Flow Regime: habitat and macroinvertebrate response.

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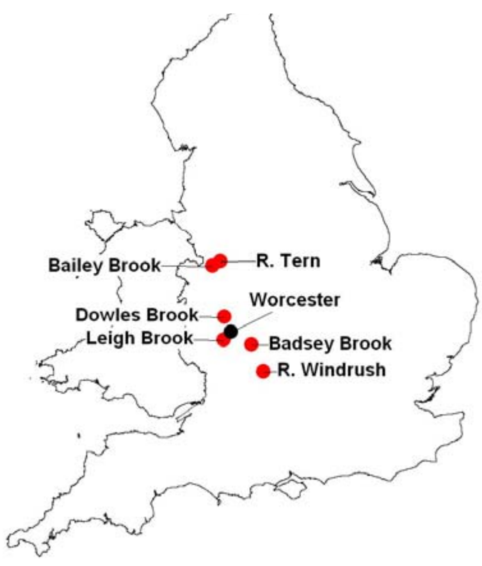
Introduction: Rivers are complex linear features, (Petts, 1994). Assessing habitat quality and composition has traditionally focused on reaches of 10s metres, recently interest has moved to the mesoscale (100s of metres) *e.g.* Paraseiwicz (2001); Maddock and Bird (1996). Assessment at the catchment scale is the ultimate goal, *e.g.* European Water Framework Directive (Bragg *et al*, 2005) and will possibly require an element of remote sensing to be effective. In field trials, inter-operator variability of four meso-scale habitat mapping methods: MesoCaSiMiR, MesoHABSIM, Norwegian Mesohabitat Classification Method and Rapid Habitat Mapping was found to be up to 85% by area surveyed (Maddock and Hill, 2005). Further, the biological relevance of some methods, such as the weighted usable area output from PHABSIM/MesoHABSIM, has been challenged by some (Thoms, 2006) and others, whilst habitat connectivity is increasingly important (Walker, 2006).

Surface Flow Types (SFTs) are patterns observed on the water surface, controlled by hydrology and channel geomorphology, they have been used as habitat descriptors (Newson *et al*, 1998) at >16 000 sites in the UK River Habitat Survey (Environment Agency, 2003). Studies have also related SFT variability to flows as part of aquatic habitat studies (Dyer and Thoms, 2006). SFTs commonly found in British lowland rivers include:

- No Perceptible (np): no obvious downstream flow, there may be upstream (eddy) flow.
- Smooth (sm): smooth laminar surface flow.
- Rippled (rp): small symmetrical ripples <1 cm high moving downstream.
- Unbroken standing waves (uw): upstream facing wavel, stationary in relation to the river bed.
- Broken standing waves (bw): white water wave crests, tumbling upstream.
- Chute (ch): low curving flow hugging the substrate.
- Upwelling (up): upward flow movements associated with 'boils'.
- Confused (cf): areas with three or more flow types (mapped but not investigated further).

Discriminant analysis of physical variables collected using Rapid Habitat Mapping on the Soča River, Slovenia, shows that SFTs are strongly related to channel geomorphic unit composition (Maddock *et al*, in press), and SFTs have been shown capable of consistent identification (Environment Agency 2003). It is contended that SFTs could be used to identify river habitats if biological relevance can be established. Benthic macroinvertebrate relationship to water quality is well known, e.g. Armitage *et al*, (1983) and Wright (2000), their community relationship to SFTs is examined here. This PhD research is on-going, and aims to establish the biological viability of habitat mapping by using SFTs.

Figure 1: Location of the six UK streams used in this study.



Sites: Six streams in the English (UK) lowlands were selected for investigation (figure 1). Streams were selected to fit the following criteria:

- wadeable rural streams;
- <200m above sea level;
- mean discharge c.0.40 – 0.80m^3/sec^{-1};
- catchment 40 – 100km^2; and
- with long-term discharge data available.

Method: Homogeneous SFTs were recorded 'as seen' to allow for lateral diversity, onto large-scale channel plans by visual estimation (figure 2), assisted by Global Positioning System (GPS) equipment although GPS signal reception under trees and in confined river valleys could be poor. Focusing on the SFT core area, depth and velocity were measured; substrate size, overhead cover; in-stream diatom, algal, bryophyte and macrophyte cover were estimated.

A representative example of each SFT habitat was selected and three one-minute kick samples, each covering an area ~0.26 x 0.30m, were conducted in each unit (figure 3) using a 500µm mesh 'D' net. The collected benthic macroinvertebrates were preserved for later identification to family level. At each kick-sample point, depth, velocity and substrate data were recorded. Data were stored in a Geographic Information System (MapInfo 8.0).

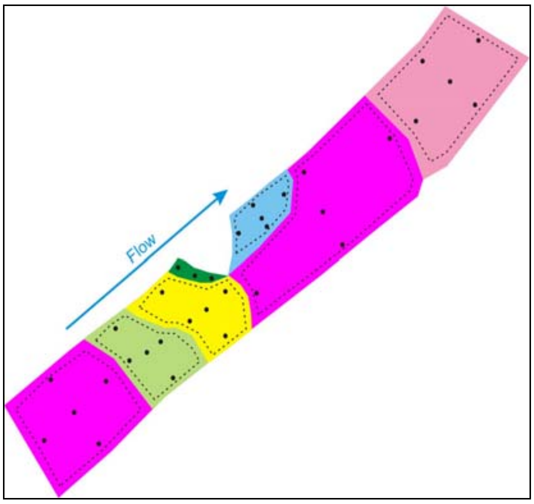


Figure 2. An example of SFT mapping; the dots represent the five data collection points in the core of the SFT unit and the dashed line the 10% edge zone.

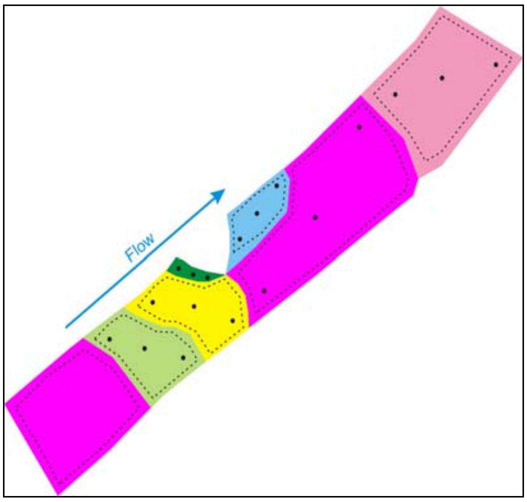


Figure 3. Macroinvertebrate collection, the dots represent the three sample points in the core of the SFT unit.

Results and discussion: The spatial extent of SFTs at three discharges on Leigh Brook, Worcestershire, UK, is shown in figure 4. At high flow (Q = 0.55 m^3/sec^{-1}) 30 habitats were identified, with 23 at mid flow (Q = 0.40 m^3/sec^{-1}) and 31 at low flow (Q = 0.34 m^3/sec^{-1}). Five SFT types were present at high flow, four at mid flow and five at low flow. As flow decreased, the area of 'smooth' flow increased whilst both 'rippled' and 'unbroken wave' flow types decreased. 'Broken wave' flow was only present at high flow; replaced by 'confused' flow at low flow. SFT mapping shows spatial changes to SFTs, e. g. 'unbroken wave' flows (riffles) are readily identified. The unbroken standing wave at A-B in figure 4 shrinks as flow increases being drowned out by c0.75 m^3/sec^{-1}, other geomorphologically controlled features may be similarly identified.

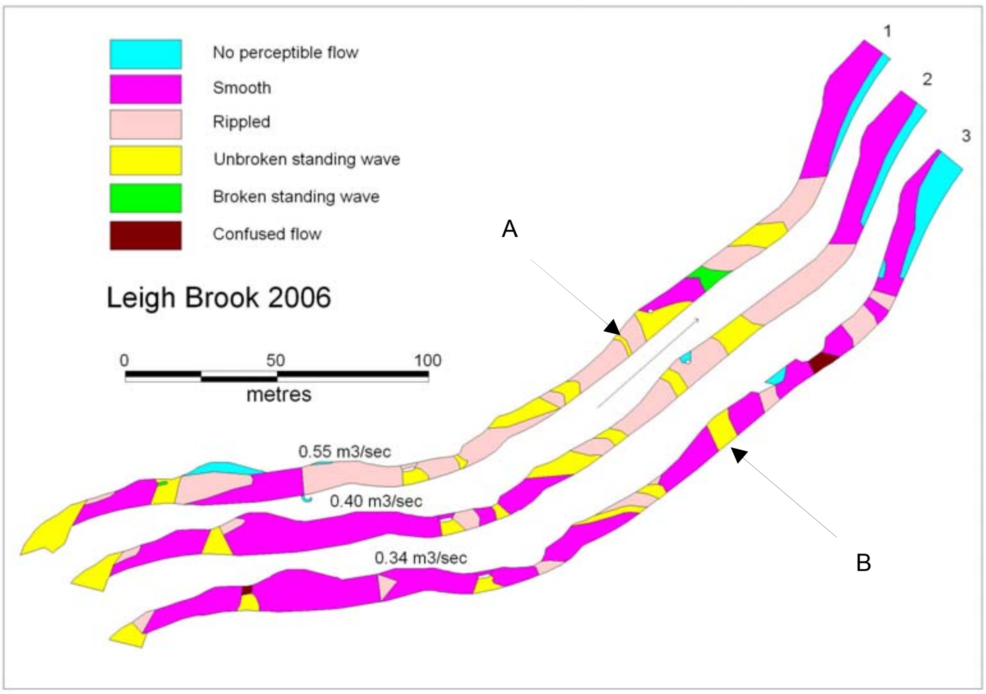


Figure 4. Spatial extent of SFTs in Leigh Brook , Worcestershire, UK, surveyed at three discharges.

SFTs lie along an energy continuum, with no perceptible flow at the low end and broken standing wave at the higher end, see the x-axis scales in figure 5. Mean depth and velocity from each SFT unit recorded in the first two survey visits (n=192) are shown in figure 5, mean depth decreases as mean velocity increases. Although upwelling flow type is plotted to the right on the x-axis, it is associated with erosion on the outside of meander bends or with scour pools and is perhaps most closely associated with no perceptible or smooth flow types. Despite the overlapping ranges of values, this data indicates that the SFTs investigated have different physical characteristics.

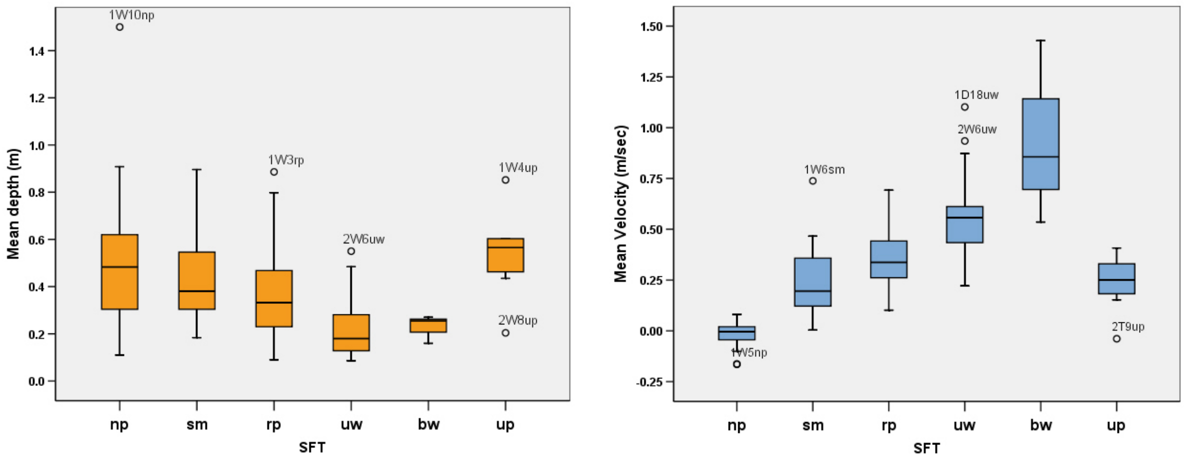


Figure 5. Comparison of mean depth (left) and mean velocities (right) recorded in 192 Surface Flow Type units.

A total of 36 macroinvertebrate families have been identified within all samples; a mean of six families per sample. One sample from a rippled SFT unit in Leigh Brook contained 16 families, whilst two samples from Badsey Brook and one from Bailey Brook contained no macroinvertebrate fauna. Macroinvertebrate communities, grouped by family and location, were analysed using Principle Component Analysis. This suggests that there are three river types - Badsey Brook – a small stream subjected to abstraction and effluent from waste water treatment, River Windrush – a stream flowing through oolitic limestone gravels and the four other streams. The environmental variables associated with these groupings will be examined later during this research.

Conclusion: Mapping SFTs from the bank onto large scale plans has been shown to be effective, and that GPS can be useful, although not reliable. The surveys showed that the SFT matrix changes with discharge, both in proportion and location, identifying topographic controls on the location of some units. SFT mapping is sufficiently sensitive to show the changes in the size of bed controlled features, partly because of the lateral diversity allowed. Physical characteristics of SFTs show some separation, in line with other mapping habitat methods; this will be further investigated using discriminant analysis in the course of this research programme. Associations between benthic macroinvertebrates and SFT habitats have not been fully investigated although initial results are encouraging, showing some association.

It is likely that effective remote sensing of lowland river habitats will rely largely on what is seen at the water surface. So far, this research has shown that those surface patterns in small lowland UK rivers appear to be meaningful, and that the biological relevance of SFTs shows promise. Further work will be undertaken to test the biological relationships of benthic macroinvertebrates to SFTs and, if possible, develop a model which may be used to monitor and manage the biological qualities of rivers at meso and macro scales.

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