

# Seasonal variations in SPM and floc characteristics in a hypertidal estuary

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Suspended particulate matter (SPM) is a highly variable and important aspect of estuarine systems. It determines turbidity; impacting water quality, generates benthic fluff, modifies biogeochemical exchanges, and constrains primary productivity. Further, SPM carries biogeochemical components (e.g. carbon, nitrogen), deciding the fates of anthropogenic system inputs. Most SPM is in the form of flocs (aggregates of dead and living organic matter, cohesive inorganic matter, and water) that are easily ruptured and/or may aggregate during sampling. Reliable information on floc behaviour is scarce particularly since floc properties change over tidal (suspension/advection), lunar (spring-neap cycle), and seasonal (storm resuspension and biological production) time scales.

The results of an extensive field campaign in the Dee Estuary (NW United Kingdom) are presented, investigating the fates of SPM. Using data from a combination of acoustics, optics, moored deployments and CTD stations particle characteristics varied across tidal, spring-neap, and seasonal time-scales. This was due to seasonal changes in both river input and levels of biological activity. During winter, turbulence-mediated flocculation and breakup dominated, with particles coming together under quiescent conditions, and breaking up during high turbulence conditions. By contrast, stronger, more shear-resistant flocs were present during summer with increased yield strength providing significant resistance to breakup. These changes significantly altered the  $W_s$  of SPM within the estuary, which would affect particle flux as  $W_s$  for similar density particles in summer may be much greater during summer than in winter.

The main channel bifurcates 12km seaward of the canalized section into two deep channels, extending into Liverpool Bay. The present study centres on observations from the easternmost channel, the Hilbre Channel, and presents a subset of results from two moored deployments of the STABLEIII benthic tripod and accompanying CTD stations undertaken in February-March and May-June 2009. Stokes' settling velocities were calculated using LISST data, while a modified version of the method of Ramirez-Mendoza *et al.* (2014).

During February-March chlorophyll and biological polysaccharide levels were found to be low and flocculation was controlled by the natural attractive forces between clay particles and levels of turbulent shear. Weak flocs were produced under low turbulence conditions during low and high water and were broken up into smaller microflocs during high turbulence conditions on the flood and ebb tides.

During May-June chlorophyll and biological polysaccharide levels were found to be higher. Two particle populations were identified: population B and population X. Floc size showed no relationship with turbulence for either population. Population B flocs were denser and settled faster than similarly-sized flocs during February-March. These flocs were resuspended on each tide without breakup. Population X particles occurred predominantly during current speeds in excess of  $0.4\text{ms}^{-1}$  and did not change density with changing size.

It is thought that the settling velocity of SPM within the estuary was changed by these altering characteristics, emphasising the importance of modelling not only the physical, but the biological aspects of estuarine SPM in order to parameterize particle characteristics correctly. Modelling estuarine SPM with a constant settling velocity, or with a relationship based on shear alone, will be highly inaccurate for time periods in which biological processes have an impact upon SPM particle characteristics.

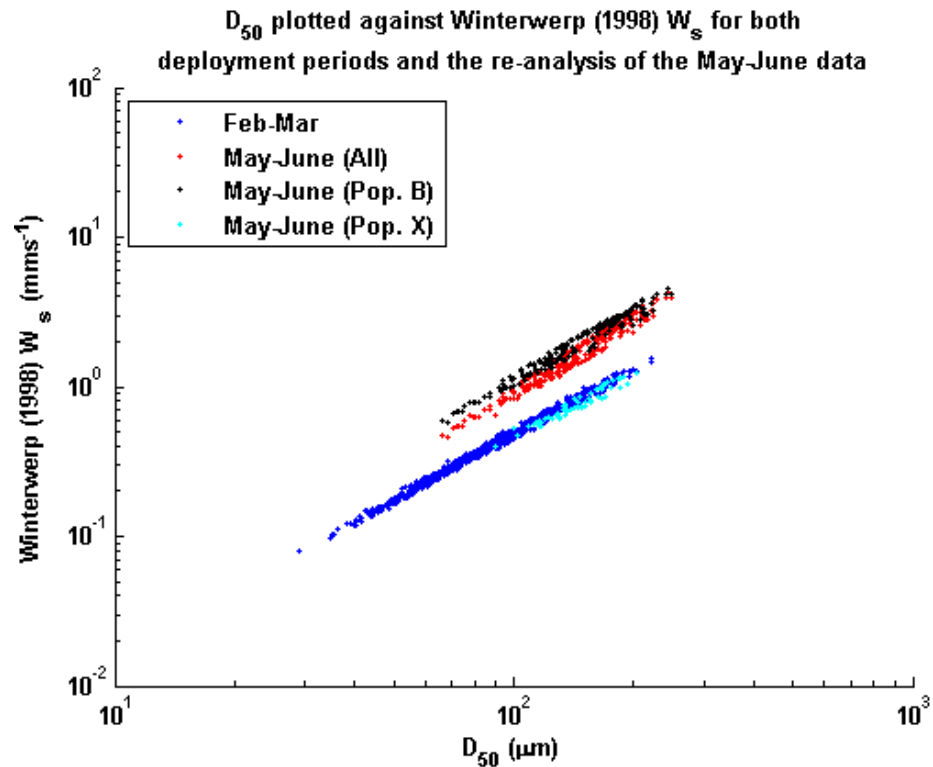


Fig. 1.  $D_{50}$  plotted against settling velocities (Winterwerp, 1998) for the February-March data, original May-June analysis and the re-analysed May-June data split into populations B and X.

#### References

- Ramirez-Mendoza R., A.J. Souza and L.O. Amoudry. 2014. Flocculation in hypertidal estuaries. *Ocean Dynamics*: 1-13.
- Winterwerp J.C. 1998. A simple model for turbulence induced flocculation of cohesive sediment. *Journal of Hydraulic Research* 36:309-326.