The University of Manchester

EPSRC Pioneering research and skills

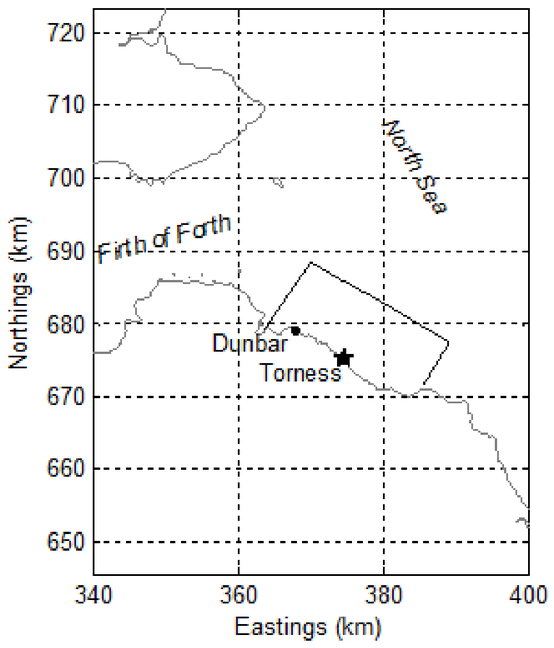
EDF ENERGY

MODELLING INGRESS MECHANISMS FOR POWER STATION INTAKES ON THE SOUTH EAST COAST OF SCOTLAND

This study addresses key scientific questions associated with ingress mechanisms by marine species:

- Validation of the hydrodynamic model concerning the coastal area around the power station.
- Understanding the mechanisms which lead to the clogging of the cooling water inlet.
- How can we predict the ingress mechanisms in the future and prevent temporary shutdowns ?

Power Station Shutdowns

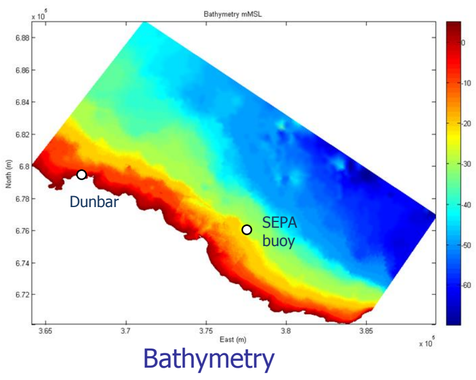


The Torness nuclear power station, located along the Eastern coast of Scotland, over the last years several has been subject to partial or complete shutdowns caused by the ingress of different types of drifters, algae, seaweed and jellyfish, into the water intake. These ingress events resulted in the clogging of the filtering drums, which filter the seawater, and thus disrupted the cooling water supply for the power station. The ingress mechanisms and conditions are still poorly understood and difficult to predict numerically.

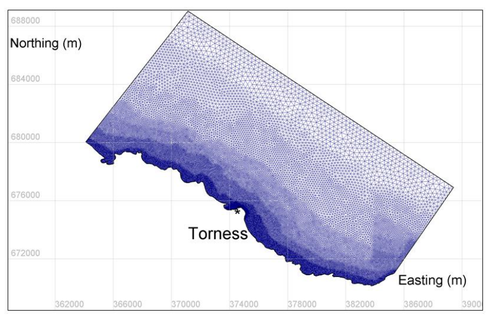
Information relevant to the ingress events such as wind data, wave climate are available for the days before the event providing the hydrodynamic conditions of the area. This enables the identification of the areas where dislodgement or fracture of seaweed may occur due to the wave forces and also the time when those phenomena occur.

The project is using the TELEMAC software which solves the free-surface flow equations based on the depth-averaged Navier-Stokes equations and TOMAWAC which solves a simplified equation for the spectro-angular density of wave action.

Validation of the hydrodynamic model

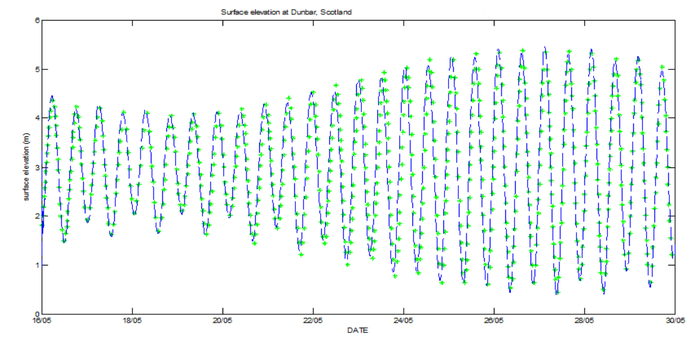


Bathymetry

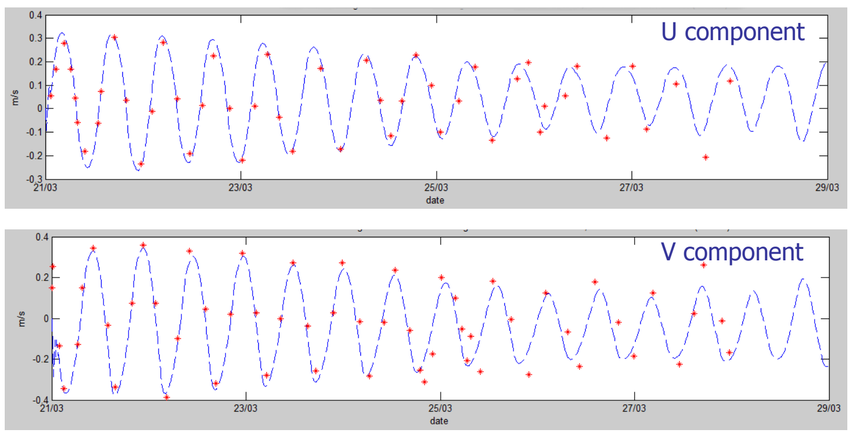


Computational mesh

- 34917 nodes
- 68472 elements
- Time step 2 sec
- Edge-based scheme
- k-ε model



Surface elevation comparison between the model (--) and data from the port of Dunbar provided from UK Hydrographic Office (*), 2013, May 16-30.



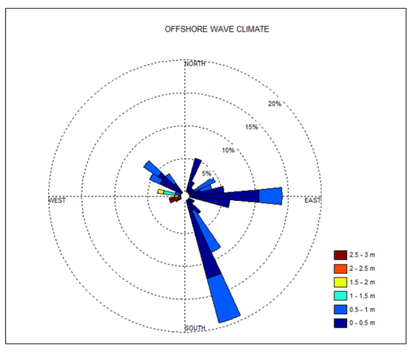
Comparison of currents between model (--) and data provided from the Scottish Environmental Protection Agency (SEPA) (·) buoy , 2008 March 21 – 28.

top (U component)
bottom (V component)

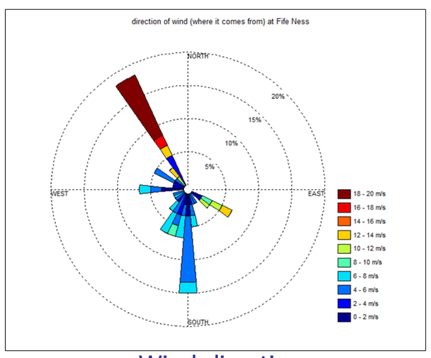
Case Study

In August of 2006 the Torness Power Station faced an seaweed ingress event which lead to a temporary reactor shutdown. The event occurred within 24 hours after the whether conditions had worsened. The hydrodynamic model was for an interval of 4 days before the event. To study the event those steps were followed:

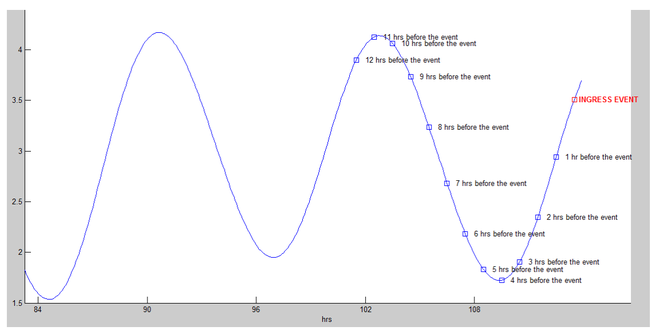
- TELEMAC is run to predict the surface elevation.
- Using the surface elevation, the offshore wave conditions from ANEMOC and the wind conditions from nearby nearshore stations TOMAWAC files were produced for every hour.
- Run TELEMAC again using the wave-induced currents information and the wind information.
- Using TELEMAC result file, release particles, randomly inside the cooling water inlet channel, determine where those particles have been 1hr, 2hrs , 3hrs , …, 12 hrs before the event. This will give us information where the particles were 1 hours,2 hours, etc. before the event.



Offshore wave direction

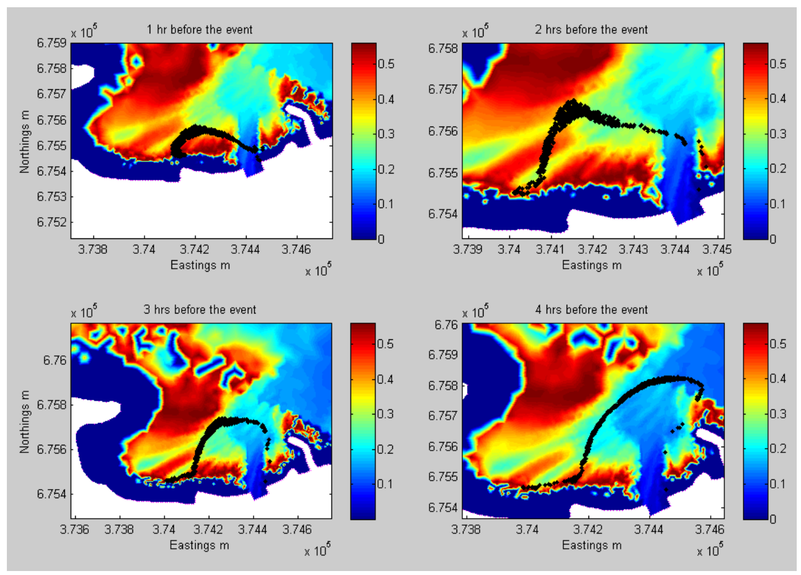


Wind direction



Computed surface elevation at the vicinity of Torness Station before the ingress event.

Offshore H_s/d = 1.9, T_p = 8 s



The figure shows the position of 900 particles representing seaweed within a time interval of 4 hours before the event (black dots). Background colour is the ratio of H_s/d. Macroalgae (seaweed) are flexible and their bodies can follow the wave flow. Therefore the seaweed are more likely to suffer failure when the wave flow can affect the substratum of the seaweed which is very close to the bed. As there is lack of information of the dislodgment location of the seaweed, it can be said that the seaweed is more likely to be dislodged in areas where the ratio H_s/d is high.

Conclusion & Future Work

- Initial results agree with observed removal of kelp in the nearby vicinity of the power station in depths of 3 m or less.
- Future work will involve running simulations for other known events and designing new hydraulic structures to prevent future ingress events of seaweed and marine species.

Research team and contacts:

Nikolaos Spanakis, University of Manchester, Nikolaos.Spanakis@manchester.ac.uk
Arnaud Lenes, EDF R&D, London, UK, Arnaud.Lenes@edfenergy.com
Benedict Rogers, University of Manchester, Benedict.Rogers@manchester.ac.uk
Peter Stansby, University of Manchester, Peter.Stansby@manchester.ac.uk

Selected publications:

- Lenes, A., and Vidaud, P. (2011) Development of a simulation tool to predict the clogging by seaweed of the water intakes of nuclear power plants. EDF R&D. H-N50-2011-02025-EN/0.2. 86pp
- Hervouet, J-M (2007) Hydrodynamics of free surface flows: modelling with the finite element method. Wiley. 341pp
- Jolly,A. (2011) : Modelling of the transport of algae in a coastal environment using a stochastic method, PhD thesis, Université Paris-Est.
- Denny,M.(1995) Predicting Physical Disturbance: Mechanistic Approaches to the Study of Survivorship on Wave-Swept Shores. *Ecological Monographs, 65(4), 371-418*