Identifying Optimal Eel Tile Installation Using Computational Fluid Dynamics

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Introduction

- Since the early 1980s, European eel (*Anguilla anguilla*) numbers have suffered a 95% reduction across Europe, and are now a species of high conservation concern[1],[2].
- This decline has been partly attributed to the number of in-stream barriers such as weirs, which are a hindrance particularly to the upstream migration of young eels (known as elver)[3].
- Installing fish passes can help mitigate against in-stream barriers; however eels are poor swimmers and require specific “eel tiles” (fig. 1).
- Guidance on the installation of eel tiles is ambiguous and sparse. Understanding the near-bed flow velocity can be used to aid in the design and installation of eel tiles.
- This research aims to quantify the near-bed velocities of various eel tile configurations and compare them to the swimming capabilities of elver.

Figure 1. Example *in situ* eel tile.

Methodology

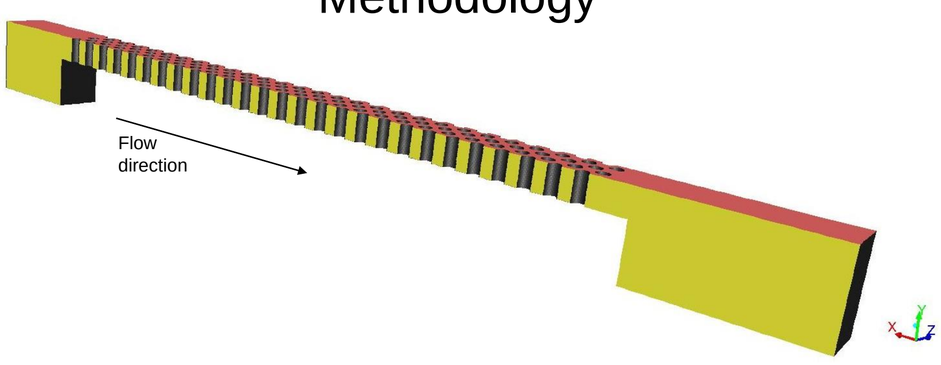

Figure 2. Isometric view of the domain.

A CFD model was constructed based on a typical eel tile installation using ANSYS Fluent 16.2 (fig. 2). The flow rate and installation angle were varied to produce a parametric study of 21 simulations, and used to determine the effect on the near-bed velocity field.

Installation angle was varied from 5º to 17º in steps of 2º. The flow rate was varied between 0.5, 1, and 1.5 Ls^{-1}. The model parameters are given in table 1. Each simulation was allowed to run until 10 seconds of flow time had elapsed, which allows water to exit from the downstream outlet of the domain.

Table 1. CFD model parameters

Boundary Conditions	Upstream velocity inlet. Downstream pressure outlet (red). Symmetry along side walls (yellow). No-slip walls on bed and studs (grey).
Turbulence Modelling	Unsteady, incompressible RANS equations. k-ω SST closure. SIMPLE pressure-velocity coupling. VOF free surface approximation using Geo-Reconstruct. Constant time step Δt = 0.0005 seconds.

The resulting velocity field from each simulation was compared to established biokinetic data for the burst swimming speed of elver for various body lengths, taken from SWIMIT[4] (fig. 3). Combining these two datasets yielded a number of binary “connectivity maps” that show the routes available to an elver based on its body length.

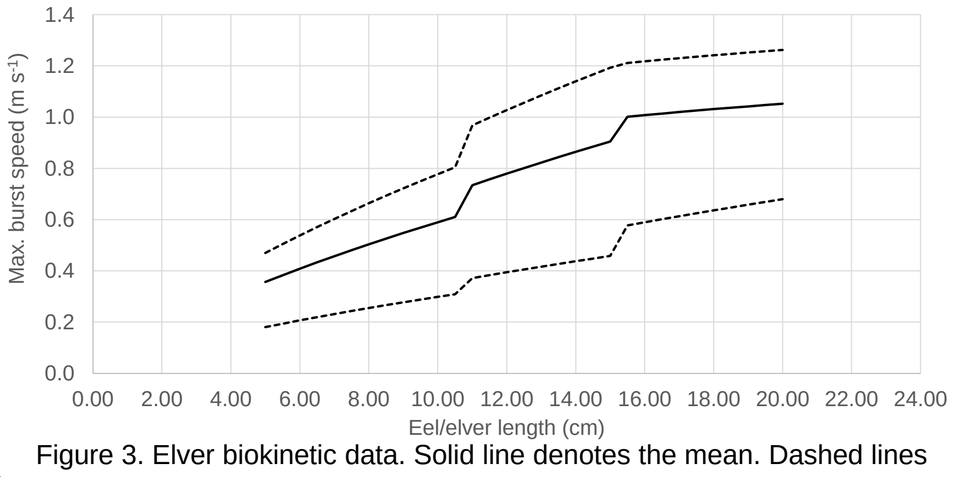

Figure 3. Elver biokinetic data. Solid line denotes the mean. Dashed lines denote the 10% and 90% confidence intervals.

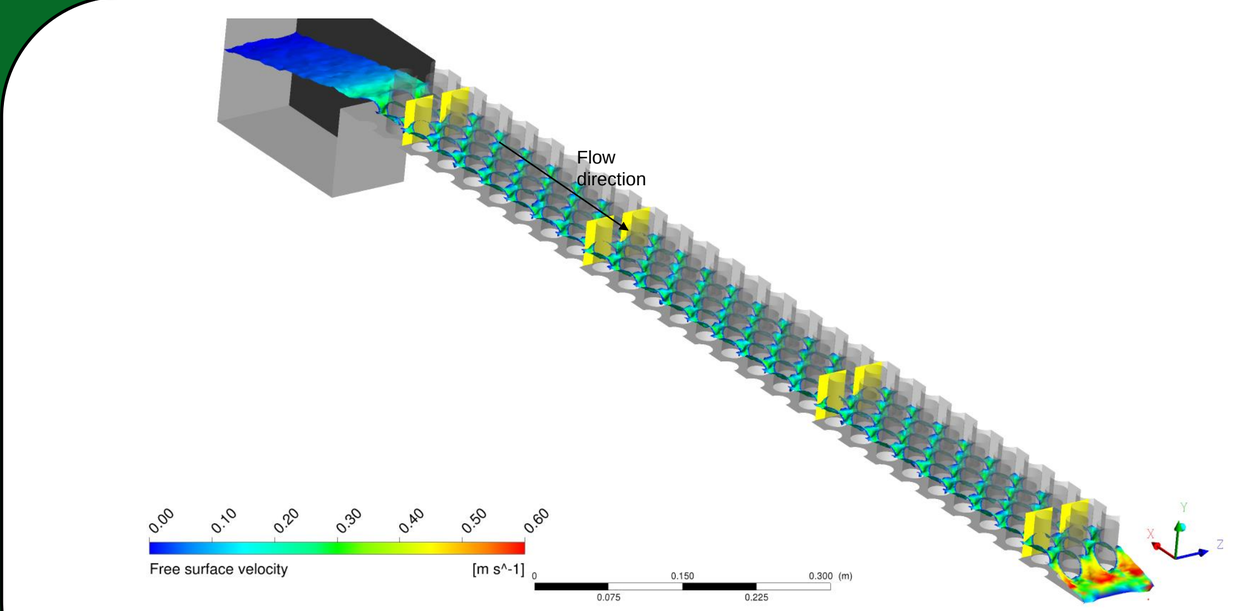

Figure 4. Eel tile with an installation angle of 11º and a flow rate of 1 Ls^{-1}, with overlain free surface after 6.5 seconds of flow time. The free surface is overlain with contours of velocity magnitude.

Results & Discussion

The free surface location and 3D velocity field were determined for each of the 21 eel tile configurations, (e.g. see fig. 4). The near-bed velocity fields can be extracted and classified to show areas that can and can not be passed by an elver of a specific length, dubbed a “connectivity map” (fig. 5).

These maps can be created for each pass configuration and each length of elver, and tabulated to inform practioners of appropriate installation angles for eel passes based on average river flow rate and target elver lengths.

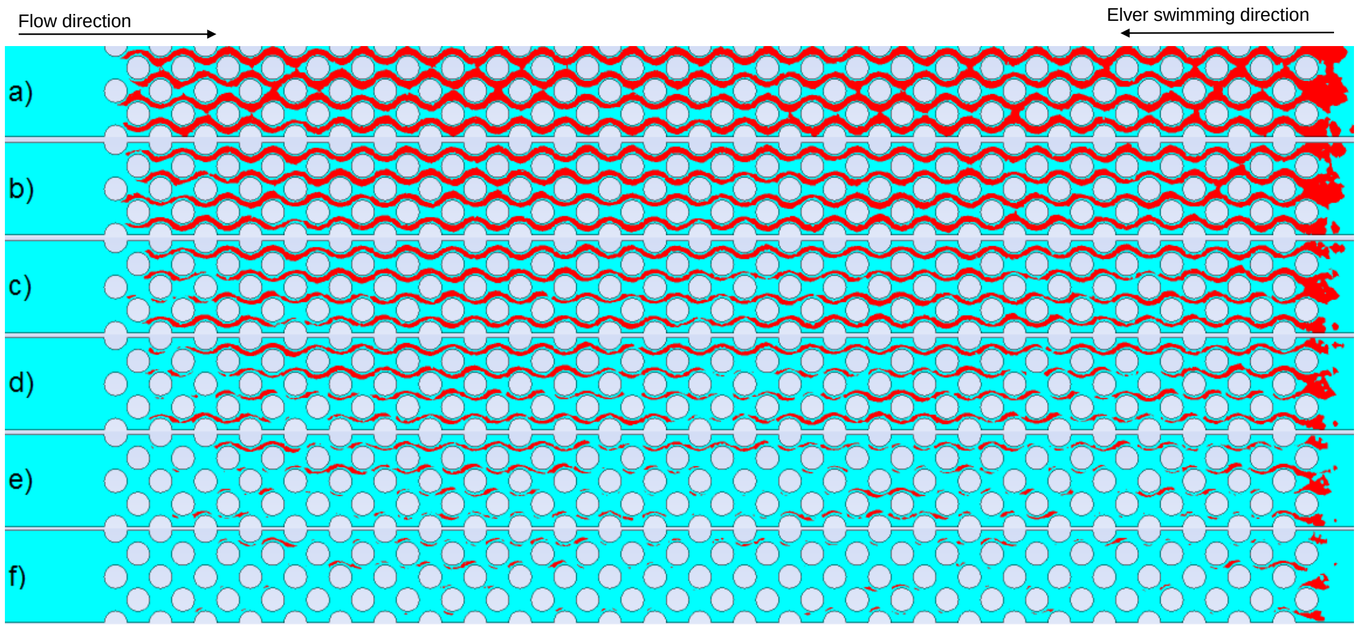

Figure 5. Example connectivity maps for an eel tile installed at 11º with a flow rate of 1 Ls^{-1} for elver of length a) 5 cm, b) 6 cm, c) 7 cm, d) 8 cm, e) 9 cm, f) 10 cm. Passable and impassable regions are denoted by blue and red, respectively.

References

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