Queen's University Belfast: The past and present research on environmental interactions of wave and tidal devices

Dr Louise Kregting

UK Centre for Marine Energy Research, Edinburgh, November 2016

SNBE | SCHOOL OF
Natural and Built
Environment

Large Scale Interactive Coupled Modelling of Environmental Impacts of Marine Renewable Energy Farms (LINC)

Develop and demonstrate the availability of numerical methods to assess the potential environmental impact of large arrays of tidal and wave energy devices

The LINC Project was funded by EPSRC grant EP/J010065/1

Key scientific advances:

Research Topics

Hydrodynamic modelling and array optimisation

Comparison between Fluidity and MIKE DHI, optimisation of arrays and turbine implementation

Culley DM, Funke SF, Kramer SC, Piggott MD. 2016. Integration of cost modelling within the micro-siting design optimisation of tidal turbine arrays". Renewable Energy 85, 215-227.

Kramer SC, Piggott MD, Hill J, Kregting L, Pritchard D, Elsäßer B. 2014. The modelling of tidal turbine farms using multi-scale, unstructured mesh models". 2nd International Conference on Environmental Interactions of Marine Renewable Energy Technologies (EIMR).

Kramer SC, Funke SW, Piggott MD. 2015. A continuous approach for the optimisation of tidal turbine farms". EWTEC.

Adam A, Buchan AG, Piggott MD, Pain CC, Hill J, Goffin MA. 2016. Adaptive Haar wavelets for the angular discretisation of spectral wave models, Journal of Computational Physics, 305, 521-538.

Sediment Processes

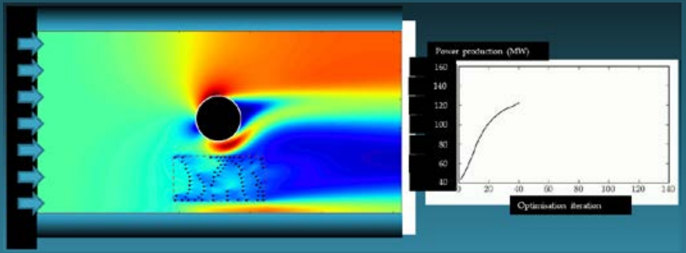
Sediment transport modelling in the Pentland Firth using Fluidity

Martin-Short R, Hill J, Kramer SC, Avdis A, Allison PA, Piggott MD. 2015. Tidal resource extraction in the Pentland Firth, UK: potential impacts on flow regime and sediment transport in the Inner Sound of Stroma". Renewable Energy 76, 596–607.

Transport Processes

Particle tracking using MIKE DHI to investigate impacts of TED arrays on transport processes

Kregting L, Schuchert P, Pritchard D, Elsäßer B "Using particle tracking models to simulate the effects of tidal arrays of devices on transport processes" In preparation



With the presence of an island (above) Open Tidal Farm uses a unique methodology to efficiently optimise the position of turbines in an array – at each iteration the turbines are moved to improve the power production.

Key scientific advances:

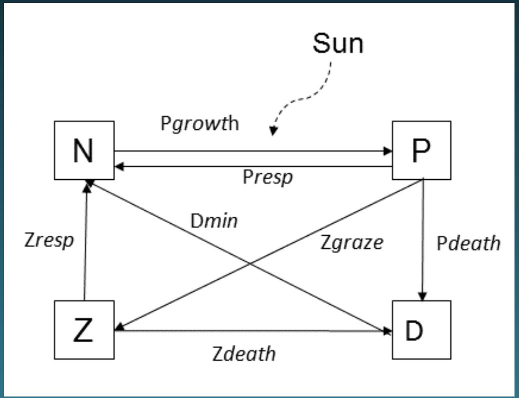
Research Topics

Biogeochemical Processes

Large scale (>100 km) effects of TED arrays on phytoplankton dynamics using GETM-ERSEM-BFM 3-D model and small and local scale (0.5-30 km) effects using 2-D NPZD (Nutrient, Phytoplankton, Zooplankton, Detritus) models in DHI

van der Molen J, Ruardij P, Greenwood N. 2016. Potential environmental impact of tidal energy extraction in the Pentland Firth at large spatial scales: results of a biogeochemical model. Biogeosciences, 13(8), 2593-2609.

Schuchert P, Kregting L, Pritchard D, Savidge G, Elsäßer B. Using 2-D coupled NPZD models to investigate local impacts of tidal turbines arrays. Submitted



Noise

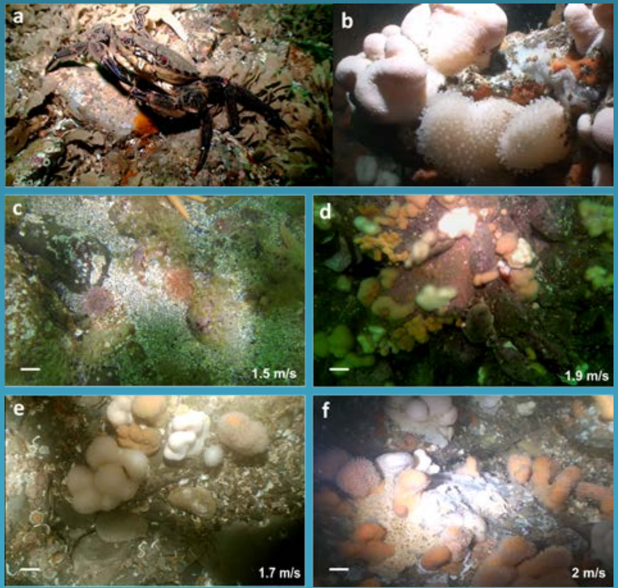
Investigation into noise propagation and acoustic characteristics of TEDs

Schmitt P, Elsäßer B, Coffin M, Hood J, Starzmann R. 2015. Field testing a full-scale tidal turbine part 3: Acoustic characteristics". EWTEC.

Benthic Communities

Influence of energy extraction on benthic communities

Kregting L, Elsaesser B, Kennedy R, Smyth D, O'Carroll J, Savidge G. 2016. Do Changes in Current Flow as a Result of Arrays of Tidal Turbines Have an Effect on Benthic Communities?. PloS one, 11(8), e0161279.



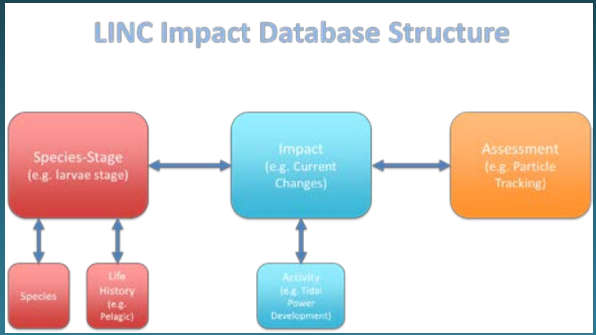
Key scientific advances:

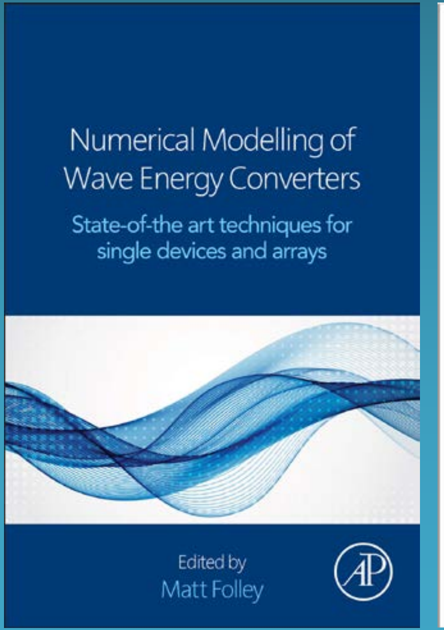
Research Topics

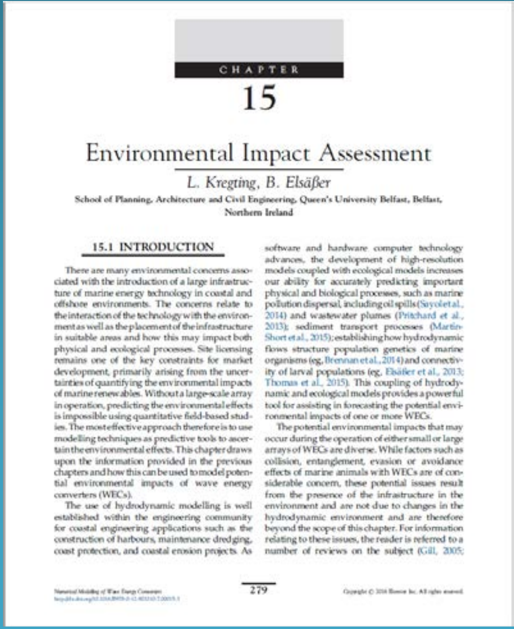
Fisheries Risk Matrix Database

Development of an interactive, spatially-explicit, web-based tool which draws upon a species risk matrix database and allows users to identify:

1. marine species and their life-history stages that occur at a planned TED array location,
2. the likely nature of any impacts from the TED Array on those species or life-history stages and,
3. the modelling approaches available for assessing the nature and scale of the impacts.







CHAPTER
15

Environmental Impact Assessment

L. Kregting, B. Elsäßer

School of Planning, Architecture and Civil Engineering, Queen's University Belfast, Belfast, Northern Ireland

15.1 INTRODUCTION

There are many environmental concerns associated with the introduction of a large infrastructure of marine energy technology in coastal and offshore environments. The concerns relate to the interaction of the technology with the environment as well as the placement of the infrastructure in suitable areas and how this may impact both physical and ecological processes. Site licensing remains one of the key constraints for market development, primarily arising from the uncertainties of quantifying the environmental impacts of marine renewables. Without a large-scale array in operation, predicting the environmental effects is impossible using quantitative field-based studies. The most effective approach therefore is to use modelling techniques as predictive tools to ascertain the environmental effects. This chapter draws upon the information provided in the previous chapters and how this can be used to model potential environmental impacts of wave energy converters (WECs).

The use of hydrodynamic modelling is well established within the engineering community for coastal engineering applications such as the construction of harbours, maintenance dredging, coast protection, and coastal erosion projects. As software and hardware computer technology advances, the development of high-resolution models coupled with ecological models increases our ability for accurately predicting important physical and biological processes, such as marine pollution dispersal, including oil spills (Sayol et al., 2014) and wastewater plumes (Pritchard et al., 2013); sediment transport processes (Martin-Short et al., 2015); establishing how hydrodynamic flows structure population genetics of marine organisms (eg, Brennan et al., 2014) and connectivity of larval populations (eg, Elsäßer et al., 2013; Thomas et al., 2015). This coupling of hydrodynamic and ecological models provides a powerful tool for assisting in forecasting the potential environmental impacts of one or more WECs.

The potential environmental impacts that may occur during the operation of either small or large arrays of WECs are diverse. While factors such as collision, entanglement, evasion or avoidance effects of marine animals with WECs are of considerable concern, these potential issues result from the presence of the infrastructure in the environment and are not due to changes in the hydrodynamic environment and are therefore beyond the scope of this chapter. For information relating to these issues, the reader is referred to a number of reviews on the subject (Gill, 2005;

279

https://tethys.pnnl.gov/events/linc-webinar

Queen's University Belfast

powerkite

- Project start date 2016-01-01
- Duration 30 months
- Budget 5 074 k€
- Grant Agreement number 654438

powerkite

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654438.

Short	Participant legal name	Type	Main Expertise	Country
ROC	Midroc Project Management AB (coordinator)	Industrial	Project development	Sweden
LBE	Engie Lab Laborelec Ltd	Industrial	Electrical power technology	Belgium
MIN	Minesto AB	Industrial	Tidal power plant	Sweden
CHA	Chalmers University of Technology	Academic	Electrical generation systems, LCA, environmental impacts	Sweden
QUB	Queen's University Belfast	Academic	Environmental impact & weather modelling	UK
SSPA	SSPA Sweden AB	Industrial	Turbine design	Sweden
AC&E	Applied Computing & Engineering Ltd	Industrial	Hydrodynamics, optimisation	UK
UWE	UW-ELAST AB	Industrial	Polyurethane specialist	Sweden
MOOR	MoorLink Solutions AB	Industrial	Mooring specialist	Sweden

Queen's University Belfast

Collision Risk Modelling

Noise

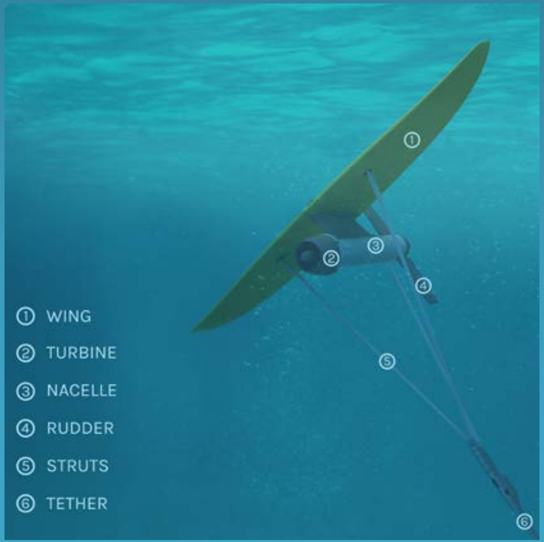
Substrate Communities

Life Cycle Analysis

QUB's main role in the project is assessing the environmental interactions of the Deep Green Technology (Kite)

powerkite

The energy extraction by the Deep Green's kite is very different from the general horizontal axis designs — the interaction with the environment is unknown



Investigating interactions:

- **Hydrophones** to understand ambient noise and PTO noise underwater
- **ADCPs** (Acoustic Doppler Current Profilers) to measure current speed, direction and turbulence – hydrographics
- **Benthic (seabed) surveys** to assess species composition
- **Simulating** the probability of collisions between the kite and marine mammals
- **Multibeam sonar** (active acoustics) to observe animal interactions with the kite underwater
- **Seal counts and behavioural studies** to assess individual variation and population dynamics