



A multi-criteria evaluation system for marine litter pollution based on statistical analyses of OSPAR beach litter monitoring time series



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ABSTRACT

During the last decades, marine pollution with anthropogenic litter has become a worldwide major environmental concern. Standardized monitoring of litter since 2001 on 78 beaches selected within the framework of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) has been used to identify temporal trends of marine litter. Based on statistical analyses of this dataset a two-part multi-criteria evaluation system for beach litter pollution of the North-East Atlantic and the North Sea is proposed. Canonical correlation analyses, linear regression analyses, and non-parametric analyses of variance were used to identify different temporal trends. A classification of beaches was derived from cluster analyses and served to define different states of beach quality according to abundances of 17 input variables. The evaluation system is easily applicable and relies on the above-mentioned classification and on significant temporal trends implied by significant rank correlations.

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1. Introduction

During the last decades, marine pollution with anthropogenic litter has become a major environmental concern worldwide. Numerous studies carried out in pelagic and littoral waters, as well as on beaches have focused on temporal and spatial trends of anthropogenic marine litter, especially on that made of plastic (Browne et al., 2010; Galgani et al., 2000; Howell et al., 2012; Ribic et al., 2010). Marine litter has adverse impacts on marine animals through entanglement of mammals, reptiles, sea birds, fish and other animals in discarded and lost fishing gear and other plastic litter items (Bullimore et al., 2001; Fowler, 1987; Gregory, 2009; Matsuoka et al., 2005; Pichel et al., 2012; Votier et al., 2011) as well as through ingestion, especially of micro- and mesoplastics (Browne et al., 2008; van Franeker et al., 2011). However, there is still no clear evidence for effects of marine litter at population level (Votier et al., 2011). Because of their durability and associated long

lifespan, floating debris can also act as a vector for invasive species (Barnes and Fraser, 2003; Barnes and Milner, 2005; Majer et al., 2012). Williams et al. (2005) give an overview of numerous case studies on marine litter highlighting the importance of its quantification, to identify its sources, and to evaluate its environmental effects.

Empirical and model studies on spatial and temporal distributions of marine litter cover a range of marine environments from tropical waters (Dameron et al., 2007; Martinez et al., 2009) to the Arctic regions (Day and Shaw, 1987; Zarfl and Matthies, 2010), however, only a few publications deal with the North-East Atlantic and the North Sea (Barnes and Milner, 2005; Dixon and Dixon, 1983; Thiel et al., 2011; Vauk and Schrey, 1987), two regions subject to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR convention) (OSPAR, 1992).

According to the Marine Strategy Framework Directive (MSFD) of the EU (EU, 2008, 2010), monitoring programs of marine litter shall monitor the success of measures implemented to combat the pollution of European coastal areas. Examination of existing monitoring data of marine compartments, such as OSPAR beach litter monitoring data, is a prerequisite to define the good environmental status (GES) of marine waters and to identify indicators for the achievement of GES. Therefore, spatial and temporal trends in OSPAR beach litter data shall be detected and can be used to link the observed results to sources of marine litter.

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Fig. 1. Map of Western and Central Europe with positions of beaches subject to the OSPAR beach litter monitoring program (taken from OSPAR, 2007). Abbreviations in the map are OSPAR beach IDs.

Within the framework of the OSPAR convention, a standardized monitoring of beach litter has been carried out since 2001 on 78 beaches of the North-East Atlantic and the North Sea (OSPAR, 2010). 1000 m and 100 m-long sections of beach were selected based on criteria, such as sediment composition, accessibility, beach cleaning programs, and other characteristics. Standard surveys of 112 litter categories were carried out in spring, summer, autumn, and winter. In addition, several non-profit environmental and scientific organizations have performed long-term monitoring on beaches since the 1980s, however, these surveys use different litter item categories to the OSPAR beach monitoring program and have a different spatial and temporal resolution.

Therefore, the dataset of OSPAR beach litter monitoring was used to identify temporal trends of marine litter on beaches. In a next

step, a beach classification system was derived based on the results of univariate and multivariate analyses of the above-mentioned OSPAR data. The application of the evaluation system to other European marine waters, such as the Baltic Sea and the Mediterranean, is desirable. For ease of usage, the evaluation system is simple and robust, and does not demand statistical expert knowledge.

In summary, the goals of this study were:

- to find out if the OSPAR data can be used to assess trends in litter pollution on beaches in the OSPAR region and sub-regions,
- to propose a method of assessing trends,
- to propose a method of presenting the results so that they are easily understandable,

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