Interaction of Marine Mammals with tidal turbines

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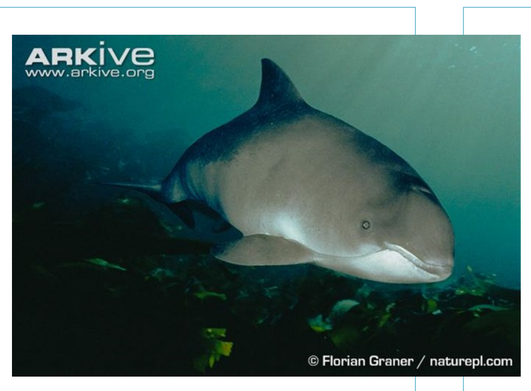
Introduction



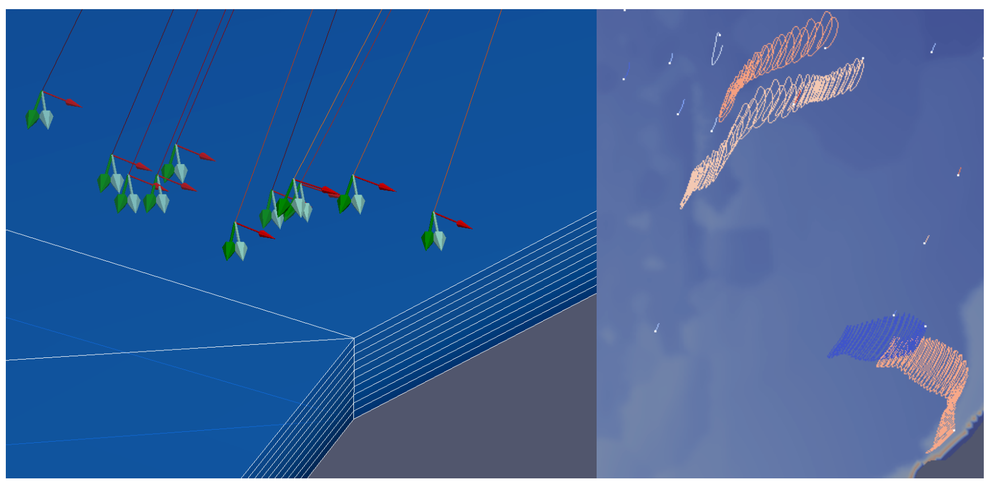
This project aims to simulate the movements of Harbour Porpoise in Ramsey sound in order to investigate the potential impacts of tidal turbine installation on the usage of the area by the porpoise population.

Individual Based Models

An IBM simulates a number of virtual creatures (boids)[1], with each boid examining the environment around itself before making decisions about it's movement and behaviour.
These models have successfully been used to mimic the behaviour of various species in the past, including larvae, different species of birds and larger mammals[2].

Simulated Environments

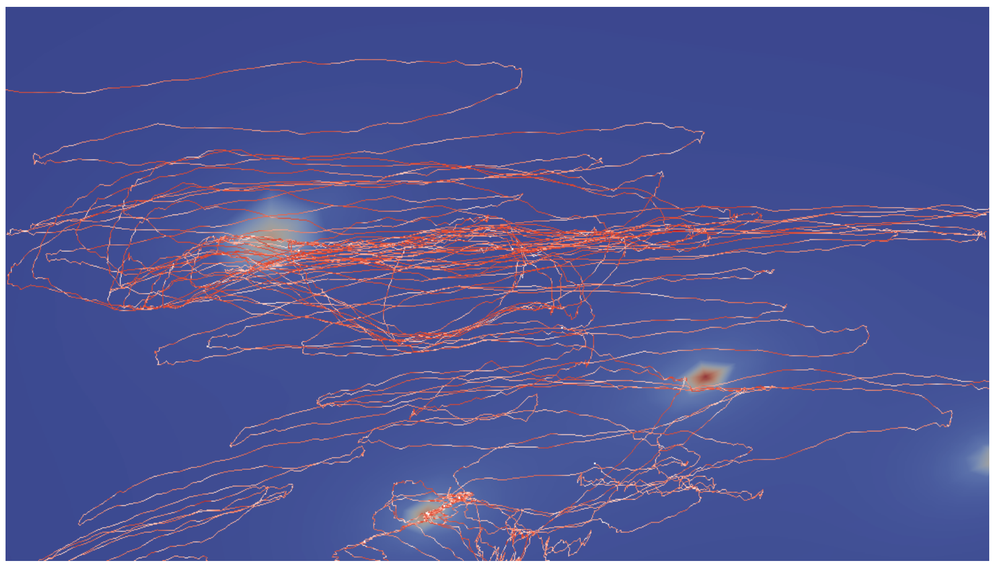
Rather than include tidal flow modelling into the same code as the IBM, the results from existing software can be used as an input to the model. In this instance, the output of openTELEMAC[3] is used to define the environment.



Left: Particles in a sample mesh, showing particle velocity (green), local fluid velocity (cyan) and direction of the force acting on particles (red).
Right: Particle trails showing tidal motion over a 45 day simulation.

Interpolation

The provided results are only known at the nodes of the mesh, and must be interpolated to obtain the effective value at the position of each particle/individual. This is done using mean value coordinates[4], which produce a smooth linear interpolation for arbitrary closed polygons.



Correlated Random Walks (CRWs)

Animal behaviour is not deterministic in nature. To simulate this, the movement of particles through the domain is a randomised by adding noise to the generated motion. The noise applied has a Gaussian distribution, and affects both heading and speed.
The image above shows particles moving on through a tidal site over a 10 day period, plotted over discrete food sources. The CRW heading was based on a combination of food availability and a minimum drag orientation.

What can this be used for?

Marine energy projects are required to assess the impact of the project on local marine life, including potential risks to protected species such as porpoise.
If this model can successfully mimic animal movements in a simulated version of Ramsey Sound, it may be possible to test the effects of a marine energy device by including it in the simulated environment and investigate the changes In modelled behaviour.

Progress and Future Work

The behavioural rules need to be extended to include more realistic responses to the simulated environment. Once this is done, the model will be run for a selection of relevant sites with realistic input data.

References

1 Reynolds, C. W. *Flocks, herds and schools: A distributed behavioral model* ACM SIGGRAPH Computer Graphics, **1987**, *21*, 25-34
2 Lake, T. et al *Methods for Individual Based Modelling of Harbour Porpoise* Proceedings of the 10th European Wave and Tidal Energy Conference, **2013**
3 See http://www.opentelemac.org/
4 Ju, T. et al *Mean value coordinates for closed triangular meshes* ACM Transactions on Graphics, **2005**, *24*, 561-566