Earth Surf. Dynam. Discuss.,
doi:10.5194/esurf-2016-24-SC1, 2016

Interactive comment on "Long-term coastal openness variation and its impact on sediment grain-size distribution: a case study from the Baltic Sea" *by* Wenxin Ning et al.

W. Ning

Wenxin.Ning@geol.lu.se

Received and published: 31 May 2016

Comments from Evan Goldstein and our replies: 1) I believe this manuscript could benefit with more description as to the mechanics of sediment transport in this specific system to justify the results (Section 3.2). For instance, what drives sand transport in the modern system? Does sand come from the Baltic into the inlet? Or is the sand coming from the terrestrial setting? i.e., as a reader it would be helpful to understand in more detail how this physical system works?

Reply: The catchment of the inlet is characterized with thin soil (<2m) and the inlet has only small rivers draining. Therefore we speculate that sediment composition from the coring site is mostly governed by internal sediment redistribution and terrigenous

input. Sediment transportation from outside the inlet possibly also contributed to the sediment accumulation to a smaller degree. However, the narrow and shallow connection between the inlet and the open Baltic Sea may restrict the sediment transportation. Over the last 1 ka, sand content in the inlet was apparently influenced by catchment disturbance. This is supported by elevated sand content together with increased regional land use intensity during the last 1 ka (Karlsson et al., 2015). Internal distribution also influences grain size. For instance, strong wind or storm events may transport sand from near-shore depth to deeper off-shore areas. During the beginning part of the record around 5.4 ka, relatively high openness has caused an elevated energy environment and relatively high sand contents. The sand content is overall low through the record, linked with the lack of source and low energy status of the inlet.

Karlsson, J., Segerström, U., Berg, A., Mattielli, N., and Bindler, R.: Tracing modern environmental conditions to their roots in early mining, metallurgy, and settlement in Gladhammar, southeast Sweden: Vegetation and pollution history outside the traditional Bergslagen mining region, The Holocene, 25, 944-955, 10.1177/0959683615574586, 2015.

2) Can the authors connect openness index with a near bottom water velocity and sediment transport in some way - i.e., fetch, wind speed, and water depth to calculate wave orbital motions at the bed using the relations presented in Young and Verhagen (1996)? Or perhaps the authors could relate the (spatial) change in openness index to the wind field (modern or ancient) and the fetch?

Reply: Thanks for these interesting ideas. However, there is a lack of reliable reconstructions on historic wind speed and direction in the Baltic Sea region. Thus, calculating the velocity or fetch in the inlet is not possible at this moment. In future, with reliable long-term scale wind speed and water depth data available, linking the openness index, together with transport velocity and wave motion to the sediment transport is of great interest. The spatial change in the openness can be interesting to compare with grain size changes in the inlet. However, due to the lack of grain-size distribution in the inlet, such comparison cannot be achieved so far. We therefore have focused on the coring site, from where we have both the temporal grain size data and variations in the openness.

3) The authors focus on developing an 'openness index' which is the average length of line from the core site to land at a given time/sea level. Why are landward vs. seaward openness indices differentiated? And a related comment, the shifting angle is discussed only briefly. Can the authors give us some guidance on picking a starting position? Do any radial lines, at any time, make it to the open Baltic sea (i.e., do any openness measurements exceed the 8 km line segments used)? Are these lines important? (i would presume so, because these directions would permit larger waves into the system and exert more work on the bed.)

Reply: The seaward openness index is the most important factor that governs the wave energy in the inlet. High wave energy in an open system leads to larger grain size. The landward openness reflects mostly changes in water depth. Lowered water depth would lead to larger grain size in an enclosed system. In the study site, as water depth decreases, the grain size also decreases. This indicates that seaward openness is more important in driving the grain size changes. The maximum 8 km lines were used because they have reached open water region for scenarios covering the last 5.4 ka and were recognized as a reasonable limit. Longer radical lines may result in relative higher values of openness index when the sea is open. For most cases, the radial lines have already intersected with islands at less than 8 km distance from the coring site (see Fig. 4). Therefore, we think the derived pattern of temporal variations in the openness indices should be similar and/or comparable with the current 8 km scenarios. These segments beyond 8 km link are considered to be small portions (see Fig. 4f) even in 5.4 ka scenarios. This will be further clarified in the revised version.

4) The authors present Figure 6 and 7 to show there is variation in the openness index for a given degree interval (or shifting angle) at a given time. Is there a way to make this analysis more quantitative? (i.e., p5, line 9; how much 'larger'?) One suggestion to

illustrate this in the figures is to plot openness variance as opposed to the raw openness index. On a related note, the authors state that they endeavor to find an optimal degree interval (p. 5 line 3). I assume 'optimal' in this context refers to a negligible variance in openness index relative to decrease computation time (associated with increasing the degree interval)? Perhaps quantifying the variation in openness index for a given degree interval will aid them in searching for an 'optimal' interval?

Reply: Different shifting angles and intervals are used to test if there is large difference among them. The results in Fig. 6 and 7 demonstrate that there are large variances among different shifting angles and intervals. To plot variances compared with shifting angle of 0 and degree interval of 1 might be a good way to illustrate the differences. But this will lead to unknown pattern of the raw openness index. Therefore we think it is good to keep Fig. 6 and 7 and add two figures on variance. The figures will be added in the revised manuscript. We think the raw openness index here means shifting angle of 0 and degree interval of 1.

5) The authors present openness index data and grain size in figure 8. I believe more quantitative analysis could be performed with this data to convince the readers. For instance, what values of shifting angle and degree interval was used? Why? What is the correlation between opening index vs sand %? or openness index vs silt/clay?

Reply: Shifting angle of 0 and degree interval of 1 are used in the figure 8 scenarios. The values were chosen because they tend to result in the most representative openness index, as discussed in 3.1 and the reply above. The correlation can be calculated to convince the readers and the coefficient matrix is listed below.

Correlation matrix for the grain size data and the calculated openness indexes Sand Silt/Clay Landward openness 0.48 0.65 Seaward openness 0.47 0.56

6) Has there been erosion of the islands since 5 ka? (i.e., is the present subaerial expression of the islands identical to the coastlines of the island in the past?) how could this impact your study?

Reply: Erosion from the island is most likely weak as these islands are mostly rocky with very thin soil. We cannot exclude that erosion has brought larger grains in size into the system during the land-uplift process, but the magnitude of the impact is difficult to evaluate. If there is continuous erosion since 5 ka, the sand contents and the silt/clay ratio would be more stable. This indirectly suggests that the impact of erosion from the islands is rather limited.

Interactive comment on Earth Surf. Dynam. Discuss., doi:10.5194/esurf-2016-24, 2016.