Potential for wider application of the CEH Displacement Model used in the Forth and Tay

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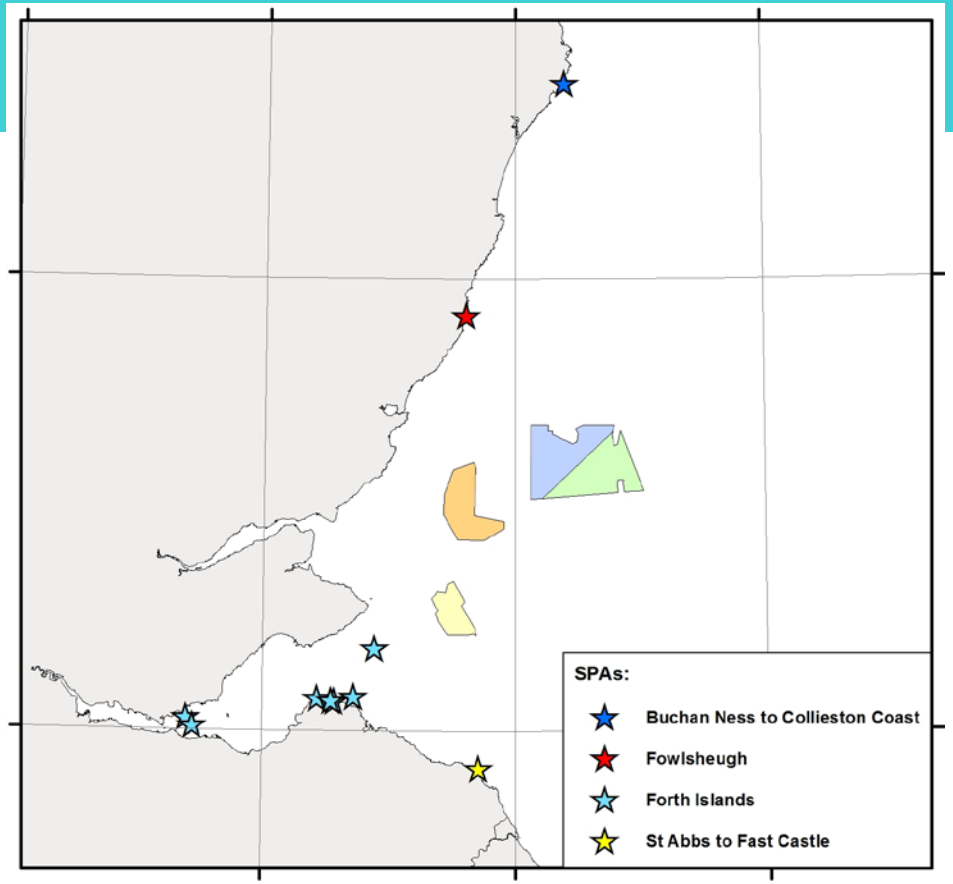
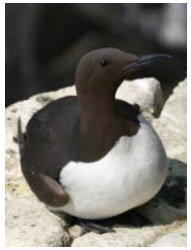
Context

- Marine Scotland project to investigate the impact of four wind farms in the Forth-Tay area on seabird demography
- Five Species
- Four SPAs + cumulative effects
- Displacement and barrier effects





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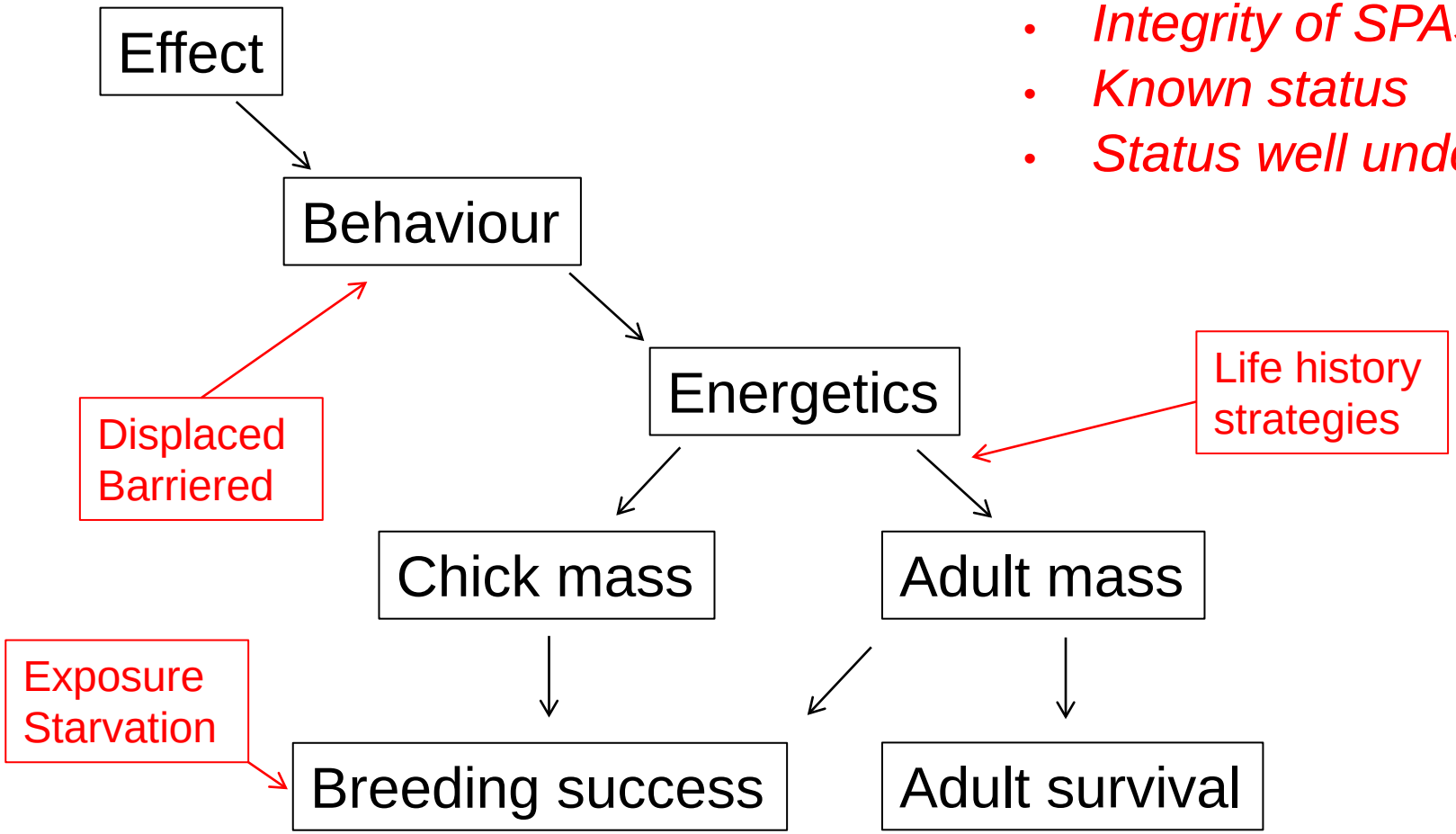
Concept

- *Breeding adults*
  - *Integrity of SPAs*
  - *Known status*
  - *Status well understood*



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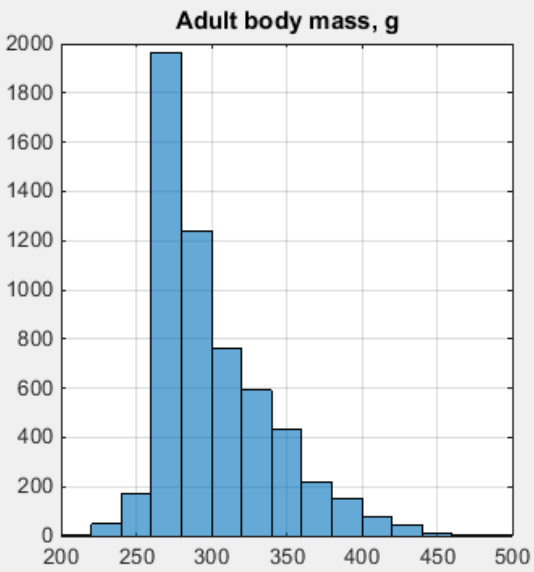
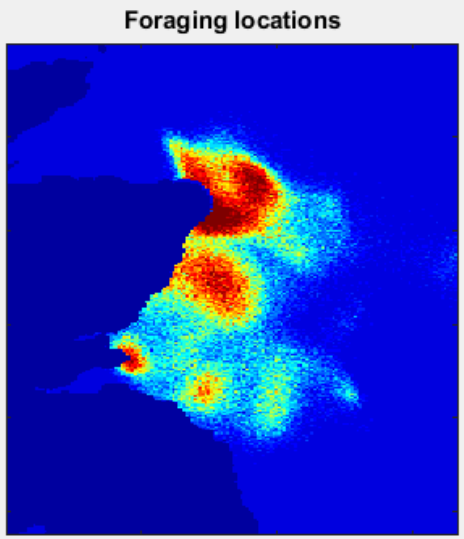
Foraging model

- Bird distribution
  - GPS tracking data from four colonies
- Simulated foraging decisions based on optimal foraging
  - Foraging site selection
  - Daily Energy Requirements
  - Prey density homogeneous or heterogeneous (informed by birds)
  - Foraging cost
  - Body mass recalculated daily based on foraging success
  - Behavioural modes for adults and chicks
- Parameterised with
  - Local data (e.g. time activity budgets)
  - Species/related species non-local data (e.g mass survival relationships)
  - Expert judgement (e.g. shape of functional response)





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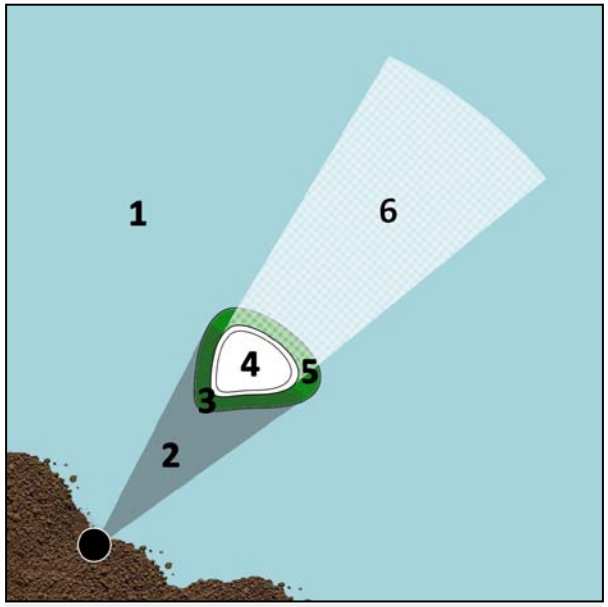
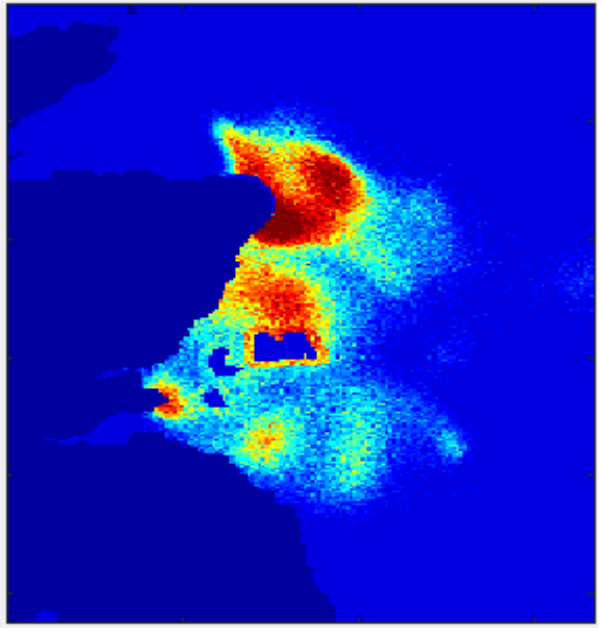
Scenarios

- Baseline model
  - Sense-checked with local data on adult survival, breeding success, adult mass, chick mass, unattendance rates
- Four wind farms and cumulative
  - Adaptive responses to wind farms e.g. adjustment of number of trips to meet DER
- Varying % displacement and barrier effect
- Varying exclusion and inclusion buffer





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Demographic rates

- Two main quantities:

  Adult winter survival with wind farm –
  adult winter survival without wind farm

  Chick survival to fledging with wind farm –
  chick survival to fledging without wind farm

- *Adult survival:* declines of more than 0.5% for Forth Islands kittiwakes, Fowlsheugh kittiwakes and Forth Islands puffins
- *Breeding success:* broadly consistent but more stochastic noise.
- Cumulative effects approximated to the sum of individual wind farms

Wider application – refinement

- Modular structure ensures flexibility

- Refinements readily incorporated based on new data e.g.
  - More complex foraging trip structure
  - More complex behaviours (site fidelity, habituation, memory)
  - Immature survival

- Model is data hungry

Wider application – other study areas

- Time spent in the footprint
- Adult body mass-survival relationships
- Other factors in the baseline situation
  - Functional response
  - Intra-specific competition
  - Total amount of prey
- Behavioural responses to wind farms
  - Displacement
  - Barrier effects
- Sensitivity to baseline may not translate to sensitivity in the wind farm effect (e.g. functional response or total amount of prey)

Conclusions

- Model strengths
  - Strong foundation: optimal foraging theory and links between energetics and demography
  - Focus on breeding individuals: pertinent to assessing SPA integrity
  - Flexible

- Data considerations
  - Data hungry
  - Many parameters are unknown, poorly estimated or estimated away from the study area

- Construction and operation phases
  - Flexibility to incorporate behavioural responses
  - Findings emphasise the importance of monitoring agreements

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