# Hydro-environmental Modelling of the Impacts of Turbine Layout in Tidal Range Schemes

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## 1. INTRODUCTION

Modelling of Tidal Range Energy across the world estimates a theoretical annual output of 25,880 TWh across 11 countries[1]. The predictability, availability and sustainability of tidal range energy makes it an ideal alternative to fossil fuels for producing baseload power but despite the presence of this plentiful resource across many countries, the development of Tidal Range Schemes (TRSs) has so far been limited to a handful of locations due to technical, financial and environmental concerns. The environmental impacts of TRSs must be addressed in order for this technology to be actualised.

## 2. METHOD

This research used a physical scaled model (1:5000) of a TRS with simplified geometry to investigate different turbine configurations and their impact on hydrodynamics. Velocity was measured using Acoustic Doppler Current Profilers whilst water level was monitored using pressure cells, and fluorescent dye was injected into the TRS and filmed in order to visualise flow. Four configurations were tested, each with two turbines, varying spacing each time (Table 1). The area, shape and tidal regime were kept constant.

**Table 1: Experiment Layout**

| Turbine Layout | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| S2A | | | | | | | | x | x | |
| S2B | | x | | | | | | | x | |
| S2C | | | | | x | | | | x | |
| S2D | | | | x | | | x | | | |

## 3. RESULTS

Contour plots of residual velocity (Figure 1) show that although there is little variation between depths for each experiment there are changes in velocity patterns between experiments. Flow is shown to be more symmetrical in the outer tank in experiment S2D, where turbines were positioned in the centre of the seawall with even spacing. Whereas experiment S2A, where turbines were placed side-by-side at the right of the seawall, has led to irregular flow patterns and the greatest variation in flow velocity. The offset positioning of the turbines in cases S2A and S2C have both led to stronger flows inside the TRS too.

**Figure 2: Regression Analysis**

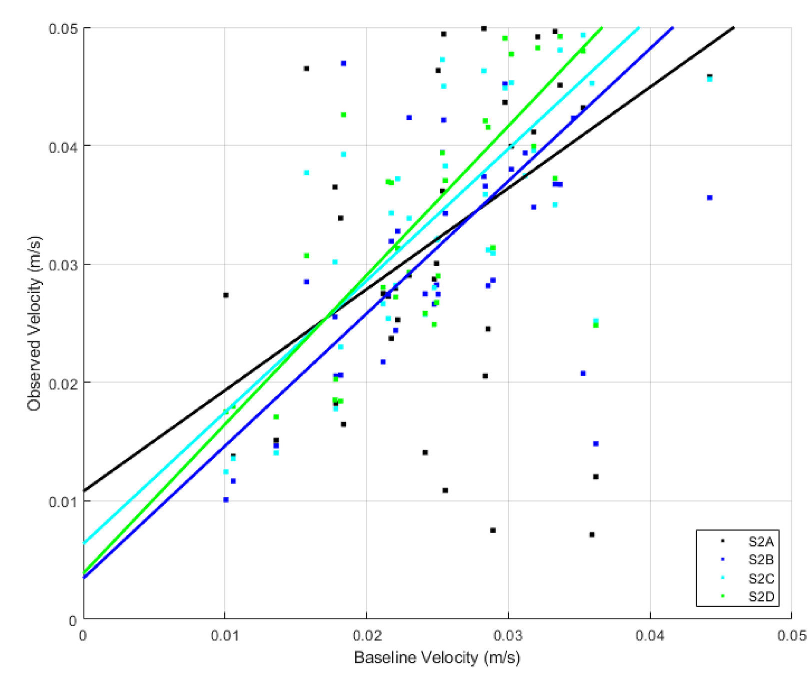
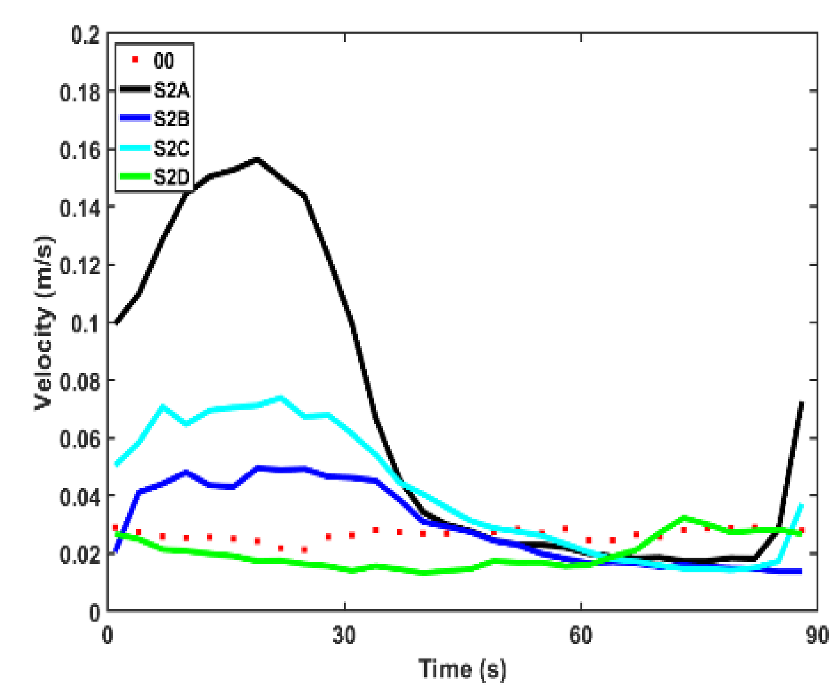
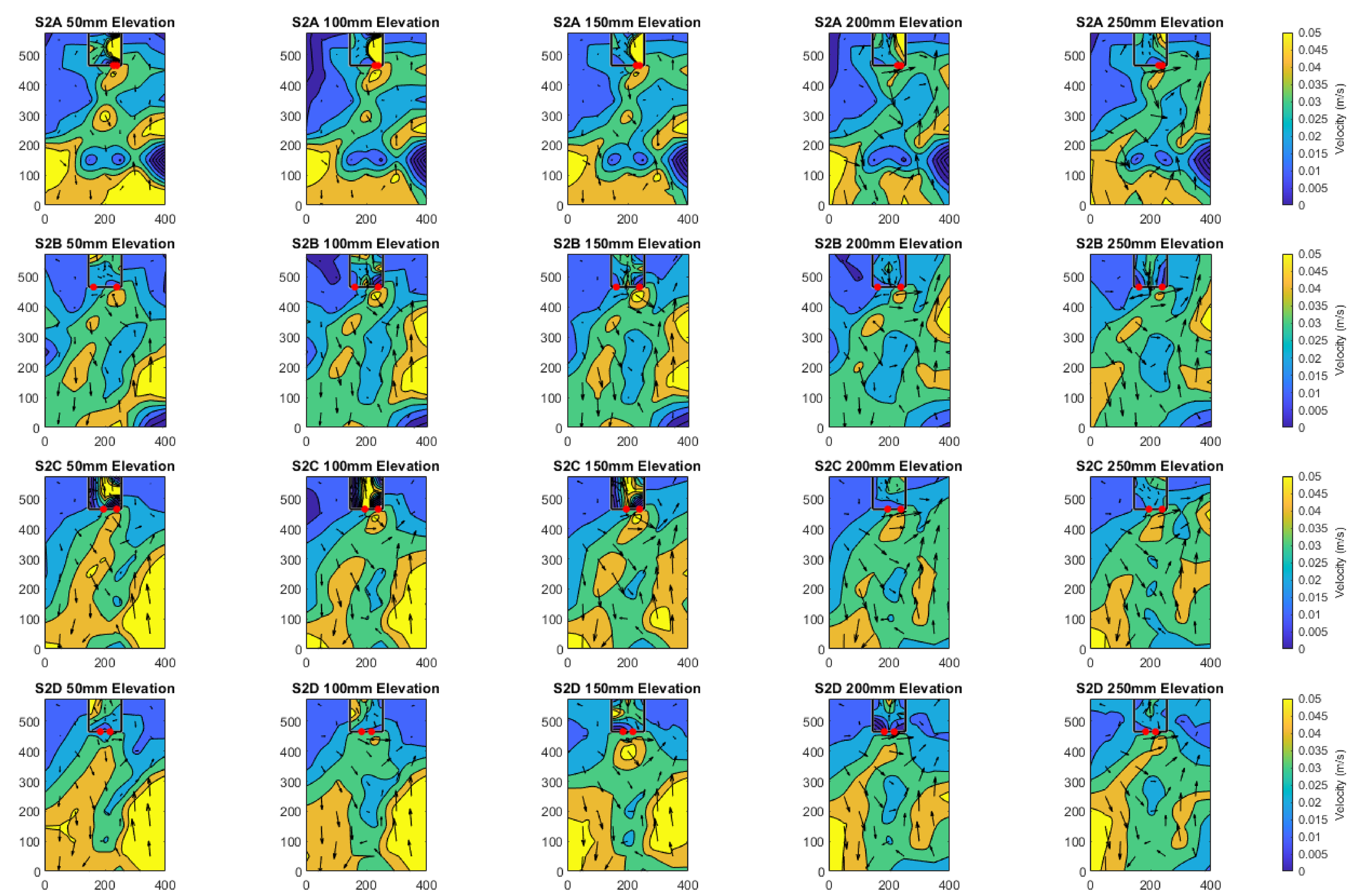



**Figure 3: Velocity at (225,525)**




Although results are highly scattered for all experiments, regression analysis compared to pre-lagoon conditions show that layouts S2B and S2D are best for maintaining original conditions, whilst S2A and S2C cause greater disruption to the natural environment (Figure 2). This is confirmed by velocity/time plots which consistently show that the close spacing of experiment S2A causes exaggerated wakes and increased velocity (Figure 3).

**Figure 1: Contour Plots of Residual Velocity**



## 4. CONCLUSION

Hydraulic structures are often grouped together to reduce the costs of construction and maintenance, however, spacing can have an impact on flow velocity and circulation patterns, which cause the greatest challenges for aquatic life and recreational activities. Analysis shows that side-by-side placement has the greatest impact on velocity range whereas wider spacing can help maintain natural conditions. Future research could be extended to look at TRSs with other geometries and the applications of this work for coastal reservoirs and natural lagoons.

**References**

[1] Neill, et al. (2018) *Renewable Energy*

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Sharing is encouraged

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