In situ characterization of estuarine suspended in the presence of muddy flocs and pellets

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IN SITU CHARACTERIZATION OF ESTUARINE SUSPENDED SEDIMENT IN THE PRESENCE OF MUDDY FLOCS AND PELLETS

G. M. Cartwright, C. T. Friedrichs, and L. P. Sanford
Flocculants

Mud

Fecal Pellets

Sand

Settling Velocity

\( W_s \propto D \rho \)

\( \lambda \downarrow \) Turbulence

\( D \sim 5 - 10 \mu m \)

\( W_s < 0.1 \text{ mm/sec} \)

\( W_s \uparrow \lambda \uparrow \% \text{ Organic} \)

\( W_s \sim 0.1 - 10 \text{ mm/s} \)

\( D = 63 - 500 \mu m \)

\( W_s = 2.3 - 60 \text{ mm/s} \)

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Mud

Flocculants

Fecal Pellets

Sand

\[ W_s \propto D \rho \]

\[ D \sim 5 - 10 \ \mu m \]

\[ W_s < \text{to} < 0.1 \ mm/sec \]

\[ D \sim O(\lambda) \]

\[ \text{Microflocs} < 160 \ \mu m \]

\[ \text{Macroflocs} > 160 \ \mu m \]

\[ W_s \uparrow \lambda \uparrow \% \text{Organic} \]

\[ D = 10s - 100s \ \mu m \]

\[ W_s \sim 0.1 - 10 \ mm/s \]

\[ D = 63 - 500 \ \mu m \]

\[ W_s = 2.3 - 60 \ mm/sec \]

Turbulence ↓

\[ \lambda \]

Settling Velocity

Fugate and Friedrichs (2003)

Sherwood (2007)

Study Site

NSF MUltiDiSiplinary Benthic Exchange Dynamics

Claybank area on York River
Chesapeake Bay, VA

Secondary Channel
~ 5 meter depth
Neap Tide
Seabed > 75% mud
~10% Organics
Sand D50 ~100 µm
<30% Pellets

METHOD

LISST 100X

15 min burst interval
100 records @ 1 Hz
(10 samples/record)

Distribution measured
2.5 – 500 µm

RipsCam

1 hour “burst” interval
5 flash exposures
at 1 min interval
Focal depth ~1mm

Distribution measured
~60 µm – 1.3 mm

ADV

15 min burst interval
2 min @ 10 Hz

Real-time Communication Cables

S2E

CTD

LISST

ADV

RipsCam
Currents, Stress and Concentration

Concentration by weight (mg/L) corresponds with peak currents.

Concentration by volume (µm/L) doesn’t.
EXAMPLE DISTRIBUTIONS

LISST time = 29-Jul-2009 11:02:24 EST Camera time = 1600 GMT

- LISST D16 = 23 µm
- LISST D50 = 171 µm
- LISST D84 = 316 µm
- LISST Peak = 351 µm

- RIPScam D16 = 300 µm
- RIPScam D50 = 758 µm
- RIPScam Peak = 1243 µm

Dominant Floc size ~315 µm

Slack after Ebb

Increasing stress toward Ebb

LISST time = 28-Jul-2009 19:55:12 EST Camera time = 100 GMT

- LISST D16 = 21 µm
- LISST D50 = 85 µm
- LISST D84 = 218 µm
- LISST Peak = 104 µm

- RIPScam D16 = 117 µm
- RIPScam D50 = 197 µm
- RIPScam Peak = 201 µm

EXAMPLE DISTRIBUTIONS

Dominant Floc size ~315 µm

Slack after Ebb

Increasing stress toward Ebb
EXAMPLE DISTRIBUTIONS

LISST time = 29-Jul-2009 11:02:24 EST Camera time = 1600 GMT

LISST D16 = 28 µm
LISST D50 = 171 µm
LISST D84 = 316 µm
LISST Peak = 351 µm

RIPScam D16 = 300 µm
RIPScam D50 = 758 µm
RIPScam Peak = 1243 µm

LISST 100X
RIPScam/10

SLACK AFTER EBb

Increasing stress toward Ebb

Dominant Pellet size ~102 µm
EXAMPLE DISTRIBUTIONS

LISST time = 29-Jul-2009 11:02:24 EST Camera time = 1600 GMT
LISST D16 = 23 µm
LISST D50 = 171 µm
LISST D84 = 316 µm
LISST Peak = 391 µm
RIPScam D16 = 390 µm
RIPScam D50 = 758 µm
RIPScam Peak = 1243 µm

RIPScam D16 = 117 µm
RIPScam D50 = 197 µm
RIPScam Peak = 201 µm

LISST time = 28-Jul-2009 19:55:12 EST Camera time = 100 GMT
LISST D16 = 21 µm
LISST D50 = 85 µm
LISST D84 = 218 µm
LISST Peak = 104 µm
RIPScam D16 = 117 µm
RIPScam D50 = 197 µm
RIPScam Peak = 201 µm

Dominant Floc size ~205 µm

Slack after Ebb

Increasing stress toward Ebb
STUDY PERIOD DISTRIBUTIONS

Low Stress
Dominate floc size ~ 315 µm
LISST Peak
LISST D84
RIPScam D50

High Stress
Pellets ~ 102 µm
LISST Peak
LISST D50
RIPScam D16

Dominate floc size ~ 205 µm
LISST D84
RIPScam Peak
RIPScam D50
Settling Velocity and Volume Concentration

Pellets
- Increase stress
- Increase eff. Ws
- Increase vol conc

Flocs
- Decrease stress
- Decrease eff. Ws
- Increase vol conc
Conclusions and Future work

- LISST Peak grain size or D84 during maximum stress is the dominant resilient grain size.
- LISST Peak grain size or D50 during slack periods is the dominant flocculent size (larger will occur but at levels that are averaged out during burst averaging).
- LISST D50 during maximum stress represents the dominant minimum flocculent size.
- Future work needs to look at LISST distributions during spring tide and episodic events to discover how the higher stress change the sizes and populations in suspension.
- Calibrations, with the Total Suspended Solids broken into resilient and non-resilient portions, needs to be done to convert volume concentration to mass concentration so the density of the dominant particles can be determined.
- Time averaged burst statistics can be used to determine the effective fall velocity of the sediment in suspension.
- Once the mass concentration of the dominant particles are identified further work can be done to calculate effective fall velocity of these size classes.
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