Distinguishing resuspension and advection signals in a hypertidal estuary

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Introduction

The Dee Estuary is a hypertidal coastal plain estuary, formed by the flooding of the river valley cut by the River Dee during the last major glaciation. One of three major estuaries employing into Liverpool Bay along with the Ribble and Mersey it is located at the junction of north-east Wales and north-west England, on the eastern side of the Irish Sea. The estuary section of the Dee is 20 km long, and 8.5 km wide at the mouth. The sea bed is covered by a thick (up to 16 m) sediment layer, deposited after the last Ice Age, consisting of fine-grained sands, silt muds, and some gravel beds. Flushing has led to the gradual accretion of the sand and mudflats, and an increase in saltmarsh area.

The estuary has a maximum spring tidal range in excess of 10 m, with an increase in tidal prism in excess of 80% occurring between mean low and mean high water during spring tides, causing tidal currents in excess of 1.2 m/s.

Data Collection

Data was collected over two month-long deployments of a bistatic instrument (STABLES) in the Hilbre Channel during February-March and May-June 2009. CTD profiles were taken at half-hourly intervals at the beginning and end of each deployment. The CTD included a transmissometer, while mass concentrations were obtained through the gravimetric filtering of water samples. Only the first 2 weeks of the May-June data were available due to 26kHz ADCP.

The salinity profiles show stratification at low water during both periods as higher river flow during February resulted in stronger stratification.

Relating SPM to salinity shows the presence of a horizontal concentration gradient during February with a single peak having a phase of -155° at the semi-diurnal frequency, indicating that these particles were predominantly quarter diurnal controlled. The large horizontal concentration gradient present during February-March and subsequent ebb dominance of concentrations, results in a weak flood dominant sediment flux by both volume and mass. During May-June, both small and large particles and mass are strongly flood dominant, while during February-March, although small particles and overall flux remain flood dominant, large particle flux is ebb dominant.

Impact on Sediment Flux

The large horizontal concentration gradient present during February-March, and subsequent ebb dominance of concentrations, results in a weak flood dominant sediment flux by both volume and mass. During May-June, both small and large particles and mass are strongly flood dominant, while during February-March, although small particles and overall flux remain flood dominant, large particle flux is ebb dominant.

Proposed Mechanism

During February-March, low biological abundance results in resuspension and a large horizontal concentration gradient. Weak flood flows break up sediment, breaking up diatom and advection. As low water begins to rise, higher, large clay flocs and resuspension are at risk due to the insufficient rate of resuspension without break up. Sediment transport therefore strongly flood dominant to velocity asymmetry resulting in a total pumping mechanism bringing material into the estuary.

During May-June, the horizontal concentration gradient is lower due to sediment limiting by biological processes. Flocs are too dense for these processes, resulting in resuspension without break-up. Sediment transport is therefore strongly flood dominant to velocity asymmetry resulting in a total pumping mechanism bringing material into the estuary.

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