LABORATORY EXPERIMENTS ON VERTICAL SLOT FISHWAYS WITH ADDED ROUGHNESS

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The Murray-Darling is a unique river system in South East Australia characterised by variable and unpredictable flows. Fish species richness and abundance in the Murray-Darling Basin is declining, a process caused by in-stream habitat changes, introduced species, changes in flow regime and water quality (Harris et al. 1997). This trend has also been attributed to the barrier effect of in-stream obstructions, which restricts the free circulation of fish impeding the completion of their lifecycle.

Fishways are usually constructed to overcome these barriers. Research and development has suggested that the Vertical Slot Fishway (VSF) is the most suitable fishway for Australian conditions as it is able to operate over a wide range of headwater and tailwater depths, provides passage for species at all levels in the water column, has reduced head loss between pools and has comparatively lower turbulence (Rajaratnam et al. 1986).

Recent research into the migration habits of Australian species suggests a need to design fishways suitable for species with lengths less than 10 cm. Under the present hydraulic parameters recommended by New South Wales Fisheries migration of these smaller and juvenile species may be compromised (Mallen-Cooper 2000).

Decreasing the slope of the fishway can solve this problem, but at considerable cost. An alternative method of improving the migration of fish is to provide areas in the fishway that can provide the hydraulic conditions necessary for passage. One such method is to introduce roughness elements in the form of rocks or blocks that generate a low velocity area within the fishway for fish passage. This work attempts to quantify the effect of added roughness elements in the bed of a VSF to provide information for the future design and operation of fishways in the Murray-Darling river system.

Experimental work was carried out in 1:5 Froude scale model of a VSF at the Civil, Surveying and Environmental Engineering Laboratories of the University of Newcastle. The VSF was set up on a sheet metal flume 5.69 m. long and 0.40 m. wide with four vertical baffles dividing the flume into three pools, each 0.60 m. long. The slope of the flume was 4% and the flow rate was 6.25 Ls^{-1}. Water levels in the flume were controlled by a downstream weir. Two runs were undertaken, one with no added roughness (control condition) and one with Lego blocks simulating the added roughness. Velocities were measured on a very dense grid using an Acoustic Doppler Velocimeter (ADV) with a sampling frequency of 25 Hz over a period of 120 seconds. Water surface profiles were measured using a point depth gauge.

Increasing the roughness in the base of the fishway led to a 1cm increase in the height of the water surface, with no change in the characteristic shape of the water surface.

Analysis of 3D velocities and kinetic energy demonstrates that this depth increase is accompanied by a reduction in velocity magnitude and kinetic energy close to the bottom due to the added roughness (Fig.2). Kinetic energy levels suitable for different fish sizes were determined based on fish swimming ability for species in the Murray Darling Basin (Mallen-Cooper, 2001). These levels were used to compute a volume suited to fish length for both the control and the roughened conditions. Fig 3 shows that the length classes of fish that receive the greatest benefit from the addition of roughness elements are the 10-15 cm and 15-25 cm classes.

Turbulent kinetic energy was also measured, revealing lower turbulence levels for the roughened condition. The turbulent kinetic energy is similar in magnitude to the kinetic energy, supporting the idea that turbulent kinetic energy must be taken into consideration, even though its effect on fish is not totally understood.

These encouraging results suggest that further research should be targeted at spacing and sizing roughness elements in order to provide optimal migration conditions for smaller fish.

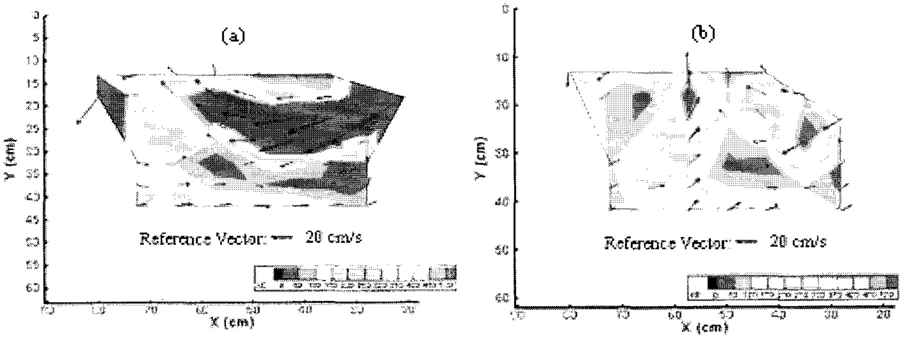

Fig. 6 Kinetic energy at a distance 0.5cm from the base of a Vertical Slot Fishway, (a) control condition, (b) with roughness. Units: cm^2s^{-2}.

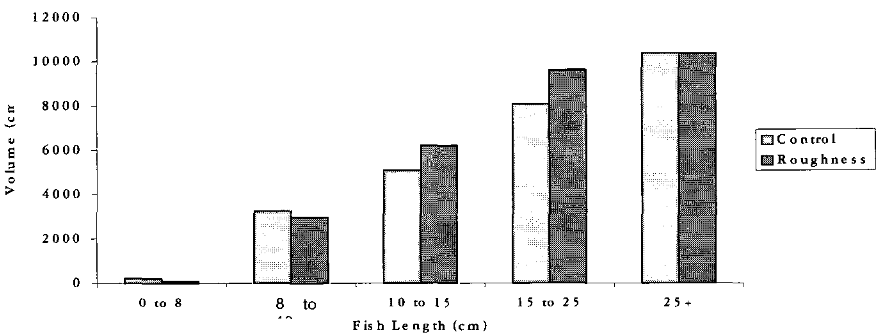

Fig. 8 Comparison of volume through which fish can pass in a vertical slot fishway with and without roughness elements.

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