Potential effects of North Sea wind regimes on Nathusius Pipistrelle migration strategies to the UK and implications for offshore wind energy

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Introduction

The impacts of onshore wind farms on bat species through collision with turbine blades has been well reported in the literature (e.g. Arnett et al 2008, Cryan & Barclay 2009). The potential impact of offshore wind farms (OWF) on bats is less well understood and studied. There have been increasing concerns about the fast growth of OWF developments in the North Sea and their potential impacts on migrating bat species. There is a clustering of OWF schemes in the southern North Sea where the most likely migration route to the UK is hypothesised and the first offshore scheme with a consent condition for curtailment for bat mitigation was consented in 2016 in this area (Borssele, Netherlands). This poster focuses on Nathusius pipistrelle (*Pipistrellus nathusii*) a western Palearctic migratory bat species that is known to migrate from continental Europe to the UK crossing the North Sea. *P. nathusii* is an under-studied and under-recorded species in the UK and there is a clear need to gain a better understanding of *P. nathusii* migration to the UK to identify potential routes and timings of migration to help understand the implications of increasing OWF development.

Migration

Hedenstrom (2009) notes that in order to maximise survival during migration a bat must balance the needs of safety, energy and time: safety considers predation and migration routes that avoid long distances across inhospitable terrain; energy considers the cost of flight vs the cost of replacing energy at unfamiliar stop-off locations; and time because bats arriving first may be able to claim the best hibernation or mating sites.

P. nathusii is thought to complete its migration using various migration strategies:

- **multistep migration strategy - utilising stopover sites during their journey**
- **mixed fuel strategy – by laying down fat and using this as a fuel (Voigt et al., 2012)**
- **fly-and-forage strategy – feeding to replace energy as they go (Suba et al 2012)**

P. Nathusius migration facts:

- **Flight speed 7 m/s estimated (Hedenstrom 2009); 11.2 – 13.2 m/s measured (Suba 2014)**
- **Active for 7.3 hrs per night in August and September (Suba et al 2012)**
- **Migration speed estimated 46km/day (Hedenstrom 2009); 47 km (32-77 km) per night, 5.1-10.2 km/hr (Petersons 2004); 30-120 km per night, 4-16 km/hr (Suba 2014)**
- **Activity up to 85 km offshore between late August and mid-October (and at a lower level in spring; Lagerveld & Platteeuw 2016)**
- **96% of activity during wind speeds <7 m/s, and 76% during wind directions between northeast and southeast (Lagerveld & Platteeuw 2016)**
- **Some activity immediately after dusk suggesting roosting at sea (Lagerveld & Platteeuw 2016)**

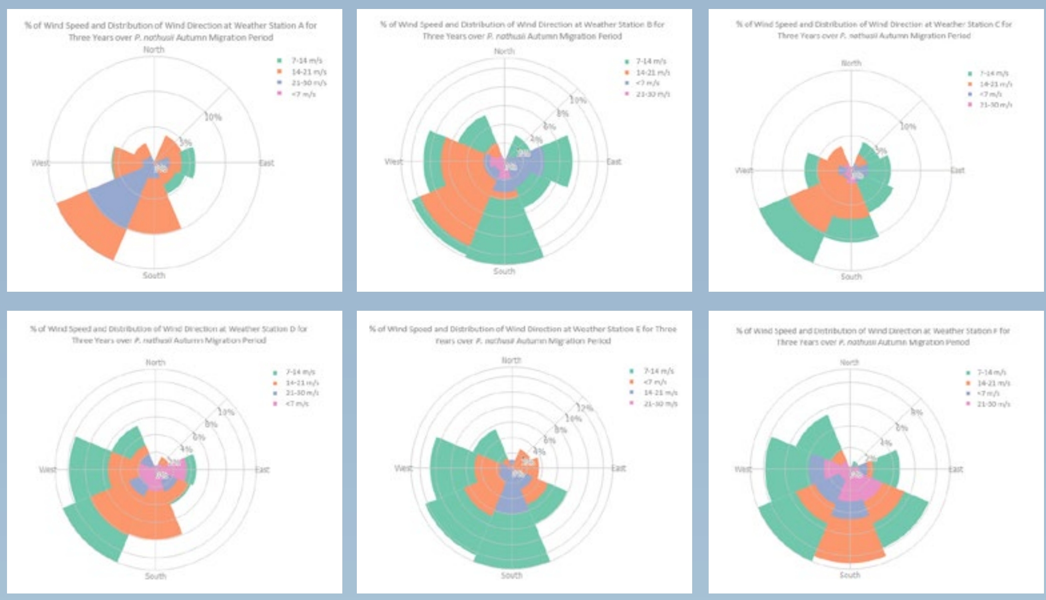

Figure 3. Wind rose diagrams show the percentage of wind speed (each circle) and distribution of wind direction (direction from which the wind is blowing) for each weather station over the migratory period (mid-August, September and October) for 2014, 2015 and 2016 combined. Based on 24-hour average measures.

Weather Station	< 7 m/s	7-14 m/s
Station A	0.3%	13%
Station B	8.1%	15.7%
Station C	5.5%	16.7%
Station D	5.7%	10%
Station E	11.5%	11.7%
Station F	4.9%	13.3%

Table 1. Percentage of favourable wind conditions (7-14 m/s and <7 m/s between SW and NW) during migration period (mid-August – mid October) at each weather station in the North Sea.

Methods

Site description

North Sea

The North Sea is peppered with offshore platforms (including wind farms). There are two hypothesised *P. nathusii* migratory routes across the North Sea: Norway to Scotland/northern England and Netherlands/Belgium/France to east/south-east England (Figure 1).

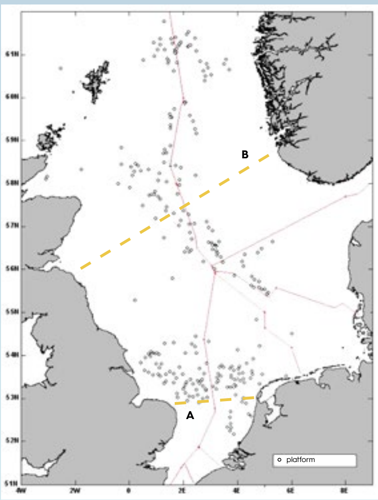

Figure 1. Locations of offshore platforms in the North Sea (black circle), and territorial boundaries (red line) of the UK, Denmark, Germany, Norway and Netherlands (from Boshamer and Bekker, 2008) and hypothesised P. nathusii migration routes to the UK (yellow dash lines).

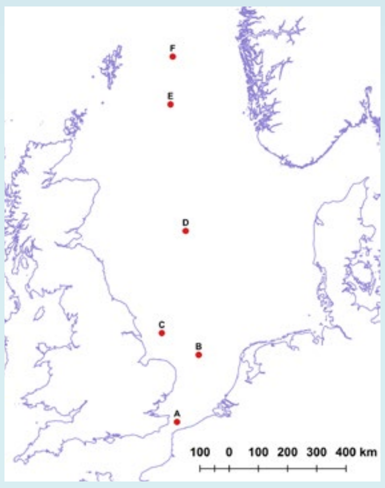

Figure 2. Map of selected North Sea weather stations, three southern stations (A, B, C), three northern stations (D, E, F).

Meteorological Data

Meteorological data for the North Sea was extracted from MIDAS: Global Marine Meteorological Observations Data attained from Met Office Integrated Data Archive Systems (MIDAS) - Land and Marine Surface Stations Data. Datasets were provided by the Centre for Environmental Data Analysis (CEDA) (http://www.ceda.ac.uk).

Weather data for 2014 -16 from six offshore weather stations were chosen, three from the northern region and three from the southern region of the North Sea (Figure 3). From this data set hourly wind speed and wind direction measurements between 15 August and 15 October were extracted for analysis.

Results and conclusion

Using the migration flight speed assumptions above *P. nathusii* could fly from France to southern England (<33km) without having to wait for optimal wind conditions or utilising stopovers. Crossing from the Netherlands to eastern England (c.190km) would potentially require stopovers or optimal wind conditions (<7m/s, NE-SE). Crossing from Norway to north-east England (c. 550km) or Norway to Shetland Islands (c. 330km) would likely require stopovers even during optimal wind conditions, although Hedenstrom (2009) suggests it would be physiologically achievable assuming sufficient fuel load could be built up.

OWF have cut-in wind speeds of around 3.5 m/s. Thus there is potential for collision during migration even if bats are choosing optimal wind conditions of < 7m/s. Optimal conditions are only present for a small proportion of the potential migration season (Table 1), meaning that should curtailment below 7 m/s be implemented during these conditions, the impact on energy yield, and therefore cost to the wind farm operator, is likely to be relatively low. However should bats use OWF as stopover sites then additional curtailment time may be required. It should be noted that the availability of optimal conditions for bats is lower than suggested by the wind rose diagrams because they cover 24 hours (i.e. not just the hours of darkness) and do not take account of other meteorological variables such as visibility.

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