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Interactive comment on "Thin terrestrial sediment deposits on intertidal sandflats: effects on pore water solutes and juvenile bivalve burial behaviour" *by* A. Hohaia et al.

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We thank this anonymous referee for her/his comments and for the time spent reviewing our manuscript. We have considered all comments and revised our manuscript accordingly.

Referee #2: The main goal of this paper, the assessment of the effect of terrestrial sediment deposits on pore water solute composition and juvenile bivalve burial, is addressed with a set of flume experiments where juvenile bivalves were placed on intertidal sediments (bioturbated or organic matter depleted) covered by a thin layer of terrestrial sediment. The terrestrial sediment increased bivalve burial, irrespectively

of sediment type, but bivalves preferred initially well-oxygenated bioturbated sediment. The topic of this research is timely and relevant as many nearshore zones are exposed to increased sedimentation caused by coastal development and enhanced sediment loads in river waters. This enhanced fine sediment deposition has the potential to affect seabed biogeochemical processes through organic matter input and activities of phototrophs. The authors found the increase of bivalve burial in sediments covered by terrestrial material unexpected and suggest that this may be attributed to the activity of resident macroinfauna or the absence of organic matter. I found it surprising that this result came unexpected for the authors. For a juvenile bivalve, a primary prey for a large spectrum of bottom feeders including shore birds, demersal fish, shrimp, crabs, polychaetes, nemertines and many other predators, staying at the sediment surface is extremely dangerous, and the immediate reaction of such juveniles is to bury into the sediment if at all possible. Burying into sandy sediment covered by a thin unconsolidated layer of sediment allows faster burial, and the origin and quality of this sediment may be of lesser influence as burial means survival.

Hohaia et al.: We used the term "unexpected" with respect to the results of Cummings et al. (2009) who demonstrated reduced burial rates by M. liliana in sediments capped by a thin layer of terrigenous sediment. We agree that burial is an important component of survival and it may dominate the initial response but it is not the only one. Dispersal from unfavourable sites is another mechanism that may aid survival and it is also strongly influenced by behaviour. At flows less that that required to mobilise sediment Lundquist et al. (2004) demonstrated that juvenile M. liliana exhibit behaviours that aid dispersal and include remaining on the sediment surface (or emerging if they initially burry) and the production of byssal threads that increases drag promoting transport. We have modified the abstract and discussion to remove any ambiguity regarding the word "unexpected" and have acknowledged the importance of the initial burial as an important survival mechanism.

Referee #2: Macoma liliana inhabits sand and mud flats with low oxygen penetration into the sediment, and can accesses oxygenated water through a siphon that can be extended through the diffusive boundary layer. Sediment composition therefore should have a lesser influence on burial as long as the boundary layer does not become oxygen depleted. Oxygen could penetrate to some depth in all experimental treatments, revealing that oxygen was not a limiting factor nor toxic sulfide that could develop under anoxic conditions. As long as the sedimentary conditions are suitable, the bivalves will unlikely move out of the sediment unless they get infected by parasites.

Hohaia et al.: We agree with the reviewer that once buried and provided that pore water chemistry does not adversely affect calcification rates (or metabolic costs), the juveniles will mainly depend on the quality of the seawater they draw from the sediment boundary. We note, however, that M. liliana are primarily a surface deposit feeder (Volkenborn et al. 2012) and if the surface layer is devoid of organic matter (e.g., fresh clay) or the sediment surface is otherwise unsuitable for feeding, then the juveniles may choose to emerge from the sediment. We wish to emphasise that our experiment addressed the decision that juveniles make when placed onto the sediment surface, not the decision made when buried, and we will revise our introduction to ensure that this framework has adequately introduced.

Referee #2: The bivalves tested here were at the post-settlement stage, the stage after the pelagic larval stage that selects the sediment for settlement. This pelagic stage would have been a better candidate for testing the effect of the terrestrial sediment deposition as these larvae likely test the sediment before settling and relocate if they find it unsuitable. Settling larvae of benthic invertebrates have been shown to select the best sediment by taste/odor, color, cohesiveness, grain size, angularity, organic coating, microbial film, compaction etc. and thus may have shown distinct reactions to the terrestrial sediment deposition. As the post-settlement larvae cannot effectively relocate, they would not have any benefits from not burying into a sediment unless the boundary layer above this sediment is oxygen depleted and sulfidic.

Hohaia et al.: We agree with the reviewer that the behaviour of settling pelagic larvae

would be useful to study but disagree that post-settlement juvenile behaviour is of little consequence. Dispersal of post-settlement juvenile stages of macrobenthic invertebrates is frequent and widespread in the marine environment (e.g., Beukema & Vlas 1989, Gunther 1992, Commito et al. 1995). Juvenile M. liliana can emerge from the sediment where they can be readily transported by boundary layer flows, a process aided by the production of byssal threads (Sigurdsson et al. 1976, Lundquist et al. 2004, Petuha et al. 2006). In the field, the potential dispersal of M. liliana juveniles on intertidal sandflats has been estimated to be on the order of km per tidal cycle (Petuha et al. 2006), which is similar to the realised dispersal distances of many benthic coastal species with a pelagic larval stage (see Shanks 2009 for a discussion). Given that post-settlement juveniles have survived metamorphosis and recruited to the benthos their contribution to local (within estuary) population connectivity and the regulation and organisation of benthic communities is significant (Dayton et al. 1994, Norkko et al. 2001). In the revised manuscript, we now better describe the broader implications of juvenile behaviour to justify our focus.

Referee #2: If the experiment would be repeated with pre-settlement larvae, it would be critical to use realistic settings for the terrestrial sediment cover. In the natural environments, such settling sediments have been exposed for some time to estuarine waters which rapidly and fundamentally changes the surface characteristics of the mineral grains due organic coatings and the attachment of bacteria. These coatings contain key clues used by settling larvae, thus, an aging of the terrestrial sediment in estuarine water and subsequent detailed characterization of the sediment including organic carbon and nutrient analyses would be required to allow a reliable interpretation of larval settlement behavior.

Hohaia et al.: We agree with the reviewer that the aging process will change the characteristics of the terrestrial sediment and ultimately make it part of the fine silt/clay fraction that comprises intertidal sediments (see Cummings et al. 2009). By using fresh terrestrial deposits we selected for the initial deposition of this material where we anticipated the strongest effect on sediment biogeochemistry and juvenile behaviour. We did this because we were interested in knowing whether juvenile bivalves made behavioural decisions based on the underlying sediment biogeochemistry which may have important consequences for site selection/recruitment. In defence of the experimental treatment we have frequently observed patches (m2 in size) of thin orange clay (denoting fresh deposition of terrestrial origin) immediately following storm events on intertidal sandflats. In experimental field manipulations these patches can persist for at least 1-2 weeks influencing macrofaunal community composition and ecosystem function (benthic primary production and nutrient fluxes; Rodil et al. 2011). As these deposited sediments age not only will the chemical properties change but simultaneously they will be reworked into the upper layers of the underlying sediment altering the sedimentary matrix and these longer term effects would indeed be valuable to study in future experiments.

Referee #2: The results of this study show that the burial of post-settlement larvae is relatively insensitive to terrestrial sediment deposition, and I don't agree with the authors that these results are unexpected. The authors may consider this and rephrasing the interpretation of the results. A follow-up study using pre-settlement larvae likely would show different results provided that the terrestrial sediments are aged in estuarine water before application.

Hohaia et al.: We believe we have addressed this summary of points raised by the reviewer in our responses above.

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