Compilation and assessment of selected anthropogenic pressures in the context of the Marine Strategy Framework Directive Descriptor 10 - marine litter

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Introduction

In the last decades, marine litter has become ubiquitous and 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, as well as through ingestion, especially of micro- and mesoplastics, by vertebrates and invertebrates (Figure 1). As part of a project embedded in the implementation of the Marine Strategy Framework Directive (MSFD), we were commissioned to analyze data from monitoring of marine litter, including microplastics, on beaches and in other compartments of the marine environment. Spatial and temporal trends should be identified, and results should be used to classify European marine waters according to their level of pollution with marine litter. Prior to evaluation, indicators of the Good Environmental Status (GES) should be defined, such as the existing OSPAR-EcoQO on the amount of plastic in the stomachs of northern fulmars. Finally for all marine compartments, recommendations for future monitoring of marine litter have to be given.

Figure 1: Marine litter on the beach of Juist (NorthSea)

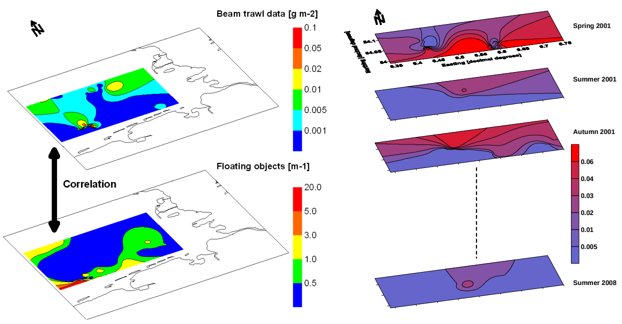

Figure 2: Results of geostatistical analyses: Interpolated data from beam trawl surveys and ship surveys of floating litter (left), and time series of beam trawl data (right).

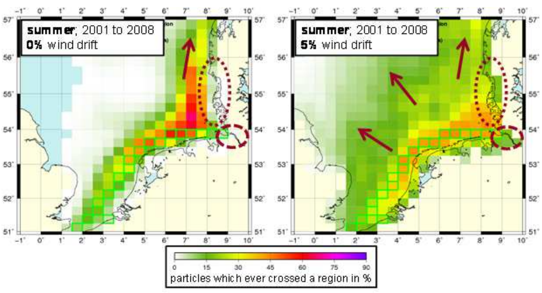

Figure 3: Results of Lagrangian transport modeling with PELETS-2D: Influence of winddrift on on simulated particle/item transport.

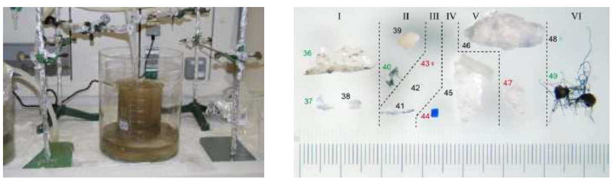

Figure 4: Preparation of microplastic samples in laboratory (left), and microplastic particles (right).

Methods

1) Statistical analyses of
   a) beach litter monitoring data, collected within the OSPAR beach litter monitoring since 2001,
   b) data from bottom trawl surveys,
   c) data on floating litter observed from ship,
2) Lagrangian transport modeling of drift trajectories of floating litter,
3) Compilation and evaluation of methods for detecting and characterization of microplastic particles and their adverse effects on marine organisms,
4) Continuation of the national OSPAR Fulmar-Litter-EcoQO program, dissecting stored Fulmars and analyzing the content of their guts,
5) Derivation of evaluation systems of pollution with marine litter for all marine compartments.

Results

1) There was little correlation between temporal trends and compositions of pelagic litter and beach litter. Rank correlations between floating litter and beam trawl data were poor, and areas of high litter density of both datasets did not overlap, perhaps reflecting different sources of litter pollution (Figure 2).
2) Significant seasonal trends in modeled litter abundances and cumulative travel histories hint at periodic seasonal variability of the wind and flow regimes in the North Sea, both of which apparently are major driving forces of the dispersal of floating litter (Figure 3). Results based on simulations of long-range transport suggest that the majority of items affected by wind drift, such as floating plastic bottles, are transported near-shore with a high probability of being washed ashore. Land-based litter in particular affects coastal regions close to its sources. In contrast, sea-based submerged litter not exposed to winds often remains at considerable distance to the coast.
3) The conventional method for separation of micro-plastics (diameter less than 1 mm) from natural material in sand samples uses the principle of buoyancy. According to the density difference of a separation fluid (usually a high density salt solution) and the solid materials, lighter particles float, while heavier ones sink to the bottom (Figure 4). Specific identification of separated particles was done by pyrolysis-GC/MS utilizing the fact that most plastics material form typical pyrolysis products that can be identified by their mass spectra after gas chromatographic separation (fingerprint).
4) Recent data of analyses of dissected fulmars emphasize considerable annual variation in the amount of plastic ingested, in mass of plastic found, and in the proportion of birds exceeding the critical EcoQO level. Incidence of plastic in stomachs of Fulmars is constantly high, ranging from 94 to 100%. Averaged over the recent 5-year period (2007-2011), 62% of 238 German Fulmars examined exceeded the critical value of 0.1 gram of plastic in the stomach.
5) Results of statistical analyses and transport modeling support the development of distinct evaluation systems for different marine compartments. A multi-criteria evaluation system for beach litter has been developed, while additionally it is proposed that the EcoQ0 on litter in fulmar stomachs should be used as an MSRL indicator for Marine Litter.

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