Identification of suspended resilient pellets in particles tracked by a Particle Image Camera System (PICS) in a muddy estuary

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Recommended Citation
Cartwright, Grace M.; Fall, Kelsey A.; and Friedrichs, Carl T.  "Identification of suspended resilient pellets in particles tracked by a Particle Image Camera System (PICS) in a muddy estuary". 9-7-2015. 13th International Conference on Cohesive Sediment Transport Processes (INTERCOH), Leuven, Belgium.

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Identification of Suspended Resilient Pellets tracked by a Particle Image Camera System (PICS) in a Muddy Estuary

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INTERCOH 2015
What does the bed look like when fresh floc layer isn’t present? Insights from “Worm Cam” and microscope:

Video from R. Diaz; Scope photo taken by K. Fall.
Study Site

YORK RIVER ESTUARY

Clay Bank (CB)
Physical
2007-Present

Gloucester Point (GP)
Biological
2006-2009
3-day Means for ADV $w_s$ and 3-day fits to ADV eroded mass at 0.2 Pa

Inverse relationship between $w_s$ and erodibility

(Biological site)

(PHysical site (in green and red))

(Biological site)

(Cartwright et al, 2009)
Biological site

Physical sites (in green and red)

Biological site

--- Erodibility based on ADV at **biological** site is generally lower.

--- At **physical** site, erodibility is bimodal and varies seasonally.

Less bioturbated layer present at surface in May.
Outline

Introduction

Study site And Motivation

Methods

Results

Conclusions

Photo by K. Fall
Benthic Tripod with Sediment Trap

August 2012 - Present

ADV

Sediment Trap

35-38 cmab
(same height as ADV sample volume)
Sediment Trap
Nov. 2014- Mar 2015
8% sand
Tripod tipped over after trap full
Sediment Trap
Nov. 2014- Mar 2015
8% sand
Tipped over due to ice flow

Short time scale re-suspension events evident
Future work to include looking at calculated concentration and stresses from Tripod ADV data
Sieve bottom sediment for:

- disaggregated sediment grain-size
- Particles without disaggregation > 63 µm

Resilient Pellets
In situ data - Calibration Cruise Profiler with PICS

![Image of PICS equipment]

![Graph showing depth over time with markers for Top, Mid, and Bottom]

- Top
- Mid
- Bottom

PICS sample depth
How PICS video sequence is processed

30 s video
8 fps

Thread Number: 3533 (82); d = 200 μm; X = 9.2 mm; $W_{x,\text{mean}} = 0.57$ mm/s

PIV ($\leq 30$ μm)

PTV ($>30$ μm)

(Smith, 2010; Cartwright et al, 2013; Smith and Friedrichs, 2012)
Outline

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And Motivation

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Photo by K. Fall
Percent Mud Fraction and Pellets in Sediment Trap and Bottom Sediment

Sediment trap well mixed before analyzed
Percent Mud Fraction and Pellets in Sediment Trap and Bottom Sediment

Disaggregated
Bottom sediments
Top 2 cm averaged
Total mud includes organics

Grain size and pellets based on total dry weight
(Wentworth Scale)
Percent Mud Fraction and Pellets in Sediment Trap and Bottom Sediment

- Percent Mud typically higher in trap than bottom sample.
- Seasonal change in Pellet concentration.
- Possibly inversely correlated with Sediment erodibility.
PICS RESULTS

• Laboratory Experiments using sediment sieved for pellets
  • Trap deployed November 2014 – March 2015
  • Trap deployed August 2013 – November 2013 (sieved August 2015)

• In-situ data collected:
  • October 1, 2014 – Anchor Station Bracket Flood
  • December 14, 2014 – Anchor Station Bracket Ebb
PICS analysis of Sediment Trap particles >63 μm

November 2014

Depth=5.5 m
N=590
\(d_{50,p}=91.6 \, \mu m\)
\(d_{50,m}=108.1 \, \mu m\)
\(W_{s50,p}=1.187 \, \text{mm.s}^{-1}\)
\(W_{s50,m}=1.681 \, \text{mm.s}^{-1}\)

1. Capture \(W_s\) and size for all particle with PTV and remove influence of background of water velocity in tube with piv
PICS analysis of Sediment Trap particles >63 μm

November 2014

Depth=5.5 m
N=590
\(d_{50,p} = 91.6 \mu m\)
\(d_{50,m} = 108.1 \mu m\)
\(Ws_{50,p} = 1.187 \text{ mm.s}^{-1}\)
\(Ws_{50,m} = 1.681 \text{ mm.s}^{-1}\)

2. Calculate mass and density of each particle and classify
Which particle group

>1800 kg . M³
Primary particles (sand)

1150 kg . m³ - 1800 kg . m³
Bed aggregates (pellets)

<1150 kg . m³
(flocs)
PICS analysis of Sediment Trap particles >63 μm

November 2014

Depth=5.5 m
N=590
\(d_{50,p} = 91.6 \, \mu m\)
\(d_{50,m} = 108.1 \, \mu m\)
\(Ws_{50,p} = 1.187 \, \text{mm.s}^{-1}\)
\(Ws_{50,m} = 1.681 \, \text{mm.s}^{-1}\)

3. Plot particles with appropriate Color and in them for distribution plots.
PICS RESULTS

- Laboratory Experiments using sediment gently sieved for pellets
  - Trap deployed November 2014 – March 2015
  - Trap deployed August 2013 – November 2013
    (sieved August 2015)

- In-situ data collected:
  - October 1, 2014 – Anchor Station Bracket Flood
  - December 14, 2014 – Anchor Station Bracket Ebb
Percent Mud Fraction and Pellets in Sediment Trap and Bottom Sediment

Two calibration cruises used for next result
**Flood**

Bottom current
Velocity = 31 cm/s

Depth = 6.09 m
718 particles

\[ d_{50,m} = 103 \mu m \]

\[ Ws_{50,m} = 0.56 \text{mm/s} \]

October 2014

**Ebb**

Bottom current
Velocity = 32 cm/s

Depth = 5.58 m
888 particles

\[ d_{50,m} = 105 \mu m \]

\[ Ws_{50,m} = 0.74 \text{mm/s} \]

December 2014
**Flood**

Bottom current

Velocity = 31 cm/s

Depth = 6.09 m

718 particles

$d_{50,m} = 103 \mu m$

$W_{s50,m} = 0.56 mm/s$

**Ebb**

Bottom current

Velocity = 32 cm/s

Depth = 5.58 m

888 particles

$d_{50,m} = 105 \mu m$

$W_{s50,m} = 0.74 mm/s$
### Flood
- Bottom current
- Velocity = 31 cm/s
- Depth = 6.09 m
- 718 particles
- $d_{50,m} = 103 \mu m$
- $W_{50,m} = 0.56 \text{mm/s}$

Dominated by lower density particles (Flocs)

### Ebb
- Bottom current
- Velocity = 32 cm/s
- Depth = 5.58 m
- 888 particles
- $d_{50,m} = 105 \mu m$
- $W_{50,m} = 0.74 \text{mm/s}$

Dominated by higher density particle (Pellets and primary particles)
Conclusions

- Automated image analysis using PIV and PTV methods can identify the size, density and settling velocity of 1000s of *in situ* suspended particles per 30s sequence.

- Pellets are very resilient. Pellets from sediment traps kept undisturbed in refrigerated storage in our lab maintained their shape and size distribution, even after 2 years.

- Seasonal changes in pellet concentration appear to be inversely correlated with the seasonal changes in bed erodibility.

- Care should be taken in interpreting $D_{50}$ statistics of suspended particle distributions.

- By first classifying particle types by density, the statistics of distinct particle subpopulations, such as flocs, denser mud aggregates (e.g., pellets), and primary particles can be separately interpreted.