# Technical challenges in coastal mapping

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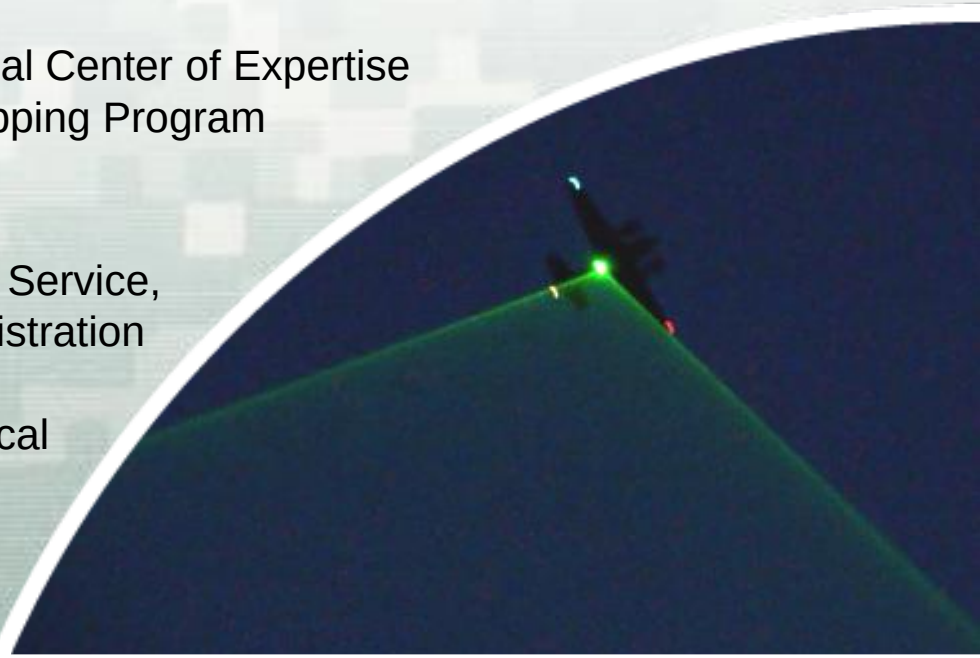

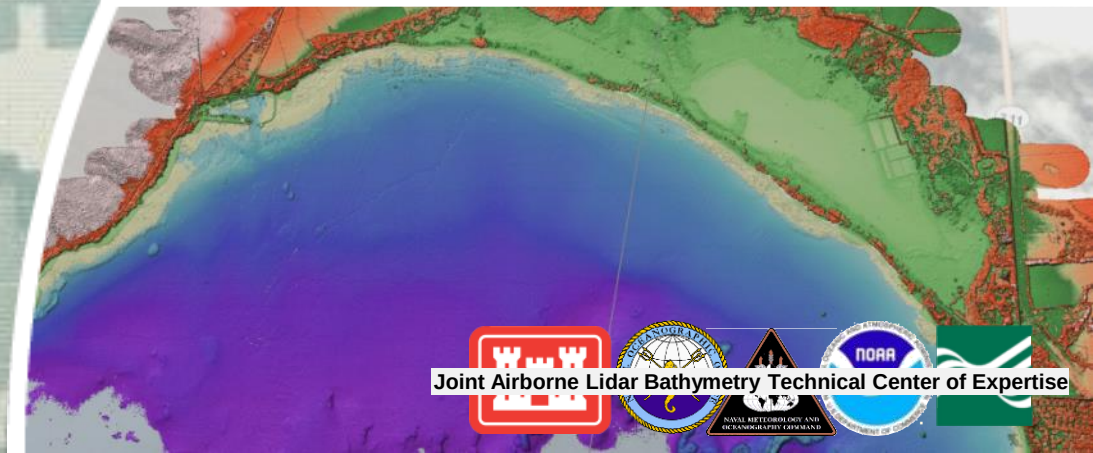

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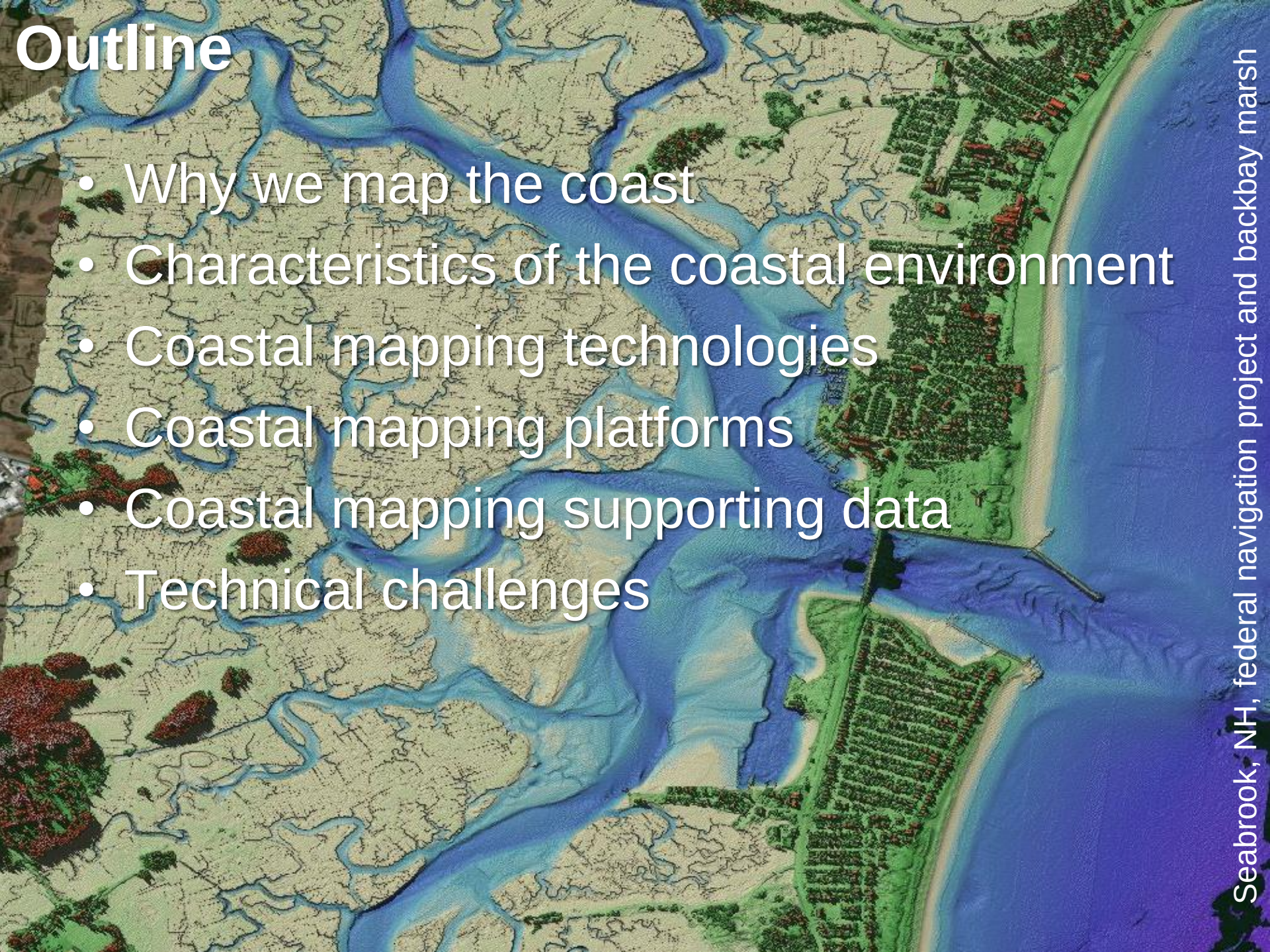
# Outline

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



Seabrook, NH, federal navigation project and backbay marsh

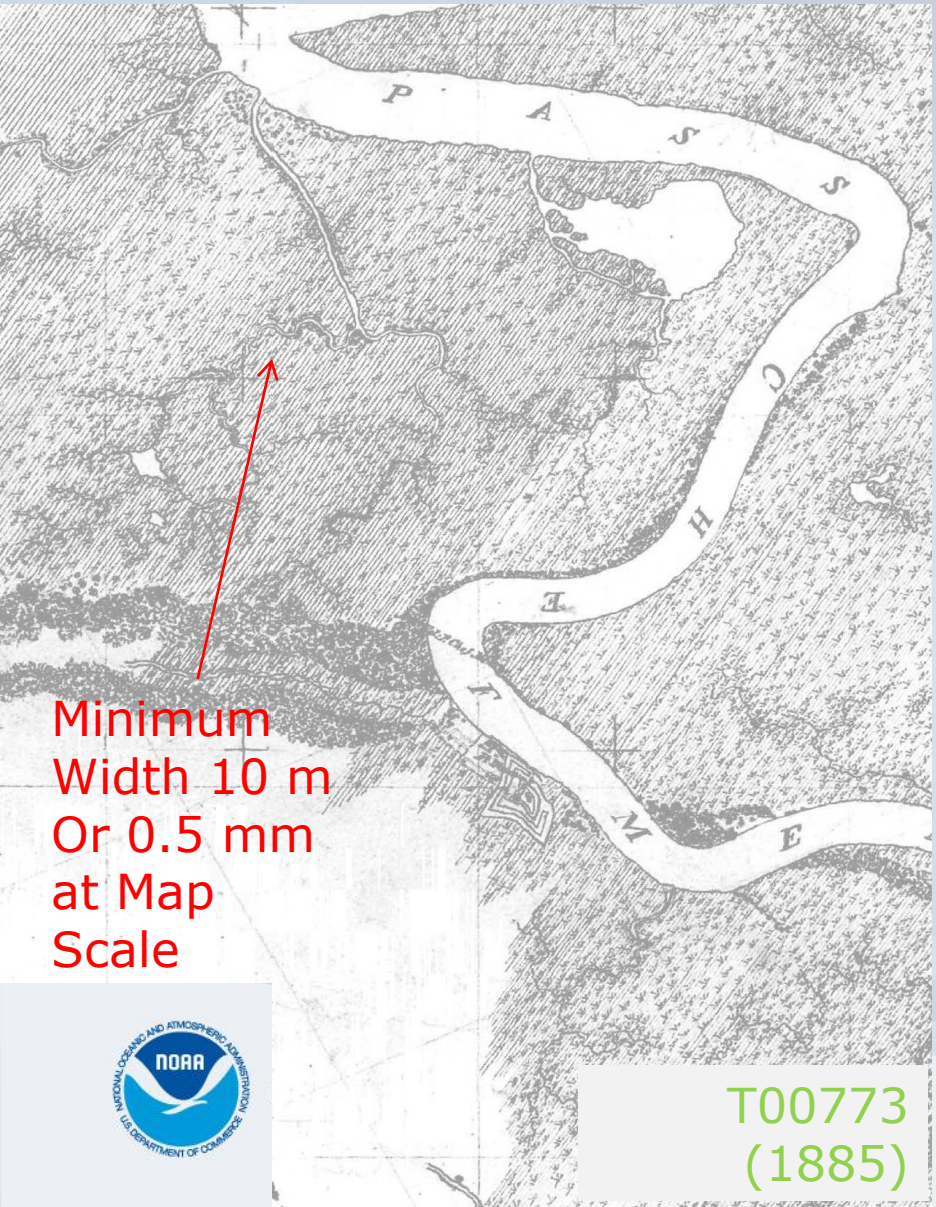
# Why we map the coast

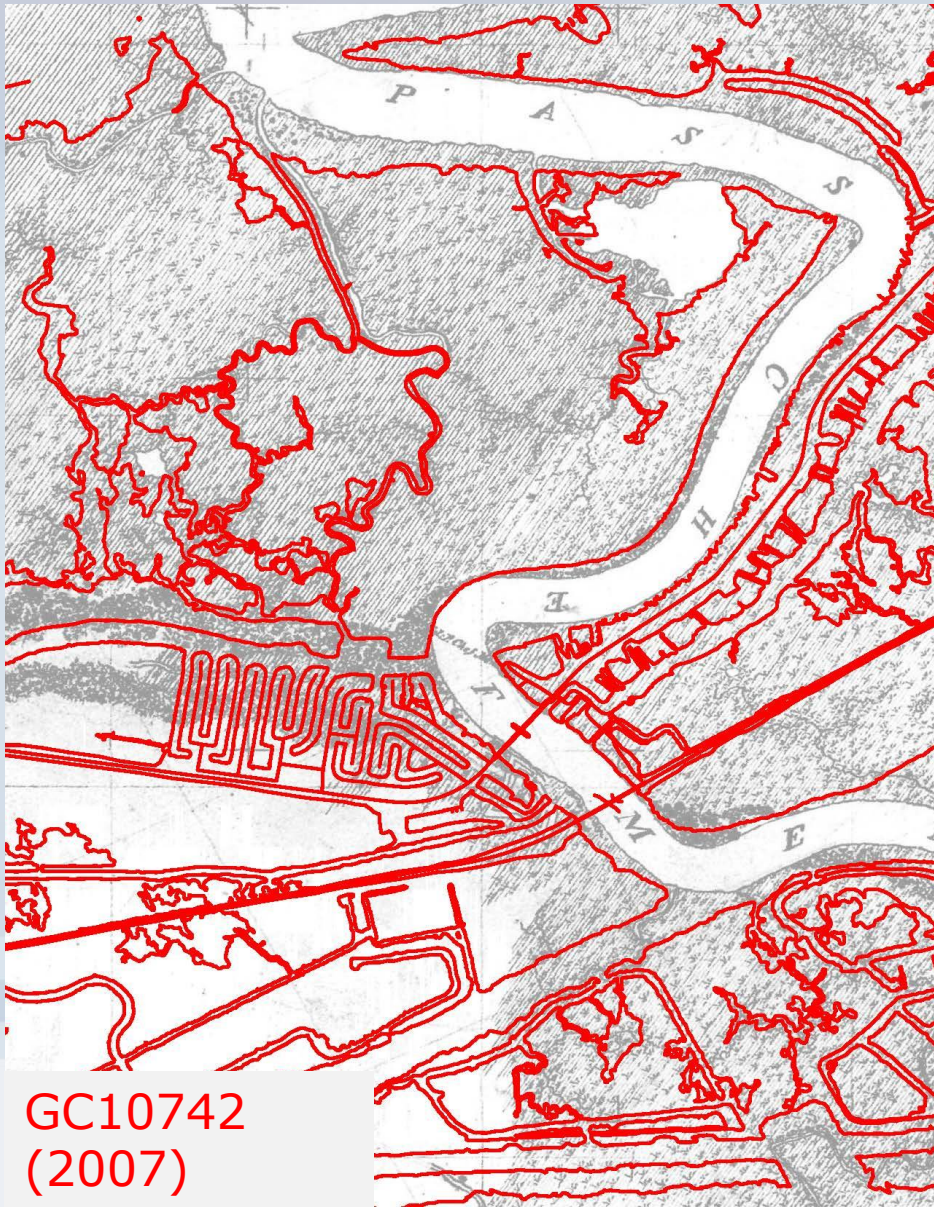
- Cartography (nautical charts and topographic maps)
- Understand coastal change, long-term and episodic
- Understand composition of the coastal landscape

- Structure condition assessment
- Post-storm damage assessment
- Regional sediment management
- Sediment transport pathways and rates
- Channel, shoal, and beach volumes and volume change
- Inundation modeling
- Planning studies
- Emergency management
- Hydraulic/hydrologic modeling
- Morphology change
- Habitat restoration design
- Environmental assessment
- Overland flooding analysis
- Surge and wave island modeling studies
- Tidal modeling
- Existing condition (topography, bathymetry, infrastructure)
- Wave modeling
- Environmental stewardship

# Coastal changes both natural and manmade

## Comparison 1:20,000 T-Series Map and Geographic Cell



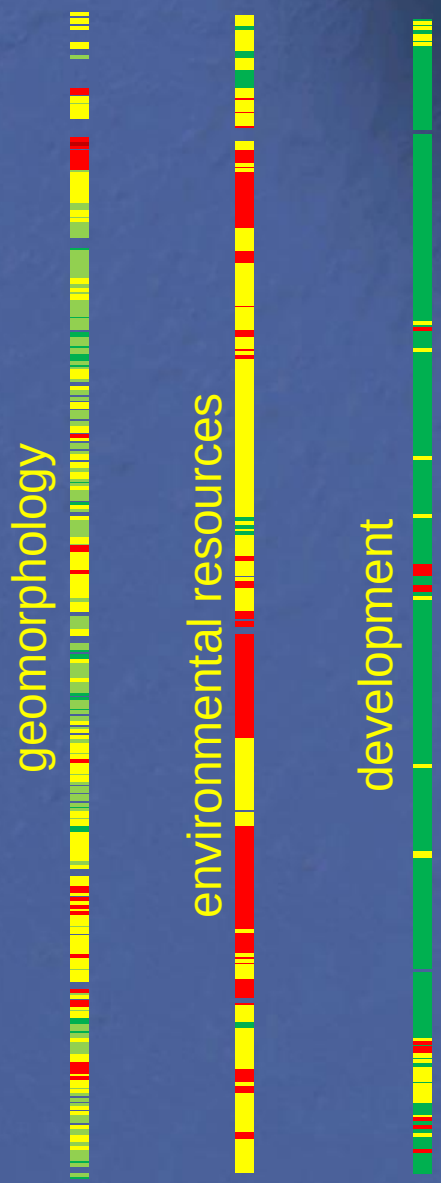



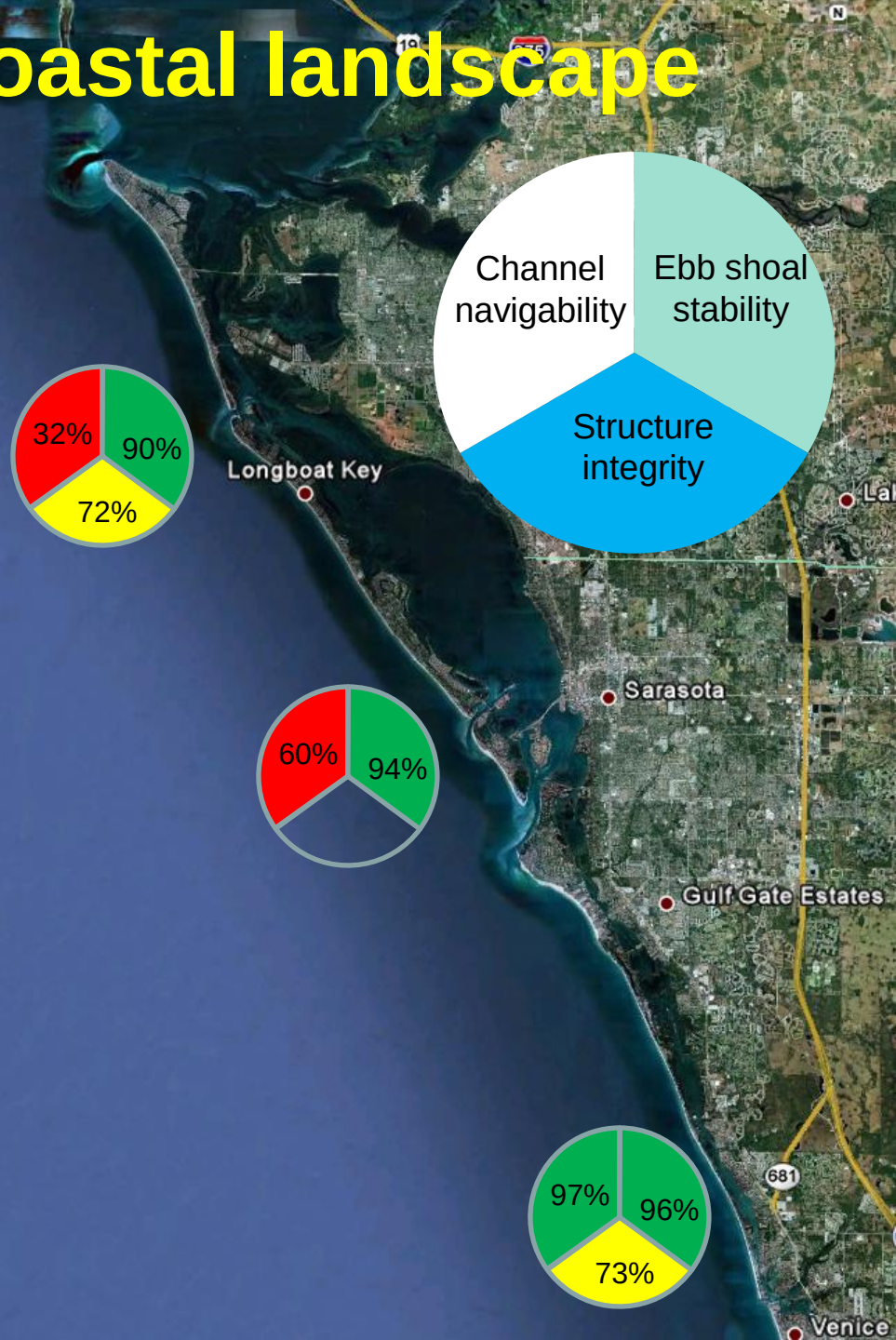
# Characterizing the coastal landscape

**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

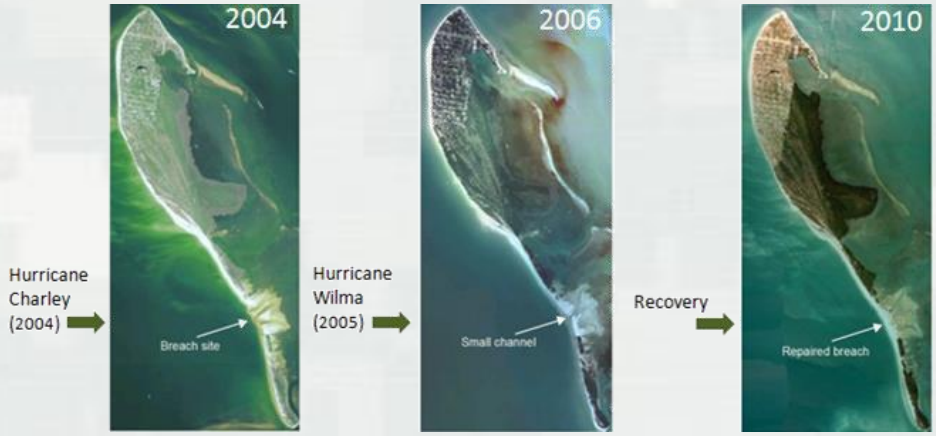
**RED**
Eroding shoreline, low dune, narrow beach, no critical habitat, developed landscape

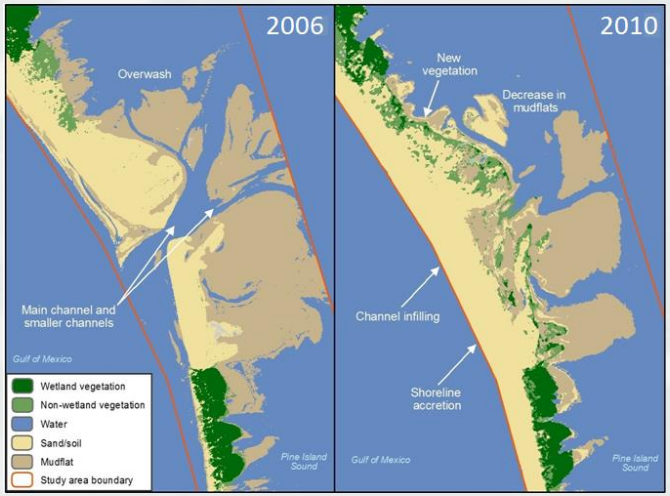


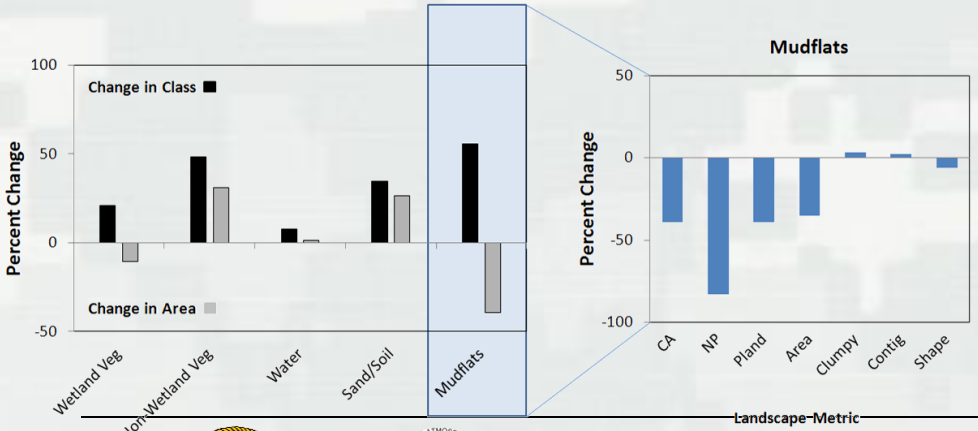
# Ecological Modeling for Landscape Change Analysis

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

*Change in Landscape Pattern*

*Change in Ecosystem Function*

*Quantify Impacts*

| Metric | Process | Benefit |
|---|---|---|
| Clumpiness | Biodiversity | ↑↓ |
| Cohesion | Connectivity | ↓↑ |

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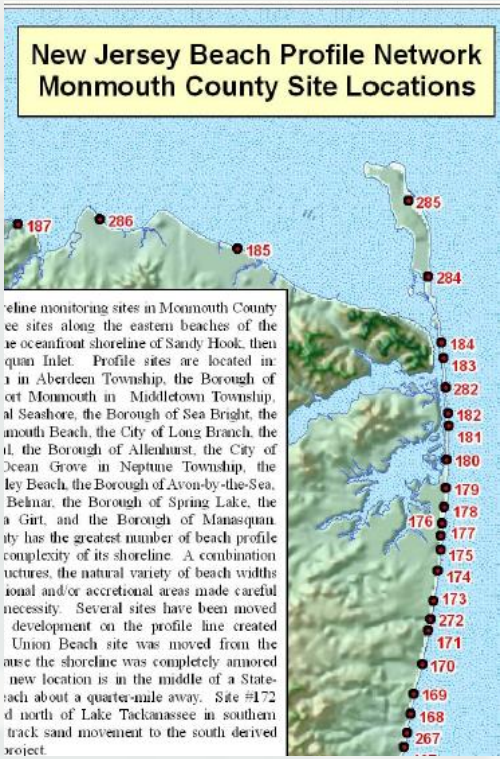
# The coastal environment

- 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



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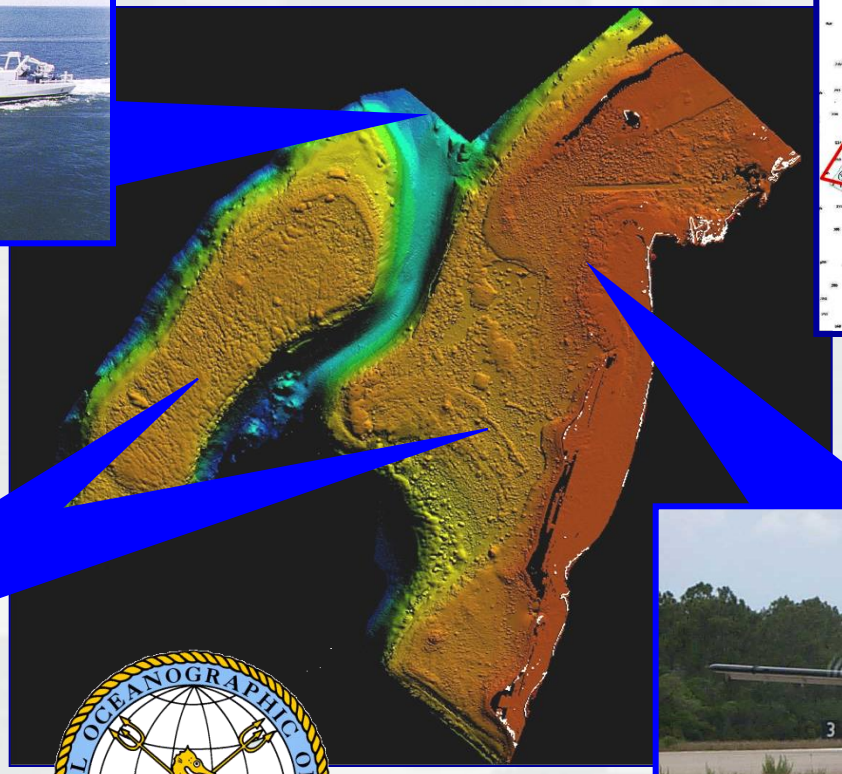
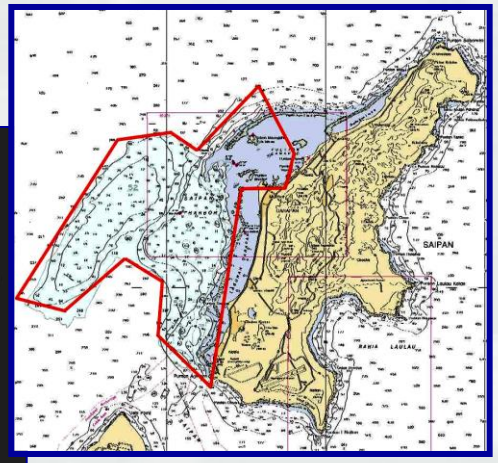
# Platforms for coastal mapping

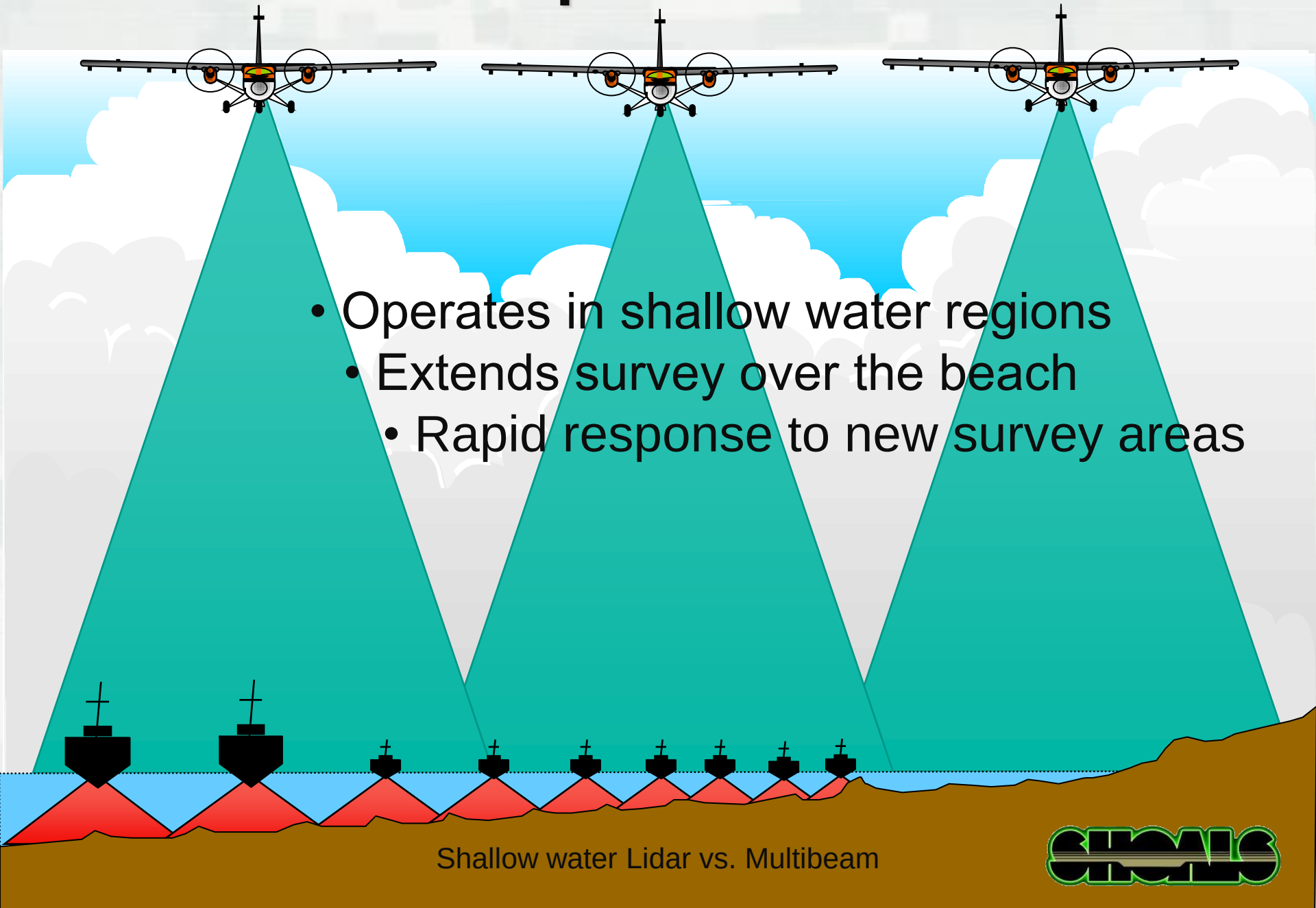
- Airplanes
- Boats, kayaks, jet skis
- SUVs
- Pedestrians, swimmers
- Tripods, masts
- Specialized vehicles
- Satellites
- Autonomous underwater vehicles
- Unmanned aerial systems

# 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

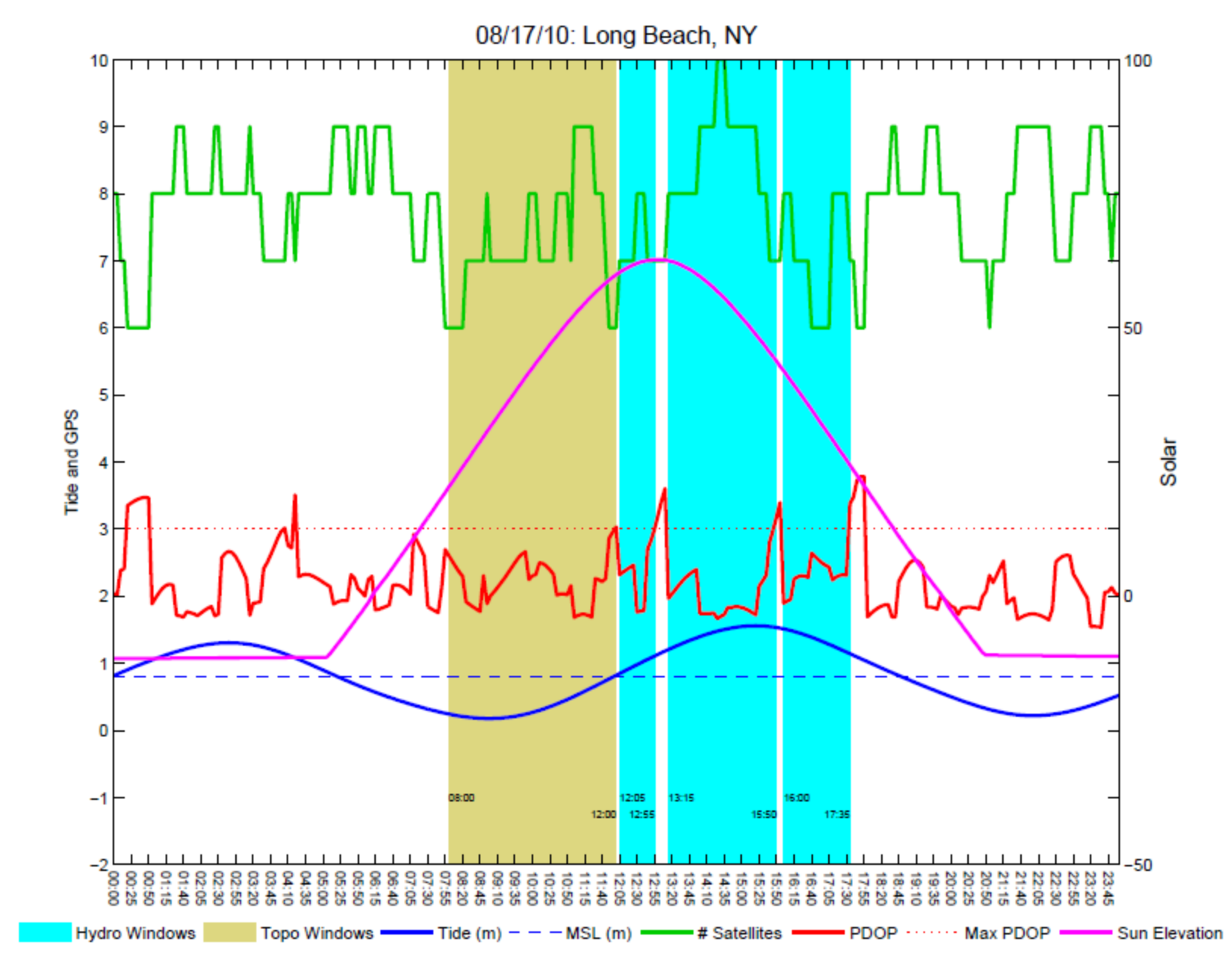
# Reference data for coastal mapping

- 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

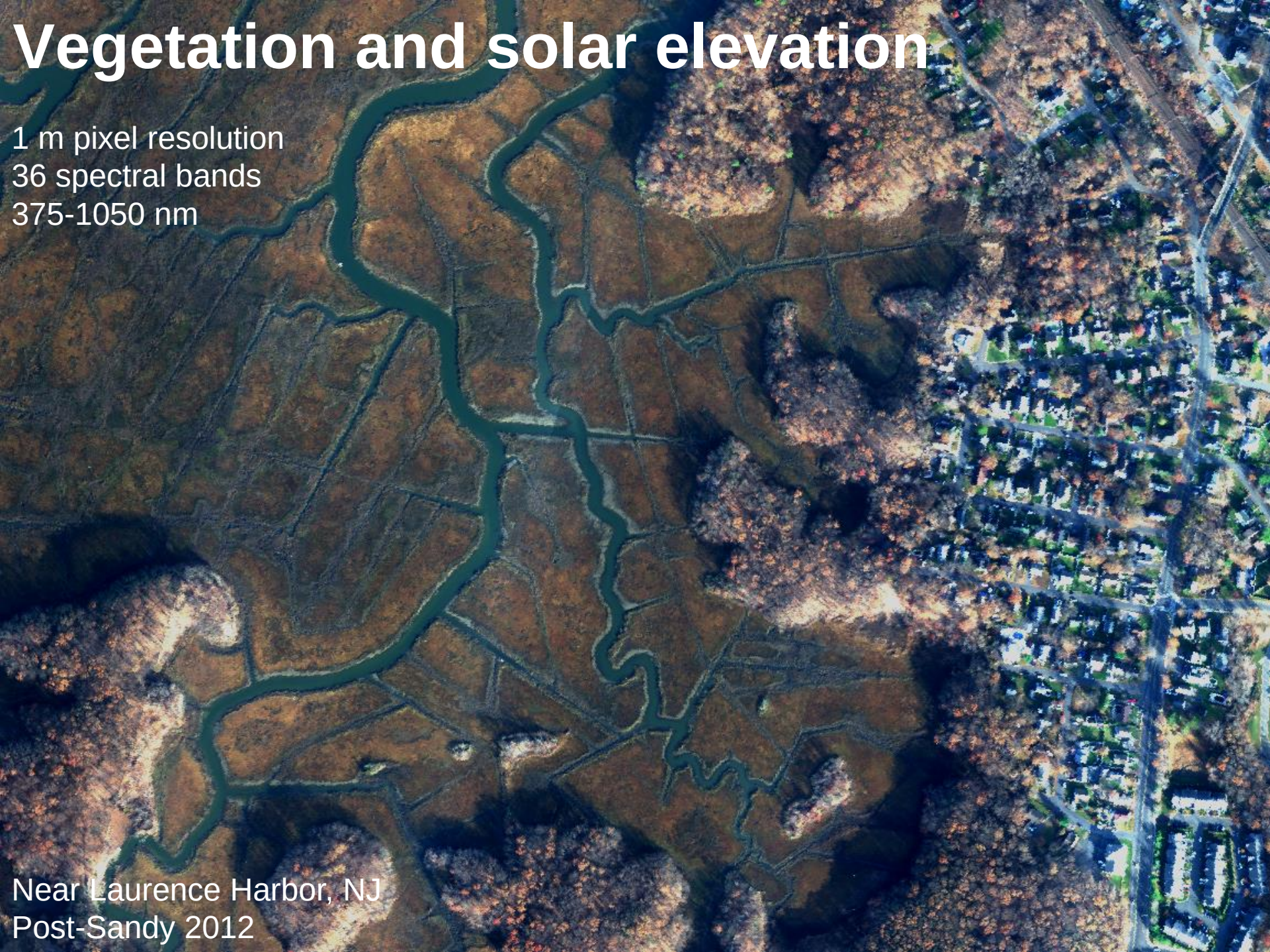
# Tide level and solar illumination

1 m pixel resolution
36 spectral bands
375-1050 nm

Seabrook, New Hampshire
2005

# Vegetation and solar elevation

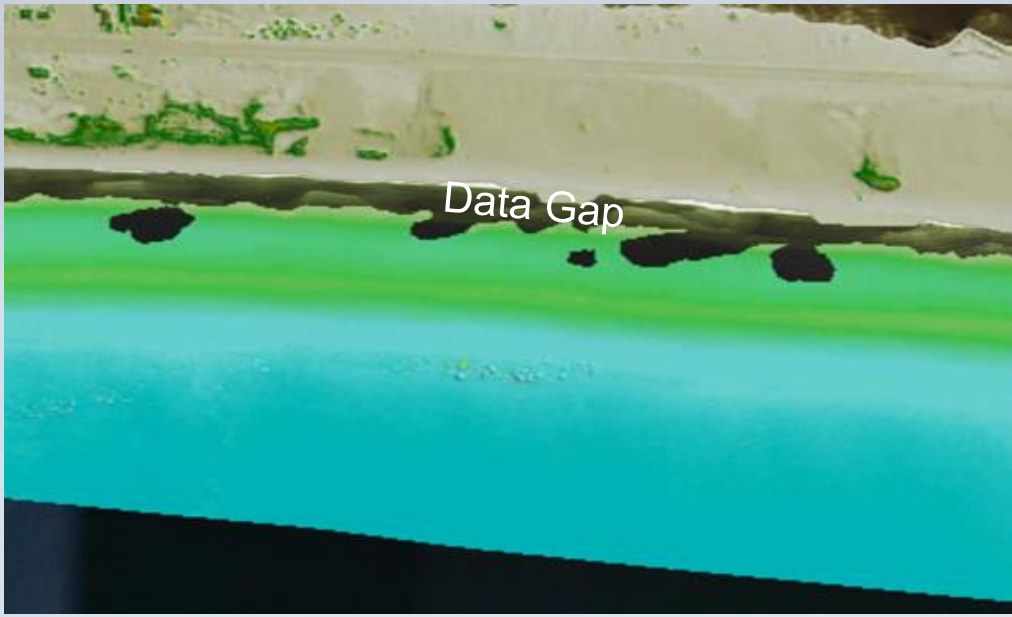
1 m pixel resolution
36 spectral bands
375-1050 nm

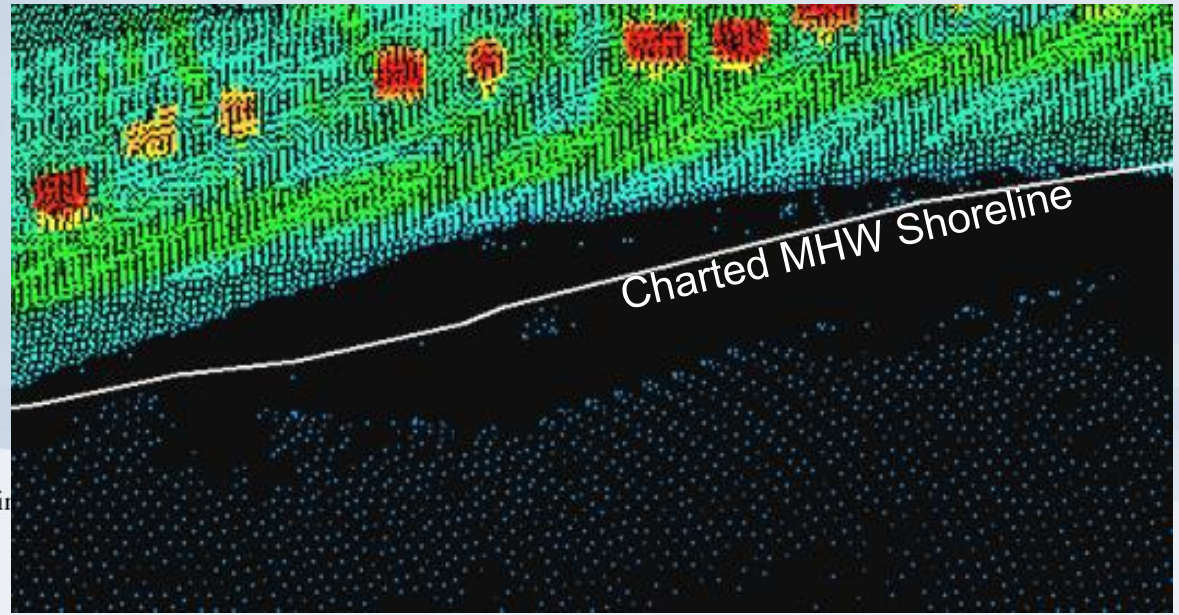


Near Laurence Harbor, NJ
Post-Sandy 2012

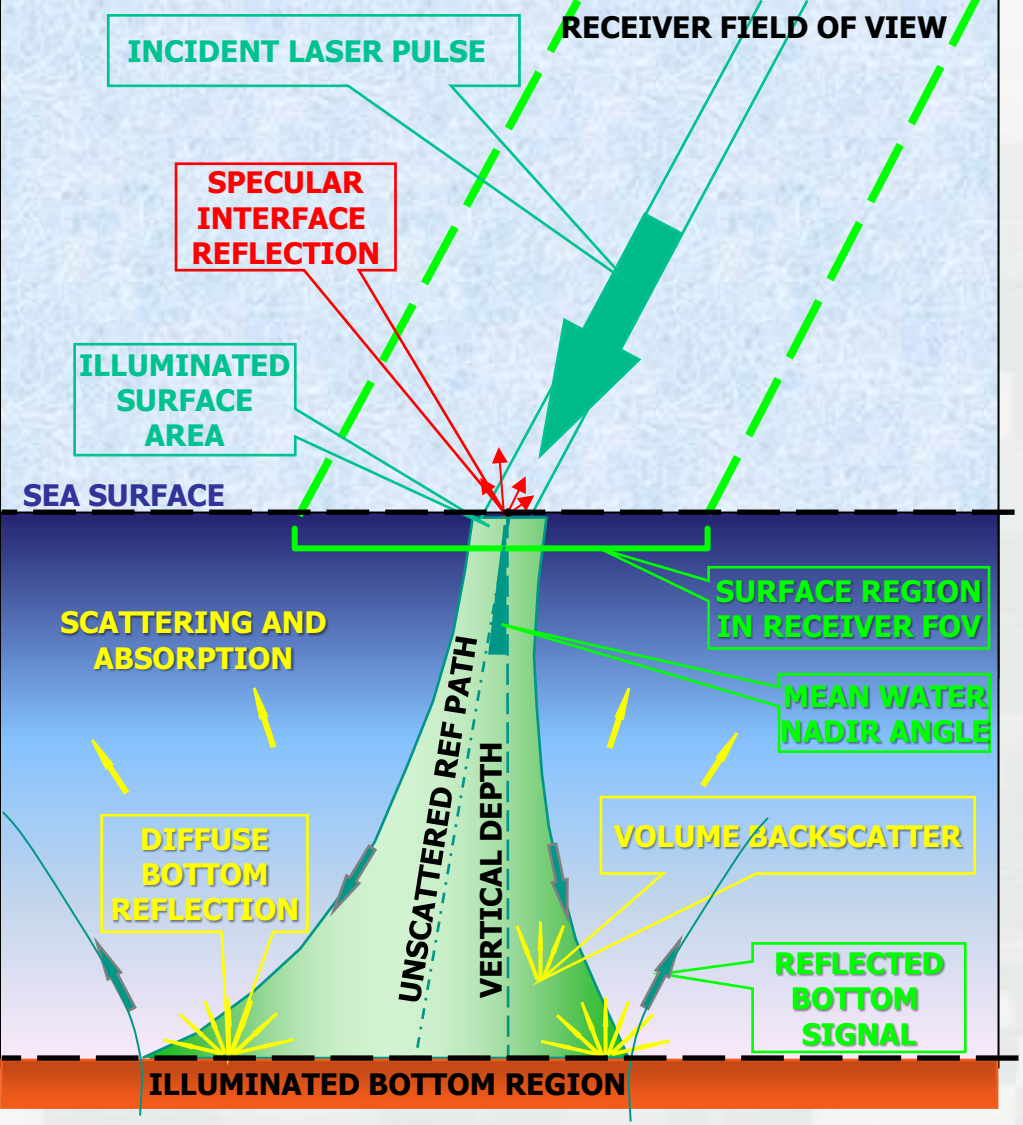
# Challenges in lidar shoreline mapping

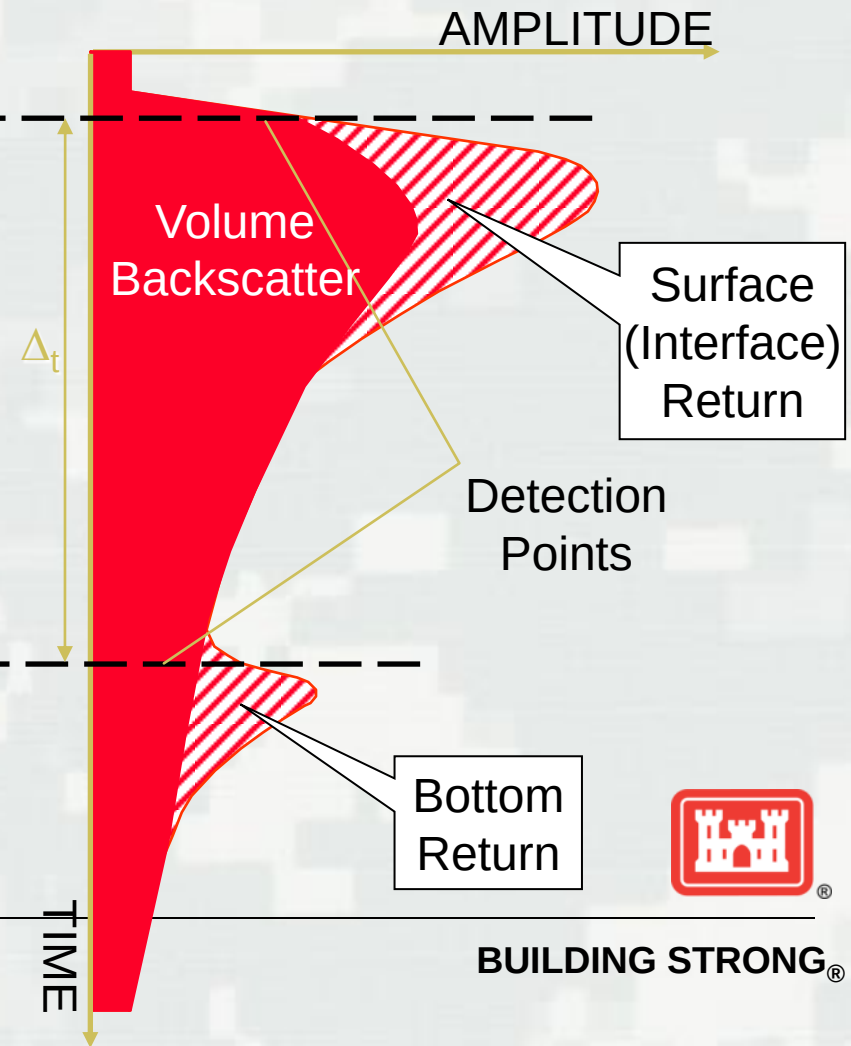
- Extremely difficult to adequately cover MLLW line in topo-only lidar
  - Very stringent collection requirement for imagery or topo lidar
  - MLLW often at the edge of dataset in area where many algorithms fail and data are sparse and noisy
  - Lots of drop outs in wet areas (due to low SNR at NIR $\lambda$'s)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



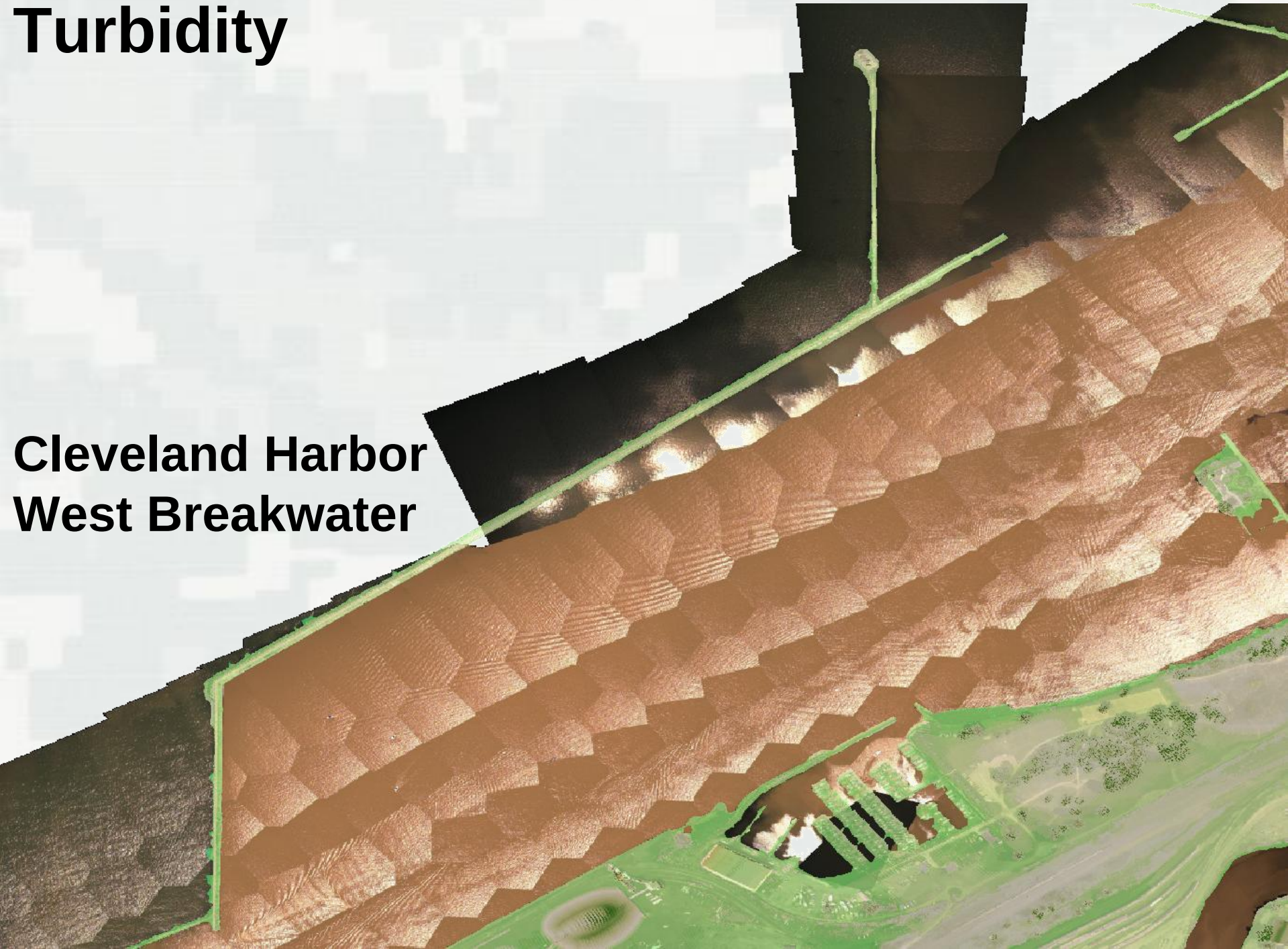



# Bathymetric lidar principle



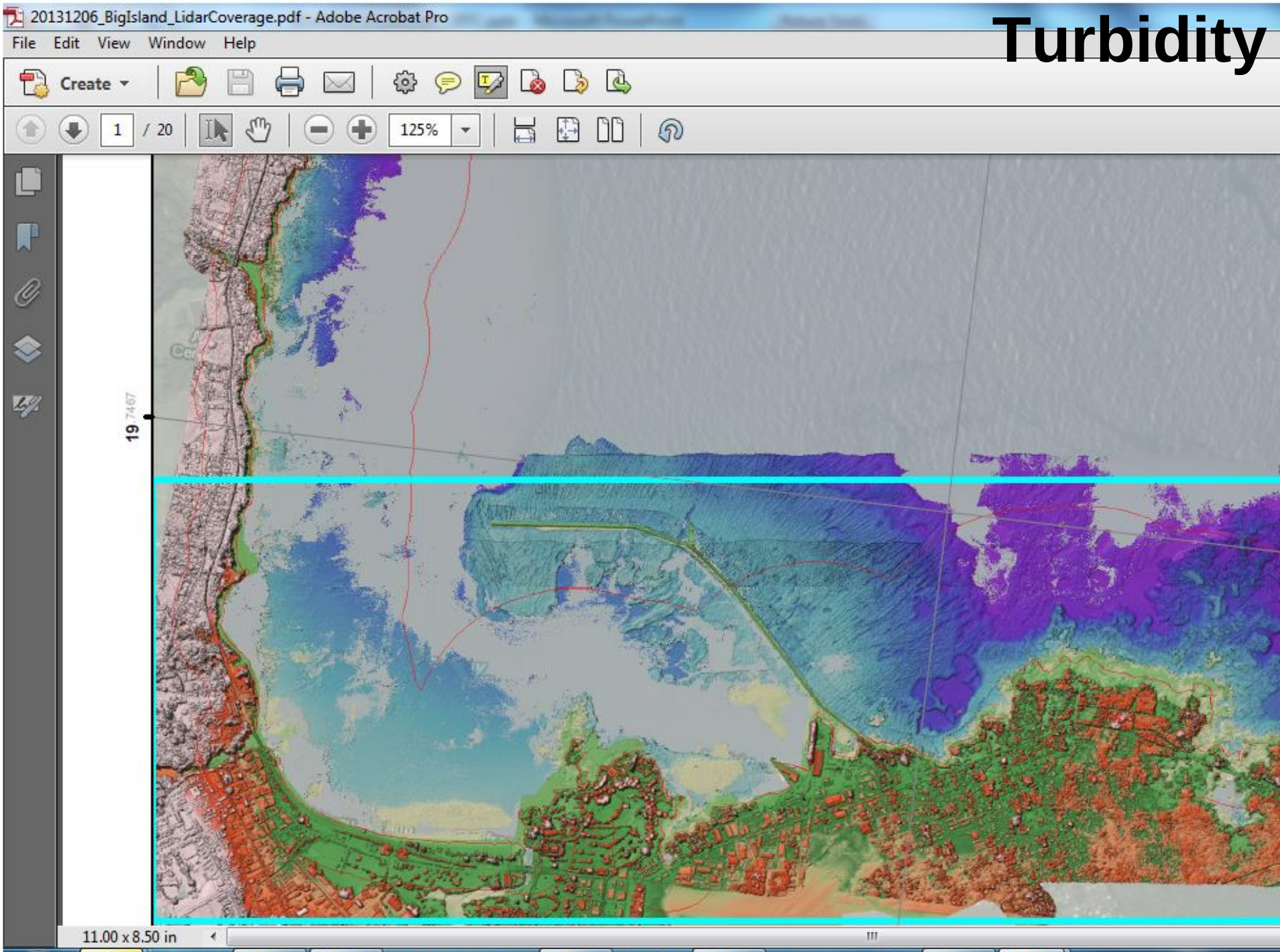



# Turbidity



## Cleveland Harbor
## West Breakwater

# Turbidity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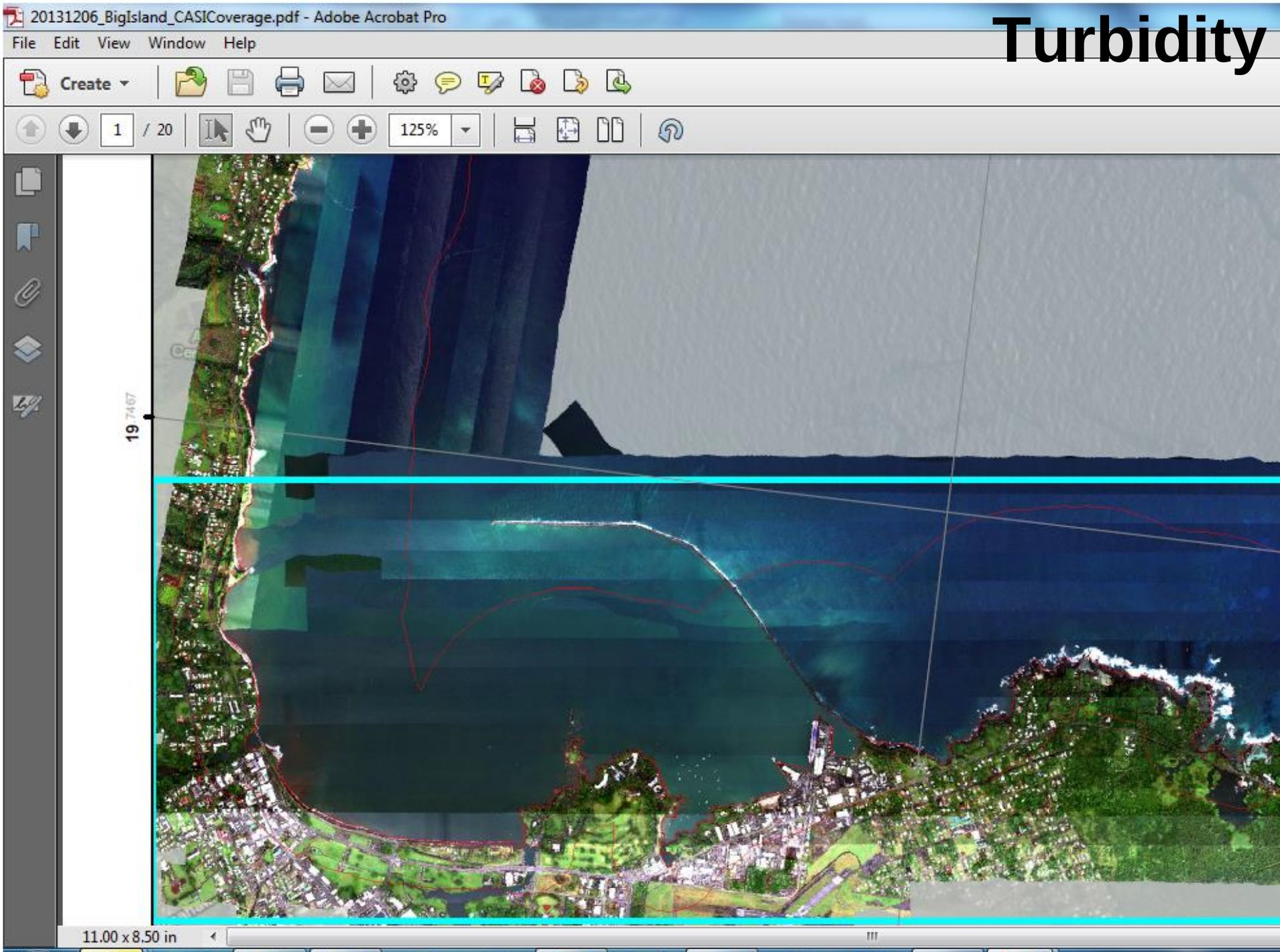
# Turbidity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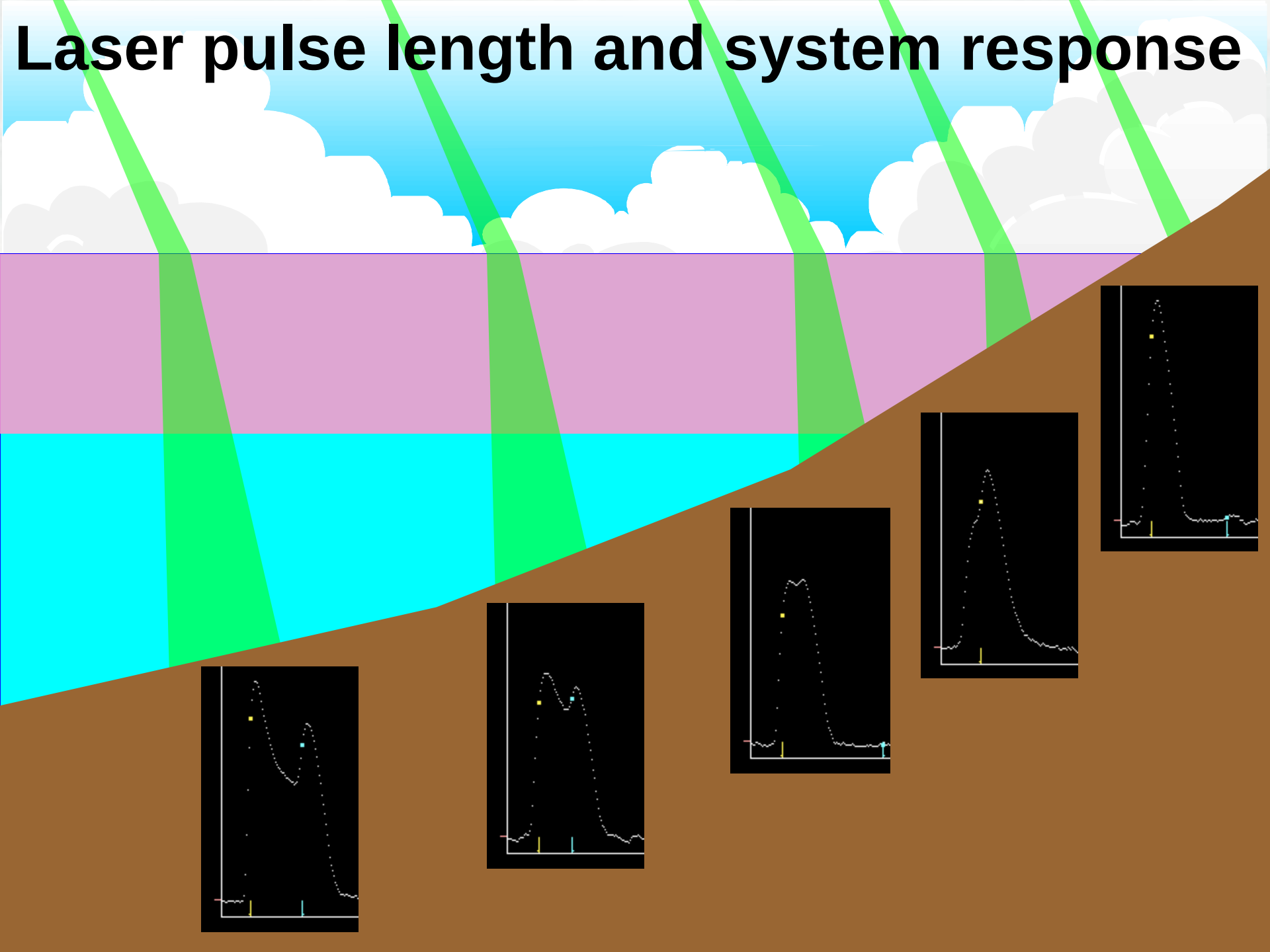
# Laser pulse length and system response



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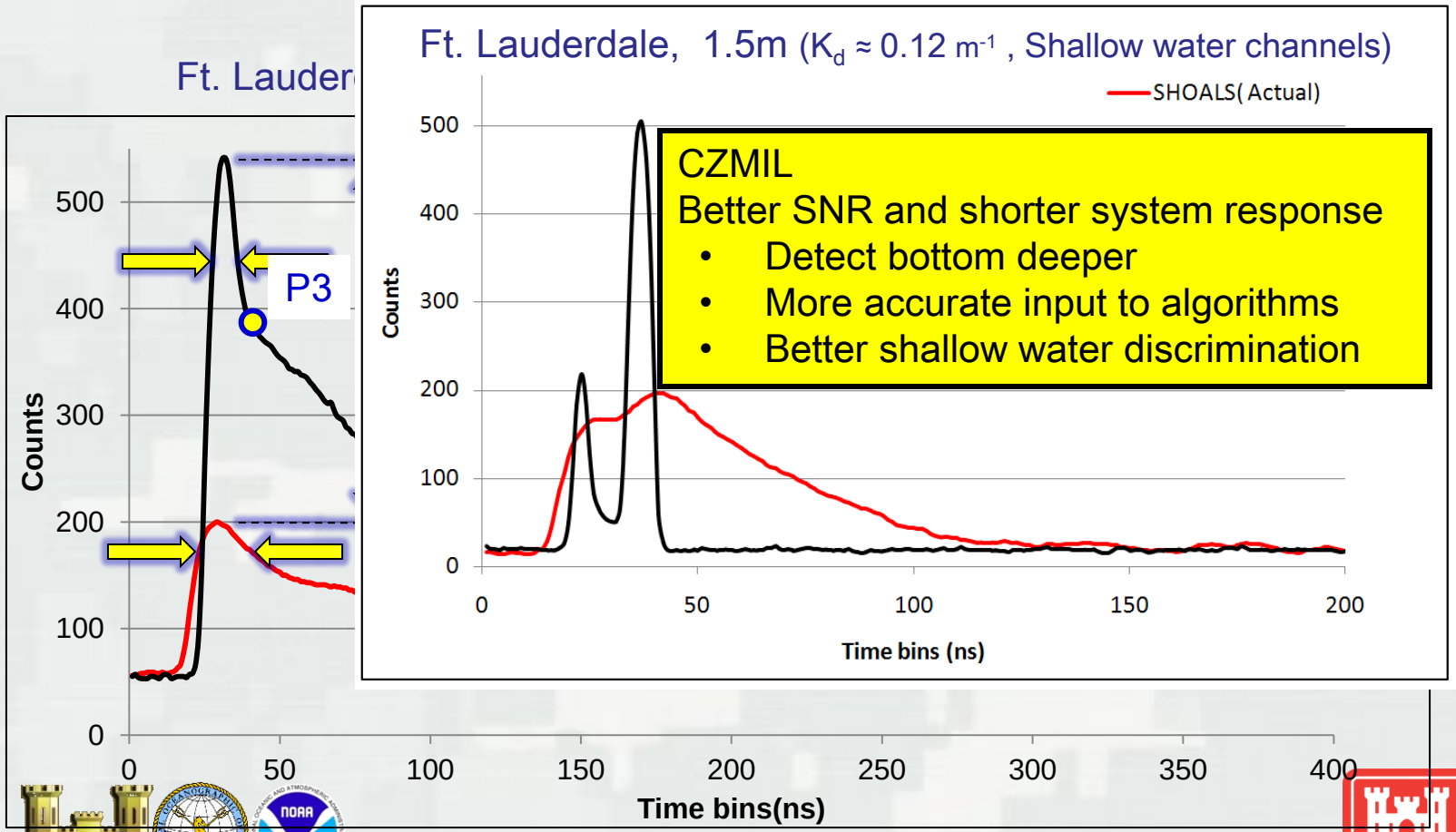


Compare ELECTRICAL domain

# 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”

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Seabrook, NH, federal navigation project and backbay marsh