Technical challenges in coastal mapping

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Outline

• Why we map the coast
• Characteristics of the coastal environment
• Coastal mapping technologies
• Coastal mapping platforms
• Coastal mapping supporting data
• Technical challenges
Why we map the coast

• Cartography (nautical charts and topographic maps)

• Understand coastal change, long-term and episodic

• Understand composition of the coastal landscape
Coastal changes both natural and manmade
Comparison 1:20,000 T-Series Map and Geographic Cell

Minimum Width 10 m
Or 0.5 mm at Map Scale
Characterizing the coastal landscape

GREEN
Accreting shoreline, high dune, wide beach, critical habitat, more natural landscape

YELLOW
Stable shoreline, medium dune and beach width, some critical habitat, more developed

RED
Eroding shoreline, low dune, narrow beach, no critical habitat, developed landscape
Ecological Modeling for Landscape Change Analysis

1) Identify changes to critical habitat using multi-temporal imagery and lidar data

2) Derive landscape metrics associated with landscape patterns

3) Integrate with ecological simulation to develop a better understanding of factors influencing change and a tool to assess project level impacts/benefits

<table>
<thead>
<tr>
<th>Metric</th>
<th>Process</th>
<th>Benefit</th>
</tr>
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<tbody>
<tr>
<td>Clumpiness</td>
<td>Biodiversity</td>
<td>⇕ ⇐⇑</td>
</tr>
<tr>
<td>Cohesion</td>
<td>Connectivity</td>
<td>⇐⇑ ⇕</td>
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The coastal environment

- Dynamic water
  - Waves
  - Tides
  - Freshwater inflow

- Dynamic land
  - Sediment transport
  - Subsidence

- Variable landscape
  - Development
  - Sediment
    - Mud
    - Sand
    - Gravel
    - Rock
    - Cliffs
  - Wetlands
  - Structures
Technologies for coastal mapping

- Conventional (lead line, rod and level, total station)
- Sonar (single beam, multibeam, sidescan)
- Lidar (topographic, terrestrial, bathymetric, mobile, topo-bathy)
- GPS
- Imagery
- Radar

http://intraweb.stockton.edu/eyos/page.cfm?siteID=149&pageID=125
Platforms for coastal mapping

- Airplanes
- Boats, kayaks, jet skis
- SUVs
- Pedestrians, swimmers
- Tripods, masts
- Specialized vehicles
- Satellites
- Autonomous underwater vehicles
- Unmanned aerial systems
Technologies for coastal mapping
Airborne vs. shipborne data collection

- Operates in shallow water regions
- Extends survey over the beach
- Rapid response to new survey areas

Shallow water Lidar vs. Multibeam
Reference data for coastal mapping

- Spatial reference system (horizontal and vertical)
- Lever arms
- Sound speed
- Water levels (tides)
- GPS constellation
- Ground truth for calibration/validation
Operational considerations

- Wave/Wind Energy
- Tide Coordination
- Weather Conditions
- Sun Angle
- GPS
- Water Clarity
- Flight Restrictions
- Vegetation stage
- Resources
- Engineering activity
- Logistic Issues
- Climatology (weather, water clarity, waves)
- Solar conditions
- GPS constellation
- Water surface
Daily flight windows
GPS control and flight restrictions
Tide level and solar illumination

1 m pixel resolution
36 spectral bands
375-1050 nm

Seabrook, New Hampshire
2005
Vegetation and solar elevation

1 m pixel resolution
36 spectral bands
375-1050 nm

Near Laurence Harbor, NJ
Post-Sandy 2012
Challenges in lidar shoreline mapping

- Extremely difficult to adequately cover MLLW line in topo-only lidar
  - Very stringent collection requirement for imagery or topo lidar
  - MLLW often at the edge of dataset in area where many algorithms fail and data are sparse and noisy
  - Lots of drop outs in wet areas (due to low SNR at NIR λ’s)
- Shoreline data gap
  - Breaking waves
  - Suspended sediments
Bathymetric lidar principle

- **Incident Laser Pulse**
- **Receiver Field of View**
- **Specular Interface Reflection**
- **Illuminated Surface Area**
- **Scattering and Absorption**
- **Surface Region in Receiver FOV**
- **Diffuse Bottom Reflection**
- **Unscattered Ref Path**
- **Mean Water Nadir Angle**
- **Volume Backscatter**
- **Detected Bottom Return**
- **Volume Backscatter**
- **Surface (Interface) Return**

**Time (t)**

**Amplitude**
Laser pulse length and system response
Laser pulse length and system response

Ft. Lauderdale, 1.5m ($K_d \approx 0.12 \text{ m}^{-1}$, Shallow water channels)

CZMIL
Better SNR and shorter system response
- Detect bottom deeper
- More accurate input to algorithms
- Better shallow water discrimination

Compare ELECTRICAL domain
The biggest challenge

• Synoptic data collection capabilities do not work everywhere!
  – Persistent turbid water
  – Wetlands
  – Persistent white water
Conclusions

• The coastal environment poses many challenges to data collectors
• Each technology and platform has limitations
• Mapping technologies are most effective used in combination
• “Coastal environment is still under sampled at wide range of time scales”