REACH-SCALE SPATIAL HYDRAULIC DIVERSITY IN LOWLAND RIVERS: CHARACTERISATION, MEASUREMENT AND SIGNIFICANCE FOR FISH

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ABSTRACT

Hydraulic conditions (velocity, depth, turbulence) strongly influence the distribution and abundance of organisms in rivers. A diverse hydraulic environment should foster biodiversity, because organisms have different hydraulic preferences. In fact, the relationship between spatial hydraulic diversity and biodiversity is largely presumed, and not well-supported by empirical studies, but it underpins efforts in river restoration and conservation. This is particularly so at the *reach* scale, indicating a stream- or river-section with large-scale homogeneous geomorphic and hydrological conditions and smaller-scale habitat patches, as perceived by organisms in the community under study.

This thesis considers the factors that create spatial hydraulic diversity, and the ways that fish respond. It presents a method to characterise hydraulic diversity, and uses this to describe temporal and spatial changes between reaches. It also demonstrates the use of hydraulic modelling for comparing reaches. Finally, it assesses the Acoustic Doppler Current Profiler (ADCP) as a method to describe hydraulic conditions in a large, open river channel.

Swimming ability tests were applied to three small freshwater fish, the pelagic Australian smelt (*Retropinna semoni*) and common galaxias (*Galaxias maculatus*) and the demersal flathead gudgeon (*Philypnodon grandiceps*). The latter species was the weaker swimmer, but the tests indicated that behaviour also should be considered.

A laboratory experiment was designed to investigate how two species with contrasting ecological habits (common galaxias, flathead gudgeon) behave in a diverse hydraulic environment. Habitat choices and activity were monitored in a constructed sinuous channel at three discharges over a 3-hour period. The galaxias favoured the pelagic habitat, and spent 20-60% of the time cruising, whereas the flathead gudgeon preferred the demersal habitat and spent <6% of the time cruising. The flathead gudgeons could access their preferred habitat at all discharges, but the common galaxias were limited by their swimming ability at the highest discharge.

Several methods to characterise reaches were compared for eight 3-D model reaches representing the effects of channel form, wood and aquatic plants. The *variogram* (a measure of the variance between samples as a function of distance) emerged as a superior method because it indicates hydraulic diversity, incorporates the spatial arrangement of hydraulic patches, and facilitates comparisons between reaches.

The ADCP proved a quick, reliable means to measure depth and 3-D velocity in rivers. It was effective only in depths >1.5 m, but modified instrumentation may overcome this limitation.

Six reaches, including weir-pool and free-flowing sections, were compared at two discharges in the River Murray, Australia. Variograms derived from the ADCP data clearly demonstrated spatial differences between the sections, but temporal differences were less well-defined, suggesting that reaches may retain characteristic hydraulic patterns despite changes in discharge.

Opportunities for further research include: the issue of optimal levels of hydraulic diversity for fish and other biota; use of variograms as a tool for field studies of aquatic biota; and measuring reach-scale hydraulic diversity and biodiversity before and after reach manipulation (e.g. the placement of wood), to elucidate the effects of changes in spatial hydraulic diversity on reach biodiversity.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available in all forms of media, now or hereafter known.

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