Investigating the ecology of black guillemots in relation to marine renewable energy and marine protected areas

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ABSTRACT:

The black guillemot *Cepphus grylle* is a diving seabird, widespread in northern latitudes, including the UK and Ireland, and with over 37,000 individuals in Scotland. Compared with other diving seabirds, the black guillemot has been little studied meaning there is limited ecological or behavioural information available. In Scotland, black guillemots have been seen to associate with tidal currents while undertaking foraging dives (Wade 2015) making them potentially vulnerable to planned tidal based marine renewable energy developments (Furness et al. 2012). Individuals have also been recorded to dive to depths at which tidal turbines will operate (Masden et al. 2013). Further research is needed to understand the spatial and temporal aspects of these dives, as the potential effects of tidal turbines may include collision risk (Masden et al. 2013), habitat modification (Shields et al. 2009), and changes in prey distribution (Langton et al. 2011).

In 2014, the allocation of six black guillemot specific Marine Protected Areas (MPAs) in Scotland, recognised the importance of their conservation (Swann 2014). Discovering the foraging movements of black guillemots could help assess how effective a conservation measure MPAs provide.

Several projects are underway at the Environmental Research Institute (ERI) to improve our understanding of black guillemot ecology. We are using GPS tags to determine the fine scale movement of black guillemots during the breeding season in the Pentland Firth and Orkney Waters, an area within which tidal energy projects are planned. To provide an insight into how foraging tracks relate to chick diet and nest success, diet observations by direct monitoring and camera traps, along with nest monitoring, provide further comparative data. Additionally, using data loggers that record the amount of time birds spend in and out of the water, we aim to collect data on the behaviour of individuals during the non-breeding season to understand the risk that tidal turbines may pose to this species. We will provide an overview of these projects as well as future planned research on this species, and present preliminary findings from the 2016 field season.

Acknowledgements

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References

Furness, R. W., Wade, H. M., Robbins, A. M., & Masden, E. A. (2012). Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science: Journal du Conseil*, *69*(8), 1466-1479.

Langton, R., Davies, I. M., & Scott, B. E. (2011). Seabird conservation and tidal stream and wave power generation: Information needs for predicting and managing potential impacts. *Marine Policy*, *35*(5), 623-630.

Masden, E. A., Foster, S., & Jackson, A. C. (2013). Diving behaviour of Black Guillemots Cepphus grylle in the Pentland Firth, UK: potential for interactions with tidal stream energy developments. *Bird Study*, *60*(4), 547-549.

Shields, M. A., Dillon, L. J., Woolf, D. K., & Ford, A. T. (2009). Strategic priorities for assessing ecological impacts of marine renewable energy devices in the Pentland Firth (Scotland, UK). *Marine Policy*, *33*(4), 635-642

Swann, R. (2014) Marine Protected Area – related black guillemot surveys 2014. *Scottish Natural Heritage Commissioned Report No. 792.*

Wade, H.(2015) Investigating the potential effects of marine renewable energy developments on seabirds. *PhD Thesis.*

Investigating the larval behaviour of *Ostrea edulis*

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The European native flat oyster *Ostrea edulis* was once a dominant feature along European coastlines, forming vast beds that constituted a central ecological and socio-economic resource. These beds were biodiversity hotspots that mediated effective coastal ecosystem functioning, while harvesting of *O. edulis* contributed to food security and spurred local economies. Yet, centuries of overfishing, combined with more recent stressors such as coastal development and disease outbreaks, have led to a dramatic decline of this species. Today, European oyster beds are considered functionally extinct throughout most of their native distribution range[1].

There is an increasing interest in restoring *O. edulis* throughout Europe to recover the ecological functions which the European oyster, as a keystone species, provides in the marine environment. This interest is underpinned by European and national legislation which aim to maintain and expand the current geographical range and abundance of *O. edulis*. However, while the adult life stage of *O. edulis* has received a large amount of scientific attention, there is a lack of knowledge on its larval ecology and hence dispersal characteristics.

This study seeks to study the larval behaviour of *O. edulis* under different environmental conditions. The response of larvae to environmental cues can alter their vertical distribution in the water column, influencing the intensity and direction of their dispersal[2]. Vertical migration of larvae is often based on a combination of responses to different cues, such as pressure, temperature, salinity, gravity, underwater sound, turbulence and light, which act at different spatial scales[3]. The hypothesis is that *O. edulis* larvae will respond to cues that can decrease predation risk, maximise food intake, and maximise their chance to settle in a suitable habitat, preferably among conspecifics.

For this purpose, a novel methodology is being developed that allows accurate, cost-effective observation and quantification of larval behaviour. The data collected through this methodology will inform the parameterisation of models of larval movement which, as a later part of the PhD project, will be incorporated into hydrodynamic models designed to predict dispersion in this species. This information will guide planned restoration projects in the selection of restoration sites which can promote larval recruitment and connectivity between restored *O. edulis* beds.

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References

[1]Beck, M.W., Brumbaugh, R.D., Airoldi, L., Carranza, A., Coen, L.D., Crawford, C. *et al.* (2009). Shellfish reefs at risk: a global analysis of problems and solutions. Nature Conservancy.

[2]North, E.W., Schlag, Z., Hood, R., Li, M., Zhong, L., Gross, T. *et al.* (2008). Vertical swimming behavior influences the dispersal of simulated oyster larvae in a coupled particle-tracking and hydrodynamic model of Chesapeake Bay. Marine ecology progress series, 359, 99.

[3]Kingsford, M.J., Leis, J.M., Shanks, A., Lindeman, K.C., Morgan, S.G. & Pineda, J. (2002). Sensory environments, larval abilities and local self-recruitment. Bulletin of Marine Science, 70, 309-340.

Sensitivity of wave models to boundary conditions

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Spectral wave modelling is essential for the assessment of wave energy resources and the risk evaluation to marine operations. Since its inception and in particular with the new impulse given by JONSWAP project (Hasselmann et al., 1973), spectral waves theory and modelling have been subject of considerable progress, including the development of state-of-the-art numerical models such as WAM, WaveWatch III or SWAN. The simulation of wind wave is essentially driven by wind forcing and boundary conditions. The size of the domain often decides on the predominance of either of these forcing, for instance boundary conditions are predominant in small scale nearshore models, while wind forcing becomes predominant for large scale global models.

Using an existing model, we investigate the influence of boundary conditions on the wave predictions in a medium-scale continental shelf domain. The SWAN model was implemented over and unstructured grid covering the Scottish waters. Gleizon and Woolf (2013) showed that boundary conditions can have a significant effect on wave predictions, mainly because swell can travel over long distances (thousands of kilometers). When applied for evaluating wave energy resources Gleizon and Murray (2014) showed the available energy can be underestimated by 60% to 80%, depending on locations and conditions, when boundary conditions are not included.
The spectral wave model SWAN allows including boundary conditions under different formats: parametric, non-directional (1D) spectrum, or directional (2D) spectrum. The model was tested with different boundary conditions, and its response analysed and compared with available wave buoys monitoring data, in 2011-2012.

The results generally show more complex wave spectra when 2D-spectra boundary conditions are applied with respect to parametric conditions. This reflects a better representation of swells at the model boundary. However this observation depends on the observation location, and in particular its distance from boundaries, or the coastal configuration. The wave spectra are also analysed with respect to the wind variability at various sample periods in order to evaluate the respective influence of local wind forcing and the boundary conditions.

Finally the impact of the various boundary conditions setup on the wave energy resource is estimated, with a view to determine whether the predictions improvement can justify the increased complexity and possibly cost for using full directional spectrum for the boundary conditions.

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References

Gleizon, P.; Murray, A. (2014) Modelling wave energy in archipelagos – Case of northern Scotland, *Proc.Environ.Interact.Mar.Renew.Energ.Technol.(EIMR2014).* Available online: http://tethys.pnnl.gov/sites/default/files/attachments/EIMR2014_968_Gleizon.pdf

Gleizon, P.; Woolf, D.K. (2013) Wave energy assessment in Scottish Seas. *Proc. of the 10th .European Wave and Tidal Energy Conferences, Aalborg, Danemark.*

Hasselmann, K.; Barnett, T.P.; Bouws, E.; Carlson, H.; Cartwright, D.E.; Enke, K.; Ewing, J.A.; Gienapp, H.; Hasselmann,D.E.; Kruseman, P.; Meerburg, A.; Müller, P.; Olbers, D.J.; Richter, K.; Sell, W.; Walden H. (1973**)** Measurements of wind-wave growth and swell decay during the joint North Sea wave project (JONSWAP), *Ergänzungsheftzur DeutschenHydrog. ZeitschriftReihe*, , *A8 (12)*, 94pp.

The Scottish Shelf Model – future developments and directions

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Are you a student? No

Due to the complex bathymetry and coastline, strong tides and waves, as well as the significant far-field forcing from neighboring waters, hydrodynamic modelling of the Scottish shelf and inshore waters benefit from adopting irregular grids. This allows for increased resolution in areas of particular interest and complexity, while a coarser resolution can be implemented elsewhere. The improved computational efficiency makes the irregular (unstructured) grid model a superior choice over the traditional structured, regular-grid models.

Here we provide an update of the Scottish Shelf Model (SSM), an unstructured grid model of the wider Scottish continental shelf as well as four smaller areas, of higher resolution, within the wider domain. An overview of the characteristics of the model and some initial results are presented. This includes maps of tidal Marine Renewable Energy resources as well as flow fields.

Our aim is to further develop the SSM as a shared resource. Here we highlight our future intentions with the SSM where we aim to facilitate and distribute this significant and influential product to the wider scientific community. Potential applications and future developments, including complementary smaller scale fine-resolution areas are discussed, and we present some ideas to facilitate model integration and to implement a well-structured and quality-assured model and model output dissemination framework.

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Ecotoxicology of Sediment-associated Carbon Nanotubes

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Carbon nanotubes (CNTs), single-walled (SWCNTs) and multi-walled (MWCNTs), are high aspect ratio nanostructures with a combination of properties making them useful in an increasing number of products and applications. Although CNTs occur in the environment as the result of natural combustion processes, significant environmental exposure to engineered CNTs would previously not have occurred and therefore they are considered xenobiotics (Méténier et al., 2002). Investigations of CNT toxicity are complicated by factors such as the large variety and synthesis methods, as well as the lack of standardized testing procedures, but also their tendency to agglomerate in aquatic systems. Few *in vivo* studies have examined the behaviour of CNTs in marine systems and their bioavailability and toxicity to marine organisms. We have previously shown that SWCNTs show relatively low toxicity to marine mussels; the main concern was that SWCNTs influence the toxicity of other contaminants at otherwise benign concentrations (Al-Shaeri et al., 2013).

CNTs in the aquatic environment are expected to rapidly precipitate and become incorporated into sediments. The aim of the present study was to assess the behaviour of CNTs in sediments, their bioavailability to benthic species and their effect on the bioavailability and toxicity of other sediment-associated contaminants. CNTs ($500 \mu gL^{-1}$) could be recovered and confirmed qualitatively using Raman spectroscopy (RS). Ecotoxicological effects of sediment-associated SWCNTs and MWCNTs (dispersed in 0.02% SRNOM) were investigated by injecting a CNT suspension (CNTs $50\ \mu gL^{-1}$, $100\ \mu gL^{-1}$ and $500\ \mu gL^{-1}$) into seawater tanks (1L) (pH7.9-8; 20°C) containing light-coloured washed (three times with distilled water and left to dry) play pen sand (half Kilo). CNTs were left 24 hours to settle on to the sediment surface, after which cockles (*Cerastoderma edule*) were introduced and left to bury and filter-feed the nephloid layer for 72hrs. A suite of biomarkers of exposure were studied, including oxidative stress (SOD, TBARS) and genotoxicity.

CNTs settled down quickly after one hour and no changes in their behaviour were observed at the naked eye after 24 – 72 hours.

DNA damage was determined using the Comet assay in gills cells and haemocytes. Oxidative stress in gills was assessed using the SOD and TBARS assays. Cockles were exposed separately to either SWCNTs and MWCNTs at nominal concentrations (CNTs $50\ \mu gL^{-1}$, $100\ \mu gL^{-1}$ and $500\ \mu gL^{-1}$) along with a negative (seawater only) and SRNOM control for 72 hours.

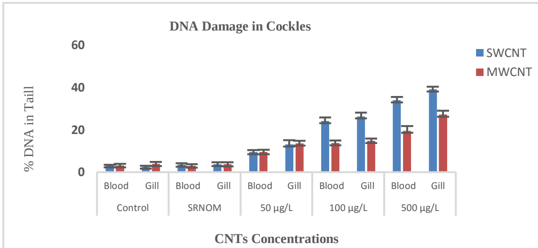

Fig.1 DNA damage in gill cells and hemocytes of cockles.

Figs.1&2 show examples of the results obtained. There was significantly increased DNA damage in gill cells and hemocytes (Fig.1) and lipid peroxidation in gill cells (Fig.2) exposed to CNTs at all concentrations compared to the controls. However, SWCNTs were generally significantly more toxic than MWCNTs.

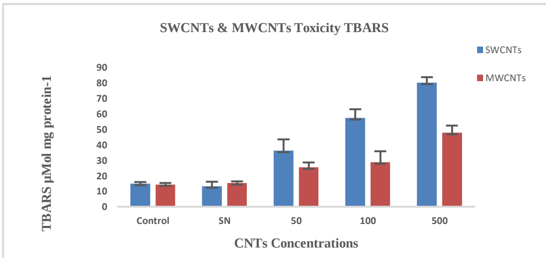

Fig.2 Lipid peroxidation in gill cells of Cockles (TBARS).

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References

- Al-Shaeri et al. (2013) Environmental Toxicology and Chemistry. 32(12): p. 2701-2710.
- Méténieret al (2002). Carbon 40, 1765–1773.