

## Validating hidden Markov models to inform seabird conservation

Conservation of marine biodiversity is vital for the survival of marine organisms. Anthropogenic activities ranging from over-exploitation, offshore wind-farm, over-fishing are primary threats to marine biodiversity. In addition, seabirds, which are good indicators of the health of marine life, are rapidly declining in population than any other type of bird due to these threats. Also, seabirds are less protected from these threats at sea than they are at the colony. Thus, effective conservation at sea is critical to help address the decline in seabird population and marine biodiversity. Furthermore, knowing seabirds' behaviour at sea can help in spatial planning and inform conservation management. For instance, foraging behaviour and areas can help to map out marine protected areas (MPAs). However, how do we identify these behaviours?

In practice, seabird researchers often use hidden Markov models fitted to seabirds' GPS tracking data to infer their behaviours since they are directly unobservable from GPS tracking data. However, the challenge with HMMs fitted to GPS movement data is the uncertainty surrounding the inferred behaviours of seabirds. These cannot typically be validated due to the difficulty obtaining directly observed behavioural data of seabirds to serve as a ground truth. As a result, the corresponding MPAs from these inferred areas may be ineffective for conservation if inferred areas are located in the wrong places.

We consider a unique dataset provided by the Joint Nature Conservation Committee (JNCC) and obtained via visual tracking of four tern species using a rigid-hulled inflatable boat to tackle this problem. The tracking was conducted in several colonies within the UK during chick-rearing and incubation. The proxy movement data-the GPS location of the boat-and the behavioural data of terns directly observed and recorded by the observers on the boat are provided in the dataset. The project aims to leverage the rare opportunity provided by the unique dataset to validate inferred behaviours from HMMs (representing different biological hypotheses in movement ecology) that will be fitted to the proxy movement data using the observed terns' behavioural data.