restoration Centre. Phases 1 and 2 included an analysis of existing information to help specify the objectives of phase 3 which is now underway. In this phase a network of demonstration river restoration sites that spans the five

countries, and in which pre- and post-restoration data can be gathered, will be established. A range of river types, sizes and restoration measures will be included.

## **Statistical modelling of river run and river network data**

*Craig Wilkie, George Vazanellis, Ruth O'Donnell, Claire Miller, Marian Scott & Adrian Bowman.*

***University of Glasgow***

Rivers are vital parts of the freshwater ecosystem, sustaining aquatic and terrestrial life. However, their health is affected by diverse factors, including anthropogenic influences. This poster reviews the statistical methods developed by members of the environmental statistics group at the University of Glasgow, accounting for the complexities of river and network data, giving examples for the Rivers Clyde, Tweed and Trent. These methods include:

- novel spatiotemporal modelling of dissolved oxygen along the River Clyde, allowing for the detection of abrupt changes in oxygen levels over time.
- prediction of nutrients across the River Tweed network and identification of sites that are clustered together spatially in terms of their temporal pattern.
- identification of sites contributing the most to explaining variation in spatiotemporal patterns in the River Trent network and hence investigating potential network reduction.

We demonstrate, through examples, how these methods enhance our understanding of complex changes and drivers of river health.

## **“Water for all” – would a Payments for Ecosystem Services scheme deliver more sustainable management in the Lunan Water.**

*Andy Vinten, Linda May, Orla Shortall, Laure Kuhfuss, Iain Gunn & Ina Pohle*

***James Hutton Institute***

“Water for all” explores the potential for innovative water level management in the Lunan Water, an agricultural catchment in Eastern Scotland, to enhance water ecosystem service delivery across a range of beneficiaries. Flexible hydraulic control using a tilting weir and penning device has been proposed to mitigate flood risk, protect high value wetlands from eutrophication and deliver water at low flows. This has been based on:

- (1) Historic and current monitoring data for the loch, river and wetlands in the catchment;
- (2) Hydrological and hydraulic modelling of impacts of flexible hydraulic control;
- (3) Ecological requirements of rivers and wetlands;
- (4) Economic analysis of alleviating the impacts of restrictions on irrigation;
- (5) Local stakeholder interviews and surveys of willingness to pay and attitudes to the scheme.

Results show potential benefits across several ecosystem services and there is positive interest in the scheme. However, “institutional gaps” for project implementation and governance are a concern.