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Biogeosciences Discussions

Interactive comment on "Biological and biogeochemical methods for estimating bio-irrigation: a case study in the Oosterschelde estuary" *by* Emil De Borger et al.

Anonymous Referee #1

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In this study, De Borger et al. investigate the irrigation activity of macrofaunal communities inhabiting estuarine mudflats of the Oosterschelde. Beyond the seasonal quantification of bioirrigation processes and the comparison of subtidal and intertidal ecosystems, the authors evaluate/validate the capacity of the community irrigation potential (IPc) developed by Wrede et al. 2018 to estimate both bioirrigation depth and rate based on biological traits. In light of their results, they conclude that the IPc give acceptable predictions of the bioirrigation depth but not bioirrigation rate. I found this paper a credible and interesting contribution with, nevertheless, a real uncertainty concerning the methodology used to quantify bioirrigation rates. Overall, the text is well written and informative and the conclusion drawn from the study is consistent with the

intention of the paper.

General comments: - My major concern deals with the use of uranine as dissolved tracer to quantify bioirrigation rates. Indeed, it is well known that uranine easily adsorbs to organic material so that bioirrigation rates can be severely overestimated if this process is not accurately quantified. To this end, the authors performed batch experiments to estimate the adsorption of uranine to the mud (i.e. sedimentary organic matter) but, if I understand well, they did not take into account the capacity of suspension-feeding bivalves to decrease uranine concentration in the overlying water through their filtration activity. I know from my own experience that bivalves such as Cerastoderma edule, Scrobicularia plana, Mytilus edulis or the filter-feeding gasteropod Crepidula fornicata are able to rapidly trap a large amount of uranine in their mantle cavity (on the gill surfaces). Given that these species were very abundant in some sampling stations (see Table 3), what is the level of accuracy of bioirrigation rates measured in the corresponding experimental cores?

- The comparison between experimentally measured bioirrigation rates and traits-based ecological indices should be discussed a little bit further.

Specific comments: - Abstract: Line 11-12: Biological traits do not really allow for the quantification of bioirrigation. This trait-based index (IPc) only give a more or less "rough" prediction of bioirrigation depth and rate. The sentence line 42 seems more correct. Line 16-17: I well understand that irrigation rates can be significantly affected by bioirrigator densities but it is not clear to me how higher densities could impact the bioirrigation depth.

- Introduction: Line 27: How do bioirrigation increase the exchange surface? Line 40: The term "pumping activity" is usually employed to describe the "filtration activity" in suspension-feeding bivalves. May "ventilation activity" be more appropriate? Line 42: Yes but over very different spatial scales.

- Materials and methods Line 74: I am wondering whether the sampling method (i.e.

small sediment cores <20 cm) really allows for the collection all bioirrigators inhabiting intertidal mudflats of the Oosterschelde estuary. It is clear that large and/or deep infaunal species such as burrowing mud shrimp could not be properly captured, thus leading to strong underestimation of bioirrigation rates. Line 80: How long have experimental cores been kept in buffering seawater tanks before the beginning of the experiments? Line 81: What was the average temperature at each studied season? That's a very important factor, which greatly determines the activity level of benthic invertebrates. Line 128-129: Batch adsorption experiments have been performed with sediment cores collected from Zandkreek (%Corg=0.79) and Dortsman (%Corg=0.07). Why not with sediment cores from Viane where the proportion of organic carbon is the highest (potentially the highest adsorption rate).

- Results Bioirrigation rates: The "pumping" rate and the irrigation attenuation coefficient were estimated by fitting a mathematical model to the tracer data. However, I'm wondering if the first part of the experiments (10-20 min) should be considered for the estimation of these parameters as the initial decrease in uranine concentration may mainly result from its rapid adsorption onto surficial organic particles as well as the mixing between overlying and burrow waters (which is not really sediment bioirrigation from my point of view).

- Discussion Line 281: I don't really understand the conclusion stating that the density of bioirrigating species would affect more the bioirrigation depth than the bioirrigation rates. I would have believed the opposite. Indeed, it has been reported that faunal activities (e.g. feeding, burrowing) can be altered by intense intraspecific interactions leading to lower bioturbation rates. Is there any references showing that increasing invertebrate densities result in increasing bioirrigation depths? Line 290-292: Another hypothesis is that high densities of C. fornicata may induce a rapid deposition of fine particles at the sediment-water interface (i.e. biodeposition) thus decreasing the permeability of upper sediment layers. Line 293: Burrows of N. latericeus can extend down to 40 cm, yet experimental chambers were only 20 cm long. Thus, the ventilation

activity of the worms may have been biased due to a constrained (shallow) benthic habitat. Lines 307-309: See comment Line 281. Why organisms of the same species (same stage) would irrigate over different depth ranges at high densities?

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