



Exploratory Workshop Scheme

Scientific Review Group for Life, Earth  
and Environmental Sciences

**ESF Exploratory Workshop on**  
**Glacier-Fed Rivers, Hydroecology And Climate**  
**Change; Current Knowledge And Future**  
**Network Of Monitoring Sites**  
**(GLAC-HYDRECO-NET)**

**Birmingham (United Kingdom), September 15 to 18<sup>th</sup>, 2013**

**Convened by:**  
**Alexander Milner, Dean Jacobsen**  
**and David Hannah**

---

**SCIENTIFIC REPORT**

---

## **1. Executive summary**

The meeting was held at the University of Birmingham campus in the West Midlands, UK between Sunday September 15<sup>th</sup> and Wednesday September 18<sup>th</sup>, 2013. Participation numbered 16 people from 9 countries, all of which had extensive experience in glacier-fed rivers. Accommodation was provided at the University's conference center, Hornton Grange, and the meeting room was at the School of Geography, Earth and Environmental Sciences. Lunch was offered by a variety of outlets across campus and the Conference Dinner was held at University Staff House on the Tuesday evening where attendees had to relate one humorous story related to prior fieldwork. One dinner was held in the City Centre at the Cube Restaurant. Surroundings permitted additional informal interaction for discussion during meal times and in the evening.

Most glaciers worldwide are shrinking, thereby reducing meltwater runoff volume and shifting the timing of peak flows. High climatic sensitivity and low human perturbation make glacial-fed river basins early indicator systems for identifying hydrological and ecological responses to climate change variability. Our understanding of these sensitive systems and their response is limited, particularly in terms of regional and global inter-comparisons. The scientific objectives of the workshop were as follows; (1) assemble the key workers together to assess current knowledge, (2) discuss the establishment of a worldwide network of monitoring sites using similar protocols to evaluate change more consistently and robustly than hitherto achieved, (3) examine funding mechanisms to develop this network, and (4) examine possible outputs including writing a review paper or assembling a special issue of a journal to synthesize our current knowledge of glacier-fed rivers.

The agenda is provided at the end of this report. The first day of the workshop was spent with all the participants giving Powerpoint presentations about their latest research findings and the areas that they were working in – the titles of these presentations can be found within the agenda and a brief synopsis is provided in section 2. These presentations are all available in a Dropbox that can be accessed by all the participants. Time was allowed for questions and discussion following each presentation. The second day involved discussing the emerging themes from the talks the previous day and this was added to by a subsequent open discussion. There then followed an examination of existing datasets and the potential for increasing their geographical range. After lunch on the second day, participants were divided into three groups to examine firstly research hypotheses to drive the network/observatory and then discuss funding, publications and knowledge transfer. Research Hypotheses were refined on the final day and then followed two breakout groups which considered protocols for the network, both physical and ecological. A potential synthesis paper of our current state of knowledge was mapped out and the meeting closed with action points and a road map for the future.

## **2. Scientific content of the évent**

The meeting opened on Monday September 16th with the convenor Alexander Milner (University of Birmingham) outlining the scientific rational of the workshop and its overall goals. Participants then introduced themselves prior to a Powerpoint présentation by ESF on the workshop process which was given by the convenor in the absence of the ESF rapporteur. There then followed a series of Powerpoint présentations by the workshop participants of their research and latest findings in the field of glacier-fed rivers.

The convenor, **Alexander Milner** gave the first presentation when he discussed the history of the conceptual Milner and Petts model (1994) of glacier-fed rivers which was originally based on Alaskan data and professional opinion. Following the AASER project the model was tested across a latitudinal gradient and modifications were undertaken in a 2001 paper to reflect the different biogeographic regions e.g. Svalbard and New Zealand. Co-convenor **David Hannah** (University of Birmingham) followed examining the linkages and cascade between climate forcing –cryospheric- processes hydrology-habitat-biota. Projected changes in glacier and hydrological regime were outlined and the need for interdisciplinary studies linking and quantifying these processes was highlighted. The ARISE conceptual model of alpine ecosystem habitat/biota based on water sources was introduced. **Eran Hood** from the University of Alaska completed the morning session before coffee by examining projected changes in glacier-fed rivers along the Gulf of Alaska and pointed out of the  $870 \text{ km}^3 \text{ yr}^{-1}$  runoff into the Gulf of Alaska, 50% is of glacial origin. Glacier nutrient fluxes are important seasonal dynamic and hydrological fluxes and the use of  $\text{O}_{18}$  to trace water source can link to important parameters such as tryptophan and nutrient concentration. The importance of iron output in the glacial runoff was highlighted.

**Gísli Már Gíslason** from the University of Iceland then discussed glacier-fed rivers in Iceland where 35% of runoff is presently glacial but where glaciers are projected to disappear within 200 years. He highlighted the need to consider the effect of island biogeography on taxa in Europe and that of the 215 Trichopteran species in mainland Norway only 12 were found in Iceland. He discussed geothermal springs in Iceland as representing an unique natural laboratory to study climate change effects with water temperatures ranging from 5 to 25 °C. **Christopher Robinson** from EAWAG, Switzerland discussed the lack of knowledge regarding bacterial communities, which are very resistant in terms of structure, and there should be greater linkage between structure and function in glacier-fed streams of bacterial community composition. He highlighted the general need to understand functionality and there should be a shift from structure to function in research/monitoring directions. Rarity is an important issue in glacial rivers and tributaries as the majority of species are rare and there are problems with plasticity and the role of generalist vs specialists. Co-convenor **Dean Jacobsen** from the University of Copenhagen followed next overviewing glacier-fed stream ecology in tropical Ecuador and considered stochastic mechanisms more important in tropical glacier fed systems than deterministic and highlighted the high diurnal variability in water temperature close to glaciers, reaching up to 10 °C during the day but freezing at night. This regime with low seasonal variation is very different than the Northern Hemisphere glacier-fed systems. Biogeography is an important consideration limited by small regional species pools at high altitudes and showing a unimodal distribution from sea level to high altitude and from the Arctic to Equatorial regions. **Sophie Cauvy-Fraunié** from IRD, (Institut de Recherche pour le Développement -France), examined diurnal cycle amplitude using wavelet analysis using long-term high resolution data as a quantitative measure of glacial influence in tropical mountain hydrosystems. Glacial floods occur all year with high frequency (> 45%) and there is a good relationship between the extent of diurnal fluctuation and glacier cover in the catchment.

Following lunch **Lee Brown** of the University of Leeds examined alpine river ecosystem response to natural and anthropogenic flood pulses in Odenwinkelkees, Austria. He highlighted the paucity of winter studies and the need to consider anthropogenic influence i.e. reservoirs, contaminants in ice and snow packs, and the production of artificial snow for ski runs. He discussed cold water inputs from reservoirs as a possible conservation measure for mimicking natural systems and repeated imagery to provide detailed

measurements of depth/aggradation/erosion as a way to quantify the stability of a river channel reaches. Food webs were discussed as a way to understand functional aspects of glacier-fed rivers and highlighted the high levels of omnivory as an interesting link between basal resources and trait analyses were overviewed. **Andy Hodson** of the University of Sheffield examined links between landscape change and the biogeochemistry of Svalbard rivers and considered permafrost an important gap in our knowledge as its degradation is affecting the biogeochemistry of these systems. Methane and iron are being released, which is affecting downstream areas and fjords. As the subglacial is frozen, change in the weathering of small glacier environments alters groundwater/surface water relationships with groundwater discharge instead of recharge. **Tom Battin** of the University of Vienna discussed biofilms in glacier-fed streams and highlighted high alpha diversity in stream samples comparable to lower altitudes. More OTUs were found in streamwater than in the ice and there is a one-way dispersal pathway for microbial community and the metacommunity species pool increases with distance downstream. Rare taxa appear to be the most active in the streams and environmental filtering the most important community assembly process. Ice locked DOC is extremely important for heterotrophic metabolism. **Martyn Tranter** of the University of Bristol discussed microbial processes on glaciers in Svalbard and the Greenland Ice Sheet and outlined the debate between autotrophic and heterotrophic processes driving these processes. Cryoconite holes on Svalbard are not neatly enclosed and microbial growth albedo changes with increased melt. Nitrogen is limited on glacier surfaces and algal biomass on ice causes a feedback mechanism.

**Valeria Lencioni** from Trento Museum discussed macroinvertebrates from alpine glacial streams moving from an ecological to a physiological and molecular approach. She discussed biodiversity extensive taxonomic surveys and creating long term datasets at a number of AASER sites and finding a change in Diamesinae composition with new orthoclads colonizing and increased abundance and richness of baetid taxa. Cold and warm resistance was found in cold stenotherms with antifreeze proteins and heatshock proteins. These techniques provide insights into adaptation and extinction risk of taxa. **Leo Fureder** from the University of Innsbruck highlighted recent studies in High Arctic and Alpine Glacial Rivers and highlighted the use of stable isotopes in Svalbard to characterize foodwebs and an enriched marine derived nitrogen signal in streams close to cliffs with sea birds nesting leading to increased richness and diversity. Species trait databases have been developed for Austrian alpine specific taxa but resistant/resilient traits may need finer coding. **Jón S. Ólafsson** of the University of Iceland discussed kettlehole pond succession at the margin of a retreating glacier across a chronosequence of 120 years and highlighted these ponds as natural laboratories to test ecological theory. Macrophyte taxa richness and chlorophyll a concentration increased with pond age with cyanobacteria N fixing closer to glacier. Cladoceran and copepods were ubiquitous, species turnover was low and there was limited predator overlap. **John Brittain** from the University of Oslo concluded the presentations with an outline of the The Arctic Freshwater Biodiversity Monitoring Plan with insights into its structure/guidelines to enable circumpolar results and the theme of standardized protocols. The importance of traditional ecological knowledge has been highlighted in the plan and impact hypotheses have been developed around the long term effects of stressors. The selection of appropriate indices depends upon the question asked.

The following day the **emerging themes** were synthesised by the convenors and additional ones added to by the participants;

- Most glaciers are in retreat in terms of mass balance
- Definitions – percentage coverage of glaciers. Quantifying glacial influence across multiple basins
- Downstream effects in terms of fluxes, biodiversity and effects on other ecosystems (e.g. Marine)
- Concepts to explain total diversity
- Rarity – importance of
- Regions – Arctic to Tropics – different behaviours of glaciers
- Importance of microbes in these systems
- Structure v Function - Traits – Body size, Net processes, production etc., Meta-community dynamics.
- Interdisciplinarity – importance of and how to achieve it
- Additional anthropogenic stressors/structures – e.g. Pollutants, regulation
- Biogeography element needs careful consideration
- Need for a more unified approach i.e. Biogeochemistry links to ecological functioning
- Natural laboratories – important for setting up network

#### **Emerging themes contributed through discussion ;**

- What makes glacier fed streams so special – compared to other streams.
- Are glacier fed streams unique? What makes them unique?
- Rate of change is much higher particularly in terms of hydrology and biota
- Colonization rates in terms of biology higher than other systems
- Ecosystem services – hydropower irrigation
- Differs with latitude – in dryer regions (i.e irrigation and water for drinking particularly in S.America)
- Differs with geographic region eg. Europe vs Monsoon
- Geographical context of the hydro power schemes.
- More than a billion people rely on meltwater – Pleistocene melt water
- Science led water management practice not currently the norm. Problems with management administrative issue often don't consider hydrological processes – some political issues.
- Link with society important.
- Industrial partners needed?
- Data access issues for the Himalayas can be a big problem.
- Problems with religion – water sacred – Ganges to go dry?
- Economic aspects and links to Marine – big money in Salmon fisheries
- Tourism generated by glaciers – will this glacier be here in 20 years?
- What are the questions which need the global perspective to answer
- Can we identify a gradient of glacier change – tipping points longer term study scope necessary
- Indicator systems of change
- Value of long term data for identifying trends and patterns – quantify rates of changes
- Mass balance data – age of ablation zone
- Industrial processes deposition of contaminants – post industrial ice
- Latent pollutant store which will soon be released

- How do streams in front of glaciers process these pollutants Alpine- Arctic ETH – repleted alpine system? – mass balance gradient – contaminant pitch.
- No current frame work for monitoring latent pollutants
- Uncertainty propagation through the linked systems
- Importance of floodplain retention – transport becomes more important as glacier stop reworking the catchment nutrient spiralling export process
- Maritime vs continental glaciers - differences in snow precipitation can mask the effects of glacier loss e.g. Himalayas vs Maritime, US Canda
- Biotic interactions increase what does this mean how can this be quantified.

Followed was a discussion on databases that were presently available on glacier-fed streams that were known as either within the participant's own data or from other colleagues. This outline was then used to identify other geographical areas that would need to be identified in the proposed network/observatory of sites.

The participants then broke into 3 groups to discuss hypotheses relating to the key themes identified that would be used to drive the proposed network. These hypotheses were then synthesised by the convenors and presented on the final morning to which the participants would agree on as steering the goals of the network.

The group then worked on drafting a potential outline for a high impact paper to a journal like Nature summarising the présent knowledge of these systems and highlighting their importance to downstream systems, particularly with respect to climate change.

The afternoon session and the meeting concluded with a series of potential **ouputs** from the workshop and a **roadmap** for the future with dates for completion.

### **3. Assessment of the results, contribution to the future direction of the field, outcome.**

The **five hypotheses** derived from extensive workshop discussions and to drive the proposed network were;

1. Reductions in glacial coverage causes a shift from a deterministic/buffered system to a more stochastic/variable system (hydrological, biogeochemical, biological).
2. The nature and extent of change is controlled by geographical location (climatic, glacier-type and biogeographical context).
3. Despite changes in biotic community structure ecosystem function will remain similar (redundancy, metabolic properties)
4. Beta and gamma diversity of all aquatic trophic levels will decrease as glacial coverage declines and alpha diversity will increase as habitats become more homogenous.
5. Connectivity will decrease with a reduction in glacial runoff.

## **Outputs and future direction following the workshop**

Summary/report of the meeting with the outputs of the meeting including the research hypotheses – send to ESF.– end of October 2013

Extended Abstract for Nature – end of October 2013 – 200 words sent in by beginning of October from small groups

Proposal for workshop in Svalbard – September 2014. November 2013. EU ITN – April 2014 – Birmingham to lead.

Open Up Drop-Box – put in PDFs of own publications, Powerpoint Presentations.

Short abstract for a special issue of Freshwater Biology (or another suitable journal) by the middle of November 2013.

Circulate spreadsheets – variables, previous data sets available

Possible NERC Large Consortium Grant March 2014

Summer School as part of ITN

## **4. Final programme**

### **FINAL PROGRAMME**

**Monday September 16th 2013**

#### **09.40-12.40 Morning Session:**

09.00-09.20 **Welcome by Convenor – Setting the scene and defining the goals – local arrangements**

**Alexander Milner, University of Birmingham**

09.20-09.40 **Presentation of the European Science Foundation (ESF)**

(Scientific Review Group for Life, Earth and Environmental Sciences)

09.40-10.00 The Milner and Petts model – AASER and beyond – Alexander Milner

10.00 – 10.20 Climate-hydrology-ecology interactions in glacierized river systems - David Hannah

10.20-10.40 Monitoring and projecting change in glacier rivers along the Gulf of Alaska. - Eran Hood

10.40-11.00 *Coffee / Tea Break*

11.00-11.20 Glacial river ecosystems in Iceland – Gísli Már Gíslason

11.20-11.40 Recent studies in the Swiss alpine realm – Christopher Robinson

11.40-12.00 Alpine river ecosystem response to natural and anthropogenic flood pulses (Odenwinkelkees, Austria) – Lee Brown

12.00-12.20 - Towards lower latitudes and higher altitudes: glacier-fed stream ecology in tropical Ecuador – Dean Jacobsen

12.20-12.40 Diurnal cycle amplitude as a quantitative measure of glacial influence in tropical mountain hydrosystems – Sophie Cauvy

12.40-14.00 *Lunch.*

### **Afternoon Session 1400-1800**

14.00-14.20 Links between landscape change and the biogeochemistry of Svalbard rivers – Andy Hodson

14.20-14.40 Biofilms in glacier-fed streams and their preferred ice-cream. Tom Battin

14.40-15.00 Microbial processes on glaciers in Svalbard and the Greenland Ice Sheet. Martyn Tranter

15.00-15.20 Macroinvertebrates from S-Alpine glacial streams: from an ecological to a physiological and molecular approach. Valeria Lencioni

15.20-15.40 Recent studies in High Arctic and Alpine Glacial Rivers – Leo Fureder

15.40-16.00 *Coffee / tea break*

16.00 – 16.20 Kettlehole pond succession at the margin of a retreating glacier. Jón S. Ólafsson

16.20 – 16.40 The Arctic Freshwater Biodiversity Monitoring Plan – John Brittain

16.40 Global Research network; Where and by whom (Plenary discussion)

20.00 - *Dinner*

### **Tuesday September 17<sup>th</sup>**

#### **09.40-12.40 Morning Session:**

9.00 to 9.40 Emerging Themes from yesterday's talks

9.40 to 10.30 Existing Databases

10.30- 11.00 *Coffee*

11.00 – 12.40 Geographical Range and who else to involve

12.40 - 14.00 *Lunch*

#### **Afternoon Session 1400-1700**

Group work – Research Hypotheses to drive network/observatory

Group work – Funding, Publications, Knowledge Transfer

19.00 - *Conference Dinner*



## **Wednesday**

### **09.40-13.00 Morning Session:**

Research Hypotheses  
Measures and approaches – two groups

The synthesis paper – sketch out

13.00 – 14.00 *Lunch*

### **Afternoon Session 1400-1530**

Action Points – Road Map

15.30 - *Workshop Close*

## **5. Final list of participants**

### **Convenor:**

#### **1. Alexander MILNER**

School of Geography, Earth &  
Environmental Sciences  
University of Birmingham  
Edgbaston  
Birmingham B15 2TT  
UK  
[a.m.milner@bham.ac.uk](mailto:a.m.milner@bham.ac.uk)

### **Co-Convenors:**

#### **2. Dean JACOBSEN**

Institute of Biology  
University of Copenhagen  
Helsingorsgade 51  
Hillerod  
3400 Copenhagen  
Denmark  
[Djacobsen@bi.ku.dk](mailto:Djacobsen@bi.ku.dk)

#### **3. David HANNAH**

School of Geography, Earth &  
Environmental Sciences  
University of Birmingham  
Edgbaston  
Birmingham B15 2TT  
UK  
[d.m.hannah@bham.ac.uk](mailto:d.m.hannah@bham.ac.uk)

### **Participants:**

#### **4. Tom BATTIN**

Department of Limnology  
University of Vienna  
Ithanstr 14  
1091 Vienna  
Austria  
[tom.battin@unive.ac.at](mailto:tom.battin@unive.ac.at)

**5. John BRITTAIN**

Zoological Museum  
Freshwater Ecology and Inland Fisheries  
Laboratory  
1 Sargsgatan  
0562 Oslo  
Norway  
[jbr@nve.no](mailto:jbr@nve.no)

**6. Lee BROWN**

School of Geography  
University of Leeds  
University Road  
Leeds LS2 9JT  
UK  
[L.Brown@leeds.ac.uk](mailto:L.Brown@leeds.ac.uk)

**7. Kieran KHAMIS**

School of Geography, Earth &  
Environmental Sciences  
University of Birmingham  
Edgbaston  
Birmingham B15 2TT  
UK

**8. Sophie CAUVY**

Institut de recherche pour le développement  
Le Sextant 44, bd de Dunkerque  
CS 90009 - 13572  
Marseille  
France  
[sophie.cauvy@gmail.com](mailto:sophie.cauvy@gmail.com)

**9. Leo FUREDER**

Department of Ecology  
University of Innsbruck  
Technikerstrasse  
6020 – Innsbruck  
Austria  
[Leopold.Fureder@uibk.ac.at](mailto:Leopold.Fureder@uibk.ac.at)

**10. Gisli GISLASON**

Institute of Life and Environmental Sciences  
University of Iceland Askja  
1S-101 Reykjavik  
Iceland  
[gmg@hi.is](mailto:gmg@hi.is)

**11. Andy HODSON**

Department of Geography  
University of Sheffield  
Sheffield S10 2TN  
UK  
[a.j.hodson@sheffield.ac.uk](mailto:a.j.hodson@sheffield.ac.uk)

**12. Eran HOOD**

Environmental Science and Geography  
University of Alaska Southeast  
11120 Glacier Highway  
Juneau, Alaska 99801  
USA.  
[eran.hood@uas.alaska.edu](mailto:eran.hood@uas.alaska.edu)

**13. Valeria LENCIONI**

Museo delle Scienze  
Via Calepina 14  
I-38122 Trento  
Italy  
[lencioni@mtsn.tn.it](mailto:lencioni@mtsn.tn.it)

**14. Jon OLAFSSON**

Institute of Freshwater Fisheries  
Arleynir 22  
112- Reykjavik  
Iceland  
[jsol@veidimal.is](mailto:jsol@veidimal.is)

**15. Christopher ROBINSON**

EAWAG  
Uberlandstrasse 133  
8600 Dubendorf  
Switzerland  
[Christopher.Robinson@eawag.ch](mailto:Christopher.Robinson@eawag.ch)

**16. Martyn TRANTER**

Bristol Glaciology Centre  
Geographical Sciences  
University of Bristol  
Bristol BS8 1SS  
UK  
[M.Tranter@bristol.ac.uk](mailto:M.Tranter@bristol.ac.uk)

**6. Statistical information on participants;**

The breakdown was as follows;

Males 14, Females 2

Age < 35 = 3; 35-50 = 5; >50 = 8

Countries represented (9); UK (6), Austria (2), Iceland (2) and one representative from Switzerland, Italy, Norway, France, Denmark and the USA.