

Development of a laboratory system and 2D routing analysis to determine solute mixing within aquatic vegetation

Patrick West*, James Hart*, Ian Guymer*, Virginia Stovin♦

*University of Warwick, UK

♦University of Sheffield, UK



EPSRC

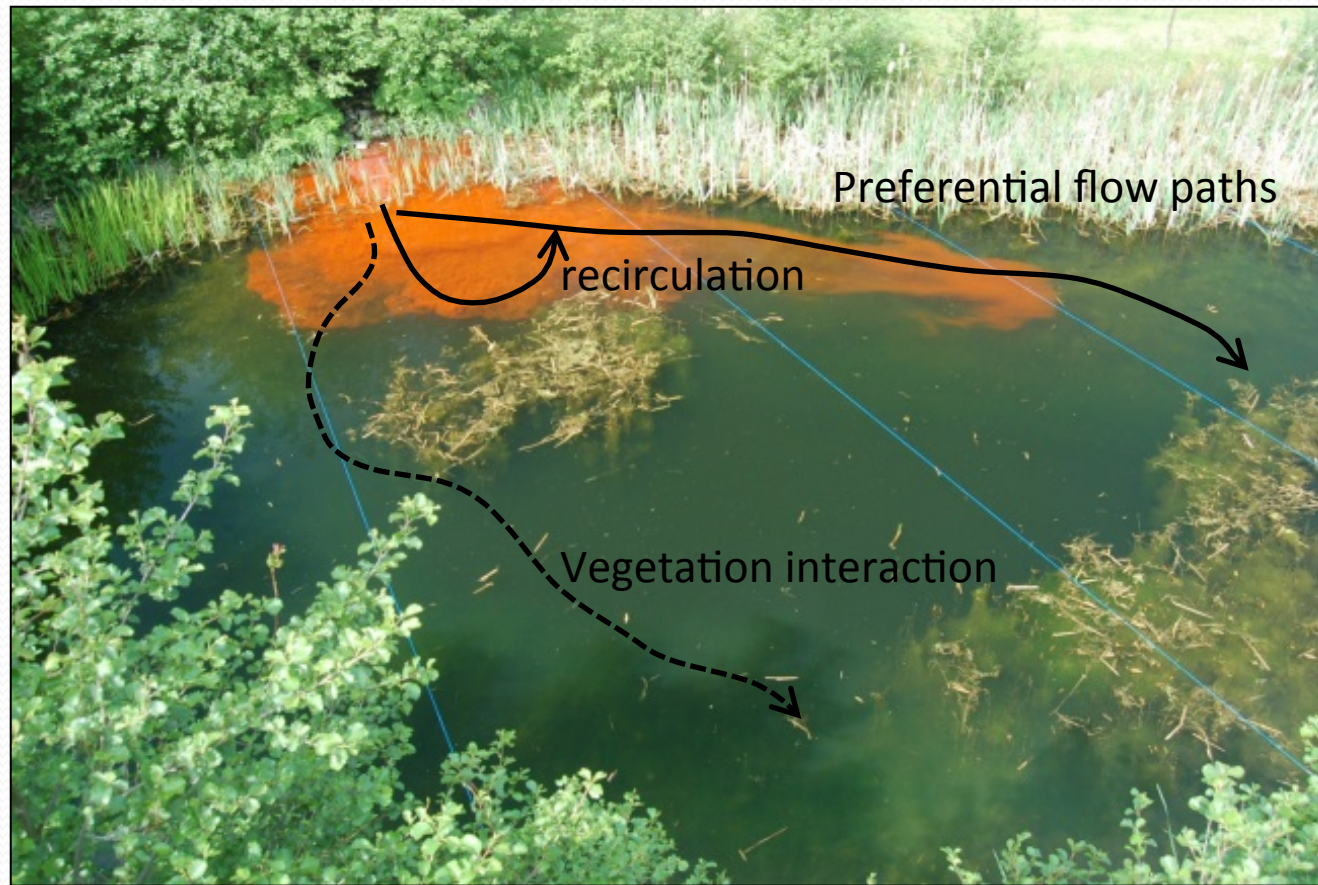
Engineering and Physical Sciences
Research Council

warwick *Water*

Background

- Diffuse pollution major problem
- Intensive use of pesticides, fertilizers from agriculture & heavy-metals motorways
- Interception of wastewater using ponds and wetlands (SuDS)
- **Retention time influences treatment**





Research Aims

- Quantify mass transport in vegetated shear layers/interfaces
- Develop precise tracer detection system
- Investigate for a range of variables (e.g. flow rate, plant age, plant density)



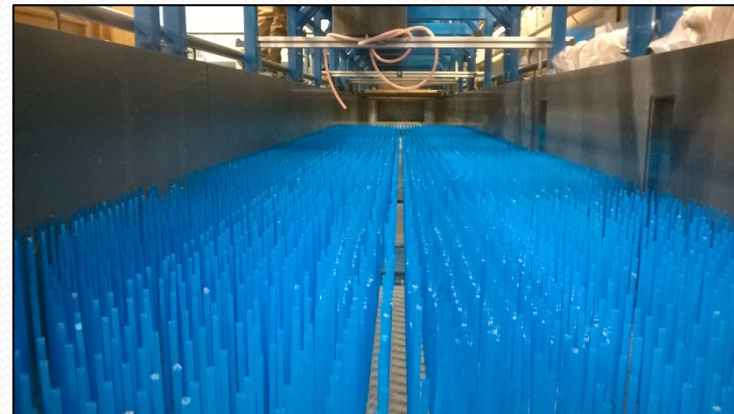
Methodology

Two tracer detection methods compared.

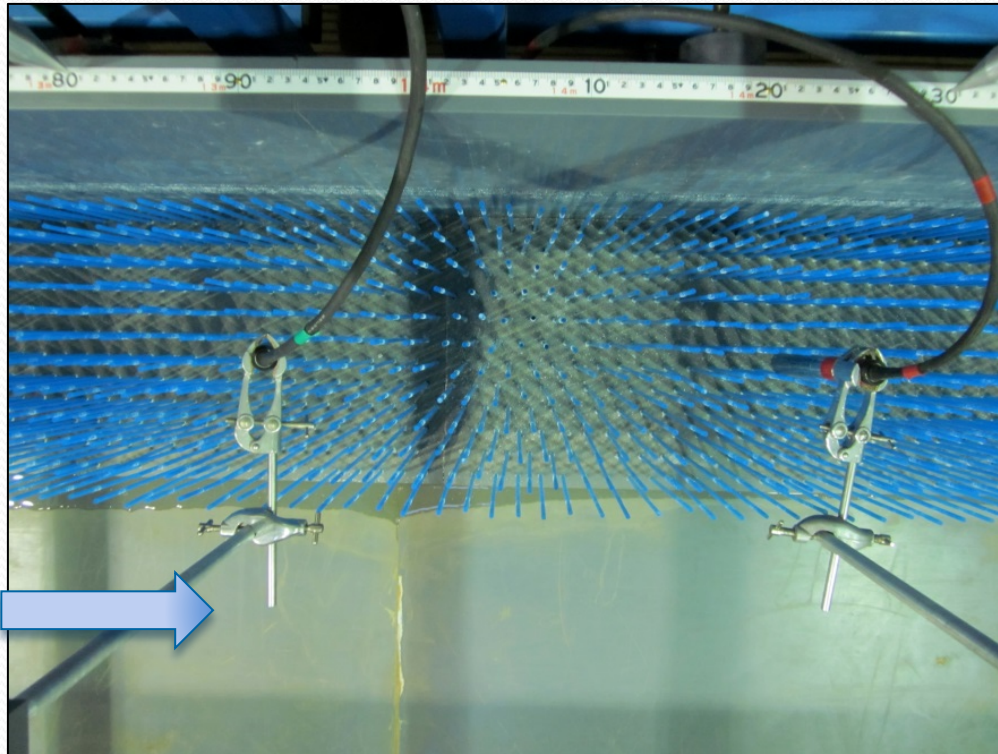
1. Point probe fluorometry
2. Laser Induced Fluorometry (LIF)

Emergent artificial vegetation is used as a test case. Temporal and spatial observations of tracer elucidate mixing characteristics.

Quantify **Transverse** and **longitudinal dispersion** coefficients.



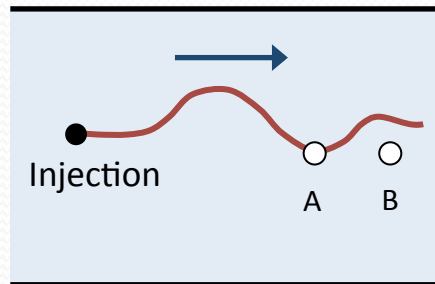
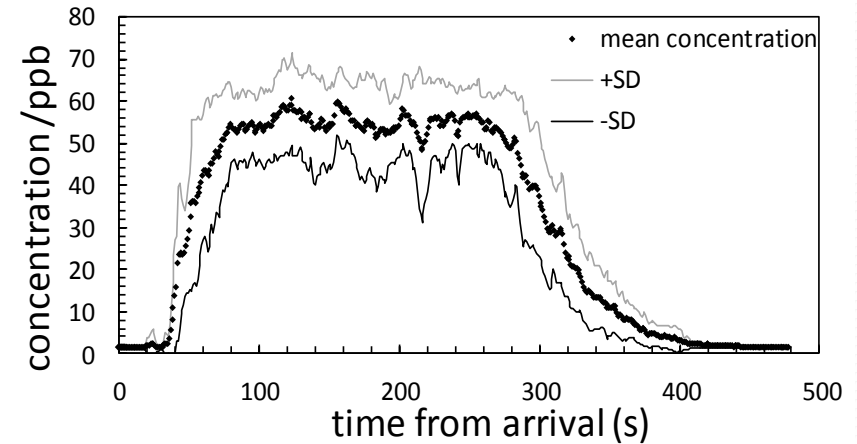
1. Point Probe Fluorometry



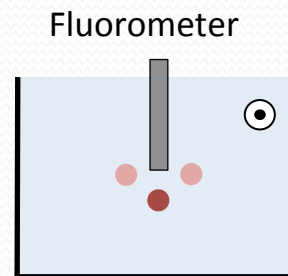
- Dye injected continuously
- Temporal concentration recorded

Point Probe Fluorometry - issues

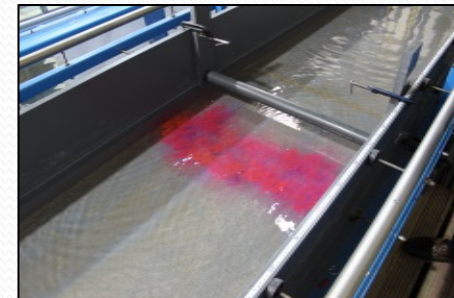
- Large spread in data
- Low mixing causes observation difficulties
- Intrusive and disruptive
- Spatially variable mixing properties cannot be extensively recorded e.g. poor spatial resolution.



Meandering



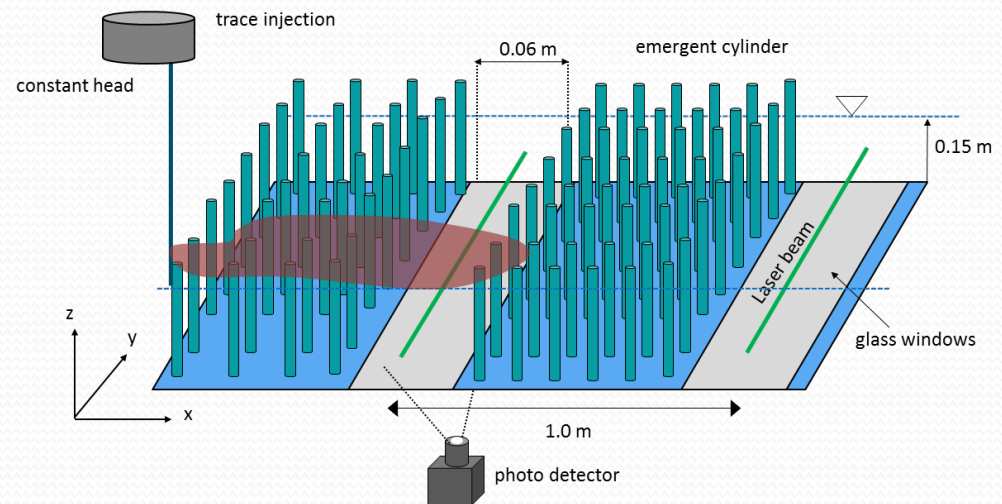
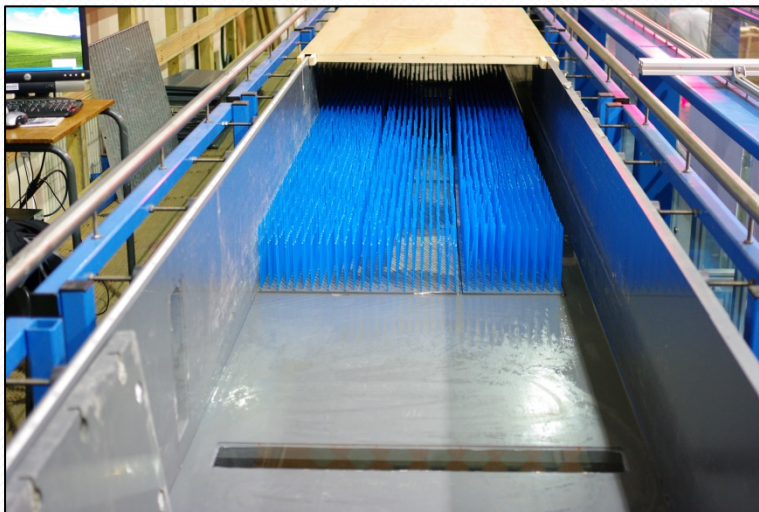
Locating device



Poor mixing

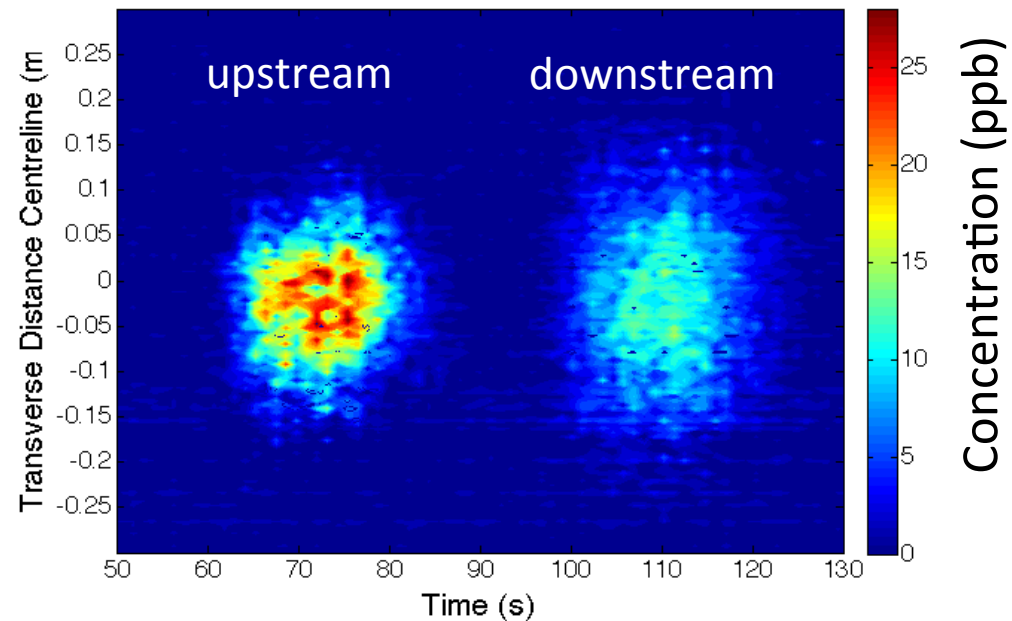
2. Laser Induced Fluorometry (LIF)

- Laser directed through flow
- Camera images from below – “black-out” conditions
- Fluorescence proportional to Rhodamine 6G concentration
- Laser/camera system calibrated with known concentrations



LIF Results

- Centreline injection, mid-depth
- 5 s pulse injections, 10 x repeats + 10 min constant injection
- 5Hz imaging at $x = 1$ m & $x = 2$ m downstream

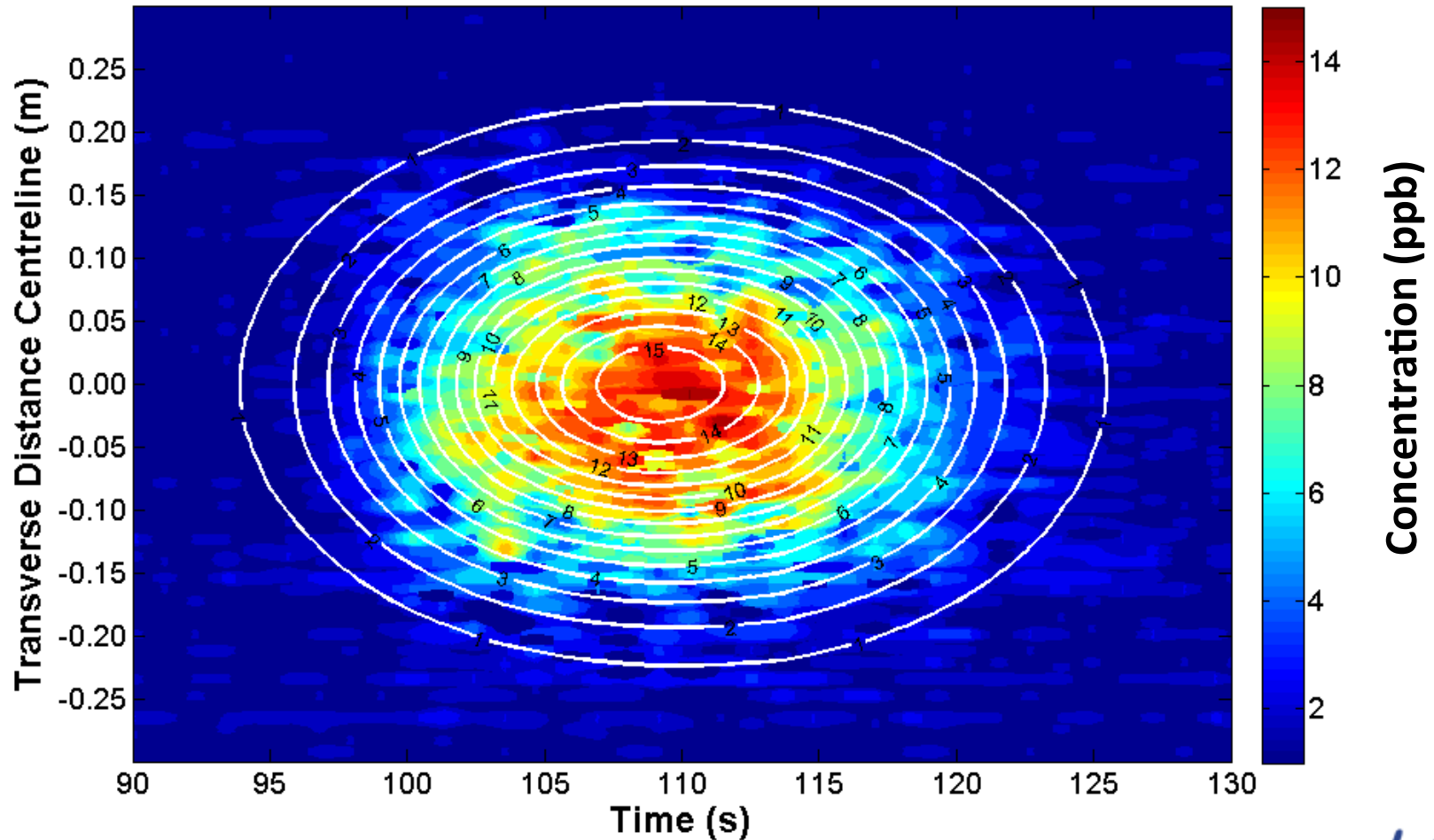


LIF Results – 2D Routing

- Upstream 2-dimensional concentration distribution **fitted** to downstream distribution using Gaussian transfer function.
- Process repeated to maximise fit using **optimisation**.
- **Four parameters** optimised: Longitudinal dispersion coefficient, transverse mixing coefficient, and depth-mean stream-wise and transverse velocities.

LIF Results – 2D Routing

Single 5s pulse (1.8 l/s), white lines = routed distribution



LIF benefits over Point Probe

- Spatially extensive
- Non-intrusive
- Greater resolution
- Reasonable error for all 10x repeats
- More reliable

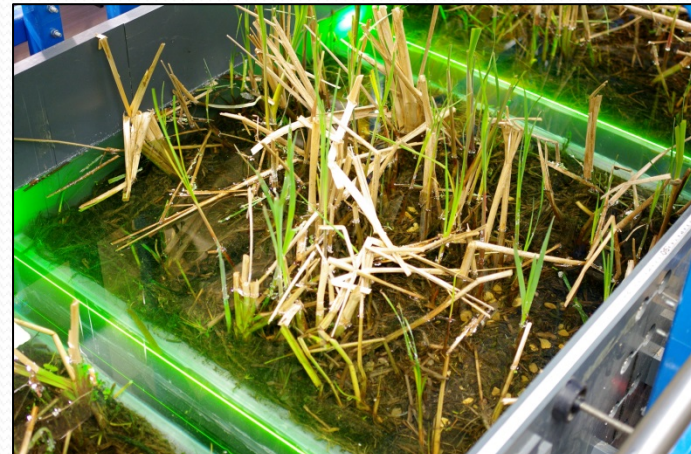
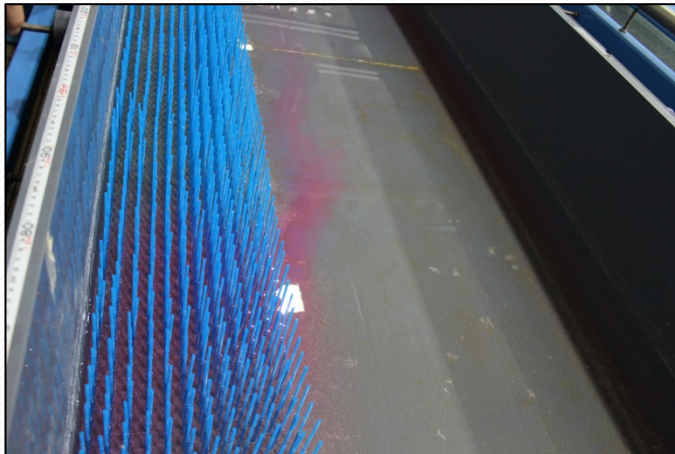
Q (l/s)	u measured (m/s)	u travel time (m/s)	$D_x \times 10^{-5}$ (m ² /s)	$D_y \times 10^{-5}$ (m ² /s)	Fit (R^2)
1.8	0.010	0.013±0.00015	8.66±16.7%	2.42±7.4%	0.90±0.01
2.4	0.013	0.017±0.00016	17.0±51.3%	2.97±18.7%	0.84±0.02
3.6	0.020	0.026±0.00007	19.0±11.1%	4.22±2.5%	0.91±0.02

Conclusion

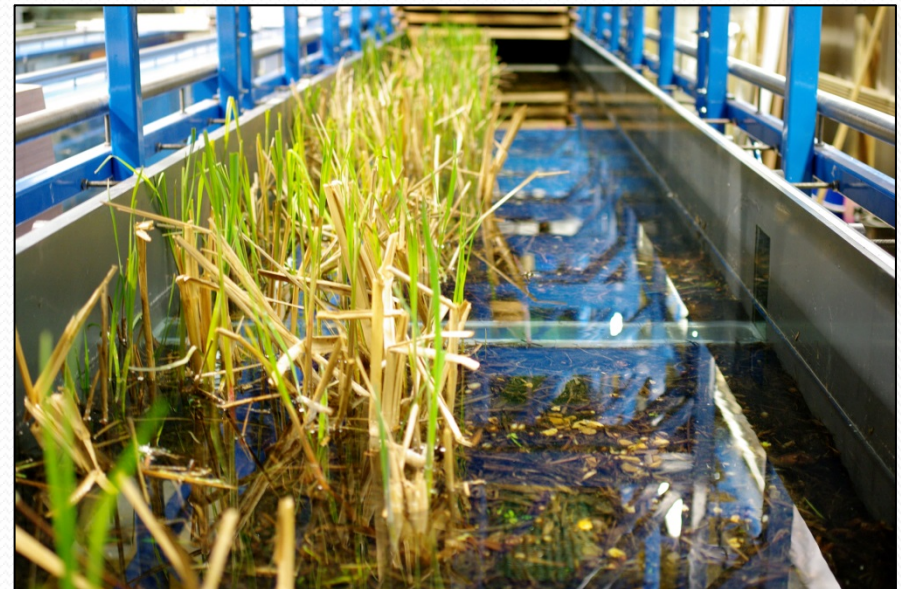
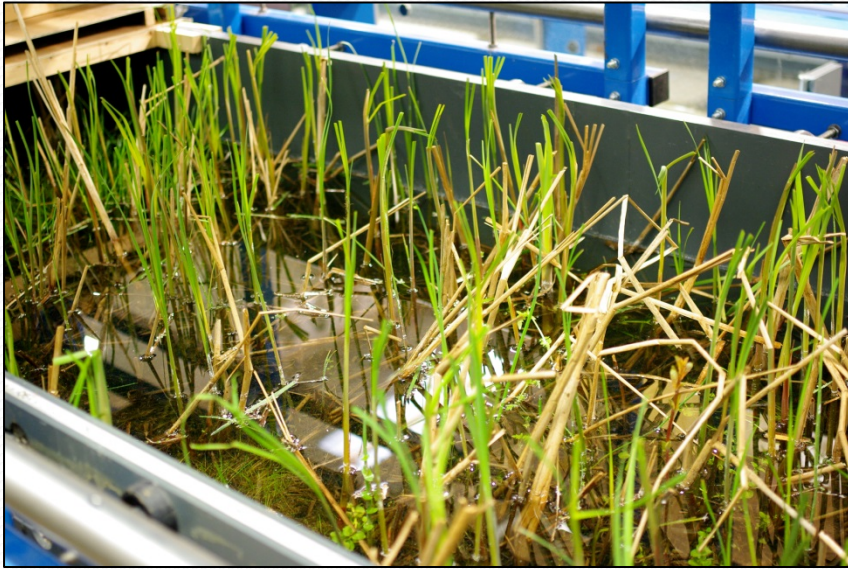
- Preliminary tracer tests conducted in full vegetated, artificial, **emergent** vegetation.
- LIF **more suitable** than point probe fluorometry for observing mixing.
- LIF is **Non-intrusive & spatially extensive**.
- 2D routing useful technique.
- Heterogeneous flow fields demand alternative analysis.

Current Work...

- Application of technique to shear vegetation and different vegetation densities – interface interactions
- Live vegetation – seasonal effects
- Comparison between real and artificial



Thank you for listening!

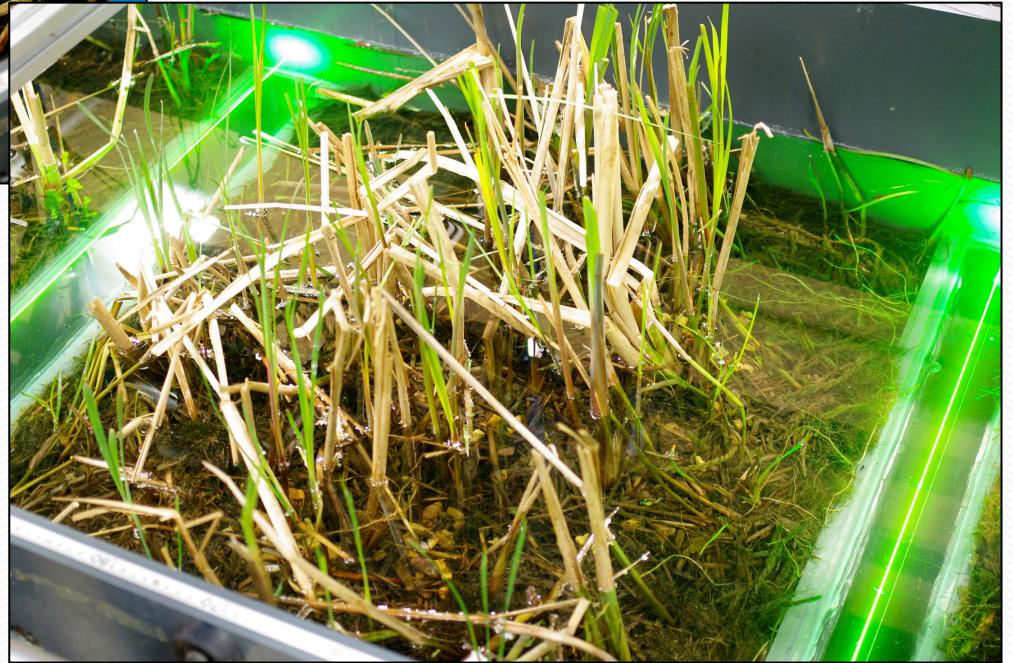
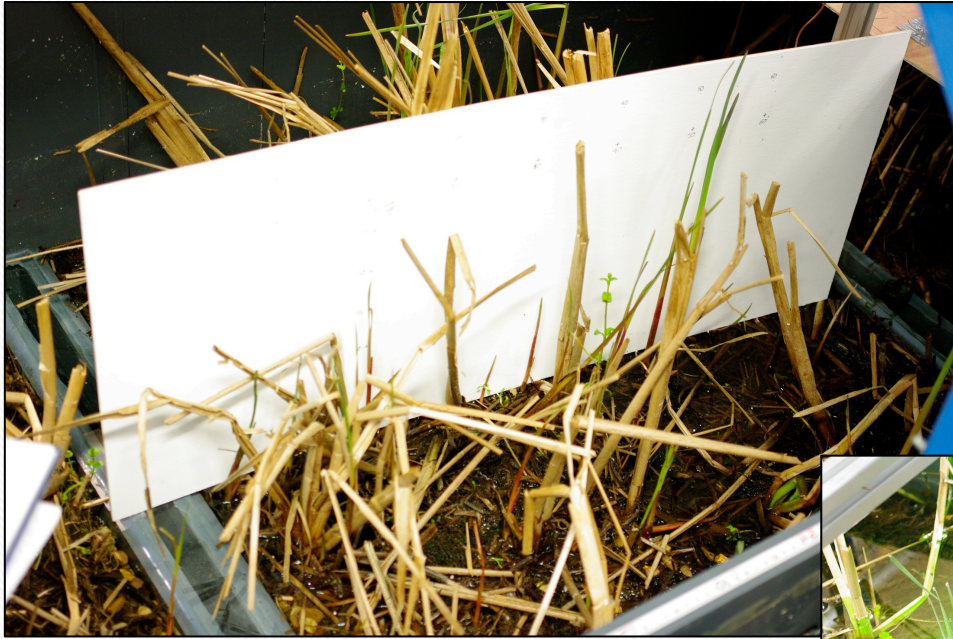


Any questions?

Determining solute mixing in aquatic vegetation



Determining solute mixing in aquatic vegetation





Determining solute mixing in aquatic vegetation

