University of Glasgow

Scottish Freshwater Group
100th Meeting

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

Dr Rhian Thomas, Prof Trevor Hoey, Dr Richard Williams

With thanks to Ed Curley, Elizabeth Clements

Some Definitions…

Fluvial geomorphology - *the study of the interactions between river channel forms and processes at a range of spatial and temporal scales*

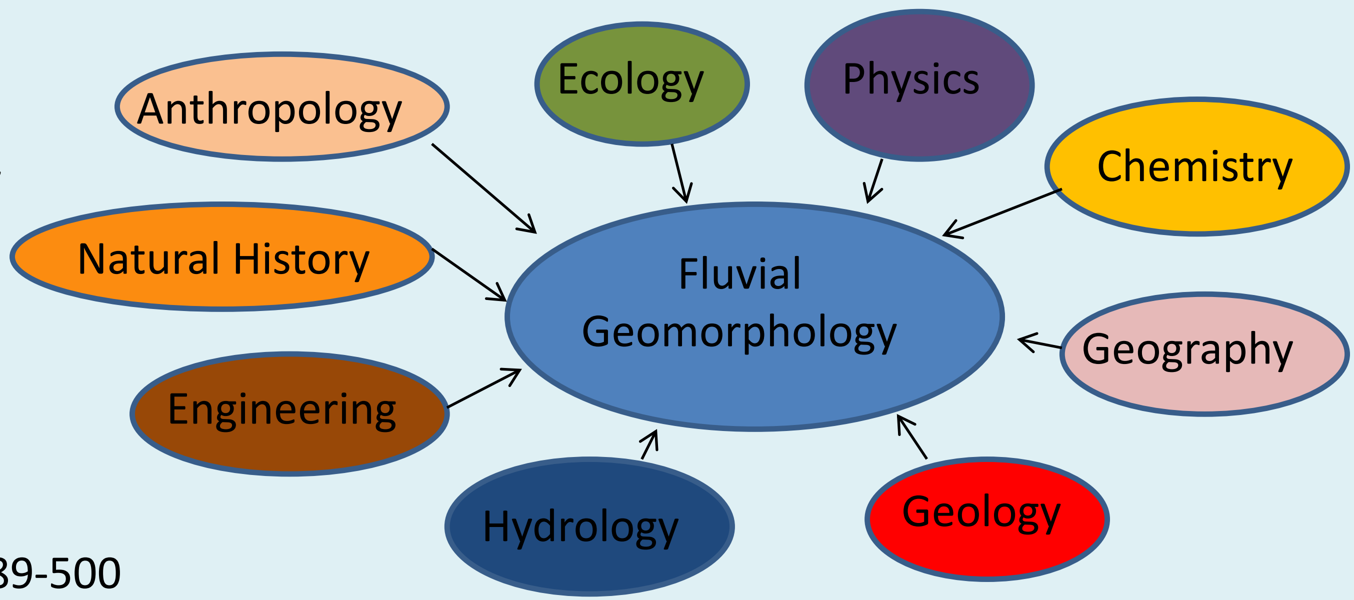
Hydromorphology - *discipline linking hydrology and geomorphology (WFD: hydrological regime, river morphology, river continuity)*

Hydrogeomorphology - *interdisciplinary science that focuses on the interactions and linkages of hydrologic processes with geomorphic processes*

Ecohydrology - *interdisciplinary field studying the interactions between water and ecosystems*

Ecogeomorphology *-study of interactions between organisms and the development of landforms*

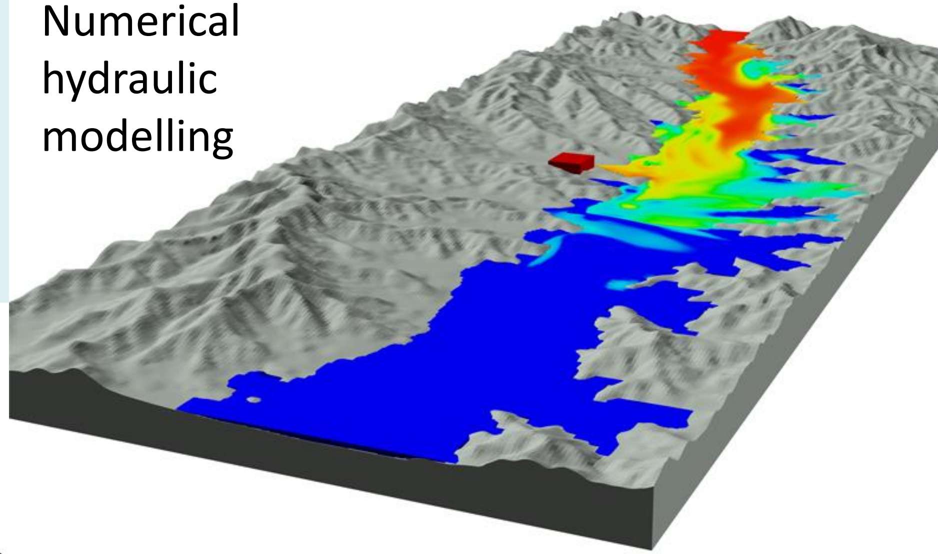
Interdisciplinary nature…



See Piegay et al (2015) Geomorphology 248: 489-500

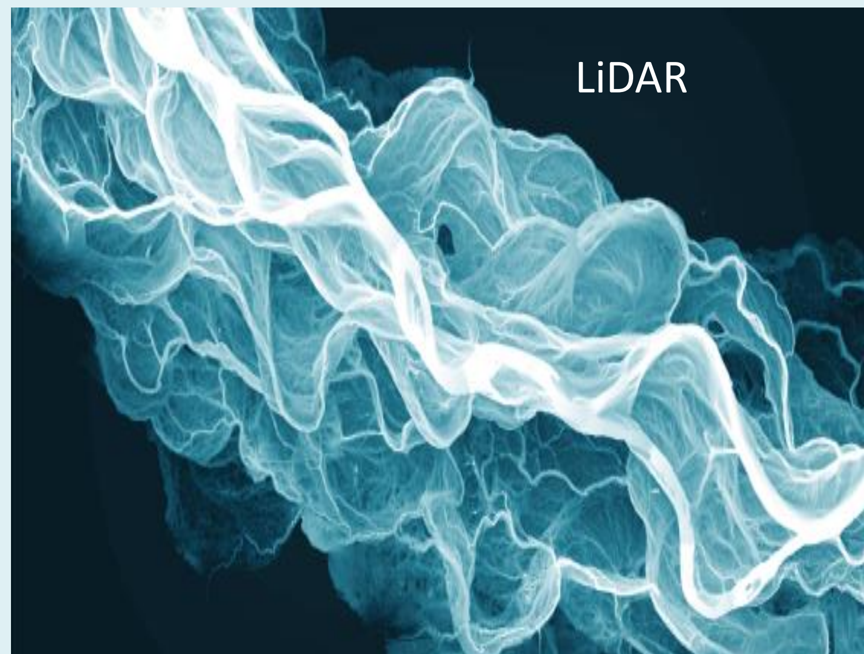
Advances in Technology & Methods

Numerical hydraulic modelling

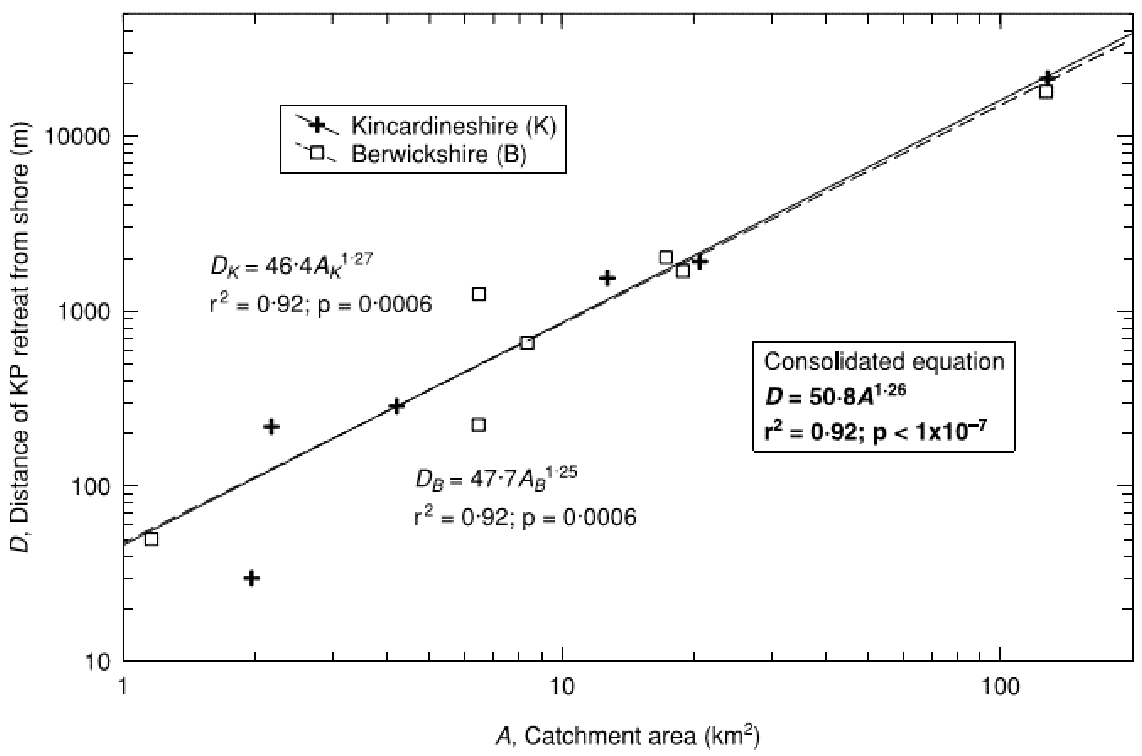


ADCPs to measure velocity

Laser scanning in sedimentological applications

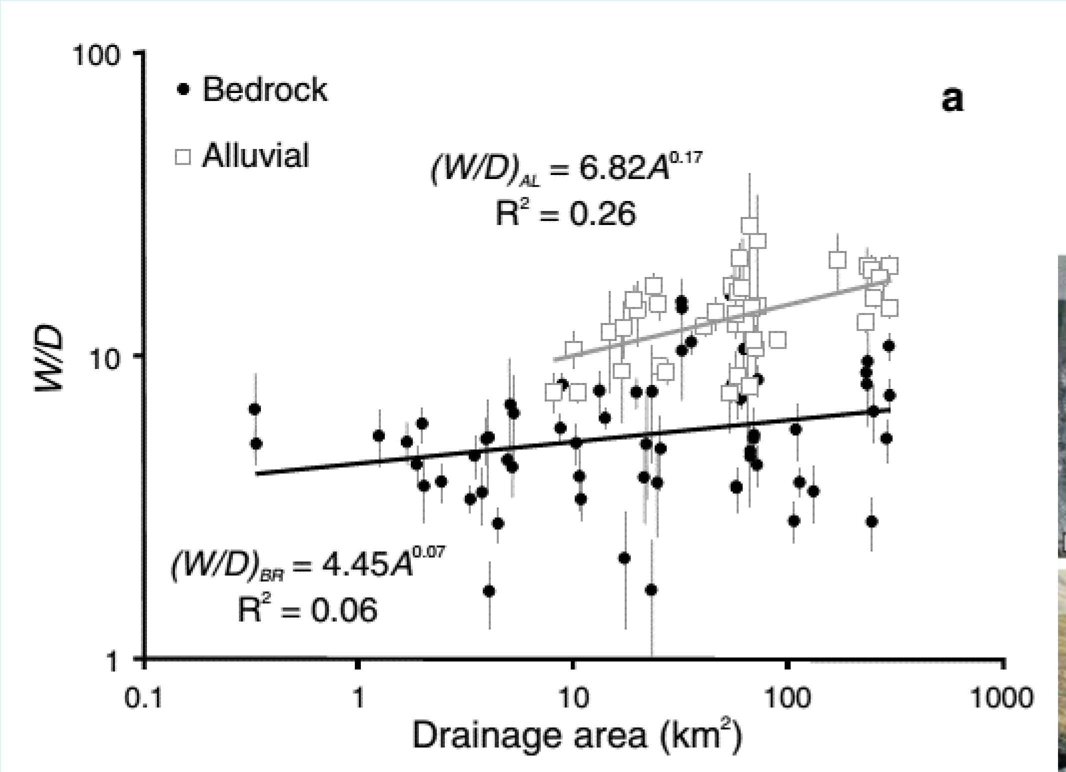


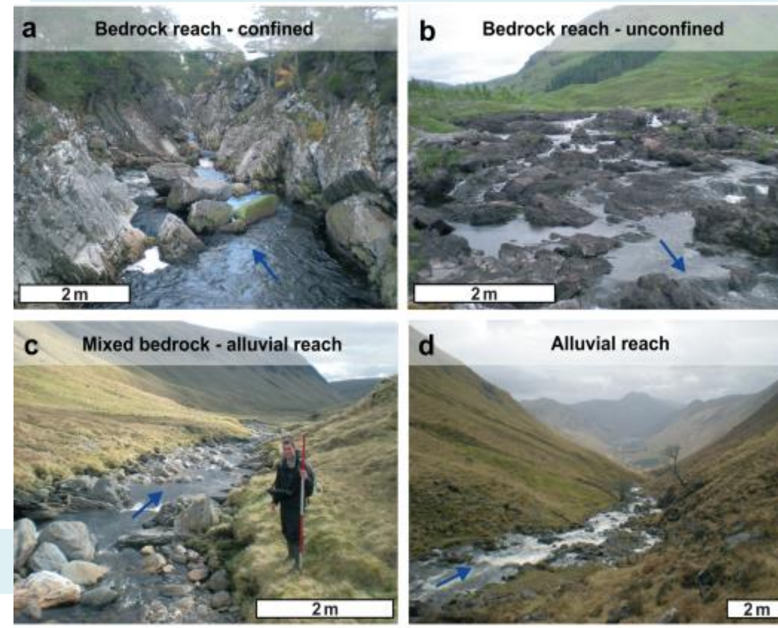
Bedrock channels: millennial scale erosion rates controlled by modern processes

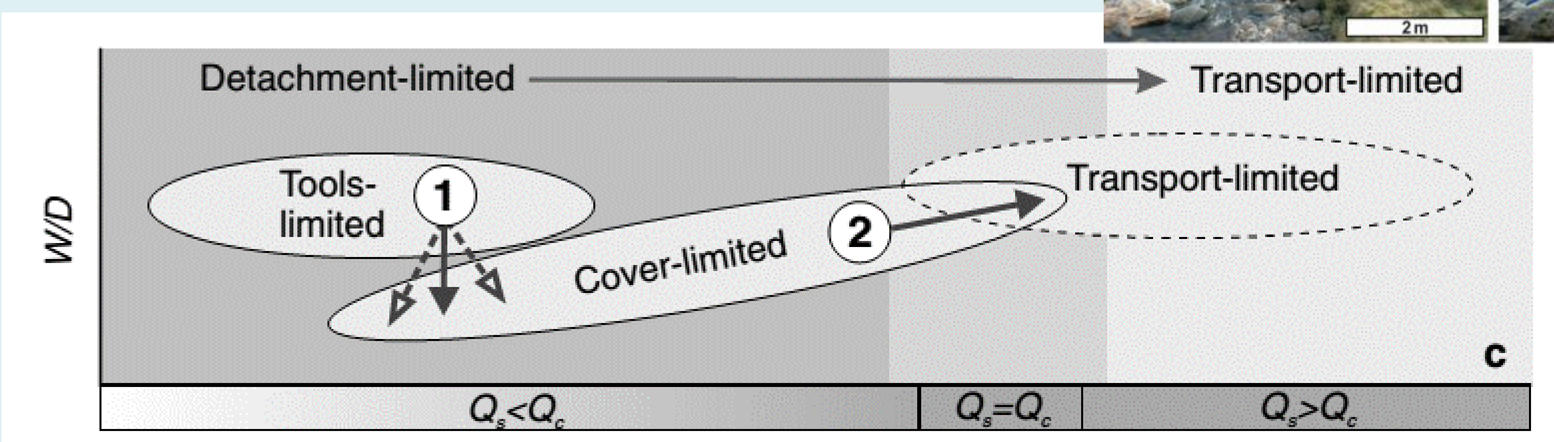


Bishop *et al* 2005, *Earth Surface Processes & Landforms* 30, 767-78

Bedrock (and alluvial) channels: channel form depends on catchment area

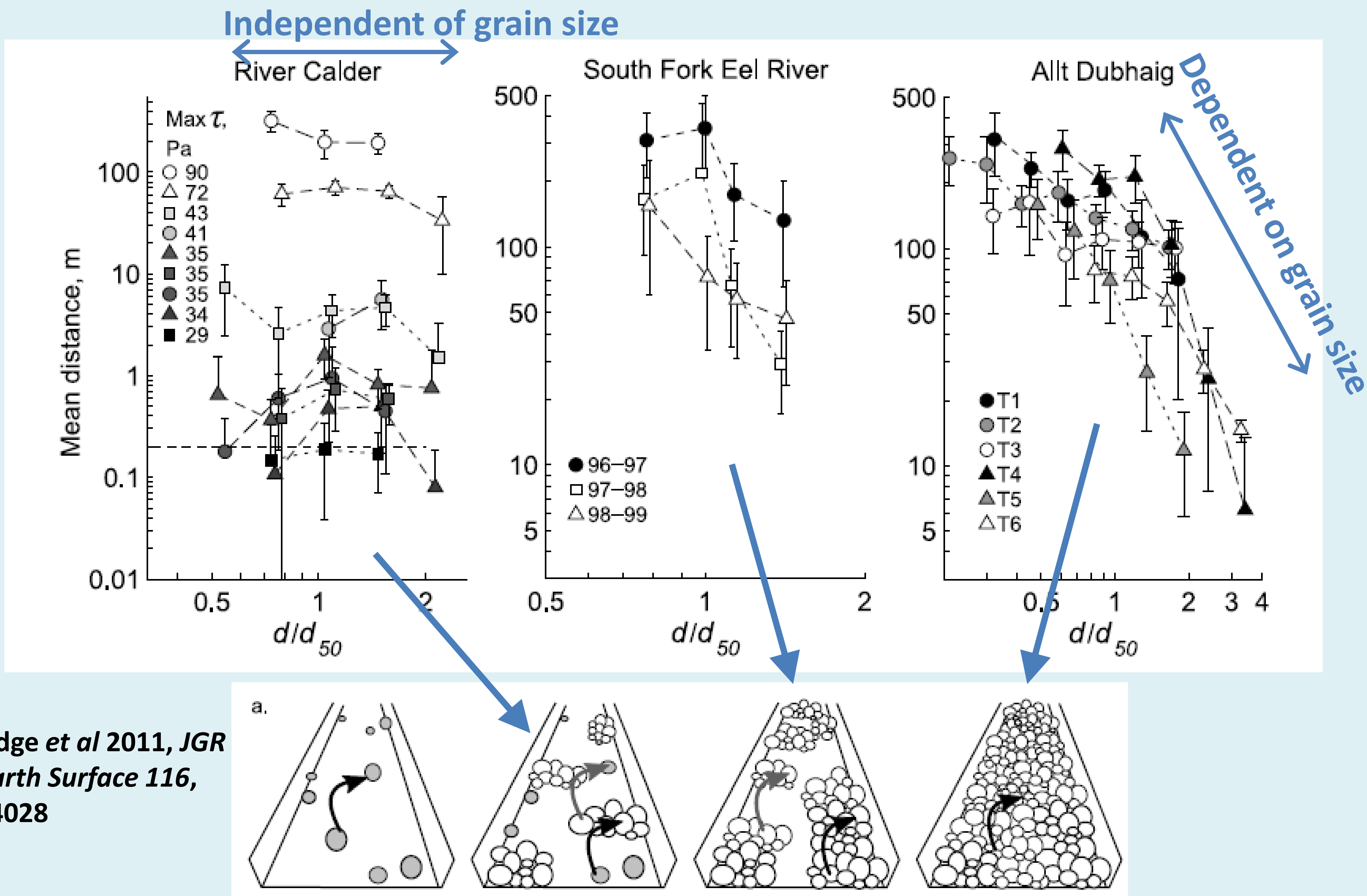




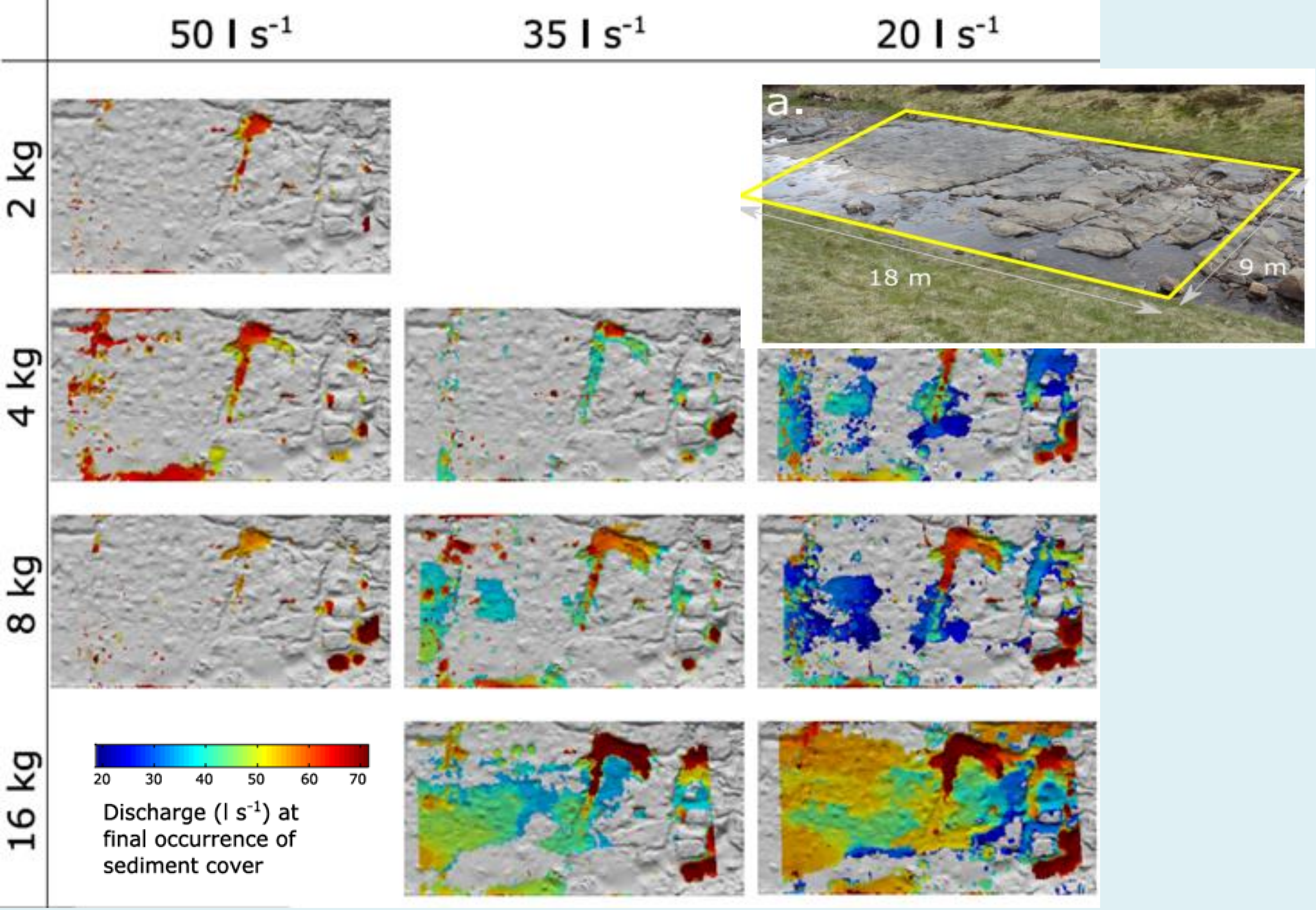


Whitbread *et al* 2015, *JGR - Earth Surface 12*0, 779-98

Bedload transport: sediment movement distance as a function of sediment size (d/d_{50}) and alluvial cover

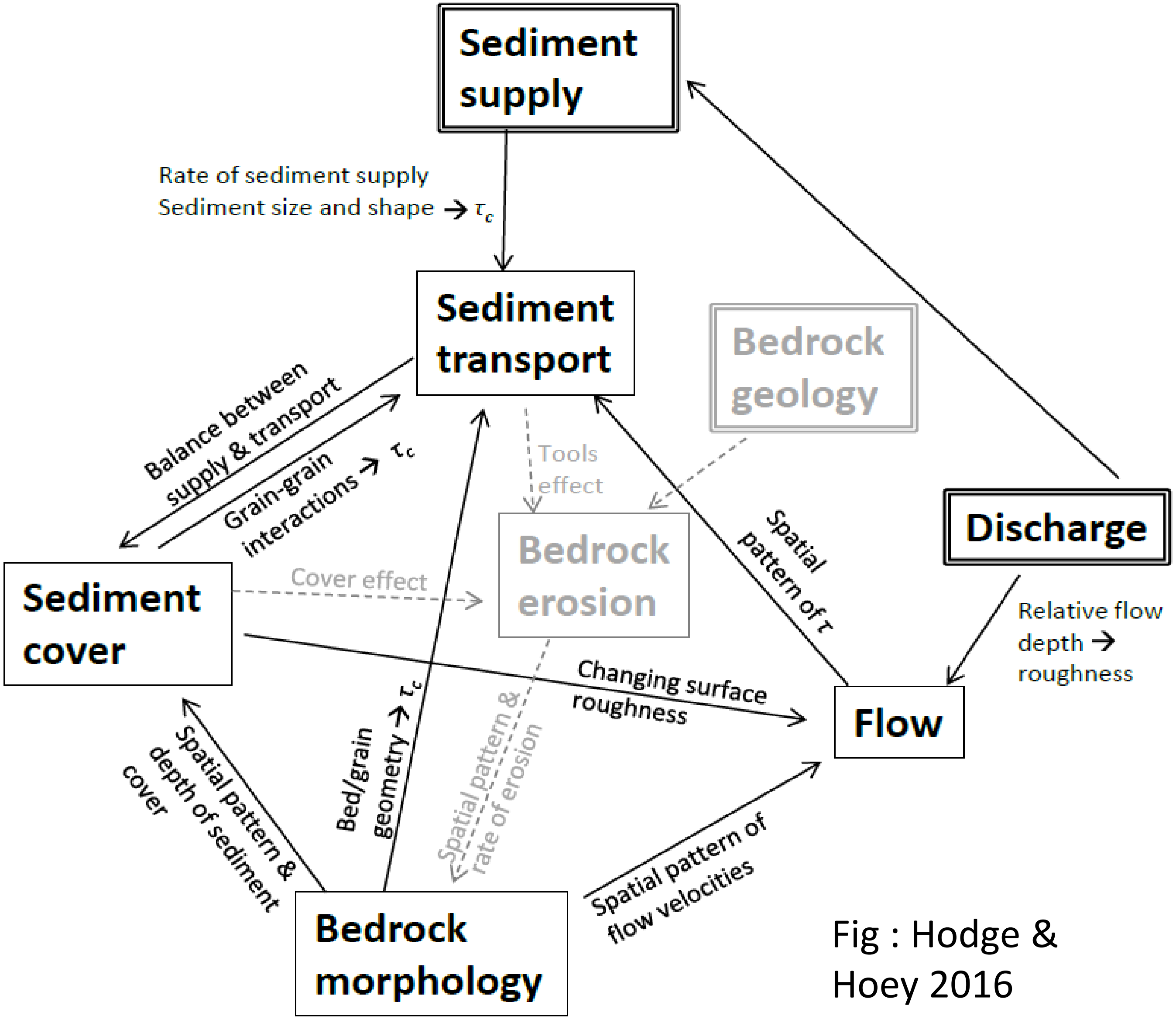


Hodge *et al* 2011, *JGR - Earth Surface 116*, F04028



Hodge & Hoey *et al* 2016, *JGR - Earth Surface*

Bedload transport in bedrock rivers: integrating form and process across timescales



Summary of morphology – hydraulics – transport relationships

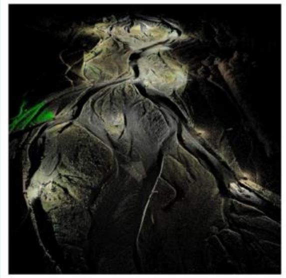
[based on Ashworth & Ferguson, 1986]

Fig : Hodge & Hoey 2016

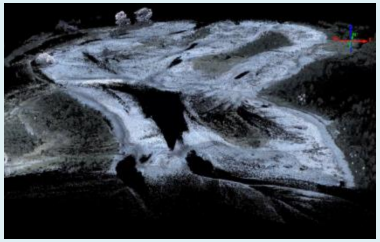
Braided river morphodynamics: monitoring topographic change from high-flow events

Real-Time Kinematic (RTK) GPS	Terrestrial Laser Scanning (TLS)	Mobile Laser Scanning
• Late 1990s • 1,000 to 10,000 survey pts / day	• Late 2000s • 100,000 to 1,000,000 survey pts / day	• Mid 2010s • 100,000 to 1,000,000 survey pts / hour

Brasington et al., 2000, ESPL

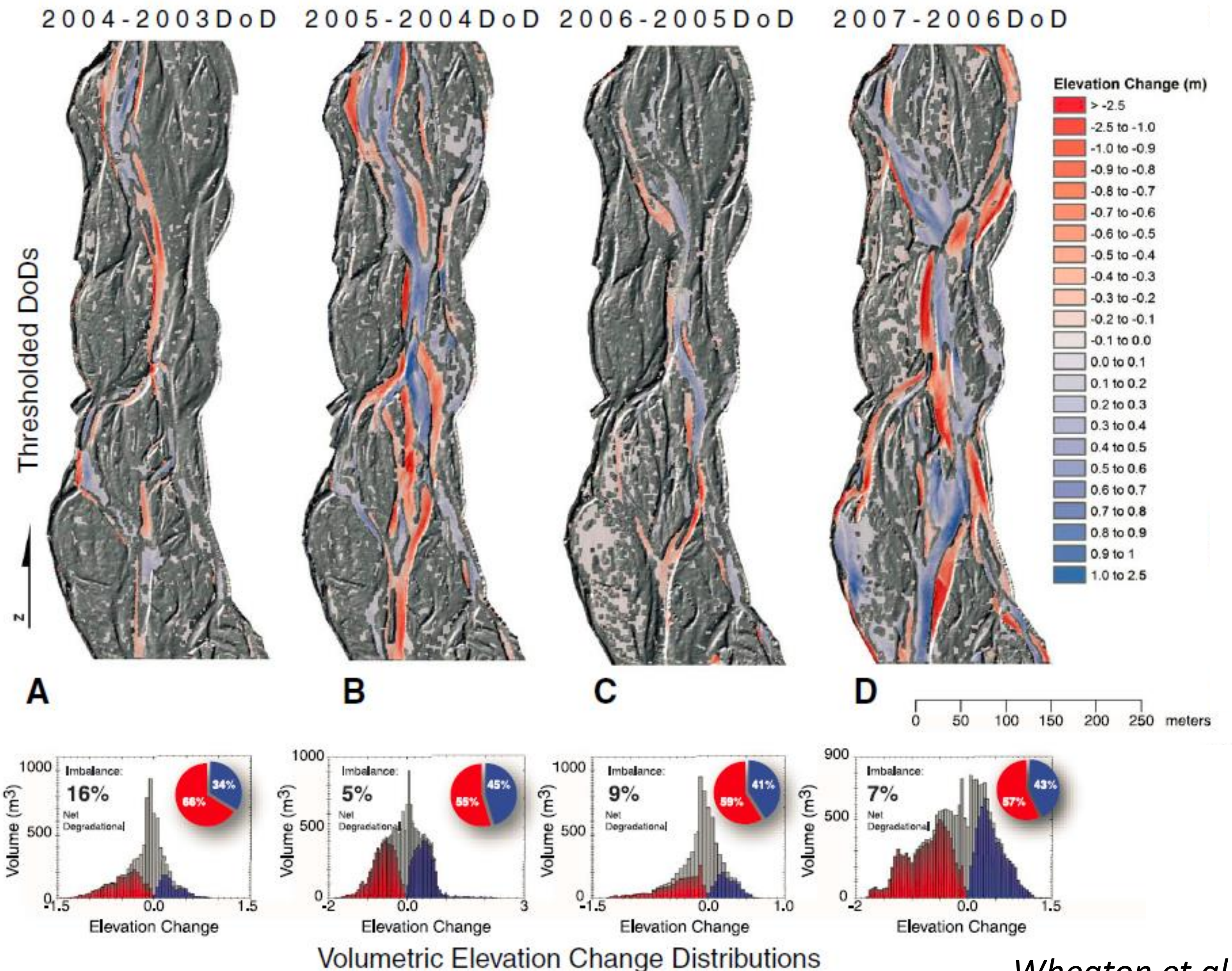


Brasington et al., 2012, WRR



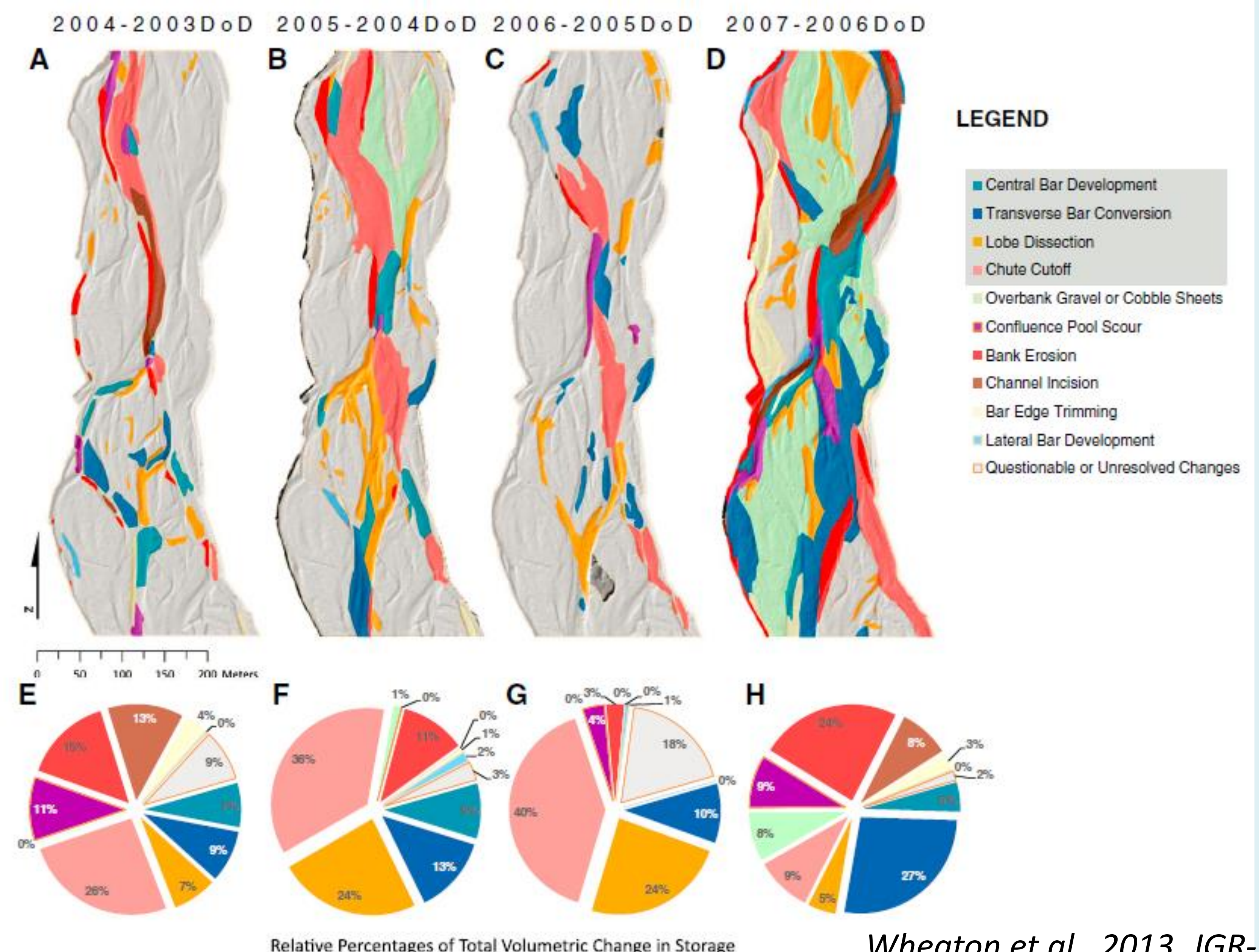
Williams et al., 2017, AGU Abstract EP34B-03

Braided river morphodynamics: quantifying topographic change from high-flow events



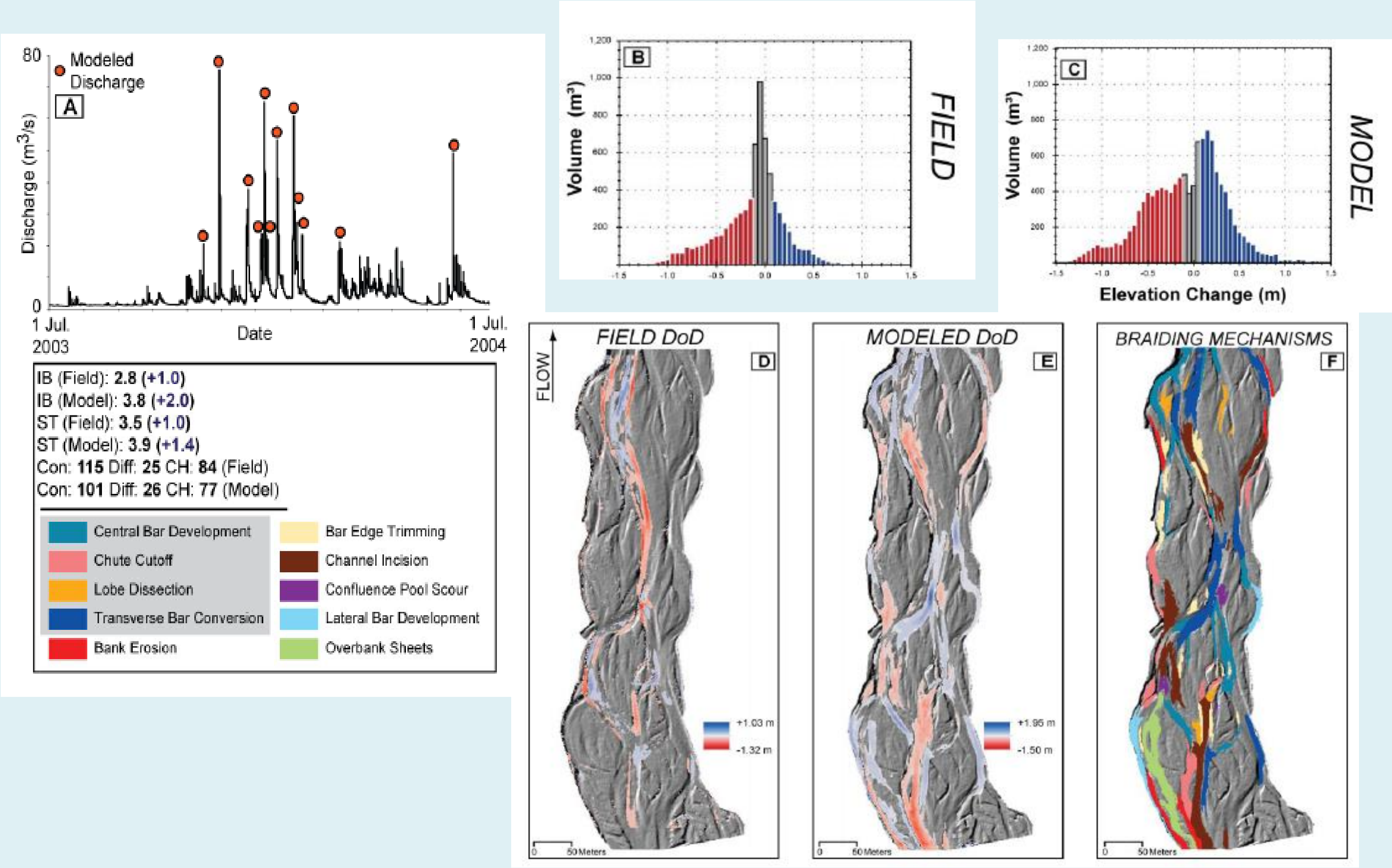
Wheaton et al., 2013, JGR-ES

Braided river morphodynamics: spatial segmentation of sediment budget by braiding mechanisms



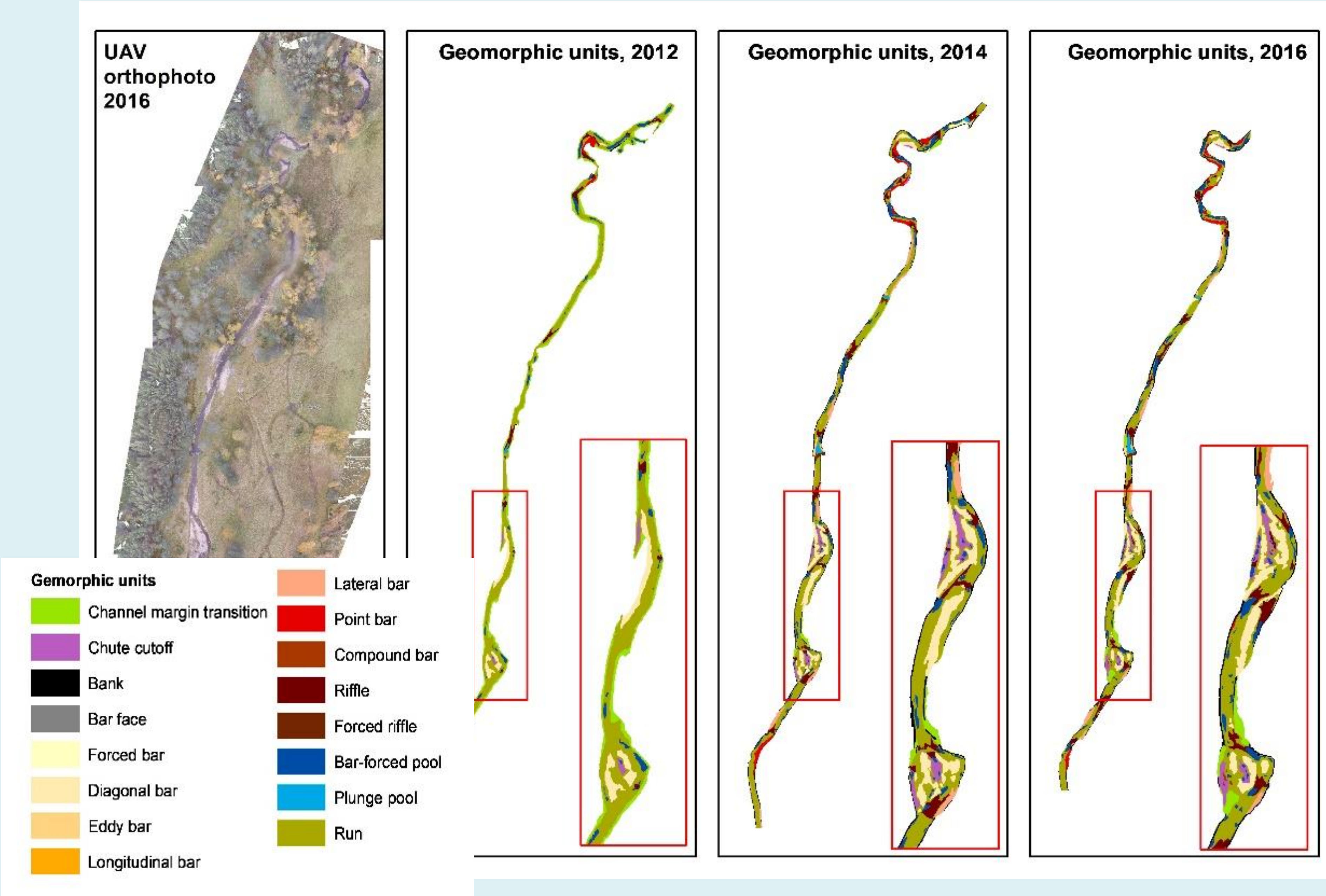
Wheaton et al., 2013, JGR-ES

Braided river morphodynamics: development of morphodynamics models



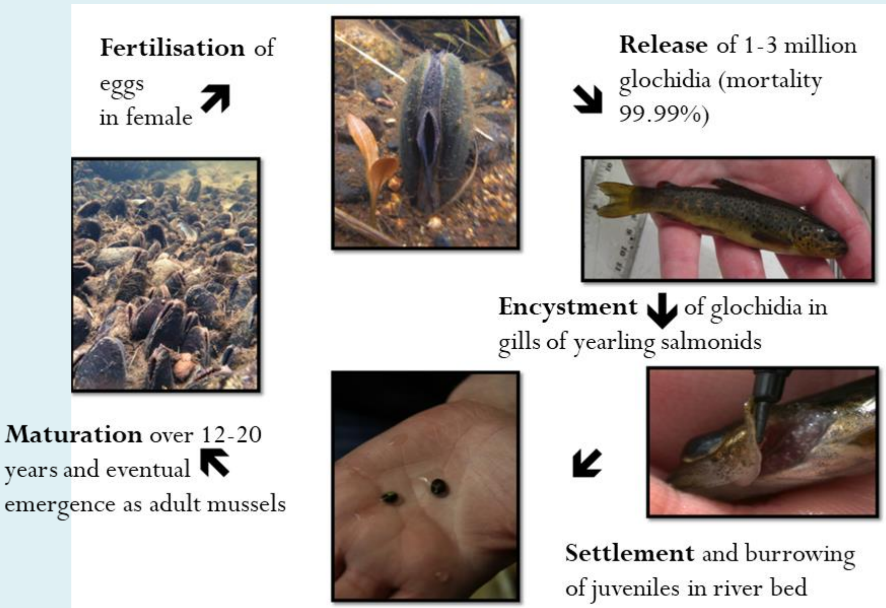
Kasprak, Brasington, Hafen, Williams and Wheaton, in review, ESurf

River restoration:
Giving a gravel-bed river back its freedom space… what do you get?



Ecological Interactions with Flow:

Freshwater Pearl Mussel (*Margaritifera margaritifera*) and host fish relationships



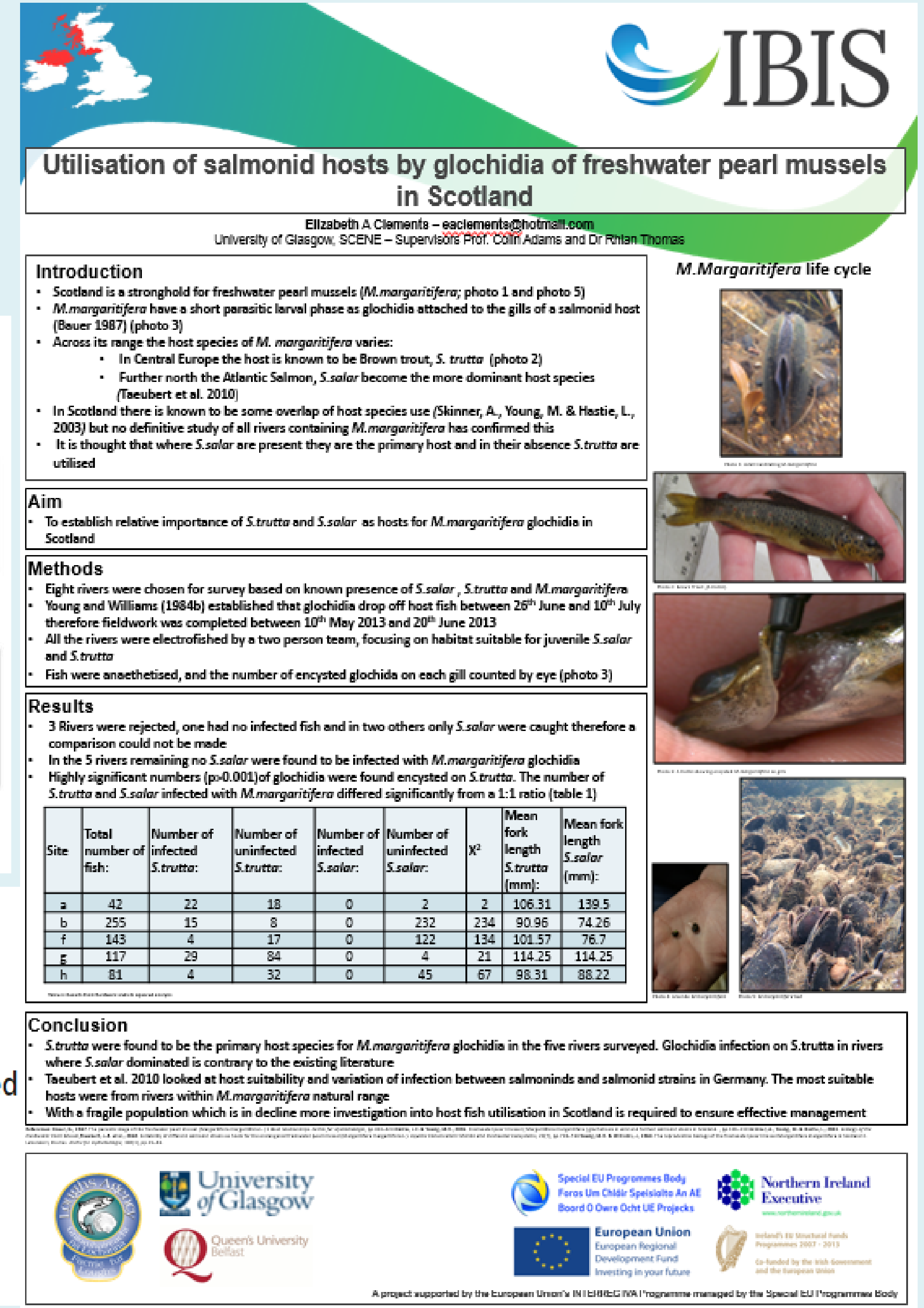
AQUATIC CONSERVATION
Marine and Freshwater Ecosystems

SHORT COMMUNICATION

An investigation of salmonid host utilization by the endangered freshwater pearl mussel (*Margaritifera margaritifera*) in north-west Scotland

Elizabeth A. Clements, Rhian Thomas, Colin E. Adams

First published: 16 April 2018 | https://doi.org/10.1002/aqc.2900



Utilisation of salmonid hosts by glochidia of freshwater pearl mussels in Scotland

Elizabeth A Clements – eaclements@hotmail.com
University of Glasgow, SCENE – Supervisors Prof. Colin Adams and Dr Rhian Thomas

Introduction

- Scotland is a stronghold for freshwater pearl mussels (*M.margaritifera*; photo 1 and photo 5)
- *M.margaritifera* have a short parasitic larval phase as glochidia attached to the gills of a salmonid host (Bauer 1987) (photo 3)
- Across its range the host species of *M. margaritifera* varies:
  - In Central Europe the host is known to be Brown trout, *S. trutta* (photo 2)
  - Further north the Atlantic Salmon, *S.salar* become the more dominant host species (Taeubert et al. 2010)
- In Scotland there is known to be some overlap of host species use (Skinner, A., Young, M. & Hastie, L., 2003) but no definitive study of all rivers containing *M.margaritifera* has confirmed this
- It is thought that where *S.salar* are present they are the primary host and in their absence *S.trutta* are utilised

M.Margaritifera life cycle

Aim

- To establish relative importance of *S.trutta* and *S.salar* as hosts for *M.margaritifera* glochidia in Scotland

Methods

- Eight rivers were chosen for survey based on known presence of *S.salar*, *S.trutta* and *M.margaritifera*
- Young and Williams (1984b) established that glochidia drop off host fish between 26th June and 10th July therefore fieldwork was completed between 10th May 2013 and 20th June 2013
- All the rivers were electrofished by a two person team, focusing on habitat suitable for juvenile *S.salar* and *S.trutta*
- Fish were anaethetised, and the number of encysted glochida on each gill counted by eye (photo 3)

Results

- 3 Rivers were rejected, one had no infected fish and in two others only *S.salar* were caught therefore a comparison could not be made
- In the 5 rivers remaining no *S.salar* were found to be infected with *M.margaritifera* glochidia
- Highly significant numbers (p<0.001)of glochidia were found encysted on *S.trutta*. The number of *S.trutta* and *S.salar* infected with *M.margaritifera* differed significantly from a 1:1 ratio (table 1)

Site	Total number of fish:	Number of infected *S.trutta*:	Number of uninfected *S.trutta*:	Number of infected *S.salar*:	Number of uninfected *S.salar*:	X^2	Mean fork length *S.trutta* (mm):	Mean fork length *S.salar* (mm):
a	42	22	18	0	2	2	106.31	139.5
b	255	15	8	0	232	234	90.96	74.26
f	143	4	17	0	122	134	101.57	76.7
g	117	29	84	0	4	21	114.25	114.25
h	81	4	32	0	45	67	98.31	88.22

Conclusion

- *S.trutta* were found to be the primary host species for *M.margaritifera* glochidia in the five rivers surveyed. Glochidia infection on S.trutta in rivers where *S.salar* dominated is contrary to the existing literature
- Taeubert et al. 2010 looked at host suitability and variation of infection between salmoninds and salmonid strains in Germany. The most suitable hosts were from rivers within *M.margaritifera* natural range
- With a fragile population which is in decline more investigation into host fish utilisation in Scotland is required to ensure effective management

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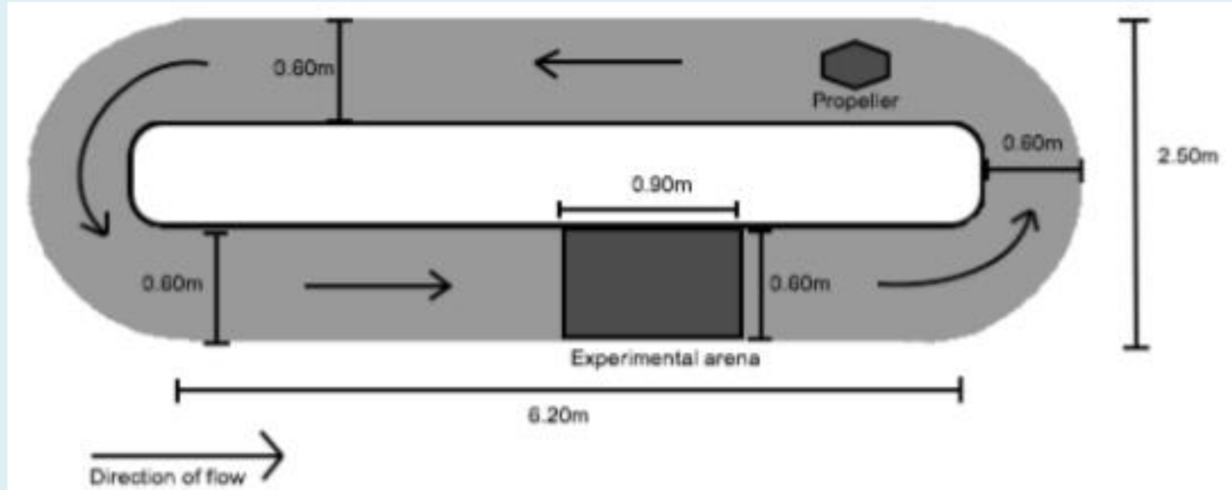
Ecological Interactions with Flow: Behavioural Response of Mussels to Changing Flow Regimes



3 Flow Regimes:
- **Constant** flow (0.231 ms^{-1})
- **Rapidly increasing** flow (up to 0.697 ms^{-1})
- **Gradually increasing** flow (from 0.231 ms^{-1} increased incrementally every 30 minutes until 0.0697 ms^{-1})

See Thompson et al (2016) River Research & Applications, 32, 1179-1186
Clements (2015) Unpublished MRes Thesis
Clements, Thomas, Adams & Stephen (in prep)

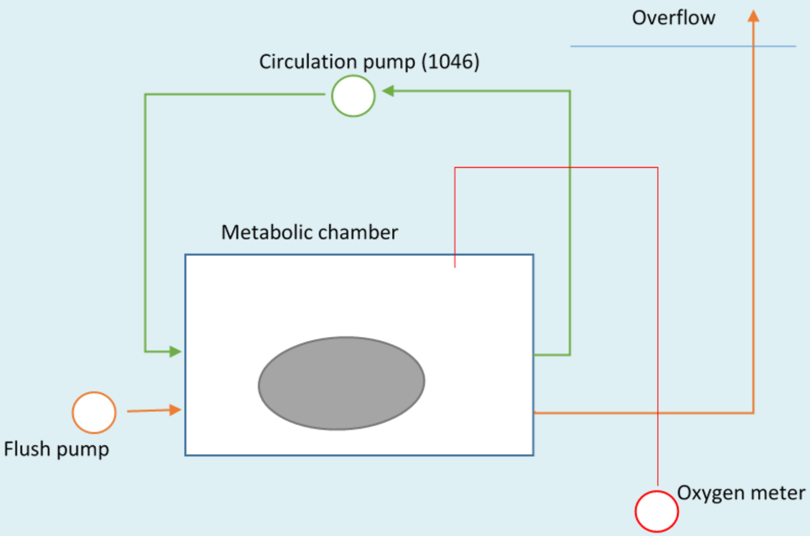
Results:
M. margaritifera bury deeper and faster in gradually and rapidly increasing flow compared with a constant flow regime over the same period of time

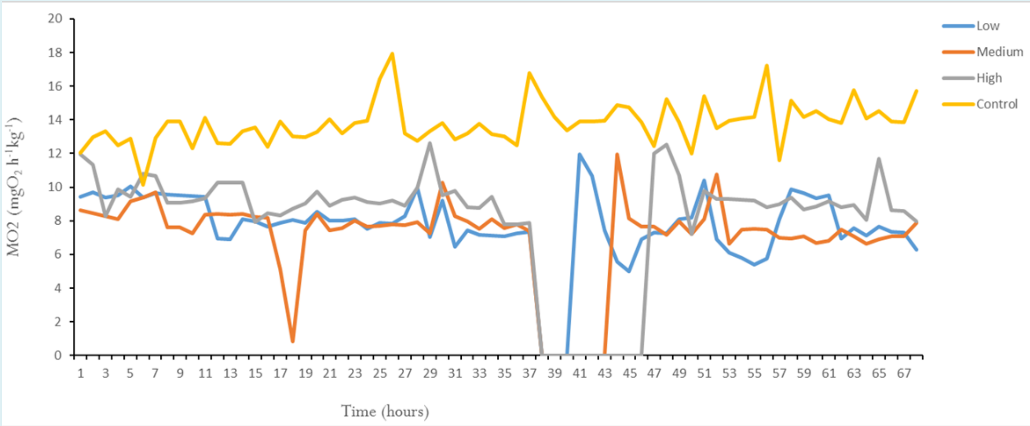
Wash out rates of mussels:
Rapidly increasing flow = 78%
Gradually increasing flow = 32%

Ecological Interactions with Flow: Mussels on the Move…

Ecological Interactions with Flow: Stress Studies

Aim: Examine the behavioural and physiological response of mussels to turbidity and aerial exposure





Method: Intermittent respirometry to monitor metabolic rate and time lapse footage to capture behaviour

Ed's drawdown experiments examining mussel response

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Conclusions

Importance of catchment-scale approaches to inform river management, encompassing hydrology, geomorphology and ecology interactions

Inherent variability in river systems

Flow and sediment regimes control channel change over a range of scales

Complex ecological responses to flow regimes

Awareness that available database is biased toward relatively unstable, changing sites and may not reliably reflect the behaviour of rivers across Scotland as a whole

Human intervention in the workings of river systems, both indirectly and directly, has produced a situation in which many Scottish rivers look and behave significantly differently from their 'natural' conditions

Advancing techniques and improving and extending data sources help to improve understanding