Tracking fish swimming behaviour in response to a vertical axis turbine

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Abstract

Hydrokinetic **vertical axis turbines (VAT)**, suitable for rivers and estuaries, are a promising alternative to traditional hydropower schemes to meet the increasing global energy demand while minimising environmental impacts. To date, there are major research gaps in quantifying the impact of VAT turbulent wake hydrodynamics on fish swimming behaviour and passage. Here, we investigate fish behavioural responses to a single VAT in a confined laboratory environment by relating fish body position and swimming kinematics to the surrounding flow field. Initial results show that although fish passed from downstream into the upstream area, they spent most time within the turbine wake area, which was characterised by a region of low momentum immediately downstream of the VAT and regions of high momentum on either side of the turbine. These experimental observations will contribute to the commercial development of VATs as sustainable renewable energy technology with low environmental impact.

Keywords: renewable energy, vertical axis turbine, Acoustic Doppler Velocimetry, fish behaviour, motion tracking.

Methods

Experimental setup

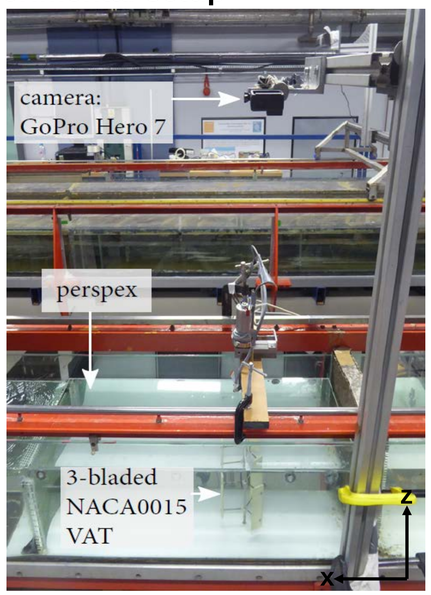

Figure 1: Experimental test section, showing a single VAT, camera, upstream and downstream mesh; flow from right to left.

Test section: 0.75x0.3x0.3m
Flow condition: Q=0.013m³/s, H=0.23m
Turbine: D=0.12m, ω=59rpm

Hydrodynamics

- Acoustic Doppler Velocimetry (ADV) measurements (200Hz, 180-300s)

Fish behaviour

- Juvenile rainbow trout (*Oncorhynchus mykiss*, ~5cm)
- 5min recording (60fps, 1920x1080px)
- Motion tracking used adapted Sensory Orientation Software (Gomez-Marin et al., 2012)

Results

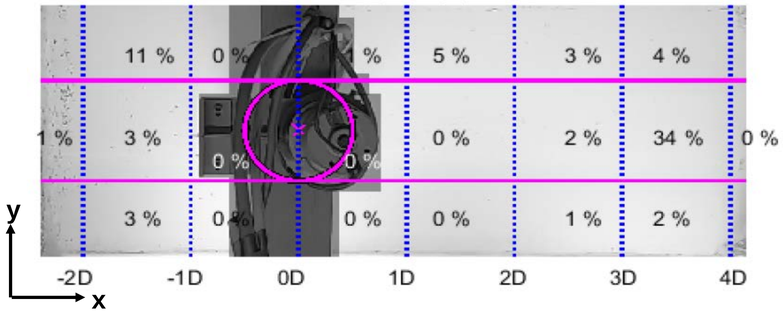

Figure 2: Example of percentage time spent within test section.

Fish behaviour

- Most time spent in the turbine wake
- Upstream passage despite high momentum flow

Hydrodynamics

- Low momentum region downstream of the turbine, asymmetric about its centreline
- High momentum regions on either side of turbine

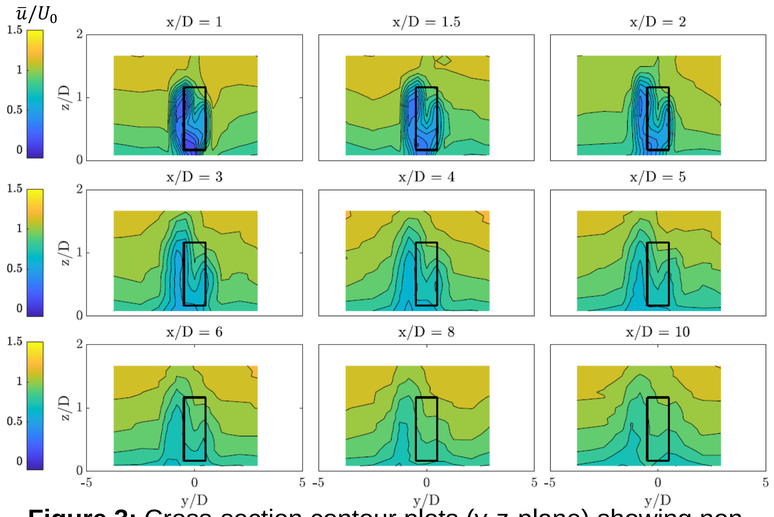

Figure 3: Cross-section contour plots (y-z-plane) showing non-dimensionalised streamwise mean velocity ($\bar{u}/U_0$) at downstream distances x/D from 1 to 10; measured in a 10x1.2x0.3m flume at H=0.23m, Q=0.053m³/s.

Conclusions

Information gathered by motion tracking:

- fish spatial preference
- swimming kinematics
- attraction and avoidance behaviour

This work aims to inform future environmental impact assessments for VAT projects.

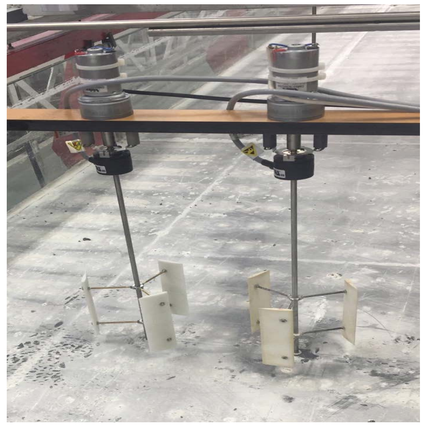

Figure 4: Experimental setup with twin-turbines which will be used in future studies.

Future work

- Fish response to single VAT for 2 discharges and turbine conditions (stationary or rotating)
- Fish behaviour (small groups) response to twin VAT

Bibliography

Gomez-Marin A., Partoune N., Stephens G. J., Louis M. (2012). Automated tracking of animal posture and movement during exploration and sensory orientation behaviors. PLoS ONE 7(8). doi:10.1371/journal.pone.0041642.

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