Joint Airborne Lidar Bathymetry Technical Center of Expertise

National Coastal Mapping Program: Coastal Engineering & Environmental Applications

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Engineer Research and Development Center

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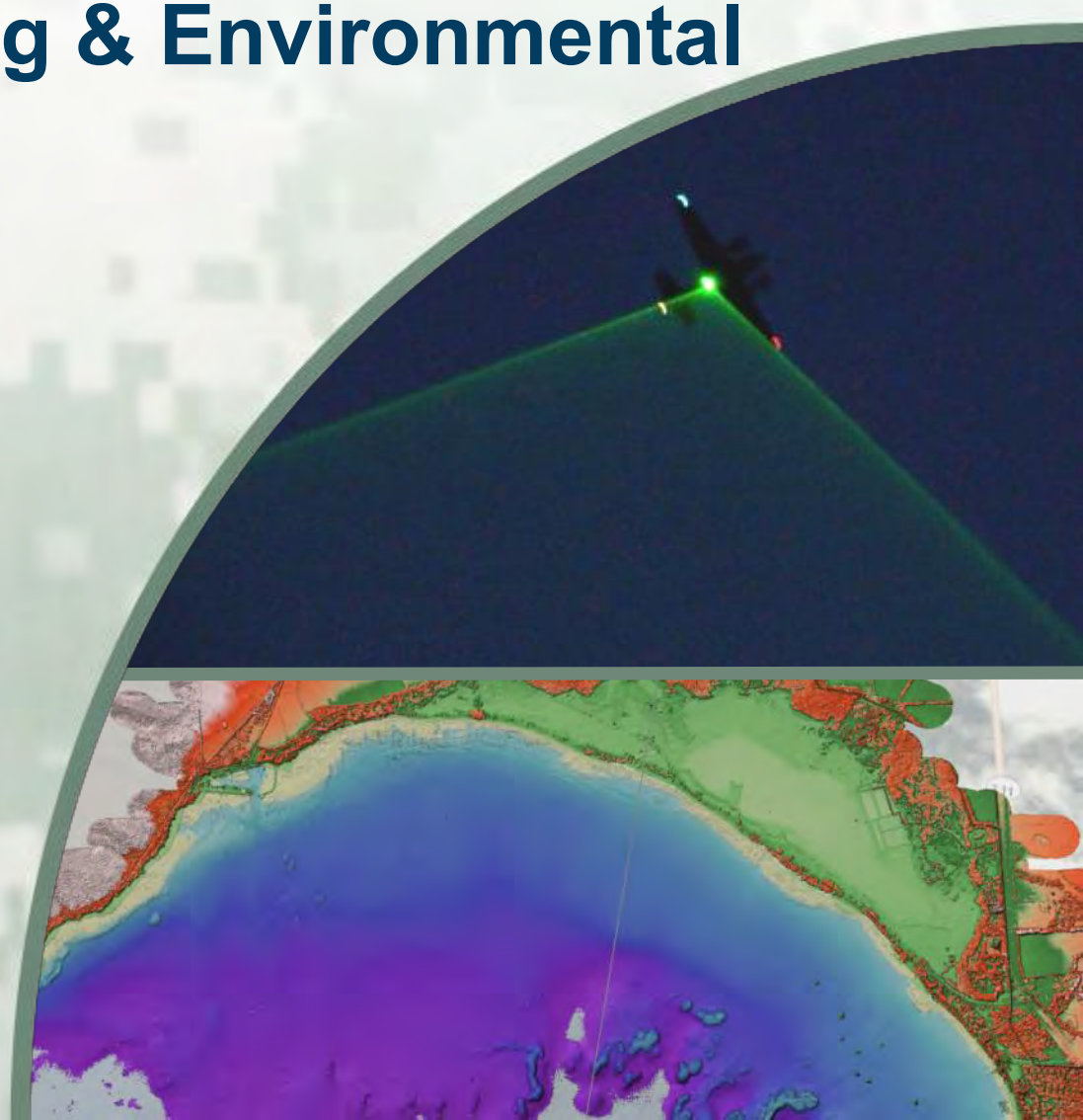
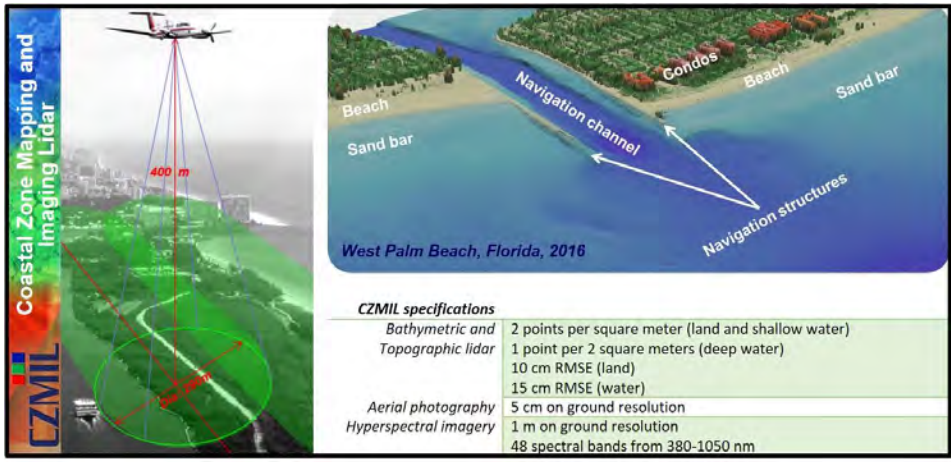


Background – Geospatial Data

- In-house geospatial data resources:
  1. High resolution, coastal airborne hyperspectral imagery and lidar elevation data collected by the JALBTCX under the USACE National Coastal Mapping Program
  2. High resolution satellite imagery available at no cost to the USACE through the National Geospatial-Intelligence Agency's EnhancedView contract (archived and tasking)
  3. Fleet of Unmanned Aircraft Systems (UASs)

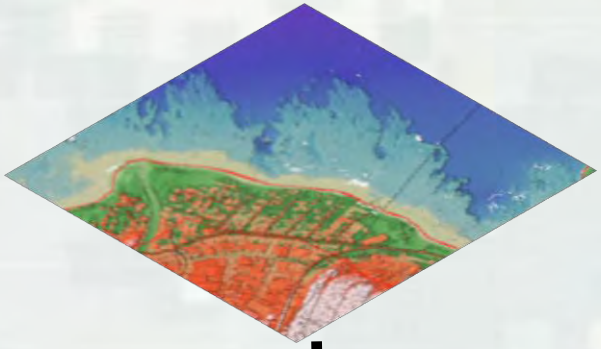


Satellite imagery	Acquisition source/contract	Resolution
Electro-optical		
WorldView-1/2/3	NGA/EnhancedView or USGS via Earth Explorer/CMT	0.5m/0.46m/0.31m
GeoEye-1	NGA/EnhancedView or USGS via Earth Explorer/CMT	0.41m
QuickBird-2 (Archived)	NGA/EnhancedView or USGS via Earth Explorer/CMT	0.6m
IKONOS-2	NGA/EnhancedView or USGS via Earth Explorer/CMT	0.8m
Pleiades 1A &1B	AIO/ADL Contract (GeoNorth)	0.5m
SPOT 5/6/7	AIO/ADL Contract (GeoNorth)	2.5m/2.0m/1.5m
EROS A/B	(ImageSat International, Israel)	1.8m/0.7m
FORMOSAT 2	Resellers/Vendors (satellite decommissioned)	2.0m
CartoSat 2A/2B	Resellers/Vendors (satellite decommissioned)	0.8m
Planet/RapidEye	NGA (CIBORG Contract ending April 2017)	3.0m/6.0m
SkySat	Skybox	0.9m
Synthetic Aperture Radar/Lidar		
RADARSAT 2	NGA COMSAR	3m (Spotlight Mode)
TerraSAR-X/TandemX	NGA COMSAR/AIO-ADL Contract (GeoNorth)	1m
COSMO/SkyMed	NGA COMSAR (limited $)	1m
IFSAR/LiDAR	AGC (AIO)/USGS (archived)	varies

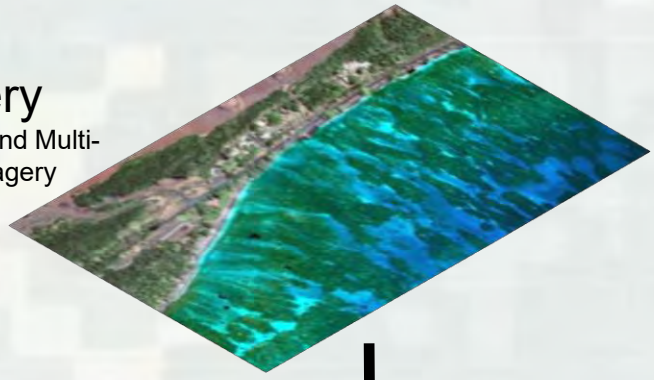
ERDC-EL UAS Platforms	SKYCRANE G4	HARRIS HX8	FIRELFY6 PRO	VAPOR 55	620 UAS
LIFT CAPACITY	< 8 lb	< 33lb	<2lb	<24 lbs	<1lb
SENSORS	RGB, FLIR, MicaSense, LiDAR/Hyperspec	LiDAR/Hyperspec	RGB, FLIR, MicaSense	LiDAR/RGB	Camera
FLIGHT TIME	12-20 MINS	20-40 MINS	1 HR (340-500 acres)	1 HR	25 MINS
# OF SYSTEMS	1	1	2	1	10
TYPE	MULTIROTOR (X8)	MULTIROTOR (X4- DUAL TRI BLADES)	HYBRID VTOL	HELICOPTER	MULTIROTOR (X4) or (x8)
COST	$28-250k	$30k	$30k each	$250k	$1k
Operational	Yes- Current	May 2018	Feb 2018	May 2018	May 2018

Metrics/Parameters

Elevation
Change
(elevation/volume)
Contour (change)
Shoal

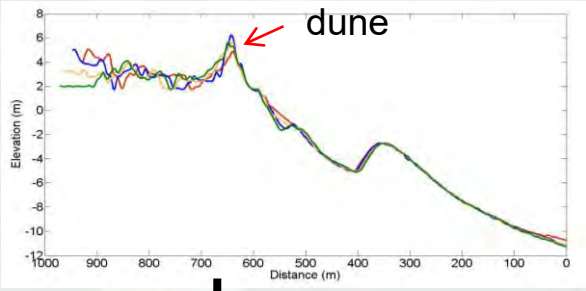


Imagery
Hyperspectral and Multi-Spectral Imagery

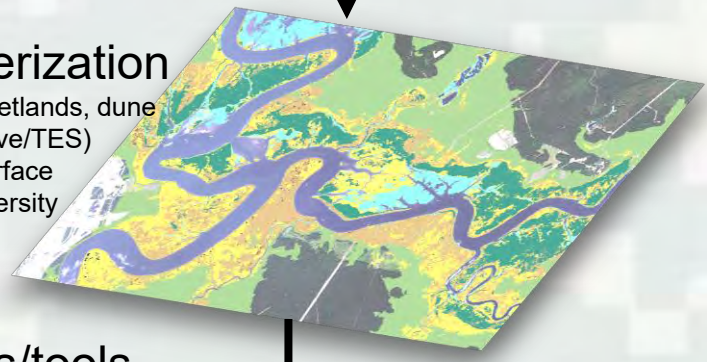


Dune
Elevation (crest/toe)
Continuity
Slope
Volume

Beach
Width
Slope



Land characterization
Critical habitat (SAV, wetlands, dune vegetation, invasive/TES)
Impervious surface
Landscape diversity



R&D/Value added products/tools

- Change Detection
  - Landscape change modeling
  - Volume/elevation/shoreline change
    - Structure assessment
- Sediment Budgets
- Monitoring Shore Protection
- Defining Coastal Regions

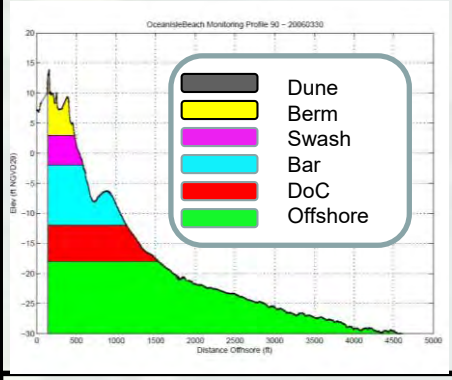
- Coastal Engineering Index
- Coastal Resilience
- Critical Species Detection and Modeling
  - Sea turtle nesting habitat
  - Oysters*
  - Salmonid

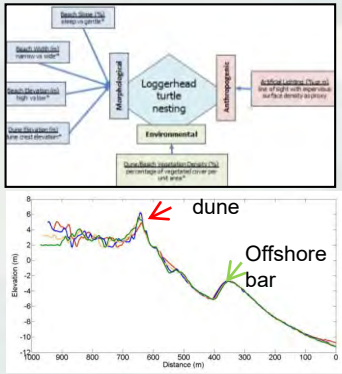
* ECO-PCX model certification

Coastal Engineering Applications

Feature Extraction

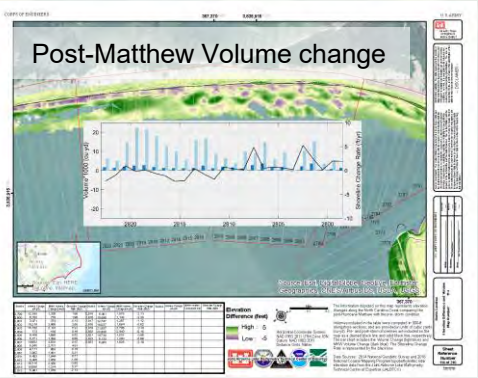
- Morphological features (dunes, beach width, slope, nearshore bars)
- Features used for additional analyses to track changes through time, support resiliency efforts, and other projects that uses the features as boundaries





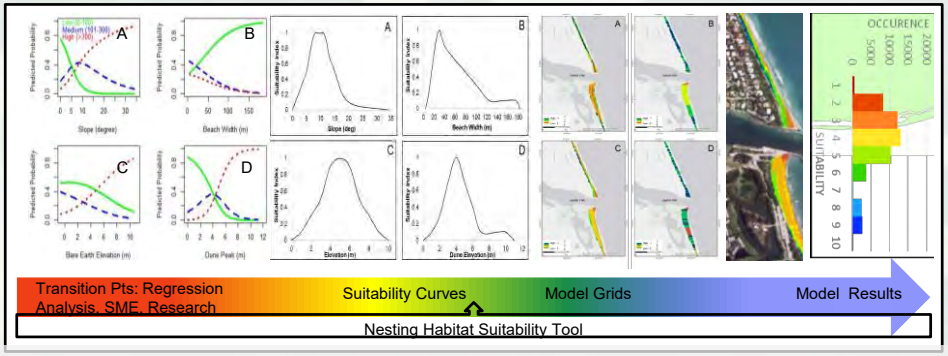
Volume Change

- Change detection for elevation, volume, and shoreline
- Post-storm change analysis
  - Post – Matthew: FL, GA, SC, NC, & VA



State	Start Date	End Date	Baseline Length	Number of Transects	Average Shoreline Change Rate	Volume Density Rate	MHW Volume Density Rate	Above MHW Volume Density Rate
			km	n	ft/yr	cy/ft/yr	cy/ft/yr	cy/ft/yr
ME	10/19/2005	6/19/2010	62	633	(0.4)	13.5	0.7	0.6
NH	11/01/2005	6/20/2010	15	152	(1.0)	2.6	(0.5)	(0.5)
MA	11/11/2005	5/26/2010	381	3,834	(2.8)	(2.8)	(0.9)	(0.8)
NY	10/26/2005	8/13/2010	192	1,921	6.9	4.5	4.1	4.2
NJ	9/2/2005	8/28/2010	203	2,034	0.6	2.1	2.2	2.2
DE	9/3/2003	9/11/2010	44	440	5.1	5.9	4.1	4.2
MD	9/3/2003	8/2/2010	50	505	(4.3)	2.8	2.7	2.7
VA	9/8/2005	7/28/2010	183	1,835	7.2	3.1	3.4	2.9
NC_2009	9/28/2005	8/16/2009	272	2,725	3.9	0.6	(1.4)	0.2
NC_2010	9/28/2005	5/4/2010	236	2,369	0.2	2.7	2.5	2.5
SC	1/13/2006	5/4/2010	277	2,778	2.1	2.3	1.3	0.9
GA	1/13/2006	5/4/2010	145	1,452	(0.2)	4.2	3.0	2.8
FL-E	7/1/2004	5/4/2010	587	5,875	(2.7)	6.2	1.0	0.8
FL-W	6/1/2004	6/20/2010	298	2,998	7.7	19.3	2.3	2.4
FL-NW	6/1/2004	6/20/2010	346	3,461	(9.2)	4.6	(0.2)	(0.2)
Total/ Average			3,289	33,012	0.9	4.6	1.6	1.7

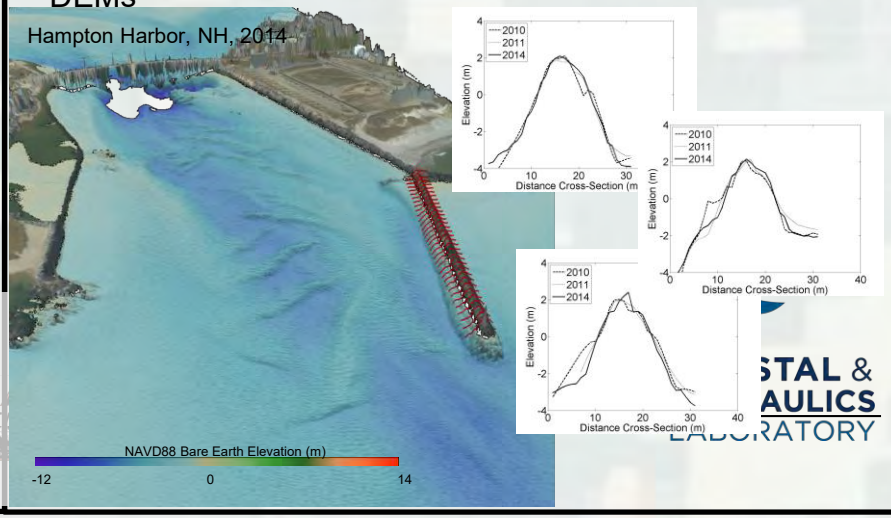
Turtle Nesting Habitat Suitability



- Regional datasets analyzed using a flexible, multi-criteria model that incorporates regional value ranges
- Spatial tool designed to streamline GIS steps and support user specified model weighting criteria

Asset Management Coastal Structures

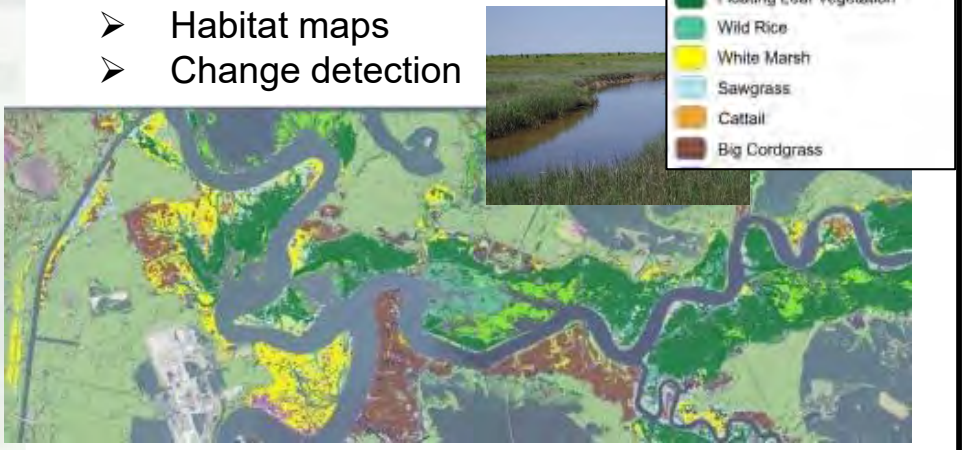
- Structure condition and change comparisons with bathy/topo DEMs



Environmental Applications

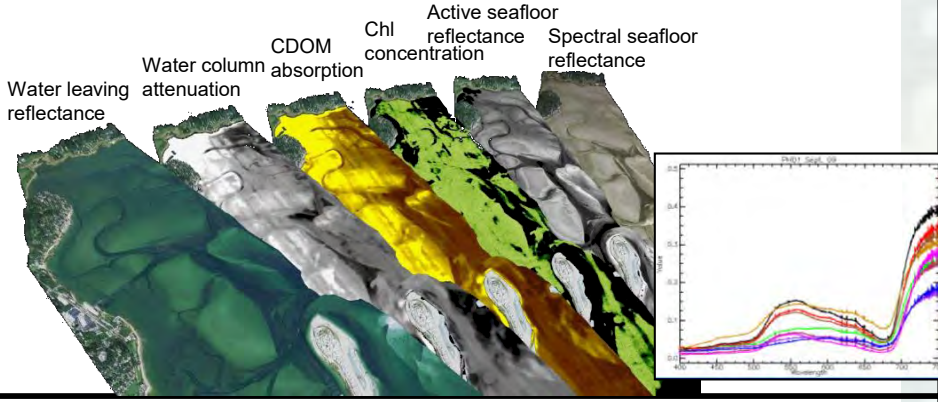
Land Cover and Habitat Characterization – identify critical physical and natural features for resource management and planning

- Wetlands identification
- Habitat maps
- Change detection



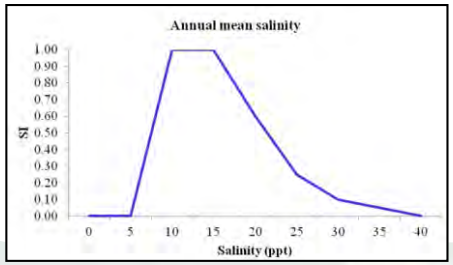
Benthic Habitat/Water Quality Mapping – identify habitats such as submerged aquatic vegetation and water quality indicators

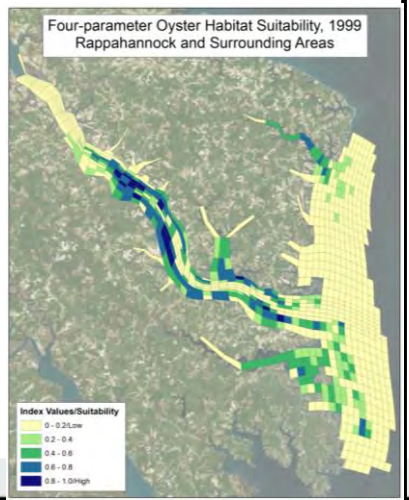
- Operations support
- Restoration/mitigation planning



Critical Species Detection & Modeling – discriminate particular species and habitat suitability for ecosystem restoration and monitoring

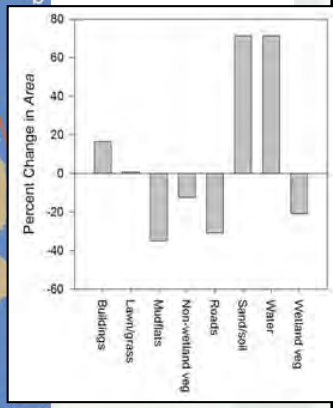
- Invasive/threatened/ endangered species identification
- Habitat suitability index analysis





Landscape Modeling – link landscapes to ecological processes to better predict ecosystem changes

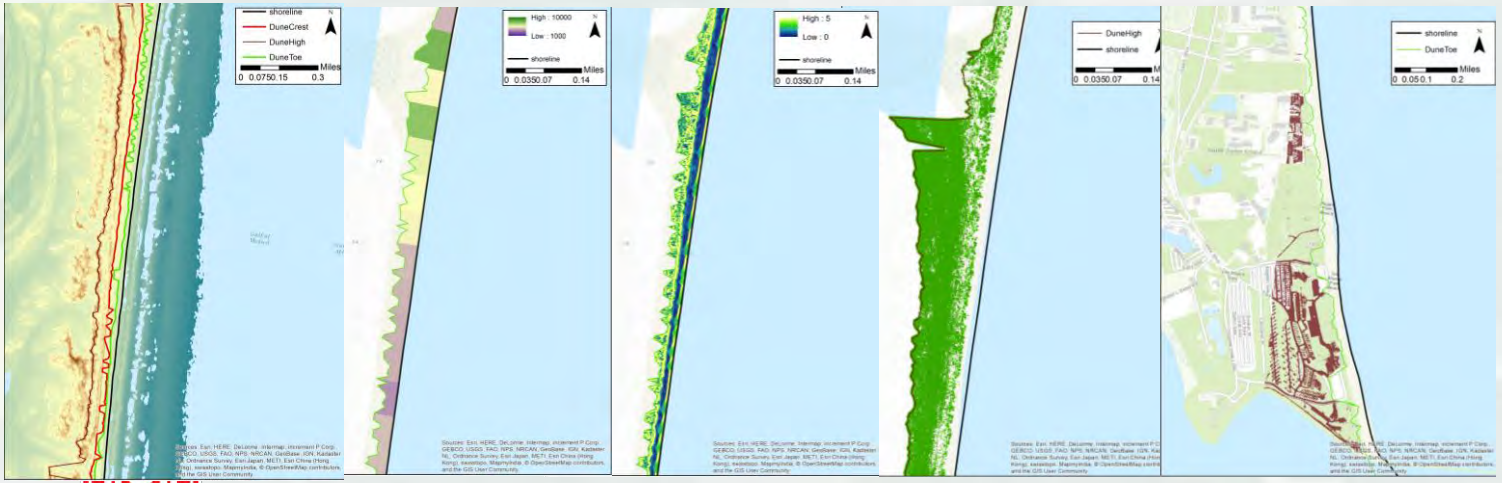
- Landscape structure analysis
- Ecosystem restoration planning



Feature Extraction

- **Operations**: Features are extracted from the remote sensing datasets and can be combined to assess condition, applied to any coastline and monitored long term to track the changing status of the coast, or the impacts of management decisions
- **Planning**: synthesized data provides ‘snap shot’ of coast
- **R&D**: Parameters are ranked relative to specific regional criteria and combined
- **District Support - -** ranking and combining could be used to address resilience related questions

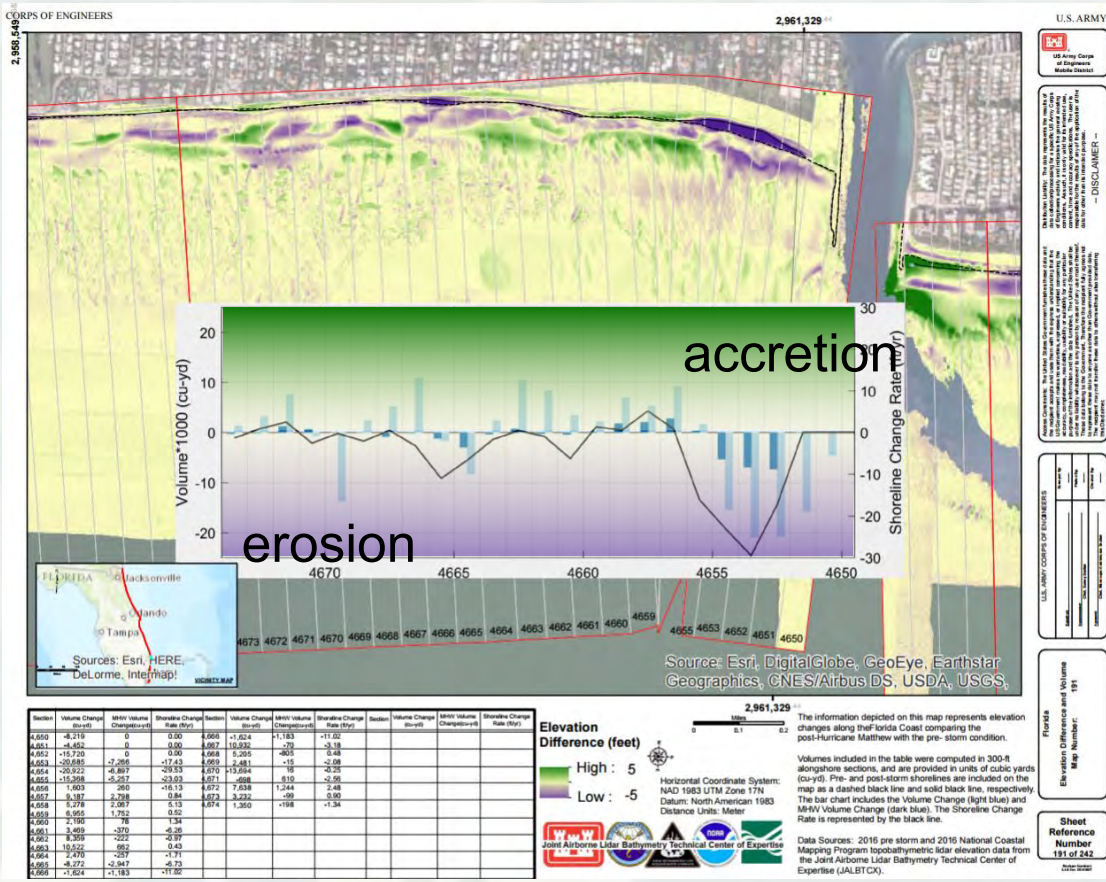
Dune Parameters | Volume | Beach Slope | Dune Vegetation | Impervious Surface



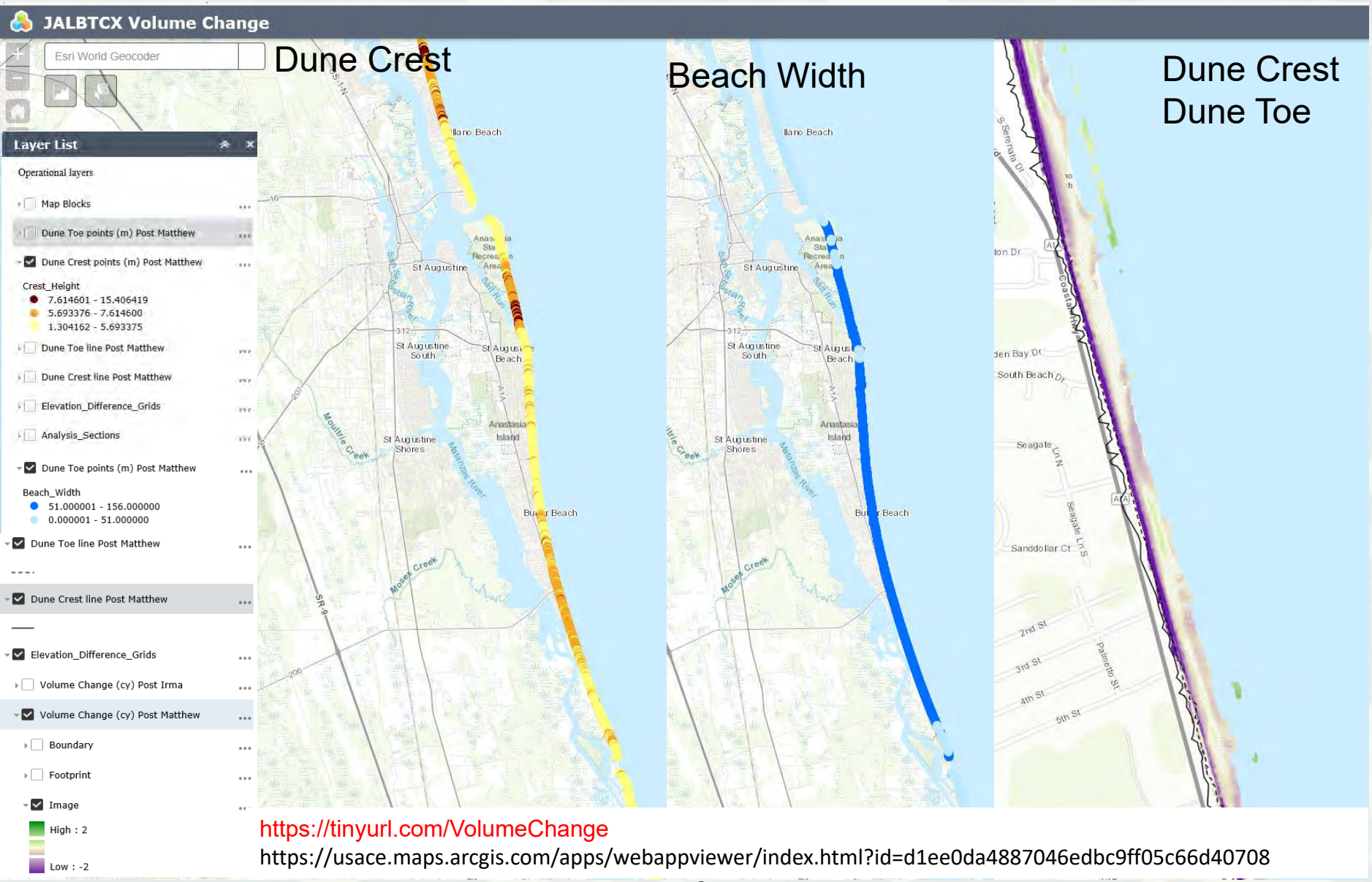
Combined Parameters: Spatial Grid

Volume and shoreline change

- **Operations**: provide streamlined method to generate volume/shoreline change datasets on a regional scale
- **Planning**: generate map products that can be used to communicate between agency partners
- **R&D**: provide input for sediment budgets (SBAS)
- **Post-Storm**: Irma (2017) and Matthew (2016) emergency response – volume change analysis for FL, GA, SC, NC, & VA



Web Map - Geomorphic Metrics

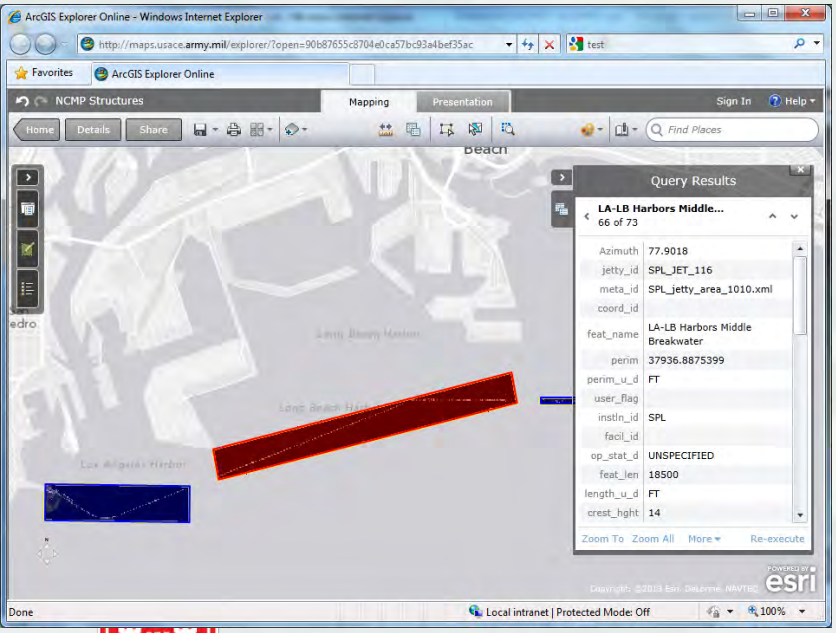


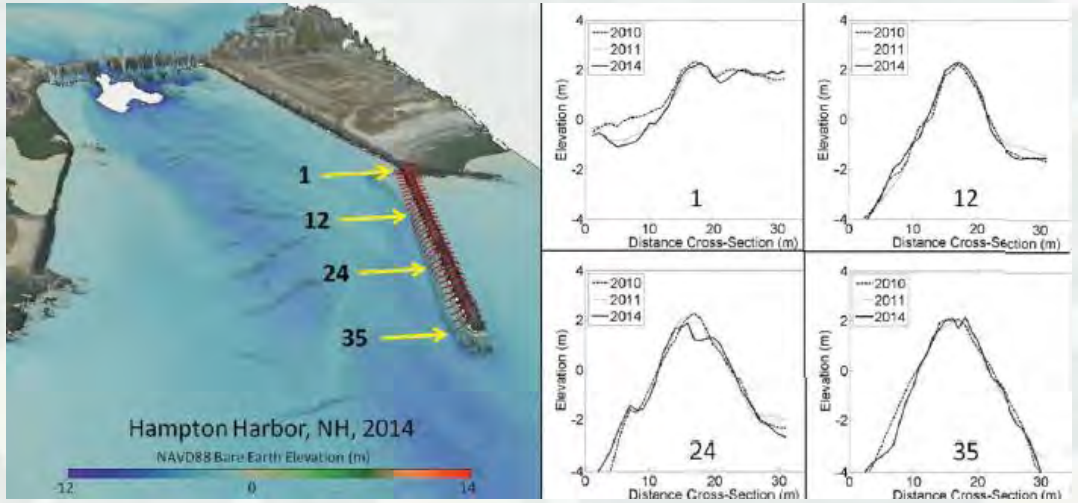
https://tinyurl.com/VolumeChange

https://usace.maps.arcgis.com/apps/webappviewer/index.html?id=d1ee0da4887046edbc9ff05c66d40708

Structures Work

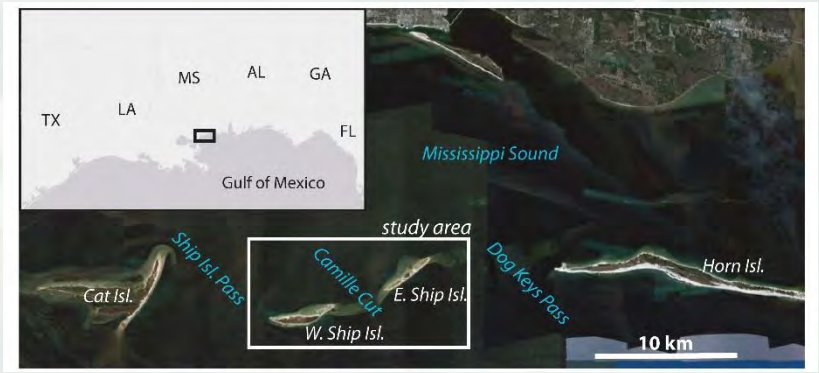
- **Operations**: extracted parameters provide data needed to determine condition and functional performance of structures in addition to bathymetric conditions around structures
- **Planning**: prioritize site visits using high resolution lidar data and imagery
- **R&D**: virtually ‘walk’ the structure using AR (Augmented Reality)



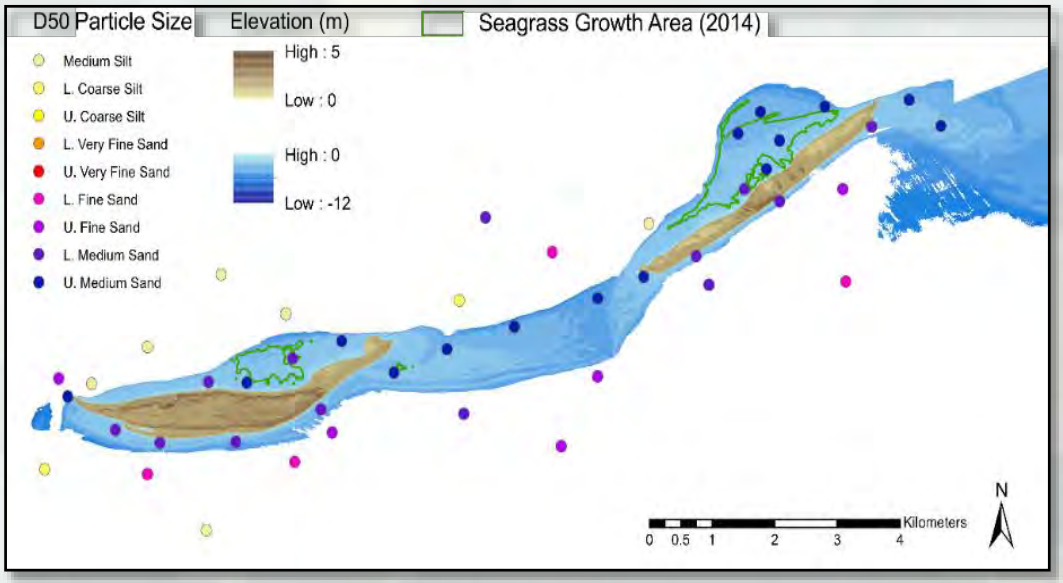


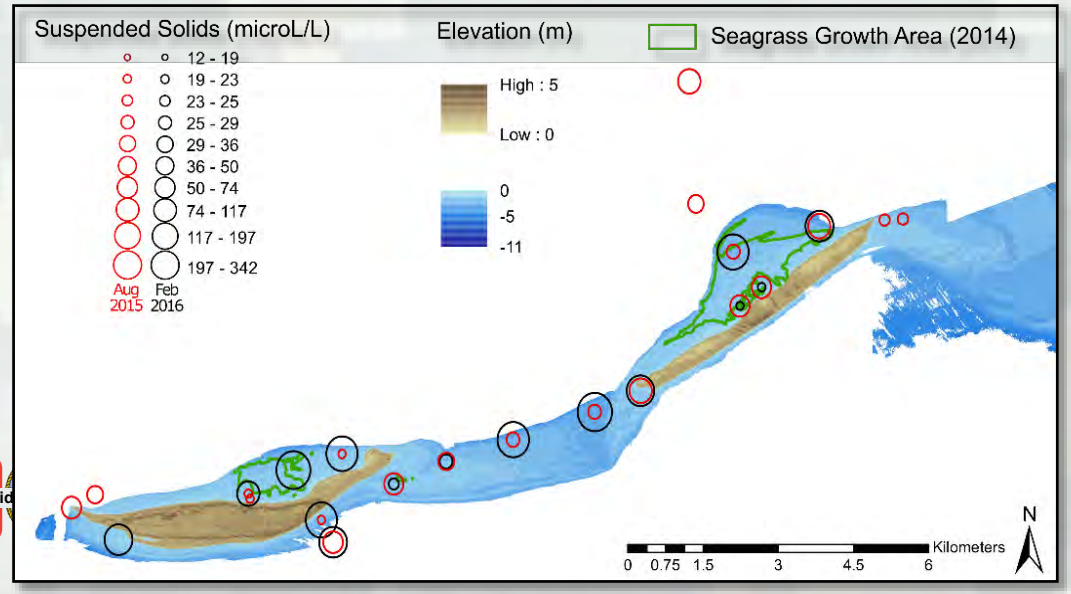
Submerged Aquatic Vegetation Monitoring & Assessment

Using bathymetric lidar data



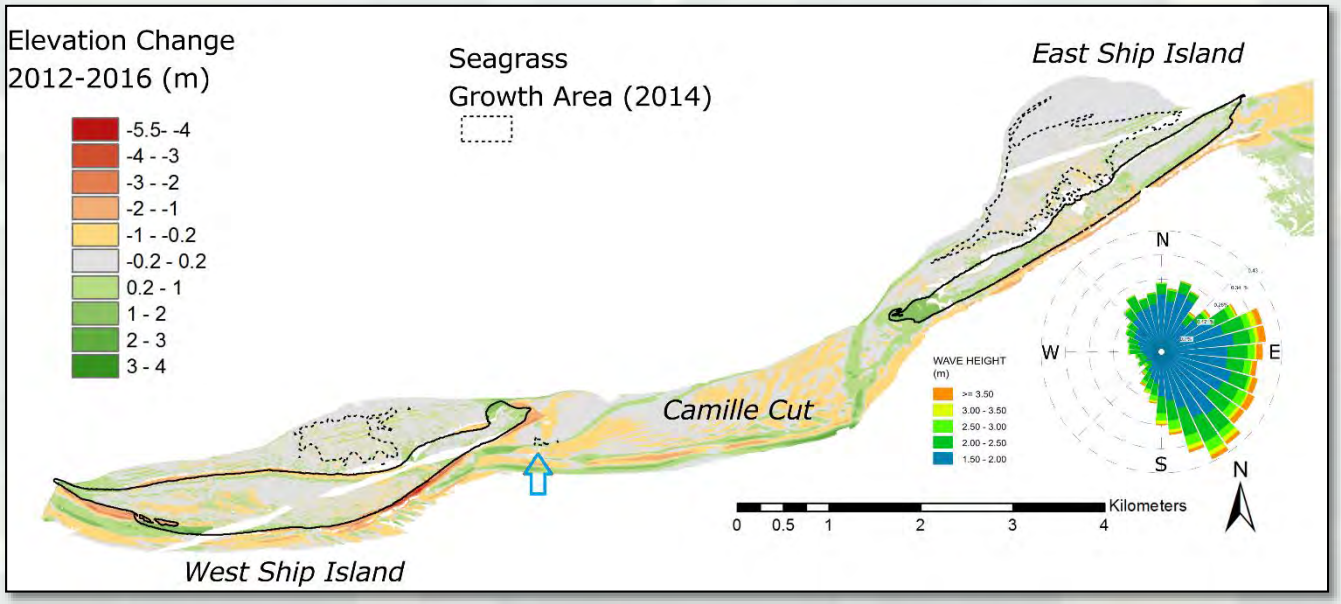
- Pre-construction assessment
- 2012 & 2016 JALBTCX topographic/bathymetric lidar
  up to ~10 m water depth
- Seagrass area mapped using aerial imagery
- Additional datasets characterize substrate and water column properties.



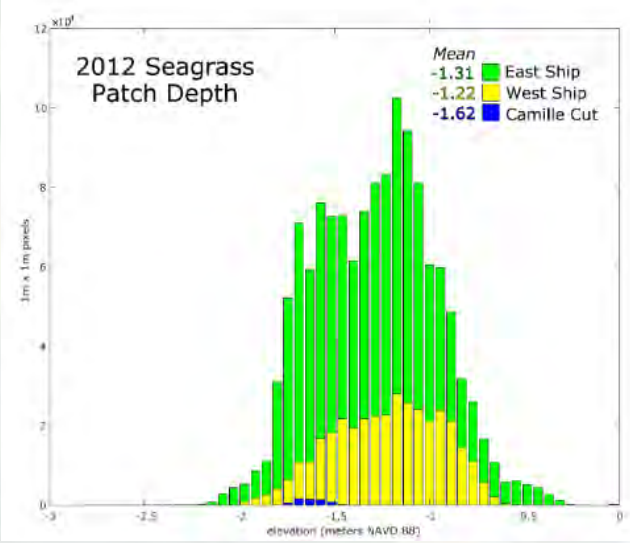


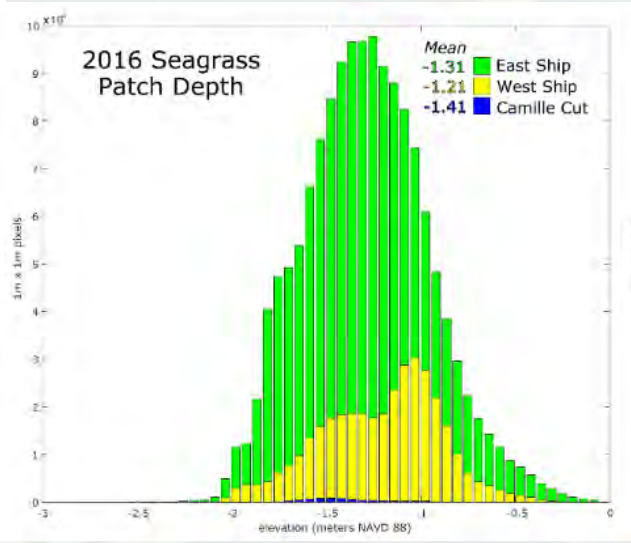
Submerged Aquatic Vegetation Monitoring & Assessment

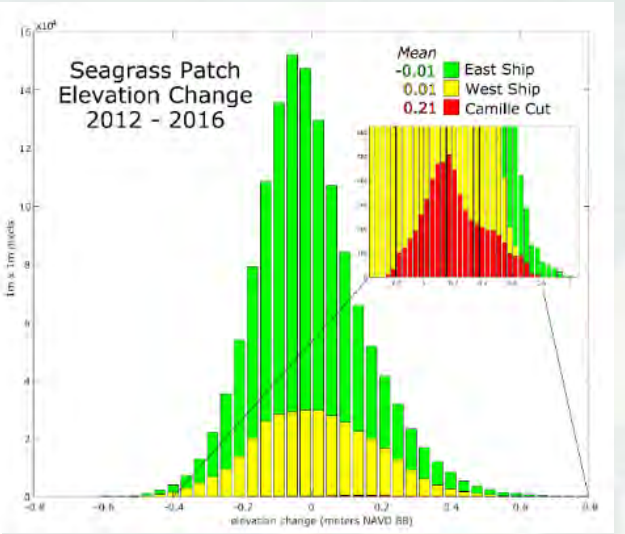
Using bathymetric lidar data



- Difference grid 2012-2016
- Elevation distribution: tolerable depth range for SAV
- Elevation change distribution: tolerable erosion or deposition for SAV





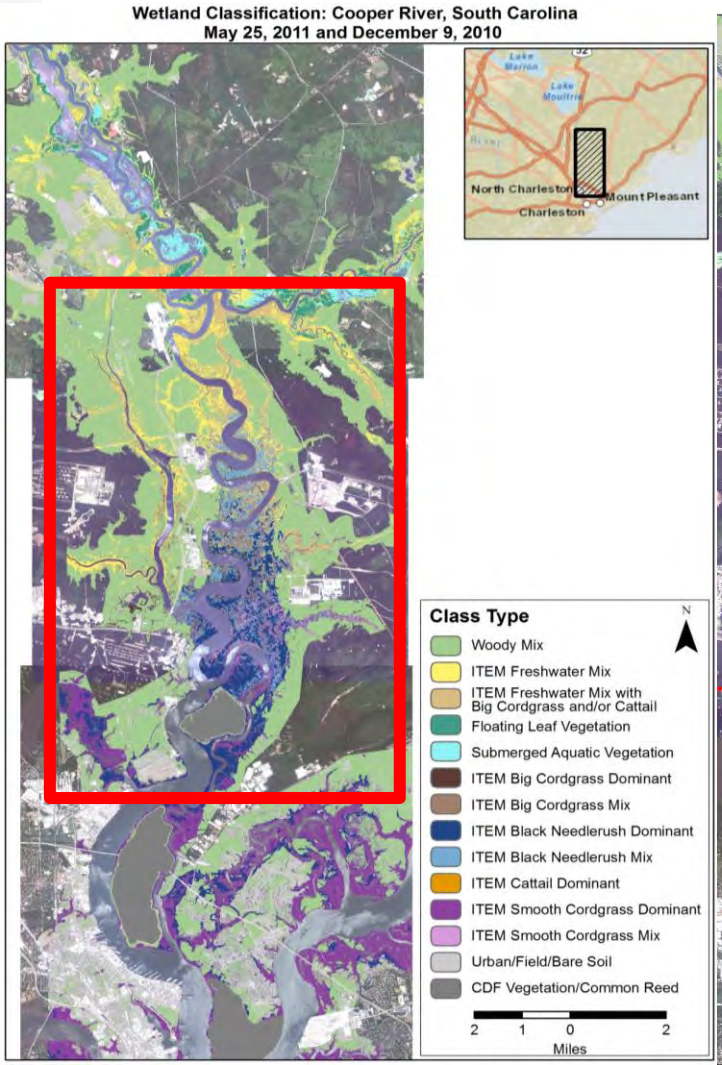


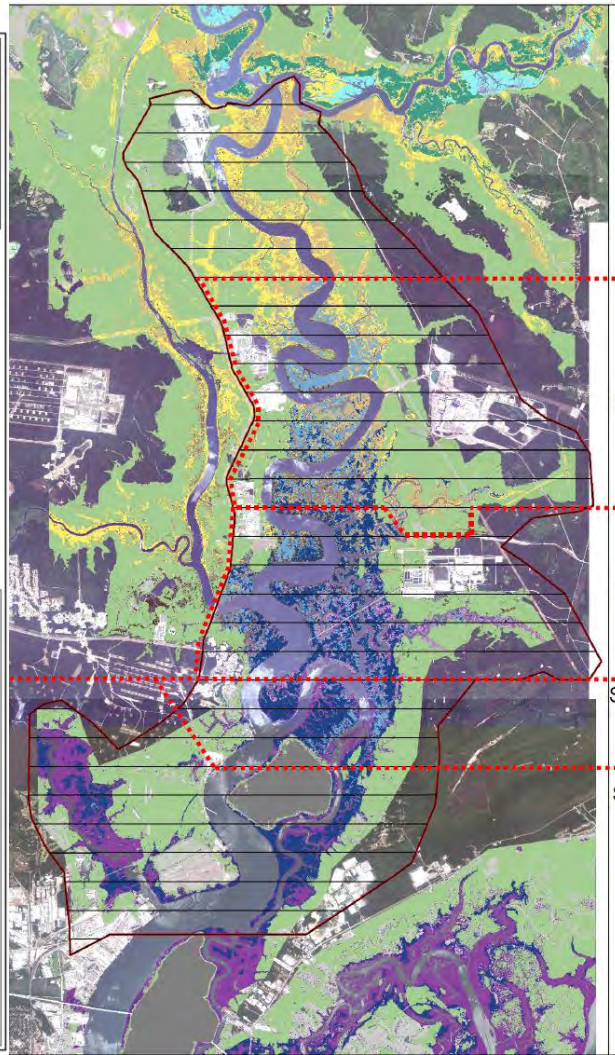
WETLAND HABITAT MAPPING

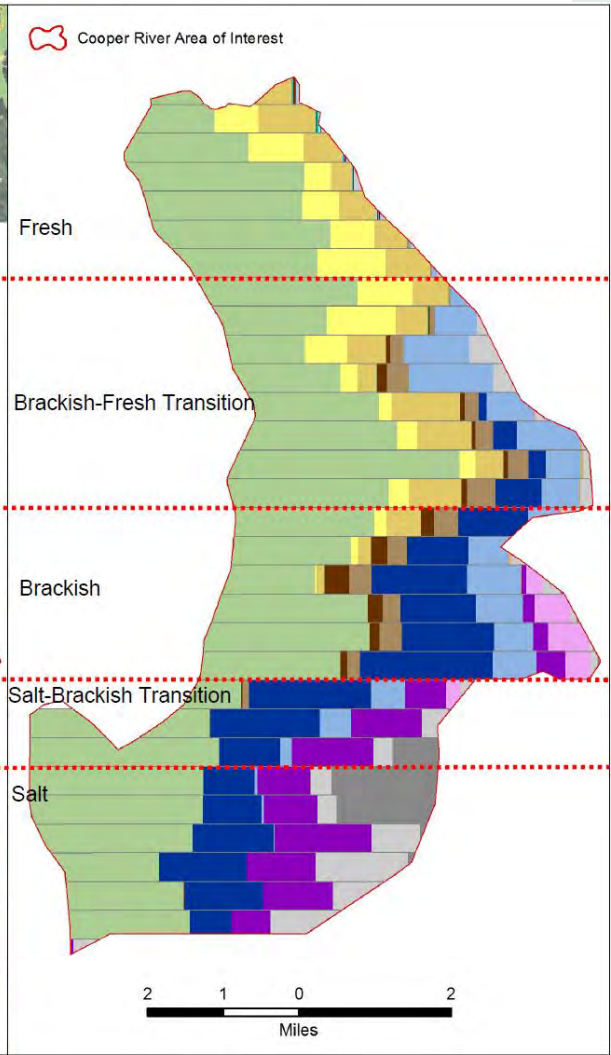
- Charleston Harbor Post 45 feasibility study analyzed and evaluated improvements to the harbor/channel
  - Assess potential project impacts to surrounding resources as a result of deepening and other modifications (impacts will be indirect)
  - Impact assessment required updated wetland characterization near the harbor as a baseline
  - Wetland maps were used with the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model to predict changes in wetland habitat composition as a result of project alternatives
  - Salinity is the primary variable affecting conversion

HABITAT IDENTIFICATION

- Analysis illustrates wetland distribution, abundance, and critical points of corresponding salinity changes
- Data used to determine % freshwater vs. saltwater vegetation within assessment reaches; wetland impacts and mitigation acreages

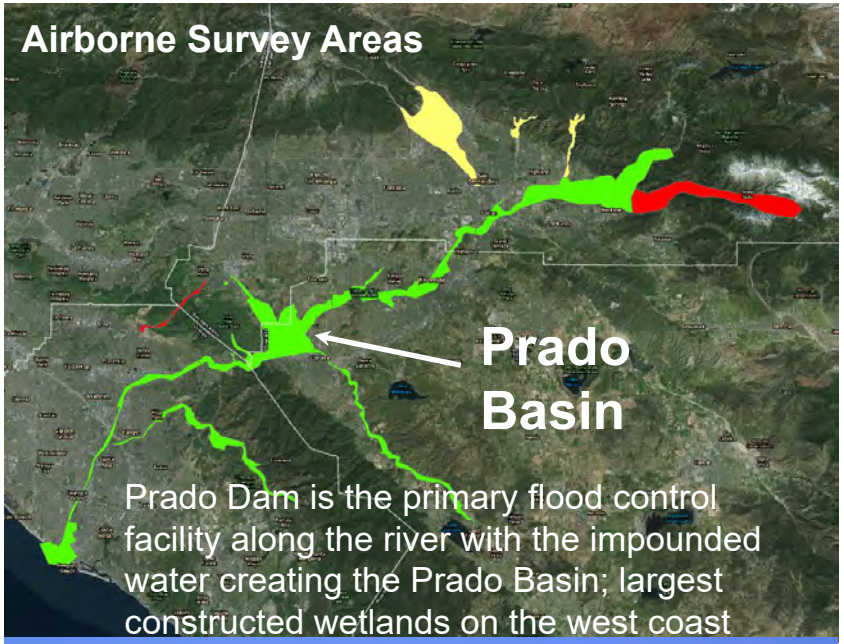






MAPPING INVASIVE GIANT REED

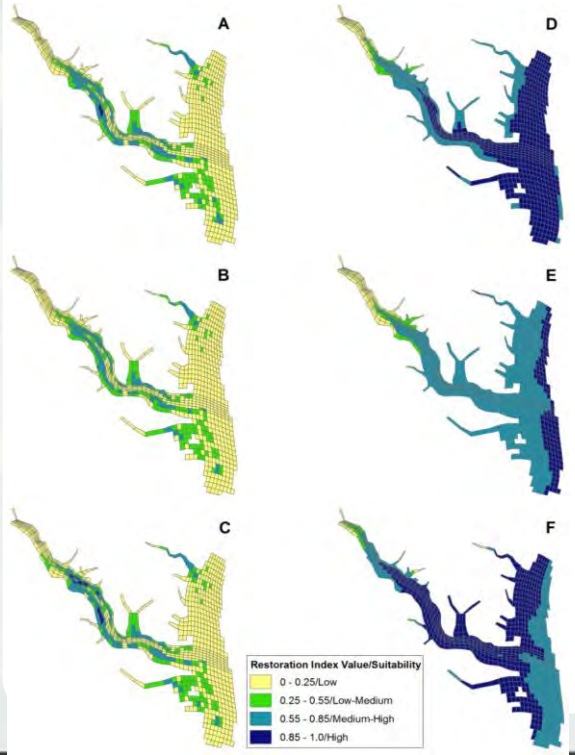
- Support the LA District's Santa Ana River Main Stem Project, a flood risk reduction project, through species-level mapping using high resolution imagery and lidar
  - Detailed and updated maps of Giant Reed (*Arundo donax*) will allow for more efficient and effective ways to identify new mitigation areas as well and monitor progress of existing mitigation areas
  - Coordinated airborne and field surveys with LA District and partner agency field biologists conducted on July 7-15, 2015 collecting data for 70 miles along the river corridor
  - Fused hyperspectral imagery and lidar to identify Giant Reed using a supervised classification approach



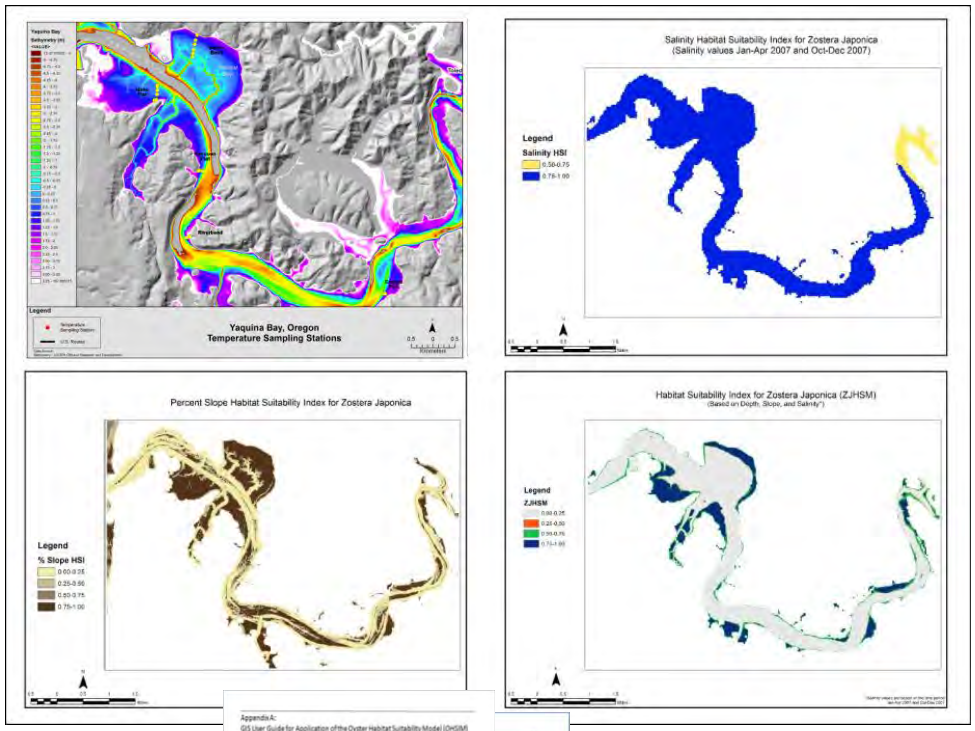
SPECIES/HABITAT MODELING

- Develop models to:
  - ✓ Plan restoration projects more efficiently
  - ✓ Better understand environmental benefits from restoration
  - ✓ Support integrated resource management concepts
  - ✓ Assist with model certification

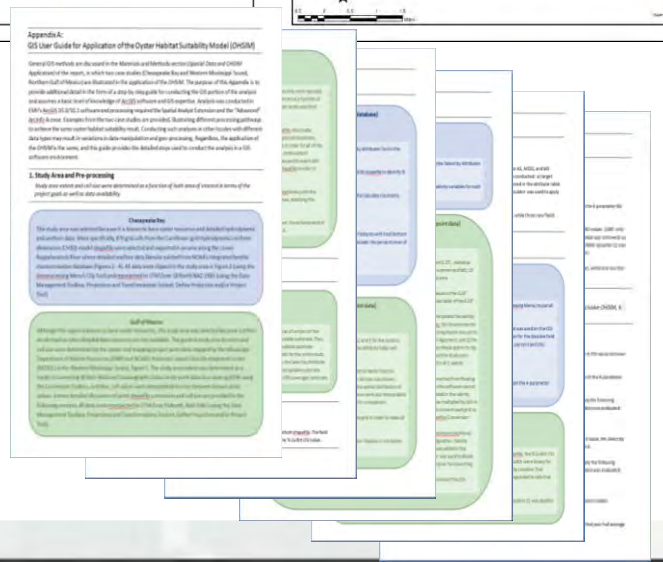
Oyster Restoration



Non-native Seagrass Habitat

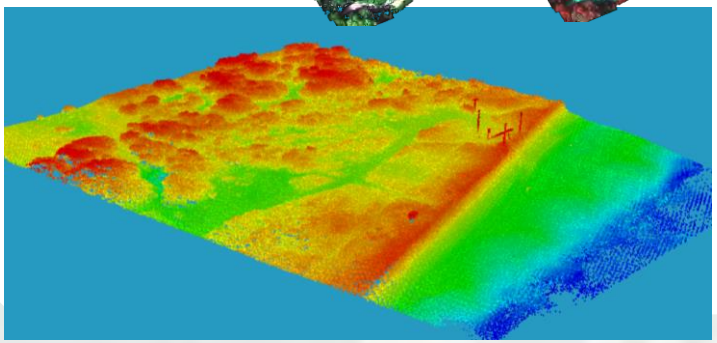


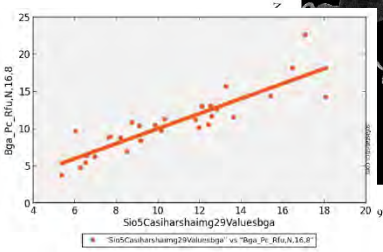
Certified model documentation: GIS Guide

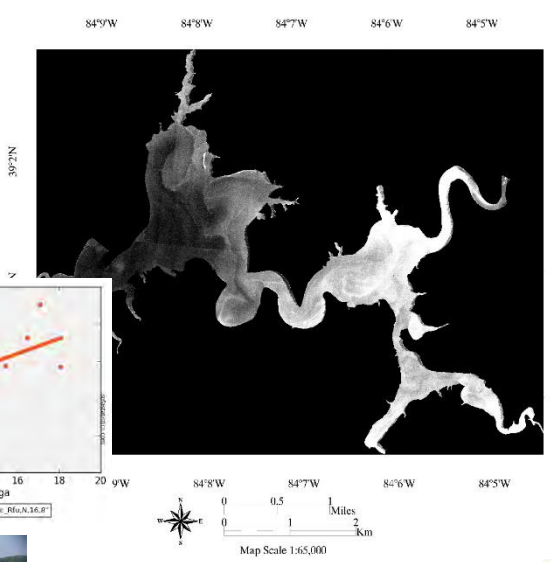


Other related research

- UAS to support Flood Risk Management
  - Ecosystem health subtask to assess vegetation impacts from storms and explore UAS data capabilities to map coastal vegetation characteristics (species composition, etc)
- Harmful Algal Bloom Monitoring
  - Assess hyperspectral and other imagery to identify water quality indicators of HABs in small, inland waterbodies
  - Develop and beta test tools that districts can u







SI05 algorithm applied to CASI imagery with pixel brightness proportional to phycocyanin (proxy for cyanobacterial or blue-green algal biomass)

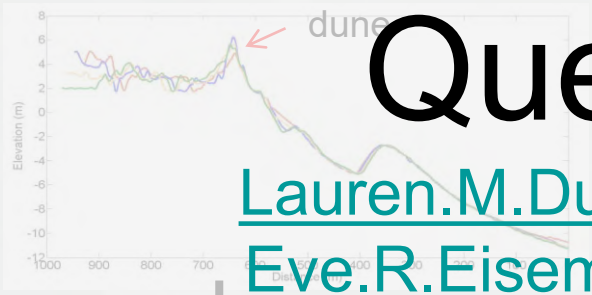
Metrics/Parameters

Elevation
Change (elevation/volume)
Contour (change)
Shoal

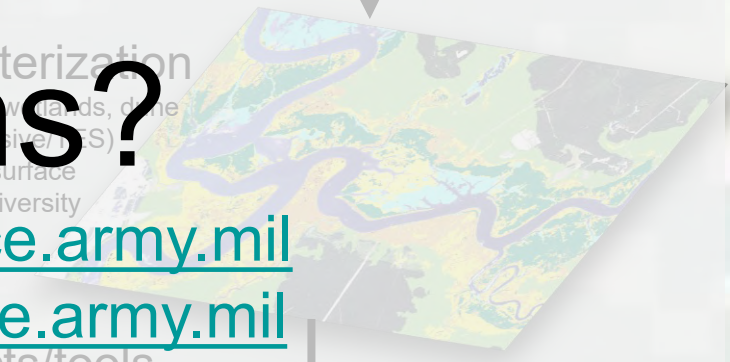
Imagery
Hyperspectral and Multi-Spectral Imagery

Dune
Elevation (crest/toe)
Continuity
Slope
Volume

Beach
Width
Slope



Land characterization
Critical habitat, SAV, wetlands, dune vegetation, invasive species
Impervious surface
Landscape diversity



Questions?

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R&D/Value added products/tools

- Change Detection
  - Landscape change modeling
  - Volume/elevation/shoreline change
  - Structure assessment
- Sediment Budgets
- Monitoring Shore Protection
- Defining Coastal Regions

- Coastal Engineering Index
- Coastal Resilience
- Critical Species Detection and Modeling
  - Sea turtle nesting habitat
  - Oysters*
  - Salmonid

* ECO-PCX model certification