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Displacement effects model for central place foraging auks with the Forth/Tay as the case study

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Offshore renewable developments have the potential to impact on seabirds by displacing individuals from foraging habitats. The impact of displacement is particularly important for breeding seabirds that, as central place foragers, are constrained to obtain food within a certain distance from the breeding colony. The current worst-case scenario is that displacement causes 100% mortality, so there is a need to model more realistic consequences of displacement. Displacement is likely to result in changes to daily energy and time budgets. Such changes may impact on the body condition of adult breeders which, in turn, can affect breeding success, adult survival and, ultimately, population size. Additionally, breeding success may be affected directly if provisioning rates alter significantly. We present a displacement model for adult Guillemots *Uria aalge* rearing chicks on the Isle of May (part of the Forth Islands Special Protection Area) in relation to proposed offshore wind farms within the Firth of Forth area. The model estimates the consequences of displacement and barrier effects on the time/energy budget of breeding birds.

Our model incorporates several novel features resulting in a step change in the degree of realism captured in terms of incorporating how Guillemots use their foraging landscape and in how their fish prey are distributed within it. The model compares the time/energy budgets of 1000 breeding Guillemots over a 24-h period in the absence or presence of a wind farm. From this, an estimate of the time/energy budget for the entire chick-rearing period can be inferred. The model is based on assumptions regarding behavioural change in response to a wind farm and explores a range of scenarios simulating different displacement effects (e.g. only 50% of birds foraging within the wind farm are displaced), different prey densities (e.g. 25% of the prey density is reduced) and different levels of intra-specific interference competition among Guillemots feeding in the same patch. The cumulative effect of multiple wind farms in the area is also explored. All scenarios tested have implications for marine spatial planning issues.

In all scenarios, the addition of the wind farm resulted in an increase in the average costs of foraging. This result is significant as it suggests that displacement effects could be important and therefore merit further consideration.