Submerged Aquatic Vegetation (SAV) Species Discrimination Using an Airborne Hyperspectral/Lidar Sensor System

Molly Reif

US Army Engineer Research and Development Center, Environmental Laboratory (EL)

Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX), Kiln, MS

June 29 – July 1, 2010

US Army Corps of Engineers
BUILDING STRONG®

Joint Airborne Lidar Bathymetry Technical Center of eXpertise

- **JALBTCX**
  - **Operations**
    - USACE
    - Navy
  - **Technology Evolution**
    - Coastal Measurements & Data Usage
    - Sensors & Systems
    - NOAA

Optech

US Army Corps of Engineers MOBILE DISTRICT

U. S. Naval Research Laboratory Stennis Space Center, MS

EARTH SCIENCE APPLICATIONS DIRECTORATE
John C. Stennis Space Center

Welcome to the US Army Corps of Engineers, Engineer Research and Development Center
Waterways Experiment Station, Vicksburg, MS

Department of Marine Science
of The University of Southern Mississippi

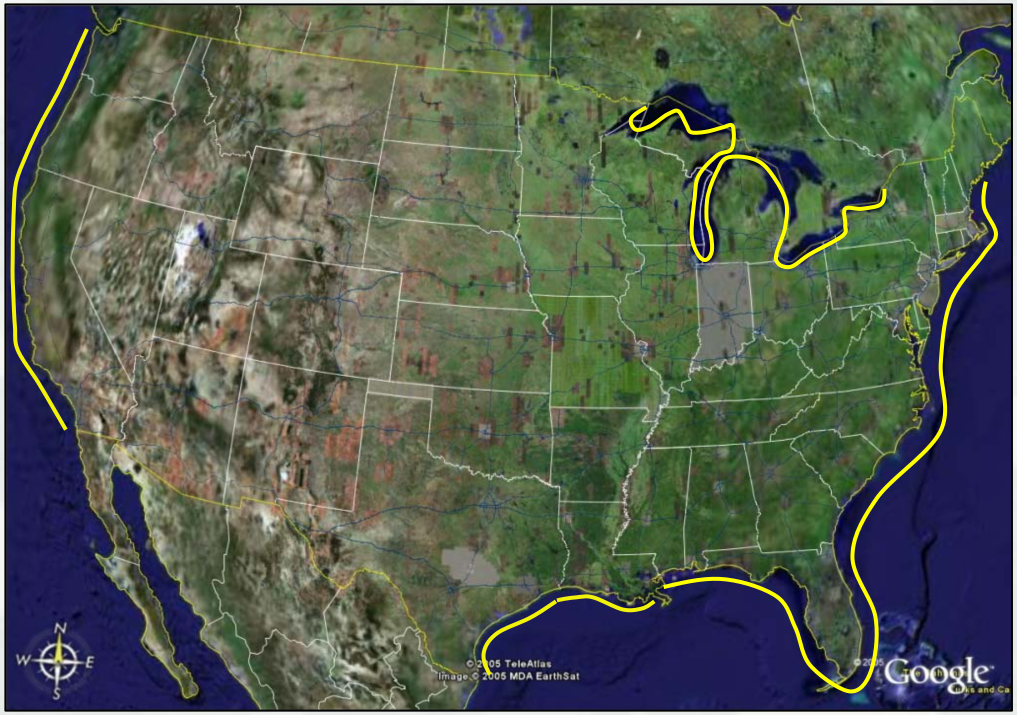
NAVAL OCEANOGRAPHIC OFFICE

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

FUGRO

3001

USACE National Coastal Mapping Program (NCMP)



- Funded by HQ
- Initiated in FY2004
- Collect lidar elevation and other imagery to support regional sediment management/navigation
- Focus on sandy shorelines
- 5-year national cycle

CHARTS

System III Specifications

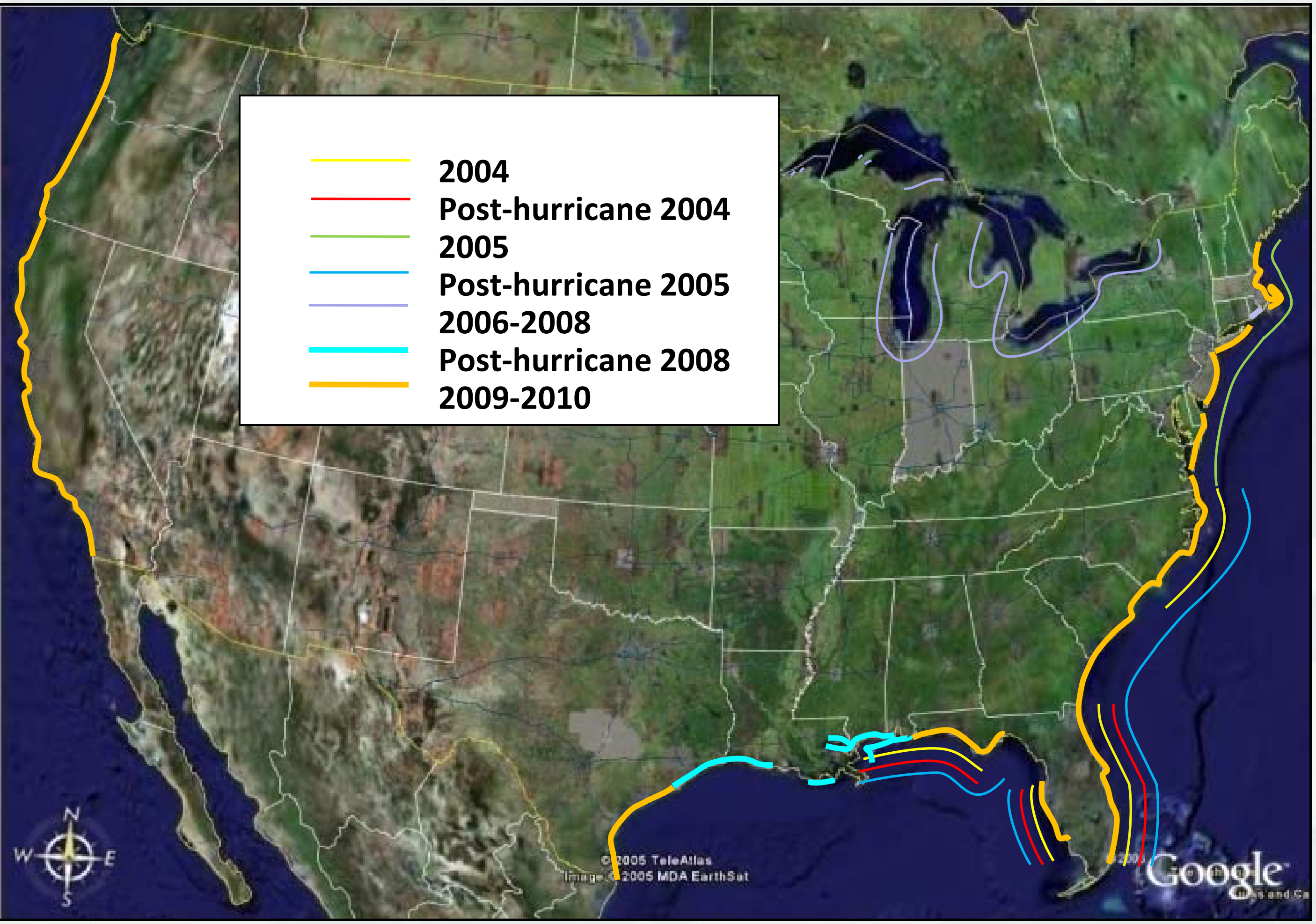
3,000 Hz Pulse Rate (hydro)
20,000 Hz Pulse Rate (topo)
RGB Digital camera (~20 cm pixel)
CASI-1500 Hyperspectral Imager
1500 cross-track pixels
380 – 1050 nm wavelength
1 m pixel w/ 36 spectral bands

Optech SHOALS Integrated Laser System

DuncanTech-4000 RGB camera

Itres CASI-1500 Hyperspectral Imager

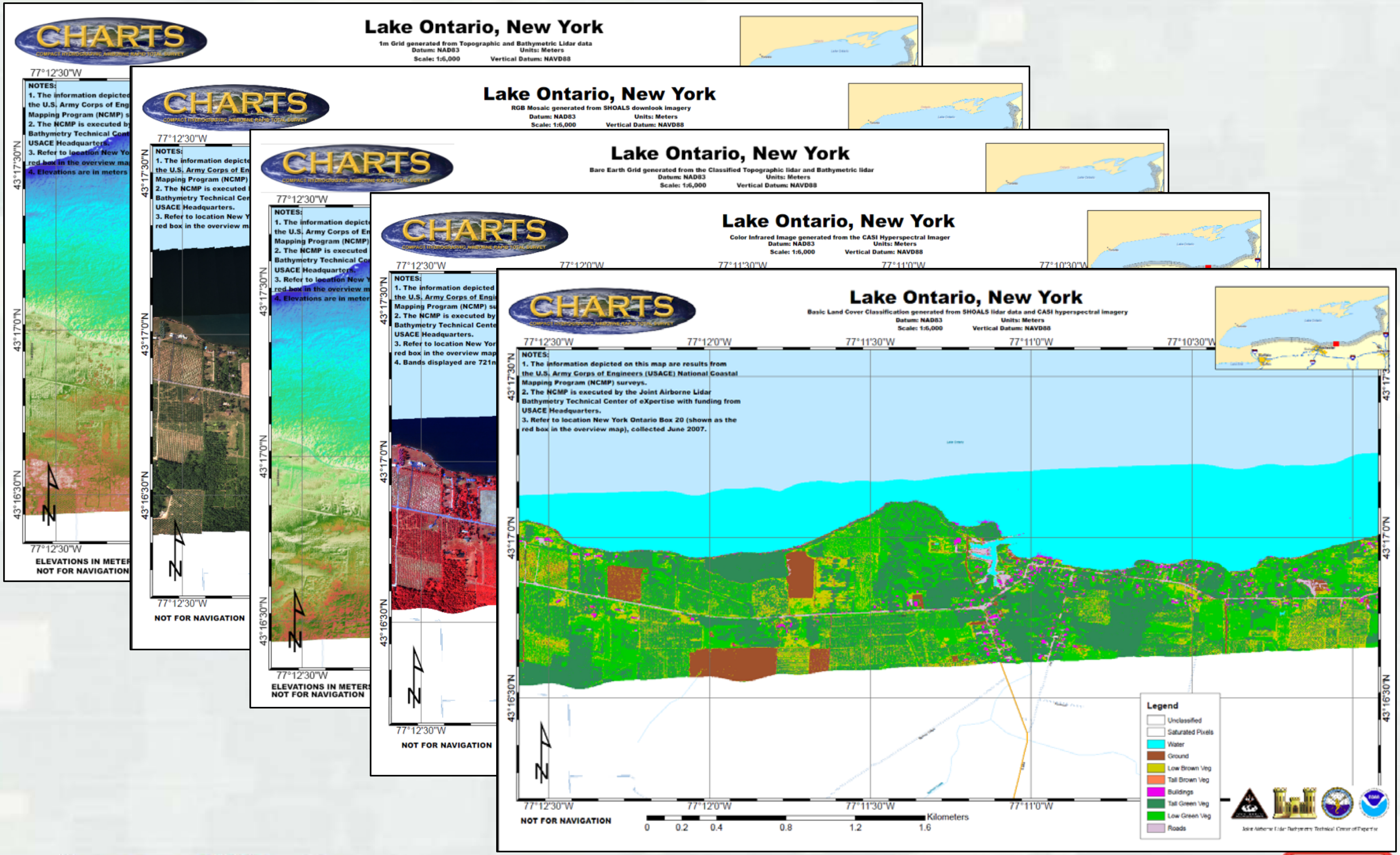
USACE NCMP Surveys and Products



Available data products:

- ASCII xyz
- RGB mosaics
- Zero contour
- 1-m bathy/topo DEMs
- LAS format topo
- 1-m bathy/topo bare earth DEMs
- Hyperspectral mosaics
- Laser reflectance
- Basic landcover classification

USACE NCMP Products

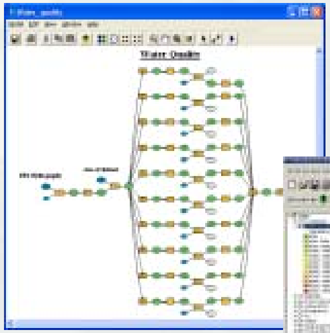


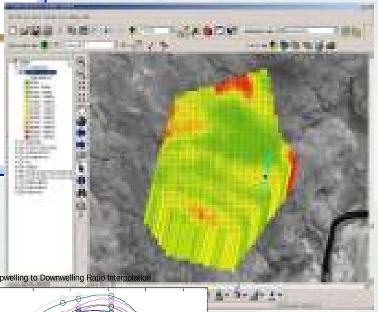
EL and JALBTCX

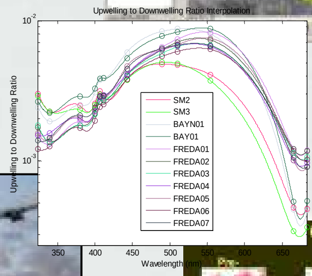
- EL has teamed up with JALBTCX to assist with the development and expansion of environmental data products
- GOAL: identify/expand environmental data products, utilizing (1) imagery resources of JALBTCX and (2) environmental expertise in EL to address environmental/geospatial needs of the coastal districts.

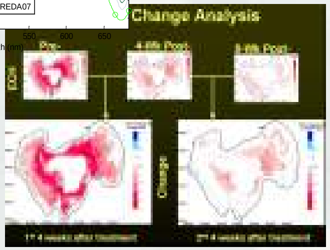
Environmental Systems Branch (EL)

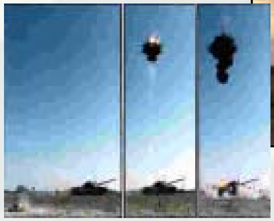
- **MISSION:** Identification, mapping, and modeling of environmental conditions in support of diverse military and civil requirements. Development of environmental sensing, characterization, and monitoring capabilities necessary to quantify environmental site conditions. Model development for the prediction and visualization of dynamic environmental characteristics for civil and military applications.





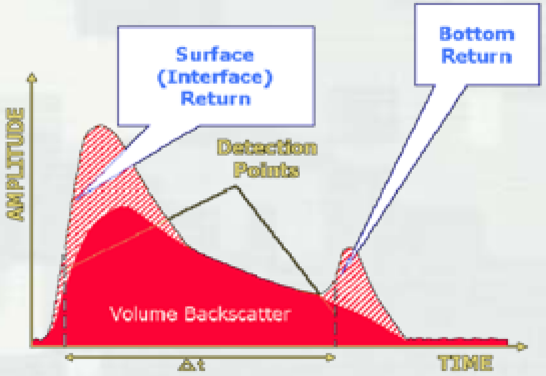


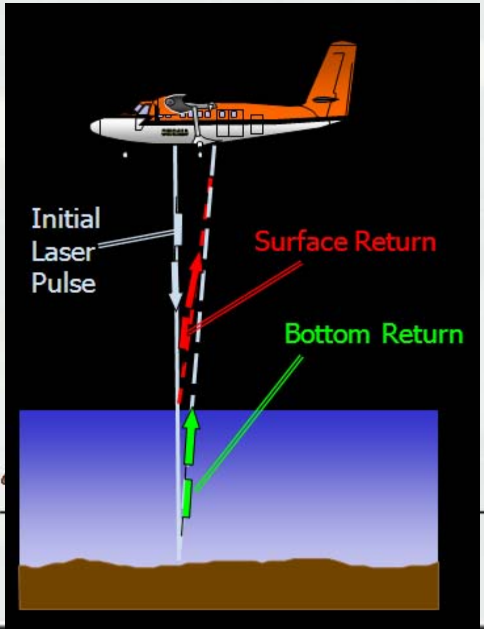


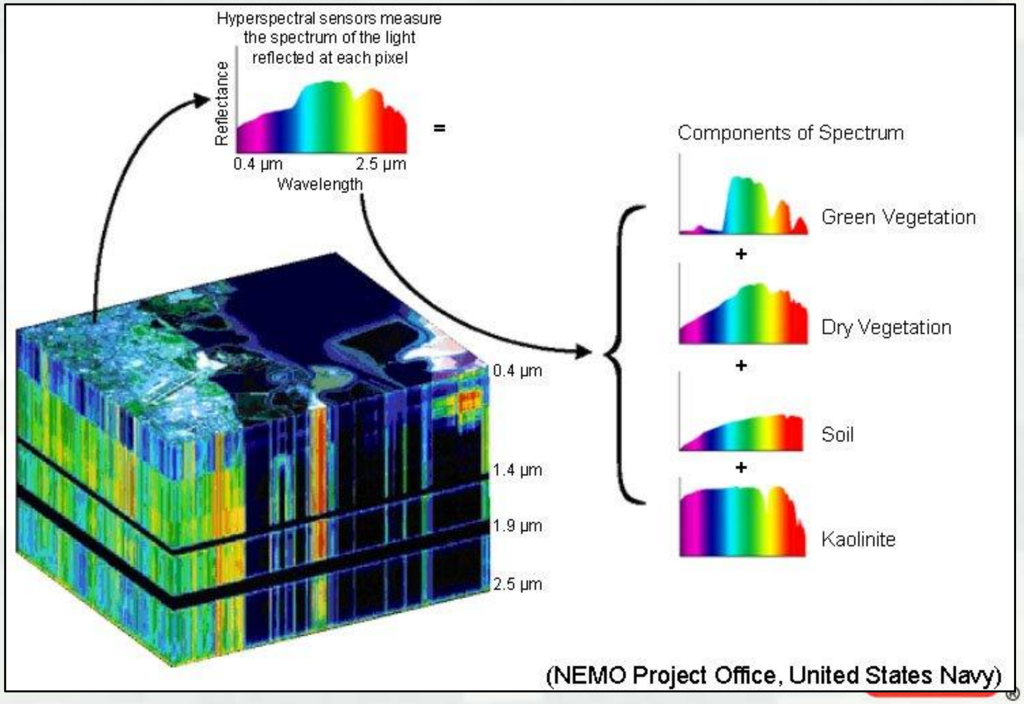


Tasks and Objectives

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

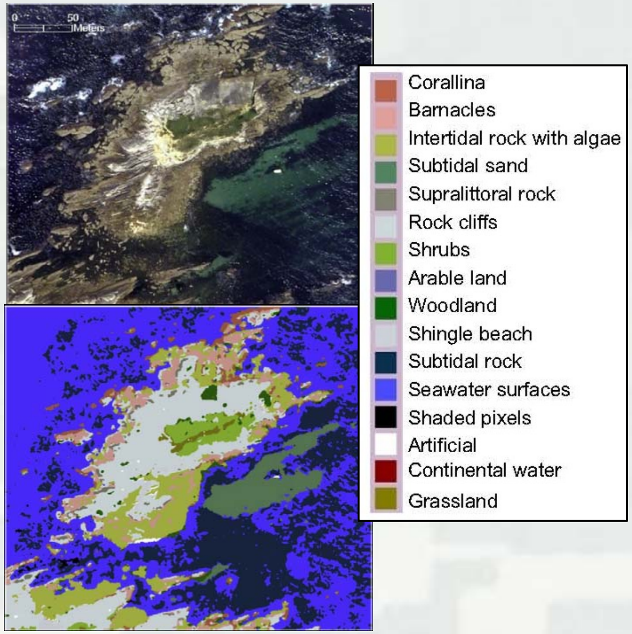




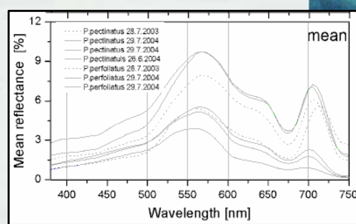


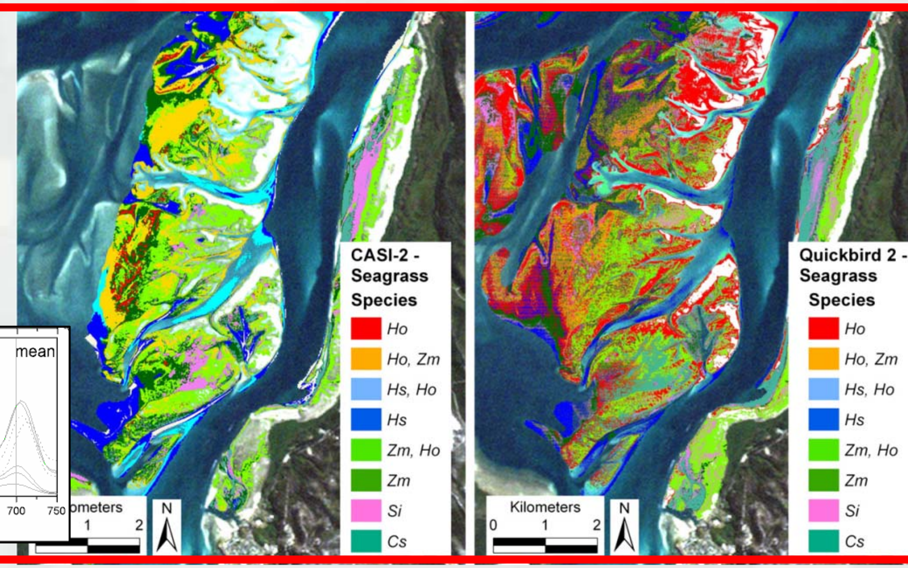
Expansion of Environmental Products

Landuse/cover & Species Composition

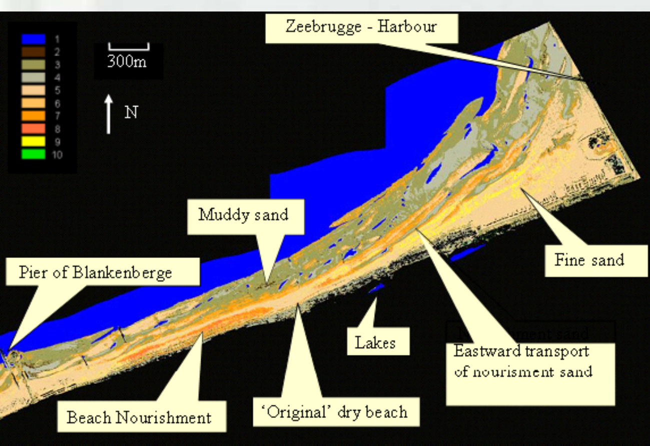


Submerged Aquatic Vegetation

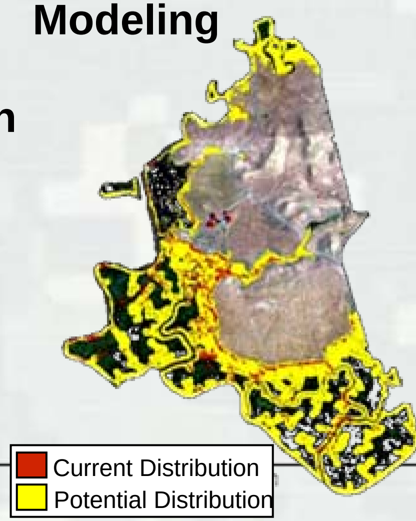




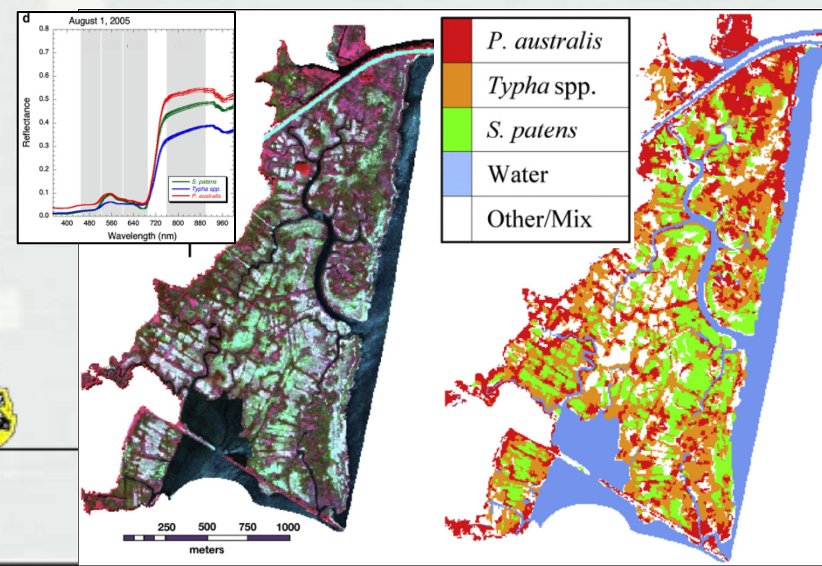
Wetlands/Beach Characterization



Ecological Modeling



Invasive Species Detection

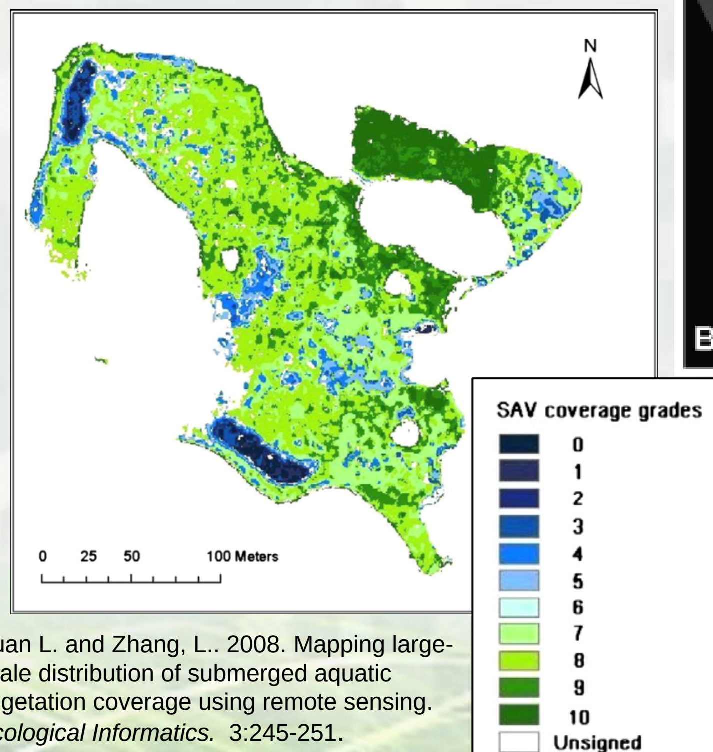


Review of Mapping Methods

Distribution

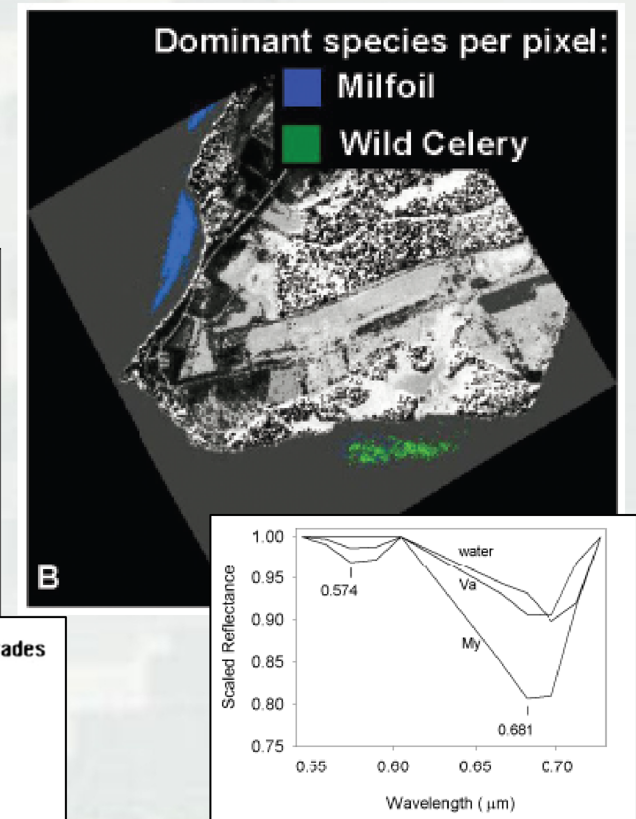
Massachusetts Dept. of Environmental Protection, 1995, 2001 eelgrass surveys and online maps

Density



Yuan L. and Zhang, L.. 2008. Mapping large-scale distribution of submerged aquatic vegetation coverage using remote sensing. *Ecological Informatics.* 3:245-251.

Species



Williams, D.J. et al. 2003. Preliminary investigation of submerged aquatic vegetation mapping using hyperspectral remote sensing. *Environmental Monitoring and Assessment.* 81(1):383–392.

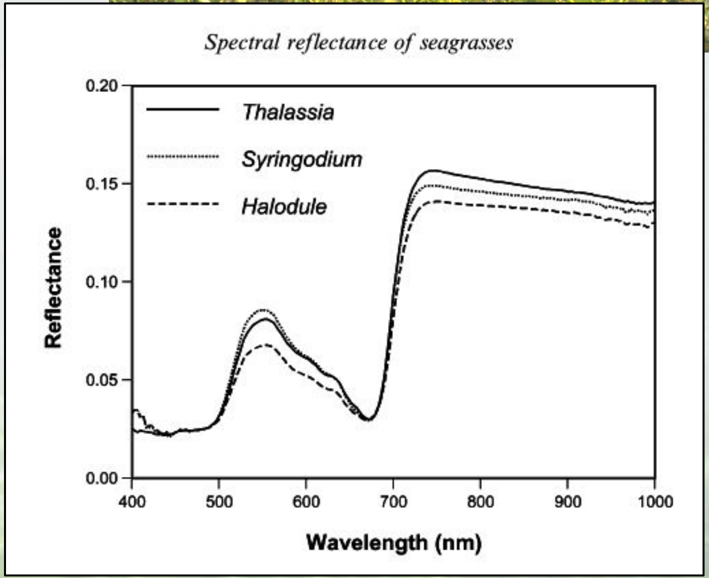
Dredging Operations and Environmental Research Work Unit:

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 among species due to different tolerance levels to environmental conditions. Understanding species composition and spatial extent is important for:

- Planning dredging operations
- Mitigating ecological damage
- Monitoring SAV



Source: Thorhaug et al. 2007

Project at a Glance

Mission Planning:

- CASI spectral bands
- Flight Line/Survey window

Ground Truthing: site visit in July!

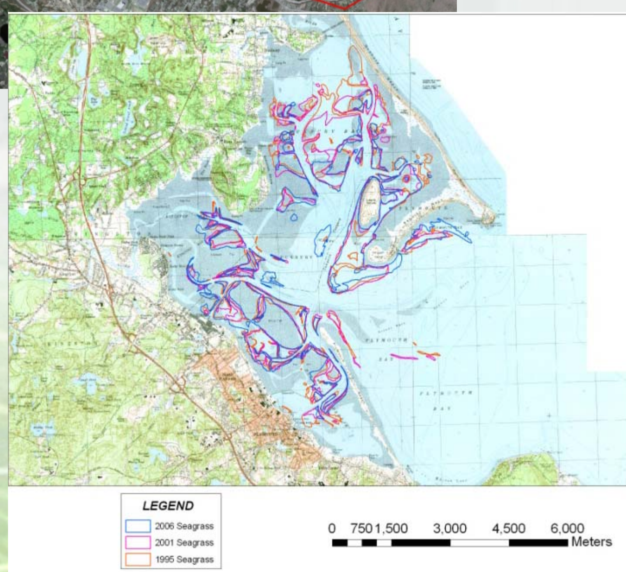
- Acoustic survey/video imaging
- Bottom sampling
- In-situ spectral measurements
- Water sampling

Image Processing:

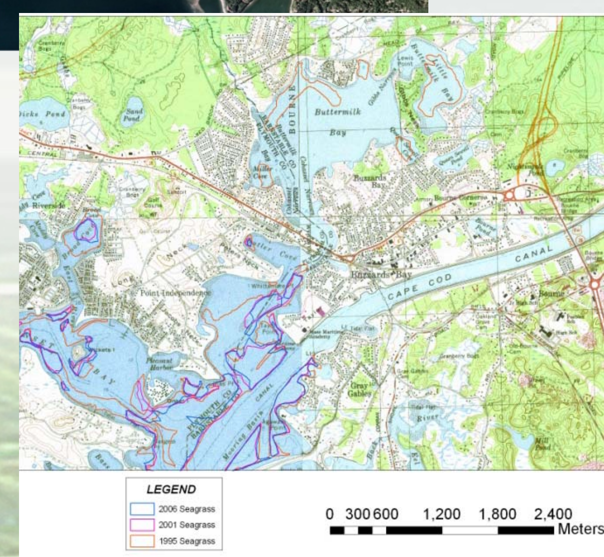
- Hyperspectral/lidar post-processing
- Spectral optimization (w/ depth correction)
- Species classification
- Accuracy assessment

Study Sites

Plymouth Harbor, MA

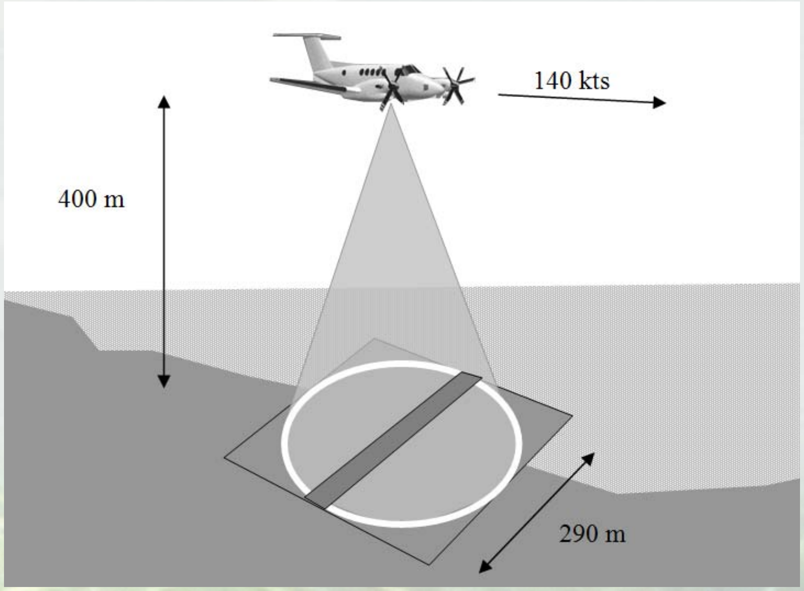


Buttermilk Bay, MA



System Components and Data

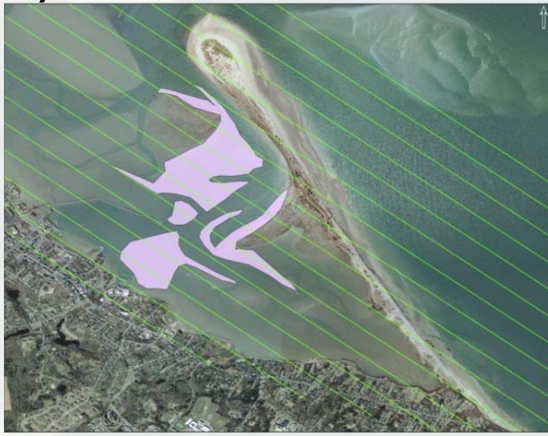
- Year 1, CHARTS:
  - 1m hyperspectral image mosaics (36 bands, 380-1050nm)
  - 3m bathymetric lidar (+/- 30cm vertical, 532nm)
- Year 2, CZMIL:
  - Same paradigm but…
    - Improved spatial densities for higher accuracy
    - Single green lidar for both survey modes
    - Circular scan pattern for challenges in the surf zone
    - Shorter pulse length = improved seafloor characterization



CZMIL system configuration

Planning and Partners

- Survey Window (based on tide, solar window and SAV biomass):
  - September 15-17, 2010 (backup, September 29-30)
  - Plymouth: A.M. survey, 2hrs, 16 flight lines
  - Buttermilk: P.M. survey, 1.5hrs, 12 flight lines



- Partners:
  - JALBTCX: survey and data support
  - USACE/NAE: local planning, boat support, field samples
  - Other (UNH, NOAA, MADEP, Cape Cod Bay, etc): local knowledge, field samples, consulting support

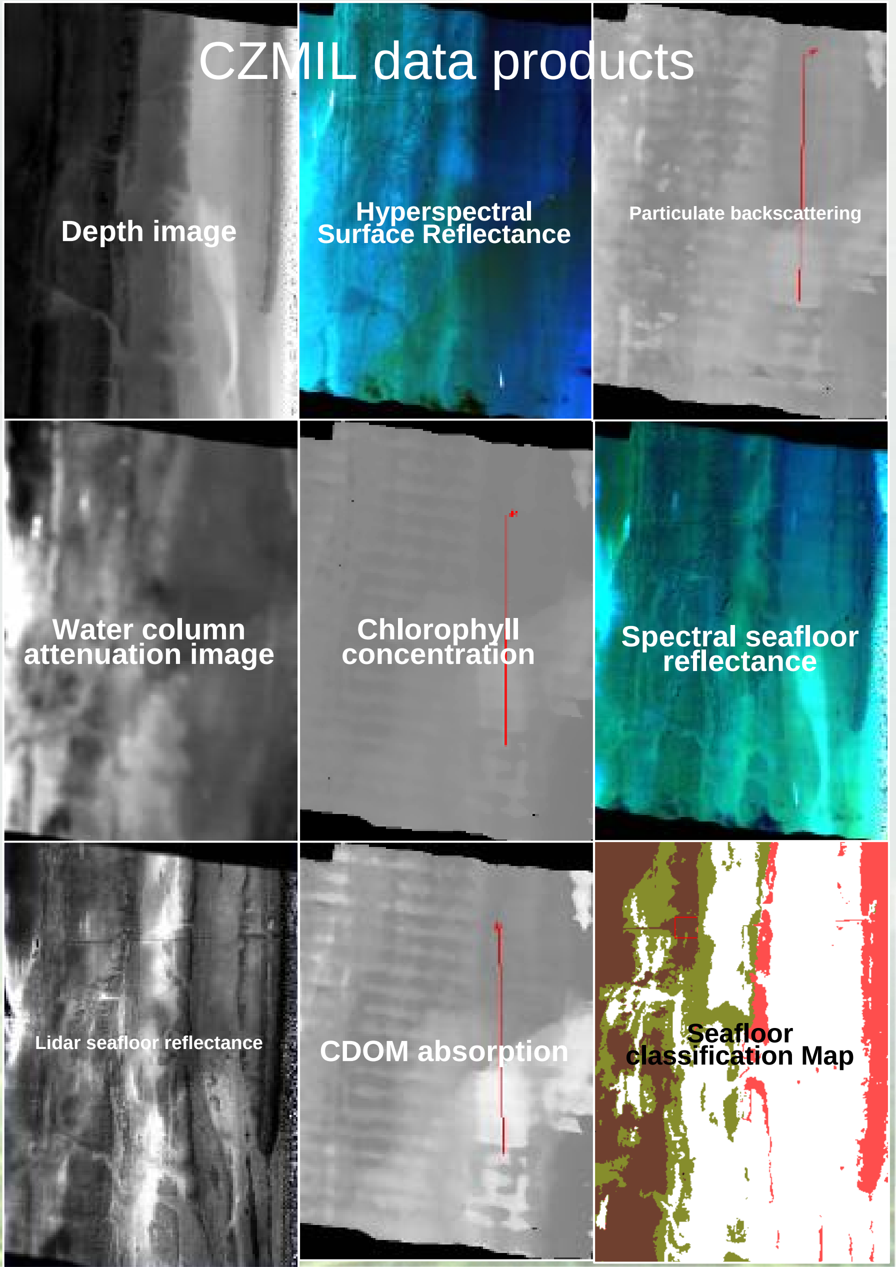
Ground Truthing

- Pre-Mission (September 7-10, 2010)
  - Acoustic Survey (SAVEWS)
  - Underwater Videography (Seaviewer Sea-drop 950)
  - Above water/below water spectral measurements (ASD, Divespec)
- During Mission (September 15-17, 2010)
  - Water bottle samples (chlorophyll A, TSS, CDOM)
  - Secchi disk depth and turbidity
  - Water column optical properties



Analysis Methods

- CZMIL Data Processing System
  - New software with *Spectral Optimization* to characterize seafloor and water column constituents
  - * Invert the hyperspectral image with bathymetric lidar depth as constraint to obtain bottom, reflectance, IOPs, etc.
  - Supervised classification of seafloor reflectance to solve for species



Challenges and Considerations

- Turbidity and bathymetric lidar
- Water column attenuation
- SAV reflectance
  - Low signal, similar characteristics
- Ground truthing
  - Above water vs. below water

“Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?" ... I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question.

Conclusions

- > 20K hectares of seagrass beds lost due to dredging in the last 50 years (grossly underestimated)
- Species impacts not well understood, although it is known that they vary in sensitivity
- Detailed species composition/distribution important for:
  - Environmental window planning
  - Way to monitor changes to SAV pre/post dredging
  - Way to understand species resilience/vulnerability

Joint Airborne Lidar Bathymetry
Technical Center of eXpertise

Questions?

Molly Reif

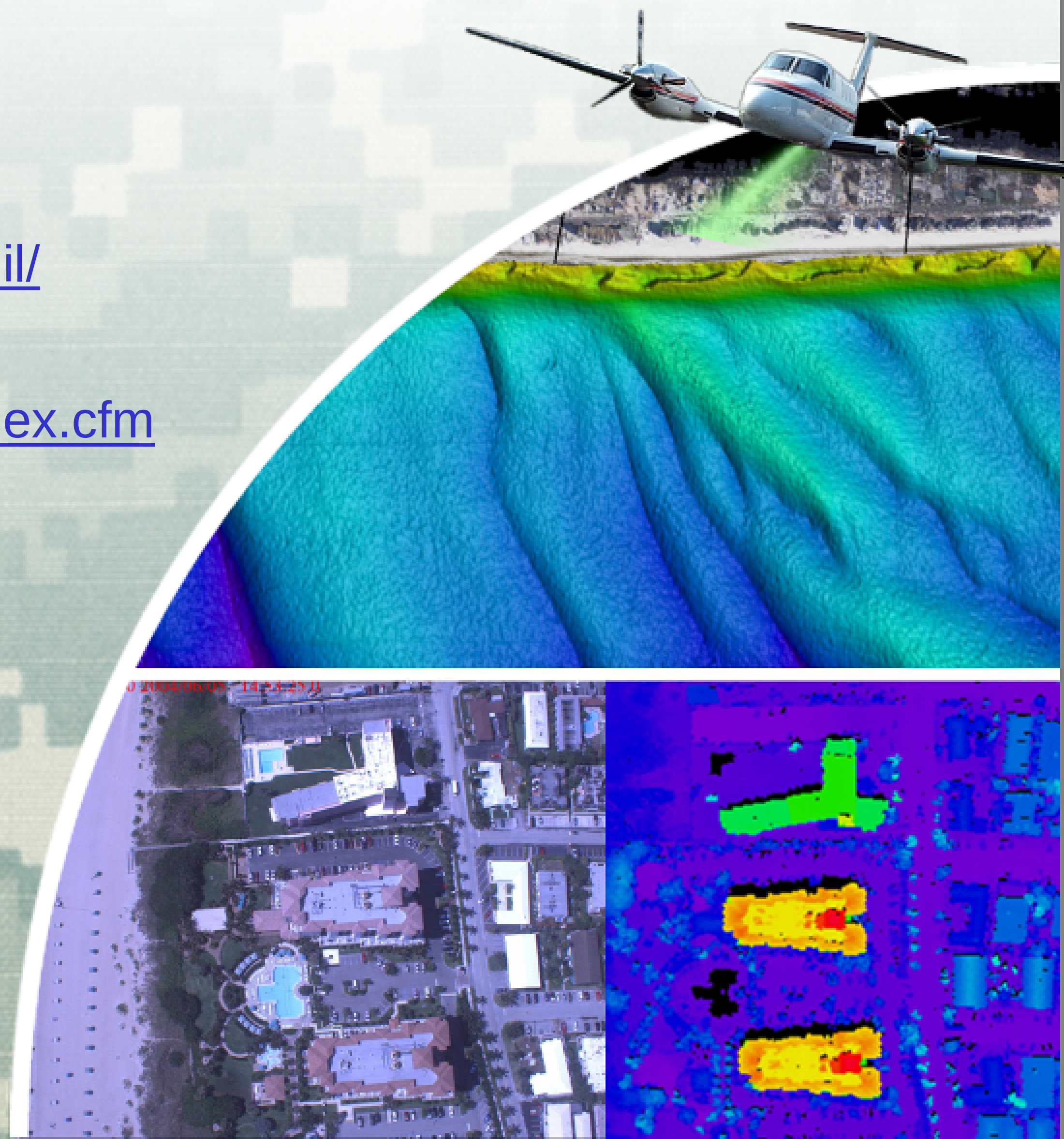
Molly.k.Reif@usace.army.mil

JALBTCX

http://shoals.sam.usace.army.mil/

EL

http://el.erdc.usace.army.mil/index.cfm



US Army Corps of Engineers
BUILDING STRONG®