Using concurrent predator, prey and oceanographic information to understand seabird foraging distributions at fine spatiotemporal scales

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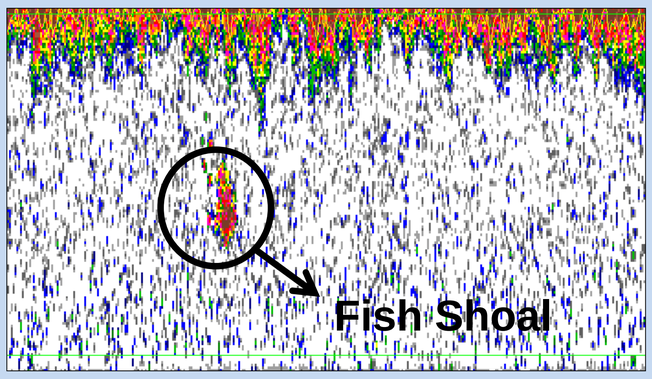
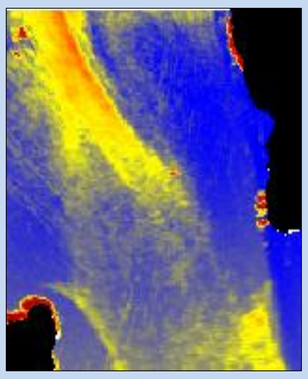
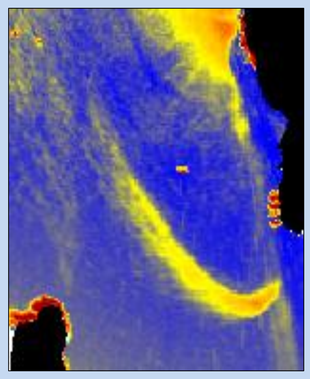
- The factors driving the fine-scale foraging distributions of seabirds within high-energy habitats remain largely unknown.
- Understanding links between dynamic oceanographic processes, prey characteristics and foraging opportunities could offer insights.
- Here we outline projects collecting concurrent seabird, prey and oceanographic datasets in high-energy habitats characterised by strong currents and complex topography/bathymetry.
- Fieldwork and analytical procedures are outlined along with preliminary results.

Methods



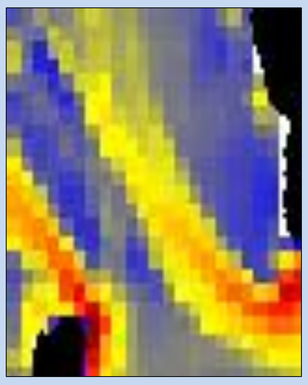
A Multi-Frequency Echosounder operating at 38, 120 and 200 kHz can quantify prey characteristics. This technology can also provide information on seabed characteristics.

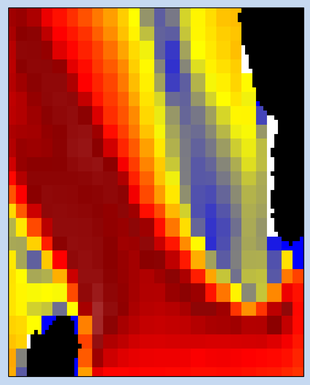




A Marine X-Band Radar deployed at the study sites can record the presence and extent of shearlines, boils and waves in real time, revealing where prominent sea surface features occur throughout study sites.

Observations performed by experienced observers from research vessels provide information on the spatial and temporal distributions of seabirds within study sites.





FVCOM 3D Hydrodynamic Model outputs provide a multitude of information on current speeds, current directions, turbulence and upwellings/downwellings throughout study sites.

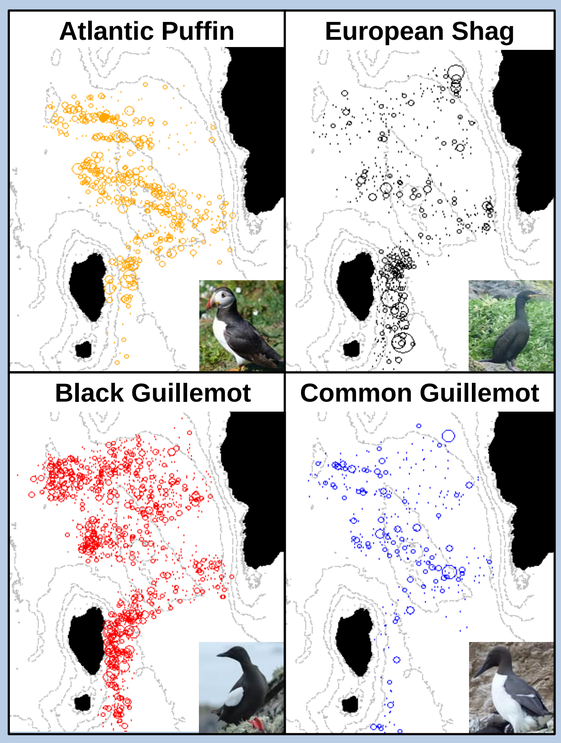
Application

Data Collection

103 vessel transects covering the same habitat numerous times in breeding and non-breeding seasons have been performed within the Fall Of Warness, Orkney, UK.

Seabird distributions recorded during vessel transects were combined with radar, hydrodynamic model outputs and echosounder derived seabed characteristics to define associations between seabirds and environmental variables within the study site.

Discriminating prey from subsurface hydrodynamics in echosounder data offers particular challenges, and prey characteristics have not yet been included in analysis.



Transect Design

Transects followed a zigzag route against the current within the study site. This improves vessel manoeuvrability, allowing it to cover intended transect routes. It also allows it to maintain a steady speed suitable for detecting seabirds. Finally, it prevents seabirds being counted twice as they drift downstream.

Analysis

Seabird distributions and concurrent environmental variables were quantified within 500m^2 grid cells and 15 minute resolution to match the minimum resolution of datasets.

General linear mixed effect models were used to investigate relationships between abundances and a suite of environmental variables. The latter included those that may enhance prey availability rather than simple habitat descriptors.

All combinations of environmental variables were tested. The best fitting models were selected using AIC. Marginal and conditional R^2 values were used to quantify the amount of variance explained by environmental variables.

Response Variables
Atlantic Puffin (May)
Black Guillemot (May,Oct)
Common Guillemot (May)
European Shag (May,Oct)

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Fixed Explanatory Variables
Current Speed
Turbulence
Upwelling/Downwelling
Seabed Characteristics
Tide Direction

↓

Random Explanatory Variables
Year and Month (Survey ID)
DateTime (15 Minute ID)
Observation (Grid Cell ID)

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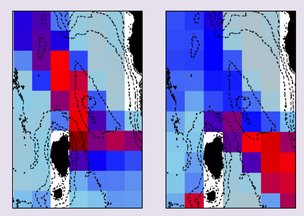
Run GLMM Model
Poisson Distribution
Area surveyed used as an offset

↓

Model Predictions



Predictions of Atlantic puffin distributions during Ebb (*Left*) and Flood (*Right*) tides showing associations with fast upwelled water near steep bathymetry. .

- Concurrent seabird distribution and environmental datasets successfully collected at reasonable spatiotemporal scales.
- Variations in the extent of spatial segregation amongst study species seen within and between seasons.
- Variations in the complexities of species micro-habitat associations also seen within and between seasons.
- Foraging technique, prey choice/availability and levels of interspecific competition could all explain these variations.
- Therefore behavioural, ecological and oceanographic factors all require consideration when explaining results.

Acknowledgements

JJW is funded by a NERC Case Studentship supported by Openhydro. Fieldwork is funded by Natural Environment Research Council and Defra grants (NE/J004308/1, NE/J004200/1 and NE/J004332/1) and also supported by Marine Scotland and Scottish Natural Heritage (SNH). We wish to thank Marianna Chimienti, Ciaran Cronin, Stuart Thomas, Tim Sykes, Ian Davies, Mike Stewart, Robert Watret and Mike Robertson for their assistance before, during and after fieldwork Thanks also to James Grecian, Samantha Patrick, Jane Reid, Alex Douglas and Thomas Cornulier for statistical and analytical advice. Finally we thank Jennifer Norris, Matthew Finn and Christina Bristow at the European Marine Energy Centre (EMEC) for their continued support of this project.