# MASTS PECRE Final Report:
## Dr Theoni Photopoulou

**Host Institutions:**

University of Glasgow
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**Hosting Faculties:**

Prof. Jason Matthiopoulos
Institute of Biodiversity, Animal Health and Comparative Medicine
School of Life Sciences
University of Glasgow

Dr Len Thomas
Centre for Research into Ecological and Environmental Modelling
School of Mathematics and Statistics
University of St Andrews

**Background:**

The aim of this fellowship was to develop system-specific mechanistic models to infer behaviour and activity from animal tracking data. Finding out how movement metrics (i.e., location, speed, altitude, depth, acceleration) relate to functional animal behaviours is central to understanding the mechanisms behind ecology and life history. This, in turn, allows us to learn more about animal populations, the ecosystems they inhabit, and the threats they might be exposed to currently, and in the future. Movement models were developed for two animal systems in relation to covariates; activity levels and flight behaviour in raptors and diving behaviour in air-breathing divers.

The PECRE facilitated collaboration between the fellow and three experts at two MASTS institutions, over the space of a two-month period. The first part of the PECRE was carried out at the Centre for Research into Ecological and Environmental Modelling (CREEM) where the fellow visited Drs Len Thomas and Roland Langrock. This resulted in the development of two hidden Markov model frameworks for raptor flight behaviour with data from black eagles (*Aquila verreauxii*); first, a 2-state model for broad scale activity in raptors using three-axis acceleration data, and second, a 4-state model for fine-scale behaviour from 3sec resolution GPS tracking data. The second part of the PECRE was carried out at the Institute of Biodiversity, Animal Health and Comparative Medicine (IBAHCM) where the fellow visited Prof Jason Matthiopoulos. This visit was successful in implementing a mechanistic model for diving in air-breathing divers, with diving data from elephant seals (*Mirounga* spp.), using proxies of the animal's internal state and the quality of the environment, as covariates.

**Interaction with the MASTS community:**

The fellow interacted extensively with members of the broader MASTS community at both visited institutions. While at CREEM, the fellow was offered an opportunity to take part in an expert workshop organised by another visitor, Dr Toby Patterson (CSIRO, Australia), who together with Dr Sophie Bestley (Australian Antarctic Division), hosted the working group on animal movement prediction 2015 (AMP2015) at CREEM June 15-18$^{th}$. During this 4-day workshop experts collaborated on how best to do predictive modelling of animal movement under different climate change scenarios.

The fellow collaborated with Mrs Esther Jones (PhD candidate, CREEM) and Dr Janine Illian (CREEM) to write a funding application to host a workshop on the Integrated Nested Laplace Approximation (INLA) methodology at the University of Cape Town, South Africa, together with Prof Res Altwegg (University of Cape Town). The application was submitted in June 2015 to the UK-SA Researcher Links scheme co-funded by the South African National Research Foundation, Newton Foundation and British Council. Unfortunately the application was unsuccessful.

Thanks to the opportunity to visit and work with Dr Roland Langrock on hidden Markov

models for acceleration data from animals, the fellow has become involved in writing a review paper, involving MASTS fellow Dr Yannis Papastamatiou and others, on the use of this methodology for the analysis of animal acceleration data to infer behaviour.

Several open presentations were delivered during the fellowship. First, a webinar was broadcast to all of MASTS from St Andrews; second, a presentation on the raptor project was delivered to Prof Jason Matthiopoulos' research group; and third, an invited talk was delivered to the IBAHCM's spatial ecology research group, while in Glasgow.

During the Glasgow portion of the fellowship, fruitful discussions were had with postdoctoral researcher Dr James Grecian, part of Prof Jason Matthiopoulos research group, regarding collaboration. The methodology being developed for the raptor project has many similarities with the research needs on Dr James Grecian seabird project. Lastly, extremely useful technical details were discussed with a masters' student of Prof Jason Matthiopoulos, Mr Robert Paton, regarding model selection and state decoding in hidden Markov models. Both sides were keen to keep in touch in the future.

**Outputs completed and expected:**

1. **A model for the movement ecology of air-breathing divers**

Model construction and fitting was successfully completed during the fellowship. It remains to run the model on the full dataset and complete the manuscript, which will be submitted by January 2016.

2. **Hidden Markov models for behaviour and activity in raptors using acceleration and high resolution GPS data**

The early stages of model construction and fitting were successfully for this project during the fellowship. The process of finding appropriate starting values, running the model on the full dataset and model selection remain. The manuscript will be submitted by March 2016.

3. **A tutorial for the analysis of acceleration data**

Work on a collaborative review paper on modelling animal acceleration data using HMMs is underway. The manuscript will be submitted by March 2016.

4. **Animal Movement Prediction Project**

The next meeting of the AMP group is scheduled for March 2016 in Hobart, Australia, which the fellow hopes to be invited to attend. This project is expected to result in at least two publications within the scope of the project (24 months).

5. **The generalized data management and collection protocol for Conductivity-Temperature-Depth Satellite Relay Data Loggers**

A manuscript that was at the review stage at the beginning of the fellowship was successfully completed, thanks to be able to have physical meetings with co-authors Prof Mike Fedak and Mr Philip Lovell (Sea Mammal Research Unit, University of St Andrews). This is now published in the journal Animal Biotelemetry (Photopoulou *et al.* 2015 *Animal Biotelemetry* 3:21)

6. **INLA workshop at the University of Cape Town in South Africa**

New sources of funding are going to be sought out for bringing Dr Janine Illian and Mrs Esther Jones to the University of Cape Town to deliver an INLA workshop and strengthen ties between the departments.

**Future plans for building on the PECRE:**

Continued collaboration with Prof Jason Matthiopoulos, Drs Roland Langrock, Len Thomas and James Grecian. Collaboration and joint funding application with Mrs Esther Jones and Dr Janine Illian. Potential collaboration with Drs Toby Patterson and Sophie Bestley.

**Award Size and Expenditures:**

Total award: £5375. Total expenditure: £3177. Travel: £964. Subsistence: £2213.