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Transport by Benthic Macrofauna: Functional Classification and Biogeochemical Response

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Fakultetsopponent: Assoc. Prof. Gary Banta, The Department of Environmental, Social and Spatial Change, RUC Roskilde University, Denmark

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Abstract

Burrowing and reworking activities by benthic macrofauna regulate rates and pathways during organic matter mineralisation in bioturbated sediments. In so doing, they also affect the overall cycling of elements crucial in the biosphere (e.g. C, N, P, Fe, Mn and S). Feeding, burrowing, respiratory ventilation and construction activities by benthic fauna alter sediment structures, creating a mosaic of microenvironments within the sedimentary deposit. By regulating input of organic material to the sediment and the vertical distribution of solids and solutes within the sediment they influence sediment-water exchange of gases and solutes such as carbon dioxide, oxygen and nutrients. While the existence of a relationship between faunal activity and biogeochemical responses is clearly established, the mechanisms behind this influence are not well constrained. In order to understand sediment response to changes, natural or anthropogenic, the role of benthic macrofauna for physical, chemical and biological processes need to be clarified. Because of the different behaviour of faunal species in sediments, observed effects of benthic macrofauna on biogeochemical variables are not necessarily directly and straight-forwardly coupled to the biomass of fauna. In fact, biomass has proven to be a relatively poor proxy for bioturbation throughout experiments presented in this thesis. Moreover, the relation may be non-linear and vary significantly between species and functional behavior of fauna.

This thesis is based on results from several experiments designed to quantify the impact of bioturbation by individual species for element cycling in surface sediments, with focus on the small-scale transport mechanisms in bioturbated sediments. The functional behaviour of fauna and feedbacks between macrofauna reworking activities and chemical signals in sulphidic environments was studied by introducing two species (the brittle star *Amphiura filiformis* and the polychaete *Nephtys incisa*) to severely reducing sediments from beneath a mussel farm. The biogeochemical response to the different modes of reworking was significantly different between the two species. *Amphiura filiformis* generally enhanced bioadvective solute transport, while *Nephtys* sp. restricted the oxic zone and reduced benthic fluxes of nitrate and silicate.

Fauna in shallow sediments experience a daily light- and dark cycle. The diurnal light regime was experimentally demonstrated to significantly affect reworking activities by the polychaete *Hediste diversicolor*. An increased activity was observed for specimens of *H. diversicolor* that were exposed to a natural light cycle in comparison to those in constant darkness, probably related to a decrease in surface feeding. A light-dependent diurnal reworking behaviour has ramifications for the daily transformation of elements in shallow illuminated sediment systems.

An important result from this thesis is that activities by macrofauna in sediments and their significance for different biogeochemical processes, are too complex to be explained by only one or two bioturbation proxies. Assessments by multivariate analysis indicated that a general and repeatable comparison and classification associated with modes of bioturbation can be readily achieved by evaluating multiple experimental proxies for bioturbation. Similar functional groups were found by multivariate analysis on particle reworking by imaging or multiple transport processes in cores, i.e. independent evaluation techniques for transport.

Keywords: Marine sediments | Early diagenesis | Bioturbation | Functional groups | Benthic fluxes | Imaging | Ecosystem function | Sediment reworking | Transport proxies | Fluorescent particles

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