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Towards the prediction of cohesive sediments dynamics: developing acoustic and optical measurements via in situ particle visualization.

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Cohesive particles in marine and costal waters remain a significant challenge to sediment transport predictions. Given the relevance to water quality, pollution, benthic ecology and coastal engineering our ability to develop process-response models of cohesive sediments is poor. Suspended cohesive particles rarely exist in their primary state but form flocs which are aggregated, heterogeneous assemblages of mineral grains, biogenic debris, bacteria and organic material. Floc formation is thus a function of numerous variables whose inter-related processes are yet to be fully elucidated.

This complexity is exacerbated by a lack of suitable data, notably in characterizing floc populations. A floc may constitute over 1 million individual particles and size can range over 4 orders of magnitude within one population. The effective densities are also highly variable, and the settling velocity can therefore span several orders of magnitude (Fennessey et al., 1994; Gibbs, 1985). The challenge is to develop data acquisition techniques that will allow accurate quantification of floc characteristics for the determination of SPM concentration and settling velocities for mass settling flux calculations.

Particle size ranges and concentrations are not adequately measurable by physical sampling which break up fragile flocs. Remote methods offer the potential to greatly enhance our understanding of floc particle dynamics. However, the responses of light and sound to floc particles remain uncertain. Differences in derived mass concentrations of flocculated and non-cohesive suspensions occur because OBS measures projected area concentration not mass concentration. Laser interferometry (e.g. LISST) is only applicable in relatively low concentrations, can disturb fragile flocs and requires a smooth size distribution and near-spherical particles (e.g. Wren et al., 2000). Acoustic backscatter methods are limited by a lack of data from floc-dominated environments which has restricted the development of suitable acoustic inversion algorithms.

Recent innovations of in situ visualization of floc size and settling velocity using INSSEV (e.g. Fennessey et al. 1994) & LabSFLOC (e.g. Manning and Dyer, 1999) have meant a step-change in our understanding of floc dynamics. Consequently, we are now in a position to make simultaneous measurements of cohesive SPM populations using in situ, remote and physical sampling to aid development of methods that account for the flaws in remote measurements.

We present selected data collected in the meso-tidal Tamar Estuary, Devon, UK over several tidal cycles. INSSEV and LabSFLOC data were acquired at multiple heights and complimented by physically sampled SPM later analysed for mass and organic content. A suite of ABS and OBS sensors were used to provide multi-frequency vertical response profiles, and a LISST-XT was positioned at INSSEV height. These measurements were augmented by vertical ADV and ADCP profiles of velocity and regular CTD profiles.

Examples are shown that reveal different responses of acoustic and optical methods across the tidal cycle. These differences are compared to changes in floc characteristics, SPM concentration, organic content, floc properties, flow hydrodynamics and water density over the tidal cycle in an attempt to determine the key parameters affecting the way in which sound and light interact with flocs.

Ultimately, this information will be used to develop inversion algorithms that will allow the recovery of cohesive sediment mass concentrations using combinations of acoustical and optical instruments without the need for extensive field calibrations.

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