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Role of benthic habitat distribution data in coastal water wind turbine site selection

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ABSTRACT

Environmentally concerned coastal zone management and marine spatial planning should minimize the risk of damaging sensitive benthic habitats. Since reliable maps of the underwater nature are scarce, planners often have to work with inconsistent data. We compare the outcomes of three hypothetical planning schemes with dissimilar input benthic ecology datasets in order to define suitable sites for shallow water wind turbine placement. The study is conducted in the northern Baltic Sea where the brown algae bladderwrack (*Fucus* spp.) forms important submerged habitats that can be disturbed by wind turbine construction. We evaluated the effects of the input data using two different approaches. In the first, we placed a maximum number of wind turbines at four different depth classes. After choosing the locations, we examined the potential area of affected *Fucus* habitats. In the second approach, we tested the accumulation of damage to *Fucus* habitats when adding new turbines to the research area by starting from the furthest available location of known important *Fucus* sites. Both approaches indicated that using data from airborne LIDAR helps coastal planners avoid the risk of unnecessary destruction of benthic key habitats. LIDAR surveys can help to optimize the locations for the detailed planning of vast areas in a way that point-based inventories or statistical predictive modeling cannot achieve.

1. Introduction

Environmentally concerned coastal development requires reliable information about the features, values and distributions of different shore habitats. Planning regulations often demand Environmental Impact Assessment surveys (EIA) to be conducted for new development projects. Finding reliable data to support spatial planning and EIA may be difficult since both the characteristics and distributions of ecologically significant submerged habitats, such as hard bottoms dominated by perennial algae or mussels are usually poorly documented. Specific subaquatic habitats can, for example, be important feeding or reproduction areas for marine life (Jackson et al., 2001; Kääriä et al., 1997), for which they should be given particular attention. The goal should be to optimize shore development in a way that enables societal aspirations with minimum damage to the most valued aspects of nature. This creates a necessity to distinguish between the areas of the highest conservation priority from those with lower significance. While a number of ecological considerations and value settings may occur, this demand also calls for reliable spatial data that can be used to describe and map the benthic nature (Barret et al., 2001; Jordan et al., 2005; Tammi and Kalliola, 2014).

Reliable data describing the underwater habitats are often scarce due to laborious and expensive field work. Although point data concerning biological values may be available from selected locations, the usefulness of such information in planning is limited if the areas in between remain undocumented. Decisions based on spatially inconsistent data may lead to undesirable situations, such as granting environmental permission to an activity that disturbs the seafloor in biologically sensitive locations. In order to avoid causing unnecessary environmental pressure, such deficiencies of spatial data should be minimized. One way is to use complementary data describing the abiotic environment, such as bathymetry, seafloor substrate or benthic illumination conditions to help identify the most likely locations for important habitats (Tolvanen and Kalliola, 2008). Additional information can also be gathered by the means of remote sensing, including aerial photographs (Barret et al., 2001; Ekebom and Erkkilä, 2003), satellite imagery

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(Mumby and Edwards, 2002; Phinn et al., 2008), multibeam sonar (Brown and Blondel, 2009), underwater video (Rinne et al., 2014) and SCUBA diving (Vahteri et al., 2000). In shallow waters, airborne bathymetric LIDAR (Light Detection and Ranging) is also a promising alternative, producing consistent data describing the benthic topography and habitats (Chust et al., 2010; Wang et al., 2007).

This paper examines how data from field inventories and LIDAR can contribute to coastal planning in a situation where human activities may threaten a benthic key habitat type. The development pressure to address in this article concerns a shallow water wind turbine construction in the northern Baltic Sea, where stands of the brown algae bladderwrack (*Fucus* spp.) provide shelter and food for many coastal species (Kautsky et al., 1992; Kraufvelin and Salovius, 2004). Our specific research question is whether the use of data from field inventories and LIDAR improves the possibilities to find suitable places for possible wind turbine locations and at the same time, to help avoid environmental damage.

2. Materials and methods

2.1. Study area

The Baltic Sea is the world's second largest brackish water basin. It borders on nine countries and has a population of around 85 million people within its drainage area. Human activities are intensive throughout the regions' coastal zone (HELCOM, 2010). Our study area is the Rönnskären archipelago in the northern part of the Baltic Sea in the Gulf of Bothnia, approximately 40 km from the city of Vaasa (Fig. 1). In this region, the coast is characterized by a complex shoreline, shallow waters (mainly less than 50 m in depth) and a multitude of islands of varying sizes. Coastal lagoons and shallow areas characterized by rocks and boulders harbor the highest biodiversity in the area. The benthic vegetation varies from extensive stands of *Fucus*-dominated areas in mainly wave exposed sites to muddy seabed with vascular plants in sheltered areas. *Fucus* is abundant in the Gulf of Bothnia and one of the most notable species in the area. Although benthic vegetation occurs down to a maximum depth of 10–12 m, the vegetative biomass generally declines at around 6–7 m. The annual Secchi depth in the study area varies from 3 to 6 m.

The exact delineation of the study area was determined by LIDAR data availability, comprising two separate, somewhat parallel blocks close to each other with a combined area of about 42 km^2. These areas constitute parts of a HELCOM (Helsinki Commission) Baltic Sea Protected Area, a Ramsar site and a Natura 2000 network. Parts of the study area also belong to the Kvarken Archipelago World Heritage site (http://www.kvarkenworldheritage.fi/visit-kvarken/). Both the geology (Breilin et al., 2005) and the benthic habitats of the study area are well inventoried, the latter by the Finnish Inventory Program for the Underwater Marine Environment (VELMU program, see Downie et al., 2013; Rinne et al., 2011). Good data availability makes this study area particularly suitable for the present work, where wind power construction is addressed as a theoretical case which may interfere with sensitive benthic nature.

There are some large-scale plans for offshore wind power development ongoing near the areas covered by this study. For this reason, reliable environmental data and knowledge is needed. However, the research area in itself cannot be used for wind turbine construction because of its protection status.

2.2. Data sources

For bathymetry, we applied both a conventionally used robust model, called ‘bathymetry-C’ (based on interpolated sea chart data with a pixel size of 20 × 20 m), as well as a LIDAR-enhanced model,

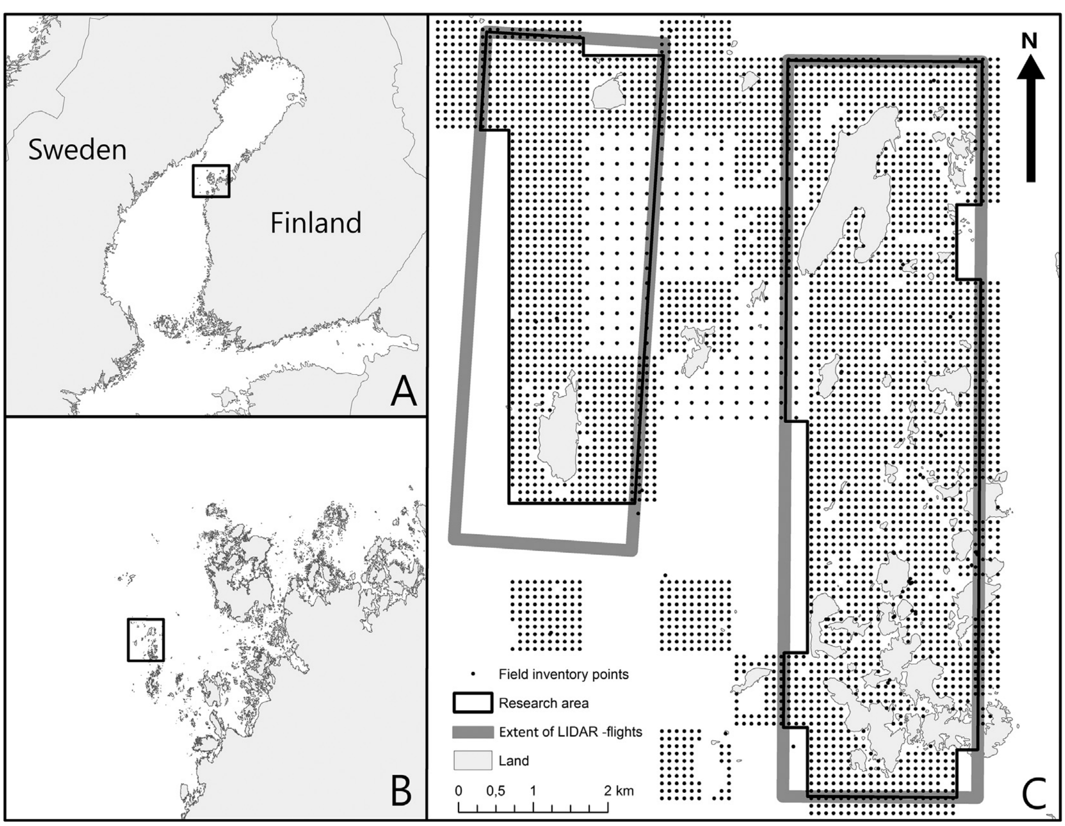

Fig. 1. A. and B. Location and of the study area. C. Coverage of the LIDAR data (areas bordered by grey outline) and underwater inventory points (black dots), and delineation of the research area in this paper (black outline).