Mesocosm Experiments To Study Benthic-Pelagic Coupling in Shallow Waters: Effects of Resuspension

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STURM facility at PEARL

STURM paddle

TSS [mg/L]

R_1

R_2

R_3

NR

NR

NR

R

R

R

Time

0:19:37
1:32:35
2:44:32
3:54:24
5:05:13
6:16:56
7:28:51
8:40:46
9:53:32
Resuspension Tanks (R)
Non-Resuspension Tanks (NR)

Same water column turbulence

Low bottom shear stress  High bottom shear stress

BUT

$q = 1.08 \text{ cm s}^{-1}$
$\varepsilon = 0.08 \text{ cm}^2 \text{ s}^{-3}$

4h mixing on, 2h mixing off (tidal cycling)
Objectives

Determine the effect of sediment resuspension on water quality and ecosystem processes:

Effect of high bottom shear (i.e., resuspension) on:
1. Seston quantity, phytoplankton, matter quality
2. The ecosystem: pigments, zooplankton
3. Particulate and dissolved nutrients
4. Light and microphytobenthos biomass
5. Sediment fluxes
6. Macrofauna

Do in controllable experimental ecosystem experiments with realistic shear & turbulence.
Experiment setup

Mud Collection.

Homogenization.

Smoothing.

Baltimore Harbor muddy sediment

Equilibration
for 14d w.
filtered water &
partial water exchange

Defaunation.

Add unfiltered water

START 4-wk EXPT

(Porter, Owens, Cornwell 2006 JCR)
Water Column Measurements

During 4-Week Experiment

Before & at End of Expt:
D/L Flux Chamber Incubations

e.g., TSS, chl a, mesozooplankton, DIN, light, sed. chl a, sed. nutrient fluxes, macrofauna
Results

Determine the effect of sediment resuspension on water quality and ecosystem processes:

Effect of high bottom shear (i.e., resuspension) on:
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6. Macrofauna
1. Effect on seston quantity, chl $\alpha$, matter quality

**TSS**

- $R_{on}$
- $NR_{on}$
- $R_{off}$
- $NR_{off}$

**Phaeophytin**

**Chl $\alpha$**

**Ratio Chl $\alpha$ : Phaeophytin**

Day and Chl $\alpha$ values are shown in the graphs.
2. Effect of resuspension on the ecosystem: pigments, zooplankton

Brown tide,
*Aureococcus anophagefferens*

19’-butanoyloxyfucoxanthin (but-fuco) = marker pigment for brown tide organisms *Aureococcus anophagefferens* (Trice et al. 2004).

*Aureococcus anophagefferens*

if Gyroxanthin diester is absent and if 19’ Hexanoylofucoxanthin is absent.

Polychaete larvae
3. Effect of resuspension on particulate & dissolved nutrients. N desorption from particles!

**Particulate nutrients**

![Graph showing the effect of resuspension on particulate & dissolved nutrients](image)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>NR (μmol L⁻¹)</th>
<th>R (μmol L⁻¹)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN</td>
<td>1.8 ± 0.2</td>
<td>4.3 ± 1.4</td>
<td>0.0260</td>
</tr>
<tr>
<td>DON</td>
<td>19.6 ± 0.5</td>
<td>15.5 ± 1.2</td>
<td>0.0126</td>
</tr>
<tr>
<td>PO₄³⁻</td>
<td>0.093 ± 0.008</td>
<td>0.149 ± 0.030</td>
<td>0.0227</td>
</tr>
</tbody>
</table>
4. Effect of resuspension on light and microphytobenthos biomass

**Light at the sediment**

![Graph showing PAR (µE m⁻² s⁻¹) over time]

- **R (NR)** represents the graphs for resuspension (NR) and non-resuspension (NR)
- **R_on** and **NR_on** show the light intensity with resuspension on
- **R_off** and **NR_off** show the light intensity with resuspension off

**Sediment Chl a**

![Graph showing sediment Chl a over time]

- **Pre**, **Mid**, **End** represent different time periods
- **a**, **b**, **c**, **d** indicate significant differences between groups
5. Effect of resuspension on fluxes

End of Experiment

<table>
<thead>
<tr>
<th></th>
<th>Dark</th>
<th>Light</th>
<th>Daily Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bef</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>140</td>
<td>130</td>
<td>0.4042</td>
</tr>
<tr>
<td>R</td>
<td>120</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>150</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>160</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

Daily Flux

p = 0.4042
6. Effect of resuspension on macrofauna

- **Polychaetes**
  - NR: 300
  - R: 0

- **Amphipods**
  - NR: 0
  - R: 100

The graph shows the number of individuals per square meter for each group of macrofauna under normal resuspension (NR) and resuspension (R) conditions.
High bottom flow/shear/tidal resuspension affected the ecosystem profoundly, often through indirect processes.
Conclusions

High bottom shear (i.e., tidal resuspension): 
1. Enhanced seston quantity, enhanced phytoplankton biomass (higher in R!), decreased matter quality.
2. Affected the ecosystem: brown tide, zooplankton dynamics; polychaetes.
3. Enhanced particulate and dissolved nutrients: desorption of N from particles.
4. Decreased light, lower microphytobenthos biomass.
5. Sediment fluxes not significantly different.
6. Macrofauna in NR but not in R (too unstable, no food)

Overall: High bottom shear/tidal resuspension affected the ecosystem profoundly, often through indirect processes.
Other 4-Wk STURM Resuspension Expts

- Effects of Shear Stress and Hard Clams on Seston, Microphytobenthos, and Nitrogen Dynamics in Mesocosms With Tidal Resuspension.
  
  2013 MEPS 479: 25-45

- Effect of Oyster Biodeposit Resuspension On Nutrient Dynamics and Ecosystem Processes.