Hidden Markov models as tools to identify seabird foraging areas

Industry partner: Joint Nature Conservation Committee

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Seabird populations are in decline worldwide (Paleczny et al. 2015). To mitigate seabird population declines, governments have designated marine protected areas for seabirds, and have regulated the development of offshore renewables in order to limit their ornithological impacts. This relies on the identification of important foraging areas. Researchers typically identify foraging areas by applying hidden Markov models (HMMs) to GPS data, which track the behaviour of individuals, using the 'moveHMM' R package (Michelot et al. 2016). Little has been done to validate these models as data on known foraging locations are difficult to collect.

One unique source of data that can be used for validation, however, involves following seabirds by boat during foraging trips to collect GPS data of bird movement and real observations of foraging behaviours. The aim of this project is to compare seabird foraging areas as predicted using GPS tracking data and HMMs with real foraging locations as recorded by observers on boats. This project will use data collected at multiple seabird colonies throughout the UK by researchers at the Joint Nature Conservation Committee (JNCC) to determine the accuracy of HMMs fitted using the 'moveHMM' R package.

Datasets are provided which include:

- GPS data from boats used to follow individual seabirds (terns *Sterna* spp) at colonies throughout the UK (recorded every 2 seconds)
- Observation data of tern behaviour collected from observers on boat
- Data were collected from multiple species, breeding colonies and years

Useful References:

Browning et al. 2017. Predicting animal behaviour using deep learning: GPS data alone accurately predict diving in seabirds. Methods in Ecology and Evolution 9: 681-692.

Langroack et al. 2012. Flexible and practical modelling of animal telemetry data: hidden Markov models and extensions. Ecology 93: 2336-2342.

Michelot et al. 2016. moveHMM: an R package for the statistical modelling pf animal movement data using hidden Markov models. Methods in Ecology and Evolution 7: 1308 – 1315. https://doi.org/10.1111/2041-210X.12578

Paleczny et al. 2015. Population trend of the world's monitored seabirds, 1950 – 2010. PLOSONE 10(6): e0129342. https://doi.org/10.1371/journal.pone.0129342

Rabiner, L., & Juang, B. (1986). An introduction to hidden Markov models. *ieee assp magazine*, *3*(1), 4-16.

Robertson et al. 2014. Resource partitioning in three congeneric sympatrically breeding seabird species: foraging areas and prey utilisation. The Auk 131: 434-446.

Wilson et al. 2014. Quantifying usage of the marine environment by terns Sterna sp. around their breeding colony SPAs. Report by the Joint Nature Conservation Committee No. 500. http://data.jncc.gov.uk/data/926cdbbd-c384-42a9-b9e5-81abd778bbd0/JNCC-Report-500-FINAL-WEB.pdf