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Seabird aggregative patterns: A new tool for offshore wind energy risk assessment

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ABSTRACT

The emerging development of offshore wind energy has raised public concern over its impact on seabird communities. There is a need for an adequate methodology to determine its potential impacts on seabirds. Environmental Impact Assessments (EIAs) are mostly relying on a succession of plain density maps without integrated interpretation of seabird spatio-temporal variability. Using Taylor's power law coupled with mixed effect models, the spatio-temporal variability of species' distributions can be synthesized in a measure of the aggregation levels of individuals over time and space. Applying the method to a seabird aerial survey in the Ebro Delta, NW Mediterranean Sea, we were able to make an explicit distinction between transitional and feeding areas to define and map the potential impacts of an offshore wind farm project. We use the Ebro Delta study case to discuss the advantages of potential impacts maps over density maps, as well as to illustrate how these potential impact maps can be applied to inform on concern levels, optimal EIA design and monitoring in the assessment of local offshore wind energy projects.

1. Introduction

Studies on marine top predators are today considered as a key component of marine ecosystem management (Boyd et al., 2006). Within top predators, seabirds are good indicators of ecosystem health (Cairns, 1987; Nettleship and Duffy, 1993; Mallory et al., 2006) and are useful indicators to evaluate potential effects of human activities at sea. Most seabirds are flagship species for the public (Fox et al., 2006) and have clear protection criteria collected in protection directives like the birds directive (79/409/EEC) and habitats directive (92/43/EEC) in Europe. Their distribution and abundance are usually provided as key information to support the establishment of marine protected areas, to implement fisheries' management measures (Boyd et al., 2006), to assess the impact of environmental disasters such as oil spills (Bretagnolle et al., 2004; Moreno et al., 2011) or to monitor the impact of oil and gas platforms at sea (Wiese et al., 2001).

In the last years, offshore wind energy has emerged as a priority field in many European countries to meet Europe's 2020 agenda that promotes renewable energies to mitigate the effects of climate change; hence offshore wind farms will likely experience an important increase in the near future. However, in the field of marine management there is a growing concern on the development of offshore wind energy and its potential impacts on coastal seabird populations, mainly because of possible collisions with windmills (Fox et al., 2006). On a large scale, countries might develop "Strategic Environmental Assessments" (SEAs) to plan their offshore wind farms network in a way that minimizes their ecological impact on the coastal environment (Directive 2001/42/EC). At a local scale, each wind farm project requires an Environmental Impact Assessment (EIA) of its potential impact in the marine environment, including the risk imposed on avian populations (Bright et al., 2008; Masden et al., 2010).

The potential impacts of offshore wind farms on seabird communities are complex. Fox et al. (2006) provided a conceptual classification of these impacts, distinguishing between (1) avoidance, (2) modification of the physical habitats, and (3) direct mortality trough collision. Most EIA guidelines suggest radar studies to assess collision risk in strongly migratory areas (Desholm et al., 2006; Fox et al., 2006; Kunz et al., 2007) and density maps as a proxy to loss of foraging habitats by avoidance and physical habitat modification (Camphuysen et al., 2004; Fox and Petersen, 2006). However, density maps do not provide a full understanding of the underlying behavioral patterns related to their movements. Seabirds often present dynamic and complex spatial patterns at sea which are far from being understood. When foraging, many species of seabirds are usually characterized by an important

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aggregative behavior (Buckley, 1997; Grünbaum and Veit, 2003), with birds forming flocks of hundreds of individuals. On the contrary, a lower aggregative behavior is expected in transitional areas solely used as flight paths between feeding areas and their resting or breeding areas. While density maps focus on high concentrations of seabirds as potential risk areas, we propose the explicit distinction between transitional and foraging areas as a key step to better predict and classify the risk of wind farm establishment on seabird populations. In transitional areas, the main risk will be direct collision and mortality (Desholm and Kahlert, 2005; Hüppop et al., 2006). In foraging areas, the risk of direct collisions is increased and potentially associated with a displacement from their preferred feeding areas, resulting in habitat loss (Masden et al., 2010; Perrow et al., 2011).

In 2004, the proposal of an offshore wind farm project in front of the Ebro Delta (North-Western Mediterranean, Fig. 1a) emphasized the necessity for adequate indicators to determine the extent and effect of potential impacts on its seabird community. Here, we use the slope of the Taylor's power law as a measure of the aggregative patterns of seabirds to identify transitional and feeding areas, and map the risk accordingly. The slope of the Taylor's power law (Taylor, 1961; Taylor and Woiwod, 1982) provides a convenient measure of the aggregation levels of animals (see Kendal (2004) for a review). It has already been used in a spatio-temporal context with seabirds (Certain et al., 2007) and has proved to be useful to describe the temporal variability associated to the spatial distribution of seabirds at multiple scales. Here, using the Ebro Delta as a case study, we first show how to take into account the aggregative properties of seabird distributions together with abundance maps. Second, we point the advantages of this method as an integrative tool to summarize in few maps the spatial and temporal variability of the potential impacts of offshore wind farms. Finally, we discuss how the resulting potential impacts maps provide a frame to inform on EIA design and monitoring in the context of an offshore wind farm proposal.

2. Method

2.1. Study area & survey method

The Ebro Delta (NW Mediterranean Fig. 1), is a very productive area because of a permanent upwelling, result of the sudden broadening of the shelf (up to 70 km) in combination with the influence of the Liguro-Provençal-Catalán front and nutrients carried by the Ebro river runoff (Arcos et al., 2001; Palomera, 1992). This high productivity supports an important fishing fleet with a high trawling activity (Palomera, 1992; Arcos et al., 2001; Louzao et al., 2006) which in turn has been pointed as a key resource for seabirds (Arcos, 2001; Arcos et al., 2008). However, the trawling activity is regulated with temporal moratoria in the area. Fishing moratoria affect the northern area (B1–2 and B14–16 Fig. 1), in May and June and the southern area (B3-B13) during July and August, and influence the distribution of some species.

Seven monthly aerial surveys were carried out from March 2005 to September 2005 on the continental shelf around the Ebro Delta (40.7°N, 0.75°E). The surveys covered a total area of 1435 km^2 from L'Ametlla de Mar harbour (24 km North; 40.86°N, 0.8°E) to Peñíscola (51 km South; 40.35°N, 0.4°E) (Fig. 1). The entire shelf area can be covered in a single day using this approach, and availability biases due to attraction and avoidance movements of seabirds were minimized. In this study, we used the standard seabird aerial survey methodology described by Noer et al. (2000).

The survey area was covered by 45 transects systematically arranged in parallel lines running perpendicular to the coast, to follow the dominant sea depth gradient, and flown at 2 km intervals. During the surveys, two observers, one at each side of the aircraft, covered 1 km strip at each side. The surveys were conducted from a twin-engine aircraft, Partenavia P68, and the aircraft GPS was used for navigation along the transect tracks. The cruising speed was set at c. 100 knots (185 km/h) with respect to the air speed and average flying height was 300 feet (100 m). Along the transects, all observed bird flocks were recorded with a voice recorder, stating information on species (or the lowest taxonomical level determinable), number of individuals, behavior (e.g. flying, flushing, sitting on water, feeding on trawler discards), age whenever possible, transect strip, date and time. The presence of trawlers was also recorded. These recordings were geo-referenced later with the transect track information provided by a GPS and a Turbo Pascal application (Ib Krag Petersen, pers. com.). In the moments of maximum glare or any other adverse light situation, the counting was interrupted. Since counts results are highly sensitive to meteorology, no surveys were conducted when Beaufort Sea state was greater than one (Table 1).

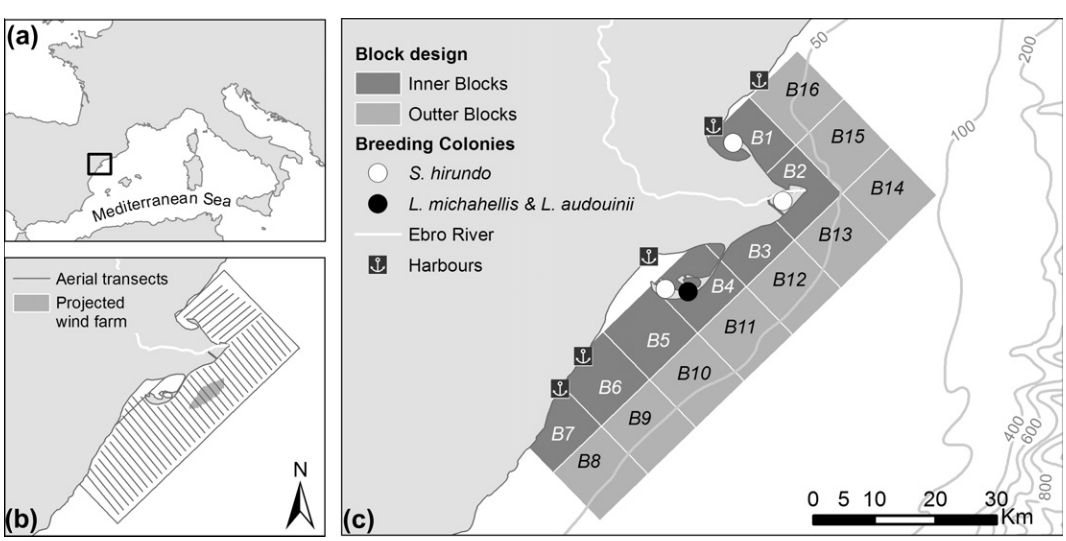

Fig. 1. (a) Situation map. (b) Survey design of aerial transects and projected offshore wind farm location. (c) Block design of the study area showing inner and outer classification and block Id. The main breeding colonies location, harbours and the Ebro river are shown.