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TITLE: Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index

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ABSTRACT:

Summary Marine wind farms have attracted substantial public interest. The construction of wind facilities offshore may become Europe's most extensive technical development in marine habitats. Due to political pressure to complete construction soon, assessments of possible wind farm locations, for example in the German sectors of the North Sea and Baltic Sea, have to be based on existing knowledge. In this study, we developed a wind farm sensitivity index (WSI) for seabirds. We applied this index to the Exclusive Economic Zone and the national waters of Germany in the North Sea. We chose nine factors, derived from species' attributes, to be included in the WSI: flight manoeuvrability; flight altitude; percentage of time flying; nocturnal flight activity; sensitivity towards disturbance by ship and helicopter traffic; flexibility in habitat use; biogeographical population size; adult survival rate; and European threat and conservation status. Each factor was scored on a 5-point scale from 1 (low vulnerability of seabirds) to 5 (high vulnerability of seabirds). Five of these factors could be dealt with by real data but four could only be assessed by subjective considerations based on at-sea experience; in the latter cases, suggestions of the first author were independently modulated by experts. Species differed greatly in their sensitivity index (SSI). Black-throated diver *Gavia arctica* and red-throated diver *Gavia stellata* ranked highest (= most sensitive), followed by velvet scoter *Melanitta fusca*, sandwich tern *Sterna sandvicensis* and great cormorant *Phalacrocorax carbo*. The lowest values were recorded for black-legged kittiwake *Rissa tridactyla*, black-headed gull *Larus ridibundus* and northern fulmar *Fulmarus glacialis*. A WSI score for areas of the North Sea and Baltic Sea was calculated from the species-specific sensitivity index values. Coastal waters in the south-eastern North Sea had values indicating greater vulnerability than waters further offshore throughout the whole year. Derived from the frequency distribution of the WSI, we suggest a 'level of concern' and a 'level of major concern' that are visualized spatially and could act as a basis for the selection of marine wind farm locations. Synthesis and applications. The wind farm sensitivity index might be useful in strategic environmental impact assessments (EIA). Results of small-scale EIA from wind installations should be considered within a more global perspective, provided, for example, by large mapping projects and detailed behavioural studies. This is difficult in normal EIA, particularly in highly dynamic coastal/marine habitats, and the results of this study fill an important gap by providing information on the potential sensitivity of seabirds and the importance of locations of wind installations.

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