Evaluating Effectiveness of UAS Mounted Sensors for Multi-purpose Mapping of Marshes and Beaches in the NERRS Sentinel Site Network

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Presentation Outline

- Project Questions/Applications
- Introduction to the NERRS Sentinel Site Program
- Project Locations
- Project Scope/Objectives
- Lessons Learned/Accomplishments

TRL STATUS

Current: TRL 5 – Concept Validated in Relevant Environment

Project End Date:

- TRL 7 – Prototype Demonstration in Relevant Environment
- TRL 8 – System-Demonstration in an Operational Environment

General Questions to Address

- **Vegetation Mapping**

Driver: Monitoring/mapping short term variability and long-term changes in habitat/vegetation through using standardized protocols

  - Can this imagery provide a product of better or equal value than imagery acquired through manned or satellite platforms?
  - If so, what are the tradeoffs?

- **Elevation**

Driver: Need to understand how current/projected water level/ inundation patterns effect vegetated habitats

  - Can a UAS mounted lidar penetrate marshes better than manned aircraft mounted lidar?
  - Can UAS-derived lidar provide a product of equal value elevation transects and manned lidar products of beach environments?
  - How does the elevation generated from structure from motion (SfM) and UAS mounted lidar compare?

Applications of UAS Products

NERRS	Local/Regional Projects
Habitat Classification	Derelict Crab-Pot Locations
Emergency Response	Sea Otter Foraging Areas
Invasive Mapping	Wildlife Surveys/Populations Census/Seabird Nesting Surveys
Submerged Aquatic Vegetation	Shellfish Bed Mapping
Digital Elevation Models	Shoreline Change Monitoring
Water Quality Monitoring	Ice Cover on marshes
Water Level Change and Inundation Impacts on Coastal Habitats	Sea Level Rise Impacts on Coastal Communities

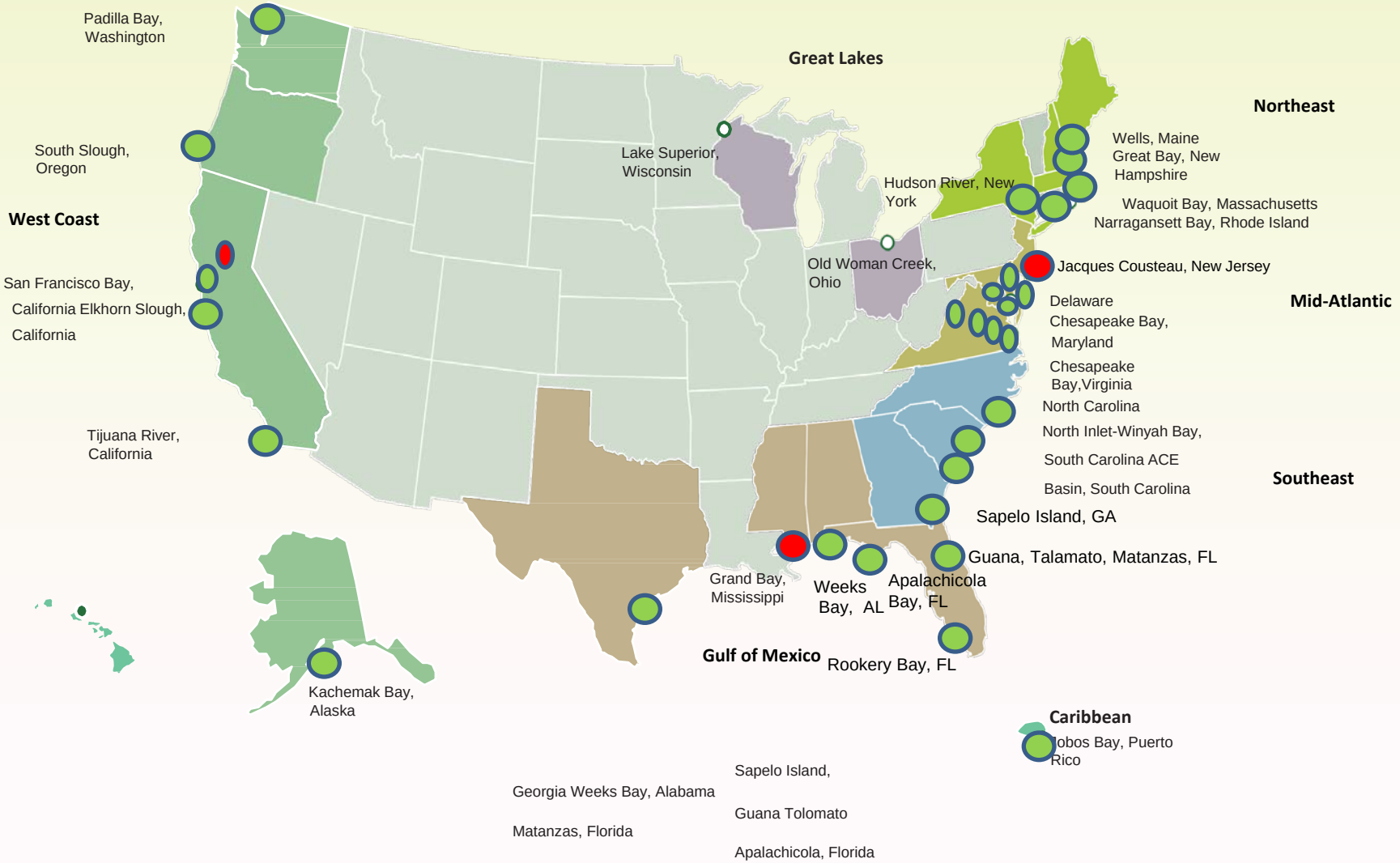
Audiences for UAS Project Outcomes

- NERRS – Mapping and Sentinel Site Priorities
- Coastal Managers -resilience planning, emergency response, and habitat management
- Wildlife Managers
- Researchers/Modelers/Decision Makers

Partners/Collaborators

- UAS Office
- NOS Office for Coastal Management
- Grand Bay, Jacques Cousteau, San Francisco Bay, and Wells NERRs
- Quantum Spatial/Precision Hawk - contractor

NERRS Sentinel Site Network



Georgia Weeks Bay, Alabama

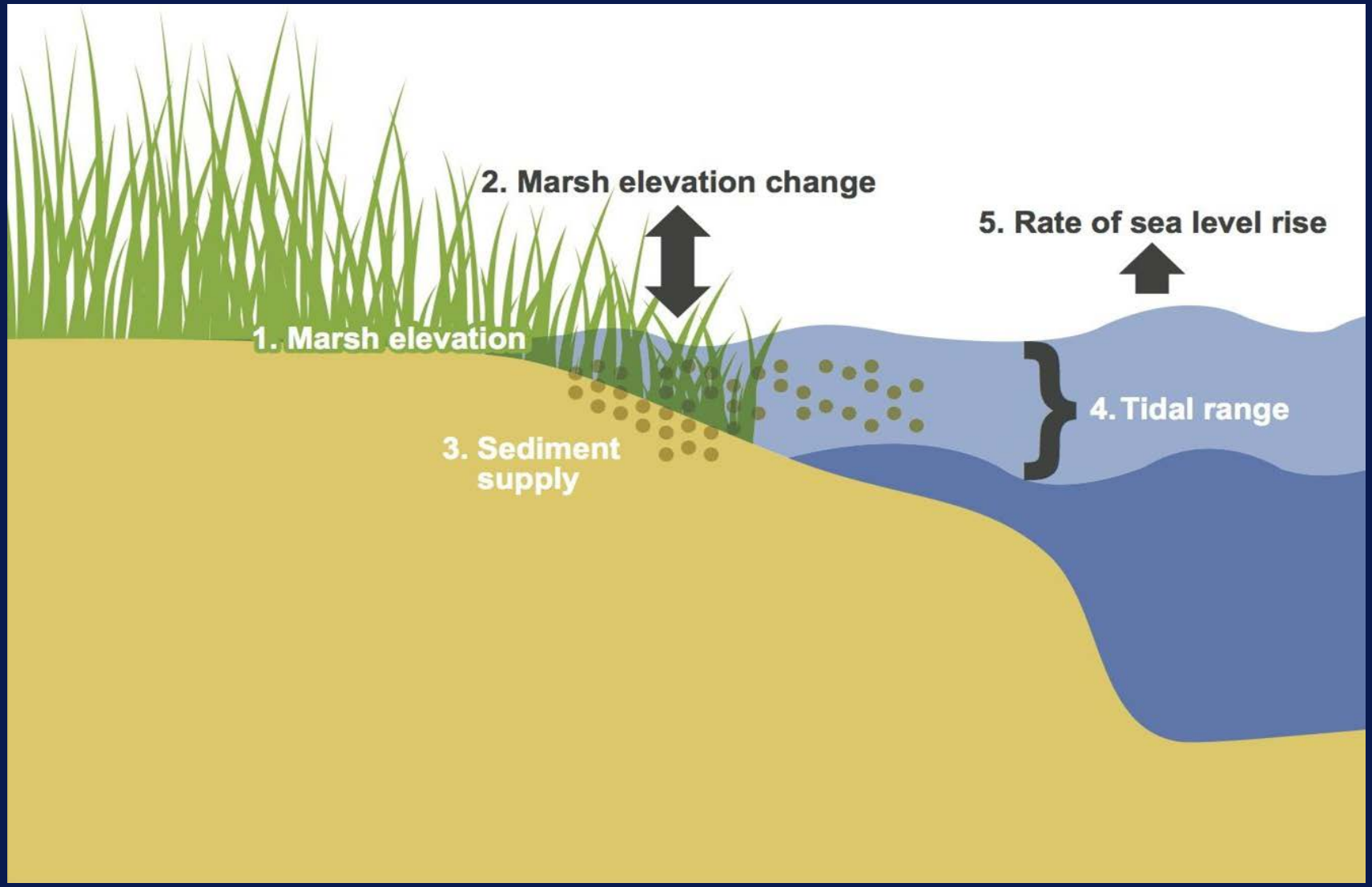
Sapelo Island,

Guana Tolomato

Matanzas, Florida

Apalachicola, Florida

Indicators of Marsh Resilience



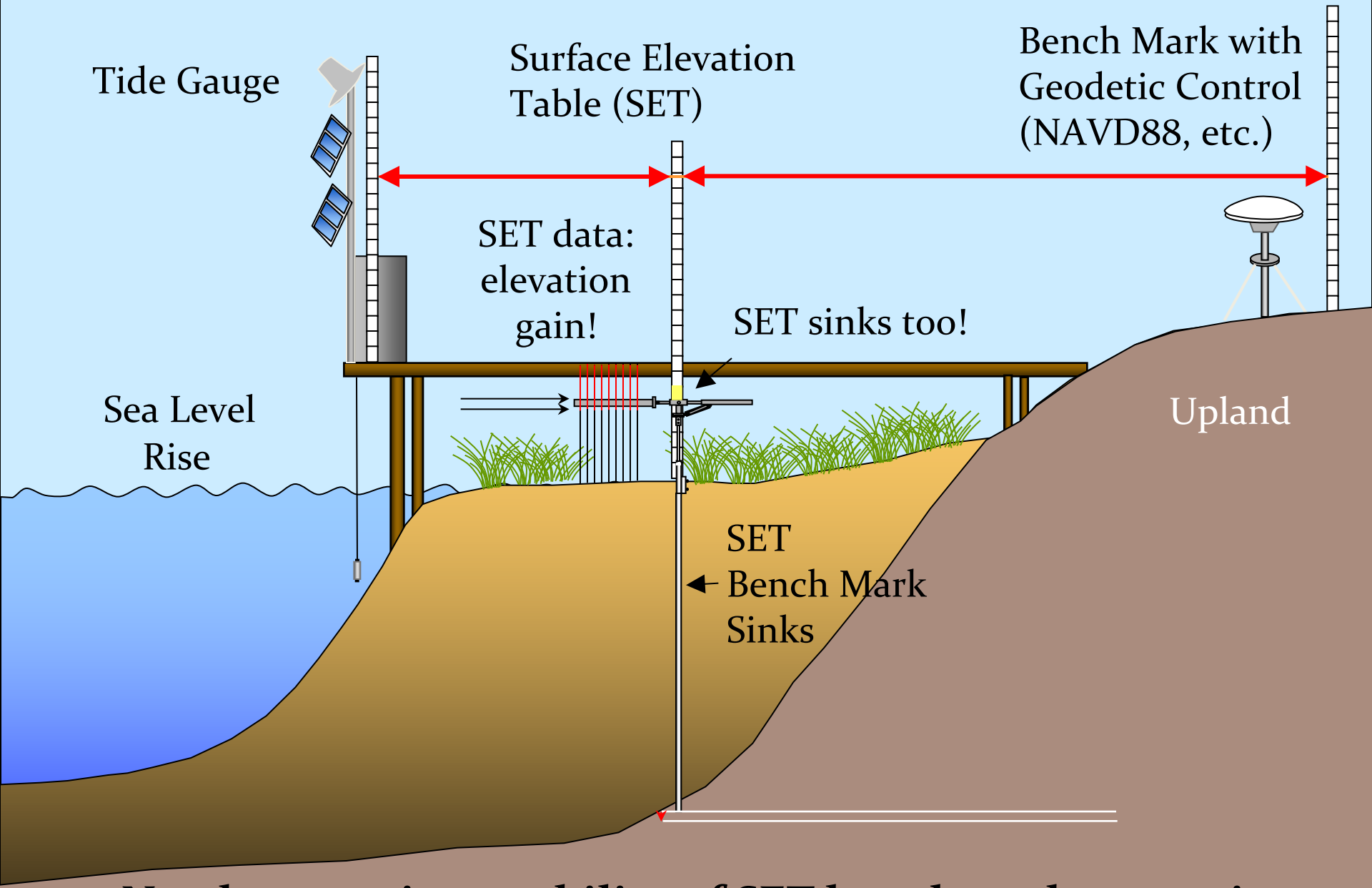
Sentinel Site Infrastructure

Vertical Control
- Benchmark network tied to NSRS
- Use of Digital leveling or GPS occupations

Elevation and sediment dynamics
- Surface elevation tables
- Marker horizons

Vegetation surveys
- Emergent marsh plots along transects
- Marsh grass elevation/species composition

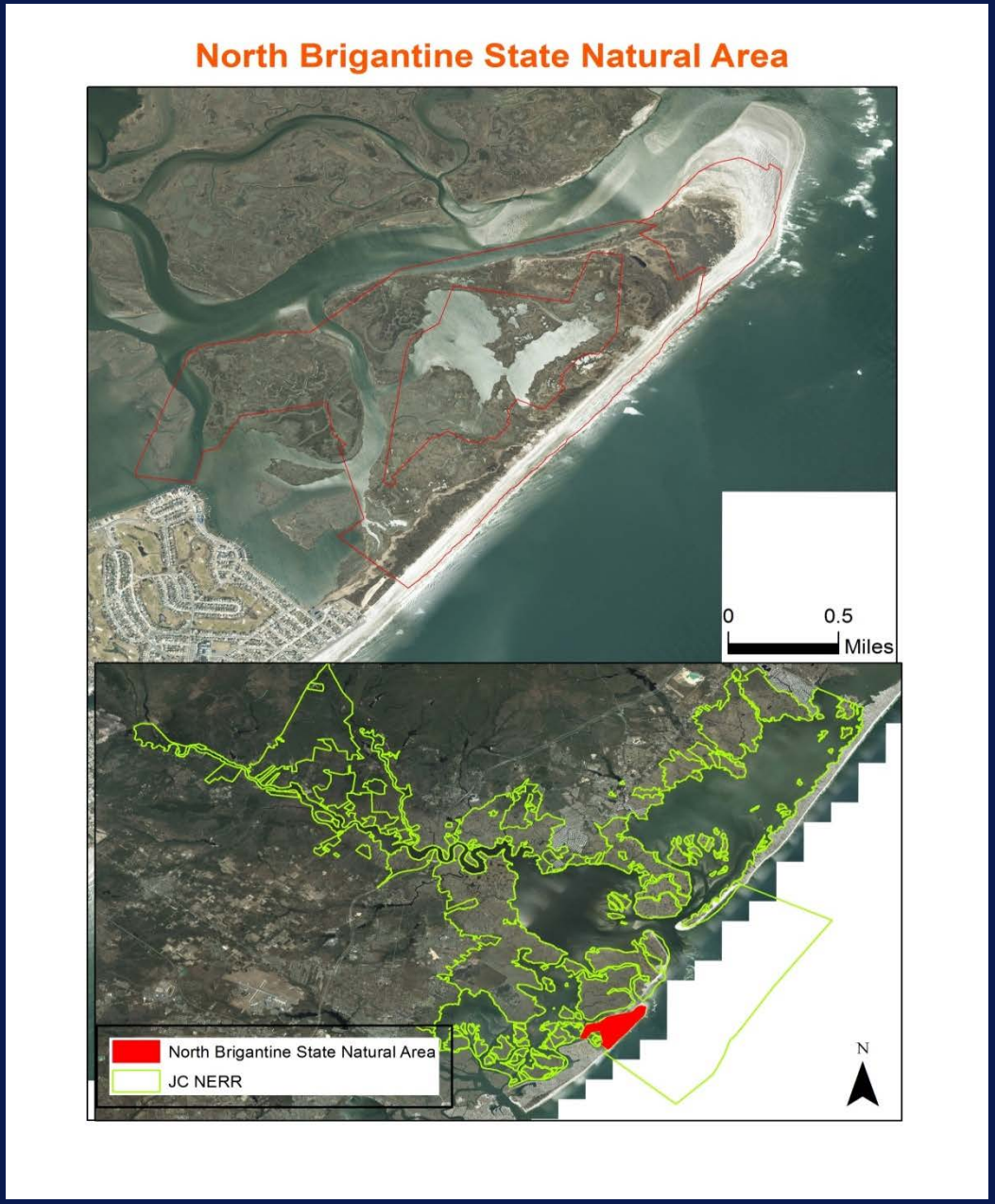
Water level monitoring
- Site-specific NERRS Data loggers/NOAA tide stations
- Ground water wells



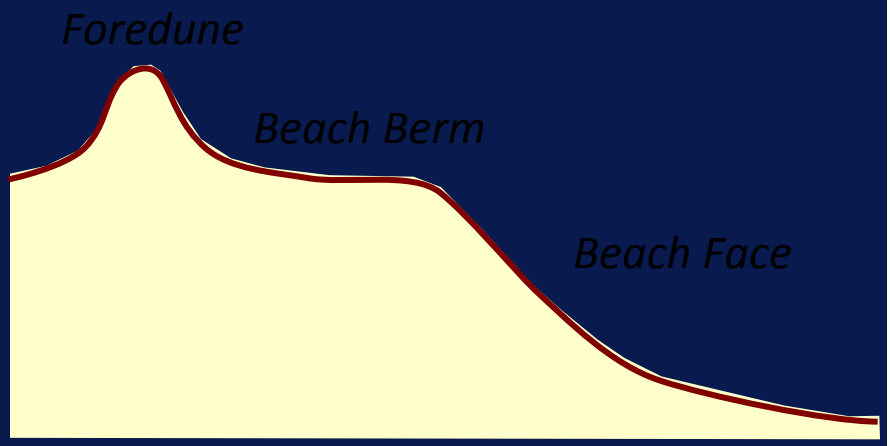
Need to monitor stability of SET benchmarks over time

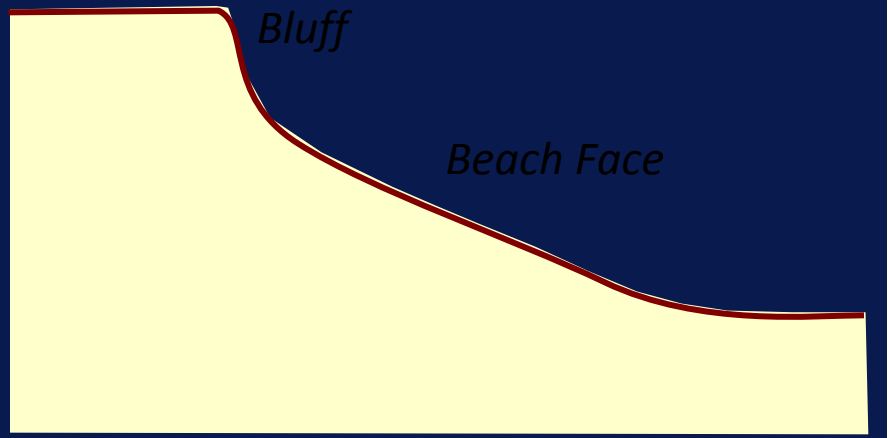
Jacques Cousteau NERR, New Jersey

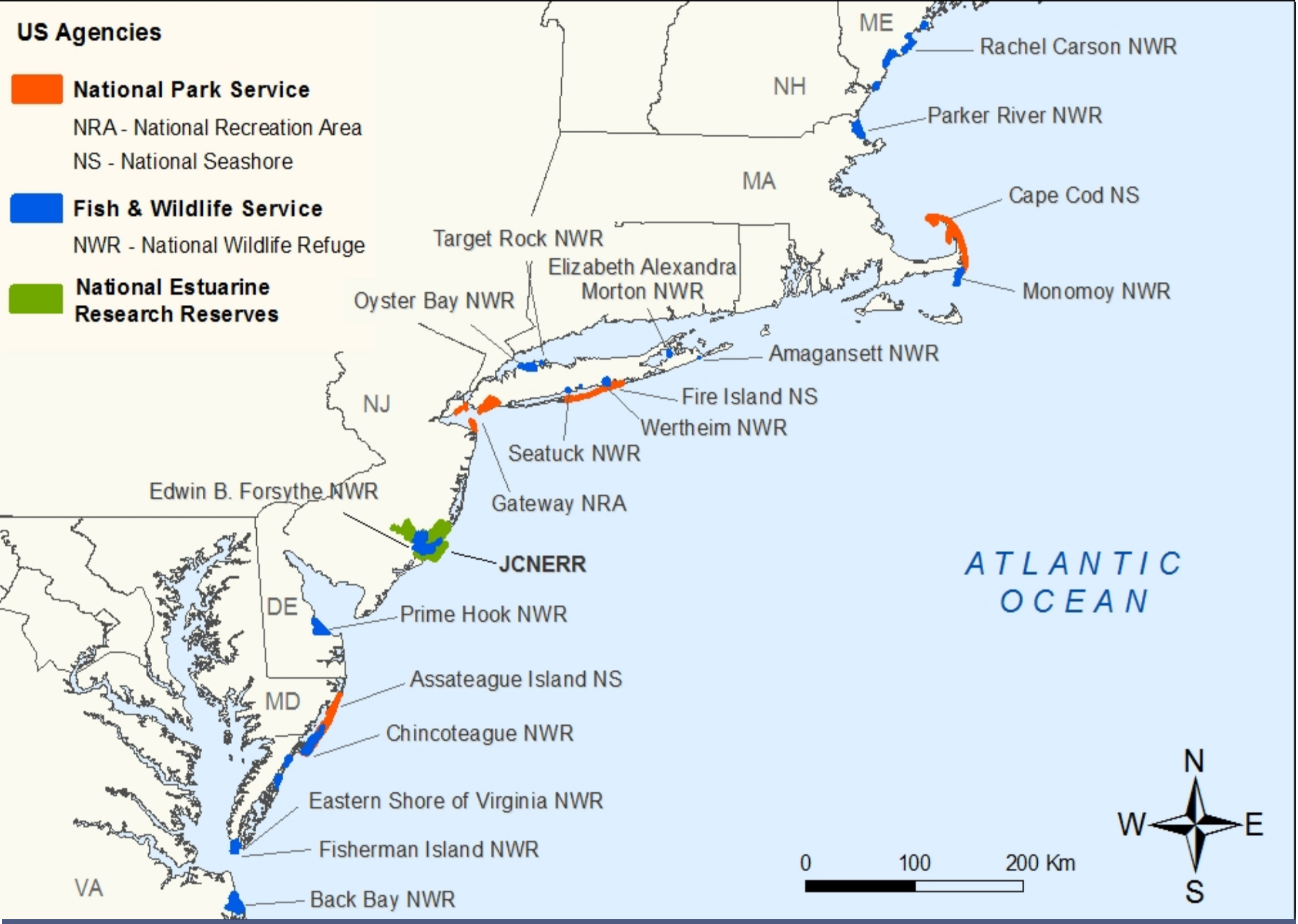
- Marsh/Dune Habitat
- Elevation captured by RTK transects and lidar from aircraft
- Focus – assessing: 1) ability of imagery to discriminate various vegetation types; 2) horizontal accuracy; and 3) accuracy of lidar from UAS compared to RTK of beach environments – can we get within 10 cm accuracy?



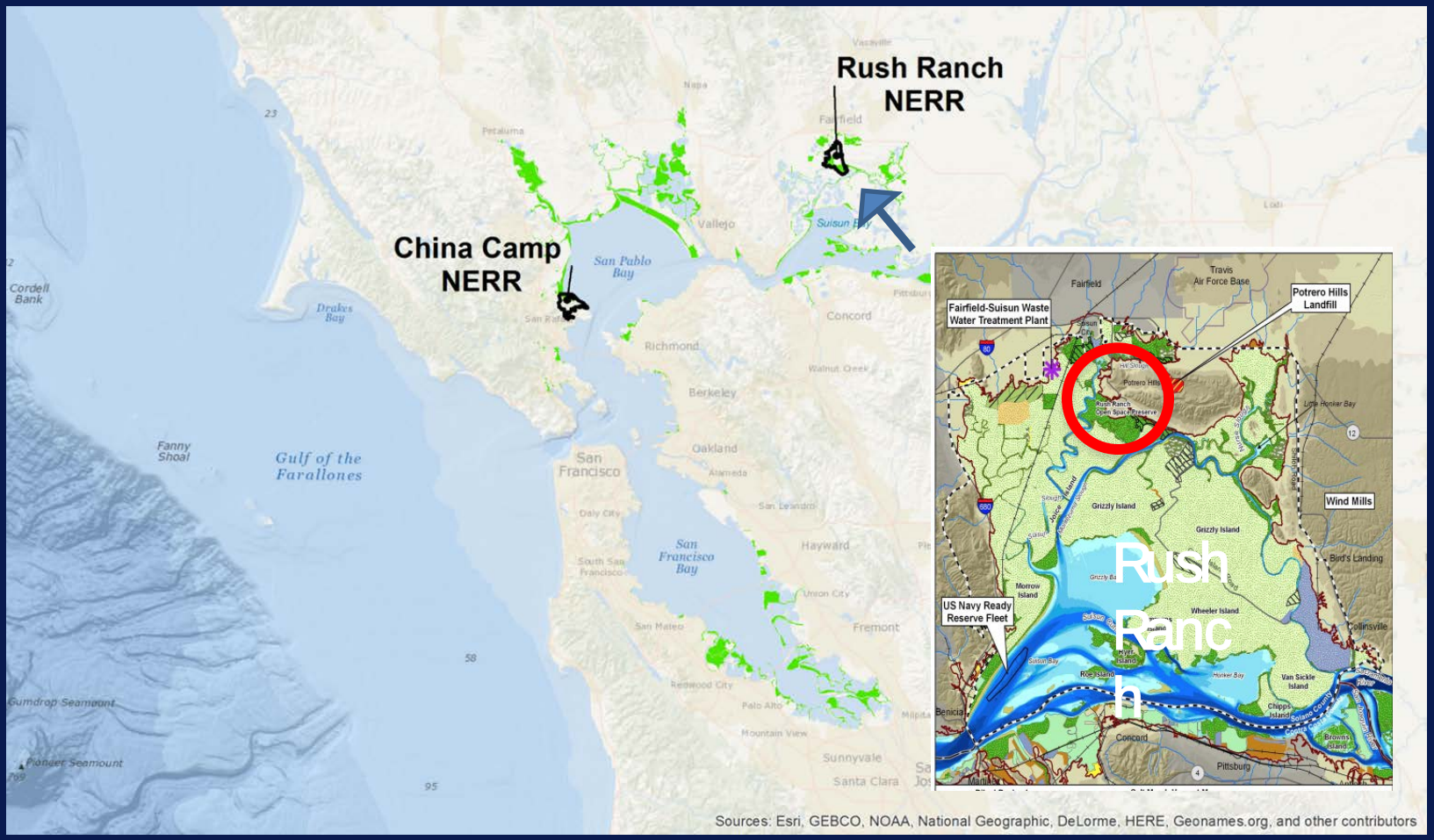
2-D Beach Cross Sections





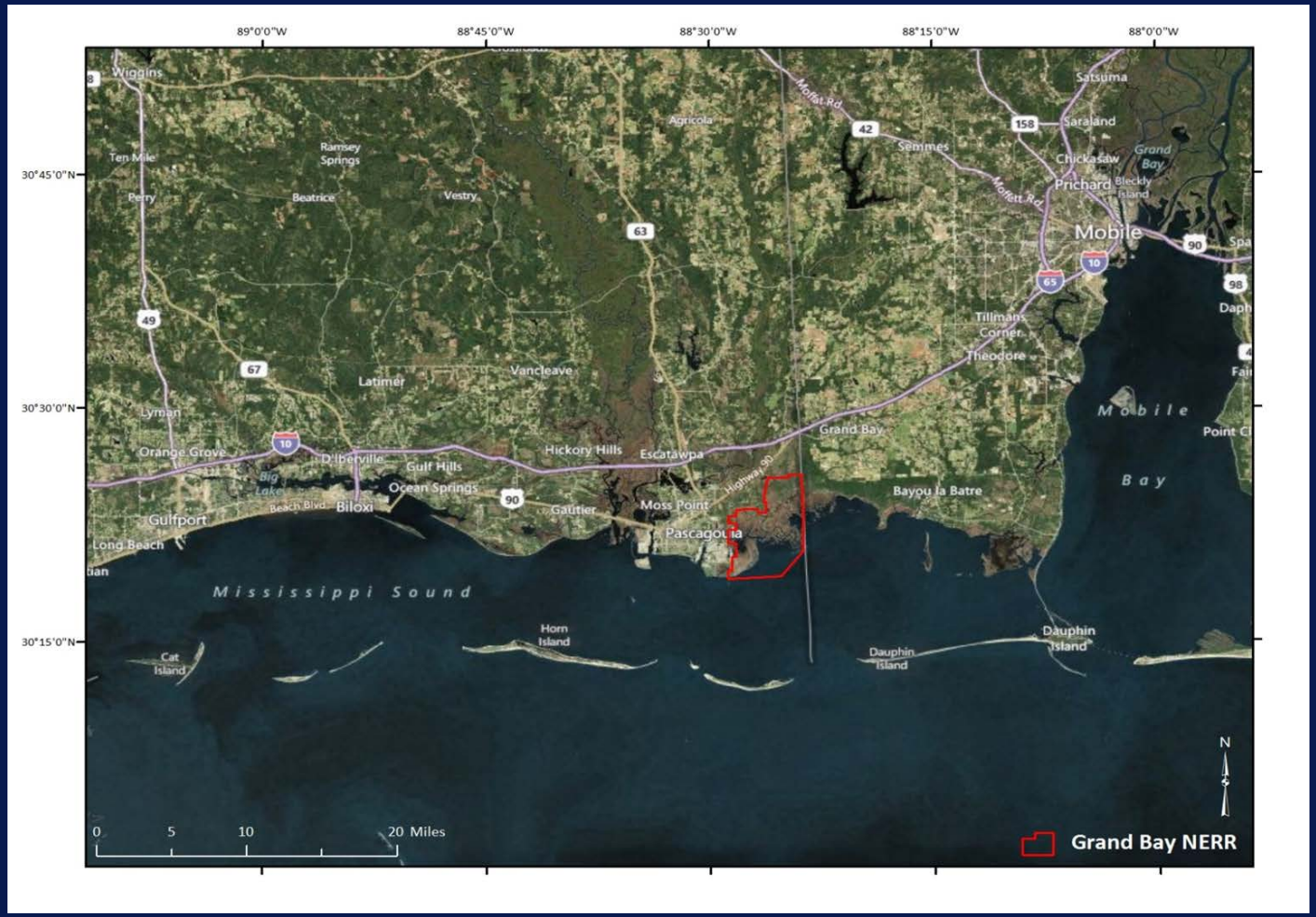

US Agencies
National Park Service
NRA - National Recreation Area
NS - National Seashore
Fish & Wildlife Service
NWR - National Wildlife Refuge
National Estuarine Research Reserves
ME
NH
MA
NJ
DE
MD
VA
Rachel Carson NWR
Parker River NWR
Cape Cod NS
Monomoy NWR
Target Rock NWR
Elizabeth Alexandra Morton NWR
Oyster Bay NWR
Amagansett NWR
Fire Island NS
Wertheim NWR
Seatuck NWR
Gateway NRA
Edwin B. Forsythe NWR
JCNERR
Prime Hook NWR
Assateague Island NS
Chincoteague NWR
Eastern Shore of Virginia NWR
Fisherman Island NWR
Back Bay NWR
ATLANTIC OCEAN
0
100
200 Km
N
W
E
S

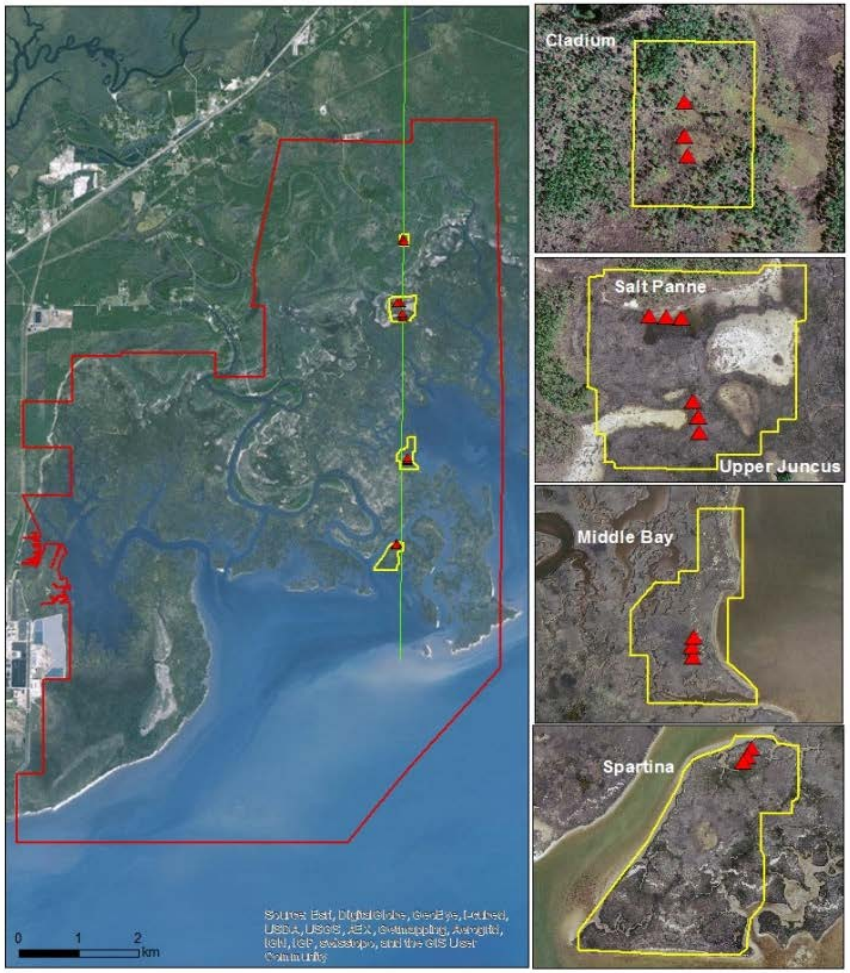
San Francisco Bay NERR, CA




THALES

Grand Bay NERR, MS





Pine savanna, *pinus elliottii palustris*

Black Needlerush, *Juncus roemerianus*

Smooth Cordgrass, *Spartina alterniflora*

Project Scope and Objectives

Acquire multi-spectral imagery and lidar in three different ecosystems

- Evaluate horizontal and vertical accuracy of unmanned aerial system (UAS) imagery and lidar
- Evaluate lidar to measure ground elevations through marsh vegetation compared to manned systems lidar
- Assess trade-offs between UAS lidar and RTK transects on dunes
- Compare accuracy of SfM and lidar-derived DEMs of marsh and dune features
- Compare effectiveness of UAS imagery to manned systems imagery for vegetation mapping
- Evaluate gains from combining UAS lidar to imagery for vegetation mapping
- Evaluate ability of the private sector to provide UAS-based data using a Brooks Act contract

One survey at JCNERR and GBNERR and two at SFBNERR to provide multi-season imagery and elevation repeatability

Project Products

- Multi-spectral (at least four-band) image three-centimeter resolution or better
- DEM from lidar flown on a UAS
- Lidar data classified for ground, water, and unclassified with a non-vegetated vertical accuracy of 10 centimeters or better
- A digital elevation model from SfM

Technical Project Plan Contract

- Contracted imagery and lidar surveys through the Coastal Geospatial Services Contract to Quantum Spatial and PrecisionHawk
- PrecisionHawk Lancaster platform, five-band multi-spectral imager, a Velodyne PUCK lidar
- Flights at altitudes of 250 to 300’ for imagery/50 meters for lidar
- Exact specifications will be determined by the contractor to meet the data requirements

Airspace Classification

Reserve	Military Area	Refuge	State Owned	Class B	Class C	Class D	Class E	Class G
Jacques Cousteau, NJ		X	X		x			
San Francisco Bay, CA	X		X	x				
Grand Bay, MS			X				x	

Lessons Learned So Far – Timing Delays in Receiving COA and Permits

Rush Ranch COA Timeline

- April 2016 – Grant awarded
- May 2016 – PrecisionHawk submitted COA request
  - Expected six-to-eight-week turnaround
- September 2016 – No COA yet, conducted field work anyway
- October 2016 – Vegetation window passed
- December 2016 – COA approved, good until April 2017
- February 2017 – COA re-issued and extended 2 years
- June 2017 – Target collect time to avoid endangered species

Conclusions and Lessons

- Certificate of Authorization
  - Takes longer than estimated
  - Might not fit your window
- Land Ownership
  - Permission can take time
  - You may be denied
- Contracting
  - Long process
  - Rapid response a challenge

Accomplishments

- Ground control/vegetation classes acquired at SFBNERR in September, 2016
- Environmental compliance completed
- COA approval/Extension for SFBNERR
- JCNERR field work completed week of March 6, 2017
- Planning for GBNERR underway