NEARSHORE DREDGED MATERIAL PLACEMENT AND TRANSPORT IN SOUTHERN LAKE MICHIGAN

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Outline

• Background

• Numerical Modeling Method
  — Coastal Modeling System (CMS)
  — Particle Tracking Model (PTM)

• Model setup

• Results

• Summary
Background

• Harbor/port complex and coastal structure interrupt natural littoral movement of sand

• Sand accretion/erosion pattern around the complex leaves Ogden Dunes little to no beach along the shoreline and put the residents and their property at greater risk from coastal hazards

• To protect the natural habitat and shoreline residences, USACE has placed 600,000 cy of dredged sand in the nearshore area as beach nourishment effort since 2006.

• This numerical modeling study is to examine the sediment transport of nearshore placed material under various hydrodynamic and wave conditions.
Numerical Modeling Method
(CMS and PTM)

- CMS-Flow: Two-dimensional (2D) finite-volume model and calculate hydrodynamics, sediment transport
- CMS-Wave: 2D spectral wave transformation model, simulate important wave processes, including diffraction, refraction, reflection, wave breaking and dissipation mechanisms ...
- Coupled system for waves, flows, and sediment transport and morphology change
- PTM is a Lagrangian particle tracker that models transport processes (advection, diffusion, deposition, etc) of representative parcels to determine constituent (sediment, contaminants, biologicals, etc) fate.

Hydrodynamic and Wave Data → Time-dependent Particle Positions $P(t,X,Y,Z)$ → Deposition Accumulation Pathways
## Study Domain

<table>
<thead>
<tr>
<th>CMS-Flow</th>
<th>CMS-Wave</th>
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<tbody>
<tr>
<td>Domain Size:</td>
<td></td>
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<tr>
<td>15.4 km</td>
<td>11.5 km along shore</td>
</tr>
<tr>
<td>10.6 km</td>
<td>7.4 km cross shore</td>
</tr>
<tr>
<td>No of Cells:</td>
<td></td>
</tr>
<tr>
<td>~ 80,000</td>
<td>~ 67,000</td>
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<tr>
<td>Cell Size:</td>
<td></td>
</tr>
<tr>
<td>10 ~ 300 m</td>
<td>10 ~ 180 m</td>
</tr>
<tr>
<td>Water Depth (MSL):</td>
<td></td>
</tr>
<tr>
<td>-2 ~ 20 m</td>
<td></td>
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<tr>
<td>Boundary Forcing:</td>
<td></td>
</tr>
<tr>
<td>~ Open lake</td>
<td></td>
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<tr>
<td>Simulation Periods:</td>
<td></td>
</tr>
<tr>
<td>~ Jul 20 – Aug 30, 2016 (validation)</td>
<td></td>
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<tr>
<td>~ Oct 10 – Nov 20, 2016 (sediment transport/ morph change)</td>
<td></td>
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</tbody>
</table>
Data

Boundary forcing:

NOAA WL Gage (Calumet Harbor)
NOAA Buoy (#45007)
Waves spectrum
Wind

Model calibration/validation:

Nearshore ADCP gage (BHSH001)
Multibeam echosounder (MBES)
Bathymetric and beach topographic surveys

Survey Periods

June-November 2016
Model Results
(water surface elevation and current)

Water surface elevation and current measurements and calculations (time series)

- Jul 20-Aug 30, 2016
- Oct 10-Nov 20, 2016
Current and Sediment Transport

- Averaged current and sediment transport vectors (Oct 10 – Nov 15, 2016)
- Strong longshore transport west of harbor/port complex
Morphology Change

- Measured and calculated morphology change (Oct 10 – Nov 15, 2016)
- Sediment erosion and accumulation on the nearshore side
- Sediment accumulation in the offshore area (survey data)
- Because of weak currents the offshore accretion could be attributed to measurement errors (±3 cm to 10 cm)
Sediment Volume Change

- Bed erosion (sediment dissipation) around dredge material placement sites

<table>
<thead>
<tr>
<th>Area</th>
<th>Volume Change (m³)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ADCP Survey</td>
</tr>
<tr>
<td>A1</td>
<td>-13032</td>
</tr>
<tr>
<td>A2</td>
<td>-367</td>
</tr>
<tr>
<td>A3</td>
<td>-1738</td>
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</tbody>
</table>
Sediment Tracking

Material Placement Sites

1: Nearshore Trap
2: Longshore West
3: Longshore East
4: Offshore Trap
5: Release Zone
Sediment Tracking
Sediment Transport

Larson’s Surf Zone Routine

Material Placement Sites

Depth (m)
- 14.0
- 10.0
- 6.0
- 2.0
- -2.0

48%
1%
2%
35%
14%
Summary

• Mean current vectors display dominant, south-southwestward longshore flows and the maximum current speed was approximately 0.1 m/sec in the surf zone area.

• Mean sediment transport pattern corresponded closely with the mean current pattern. Coastal sediments were dominantly transported alongshore towards the south-southwest and no apparent sediment movement was identified in deeper lake area.

• During the simulation period, mean longshore current and sediment movement were driven by dominant, northerly directed storm waves.

• About 25-35% of placed material move to nearshore zone and 50-65% are within the offshore zone.

• Longer term simulations need to be conducted to further investigate sediment transport pathways.
Thank You!

Questions?