PrePARED

Predators + Prey Around Renewable Energy Developments

Forth and Tay Fish and Seabirds

Marine Directorate, BioSS, UKCEH

Scottish Government Riaghaltas na h-Alba · SMRU Consulting · Sea Mammal Research Unit · University of Aberdeen · University of Exeter · Aarhus University · UK Centre for Ecology & Hydrology · BioSS · NatureScot · Crown Estate Scotland · Offshore Wind Evidence + Change Programme

Workstream A: Firth of Forth

Fish community (prey) changes with OWF development.

Characterising seabird (predator) and prey distribution with OWF development.

Adding biological realism to SeabORD

Workstream C: Relevance and Application

Identifying generalities in fish and marine mammal response to OWF development

Minimum data requirements and survey design

Impact assessment tools for CIA

Improved understanding of variation in dose-response

- Informed recommendations on which data important to collect
- Habitat similarity assessment

MM: DEPONS & IpCoD

Seabirds: SeabORD

Incorporation into the CEF

Workstream B: Moray Firth

Fish community (prey) changes with OWF development.

Improved marine mammal understanding and modelling of response to OWF development.

Integration with iPCoD and DEPONS

Workstream D: Dissemination

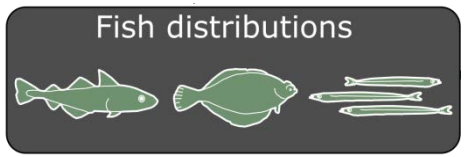
Stakeholder and Network Analysis + Comms Plan

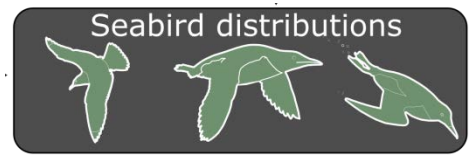
Annual Knowledge Exchange Meeting + Scientific Symposium

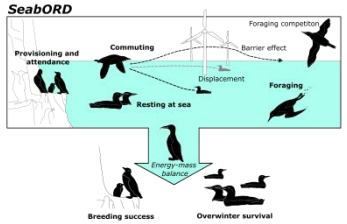
Scientific publications, reports, workshops and webinars

Forth and Tay Fish and Seabirds

- Fish in the Forth and Tay
- Seabirds in the Forth and Tay
- Feeding into EIA tools (SeabORD)







What does it deliver?

- **Improved confidence in EIA** by increasing **biological realism** and **validating tool mechanisms**
- **Improved application of tools in new regions** through more mechanistic understanding of how key processes are influenced by environmental context

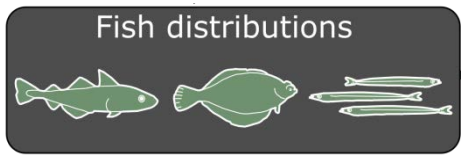
Fish in the Forth and Tay

Thomas Régnier, Marine Directorate

Objectives

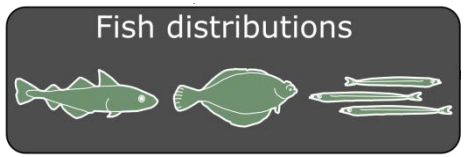
- Understand **the broad-scale** drivers of fish distributions

Ecological drivers/ baseline scenario



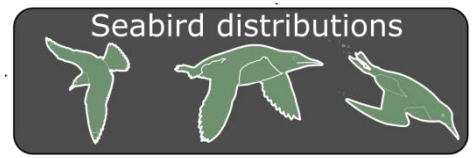
- Quantify/assess the **effects of OWF** on fish distributions

Fine-scale effects OWF related variables



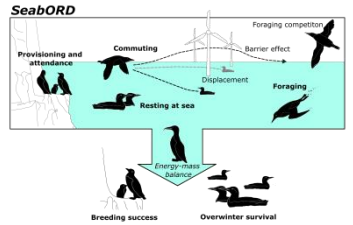
- Predict fish distributions: baseline and OWF scenarios

Decrease uncertainty in predator distribution and movement models



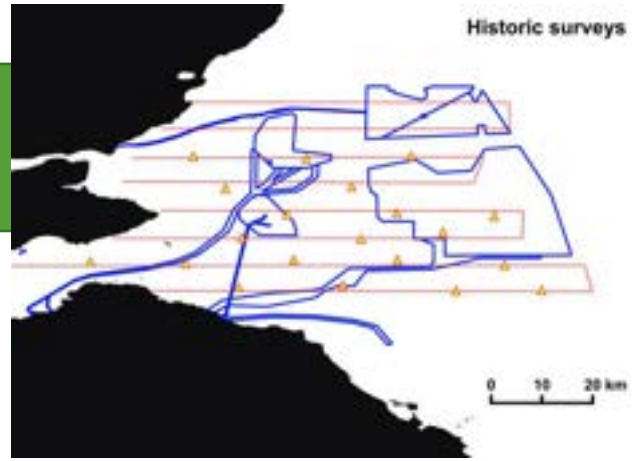
- Use the acquired knowledge to update Environmental Impact Assessment tools

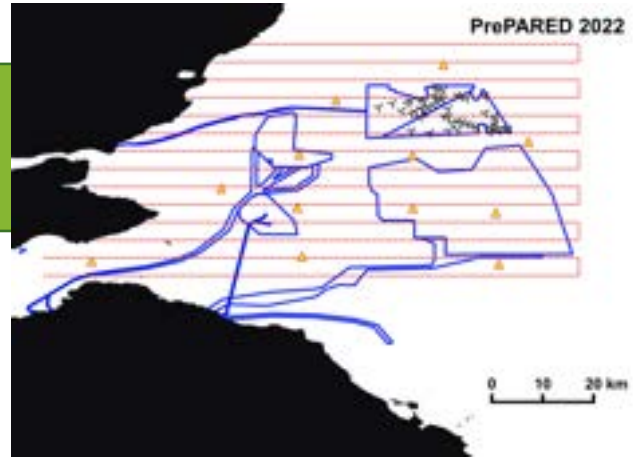
Decrease uncertainty in EIA

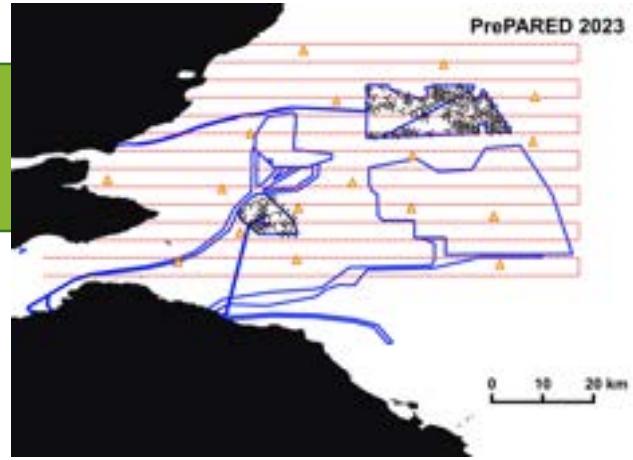


Obtain data on broad-scale fish distributions

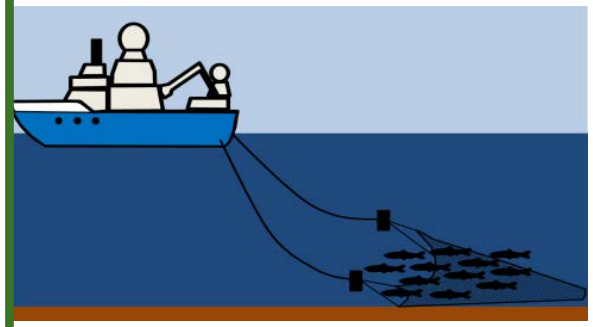
Year 1 | **Year 2** | **Year 3**



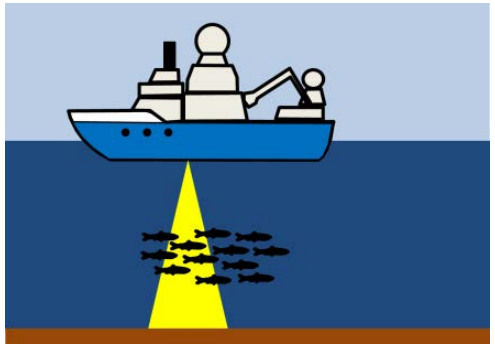


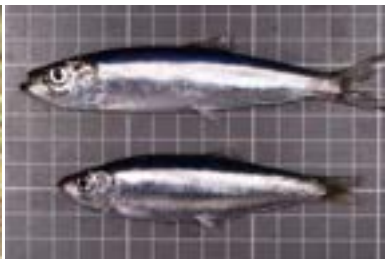


Fishing stations



Acoustic transects





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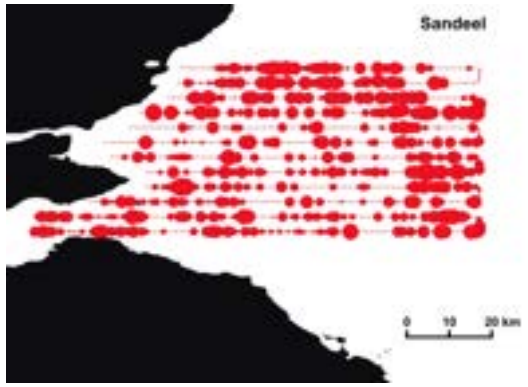
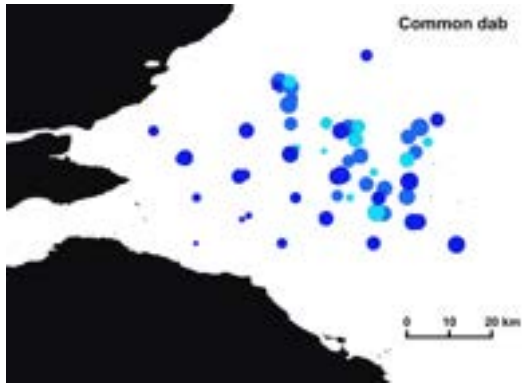
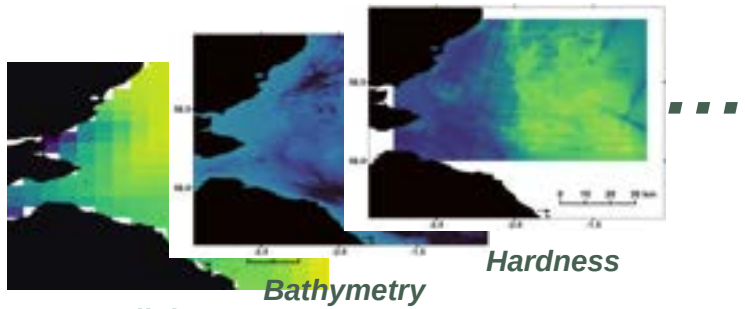
Model broad-scale fish distributions

Fish distribution data



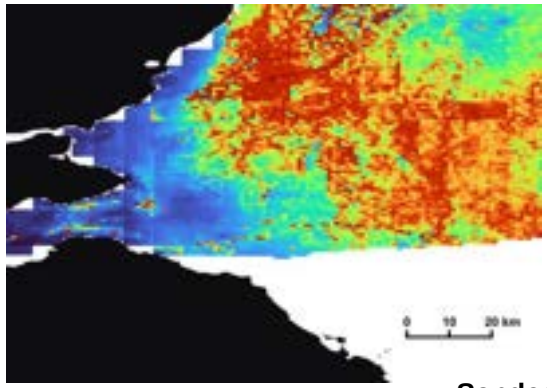


Environmental variables

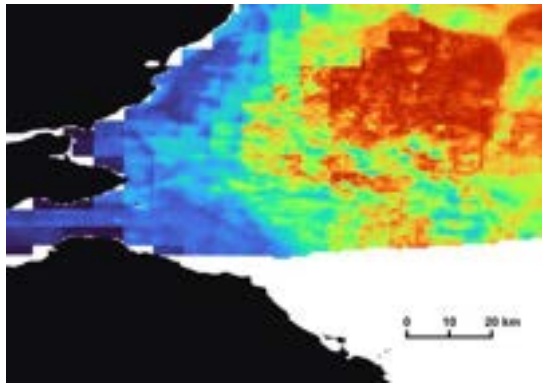


Species Distribution Model Ensemble model (GAM, Random Forest)

Predicted distributions



Sandeel



Common dab

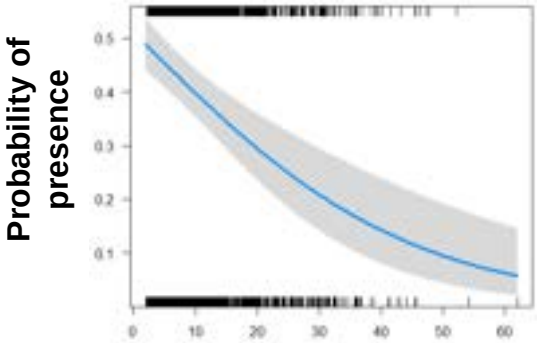
Model broad-scale fish distributions

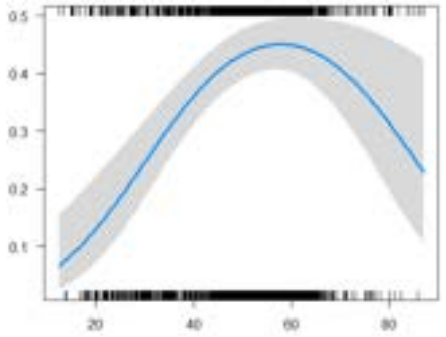
Fish

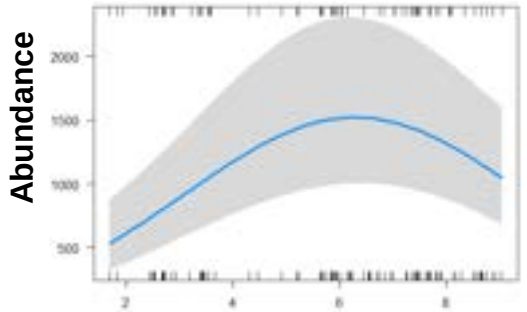
Sandeel

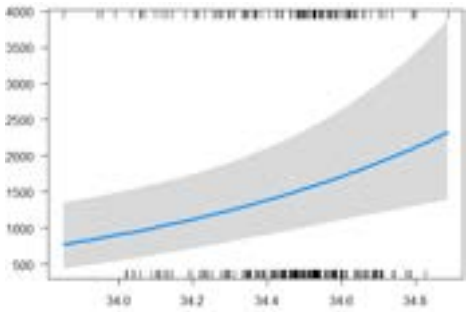
Common dab

Main ecological drivers

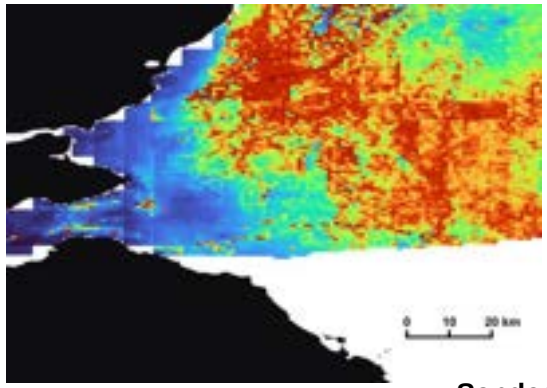




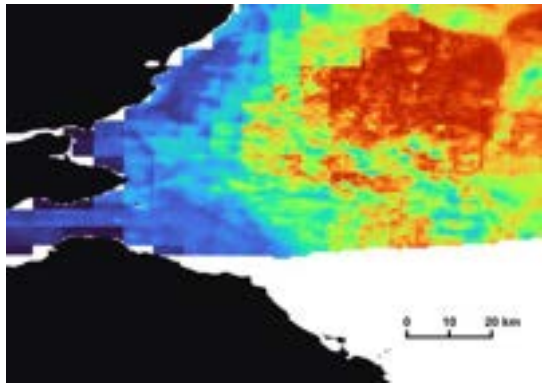




Predicted distributions

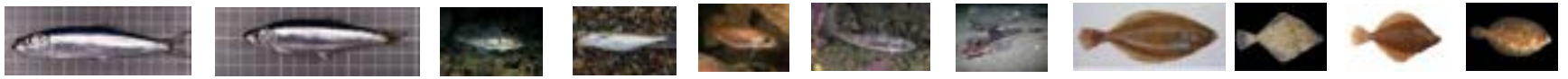


Sandeel

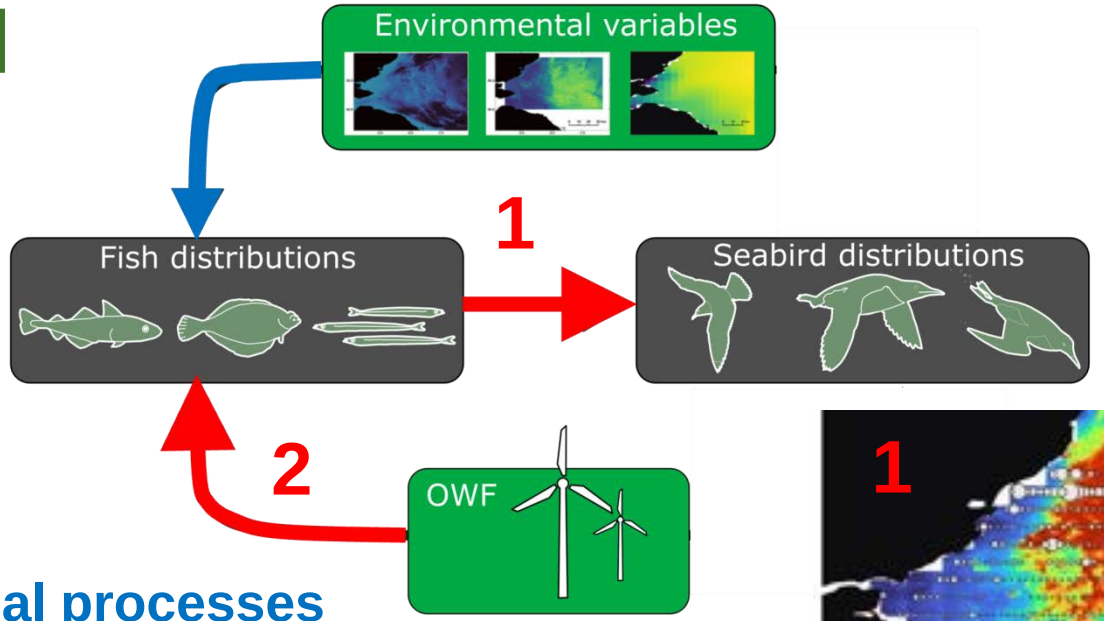


Common dab

And more…



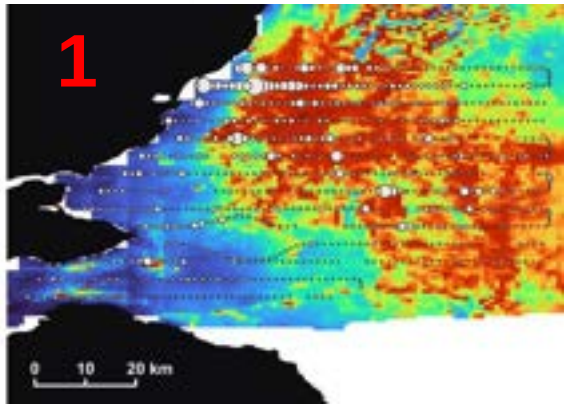
How the outputs will be used



Prey distributions in response to ecological processes

1-Baseline scenario (No OWF): seabird distributions

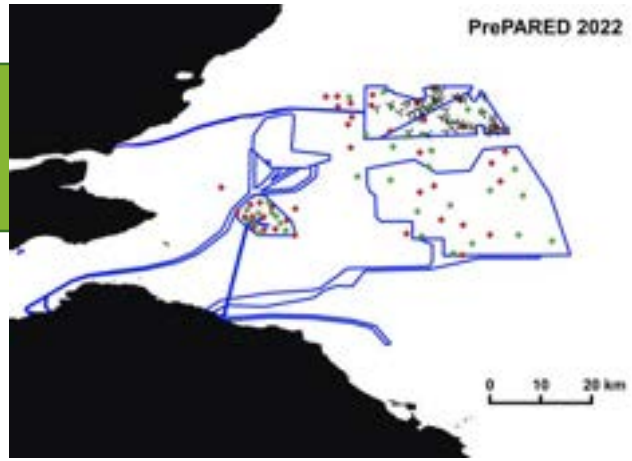
2-Effect of OWF: control for habitat suitability

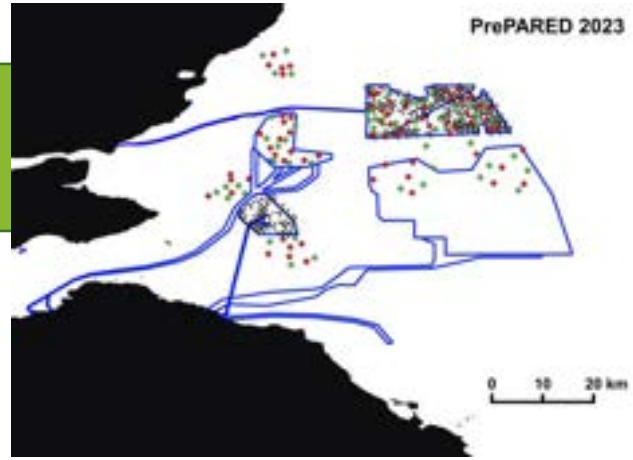


Sandeel baseline Guillemots 2023

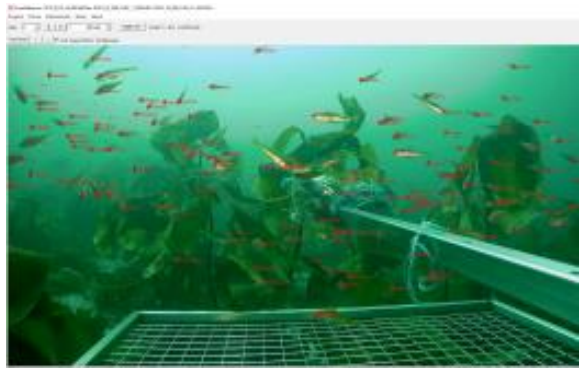
Obtain data on fine-scale fish distributions

Year 1 | **Year 2** | **Year 3**

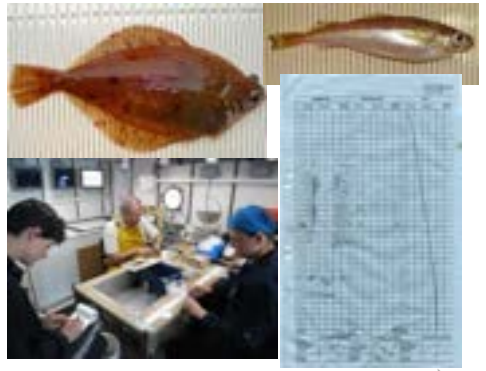




- **Baited cameras**

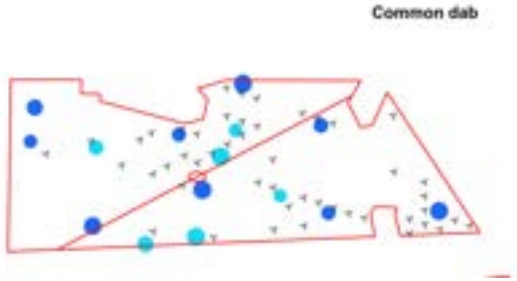


- **Fish traps**

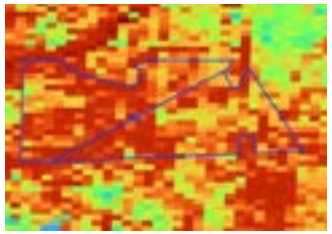


Model fine-scale fish distributions

Fish distribution data



Variables

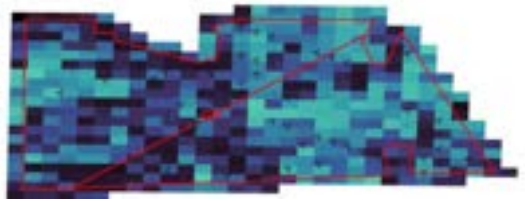


Habitat suitability

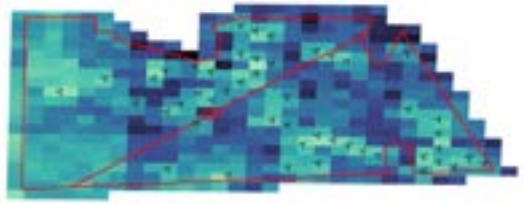
OWF variables (Turbines, Cables, distance, density, age…)

Fine-scale distribution model GAM

Predicted distributions



Sandeel in Seagreen OWF



Common dab in Seagreen OWF

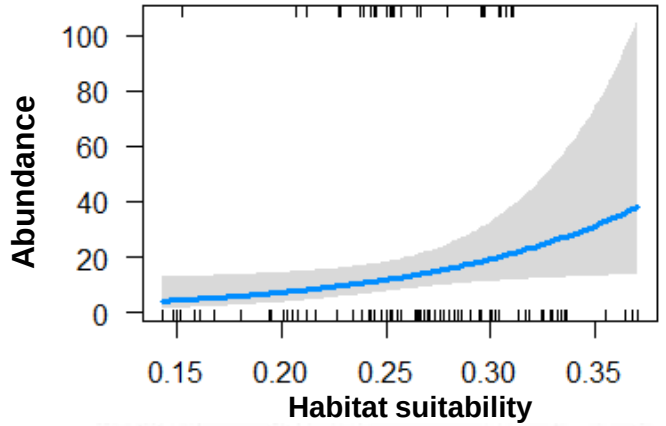
Model fine-scale fish distributions

Fish

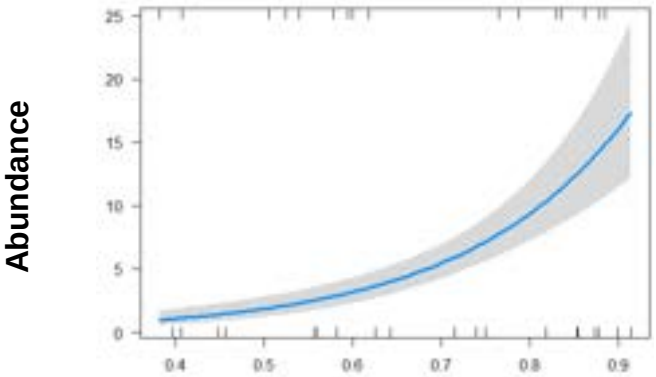
Sandeel

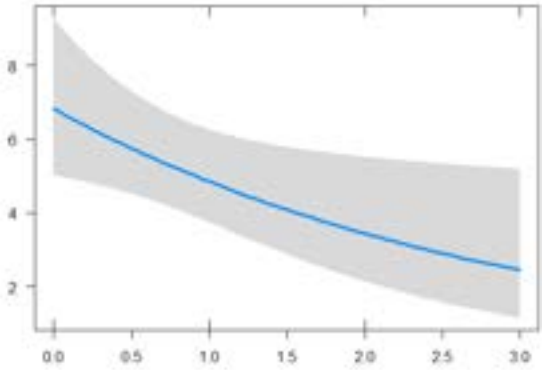
Common dab

Effects

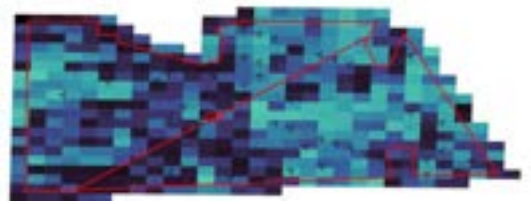


No OWF effects found in 2022

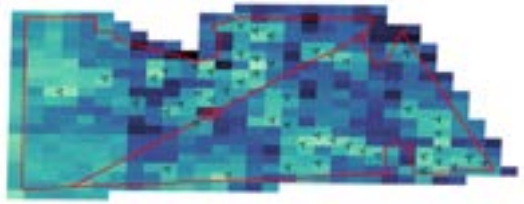




Predicted distributions

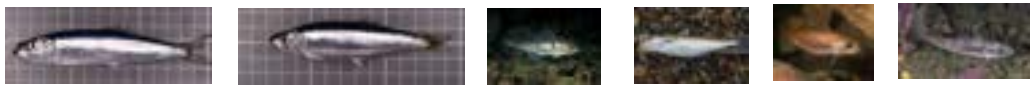


Sandeel in Seagreen OWF

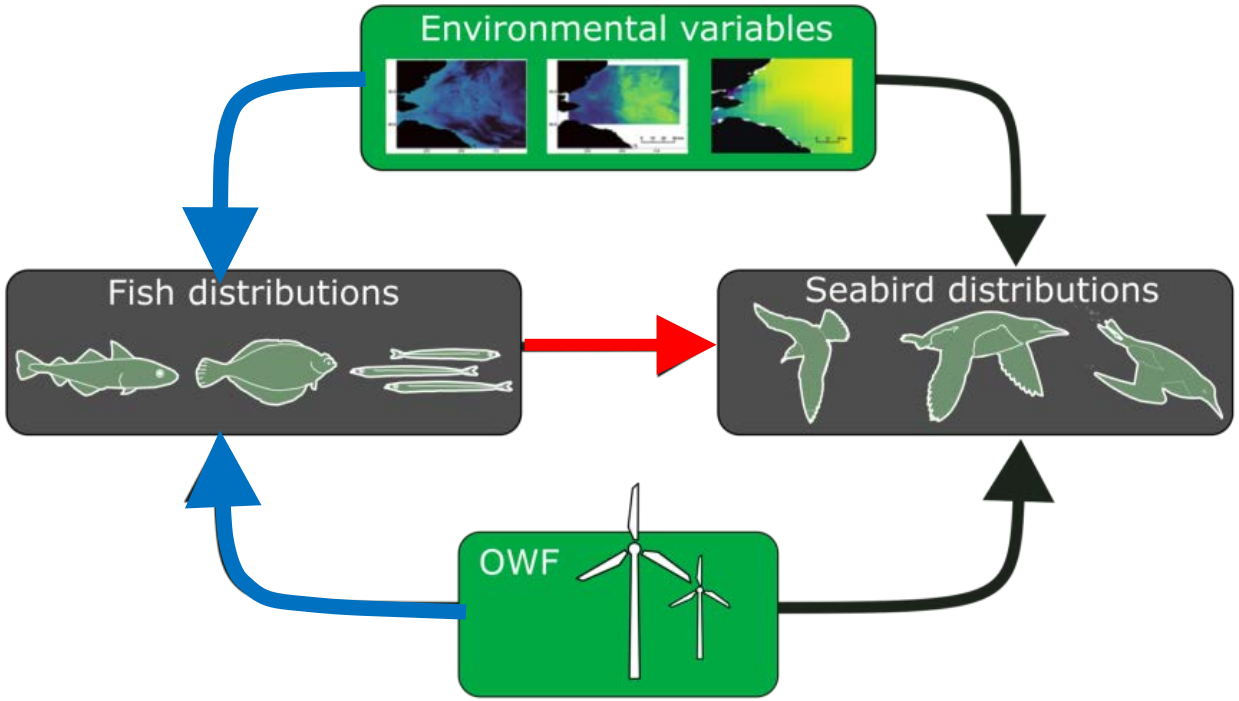


Common dab in Seagreen OWF

And more…



How the outputs will be used?



Prey surfaces in response to ecological processes and OWF

Decrease uncertainty in predator distributions

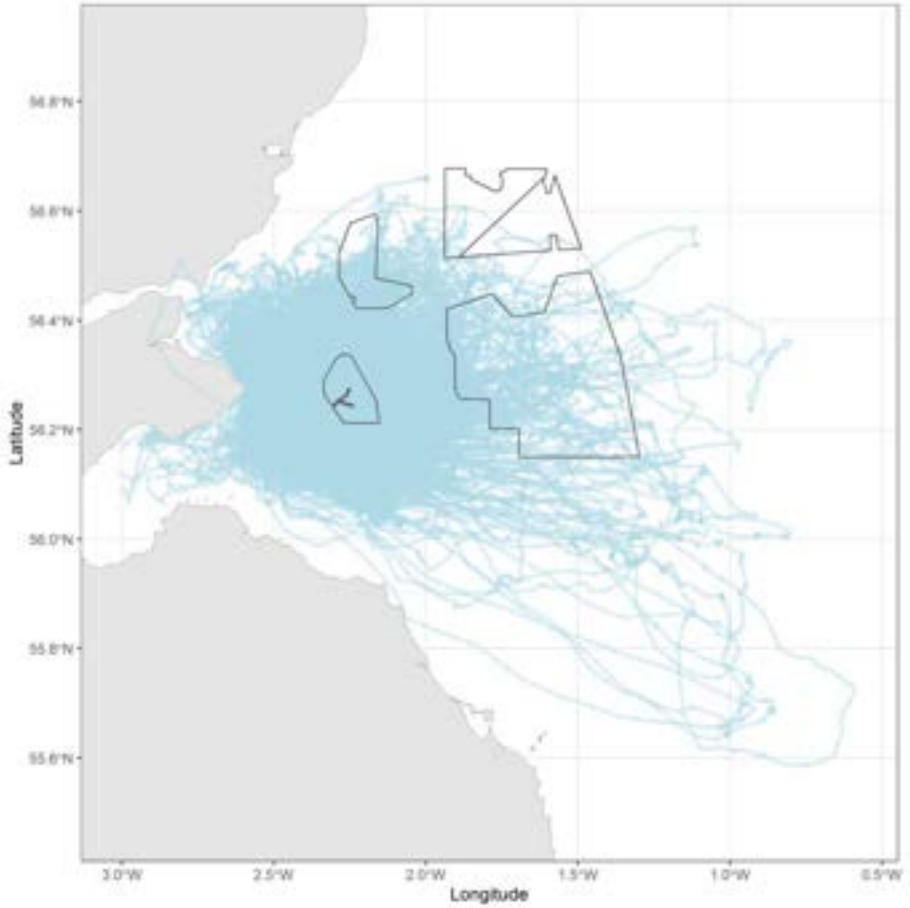
Seabirds in the Forth and Tay

Katherine Whyte, BioSS

Seabird data collection

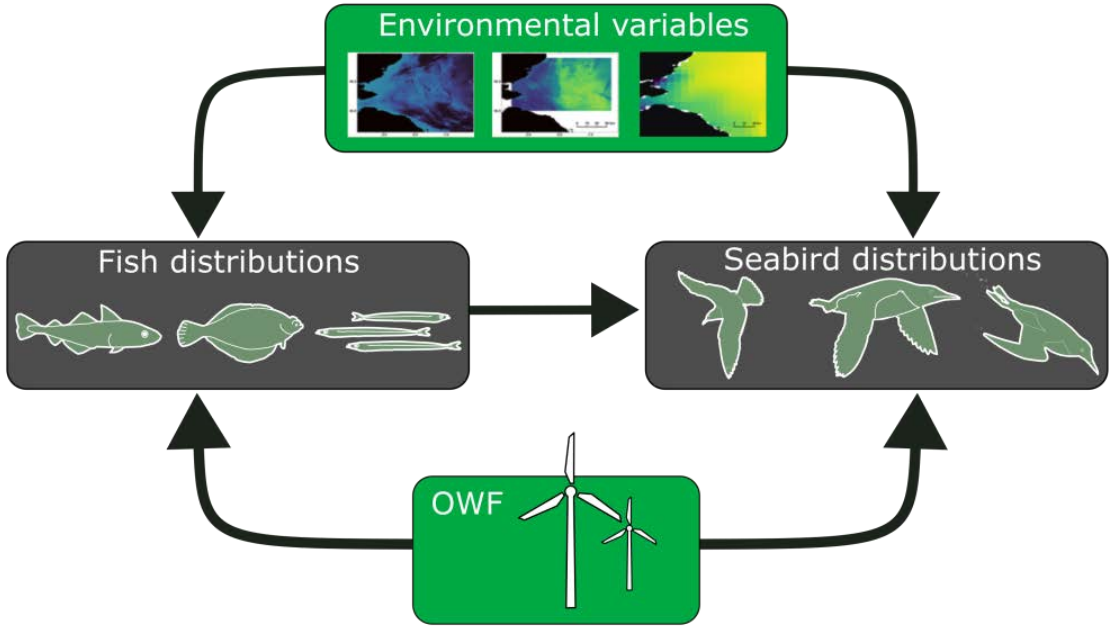
- Seabird GPS tracking data in Forth and Tay collected by UKCEH
- Post consent monitoring funded by NNGOWL, Seagreen and Berwick Bank
- Data collection objective to estimate population level consequences of Forth-Tay windfarms for protected populations
- Seabirds not tagged in 2022 due to HPAI

2021: kittiwakes tagged on the Isle of May



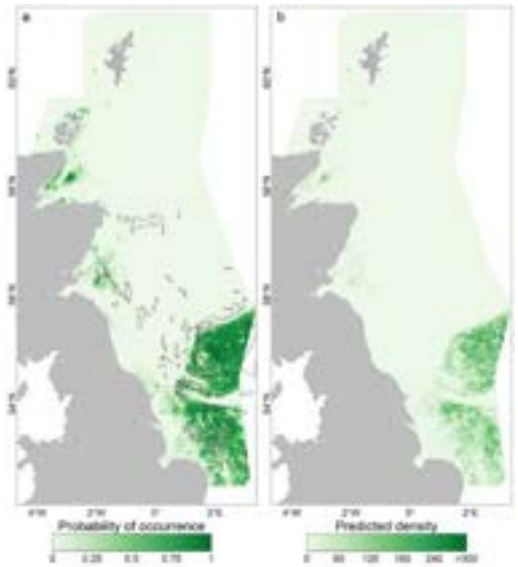
Seabird data collection

- Spatial and temporal matching with prey data over the breeding season
- Identifying predator-prey interactions:
  - Quantifying ecological relationships
  - How do relationships alter in the presence of wind farms?
  - Using historic data to build a robust baseline



Predator-prey interactions at a range of scales

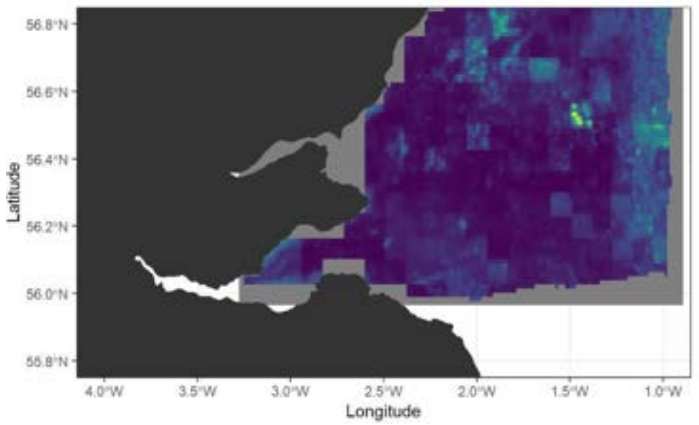
Regional



Sandeel distribution model (Langton 2021)

What drives long-range and long-term movement?

Area-specific

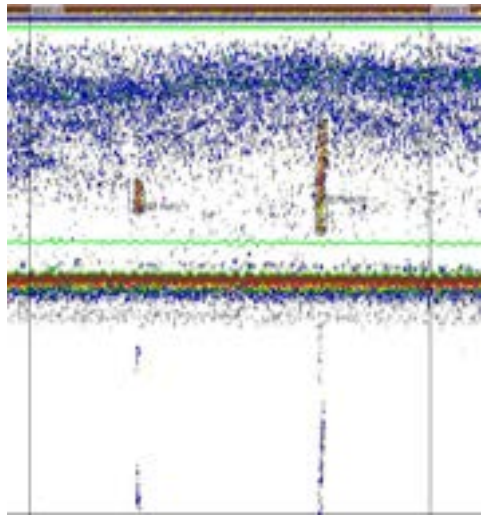


Prey distribution models (PrePARED)

Scottish Government Riaghaltas na h-Alba

What drives foraging activity on a trip?

Localised



Prey school detections (PrePARED)

Scottish Government Riaghaltas na h-Alba

Which fish schools do seabirds forage on?

Predator-prey interactions: approaches

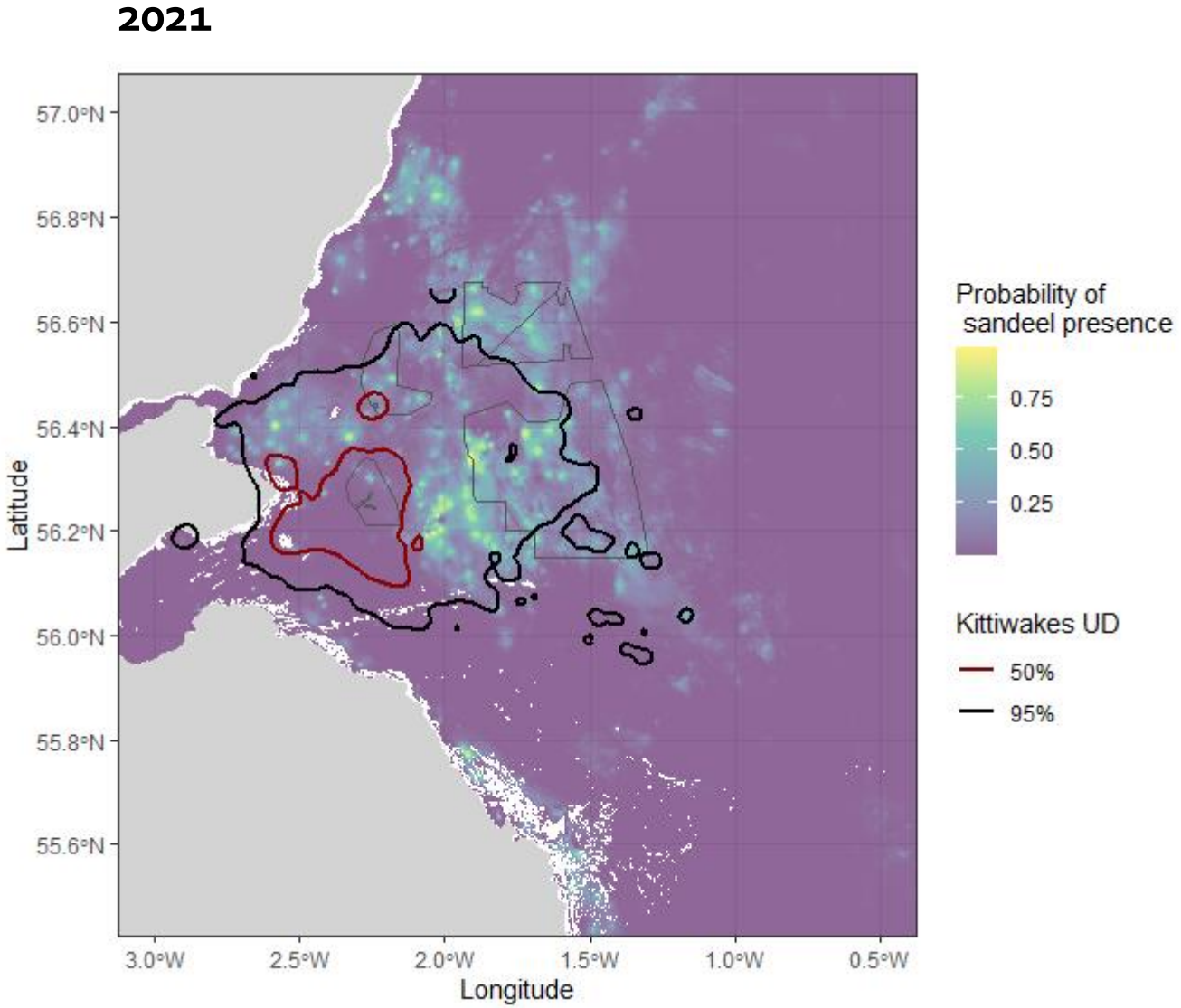
- Multiple modelling approaches to examine predator-prey interactions
- Particular approaches may be more relevant to specific scales (spatial, temporal, ecological)
- Accounting for spatial and temporal matching in seabird and fish data

Approach	Regional	Area-specific	Localised
Spatial modelling (GPS data)	✓ 1	✓	
Movement modelling (GPS data)	✓ 2	✓	✓
Exploratory visualisation (Seabird-at-sea observations)		(✓)	✓ 3

1. Spatial modelling

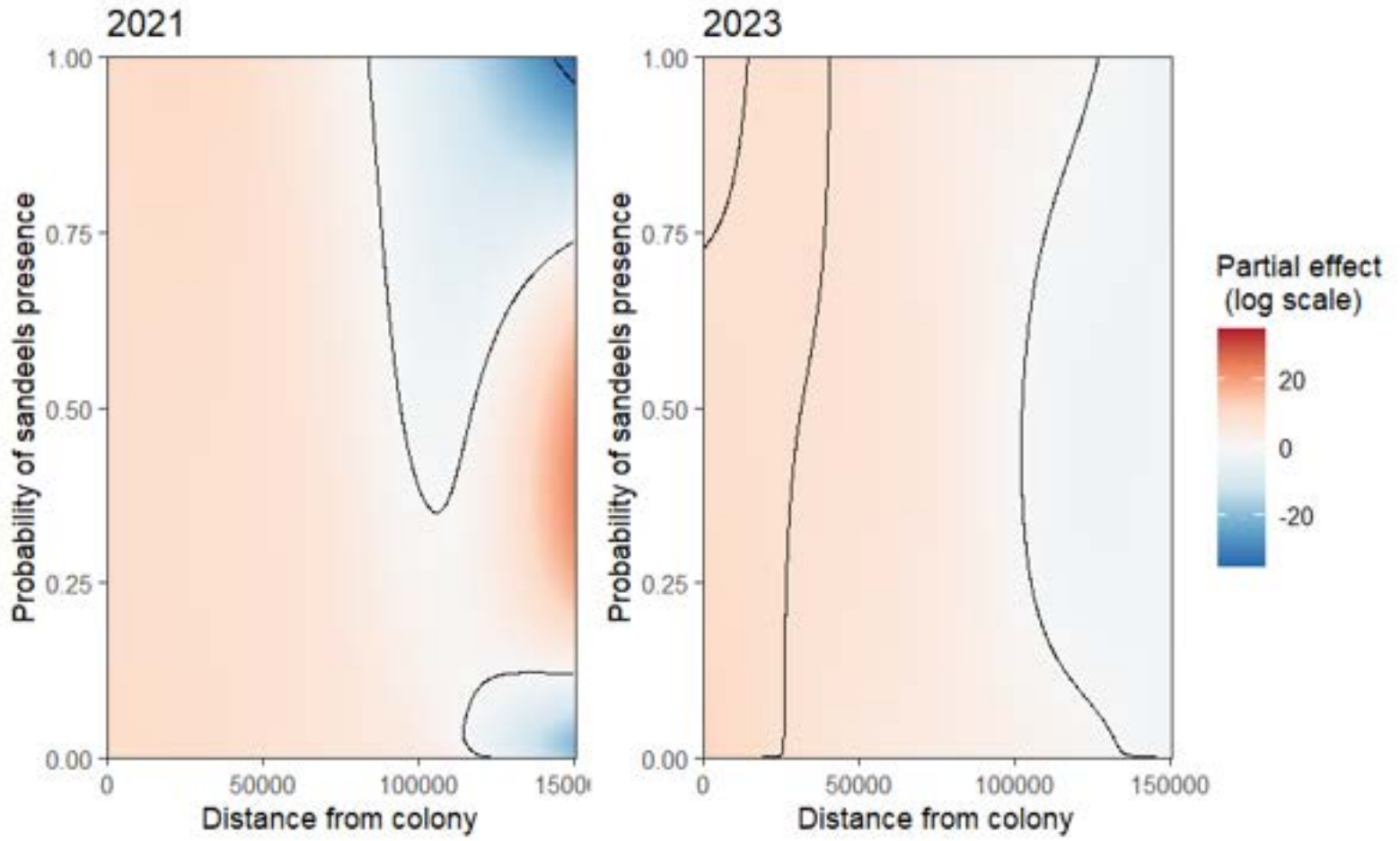
Spatial modelling framework has been developed to learn about:

- Predator-prey spatial overlap
- The importance of prey in model predictions
- How prey may interact with other drivers of seabird distribution
- Transferability to regional scale



1. Spatial modelling

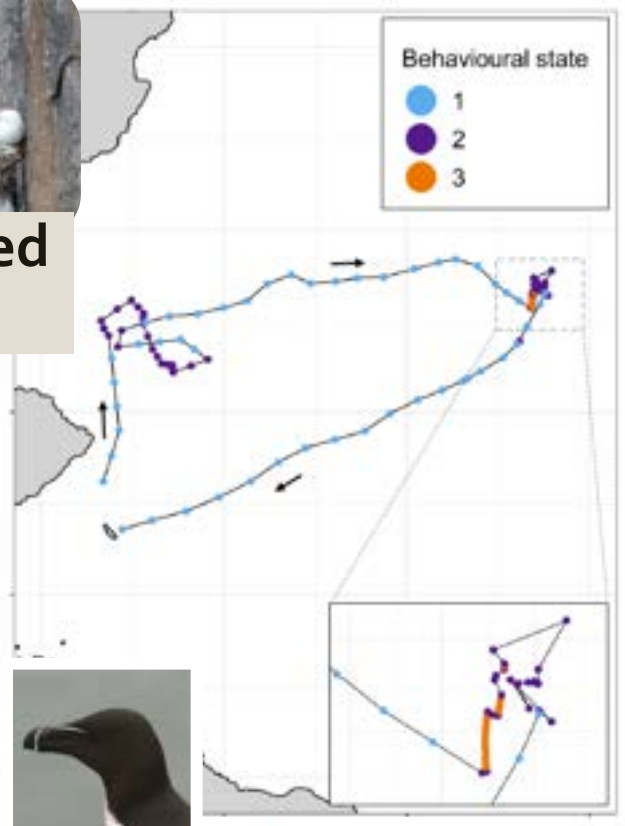
- Change in seabird distribution is driven by distance to colony rather than prey but sandeel model is static
- Future models will use area-specific prey fields
- Changes in predator distribution can then be linked explicitly to dynamic prey fields



See Shiny App in "Technology Highlights" session

2. Movement modelling

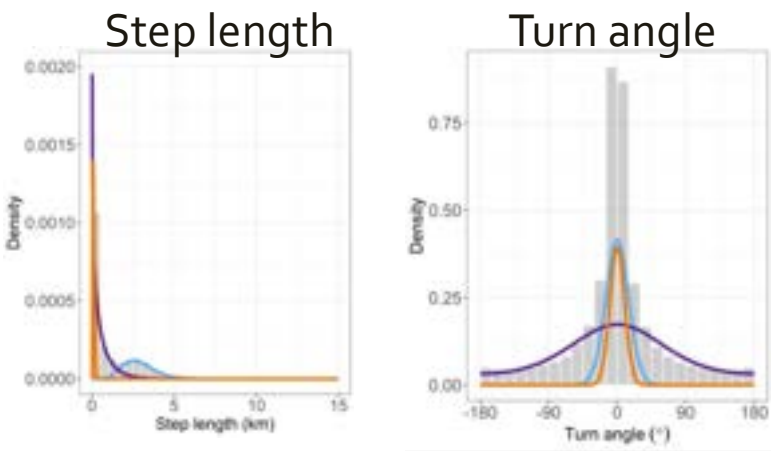
Black-legged kittiwake



UK Centre for Ecology & Hydrology

Seabird photos: K Whyte

Classify movement characteristics to estimate behavioural states using Hidden Markov models (HMMs)



Which behavioural activities might create these movement characteristics?

e.g. foraging, commuting, resting?

Future work within PrePARED will incorporate prey data into the models to investigate predator-prey relationships

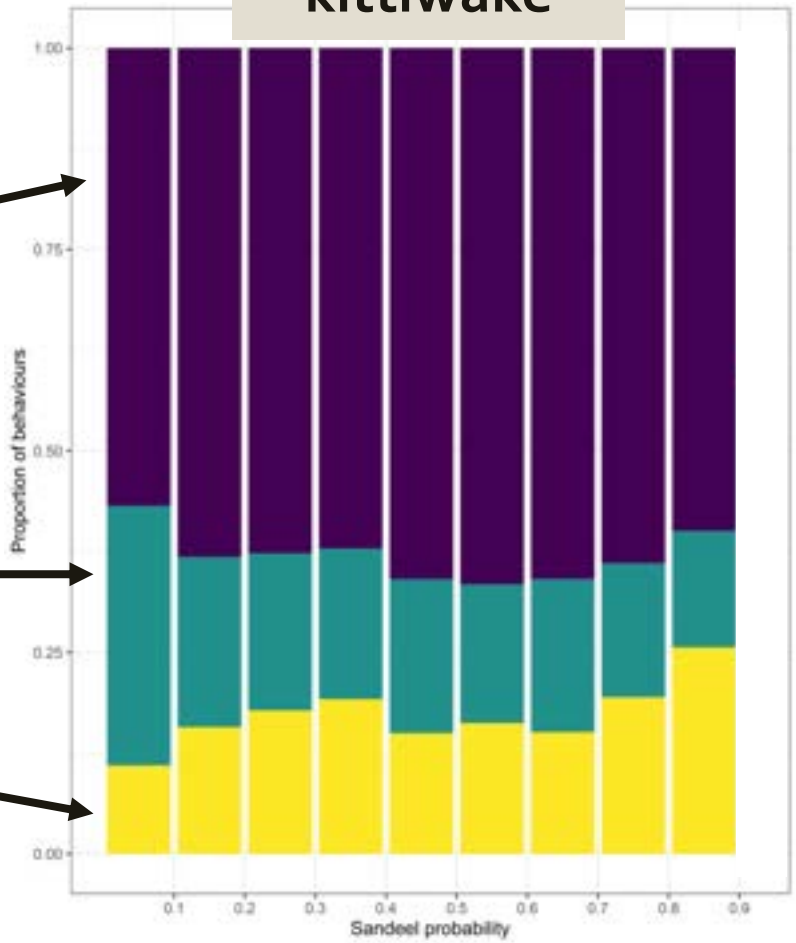
2. Movement modelling

Black-legged kittiwake 2021

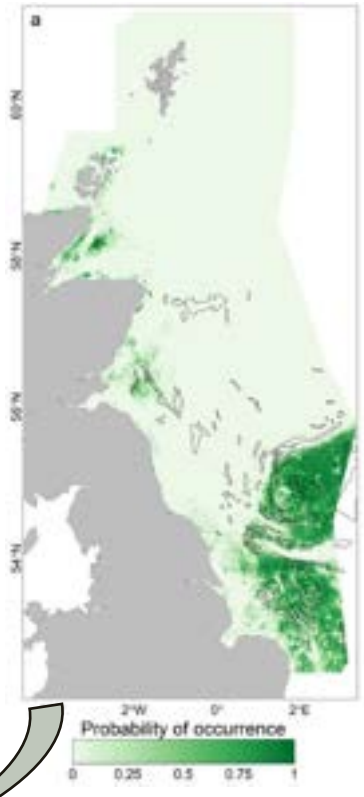
"Foraging"

"Commuting"

"Resting"



Sandeel distribution model (Langton 2021)

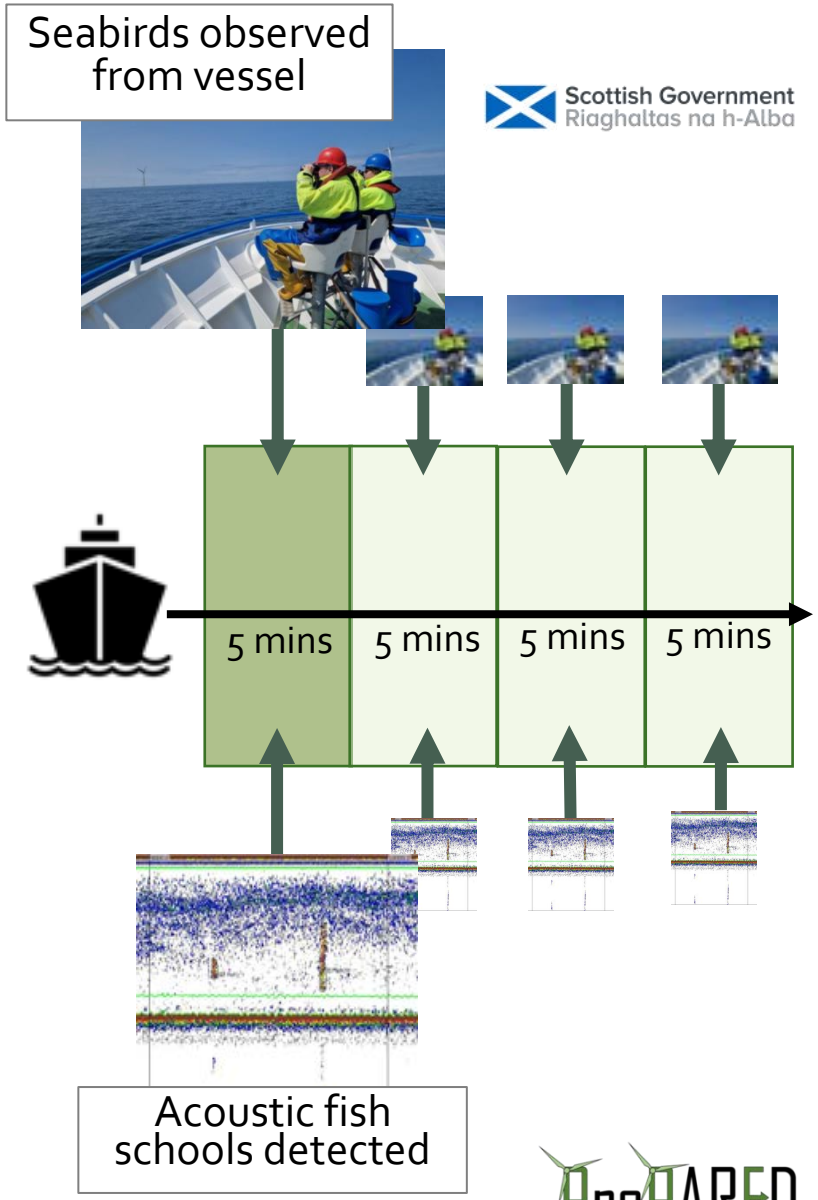


3. Seabird-at-sea observations

- Contemporaneous data collected by PrePARED survey vessel
- **Seabird data:**
  - Counts: by species
  - Behaviour: flight, on sea surface
- **Fish data:**
  - Schools detected by acoustic survey
  - School characteristics, e.g. density, depth, area

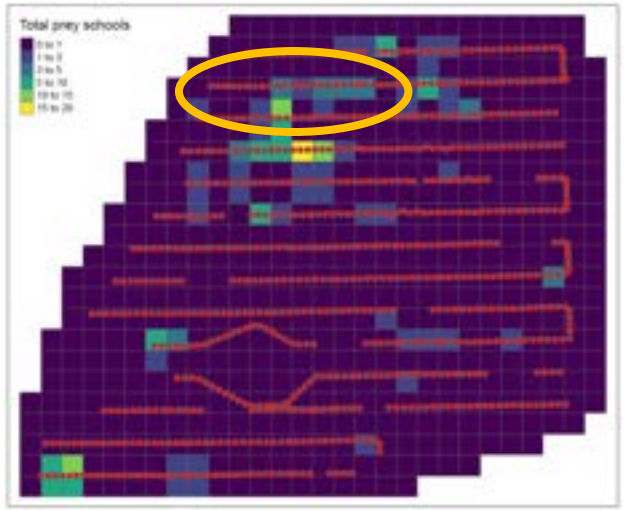
Use these data for:

- exploratory visualisations
- verify or qualitatively validate spatial and movement models

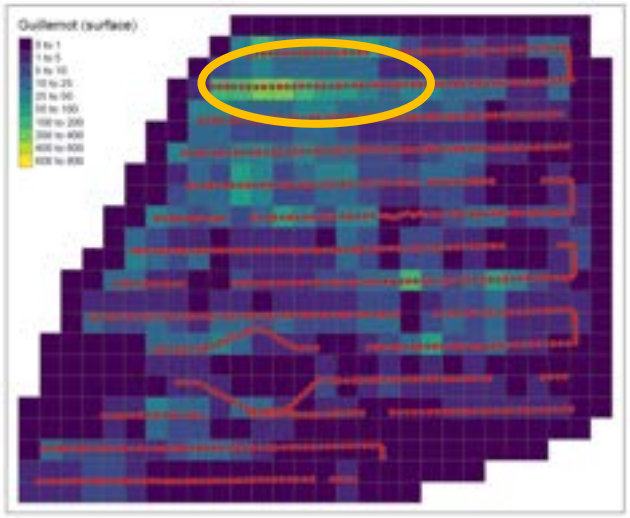


3. Seabird-at-sea observations

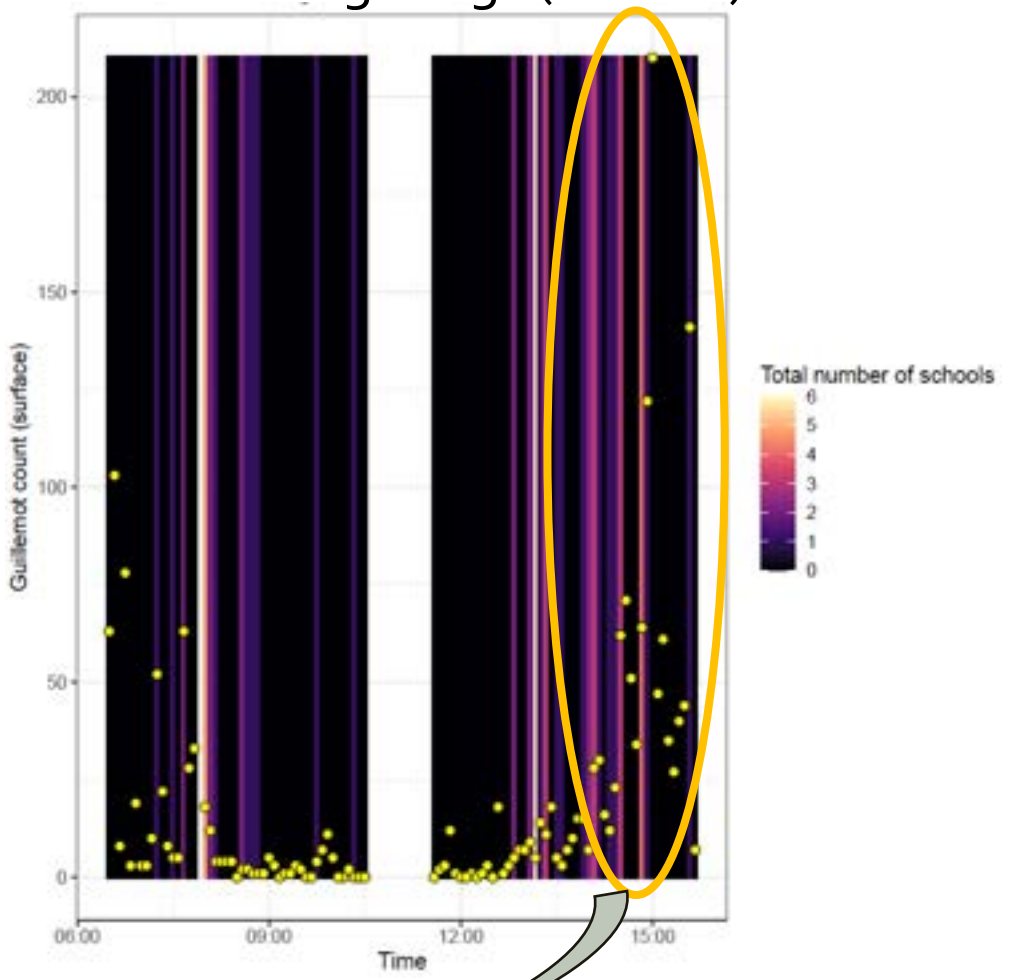
Prey schools



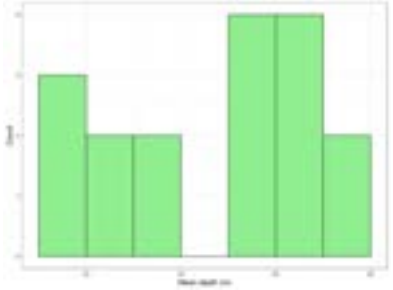
Guillemot sightings (surface)



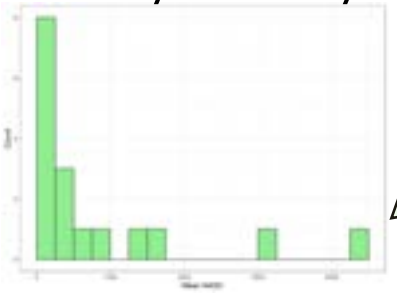
Guillemot sightings (surface)



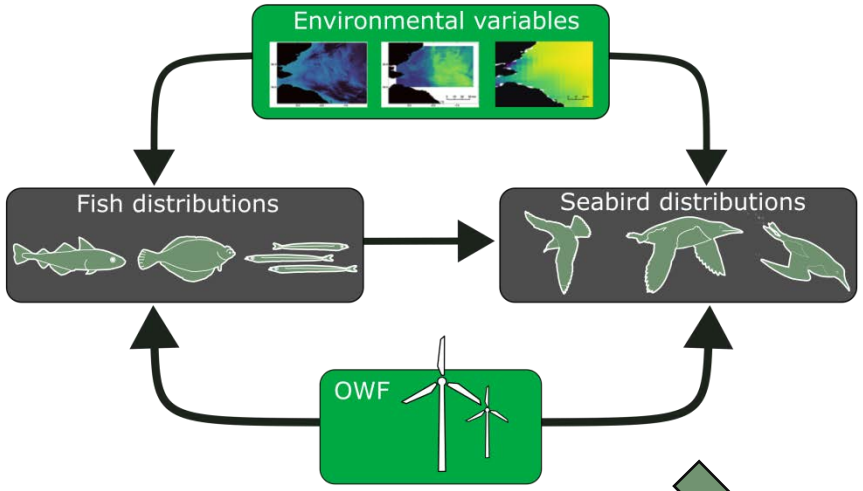
Prey depth

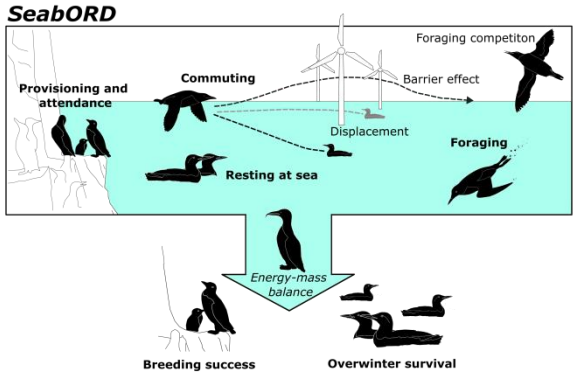


Prey density



How outputs will be used



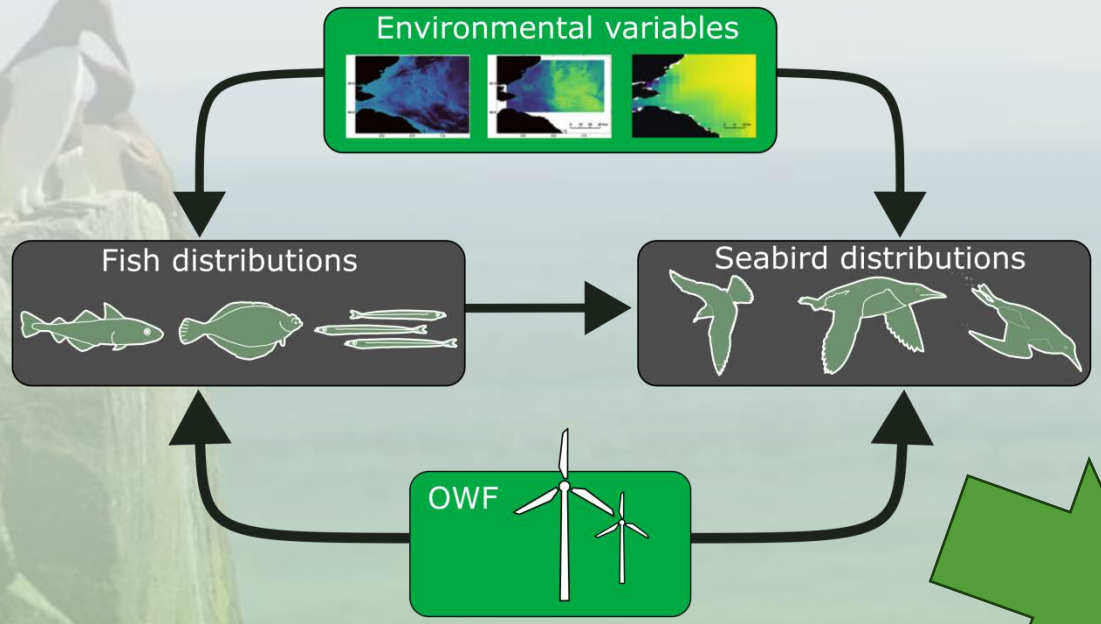


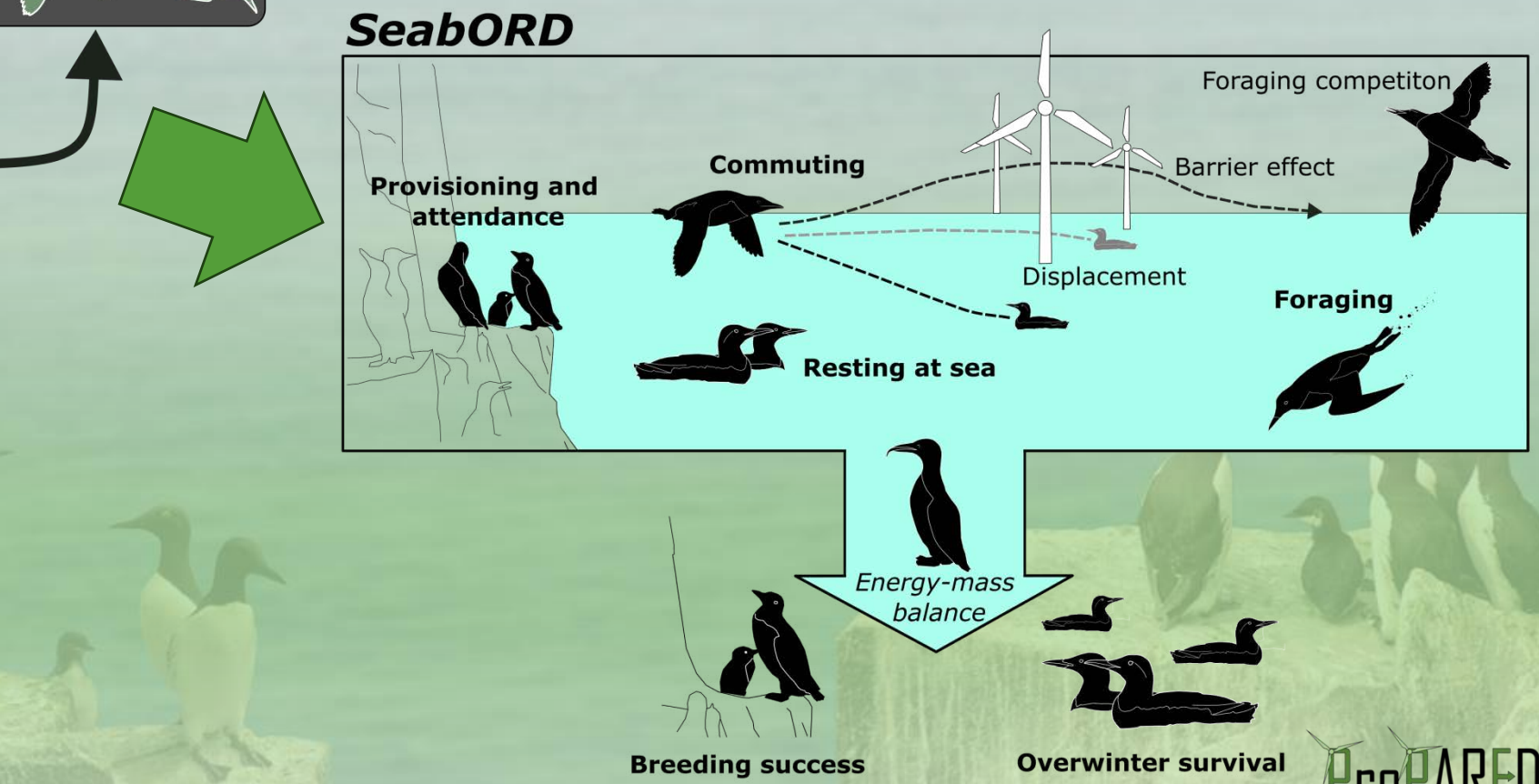
Spatial and movement analyses will produce:

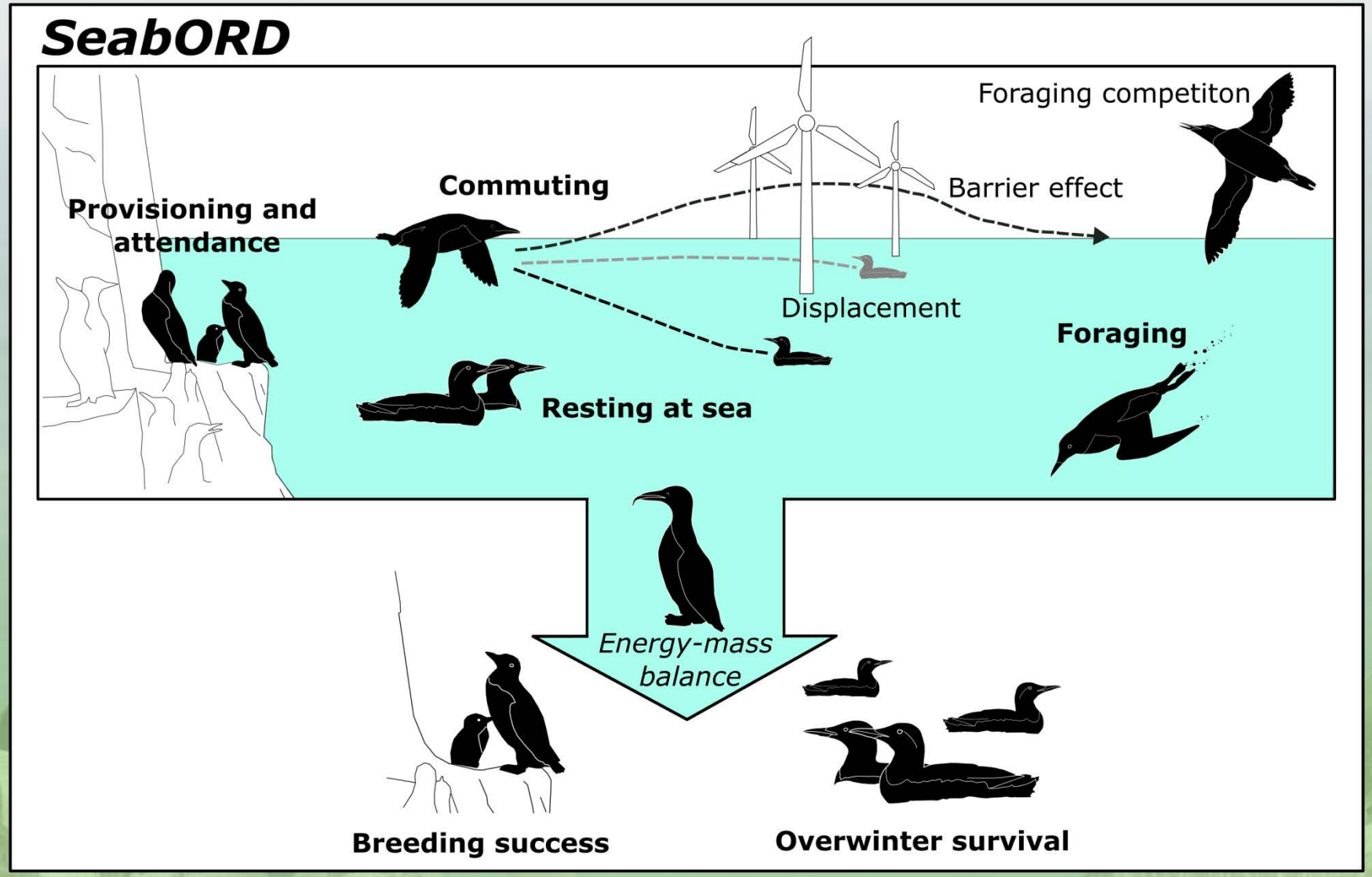
- Behavioural classifications to improve simulations of seabird foraging tracks in individual-based models
- Key metrics of predator-prey interactions that will inform simulation improvements
- Utilisation distributions to help develop improved EIA tools

Improving EIA tools

Chris Pollock, UKCEH


Environmental variables
Fish distributions
Seabird distributions
OWF


SeabORD
Foraging competiton
Commuting
Barrier effect
Provisioning and attendance
Displacement
Foraging
Resting at sea
Energy-mass balance
Breeding success
Overwinter survival

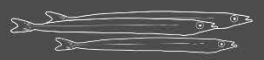


PrePARED Predators + Prey Around Renewable Energy Developments

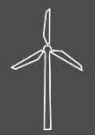
Inputs

1. Select species and corresponding bird distribution maps

2. Prey distribution maps and prey levels

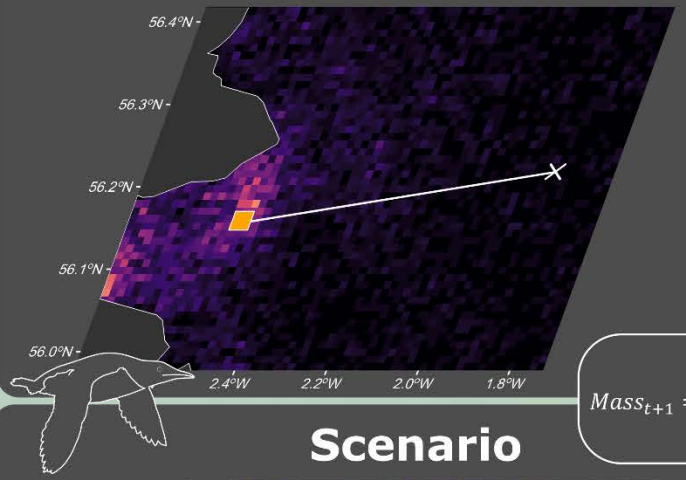


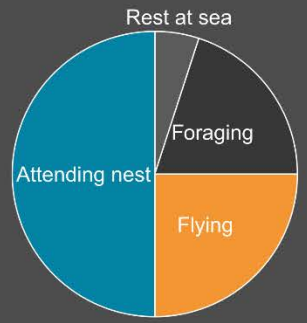
3. ORD footprints and characteristics



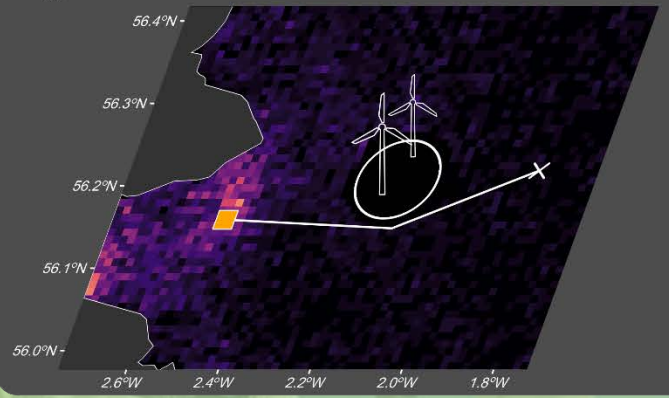
Simulate individuals

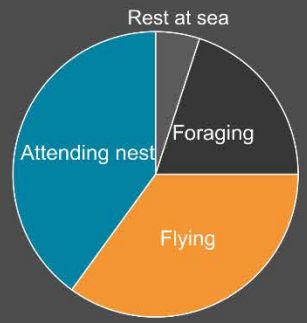
Baseline





Scenario

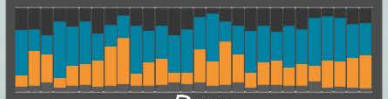




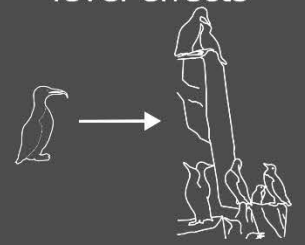
$$Mass_{t+1} = Mass_t + \frac{Energy\_gained_t - DER_t}{K_G}$$

Outputs

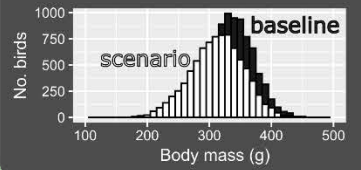
Daily activity at **individual** level



Tally all individuals to get **population** level effects



Metrics for bird mass and breeding success

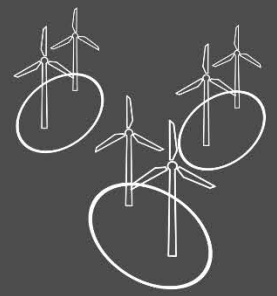


Application

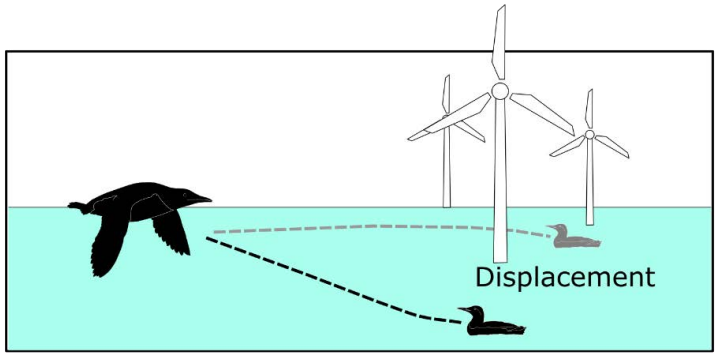
Difference between baseline & scenario = Change in survival and breeding success due to ORDs

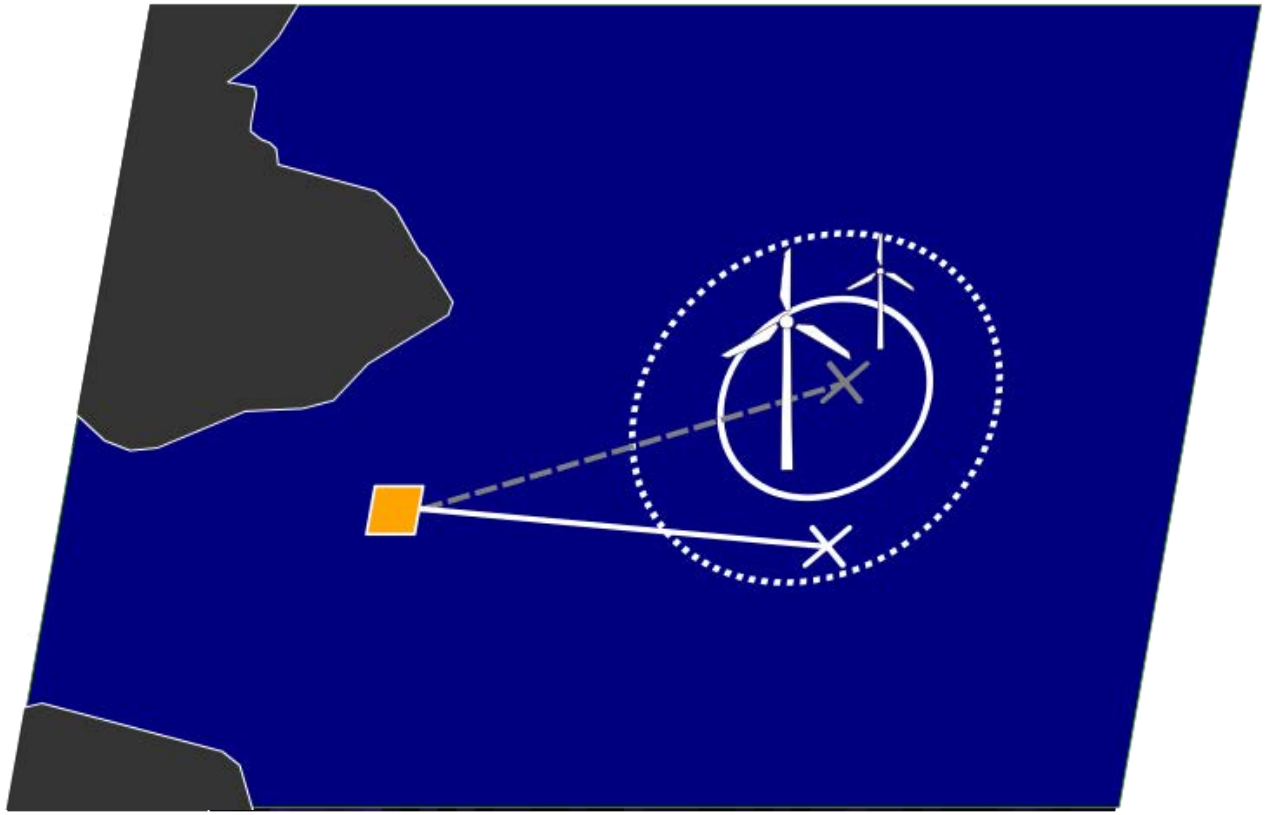
For one ORD

Or in combination



Incorporating prey distributions

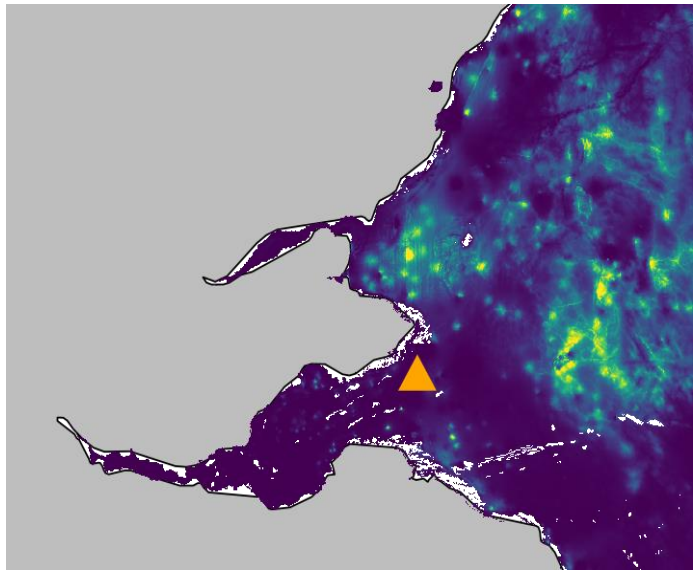




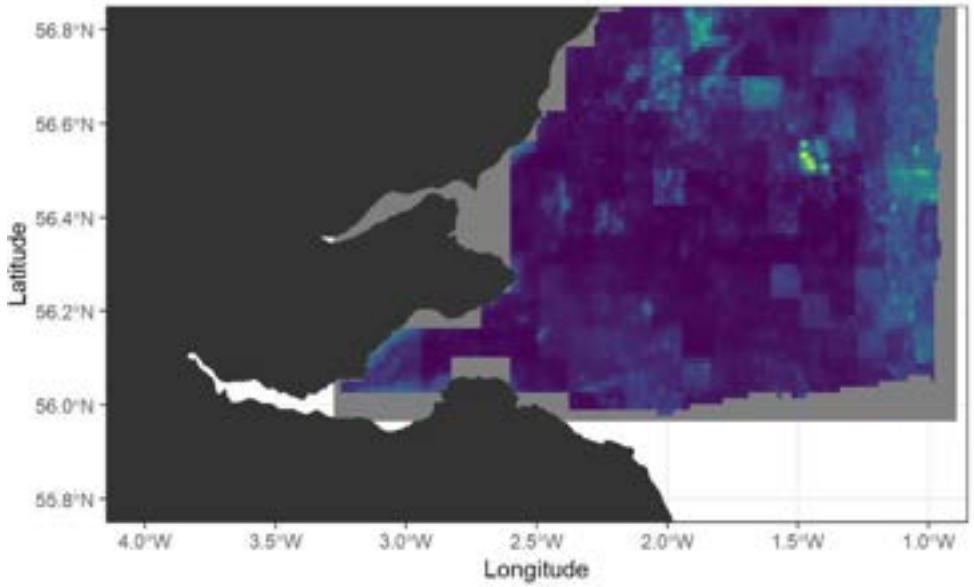
- Common to use the model with uniform prey distribution
- This means that displaced birds are displaced into an environment that is equally as good

Incorporating prey distributions

- Currently working on incorporating modelled prey distributions of actual prey now that they are available
- Will allow us to model OWF effect on prey distribution (currently assumed to have no effect on prey field)



Sandeel distribution (Langton et al. 2021)

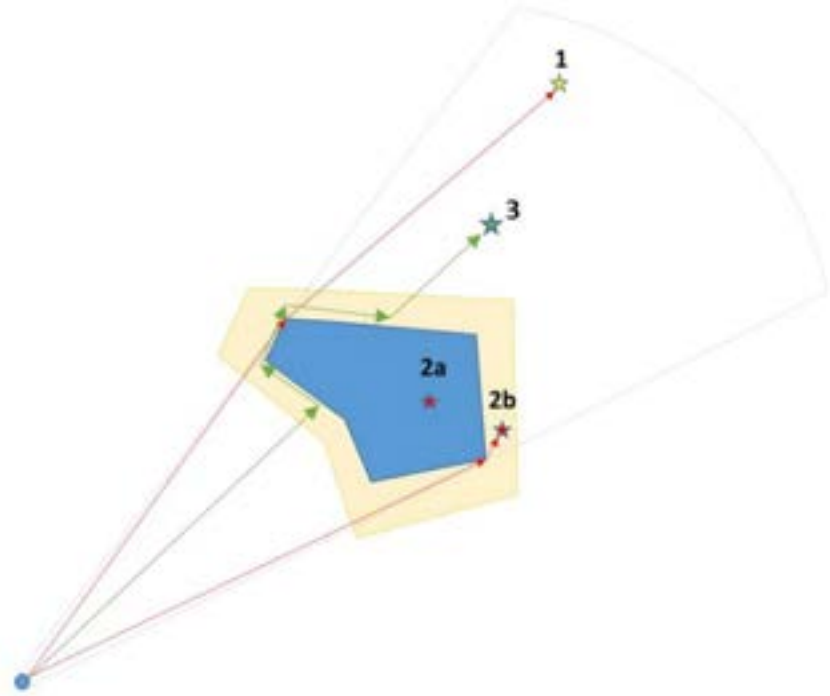


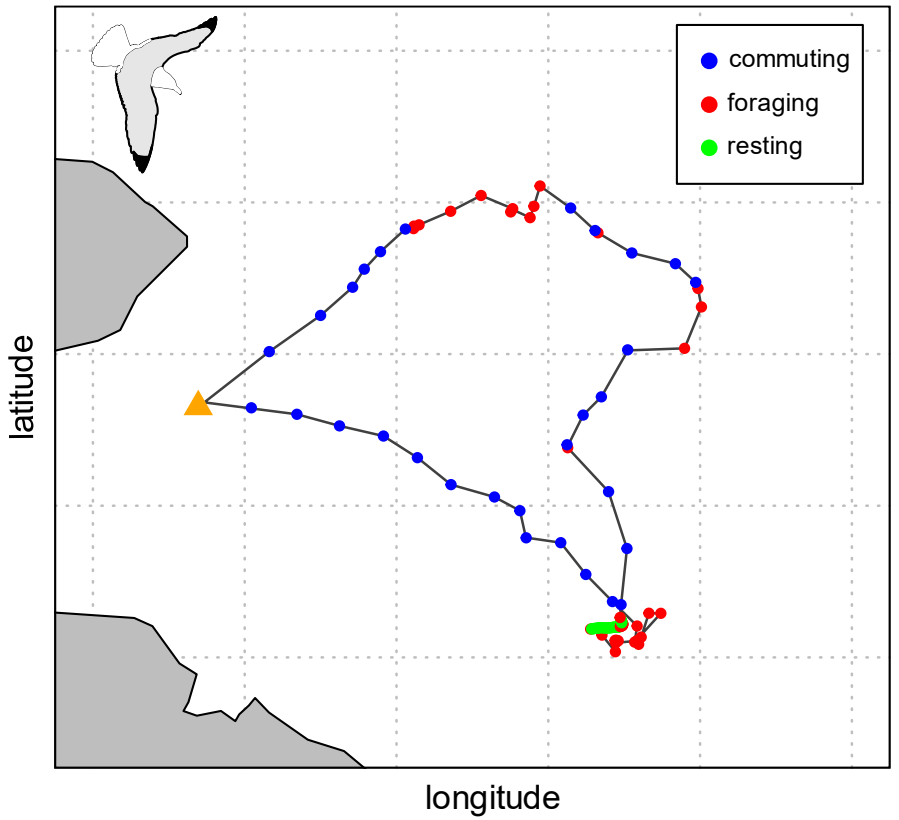
PrePARED distribution models (PrePARED)

More realistic foraging tracks

In current SeabORD foraging trips are:

- Straight lines
- Same foraging location within each time step
- No site fidelity over time steps
- ORD interactions are simplified

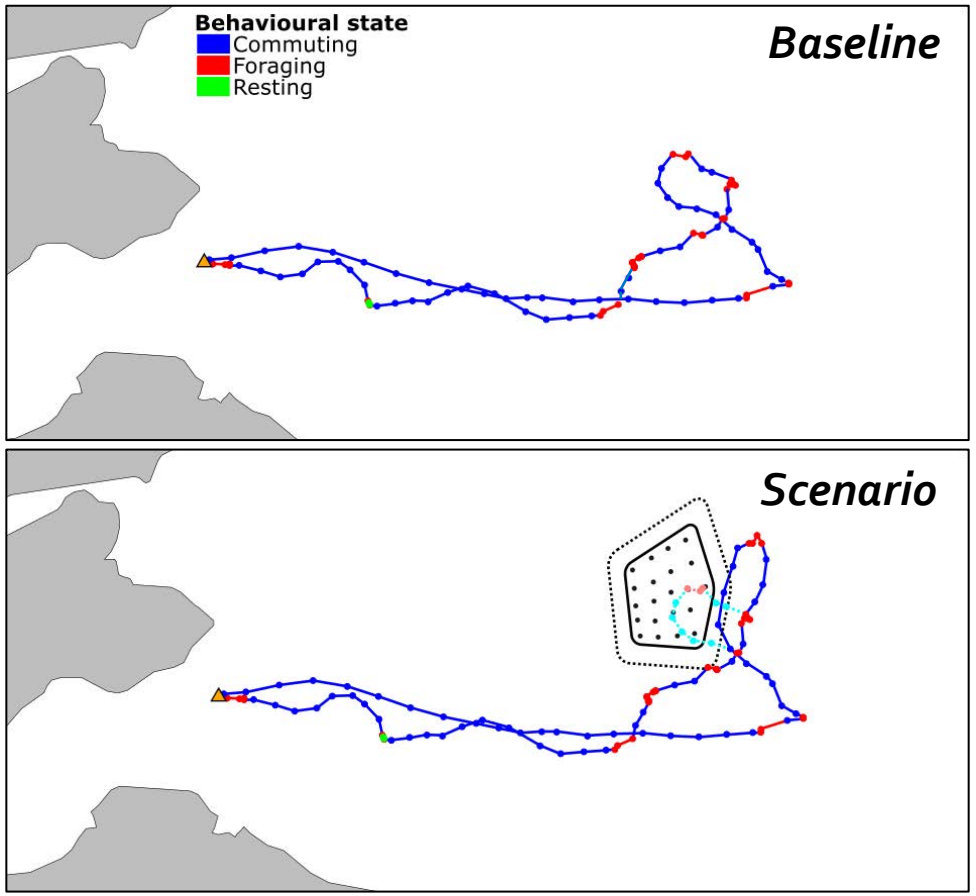




More realistic foraging tracks

Simulating more realistic foraging tracks

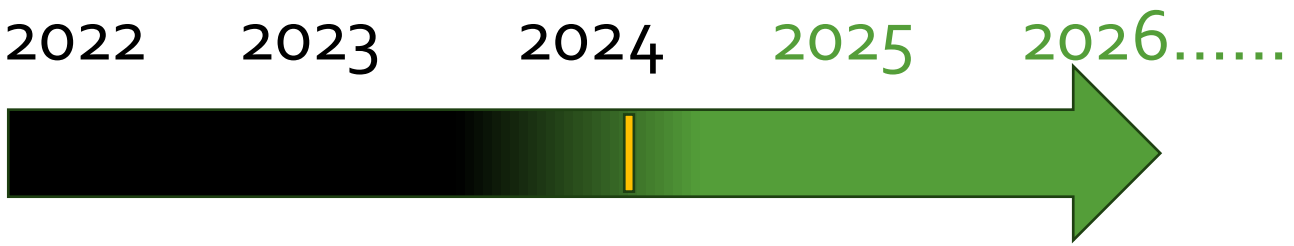
- Capturing ecological processes more accurately (i.e. different movement modes explicitly modelled)
- More realistic interaction with prey
- More realistic interaction with OWFs



Summary and outlook

We are:

- Predicting fish distributions in response to environmental drivers and offshore wind farms
- Developing methods for quantifying predator-prey interactions on different spatial and temporal scales
- Developing methods to simulate more realistic seabird foraging tracks



Next steps:

- Combining seabird tracking data with PrePARED broad-scale prey maps to quantify interactions during the breeding season
- Linking fish distribution models to energetic analyses to explore marine predator energyscapes (seabirds, marine mammals)
- Assessing the relevance of the findings outside the Forth and Tay
- Building more realistic interactions between seabirds and prey into SeabORD

Thanks to the team

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Adam Butler
(Group lead- impact)

Thomas Cornulier
(Senior statistician)

David L Miller
(Senior statistician)

Deena Mobbs
(Ecosystem modeller)

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(Quantitative ecologist)

Kate Searle
(Animal ecologist)

Maria Bogdanova
(Animal population ecologist)

Francis Daunt
(Group leader)

Mark Newell
(Isle of May field manager)

Josie Hewitt
(Avian ecologist)