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Mobile demersal megafauna at artificial structures in the German Bight – Likely effects of offshore wind farm development

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ABSTRACT

Within the next few decades, large underwater structures of thousands of wind turbines in the northern European shelf seas will substantially increase the amount of habitat available for mobile demersal megafauna. As a first indication of the possible effects of this large scale habitat creation on faunal stocks settling on hard substrata, we compared selected taxa of the mobile demersal megafauna (decapods and fish) associated with the foundation of an offshore research platform (a wind-power foundation equivalent) with those of five shipwrecks and different areas of soft bottoms in the southern German Bight, North Sea. When comparing the amount of approximately 5000 planned wind-power foundations (covering 5.1×10^6 m^2 of bottom area) with the existing number of at least 1000 shipwrecks (covering 1.2×10^6 m^2 of bottom area), it becomes clear that the southern North Sea will provide about 4.3 times more available artificial hard substratum habitats than currently available. With regard to the fauna found on shipwrecks, on soft substrata and on the investigated wind-power foundation, we predict that the amount of added hard substrata will allow the stocks of substrata-limited mobile demersal hard bottom species to increase by 25–165% in that area. The fauna found at the offshore platform foundations is very similar to that at shipwrecks. Megafauna abundances at the foundations, however, are lower compared to those at the highly fractured wrecks and are irregularly scattered over the foundations. The upper regions of the platform construction (5 and 15 m depth) were only sparsely colonized by mobile fauna, the anchorages, however, more densely. The faunal assemblages from the shipwrecks and the foundations, respectively, as well as from the soft bottoms clearly differed from each other. We predict that new wind-power foundations will support the spread of hard bottom fauna into soft bottom areas with low wreck densities.

1. Introduction

The offshore wind energy industry is expanding towards the northern European shelf seas. Where the seafloor in the respective areas is dominated by soft bottoms, i.e. sandy and muddy grounds, all offshore wind-power foundations provide artificial hard substratum habitats which will potentially become colonized by an assemblage of epi- and mobile megafauna, clearly differing from the otherwise prevailing species composition and abundance (Wilhelmsson et al., 2006; Wilhelmsson and Malm, 2008; Langhamer et al., 2009; Lindeboom et al., 2011; Reubens et al., 2011; Degraer et al., 2012; Krone et al., 2013). In the North Sea, which is dominated by sandy bottoms, there have been applications for the deployment of 6071 foundations (Schleicher, 2012).

It can be assumed that local stocks of hard bottom settlers, so far limited by the low presence of their preferred habitats in the open North Sea, will increase in the future (Wilson and Elliott, 2009). This will lead to a change in the epibenthos and the mobile demersal megafauna (MDM)-communities in the North Sea for which to date the dimensions and effects on the autochthone fauna are very difficult to assess.

Together with the macrozoo–epibenthos settling on artificial constructions (fouling), which can be viewed as the central trigger of reef effects (Lindeboom et al., 2011; Krone, 2012), the MDM is an important functional group including numerous predators that potentially control the epibenthos (Freire and González-Gurriarán, 1995; Relini et al., 2002; Baum and Worm, 2009; McCauley et al., 2010). Some typical MDM hard bottom species, for example the

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edible crab *Cancer pagurus* and the European lobster *Homarus gammarus* are even of commercial importance.

The change in the faunal composition, however, will take place in a marine area which already has undergone anthropogenic structural changes: decades before the establishment of any wind-power foundations thousands of shipwrecks in wide areas of the North Sea and some oil and gas-rigs in the central North Sea have provided substantial amounts of artificial hard substrata habitats on the seafloor (Kingsbury, 1981; Leewis et al., 2000; Zintzen et al., 2008b; Krone and Schröder, 2011). Numerous studies from different areas globally have shown that wrecks and offshore platforms are permanently colonized by typical hard bottom faunal communities and are frequented by such species foraging on such fouling (Wolfson et al., 1979; Stephan and Lindquist, 1989; Page et al., 1999; Jørgensen et al., 2002; Løkkeborg et al., 2002; Arena et al., 2007).

In order to assess the relevance of the constructional development of wind-power foundations in a shelf sea such as the North Sea for the MDM, it is also necessary to quantify faunal communities already established on the numerous older shipwrecks and to compare those to the autochthon communities from the prevailing seabeds. Most studies in the North Sea in which the biota on artificial structures have systematically been quantified, however, focused on biofouling communities (Forteath et al., 1982; Whomersley and Picken, 2003; Zintzen et al., 2006; Joschko et al., 2008; Wilhelmsson and Malm, 2008; Zintzen et al., 2008a; Hiscock et al., 2010; Zintzen and Massin, 2010; Krone et al., 2013) or selected megafauna species (Reubens et al., 2011). To date, there are only semi-quantitative records of mobile crustaceans and fish species often abounding at shipwrecks and wind-power foundations in the North Sea (Hiscock, 1980; Leewis et al., 2000; Massin et al., 2002; Bouma and Lengkeek, 2012).

To our knowledge, there are no previous systematic quantitative recordings, allowing for comparisons between fauna from soft bottoms, shipwrecks, and offshore foundations in the same area and thereby assessing the relevance of the plentiful introductions of wind-power foundations in a shelf sea such as the North Sea for the MDM stocks. It is as yet unknown whether offshore wind-power foundations will simply add to the existing pool of wrecks or whether they will represent a new artificial habitat to the benthic system. Wind-power constructions differ from wrecks in that they reach through the entire water column while wrecks usually extend only a few metres above the seafloor. Previous studies have shown that water depth, gradients in light intensity and wave force are important structuring factors for epifaunal assemblages on natural and artificial hard substrata (Castric and Chasse, 1991; Whomersley and Picken, 2003). Particularly in deeper offshore waters, wind-power foundations will therefore provide a more heterogeneous habitat with regard to water depth and light intensity distribution than wrecks and might be inhabited by a qualitatively and quantitatively different biota (Krone et al., 2013).

In the German Exclusive Economic Zone (EEZ, comprising the German Bight) a total of about 5000 single wind turbines are planned for construction within the next two decades (IEA, 2008; Krone, 2012; RAVE, 2013). The wind farms in the German Bight will provide numerous artificial hard substratum in areas which are naturally dominated by soft bottoms where the island of Helgoland and few glacial bolder reefs provide the only natural subtidal hard bottom habitats (Figge, 1981). More than 1000 wrecks have been registered in coastal and offshore waters of the German EEZ (Krone and Schröder, 2011). In the southern German Bight the research platform FINO 1 was erected in 2003 on a so-called jacket foundation which is very similar to the constructions of offshore wind-power foundations. The platform is situated in an area where the water depth allows for assessing quantitative MDM-abundances via scuba diving. At the same time, detailed wreck reports allow for secure diving on site for investigations of the respective wrecks in the same area.

The present study, conducted within the soft area of future wind farms in close vicinity to the research platform FINO 1 and at several shipwrecks at a maximum water depth of 33.5 m in the southern German Bight, addressed the following questions: (1) What are the abundances and population structures of the MDM communities on a submerged foundation equivalent to a wind-power foundation, on shipwrecks and autochthonous soft substrata? (2) Are there qualitative and quantitative differences in the MDM communities between the wrecks and the foundation? (3) For which and for how many species of the MDM in the North Sea will the construction and deployment of wind-power foundations provide new habitats and hence increase a so far habitat-limited carrying capacity?

2. Materials and methods

We catalogued the MDM ($\geq$1 cm) on the submerged construction of the offshore research platform FINO 1, five wrecks and the open soft bottom (also referred to as soft substrata) in the German Bight (southern North Sea). FINO 1 was built to measure biological and physical parameters relevant for the operation of offshore wind farms. The underwater construction of the platform is similar in size and shape to the common jacket type foundations of wind turbines in the German Bight. It is, therefore, considered a wind-power foundation equivalent which allows for drawing direct conclusions on the implications of the underwater constructions of offshore wind-power constructions on marine biota.

2.1. Study sites

From summer 2007 to spring 2009 visual censuses were performed on the MDM on four shipwrecks and a sunken floating dock, the underwater construction of the offshore research platform FINO 1, and on soft bottom (Fig. 1, Table 1). The four-legged steel underwater construction of FINO 1 rests on the seafloor and is anchored by four pylons driven through sleeves (anchorages) in each corner of the foundation (for details compare Joschko et al., 2008; Krone et al., 2013). The soft bottom MDM was surveyed at 21 reference positions scattered around the wrecks and the platform. Furthermore, 366 beam trawl catches distributed over the German Bight were used to gain approximate information on MDM stocks of the entire German EEZ.

2.2. Diving censuses

To quantify the MDM on the wrecks and FINO 1 visual censuses were conducted by airline-supported scientific diving around slack water. It was not possible to conduct the recordings on the wrecks, the soft bottom and the research platform all at the same time in each year and season. Despite this, we were able to sample records from all sites within the time frame of three years (Table 1).

On each wreck the MDM was recorded in total by three to four $15 \times 1 \times 1$ m transects (Table 2). Transect length was controlled by a 15 m transect line. Transect widths and heights were controlled by a 1 m-spacer clipped to the line reel. The transects stretched linearly above the wreck in random directions from where the diver first hit the wreck, thereby ignoring minor three dimensional structures of the wreck surface. The diver stopped every marked metre along the transect to search the cubic metre ahead for fishes and mobile decapod crustaceans (Wilhelmsson et al., 2006). If a transect extended beyond the wreck area, the diver changed direction at the edge of the wreck to complete the transect within the wreck area (Fig. 2A). Small interspersed patches (approx. 0.25–2.25 m^2) of sediment among wreck fragments were not excluded