Can we use Particle Tracking Models to Investigate Effects of Tidal Energy Device Arrays on Transport Processes?

Tethys Webinar April 28th 2016

Queen's University Belfast

SPACE | SCHOOL OF Planning Architecture & Civil Engineering

Organism transport

Plankton communities (animals, protists, algae and bacteria) are transported vast oceanic distances by water motion

- Provide a food source for higher trophic levels (mammals, fish, invertebrates)
- Assist dispersal processes important for processes such as reef connectivity

Queen's University Belfast

Changes in hydrodynamics arising from tidal turbine arrays may result in changes in transport patterns

- Impede species reaching suitable habitat
- Potentially affect trophic relationships

Wake of SeaGen Pile (credit Craig Stevens)

When considering particle transport – there are two main mechanisms:

- ADVECTION – describes transport from A to B (mean water flow ($\bar{u}$)

- DISPERSION – influenced by turbulence and concentration gradients

Particle tracking models used to simulate the fate of dissolved and suspended substances

- Coupled to hydrodynamic models
- Used for establishing hydrodynamic influence on biological processes

Particle tracking models have been used for:

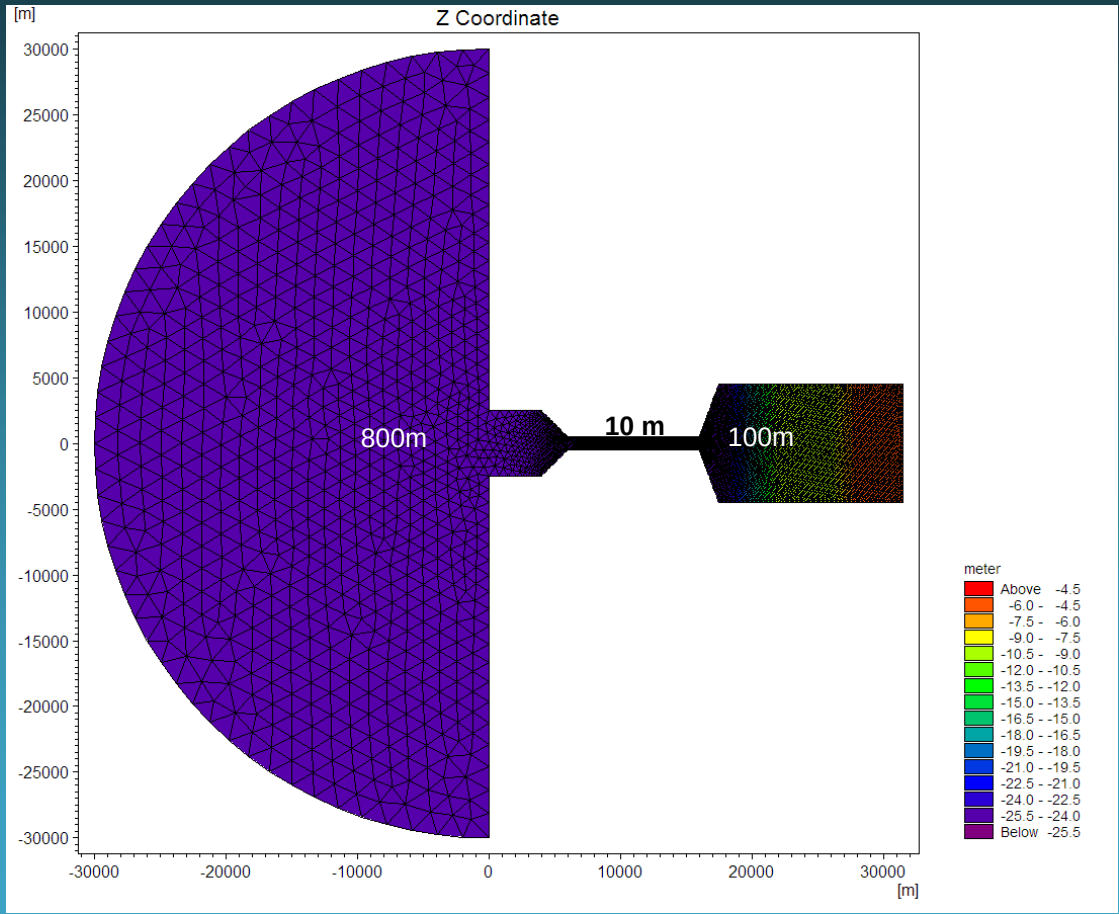
- Structuring population genetics
- Connectivity of larvae
- Sediment transport processes

Can we use them to predict transport effects of Tidal Energy Devices?

This work discusses considerations of using Particle Tracking models in high flow environments to simulate the influence of tidal energy arrays on transport processes using MIKE 21

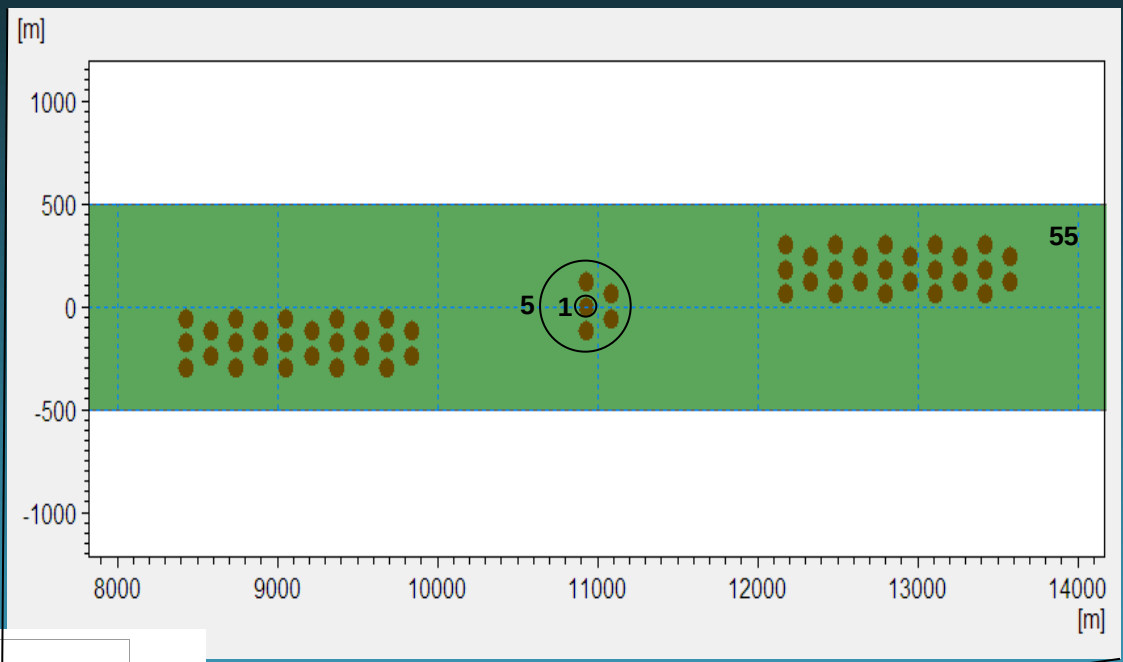
Queen's University Belfast

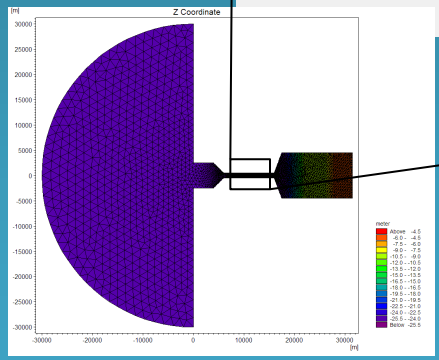
Hydrodynamic model setup



- Idealised, depth averaged domain
- 54589 cells
- Tidal free surface forcing on the open boundary
- 5 minute timestep

Turbine placement

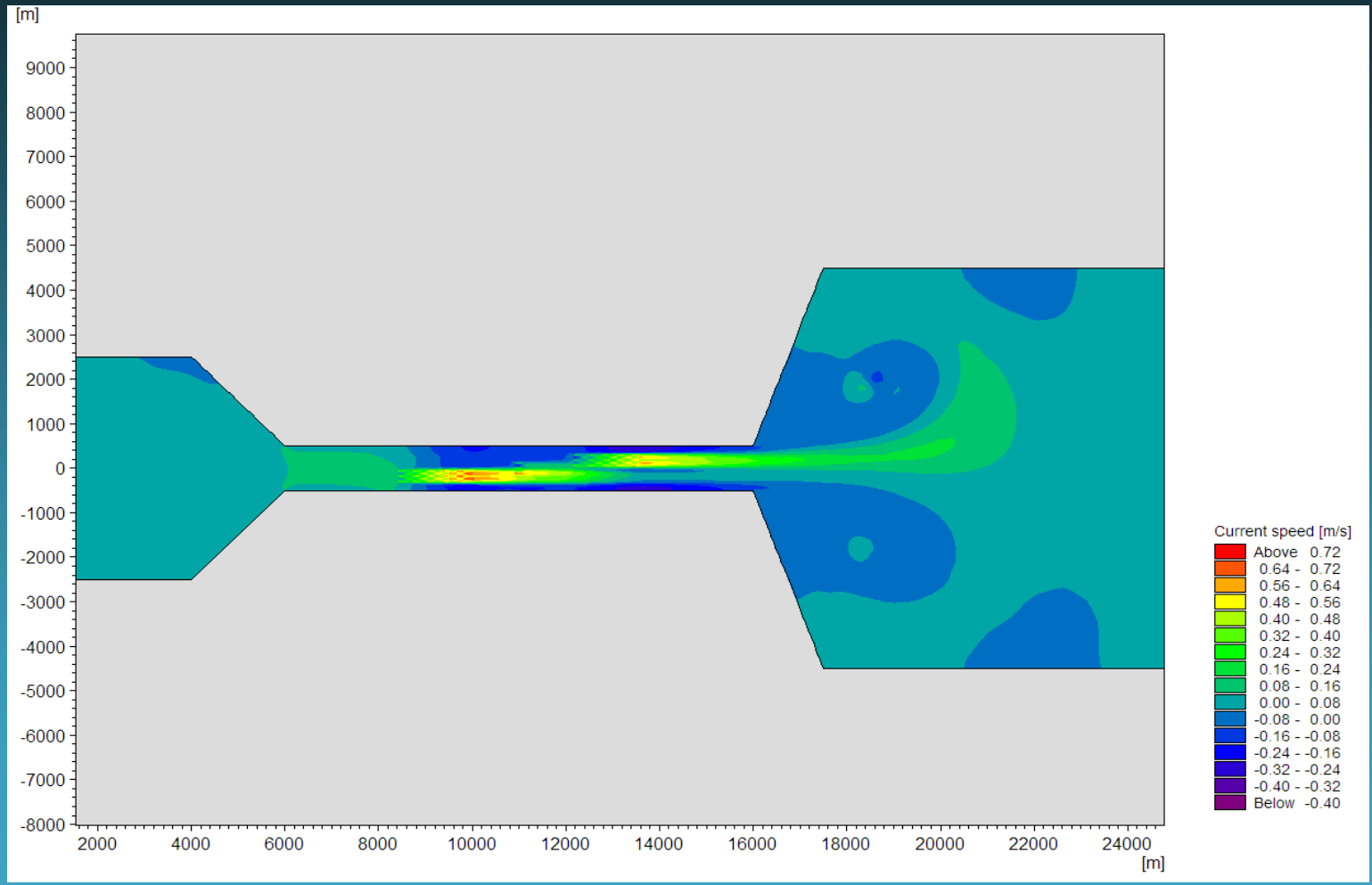




- 0, 1, 5 and 55 Turbines
- Design to provide corridors
- 200 m distance between turbines

Method

Difference in current speed (m/s) between scenarios no turbines and 55 turbines



Queen's University Belfast

Particle Tracking Module

Uses the Lagrangian approach

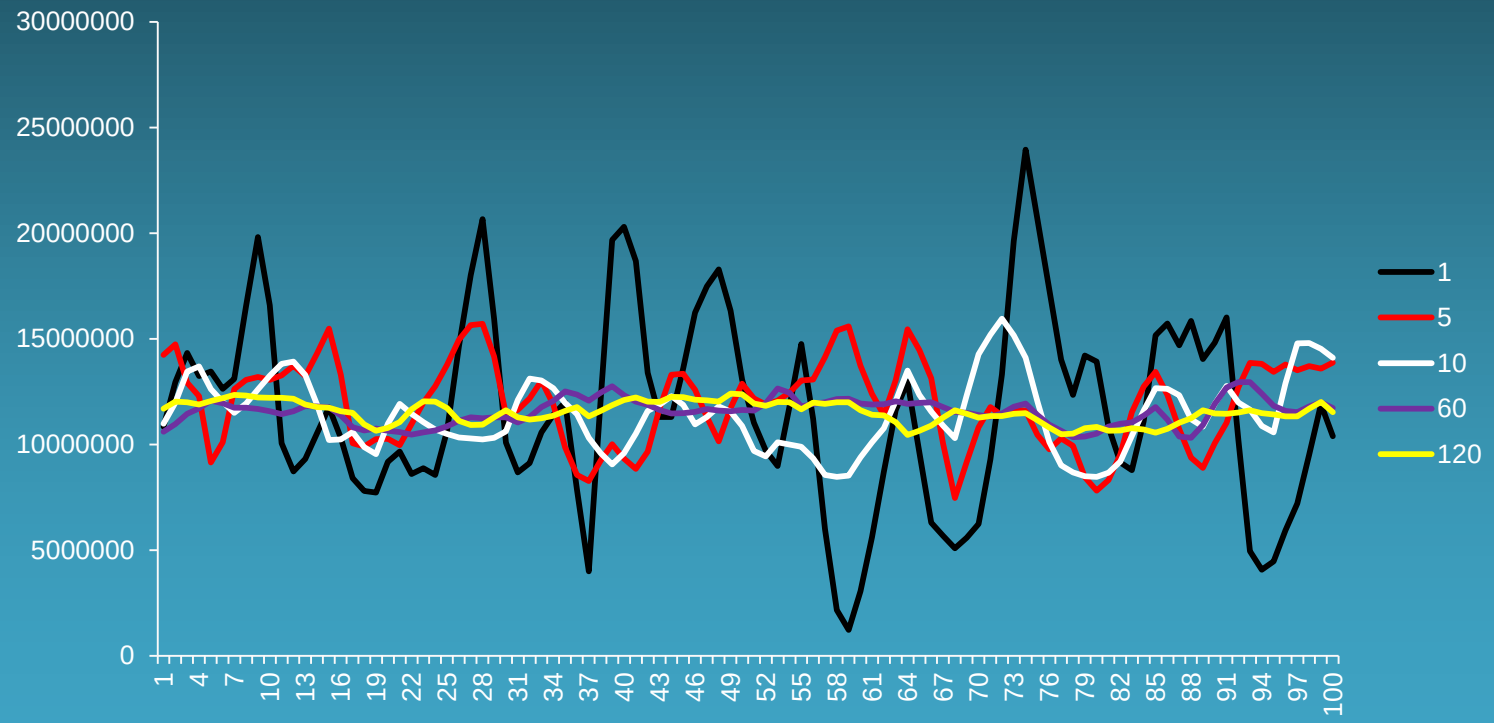
- 7-sources
- Particles released on incoming tide 10 m above the substrate

First question:
How many particles to release each time step?

Method

Convergence study carried out:

- Released 1, 5, 10, 60 & 120 particles
- Extracted a transect across the channel

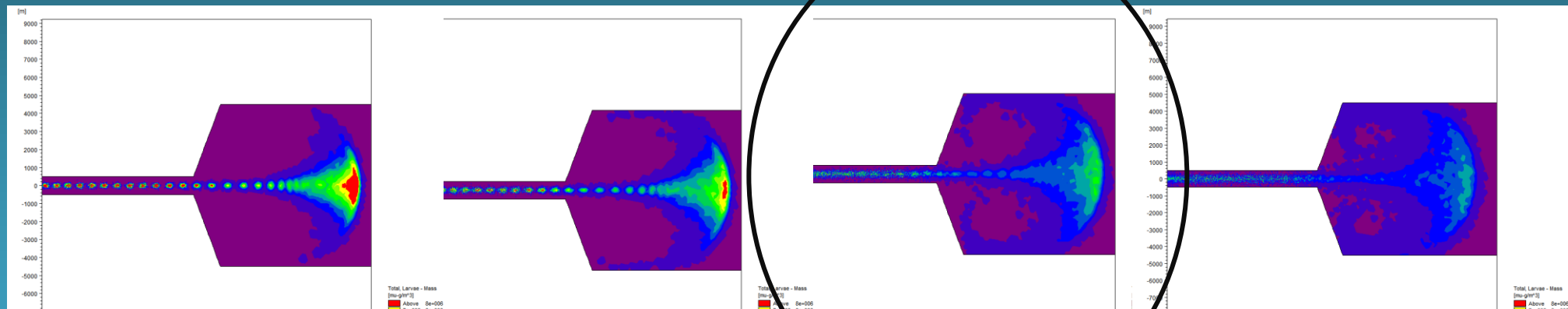


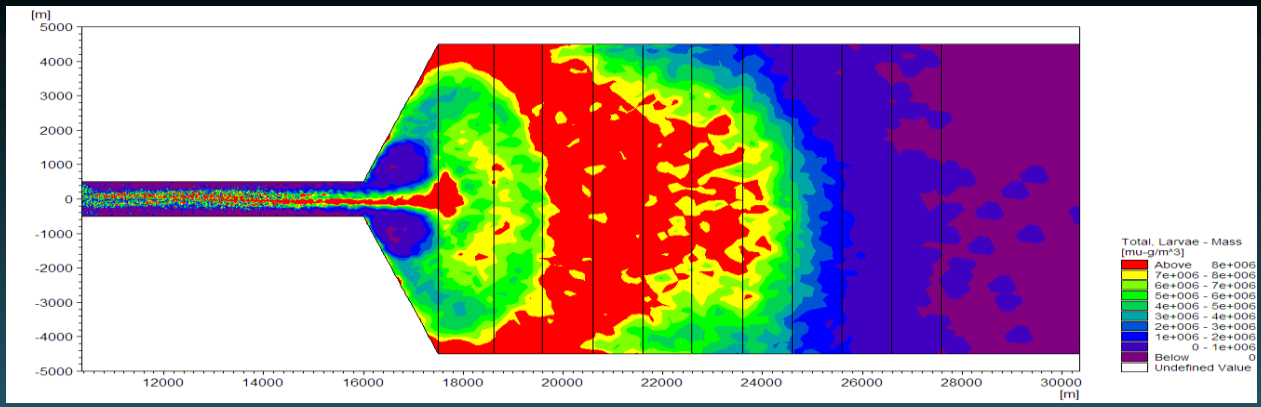
Method

Horizontal dispersion factor:

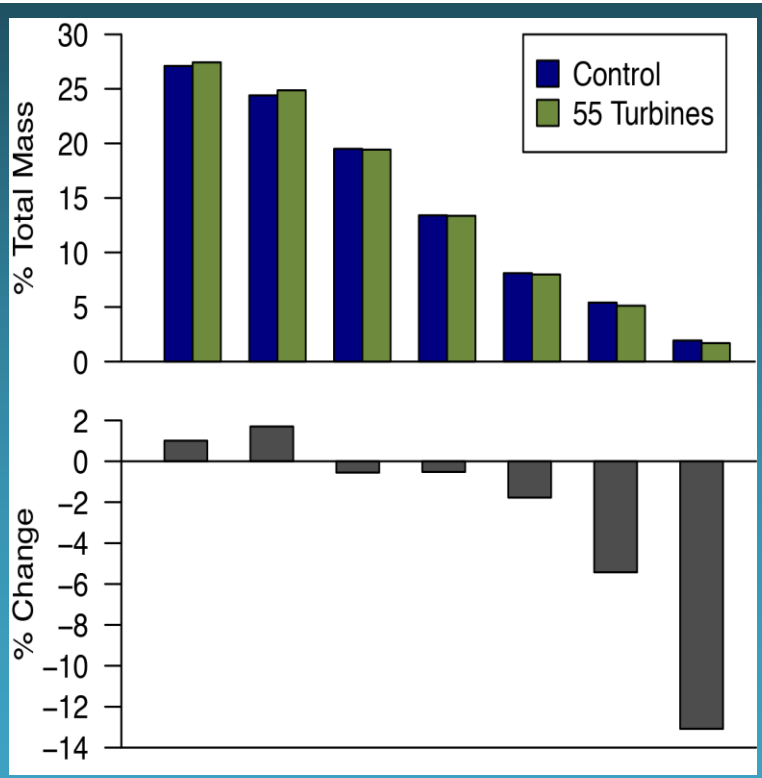
To be stressed that this needs validation

1 2 5 10





PT results



Key results:

- Large differences in spatial patters of transport into the lagoon
- In areas where 95% of the mass accumulated (first 1/3 of the basin), we observed a maximum 2% change between simulations (control vs. turbines).

Summary

- We now have a very good understanding of M21 FM transport code
- More confident with using the PT approach and believe conclusions valid
- In an ideal world, would be good to use field data to validate – especially the horizontal dispersion
- Future work – noise introduced such as wind effects.

Queen's University Belfast

For more information, please contact
Louise Kregting: l.kregting@qub.ac.uk