Spatially-nested hierarchical geomorphic controls on salmonid spawning habitat

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Talk Outline

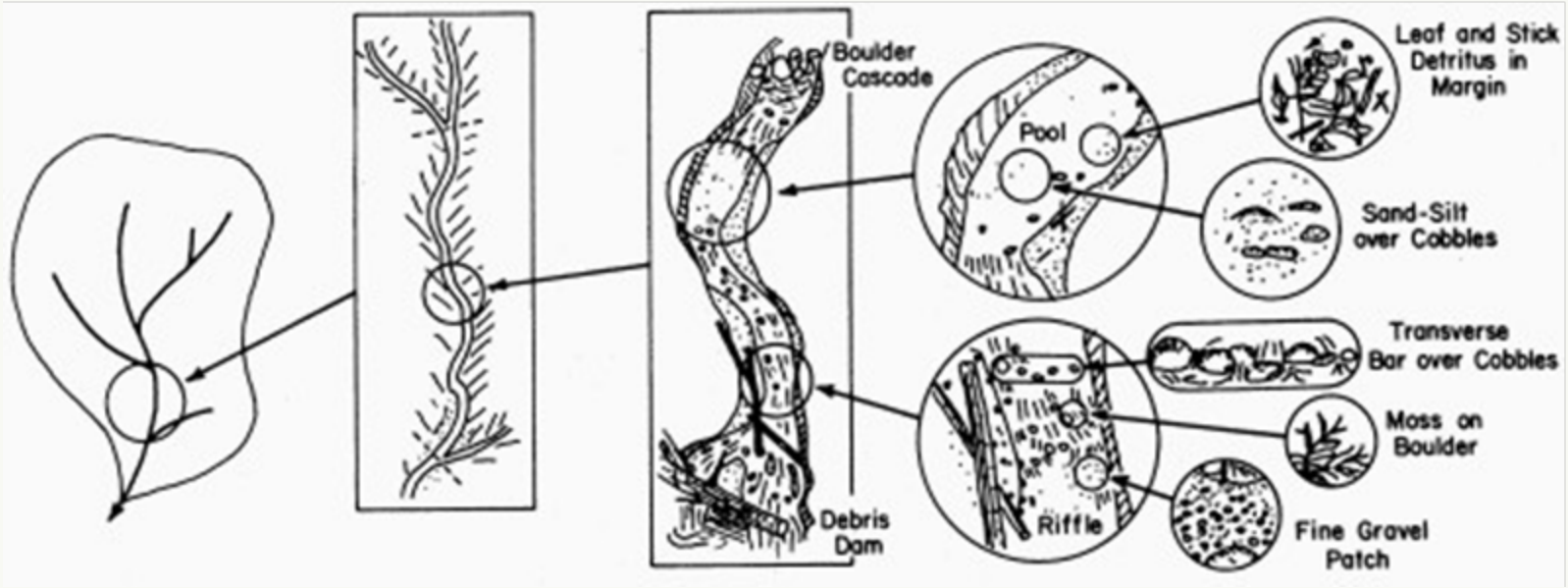
- Introduction – hierarchical organisation of rivers systems and physical controls on channel morphology
- Watershed – reach scale analysis: channel morphology and flow regime
- Morphological unit (meso) scale analysis: channel morphology and ‘energy regime’
- Micro-scale analysis: detailed hydraulic and sedimentary characteristics
- Linking between scales: the benefit of modelling

Introduction: why link physical river condition ('hydromorphology') to ecology?

- **Water Framework Directive:** provide defensible benchmarks of 'high ecological status' in order to define 'good ecological status' targets.
- **Habitats Directive:** full understanding of habitat requirements of key SAC-defining species required.
- **River restoration:**
  - objectively consider ecological requirements rather than design based on subjective aesthetic appearance.
  - set appropriate site-specific restoration within broader 'geomorphic regime' of the river system.

Introduction: concept of nested spatial hierarchies in fluvial systems

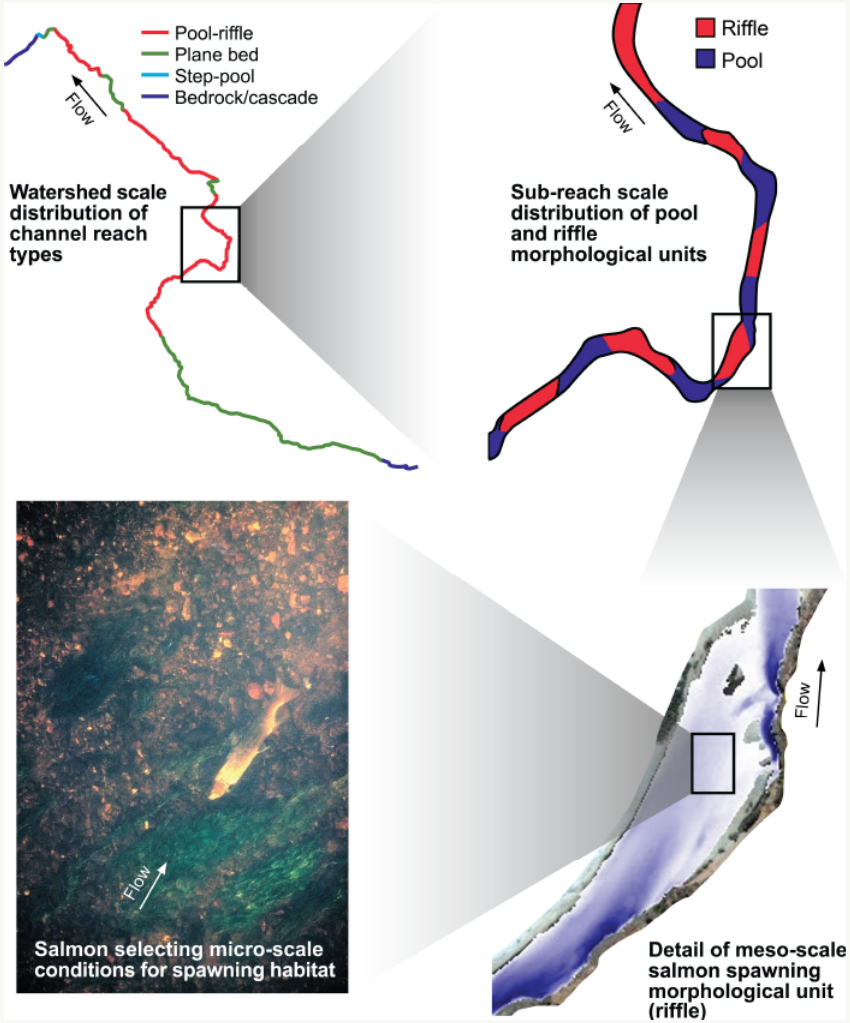
Catchment (>1000w)	Segment (100-1000w)	Reach (5-100w)	Morphological unit (0.1-5w)	Biotope/ hydraulic unit/ microhabitat (0.001-10w)



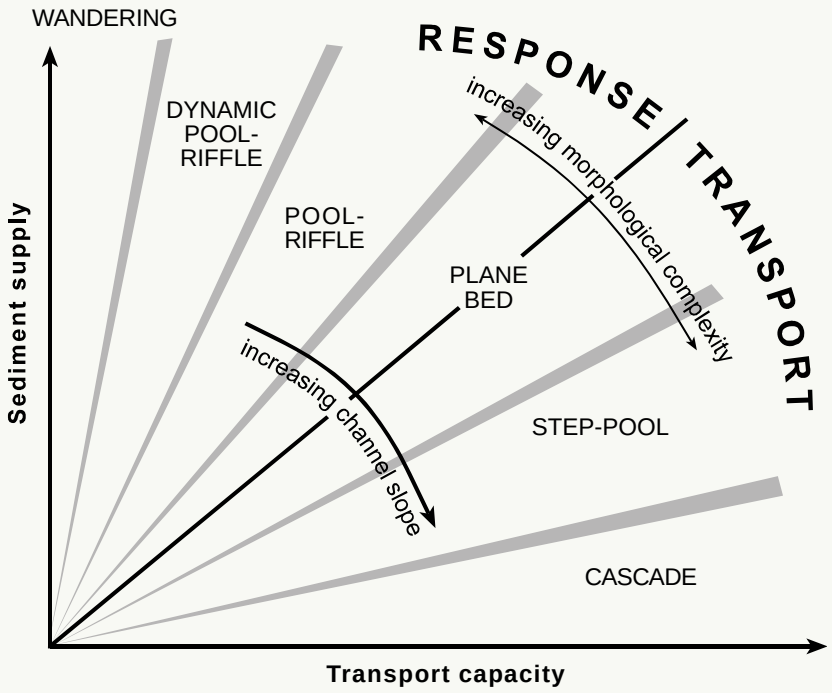
e.g. pool-riffle, plane bed

e.g. run, pool, lateral bar, riffle

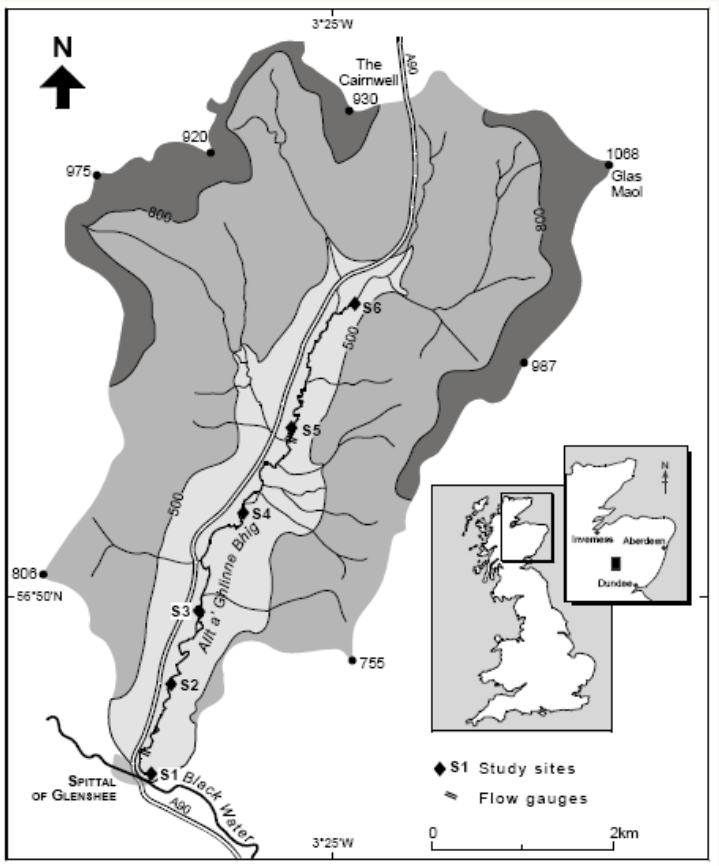
Introduction: spatial scales relevant to salmonid spawning habitat



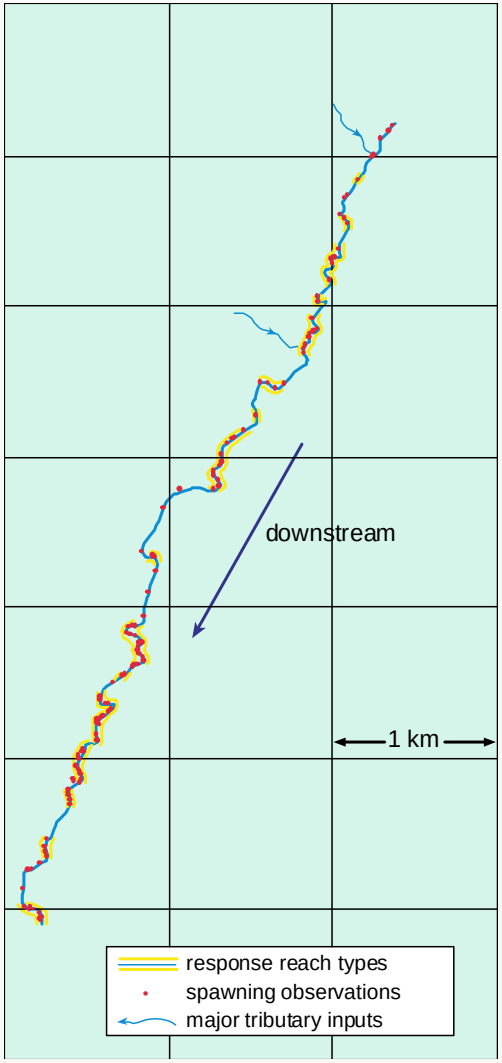
Introduction: controls on reach scale channel morphology

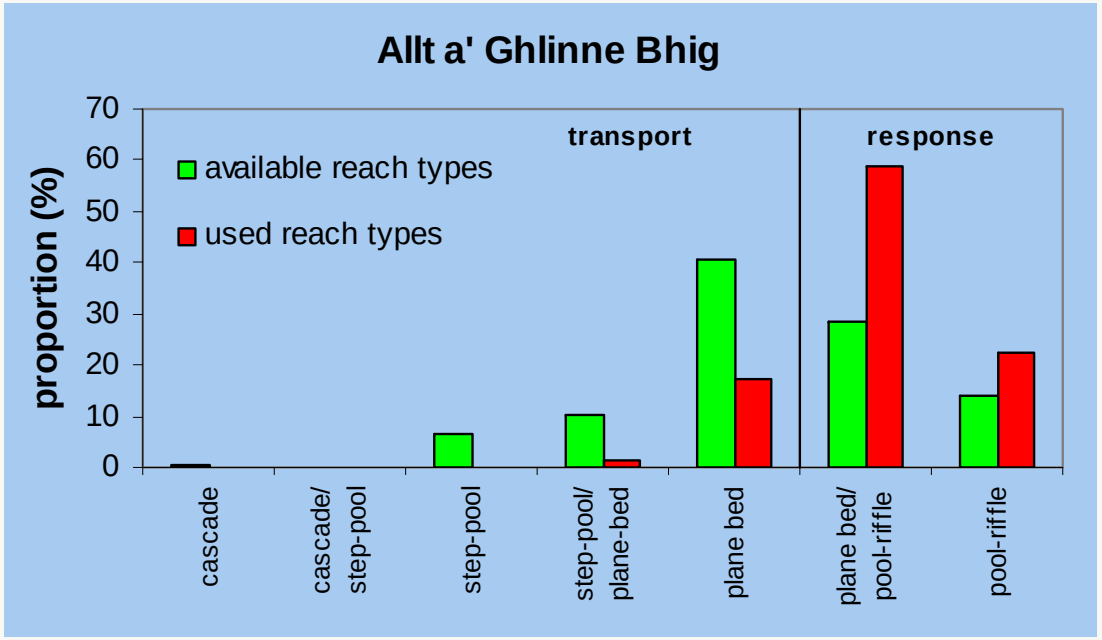


Allt a' Ghlinne Bhig, Upper Tay

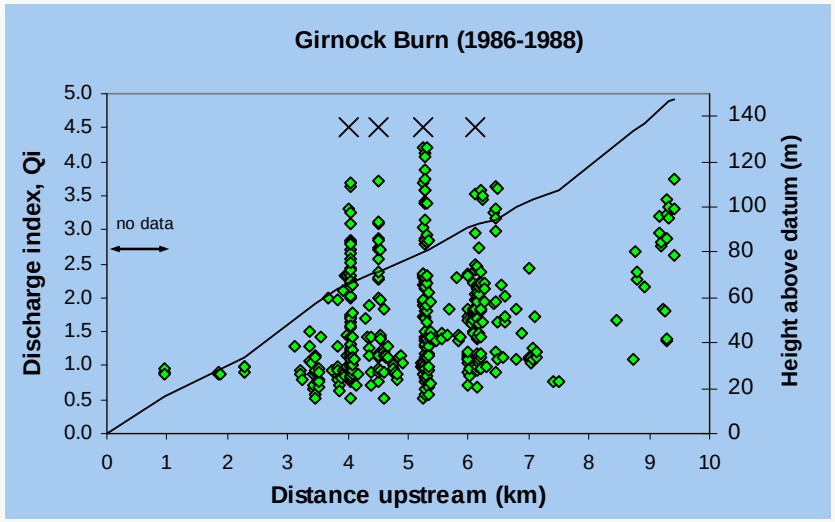


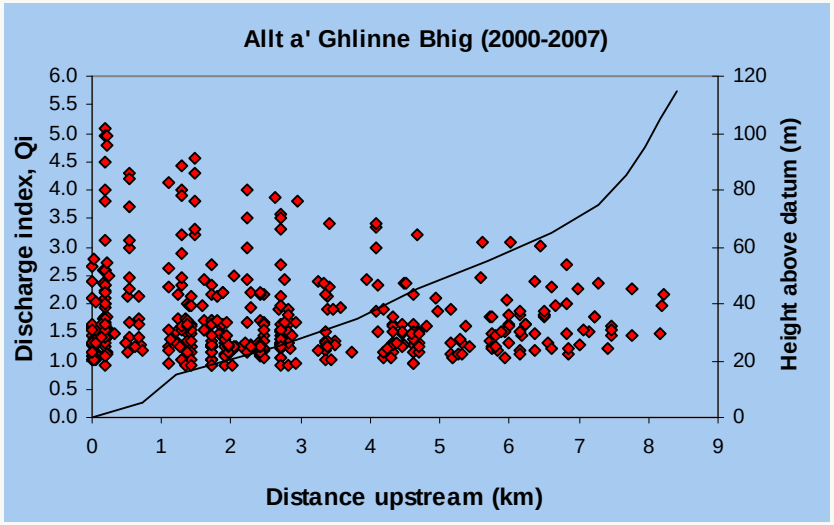
Reach scale analysis

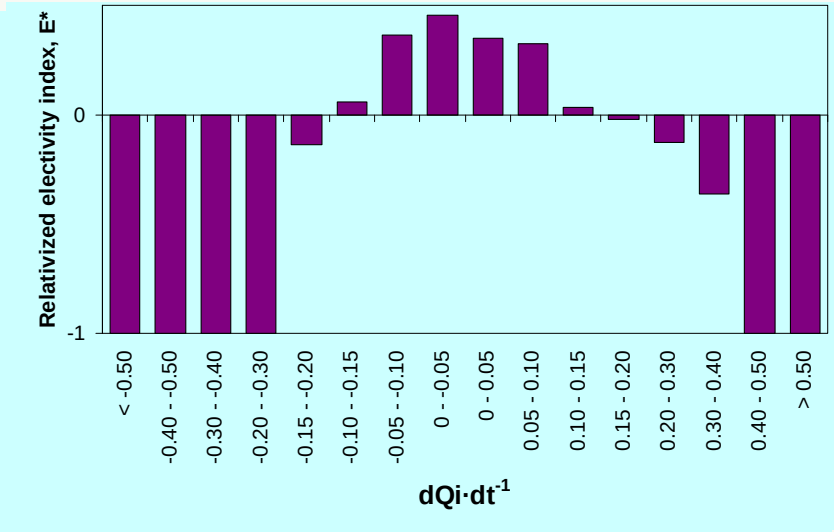


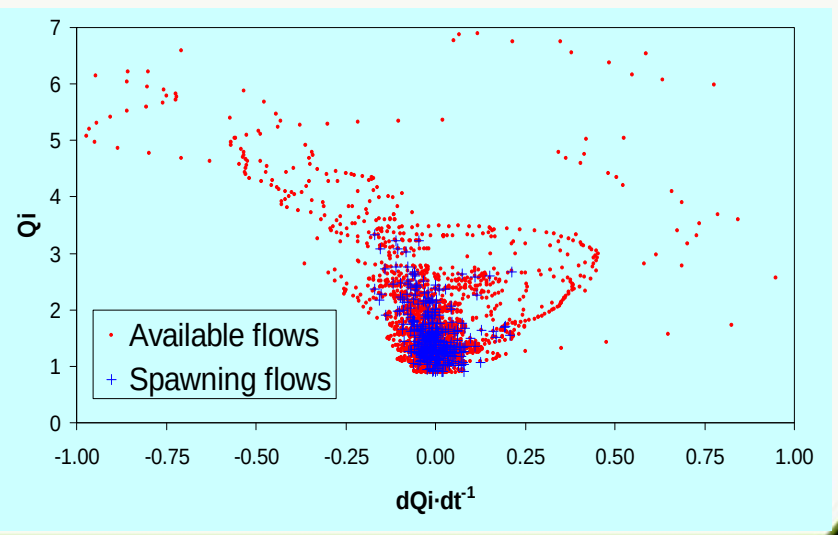


Broad-scale discharge use by spawning Atlantic salmon

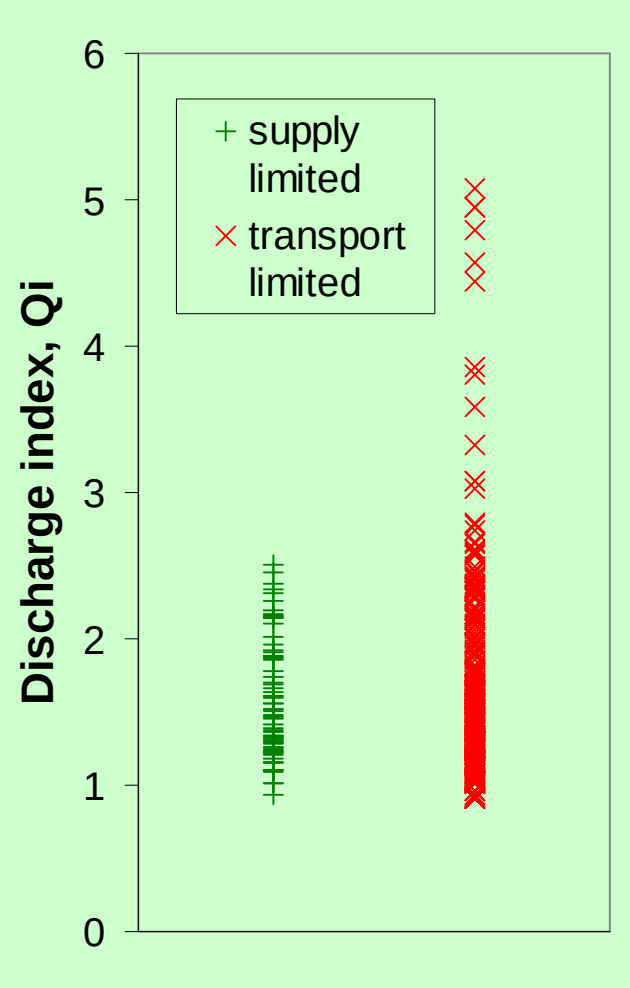


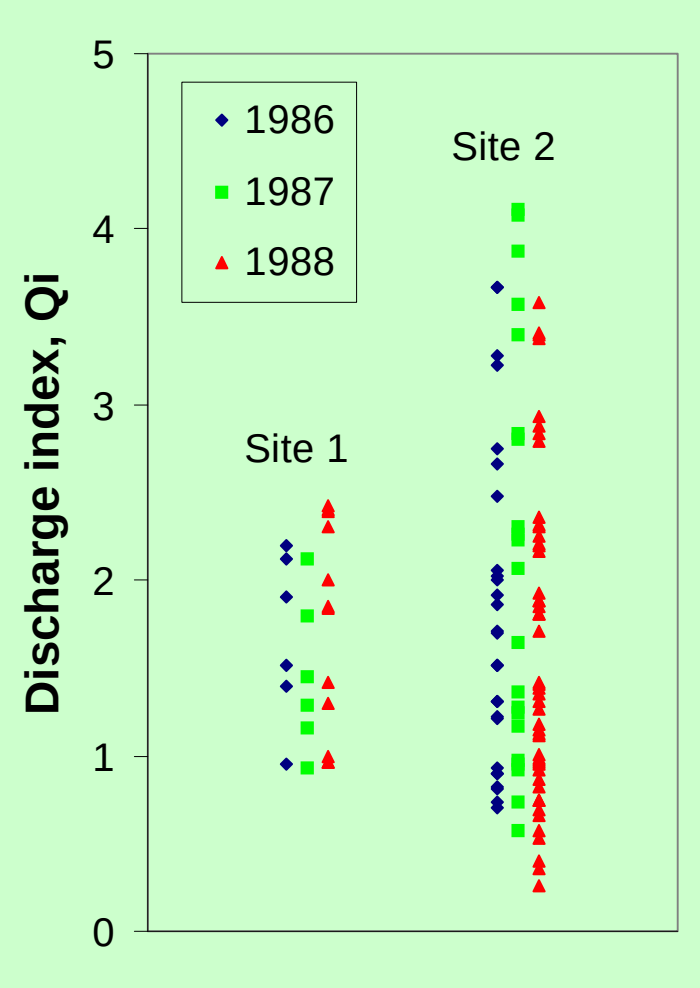






Linking reach-scale channel morphology and discharge use by spawning Atlantic salmon





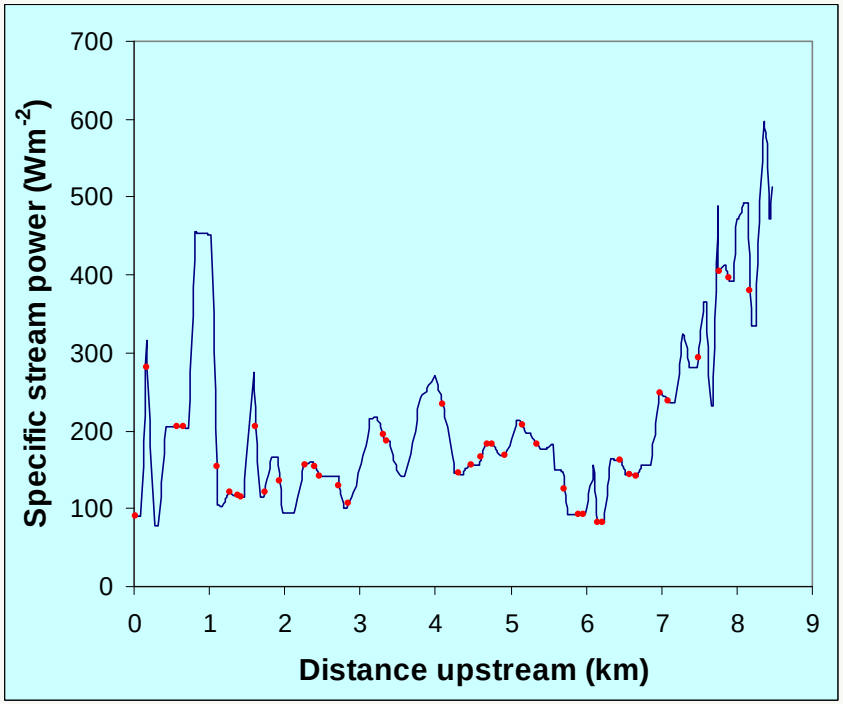
Morphological unit/ meso-scale analysis

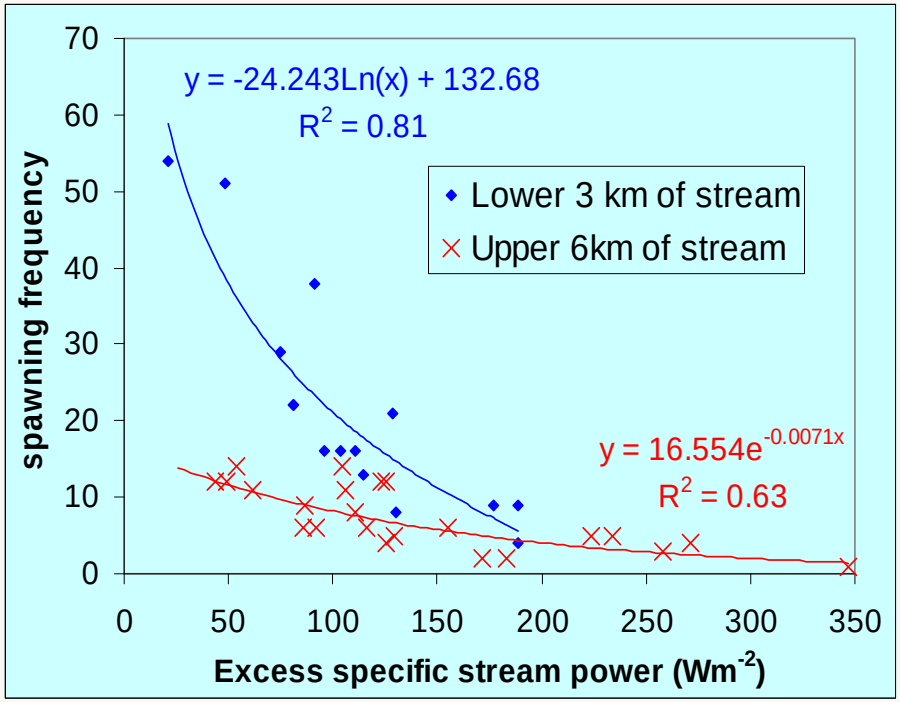
- **Linking reach scale patterns to micro-habitat use.**

Morphological unit scale analysis: specific stream power

- Specific stream power: $\omega = \frac{\rho g Q S}{w}$

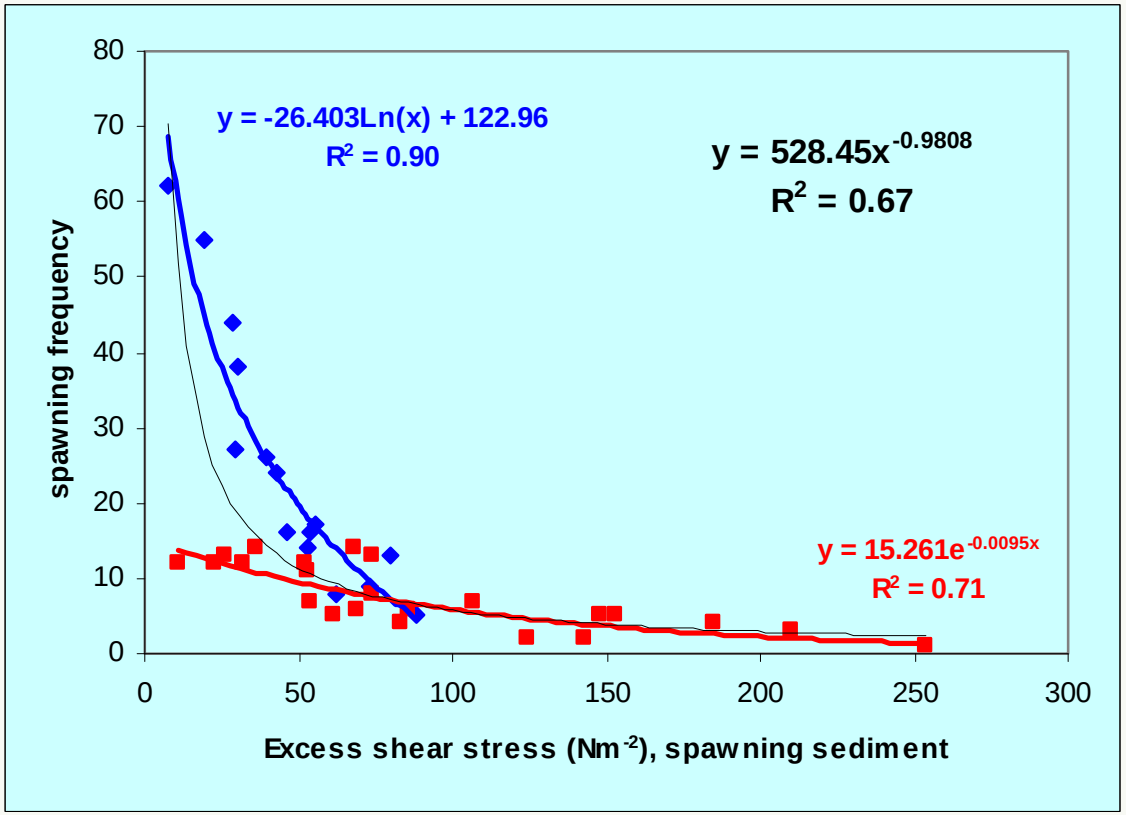
(**variables**: Q = water discharge, S = slope, w = channel width)



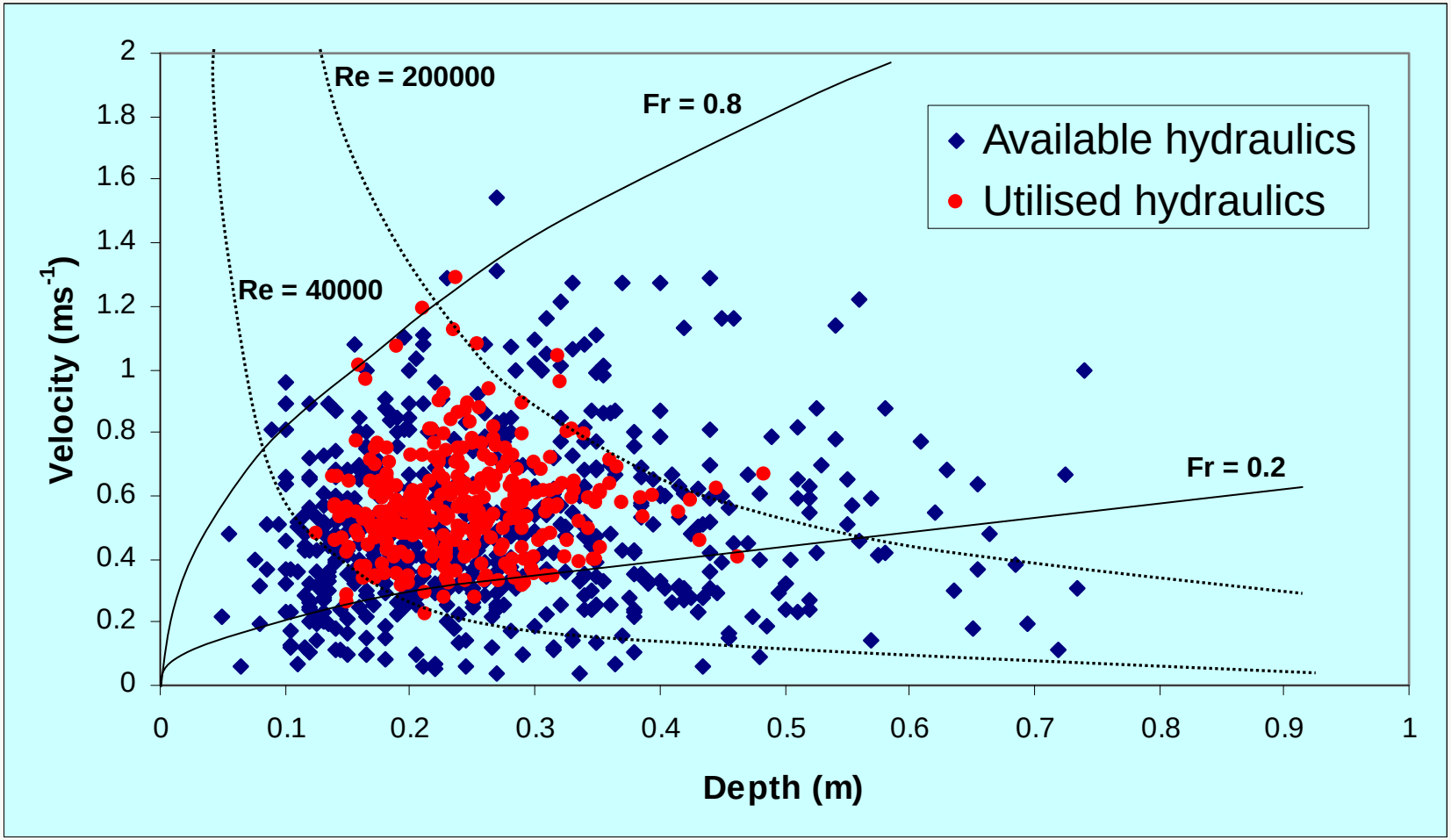


Morphological unit scale analysis: excess shear stress

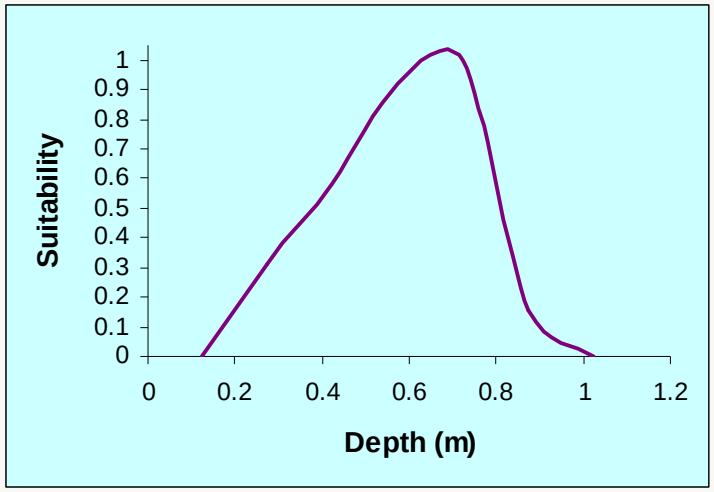
$$\text{shear stress} = \frac{\textit{specific stream power}}{\textit{mean velocity}}$$

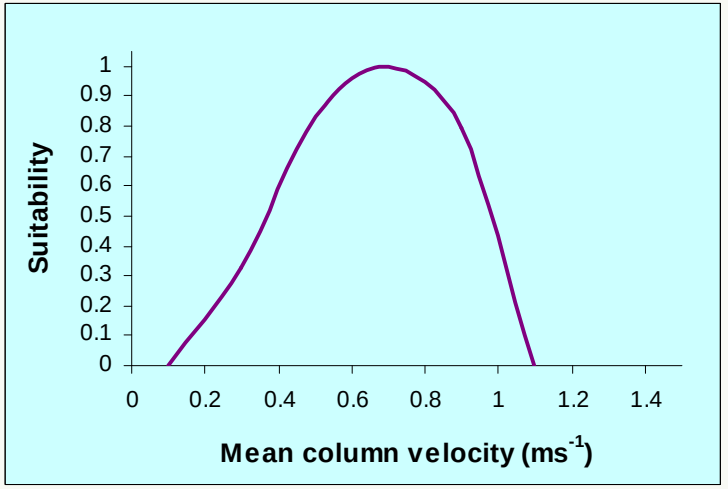


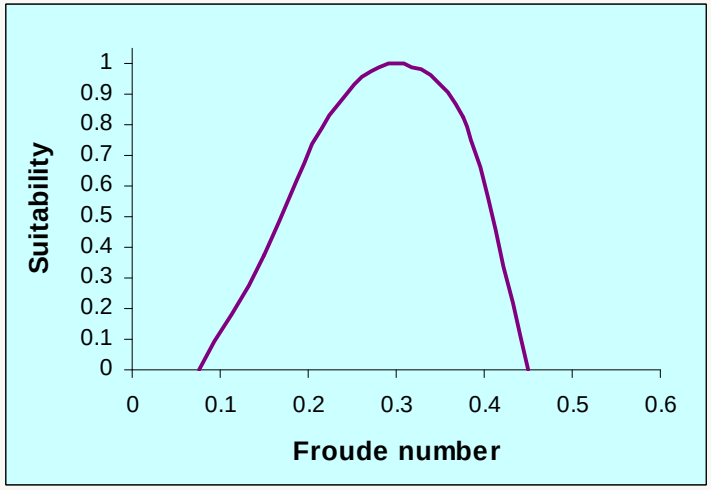
Characterisation of micro-habitat use by spawning salmonids

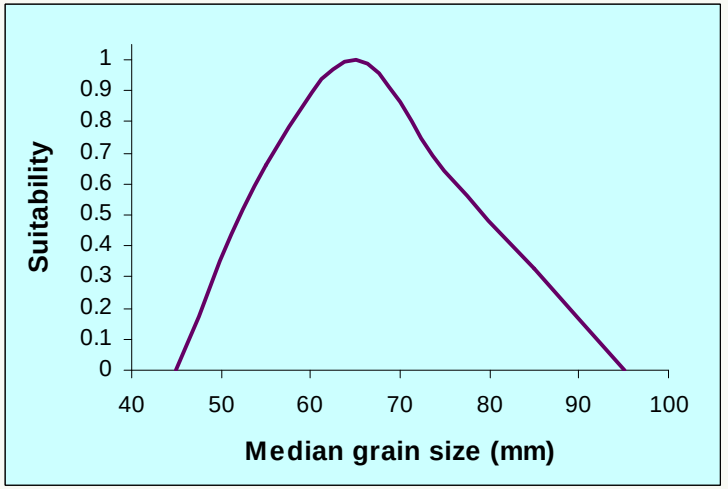


Micro-habitat suitability criteria

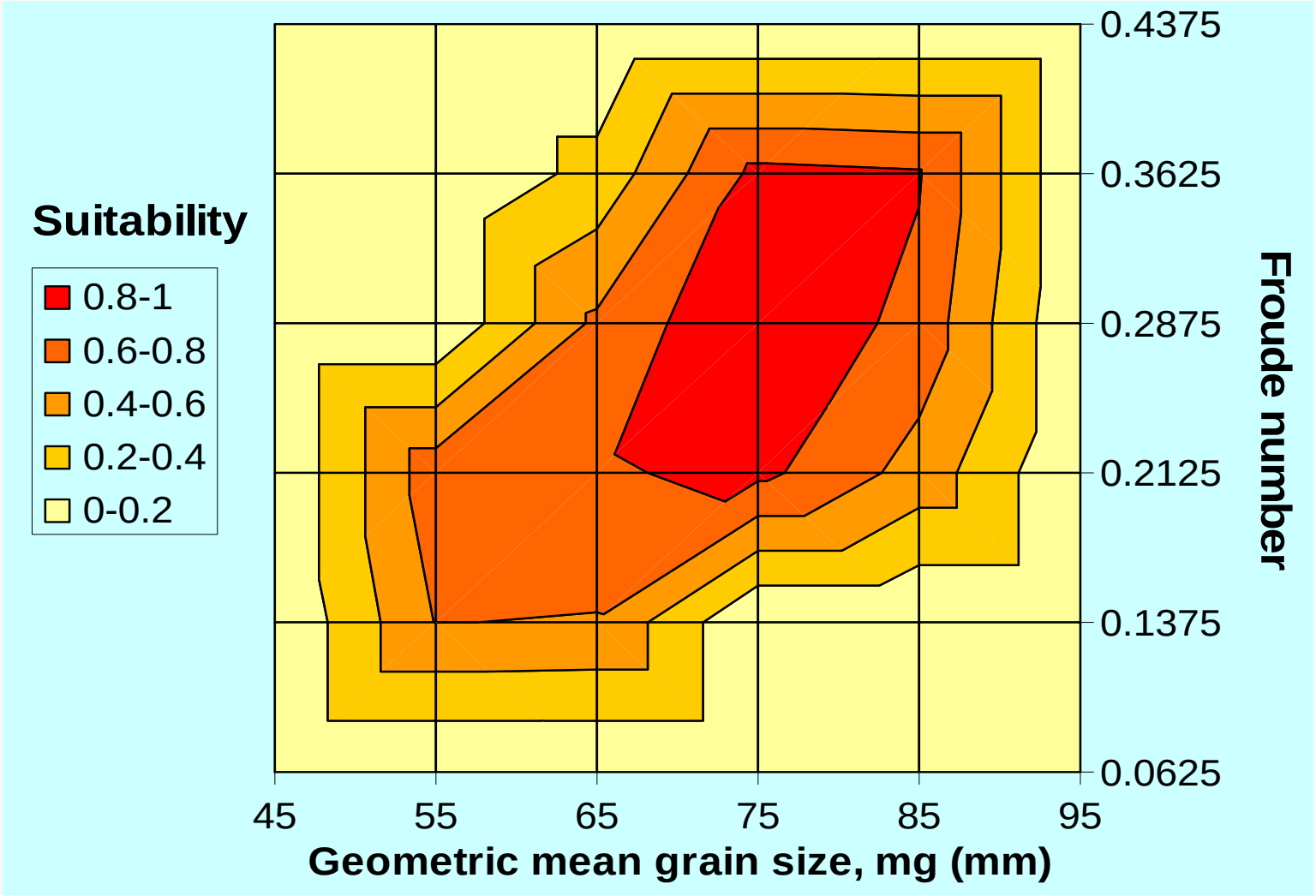






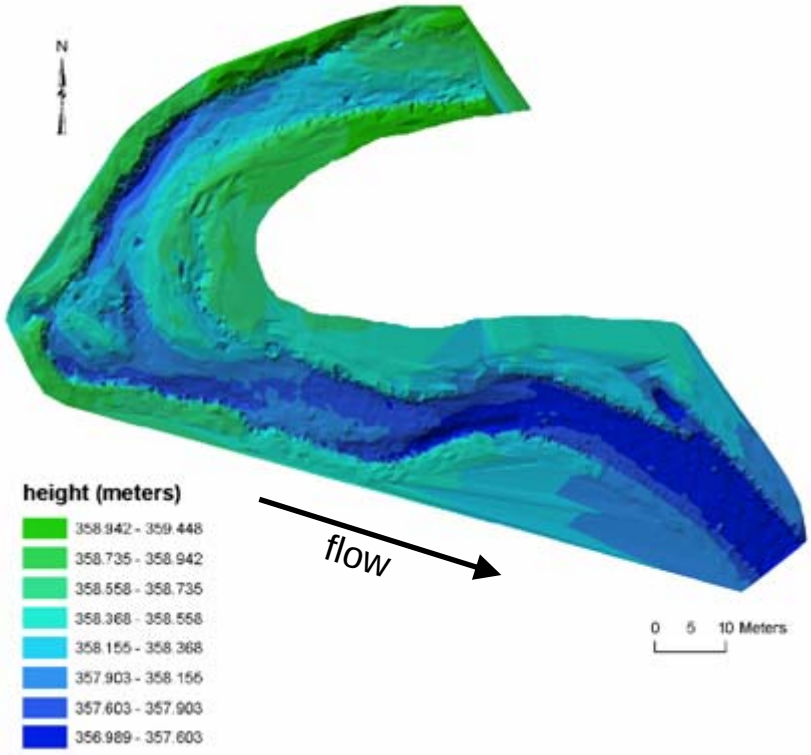


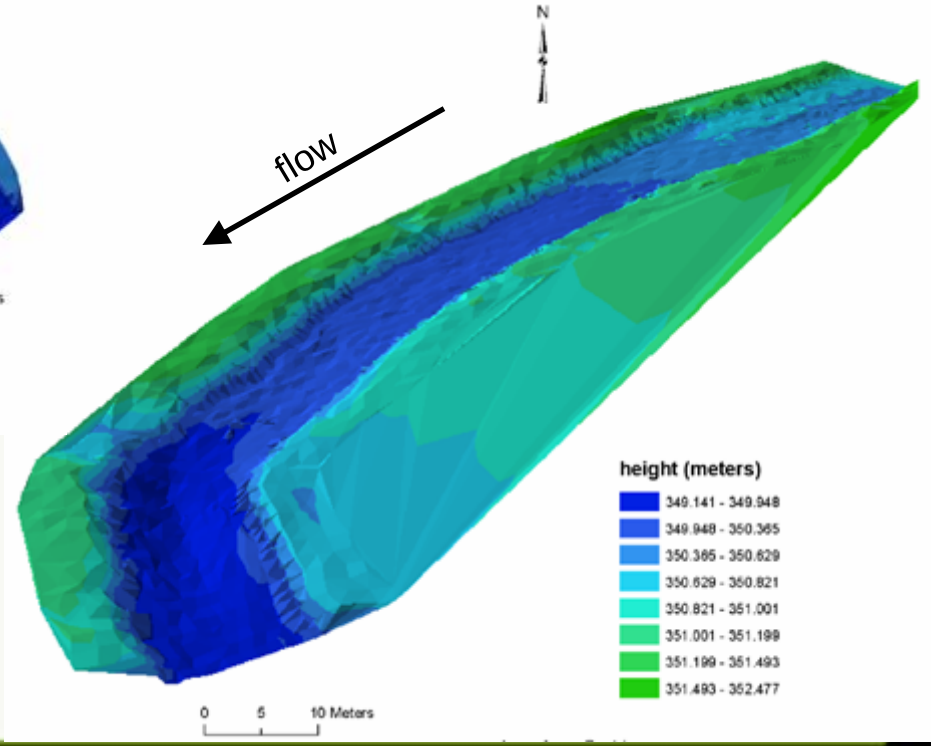
Integration of micro-habitat variables



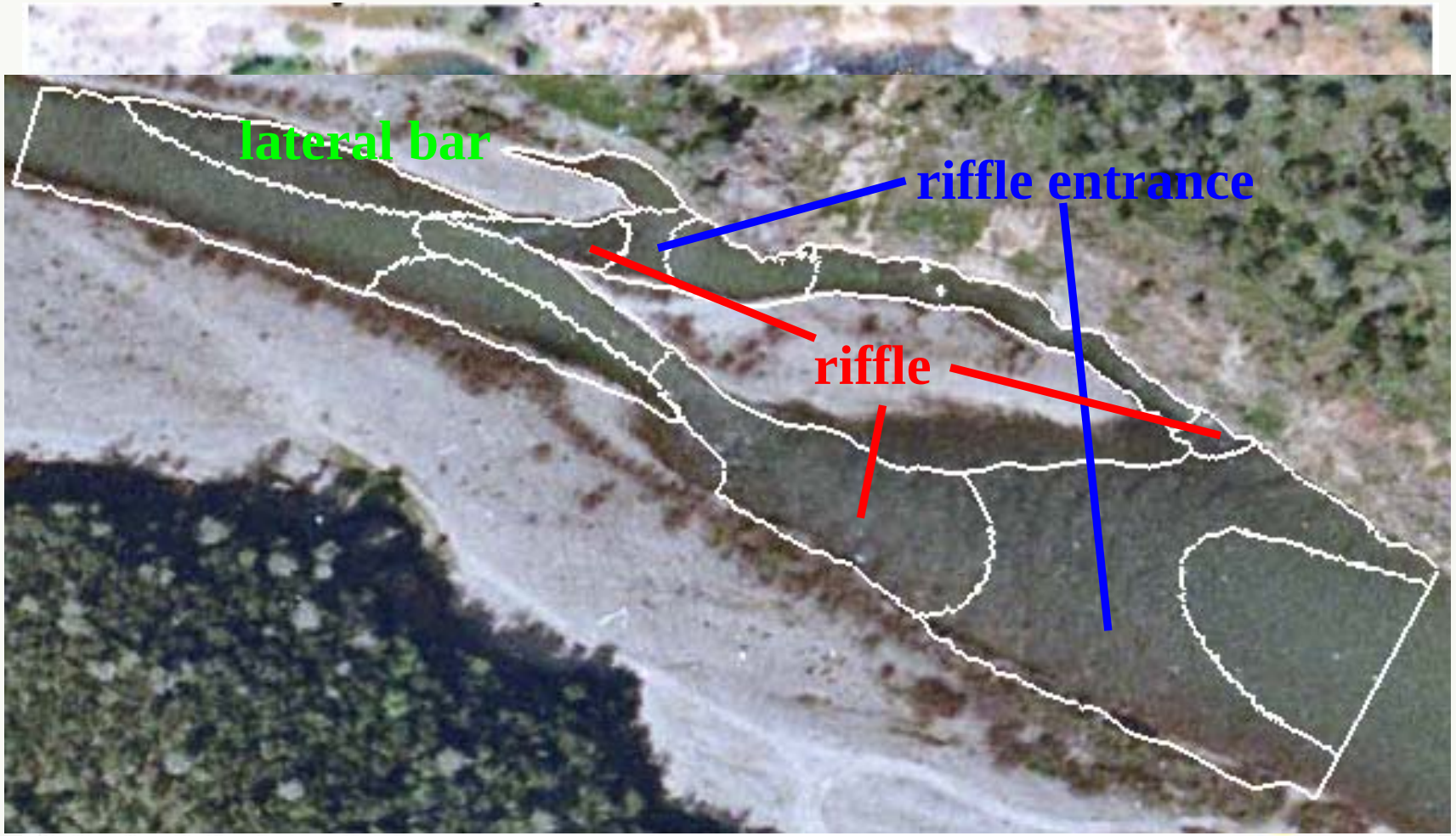
Ongoing work: linking micro- and meso- scales

High resolution topographical surveying of spawning units

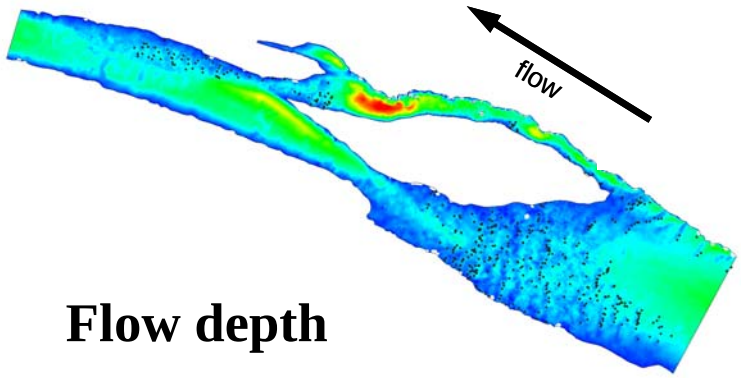




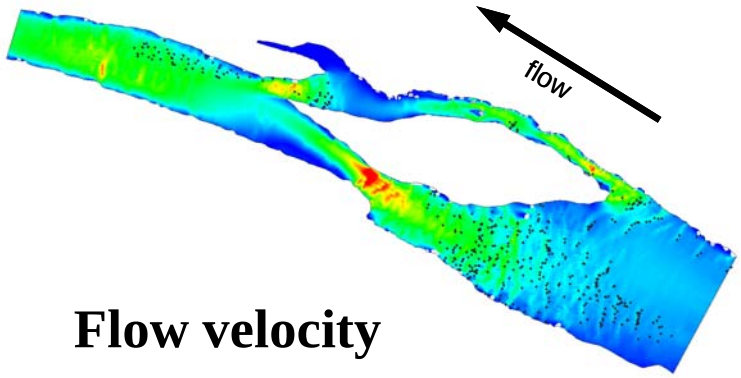
Meso- to micro-scale links



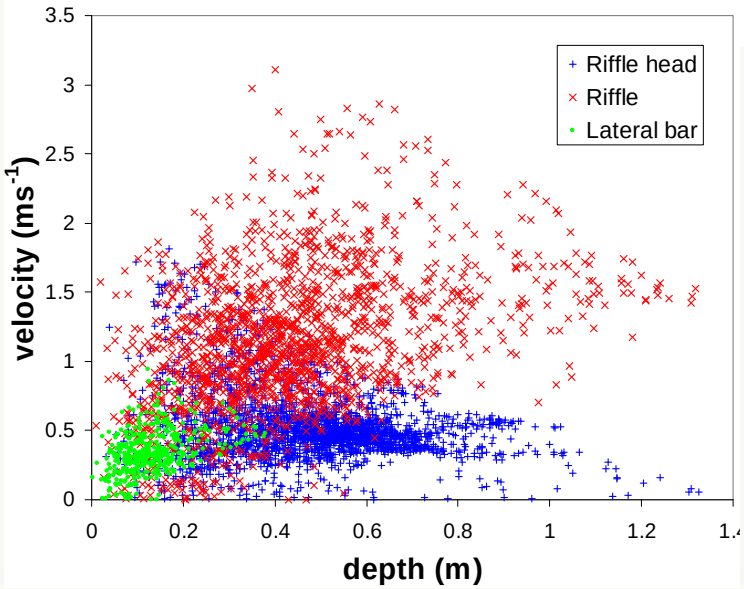
Application of 2D hydrodynamic modelling: linking across scales

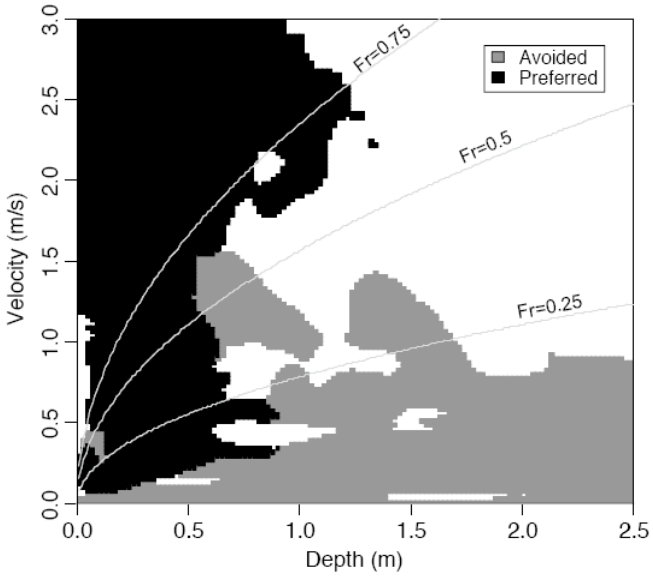


Flow depth



Flow velocity





Conclusions

- Many factors operating over wide range of scales control salmonid spawning patterns – no single factor exerts ultimate control.
- Geomorphic processes at broader scales control the distribution and provision of habitat at finer scales.
- Other non-physical factors also crucially important (e.g., competition, predation, community behaviour).
- Multi-scale factors must be considered to properly define ‘Ecological Status’ and when planning/ designing river restoration projects that are designed for ecological benefit.