

Statistical analyses of OSPAR beach litter monitoring time series

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Introduction

During the last decades, marine pollution with anthropogenic litter has become a major environmental concern worldwide. The European Marine Strategy Framework Directive (MSFD) promotes the attainment of the Good Environmental Status (GES) of European marine waters, which include regions subject to the OSPAR convention, by 2020. Amongst others, scientific works shall target at classifying water bodies of the EU according to different qualitative descriptors, which subsequently shall be evaluated using appropriate criteria. Concerning the pollution with marine litter, properties and quantities of marine litter should cause no harm to the coastal and marine environment. Examination of existing monitoring data of different compartments of the marine environment, such as OSPAR beach litter monitoring data, is a prerequisite to define the GES of marine waters and to identify indicators for the achievement of GES. Therefore, we used the database of OSPAR beach litter monitoring to identify spatial distribution patterns and temporal trends of marine litter on beaches.

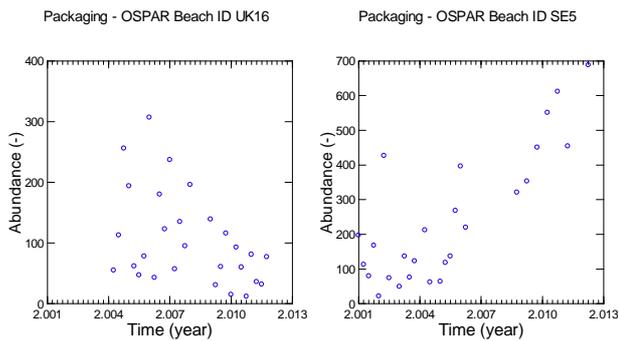


Figure 1: Exemplary scatter plots of input variables against time

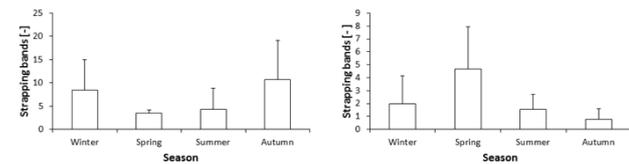


Figure 2: Typical seasonal trends of input variables in the North-East Atlantic (left) and the North Sea (right).

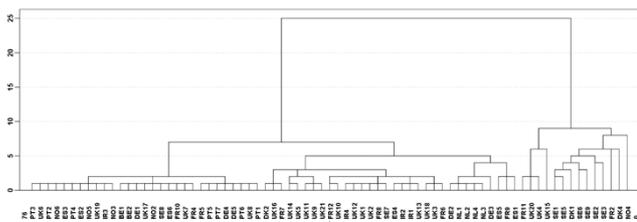


Figure 3: Exemplary Dendrogram of beaches based on the input variable 'packaging material'. The x-axis gives variance within groups standardized to a scale from zero to 25.

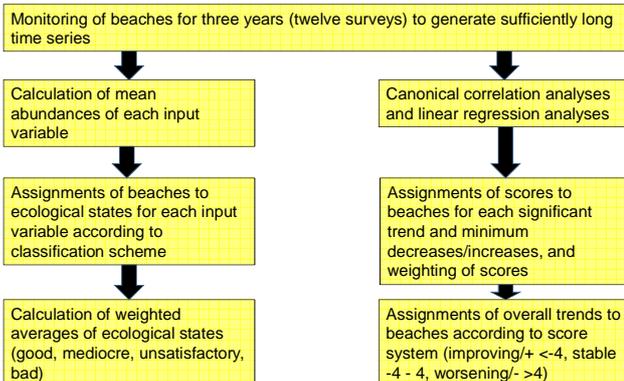


Figure 4: Schematic of the proposed evaluation system.

Materials and Methods

Data from regular OSPAR surveys of beach litter pollution on standard sections of beach on the NE-Atlantic coast since 2001 were used.

Seventeen input variables were selected, because they occurred sufficiently abundantly, displayed obvious temporal trends, were regionally differentiating, and represented risk potential for animals.

- 1) Rank correlation analyses between time and abundance of marine litter,
- 2) Linear regression analyses between time and abundance of marine litter,
- 3) Non-parametrical analyses of variance and post-hoc tests to identify significant seasonal trends,
- 4) Cluster analyses (Ward method) for clustering beaches,
- 5) Classification of beaches based on results of cluster analyses.

Results

1) Results of rank correlation analyses, indicative of temporal trends, were spatially heterogeneous. Negative correlations corresponding, when trends were significant, to decreasing trends were found mainly on German and Danish OSPAR beaches. Other regions, such as Dutch and several Spanish and Swedish beaches mainly revealed positive correlations, corresponding, when correlations were significant, to increasing trends.

2) Thirty-five of 47 linear regression models between input variables and time were significant with $p < 0.05$. Nearly all significant regression models gave substantial linear increases or decreases of more than 20% of the start value (Figure 1).

3) Seasonal differences within time series of selected input variables were partly significant with $p < 0.05$. Spatial distribution of significant seasonal differences was heterogeneous. Results of Games-Howell post-hoc tests indicated two water bodies with different significant seasonal pattern. These two seasonal patterns were independent from input variables and could be assigned to a) the North-East Atlantic and b) the North Sea. The typical North-East Atlantic pattern peaked in autumn and winter, while the typical North Sea pattern had its maximum in spring (Figure 2).

4) Dendrograms resulting from cluster analyses showed grouping in three major clusters, as was intended by the applied procedures (Figure 3).

5) Subsequently, these three clusters of each cluster analysis were assigned to the three classes of environmental status 'mediocre = 2', 'unsatisfactory = 3', and 'bad = 4', while GES was defined as 10%-percentile of the mediocre status (Table 1). Based on beach classification and significant rank correlations, we propose a multicriteria two-part evaluation system (Figure 4).

Table 1: Classification of beaches based on results of cluster analyses.

OSPAR ID/ Sum variable	good	mediocre	unsatisfactory	bad	Remark
Plastic drink bottles (Drinks)	< 2	2 - 20	21 - 34	> 34	
Caps/lids	< 7	7 - 65	66 - 156	> 156	
Crisp/sweet packets and lolly sticks	< 2	2 - 16	17 - 61	> 61	
Tangled nets/cord	< 1	1 - 6	7 - 12	> 12	
Fishing line (angling)	< 1	1 - 10	11 - 32	> 32	manually adapted limits
Strapping bands	< 1	1 - 11	12 - 25	> 25	manually adapted limits
Shotgun cartridges	< 1	1 - 6	7 - 17	> 17	
Balloons	< 1	1 - 8	9 - 18	> 18	manually adapted limits
Cotton bud sticks	< 3	3 - 26	27 - 56	> 56	
Rope/cord/nets < 50 cm	< 6	6 - 59	60 - 121	> 121	manually adapted limits
Rope/cord/nets > 50 cm	< 2	2 - 16	17 - 34	> 34	
Cartons/Tetrapacks	< 1	1 - 4	5 - 10	> 10	manually adapted limits
Fishing	< 13	13 - 119	120 - 385	> 385	
Shipping	< 3	3 - 22	23 - 88	> 88	
Tourism	< 6	6 - 55	56 - 164	> 164	
Packaging	< 14	14 - 143	144 - 336	> 336	
Plastic/ Polystyrene	< 50	50 - 502	503 - 1533	> 1533	

The study was funded by the German Federal Environmental Agency (UBA), FKZ 3710 25 206.

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