Spatio-temporal variation in contribution of biodiversity and environment to benthic ecosystem functioning in the Scheldt estuary

Mestdagh Sebastiaan[1], Fang Xiaoyu[1], Ysebaert Tom[2], Moens Tom[2] and Van Colen Carl[2]

[1] Marine Biology Research Group, Biology Department, Ghent University, Krijgslaan 281-S8, 9000 Gent, Belgium
E-mail: sebastiaan.mestdagh@ugent.be
[2] Department of Estuarine and Delta Systems, NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, P.O. Box 140, 4400 AC Yerseke, The Netherlands

Biodiversity in coastal ecosystems is currently dealing with great pressure caused by human presence. The importance of coasts and estuaries for economical, ecological or recreational purposes has inspired research focusing on the relationships between biodiversity and ecosystem functioning. These relationships and their spatio-temporal variation are important topics of investigation. In the estuary of the Scheldt (Belgium, the Netherlands), we performed an experiment based on a sampling campaign, during which we collected sediment cores for laboratory analysis. Sediment communities were collected in each of the three major salinity zones and ecotopes in summer, autumn, winter and spring. In subsequent laboratory incubations, abiotic properties, biodiversity measures and the biotic processes bioturbation (measured and potential) and bio-irrigation were measured. As functional variables, we determined biogeochemical fluxes of oxygen and nutrients between the sediment and the water column. All variables were tested for their spatial (salinity and ecotope) and temporal variation, and variance partitioning was performed to assess the relative contribution of biotic and abiotic variables to the total variation in ecosystem multifunctionality. Results show a decrease in species richness with decreasing salinity, but consistent high macrofaunal densities and bioturbation potential in low-dynamic intertidal habitats along the estuary. Bio-irrigation was highest on high-dynamic intertidal sites and during winter. Furthermore, oxygen fluxes dropped to lowest average values in winter for low-dynamic intertidal and in summer for high-dynamic intertidal ecotopes. The fluxes of nutrients in most ecotopes tend to change from efflux in summer to influx in winter. Redundancy analysis, performed on the total data set, revealed that the multivariate variation in benthic fluxes can be best predicted by species richness. Biotic variables generally contributed more to benthic ecosystem functioning than abiotic variables, except in December and for the subtidal ecotope where both biotic and abiotic contributions, and hence overall model performance, were low (< 14 % explained). Between 40 % and 67 % of the total multivariate benthic flux variation was explained by biotic and abiotic variables in all other models. Species richness and temperature were selected as significant predictors for benthic ecosystem functioning in both intertidal ecotopes, with additional contributions of macrofauna biomass, bio-irrigation, bioturbation and salinity in high-dynamic intertidal ecotopes, and total macrofauna densities in low-dynamic intertidal ecotopes. Our results show that benthic ecosystem functioning is greatly dependent on biodiversity (including macrofauna-mediated ecosystem processes) and the abiotic environment, but their relative contribution appears to vary seasonally and among ecotopes.

Keywords: biodiversity; ecosystem functioning; macrobenthos; bioturbation; biogeochemical fluxes; Scheldt estuary