The effects of mixed cohesive and non-cohesive sediment properties on bedform and suspended sediment dynamics in the intertidal Dee Estuary

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Introduction

Accurate sediment transport models are essential for the management of coastal erosion, maintenance of navigation channels and understanding the impacts of climate-induced habitat change. Many of these coastal environments are dominated by mixtures of sand and mud. While reasonable sediment transport predictors are available for pure sands, this is not the case for mixed cohesive and non-cohesive sediments. Existing ripple predictors mostly relate bedform dimensions to hydrodynamic conditions and median sediment grain diameter, assuming a narrow unimodal particle size distribution. Under natural conditions, deposited beds may be comprised of mixed sediments affected by both physical and biologically-mediated cohesion (biogenic stabilisation). This natural complexity severely limits the applicability of standard predictors. Indeed, recent laboratory experiments mixing cohesive and non-cohesive sediments and adding bacterial polymers as a proxy for natural biogenic stabilisation have shown that bedform dimensions decrease with increasing bed clay content and that the bedform development rate is reduced by biological action (Baas *et al.*, 2013; Malarkey *et al.*, in press). In the field, it is expected existing predictors will match data for well-sorted sands closely, but will be inaccurate for mixed sediments containing cohesive sediments and natural biota. The paper reports on an extension of laboratory work to examine mixed sediments in the field.

Methodology

Over a two week period, 21 May to 4 June 2013, a field study was carried out on the tidal flats in the Dee Estuary, on the NW coast of England. A range of instrumentation was deployed to measure the sediment properties and hydrodynamics, while sediment samples were collected for laboratory analysis. As part of the fieldwork, a suite of instruments was deployed collecting co-located measurements of the hydrodynamics, suspended sediment properties and bed morphology (Fig. 1). The instruments occupied three sites across the tidal flats collecting data for different bed compositions and morphology. Site 1 was located higher on the intertidal flats than site 3, and site 2 was the lowest and located in a creek. The experiment covered a tidal cycle from springs to neaps, and the weather during the sampling window provided onshore and offshore winds of varying strength.

Bedform measurements were taken every half an hour using an Acoustic Ripple Profiler (ARP) that covered an area of about a $10m^2$. Dynamic measurements of tides and waves were made using an Acoustic Doppler Velocimeter (ADV) at 8Hz. Bed samples were taken when the tidal flats became exposed at low water and a multi-tier sediment trap collected suspended sediment load at five heights during the periods of sufficient inundation. Measurements of the suspended sediment were made using Acoustic Backscatter System (ABS) and LISST (Laser In Situ Scattering and Transmissometry) instruments. Combined bedform and suspended sediment measurements were collected using the BASSI (Bedform and Suspended Sediment Imager). Auxiliary measurements were made by a CTD (Conductivity, Temperature and Depth) with an OBS (Optical Backscatter Sensor).

The bed and multi-tier samples were analysed for particle size distribution (PSD), and separate bed samples were analysed for carbohydrate content as a proxy measure of biological cohesion.

Fig. 5. SEDbed frame deployed at site 1, on the West Kirby tidal flats in the Dee Estuary.

Aims

This paper will present results that show comparisons under different hydrodynamic conditions of ripple dimensions and migration, and suspended sediment size distributions and properties, using measurements of the proportion of mud and content of natural polymers as a proxy for biological stabilisation. Specifically, the following objectives and progression towards these outcomes will be considered and presented:

- compare the field data with laboratory results that showed reduced ripple length due to cohesive sediment content and increased ripple development time caused by biological stabilisation;
- assess how the bed dynamics of ripple migration are affected by cohesion and biological stabilisation;
- assess the performance of a selection of ripple predictors for mixed sediment data, with a view to creating an improved predictor;
- gain a better understanding of how bed and suspended sediment relate to each other using the particle size distribution.

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References

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