Geophysical Research Abstracts
Vol. 16, EGU2014-6041, 2014
EGU General Assembly 2014

Factors controlling floc settling velocity within San Francisco Bay, USA and comparisons with parameterisation approaches

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Much of the sediment within San Francisco Bay (SFB) is cohesive and can therefore act as transport mechanism for pollutants which adsorb to clay minerals. Furthermore, muddy sediment can flocculate when resuspended; this significantly alters their transport characteristics, which poses a serious complication to the modelling of sediment pathways. The aim of this research was to determine the factors that affect floc settling velocity along a longitudinal transect in an estuary. We collected and analysed data on flocs and on potential controlling factors along a 147 km transect the length of San Francisco Bay, USA, on June 17th, 2008. The INSSEV-LF video system, which includes the novel video-based LabSFLOC instrument (developed by Manning) was used to measure floc diameters and settling velocities at 30 stations at a height of 0.7 m above the estuary bed.

Floc sizes (D) ranged from 22 microns to 639 microns settling velocities (Ws) ranged between 0.04 mm/s to 15.8 mm/s during the longitudinal transect. Nearbed turbulent shear stresses throughout the transect duration were within the 0.2-0.5 Pa range which typically stimulates flocculation growth. Individual D-Ws-floc density plots suggest the suspended sediments encountered throughout SFB were composed of both mud and mixed sediment flocs. The macroflocs and microflocs (demarcation at 160 microns) sub-populations demonstrated parameterised settling velocities which spanned nearly double the range of the sample mean settling velocities (Ws_mean spanned 0.6-6 mm/s). The macroflocs tended to dominate the suspended mass (up to 77% of the ambient suspended solids concentration; SSC) from San Pablo Bay through to Carquinez Strait (the vicinity of the turbidity maximum zone). Microfloc mass was particularly significant (typically 60-100% of the SSC) in the northern section of South Bay and most of Central Bay. During slack tide, larger and faster settling flocs deposited, accounting for most of the longitudinal variability. The best single predictor of settling velocity was water velocity 39 minutes prior to sampling, not suspended-sediment concentration or salinity. Resuspension and settling lags are likely responsible for the lagged response of settling velocity to water velocity.

The distribution of individual D and Ws indicates floc density varies greatly. The inclusion of fine sand grains within floc structures appears likely. Wide variability in the processes which contribute to flocculation, mean that spatial floc data is required in order to accurately represent the diverse floc dynamics in SFB. The complexity in floc properties present in SFB, is perfectly demonstrated by the comparison of INSSEV-LF measured mass settling fluxes (MSFs) and the large errors in fluxes calculated using a simple constant Ws assumption. For example, a slow constant Ws of 0.5 mm/s rarely estimated more than 20-25% of the mass settling flux measured at the various stations throughout the Bay. At the other extreme, an 8 mm/s settling parameter inferred that the total transect MSF was double what was actually present; locally this rose to a thirteen fold flux over-prediction within South Bay. Thus, no single settling velocity will adequately mimic the MSF distributions throughout SFB.