Evaluating Sediment Mobility for Nearshore Placement

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Sediment Mobility Tool

- Preliminary/Reconnaissance Tool
- Frequency of Sediment Mobility
- Single Depth or Range of Depths
- Matlab Script to Automate Process
- Applied to WIS, NACCS, or Other Wave Gauge Data
Why is it Helpful

- **Answers:**
  - Will the Berm Move?
  - Where Is Sediment Likely To Go?

- **Ideal for:**
  - Preliminary Siting of Nearshore Berms
  - Small Projects That Don’t Warrant a Full Numerical Model
Application

- 2 Sites
- 3 Different Data Sets:
  - WIS (Duck)
  - NACCS (Milford)
  - U. Conn. Buoy (Milford)
User Defines:

- Data Source
- Offshore Water Depth of Data Source
- Shoreline Orientation
- Median Grain Size
- Current Velocity 1 m above the Bed
Wave Theories

- **Frequency of Mobility:**
  - Linear Wave Theory (Bed Shear Stress)
    \[ \tau_{cr} = \theta_{cr} g (\rho_s - \rho) d_{50} \]
    \[ \tau_m = \tau_c \left[ 1 + 1.2 \left( \frac{\tau_w}{\tau_c + \tau_w} \right)^{3.2} \right] \]
    \[ \tau_{max} = \left[ (\tau_m + \tau_w \cos \phi)^2 + (\tau_w \sin \phi)^2 \right]^{1/2} \]
  - Nonlinear Stream Function Wave Theory (Near-bed Velocity)
    \[ u_{cr} = \sqrt{8 g \gamma d_{50}} \quad d_{50} \leq 2.0 \text{ mm} \]
    \[ u_{max\,crest} = \left( \frac{H}{T} \right) \left( \frac{h}{L_o} \right)^{-0.579} \exp \left[ 0.289 - 0.491 \left( \frac{H}{h} \right) - 2.97 \left( \frac{h}{L_o} \right) \right] \]
Site 1: Duck, NC

- $h = 8 \text{ m}$
- WIS Station 63218
- $0.1 \leq d_{50} \leq 0.5 \text{ mm}$
Site 1: Duck, NC

\[ M = \left( \frac{\tau_{\text{max}} - \tau_{\text{cr}}}{\tau_{\text{cr}}} \right) \]

\[ M_u = \left( \frac{u_{\text{max}} - u_{\text{cr}}}{u_{\text{cr}}} \right) \]
Site 1: Duck, NC

Significant Wave Height and Period

\( H_o = 1.82 \text{ m}, T_p = 8.98 \text{ s} \)

**Bed Stress [Pa]**

- \( d_{50} = 0.1 \text{ mm}, \tau_{cr} = 0.14 \text{ Pa} \)
- \( d_{50} = 0.2 \text{ mm}, \tau_{cr} = 0.17 \text{ Pa} \)
- \( d_{50} = 0.3 \text{ mm}, \tau_{cr} = 0.20 \text{ Pa} \)
- \( d_{50} = 0.4 \text{ mm}, \tau_{cr} = 0.23 \text{ Pa} \)
- \( d_{50} = 0.5 \text{ mm}, \tau_{cr} = 0.26 \text{ Pa} \)

**Near-Bottom Velocity, \( u_{max} \text{ [m/s]} \)**

- \( d_{50} = 0.1 \text{ mm}, u_{cr} = 0.11 \text{ m/s} \)
- \( d_{50} = 0.2 \text{ mm}, u_{cr} = 0.16 \text{ m/s} \)
- \( d_{50} = 0.3 \text{ mm}, u_{cr} = 0.19 \text{ m/s} \)
- \( d_{50} = 0.4 \text{ mm}, u_{cr} = 0.22 \text{ m/s} \)
- \( d_{50} = 0.5 \text{ mm}, u_{cr} = 0.25 \text{ m/s} \)
Site 2: Milford, CT

- Milford, CT
- 20,000 cy
- $d_{50} = 0.21$ mm
- $0.1 \leq d \leq 0.5$ mm
Wave & Current Info

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Sed. Mobility

\[ d_{50} = 0.21 \text{mm} \]

Typical Waves:
\[ f_M = 13.6\% \]

Storm Waves:
\[ f_M = 71.4\% \]
Sed. Migration Direction

- Dean’s Number

\[ D = \frac{H_0}{\omega T} \]

> 7.2, Offshore Migration

< 7.2, Onshore Migration \((\text{Larson & Kraus, 1992})\)

<table>
<thead>
<tr>
<th>d (mm)</th>
<th>Typical Waves</th>
<th>Storm Events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted Sediment Migration</td>
<td>Predicted Sediment Migration</td>
</tr>
<tr>
<td>0.1</td>
<td>83% Offshore</td>
<td>97% Offshore</td>
</tr>
<tr>
<td>0.2</td>
<td>60% Onshore</td>
<td>52% Offshore</td>
</tr>
<tr>
<td>0.21</td>
<td>63% Onshore</td>
<td>52% Onshore</td>
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<tr>
<td>0.3</td>
<td>84% Onshore</td>
<td>74% Onshore</td>
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<tr>
<td>0.4</td>
<td>96% Onshore</td>
<td>91% Onshore</td>
</tr>
<tr>
<td>0.5</td>
<td>99% Onshore</td>
<td>99% Onshore</td>
</tr>
</tbody>
</table>
**Storm Wave Direction**

- Storm waves
- Resultant: 136°
- Accretion Towards Northwest
Conclusions

- **Answers:**
  - Will the sediment move?
  - Where is likely to go?

- **Estimates**
  - Frequency of mobility
  - On/Offshore migration direction
  - Dominant axis of wave dominated transport

- Preliminary tool to make educated decisions with little data
Thank you!