Three-dimensional space use by a top marine predator: New perspectives in animal movement at the interface between air and sea

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Project description: Recent developments in biologging science have fundamentally altered our understanding of animal movement. While much research has focussed on studying space-use and habitat utilisation in two-dimensions, the study of 3-D movement has been hampered by hardware and analytical limitations – generating an incomplete picture of animal/environment interactions. The aim of the current proposal is to utilise technological developments in miniaturised biologging sensors, analytical tools and remote-sensing capability to conduct the first study of 3-D movement in both air and water by a plunge-diving marine predator (the northern gannet *Morus bassanus*).

Gannets are top predators in marine ecosystems, regarded as paradigmatic examples of plunge-diving behaviour. They are exceptionally well studied and are excellent models for studying marine predator movement - in part because of their ability to carry a suite of bio-logging devices without deleterious effects (Wakefield et al. 2013). Here, building on a 7-year gannet tracking programme, we will deploy next generation miniaturised GPS/altitude loggers, in tandem with Time Depth Recorders to reconstruct gannet at-sea behaviour in true 3-D (i.e. in air and water).

Two-dimensional tracking has shown that foraging seabirds such as gannets employ scale-dependent search behaviour to locate spatially predictable prey patches, and these adjustments are linked with oceanographic processes (Patrick et al. 2013). Our 3-D approach will enable the first detailed appraisal of altitudinal adjustments in response to remotely-sensed environmental data (provided by PML), and importantly link aerial distribution with movement in the water column. This research spans the disciplines of animal movement and oceanography and will use state-of-the-art animal movement analysis tools to enable us to address fundamental questions about how gannets use the marine environment in unprecedented detail. It will also answer long-standing questions about the relationship between behaviour in the air and behaviour in the water for this specialist plunge-diver. Moreover, this work is timely with regard to marine spatial planning. Current offshore windfarm collision risk models currently omit vital information on seabird flight height, rendering current predictions unreliable.

Wakefield E, et al. (2013) Space partitioning without territoriality in gannets. *Science* **341:** 68-70
Patrick SC, et al. (2013) Individual differences in searching behaviour and spatial foraging consistency in a central place marine predator. *Oikos* (in press)

Training opportunities:

Analysis of animal movement data – the student would receive exceptional training in the analysis of animal-movement data from leaders in this field, with experience of working on a wide variety of taxa using a number of different sensors. This training is of great significance in one of the most rapidly growing fields of ecological research.

Analysis of satellite remote sensing data – the student would be trained in the usage of satellite ocean colour and temperature data as environmental variables towards the modelling of gannet dive behaviour. In particular, PML has expertise on analysing oceanic fronts, which may affect dive altitude; and involvement in marine protected area projects. This will increase the interdisciplinary scope of the project and training.