National Coastal Mapping Program Update on Products

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Joint Airborne Lidar Bathymetry Technical Center of Expertise
GIS Day, Vicksburg, MS March 14, 2012

Outline:
- USACE National Coastal Mapping Program
- Product examples and surveying update
- Data access
- R&D progress (Environmental/Coastal Engineering)
- Coastal Zone Mapping and Imaging Lidar (CZMIL)
National Coastal Mapping Program

- Started in 2004 to support regional sediment management initiatives
- Regional, repeat datasets quantify regional-scale change
- High-resolution, high-accuracy data

Marquette Harbor, MI, Lake Superior, 2011
National Coastal Mapping Progress

Products
- ASCII XYZ
- Aerial photos
- Zero contour
- Aerial photo mosaics
- 1-meter bathy/topo DEM
- LAS format topo
- 1-meter bathy/topo bare earth DEM
- Hyperspectral image mosaics
- Laser reflectance images
- Basic landcover classification
- Volume change

Number of times surveyed since 2004
- One Time
- Two Times
- Three Times
- Four Times
- Five Times
2011 NCMP Collection

- **Mission Stats**
  - Survey Season from 05/31/2011 to 10/01/2011
  - 5 Bases of Operation
  - Lake Superior completed
    - Stamp Sands Project
  - Lake Ontario completed
  - Niagara postponed
  - Lake Erie partially completed
  - Gulf Coast and New England completed

- **Coverage Stats**
  - 600 Total Miles Shoreline Covered
  - 1.5 Billion Total Lidar Shots
  - 630,000 Total Aerial Photos
  - 2000 Hyperspectral Images
  - 23 Federal Navigation Projects
  - 40 Federal Navigation Structures
# Project Status

<table>
<thead>
<tr>
<th>Project</th>
<th>Date/Status</th>
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<tbody>
<tr>
<td>Gulf Coast</td>
<td>06/10/2011</td>
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<tr>
<td></td>
<td>06/28/2011</td>
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<tr>
<td></td>
<td>Delivered</td>
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<td></td>
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<td>Lake Superior</td>
<td>07/21/2011</td>
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<td>January</td>
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<td>Lake Ontario/Erie</td>
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<td>East Coast</td>
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<td>Delivered</td>
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<td>January</td>
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</table>

| Collection | Processing | Products | Delivery* |

*Estimated Delivery Dates
± Preliminary Priority areas delivered already
Bathymetry and topography

Marquette Harbor, MI
Laser reflectance imagery

5-m resolution
Aerial photography

RGB imagery
20 cm
NCMP 2012 planned survey areas
Data Access

www.jalbtcx.org
Track our progress

2. Search NCMP
3. Choose 2011 NCMP Field Coverage
4. Maps can be modified
5. Under Layer Details\Service Details, layers can be exported as layers or a kmz to be viewed in ArcMap or GoogleEarth

Don’t need ArcGIS Desktop
Only Web Browser with MS SilverLight Installed
Mobile Device compatible
**GOAL**: identify/expand environmental and coastal engineering products, utilizing (1) data resources of JALBTCX and (2) expertise in ERDC to address district needs

**Environmental Applications:**
- Site Characterization
- Environmental Monitoring
- Habitat Identification
- Ecosystem Restoration Planning
- Emergency Response/Recovery
- Water Quality

**Coastal Engineering Applications:**
- Coastal Vulnerability
- Shore Protection and Navigation Projects
- Sediment Budgets
- Input into Numerical Models
- Volume Change Assessment
- Asset Management
Hyperspectral and Lidar Fusion

- Target features spectrally with hyperspectral and structurally with lidar through image fusion

Northern tip of Hunting Island, SC, 2010

CASI hyperspectral, RGB 1m topo lidar hillshade Fusion of hyperspectral and lidar
Landscape changes


17th Street Canal New Orleans, LA
Invasive species detection

- Spectrally and structurally target species of interest
- Emphasize changes in composition, structure and function in ecosystems caused by invasives

Times Beach, Buffalo NY, 2007
Emergent marsh dominated by *phragmites*
Wetlands Characterization

- Mapping Wetland Habitats
  - Spectrally and structurally target wetland species
  - Emphasize species pattern characterization and zonation related to elevation gradients
  - Wetland condition assessment

Edisto Island, SC, 2010; south of Jeremy Inlet
Stamp Sands Discrimination

**Objective:** classify lake bottom using hyperspectral/lidar reflectance. Map stamp sands distribution, estimate movement/loss of stamp sands to lake, and aid in reef restoration.
Dredging Operations and Environmental Research Work Unit:

Use of Airborne Lidar and Hyperspectral Data to Detect and Discriminate SAV Species at Corps Dredging Sites

**Purpose**: evaluate and demonstrate the use of fused airborne hyperspectral and bathymetric lidar data to detect and discriminate species of estuarine SAV and macroalgae in two representative small-craft dredged harbors

**Background**: Dredging impacts to SAV vary by species; CWA lists SAV as a Special Aquatic Site; Mapping species is important for:

- Planning dredging operations
- Mitigating ecological damage
- Monitoring SAV

**PI**: Bruce Sabol, EL

Submersed Eelgrass spectra, Plymouth Harbor, MA
Image Processing Methods: DPS

- Coastal Zone Mapping and Imaging Lidar (CZMIL) Data Processing System (DPS)

*Spectral Optimization* to characterize seafloor and water column

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**Spectral Angle Mapper Classification Results: Optimized Bottom Reflectance**

<table>
<thead>
<tr>
<th>Classified image</th>
<th>Non-Veg</th>
<th>Veget.</th>
<th>Total</th>
<th>Row Total</th>
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<td>Non-Veg</td>
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<td>1</td>
<td>6</td>
<td>10</td>
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<tr>
<td>Veget.</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>20</td>
</tr>
</tbody>
</table>

Overall Accuracy: 87.8%

User's Accuracy: Non-Veg (6/10) = 60.0%; Veg. (6/10) = 60.0%; Total: 60.0%

*Note: The 5 meter buffer was applied to sites to account for GPS error (sampling locations around a GPS recording from a non-anchored boat, and raster spatial resolution accuracy (2 meters)).

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**Air-Photo Classification Results**

<table>
<thead>
<tr>
<th>Delineation Data</th>
<th>Training Data</th>
<th>Row Total</th>
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<tbody>
<tr>
<td>No Veg Poly</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Outside No Veg Poly</td>
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<td>20</td>
</tr>
<tr>
<td>Column Total</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

Overall Accuracy: 82.5%

User's Accuracy: No Veg Poly (10/20) = 50.0%; Total: 50.0%

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**Photo-interpretation of Seagrass, Plymouth Harbor, MA**

By Massachusetts Department of Environmental Protection

Overall Accuracy: 82.5%

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**Image Classification of SAV, Plymouth Harbor, MA**

Overall Accuracy: 87.8%

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- Water leaving reflectance
- Water column attenuation
- CDOM absorption
- Chl concentration
- Active seafloor reflectance
- Spectral seafloor reflectance
Asset management: Structures

Couple NCMP activities and data products with R&D for condition assessment tools.

JALBTCX Tasks:
1) Elevation and imagery clips
2) Initial screening to support condition assessments
   - Length
   - Average height
3) Enterprise Coastal Structure Database (eCID) support
Asset management: Structures

- Clip elevation and imagery data from NCMP using structure centerlines from NCDB
- Populate eCID with basic structure information: length, average height, maximum height, minimum height

Average Height \(\text{blue seg} = 185.73\) m

Length \(\text{blue seg} = 16\) m
Asset management: Applications

- Change detection along cross-sections
  - As-builts
  - Historical
  - Recent

- Additional parameters to populate eCID
  - Side slope
  - Crown width
Volume Change
Volume Change

Time Series: Pre- and Post- Ivan

June, 2004

December, 2004

FDEP Monuments

100-m spacing transects
Volume Change

Surface Difference
- Preserve data gaps for analysis
- Transect bins (gray shaded area)

\[ NV_1 = \frac{V_1}{A_1} \]

\[ dV = NV_2 - NV_1 \]

\[ MHWV = V_2 - V_1 \]
Volume Change
Volume Change

Total Volume Change

Elevation Change (meters)
- > +1 m
- 0.2 m to 1 m
- -0.2 m to 0.2 m
- -1 m to -0.2 m
- > -1 m

Volume Change (CY/ft)

Transect Number

R-2 R-3 R-4 R-5-T R-6 R-7 R-8 R-9-T R-10 R-11 R-12 R-13-T R-14 R-15

1565 1560 1565 1570 1575 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635
Sediment Pathways & Budget - RSM

- Delineate morphological features of the shoal system using automated feature extraction
- Quantify amount of sediment entering/leaving system
  - Sediment budget
- Volumes/ Volume change from bathymetric data to provide input into sediment budgets
- Refine sediment budgets and identify areas of viable fill material
Coastal Vulnerability

- Geomorphic Metrics
  - Automated feature extraction
  - Seaward most dune
  - Minimum wet/dry contour
  - Identify areas of vulnerability
  - Narrow beach width
  - Low elevations in dune line

Cells for a typical beach profile

- Wide beach and dunes
  - provide protection to upland infrastructure
  - valuable habitat

Metrics as indicators of vulnerability
Shore Protection

- Beach Nourishment Projects
  - Placing sand on the beach provides recreational area, storm protection, environmental habitat
- NCMP data available for monitoring project performance
  - Volumetric and contour change
  - Identifying re-nourishment requirements
  - Determine storm damages prevented
- Hot-spot analysis

Average Volume Change: 10 m$^3$/m

2006 Post Nourishment – 2005 Post Katrina
Navigation Projects

- Automate channel condition assessment using bathymetric data and channel framework
- Channel availability

<table>
<thead>
<tr>
<th>Navigation Channel Condition Ranking</th>
<th>Condition Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>95% Channel Navigable</td>
</tr>
<tr>
<td>Moderate</td>
<td>75% Channel Navigable</td>
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<tr>
<td>Poor</td>
<td>50% Channel Navigable</td>
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<tr>
<td>Failing</td>
<td>25% Channel Navigable</td>
</tr>
<tr>
<td>Failed</td>
<td>0% Channel Navigable</td>
</tr>
</tbody>
</table>

- Identify areas of concern after storm events and use multiple surveys to show migration of the channel

2010 NCMP

Dredged Channel

Waukegan Harbor

Centerline
Quarter lines
Toe lines

Spur Jetty

Ebb Shoal

2005 Post-Katrina channel condition assessment of East Pass, FL

BUILDING STRONG®
Models

• CMS – Coastal Modeling System
  – Simulating waves, currents, water level, sediment transport, and morphology change at inlets
    • effects of changes to the inlet features (mining ebb shoal for beach fill material, changes in dredging, etc.)
    • Friction values from land cover and substrate classification
• Beach-fx
  – Corps approved economic model for coastal storm damage reduction studies
    ▪ Characteristic beach profile delineation
• GenCade – long-term shoreline change model
  • Lidar extracted wet/dry line
  • Structure data as break line

More powerful models require more accurate and extensive data sets for model input and for validation of model output.
Coastal Zone Mapping and Imaging Lidar

Hardware development

- shorter laser pulse length
- circular scan
- faster laser pulse rate
- faster area coverage
- operation in more turbid and deeper waters
- improved performance in breaking waves
- improved navigation hazard detection
- improved accuracy for depth measurement, water column properties, and bottom characterization
- higher-density topographic and shallow bathymetric measurements
- shorter system response
- more sensitive receivers
- segmented detector
- larger field-of-view
- single-laser solution
Questions?

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