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A COMBINATION OF EMPIRCAL AND MODELLED DATASETS REVEALS ASSOCIATIONS BETWEEN DEEP DIVING SEABIRDS AND OCEANOGRAPHICAL PROCESSES AT FINE SPATIOTEMPORAL SCALES IN A HIGH ENERGY HABITAT

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ABSTRACT

It remains unknown how tidal stream turbines could impact deep diving seabird populations such as auks *Alcidae sp* and cormorants *Phalacrocorax sp*. Predicting whether and how devices could affect populations is hampered by poor knowledge of what influences seabird foraging distributions in the tidal pass habitats favoured for installations. Here distributions of foraging seabirds are compared with a suite of concurrent environmental variables within the Fall of Warness, Orkney, UK to investigate associations between auks, cormorants and oceanographical processes. Results are presented for Atlantic puffins *Fratercula arctica*, black guillemots *Cepphus grylle*, common guillemots *Uria algaa* and European shags *Phalacrocorax aristotelis*. These studies provide the information that is needed to predict auk and cormorant distributions within tidal pass over different scenarios, revealing which and when species may interact with devices within these habitats.

INTRODUCTION

It is likely that the number and extent of tidal stream turbine installations will increase exponentially in the next few years (Adams et al. 2013). Despite this, the environmental impacts of tidal stream turbines remain largely unknown. Among seabird species, auks and cormorants appear the most vulnerable to impacts from tidal stream turbines (Furness et al. 2012). However, predicting whether and exactly how installations could affect these species is hampered by poor knowledge of what influences their foraging distributions within the tidal pass habitats favoured for installations. Foraging seabirds are likely to be associated with the presence of oceanographical processes which promote the availability of chosen prey items and/or suit their foraging techniques. Therefore, revealing associations between foraging seabirds and oceanographical processes within tidal passes is a key step towards predicting impacts from tidal stream turbines (Waggitt & Scott 2014).

Tidal passes are spatiotemporally complex habitats encompassing many 'micro-habitats' characterised by different oceanographical processes. The location and extent of these micro-habitats changes consistently over tidal cycles as current dynamics change. If foraging seabirds associated with certain micro-habitats, then seabird distributions would also demonstrate spatiotemporal heterogeneity. Therefore studies studying associations between foraging seabirds and environmental conditions within tidal passes must cover the whole habitat over many different tidal states to sufficiently capture the variance in seabird distributions and environmental characteristics.

Here concurrent environmental and seabird distribution datasets are collected from the Fall of Warness, Orkney, UK with the aim of identifying associations between foraging seabirds and environmental variables. Results from analysis were then used to predict species distributions in breeding/summer and non-breeding/winter seasons.

METHODS

Seabird Distributions: In total, 102 transects were performed in May 2012, October 2013, May 2013 and October 2013 by the Marine Scotland vessel FRV *Alba-Na-Mara*. During transects experienced seabird observers recorded foraging seabirds seen within 300m of the vessel. Seabird locations were estimated to be accurate to around 150m.

Environmental Variables: A Simrad EK60 echosounder deployed during transects quantified seabed roughness and hardness using the Roxann software. These were combined into one substrate variable. FVCOM 3D Hydrodynamic models provided current speeds, turbulence and vertical water movement at 100m and 15 minute resolution.

Data Analysis: Environmental variables and seabird distributions were quantified using a grid system consisting of 500m^2 cells. For environmental variables, mean values within each cell was calculated. This procedure was repeated for every 15minutes of surveying effort, providing concurrent seabird and environmental measurements at a resolution of 500m^2 and 15minutes. Analysis focussed on abundant auk and cormorant species. In summer months (May 2012, May 2013) this was

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Atlantic puffins *Fratercula arctica*, black guillemots *Cepphus grylle*, common guillemots *Uria aalge* and European shags *Phalacrocorax aristotelis* In winter months (October 2012, October 2013) this was only black guillemots and European shags. General linear mixed effect models (GLMM) were used to identify relationships between seabird abundances and environmental variables. All possible combinations of environmental variables were tested. The best fitting model was then selected using Akaikes Information Criteria (AIC).

PRELIMINARY RESULTS

Predictions of each species mean and relative foraging distributions over an entire tidal cycle from the best fitting model are shown in Figure 1 and 2. Relationships between foraging seabirds and environmental variables showed variations in complexity among species and within species between seasons. However, some general patterns were apparent. During summer months, similarities were seen in general foraging distributions within foraging guilds. Higher abundances of Atlantic puffins and common guillemots were seen in fast currents whereas higher abundances of black guillemots and European shags were seen in slow currents. However, model outputs showed subtle differences among species sharing areas of fast and slow currents. In contrast, during winter months, differences were seen in general foraging distributions within foraging guilds. Higher abundances of black guillemots were found in fast currents whereas higher abundances of European shags were found in slow currents. Therefore black guillemots and European shags shared similar areas in summer months but different areas in winter months. These changes were associated with black guillemots shifting from slow to fast current speeds.

CONCLUSIONS

Preliminary results show variations in micro-habitat associations among species and within species between seasons. It is possible that foraging techniques, interspecific interactions and prey choice/availability could underlie these variations. In any case, these studies are starting to provide the information that is needed to start understanding how tidal stream turbines could impact vulnerable seabird populations by not only revealing the factors that influence foraging distributions within tidal passes, but also which and when species may interact most with devices within these habitats.

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REFERENCES

Adams J, Gardner P, Jones F, Kohn D, Valpy B, Woods M (2013) Wave and tidal energy in the UK: Conquering challenges and generating growth. Renewable UK

Furness RW, Wade HM, Robbins AMC, Masden EA (2012) Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. ICES Journal of Marine Science 69:1466-1479

Waggitt JJ and Scott BE (2014) Using a spatial overlap approach to estimate the risk of collisions between deep diving seabirds and tidal stream turbines: A review of potential methods and approaches. Marine Policy 44: 90-97

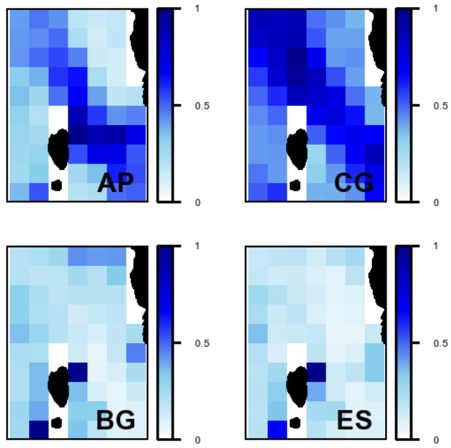

Figure 1: Predictive outputs from General linear mixed effect models showing the mean and relative foraging distribution of Atlantic puffins (AP), common guillemots (CG), black guillemots (BG) and European shags (ES) over a tidal cycle in the Fall Of Warness during summer months.

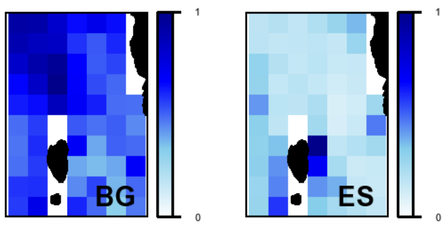

Figure 2: Predictive outputs from General linear mixed effect models showing the mean and relative foraging distribution of black guillemots (BG) and European shags (ES) over a tidal cycle in the Fall of Warness during winter months.