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SHORT COMMUNICATION

Possible impacts of offshore wind farms on seabirds: a pilot study in Northern Gannets in the southern North Sea

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Abstract We studied the impact of offshore wind farms on the distribution of Northern Gannets in the southern North Sea. Distributions were derived from ship-based and aerial-transect counts, and from global positioning system (GPS) tracking of chick-rearing adults from the colony on Helgoland. Foraging trips of tagged Gannets lasted from 0.4 to 53.5 h, with a total distance flown per trip of 4.7–937.9 km, and range of 2.0–320.8 km. Gannets largely avoided the wind farm area north of Helgoland. This avoidance behaviour implies that, although Northern Gannets may not be killed by rotor blades, they may experience substantial habitat loss. GPS tracking is well suited to the study of wind farm effects on birds and possible habituation processes at the individual level.

Keywords Wind energy · Global positioning system tracking · Habitat loss · Foraging

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Zusammenfassung

Mögliche Effekte von Offshore-Windparks auf Seevögel: Eine erste Studie an Basstölpeln in der südlichen Nordsee

Um mögliche Effekte von Offshore-Windparks auf Seevögel zu untersuchen, wurde die räumliche Verteilung von Basstölpeln in der südlichen Nordsee analysiert. Dafür wurden Zähldaten von standardisierten Erfassungen vom Schiff und vom Flugzeug aus sowie Telemetriedaten besenderter, Küken-fütternder Altvögel der Brutkolonie auf Helgoland herangezogen. Die Nahrungsflüge der besenderten Basstölpel dauerten 0,4–53,5 h mit einer zurückgelegten Gesamtdistanz pro Flug von 4,7–937,9 km und einer maximalen Reichweite von 2,0–320,8 km. Die Basstölpel zeigten größtenteils eine Meidung der Offshore-Windparks nördlich von Helgoland. Dieses Meidungsverhalten deutet an, dass Basstölpel zwar nahezu nicht mit den Rotorblättern der Windkraftanlagen kollidieren, aber durch die Offshore-Windparks einen Großteil ihres Nahrungshabitats verlieren. Die Studie zeigte ebenfalls, dass sich GPS-Telemetrie gut dazu eignet, mögliche Windparkeffekte auf Vögel und auch mögliche Gewöhnungsprozesse der Tiere individuenbasiert zu untersuchen.

Introduction

Concerns about the effects of offshore wind farms on birds are intensifying in light of the expansion of these developments in coastal and offshore marine environments (Garthe and Hüppop 2004; Furness et al. 2013). Several thousand wind turbines are currently proposed for the North Sea, with similar plans in the western Atlantic, other European areas, and, worldwide. Assessing the potential risks associated with proposed wind-energy installations is essential.

Seabirds may be affected by offshore wind turbines in four ways (Dierschke and Garthe 2006): (1) collision; (2) creation of a barrier effect causing birds to avoid wind farms by flying around, under, or over them, thus increasing energy and possibly stress costs; (3) displacement caused by disturbance from operating turbines and associated ship and helicopter traffic, leading to habitat loss; and (4) attraction by artificial resting sites and increased food availability associated with the creation of new substrate at turbine bases, and fishing bans near sites.

We conducted a pilot study of the possible effects of operational wind farms on seabirds in the southern North Sea in 2014, with Northern Gannets (*Morus bassanus*; hereafter 'Gannet') as the target species, given that it is ranked amongst the species at highest overall risk in relation to offshore wind farms in the UK (Langston 2010). We tagged birds at a breeding colony in Helgoland using global positioning system (GPS) data loggers, and analysed long-term seabirds-at-sea data to obtain information from a comprehensive data set.

Methods

This study took place in the southeastern North Sea, with a focus on the island of Helgoland (54°11′N, 7°55′E; Germany), which holds the only Gannet colony in the southeastern part of the North Sea. Gannets started breeding on Helgoland in 1991 and reached a maximum of 656 nest sites in 2014 (J. Dierschke, personal communication).

The distribution of Gannets was derived from ship-based and aerial-transect counts (Markones and Garthe 2012). A comparative study of seabird survey methods revealed that densities of Gannets were equally well assessed using either counting platform (Markones and Garthe 2012), and the two data sets were therefore combined in this study. Abundances were derived using distance sampling methodology by calculating correction factors for birds increasingly overlooked in the outer transect bands. Only two small wind farms existed in the southeastern North Sea prior to 2013, and data from this period were therefore used to represent the situation almost without wind farms. Abundance estimates took account of the increasing size of the Gannet colony on Helgoland, and we therefore only selected data from 2005 onwards, when the population comprised ≥200 pairs. Total effort comprised 21,799 km of ship-based and 41,593 km of aerial surveys. Distribution data from at-sea surveys were spatially interpolated using a generalized additive model. Data on proportions of adults and immatures based on plumage characteristics were analysed only from ship-based data as these were considered to be more accurate for this question.

Seven chick-rearing adults were caught on 4 July 2014 and equipped with GPS data loggers [Bird Solar (e-obs, Munich); CatLog-S GPS (Catnip Technologies, Hong Kong)]. Loggers were taped to the base of the four innermost tail feathers. Data from three birds were retrieved by remote-reading from 8 to 10 August and/or by recapturing on 11 September. One device malfunctioned, two were lost to on-going tail-feather moult, and one could not be retrieved because the chick had fledged at recapture. Data sets for three birds, tracked for 69, 37, and 24 days, respectively, were therefore available for analysis. Foraging trips were defined as absence from the nest site for at least 20 min and 2.0 km distance. The total attached mass of the devices was ca. 48 g (Bird Solar) and 39 g (CatLog-S), representing 1.5 and 1.2 %, respectively, of the Gannet mean body mass of 3286 g (Wanless and Okill 1994), i.e., below the potential threshold of 3 % (Phillips et al. 2003). All pairs successfully raised their chicks, and no visible effects on bird behaviour were detected.

Results

The distribution of Gannets extended throughout the German Bight, with a core area of birds at sea to the west of Helgoland, and another hotspot further west, apparently not linked to Helgoland (Fig. 1). The proportion of adults was on average 36 % (2005–2015) and has increased from previous periods (1995–2004, 15 %) along with a general increase in the study area due to the establishment of the breeding colony on Helgoland.

The flight tracks of the three tagged adults showed the highest density of positions at sea to the west, but also to the south, with a marked axis to the northwest of Helgoland (Fig. 2a). A few long foraging trips led to areas west of Jutland (Denmark), with no trips directed far to the west.

Foraging trips of Gannets breeding on Helgoland lasted 0.4–53.5 h (mean ± SD, 7.9 ± 8.0 h; $n = 168$ foraging trips; $n = 3$ individuals), with individual means of 6.9–8.6 h. Total distance flown per foraging trip was 4.7–937.9 km (124.6 ± 138.6 km; $n = 168$ foraging trips; $n = 3$ individuals), with individual means of 70.7–146.1 km. The mean foraging range of the Gannets was 42.0 ± 45.7 km (range 2.0–320.8 km; $n = 168$ foraging trips; $n = 3$ individuals), with individual means of 23.8–51.4 km.

Flight tracks (Fig. 2a) revealed a gap north-northwest of Helgoland. Projection of wind farm sites onto the map

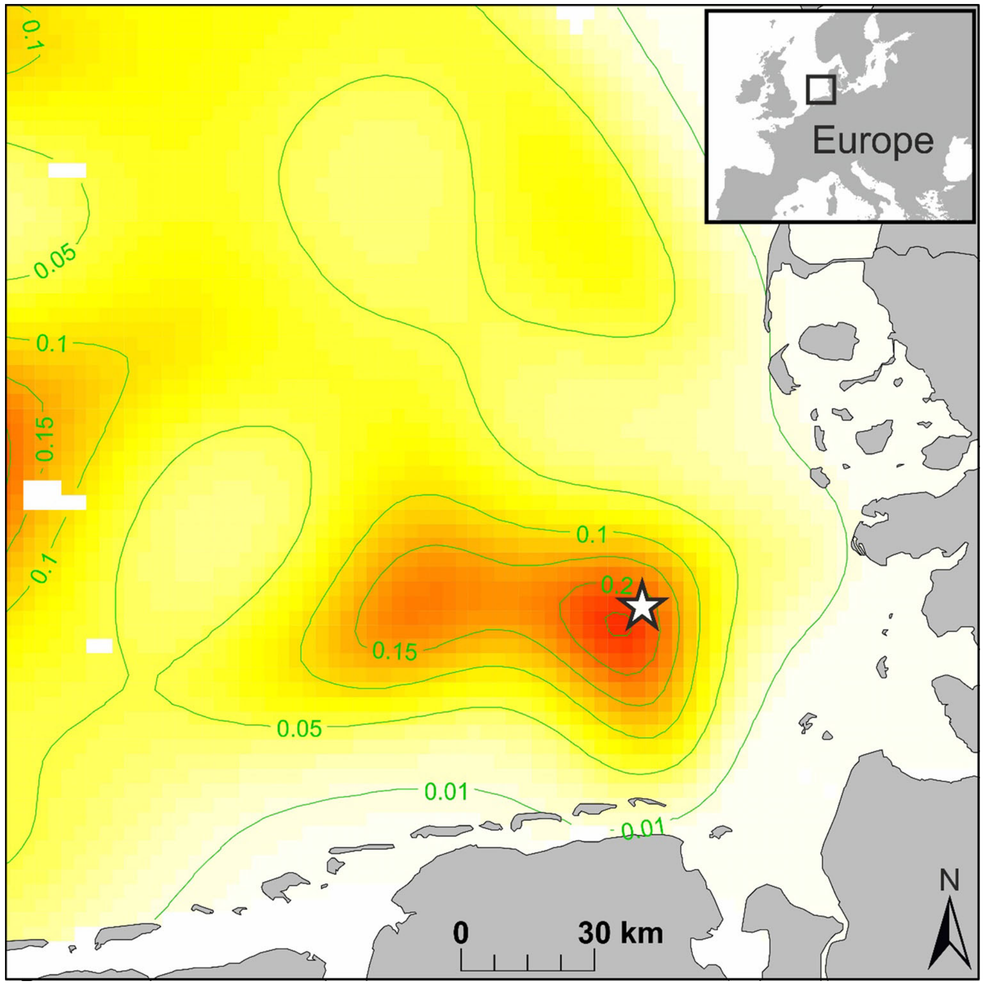

Fig. 1 Distribution of Northern Gannets from ship-based and aerial seabirds at-sea counts during the breeding period (June–September). Data represent a situation with nearly no wind farms, 2005–2012. Increasing Gannet densities are visualised by *colours* from *yellow* through *orange* to *red*. *Green contours* and *numbers* represent the abundance (log no. birds/transect km) of Gannets (colour figure online)

showed that the birds avoided the wind farm area (Fig. 2b). Although all three birds apparently approached the wind farm sites during their trips, only one bird flew through the northernmost area of the three wind farms located north of Helgoland. The bird crossed the site four times. During that time, only a transformer station, platform, and foundations were installed, and the turbines were not installed until February 2015.

Discussion

This study demonstrates that Gannets use wide areas of the German Bight, with a focus on areas to the west and northwest of the breeding colony. The three tagged individuals showed clear avoidance of areas where wind turbines were installed, over several weeks. Seabird distribution data prior to erection of the wind turbines showed that these areas were visited at the same intensity as other nearby areas. Nevertheless, all wind farms were approached by Gannets, and sometimes flown around. Despite the small sample size in this pilot study, the results are in accordance with studies conducted at operating wind farms, which generally found strong, but not complete avoidance of wind farms by Gannets (e.g. Leopold et al. 2013; Vanermen et al. 2015).

This behaviour has two implications for Gannets. First, avoidance of wind turbines reduces the risk of direct mortality. Although Gannets predominantly fly at low altitudes (Johnston et al. 2014; Cleasby et al. 2015), below the minimum height of the turbine rotor blades, they may exceed altitudes of 50 m when searching for food (Krijgsveld et al. 2011; Garthe et al. 2014; Cleasby et al. 2015), making them at risk of colliding with the blades. Second, Gannets may experience habitat loss as a result of total or partial displacement from wind farm areas. This may not present a problem if only a few wind farms are established, but the effect of an increasing number of wind farms may eventually have a considerable impact on the species (e.g. Busch et al. 2013). Effects may relate not only to the wind farm area itself, but possibly also to buffer zones and wind-turbine-wake zones either side of the wind farms, especially for birds commuting to/from a colony.

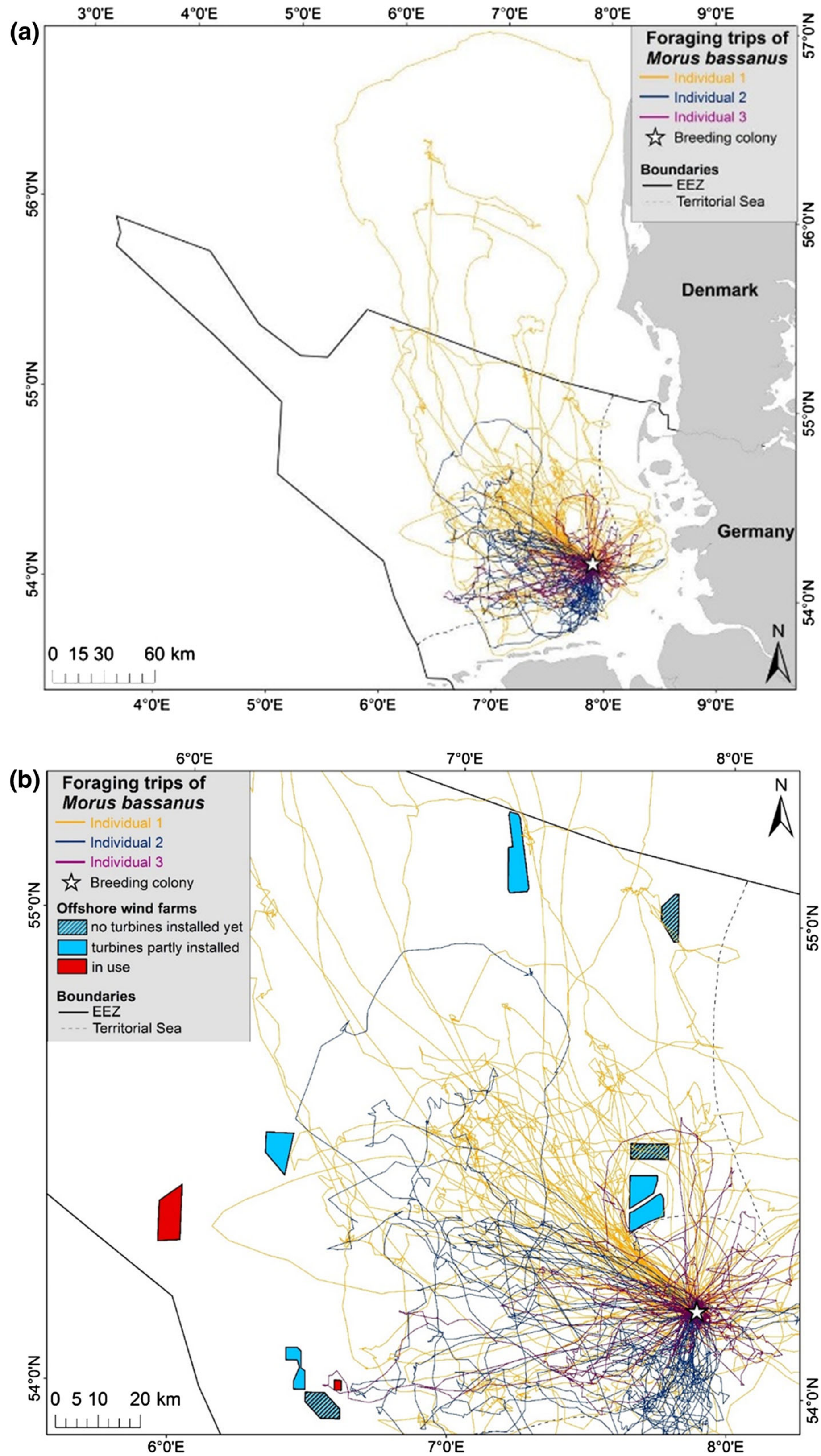

Fig. 2 Flight tracks of three Northern Gannets breeding on Helgoland, Germany, over 4, 5, and 9 weeks, respectively, from early July 2014 onwards. **a** Complete flight tracks. **b** Overlap with wind farm area

GPS tracking of foraging seabirds provides valuable data at operating wind farms (Thaxter et al. 2015), and this methodology is particularly well suited to studying wind farm effects and possible habituation processes at the individual level. Repeated tracking of the same individuals may help identify changes in birds' responses over time to existing wind farms. This is of particular interest in the case of breeding birds that may become accustomed to wind farms over long periods of time, in contrast to migrating birds that usually encounter the same wind farm sites only a few times per year. Considering the extensive plans for offshore wind farms within the distribution areas of Gannets, a comprehensive understanding of the imposed risks and the birds' responses is essential for an assessment of the conservation implications for this species.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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