Tutorial: Litter modelling & risk analysis

The tutorial is now available on the SEAwise website, while the code is public and temporary freely available at the COISPA GitHub (https://github.com/COISPA/Litter_SEAwise_quarto).

SEAwise developed a methodology under Task 4.5 to estimate the trends and mapping marine macrolitter on the seafloor, using data from scientific surveys at sea around Europe (Spedicato et al., 2023). Modelling was based on Generalised Additive Models (GAMs) (Wood, 2017). These analyses also represent the basis for the evaluation of risk of entanglement that fisheries related litter poses to key species (Rindorf et al., 2025). The GitHub repository includes main files coded in R language to perform di analysis from the data preparation to the risk assessment analysis:

1) 00_data_preparation.r;
2) 01_Litter_analysis_(GAM_analysis).Rmd
3) 02_Risk_analysis.Rmd.

Data preparation

Data from trawl survey around the European Seas are used, applying the swept area method. The scripts are generalised for any type of survey, provided that data are in the requested format, as in the "templates". The 00_data_preparation.r script allows to merge data of survey stations and litter. Litter categories and sub-categories can be post-classified for distinguishing e.g. fisheries related litter (FR) or litter posing risk of entanglement or ingestion (e.g. ENT, INGSC).

Modelling marine macrolitter on the seafloor

The script 01_Litter_analysis_(GAM_analysis).Rmd, allows to perform the fitting of three candidate models to estimate the spatio-temporal distribution of macro litter and time series trends. All models include a two dimensional Duchon smoother (Duchon, 1977) of longitude and latitude, while the temporal component is represented in three alternative ways: a thin plate spline of the continuous time variable (model 1) that let a smooth function capture gradual non linear trends over time, an additive parametric term that treats the year as a categorical effect capturing mean level differences (model 2), or a linear trend (model 3). Continuous density responses are modelled with a Tweedie distribution (Wood et al., 2016), whereas presence–absence data are handled with a binomial logit. Model performance is summarised by the percentage of deviance explained and by the Akaike Information Criterion (AIC; Akaike, 1974). Once each model has been fitted, the script builds annual indices of abundance by resampling from the multivariate normal distribution of the model coefficients, which provide confidence intervals for the trend. Spatial maps of litter distribution are based on the GAM results, averaging the last three-years distribution maps, though any time interval can be set by the user.

Risk analysis linked to fishery-related litter

The spatial distribution of the FR litter is used as a proxy for hazard risk of entanglement, representing the magnitude of potential pressures on key species and habitat, while the overlap of FR litter and the distribution of the species is used as a proxy of exposure. The assessment of the risk linked to the FR litter is based on the assumption that the proportion of lost gears or lost elements of the fishing gears is proportional to the effort in the study area. Risk classification integrates hazard levels with multispecies abundance to assess overall exposure risk. Finally, this is combined with fleet-specific impact, classified according to the possibility to be lost during fishing activities on the basis of literature evidences (02_Risk_analysis.Rmd).