<u>Drones in the Coastal Zone Community of Practice Meeting – August 7, 1:30 - 3:00pm</u>

Number of folks in attendance: 42

Welcome & Introductions

- Steering Committee Update - Abbey Wakely
  - The Steering Committee is meeting monthly to plan for a Drone in the Coastal Zone in Person Meeting on February 6-8, 2023. It will be hosted in Beaufort, NC. Duke University has graciously offered to host training at their facility focused on data collection, data processing, and flight skills. The team is also looking into offering a National Institute of Standards and Technology (NIST) certification at Duke University for an extra fee.
  - An official save-the-date for the workshop will come soon. Outline will be as followed (subject to change):
    - Feb. 6 - afternoon meeting and welcome social
      - Exploring option of morning trainings at Duke based on interest / capacity
    - Feb. 7 - all day workshop
    - Feb. 8 - trainings at Duke University (limited capacity)

Presentation: Uncrewed Tech for Ocean Protection: How commercial drones are being utilized for coastal and marine environmental research and monitoring – CDR Matt Pickett, NOAA (Ret)
www.oceansunmanned.org

- See slides
- See videos on YouTube: https://www.youtube.com/channel/UCn7CssZbin2a4OjCZq6VnUQ

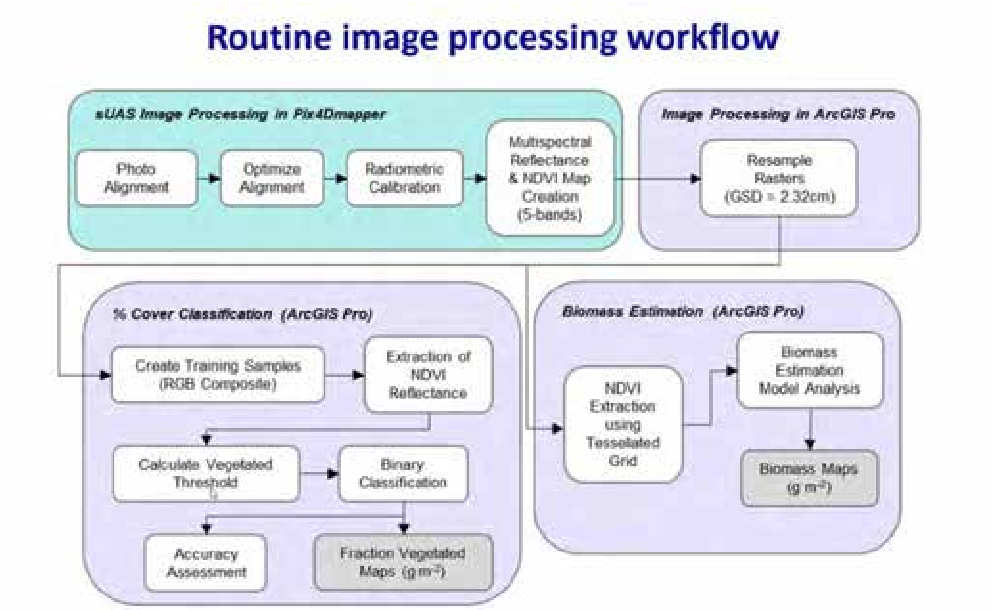
- Intro
  - Operationalist, not specialist. Support researchers.
  - Non-profit, facilitate use of technology
  - 3 platforms
    - Multi rotor, Fixed wing, VTOL (ability to take off land boats and maintain long flight time)
  - UAS Payloads examples: RGB, Multispectral, LiDAR, telemetry, etc.
- Marine Protected Area Management Requirements Utilizing Drones
  - Living marine resource surveys
    - Thermal data and use computer learning to identify hotspots. It can be challenging
    - Topographic lidar for seal counts (?)
      - RGB to count pups - hand count of dots of seals
    - RGB to determine school size estimates
  - Visitor and vessel use surveys
    - Anchorage count
  - Habitat mapping
    - Correlated vegetation density index and overlaid with seals to correlate habitat to seal density.
    - Salmon habit mapping (multiple spec, topographic, RGB)
  - Enforcement

        - Anti-poaching efforts, drone provides presence with a spotlight and recorded message
    - Emergency Response
        - Responding to oil spills and vessel groundings to do damage assessments
    - Maritime Heritage
        - Shallow water shipwrecks
    - Marine Debris
        - Ocean cleanup (map debris field and create hotspots) and maldives (beach surveys with fixed wing)
    - Coastal mapping for nautical charts
        - Dynamic coastal areas
- Program
    - freeFLY
        - Volunteer network of trained drone operators to support marine mammal entanglement response efforts
    - Eco-Drone
        - Advance and encourage environmentally conscious operations of recreational drones to protect and limit disturbances (education and outreach effort - social media, documentary)
- Discussion:
    - Ryan Druyor: Does anyone have training images of marine debris within mangroves or a vegetated shoreline for machine learning or AI?
        - Oceans Unmanned has beaches or open ocean
        - Alix: has many from Hurricane Michael
    - Chuan Hu: requesting marine debris images from the Pacific are available to share?
        - Oceans Unmanned will send to Whitney

Presentation: Incorporating drones in long-term saltmarsh monitoring: mapping biomass and vegetation cover at high temporal and spatial scales – Erik Smith, North Inlet-Winyah Bay National Estuarine Research Reserve - See slides

- NERRS Long-term emergent marsh vegetation monitoring
    - National goal: Understanding impacts of changing sea level and tidal inundation on marsh habitats to inform management, mitigation and restoration strategies
    - A key question: What are the current distributions of vegetated communities with respect to tidal range, and how sensitive are these distributions to changes in tidal inundation and sea level rise?
        - Focus on vertical accretion and horizontal migration
- Approach: permanent sampling plots and standard non-destructive vegetation metrics (% cover, stem density)
- Limitation of sampling design: resolution of spatial and temporal data
    - Need to improve sampling of dynamics of the marsh to increase spatial and temporal data collection
- Funding: NOAA funded collaboration to develop standardized workflows, protocol to do same work in their marshes. NERRS science collaborative funded drone marsh monitoring protocol: https://nerrssciencecollaborative.org/resource/protocol-monitoring-coastal-wetlands-drones

- o Davis et al. Best Practices document: https://nccospublicstor.blob.core.windows.net/projects-attachments/481/Best%20Practices%20Final%20Tagged.pdf
- Flights
  - o Sensor = MicaSense Altum
    - 5 bands: B, G, R, "rededge" (717nm), NIR (842 m)
    - Radiometric calibration
    - 1 flight = 700 images / band
  - o Airframe = DJI Matrice 200 v2
  - o Flights at morning low tides (every 2 weeks)
  - o 50m altitude; GSD = 2.3 cm
  - o permanent ground control (= 2/ha)
- Data processing
  - o Pix4DMapper: image processing
  - o ArcGIS Pro: data manipulation & analysis
- Ground-truth data collection
  - o S. alterniflora biomass (g dry weight m-2)
    - 0.25 m? clipped plots, sorted as live vs. dead, washed, dried (60 °C), and weighed.
    - Sampling seasonally in both marsh segments
  - o RTK-GPS for ground control and biomass plots
- Workflow
  - o Operationalized the program. See diagram.



- Converting NDVI to S. alterniflora aboveground biomass (most important)
  - o Showcased a biomass time-series example of grass growing on marsh
  - o Argument for effort to make seasonal measurements
- Calculating fraction vegetated from NDVI (percent coverage)
- Summary
  - o The use of UAS allows us to routinely and reliably monitor changes in vegetation biomass and cover.

        - Multispectral imagery is a robust predictor of live aboveground biomass of S. alterniflora. Can use a single model across time and location
    - Pixel-level classification allows robust estimates of s. alterniflora % cover.
    - Repeat flights demonstrated distinct spatial and inter-annual variability in seasonality of biomass growth.
    - Next steps:
        - Continue time-series
        - Classification of additional marsh plant communities
        - Expand marsh elevation surveys (e.g., drone-based LiDAR)
- Discussion
    - Allix: will the tessellation grid be added as an appendix to the current marsh monitoring protocol?
        - Erik: yes that is the recommended and will be added
    - Plans for PPK (??) drones might eliminate the need for ground control points in future. Interested in flying drones to compare.
        - Still need ground control for vertical

Discussion:

- Erik Smith - FAA no pushback on remote ID deadline?
    - Gary Sundin: drone tags on order--hopefully arrive by Sept 16th
        - Link: https://dronetag.cz/products/beacon/#specifications
        - Scott: 10 weeks waiting for drone tag (all on backorder). Aircraft will be grounded in a month
    - Ocean Unmanned has recommendations to retrofit fleet
    - Troy: everything on back order, official name Drone Tag Mini ($300).
        - Transferable among drones? Yes, but you need to change the serial number to the drone in use and register by FAA on the website each time you move the tag.
        - Scott: Can't transfer 107 easily
- Survey to inform February 2024 in-person meeting, results:
    - 36 respondents
    - Top 4 drone applications that interest you the most
        - Data processing techniques, data products, and analytical workflows
        - Emerging techniques and technologies
        - Best practices for drone operations including mission planning and survey methodologies
        - Information gaps in coastal ecosystem management
    - Top 4 training and demonstrations would you like to see at the workshop
        - Mapping Exercise that involves the collection and processing of a mapping image dataset.,
        - Photogrammetry Exercise that involves the collection of imagery for photogrammetric analysis.,
        - Flight Skills exercise to improve flying skills,
        - Certification for NIST (National Institute of Standards and Technology) for an extra fee: https://www.nist.gov/el/intelligent-systems-division-73500/standard-test-methods-response-robots/aerial-systems/open-test
    - Discussion
        - NIST course teach how to use camera and drone to fly safely and receive certification

- Provides a mechanism for certification - need another group to provide the certification.
- From Scott Reynolds: APSA-Basic Proficiency Evaluation for Remote Pilots (BPERP) Certificate Application (publicsafetyaviation.org). They also do a train-the-trainer. Some SC Interagency Drone Users Consortium (SCiDUC) members have done both.
    - If nothing else, a few of the bucket stands can provide a good exercise for honing flying skills and complex maneuvering. A full NIST lane is not necessary… and a stand with buckets is inexpensive and easy to build.

Oceans Unmanned

Bringing Tech to Ocean Protection

Unmanned Tech for Ocean Protection

How commercial drones are being utilized for coastal and marine environmental research and monitoring

Drones in the Coastal Zone – Community of Practice

07 August 2023

CDR Matt Pickett, NOAA (ret)   CAPT Brian Taggart, NOAA (ret)

Founders, Oceans Unmanned, Inc.

www.oceansunmanned.org

Unmanned Tech for Ocean Protection

Unmanned Tech for Ocean Protection

Overview

- Intro to Oceans Unmanned
- Ocean and Coastal Research Projects
- freeFLY Program
- ECO-Drone Program
- Discussion

Unmanned Tech for Ocean Protection

Oceans Unmanned, Inc.

A nonprofit dedicated to protecting our oceans and marine resources through the use of unmanned technologies and promoting their safe and Environmentally Conscious Operations

Unmanned Tech for Ocean Protection

Multi-Rotor

Fixed-Wing

VTOL

Bringing Tech to Ocean Protection

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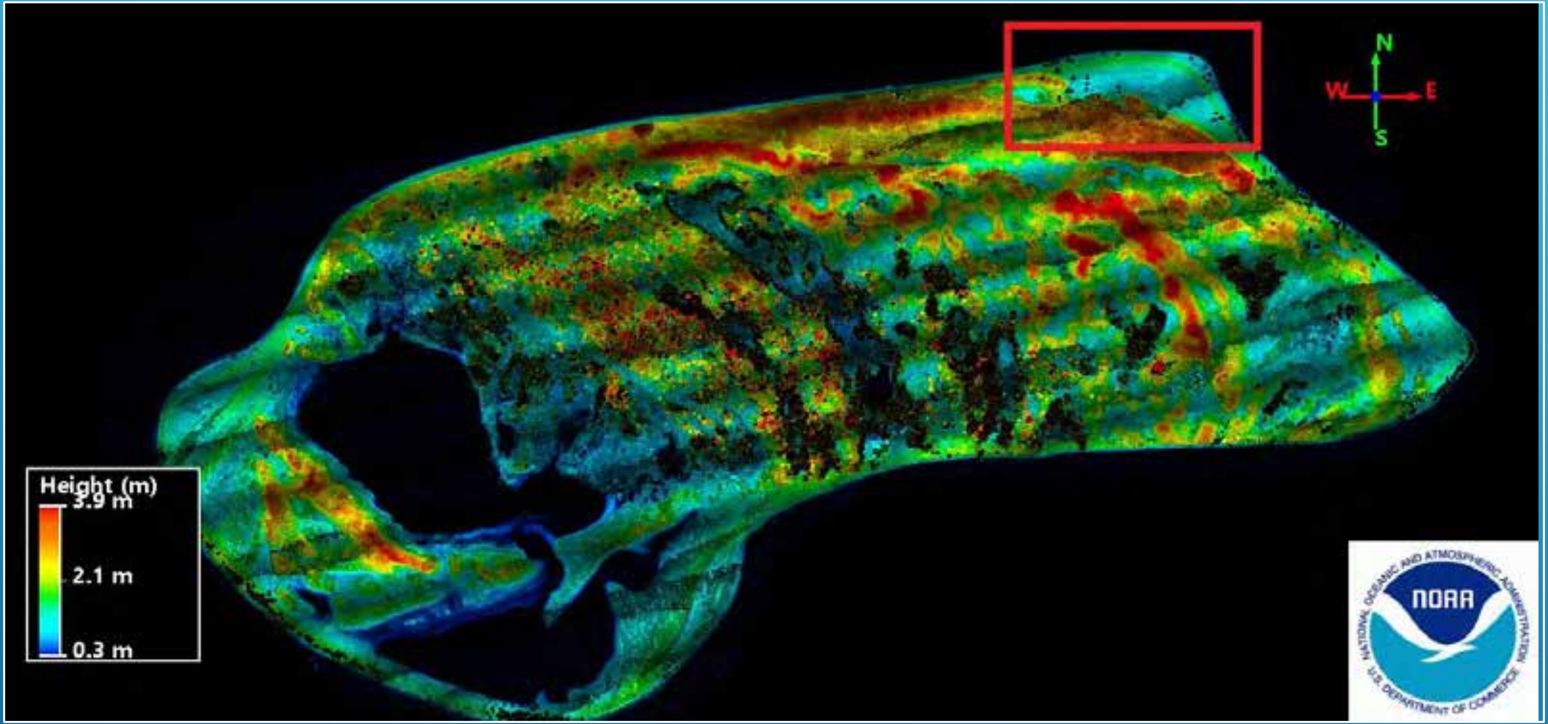

UAS Payloads:

- RGB
- IR / Thermal / NIR
- Multispectral
- Hyperspectral
- LiDAR
- Telemetry

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MPA Management Requirements Utilizing Drones

- Living Marine Resource Surveys
- Visitor and Vessel Use Surveys
- Habitat Mapping and Characterization
- Enforcement
- Emergency Response
- Maritime Heritage
- Marine Debris

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Living Marine Resource Surveys

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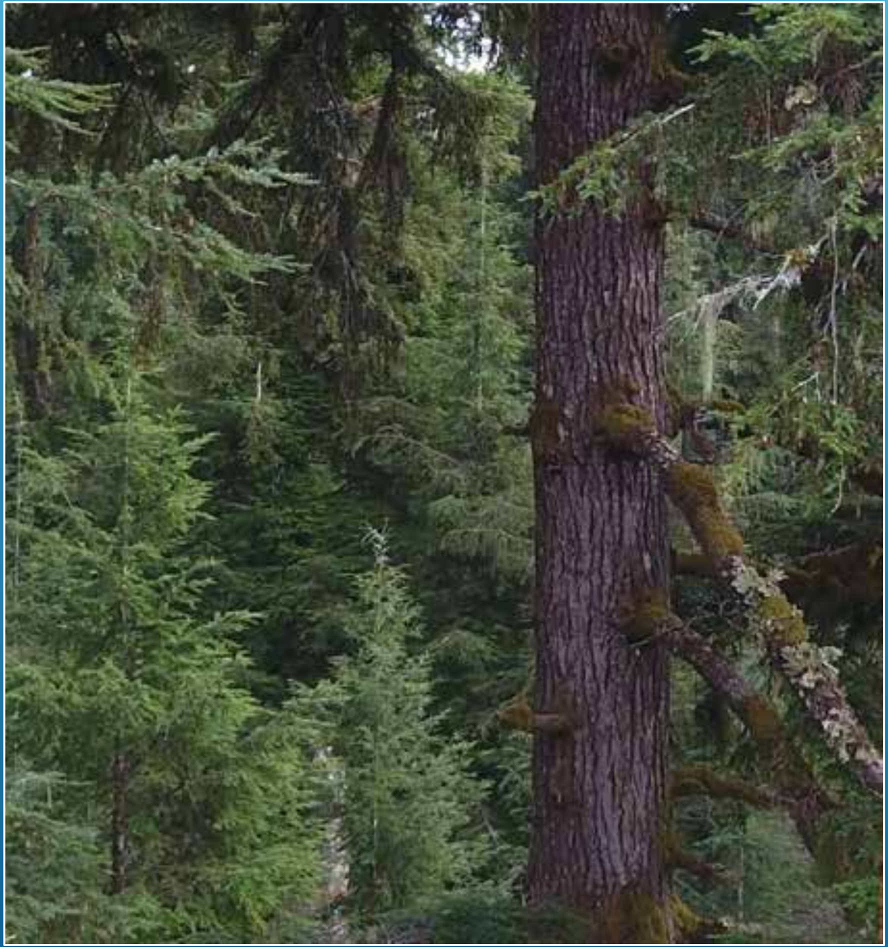
Living Marine Resource Surveys



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Living Marine Resource Surveys

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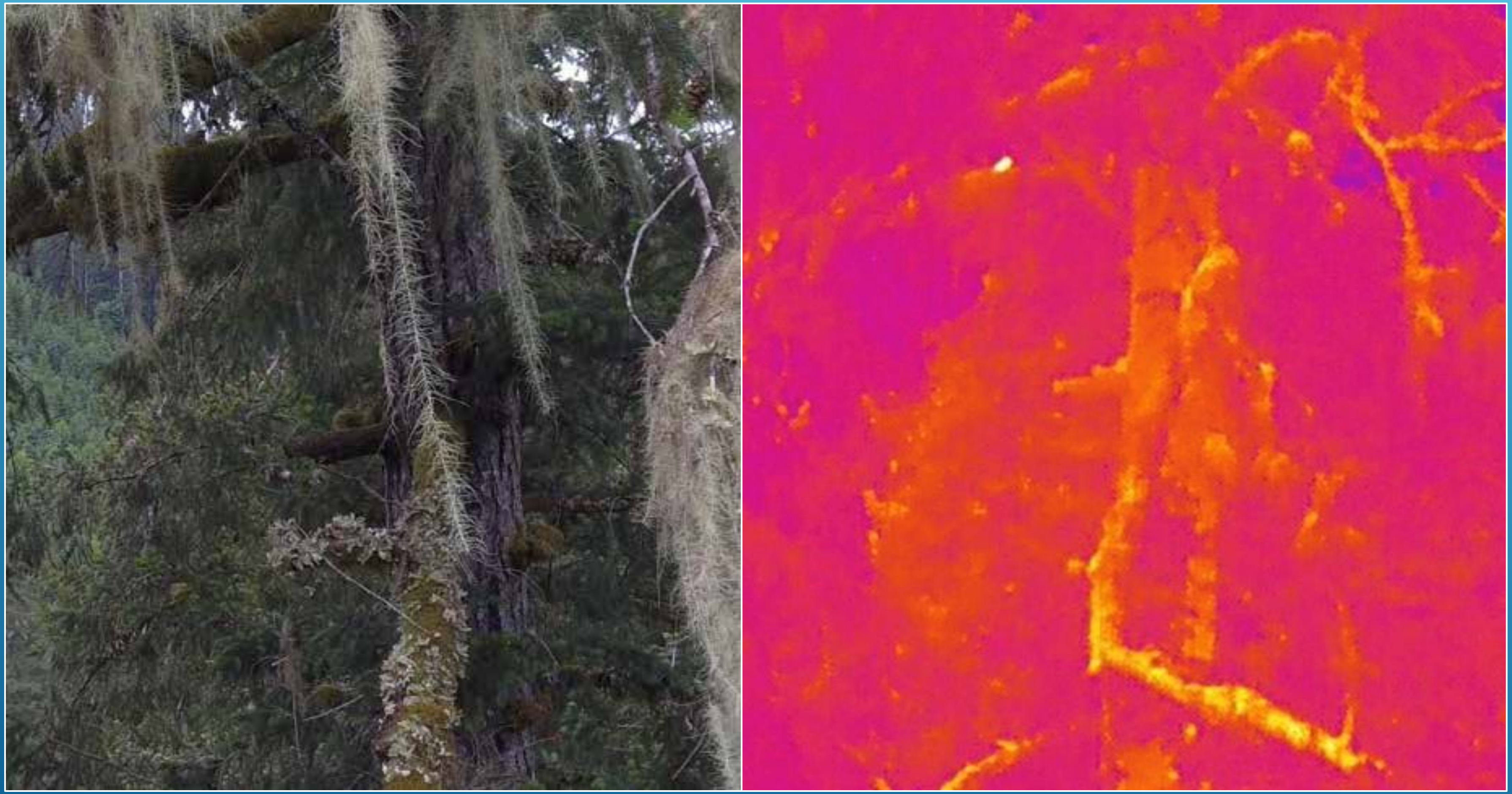

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Living Marine Resource Surveys

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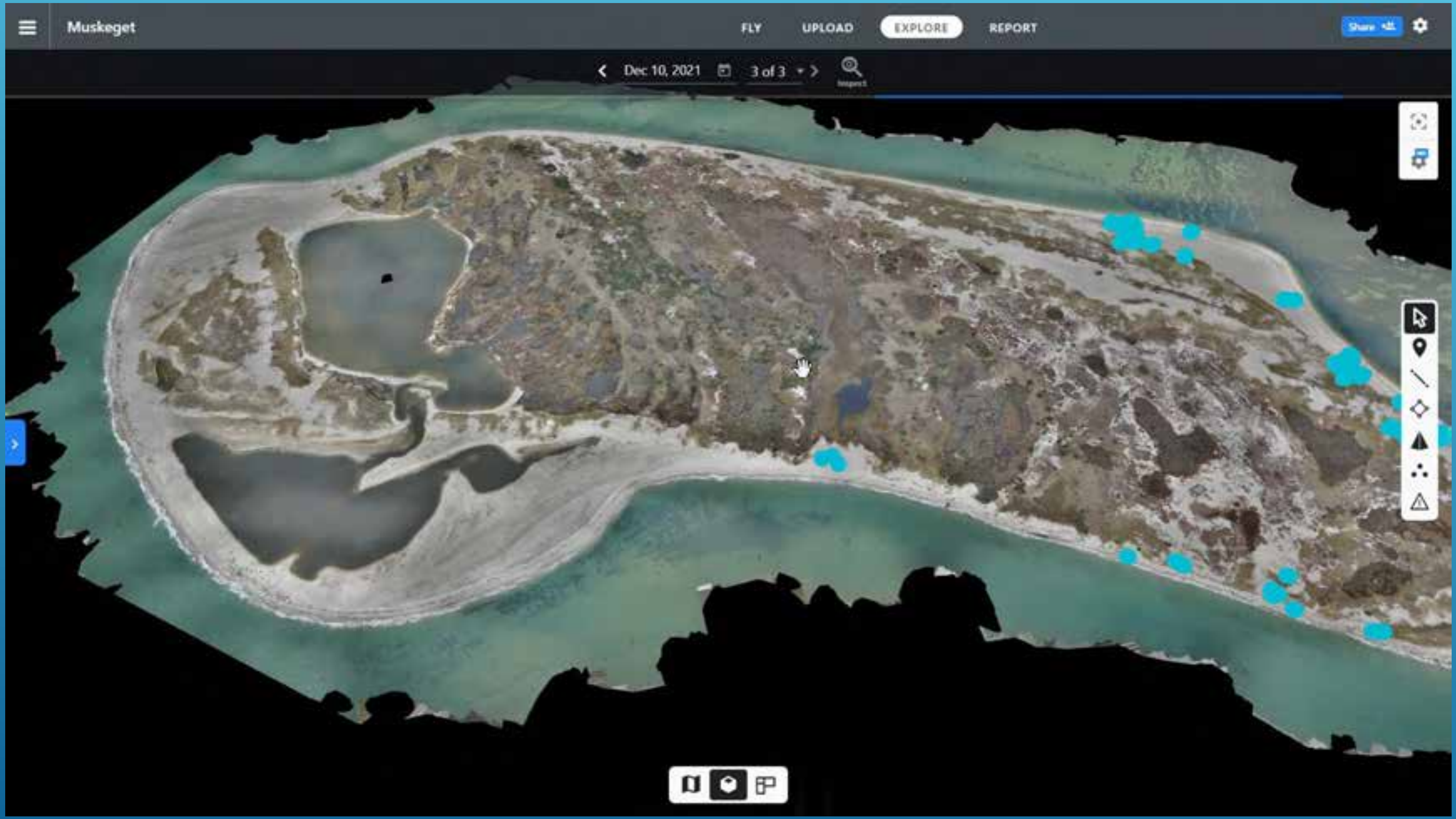

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Living Marine Resource Surveys

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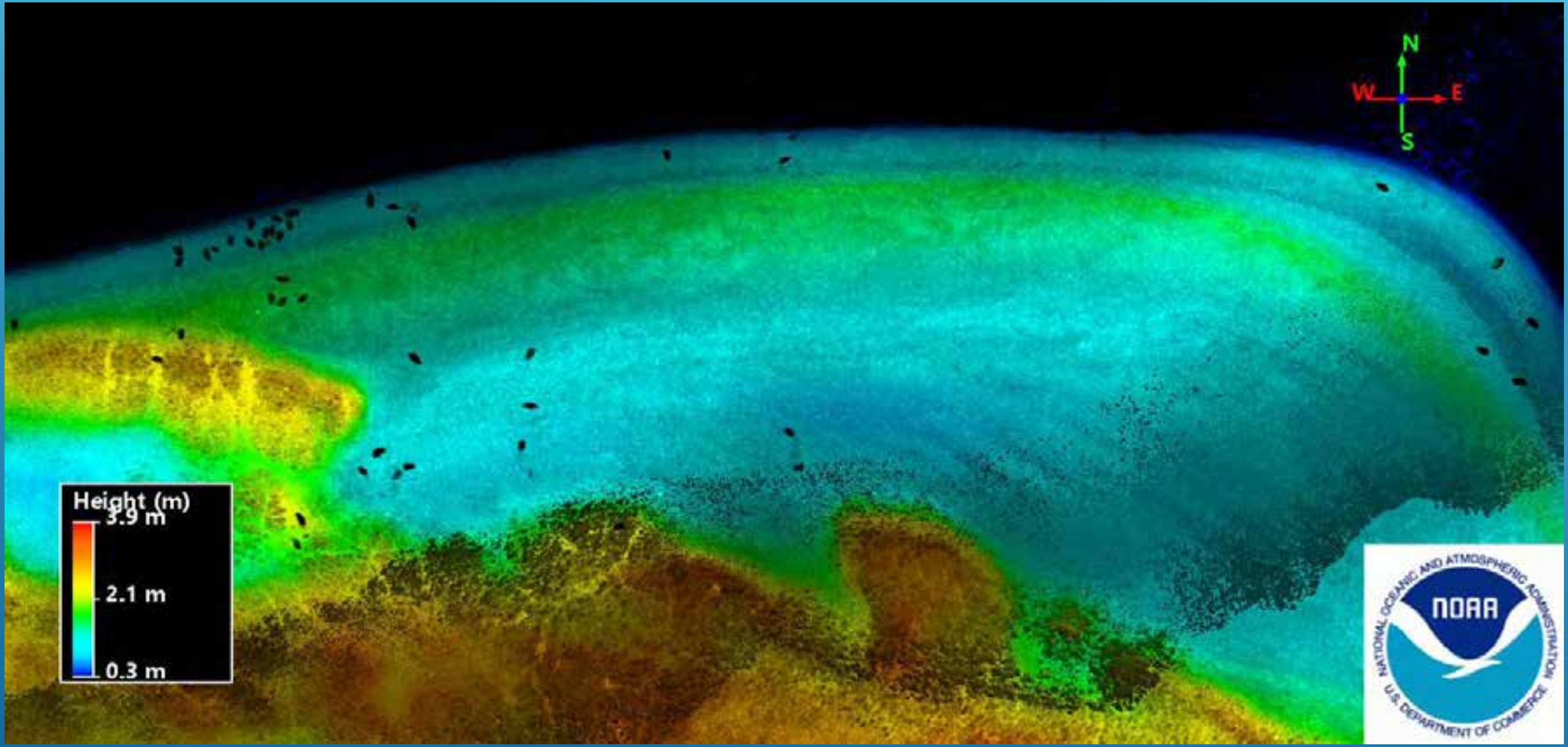

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Living Marine Resource Surveys

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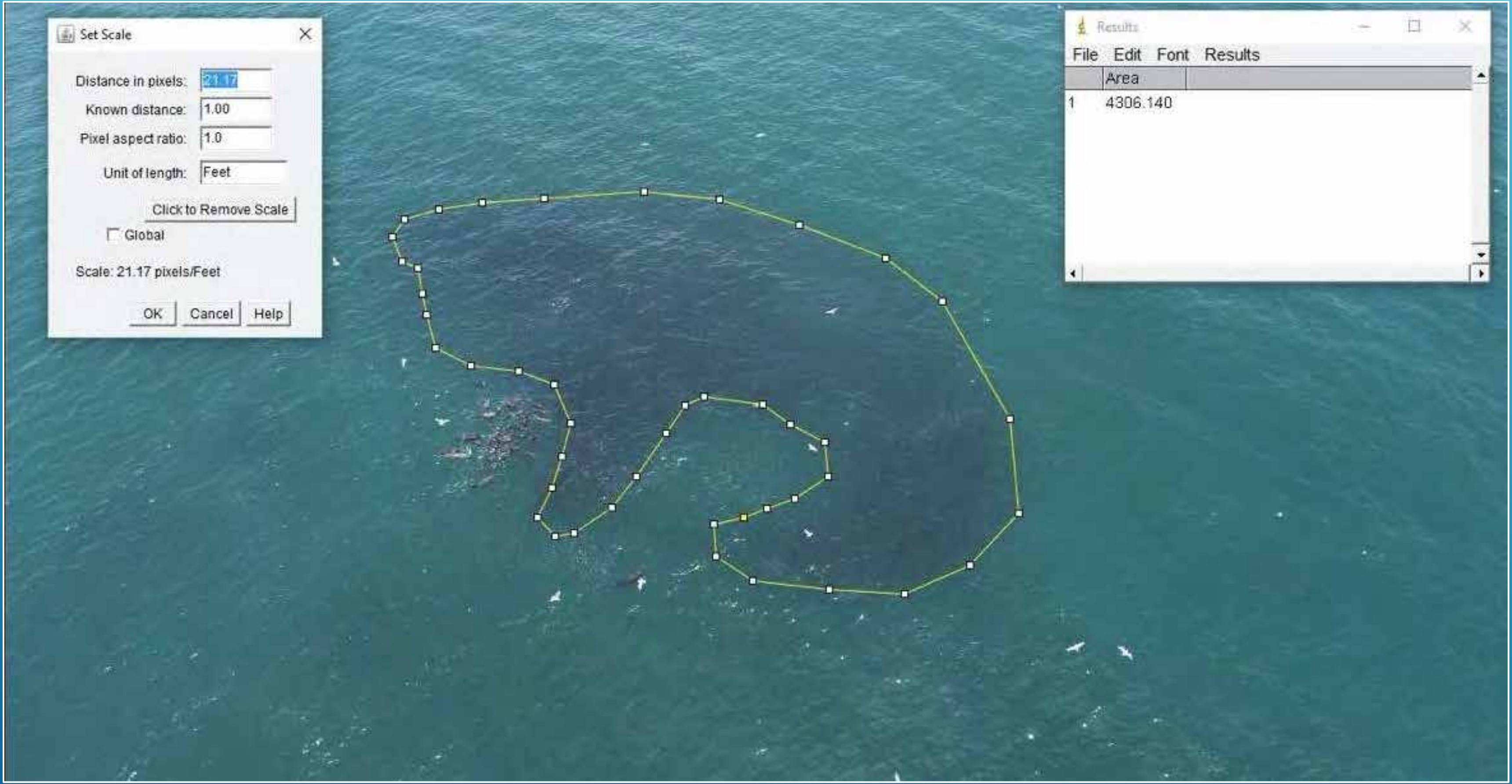
Living Marine Resource Surveys



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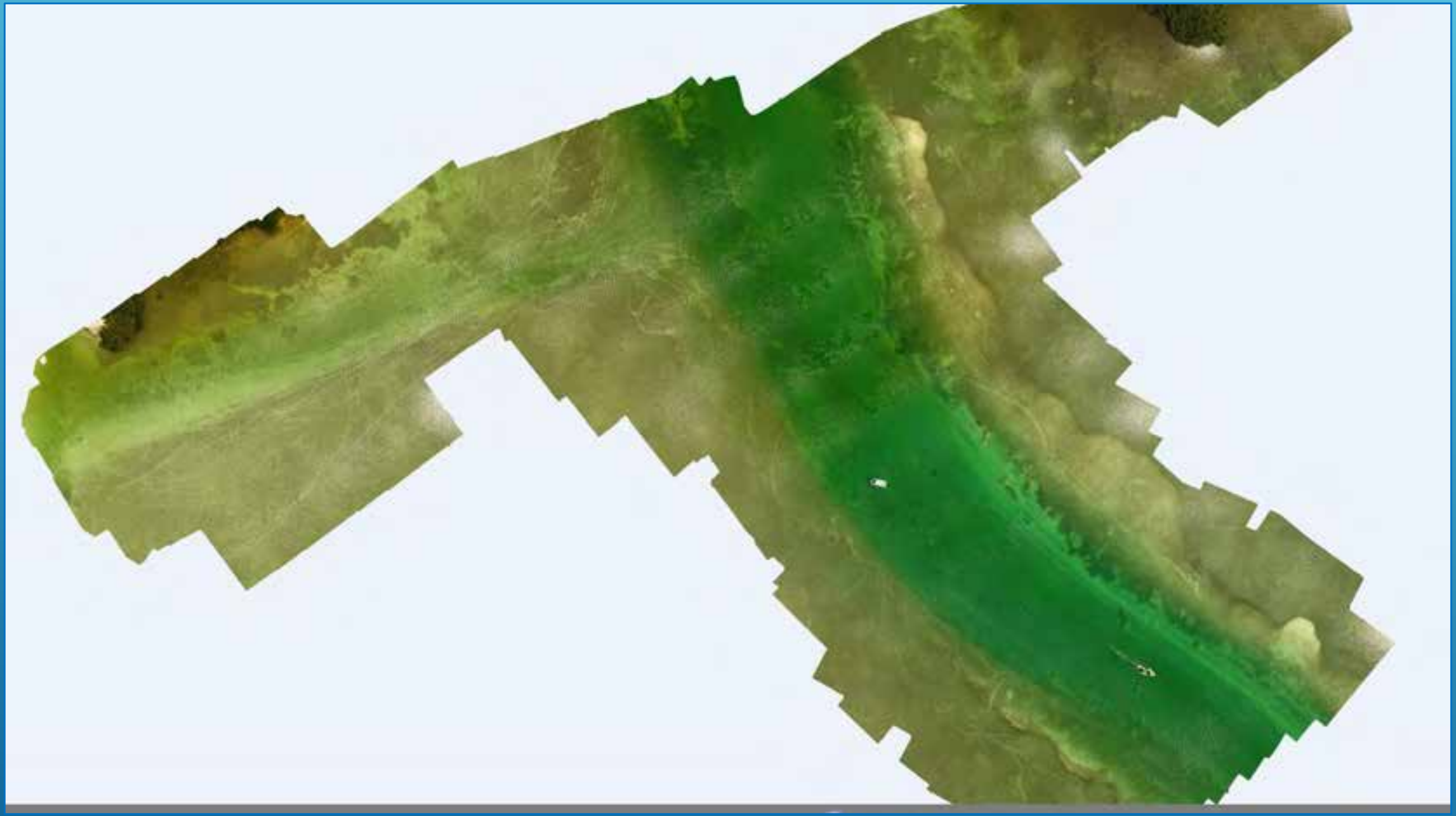
Visitor and Vessel Use Surveys



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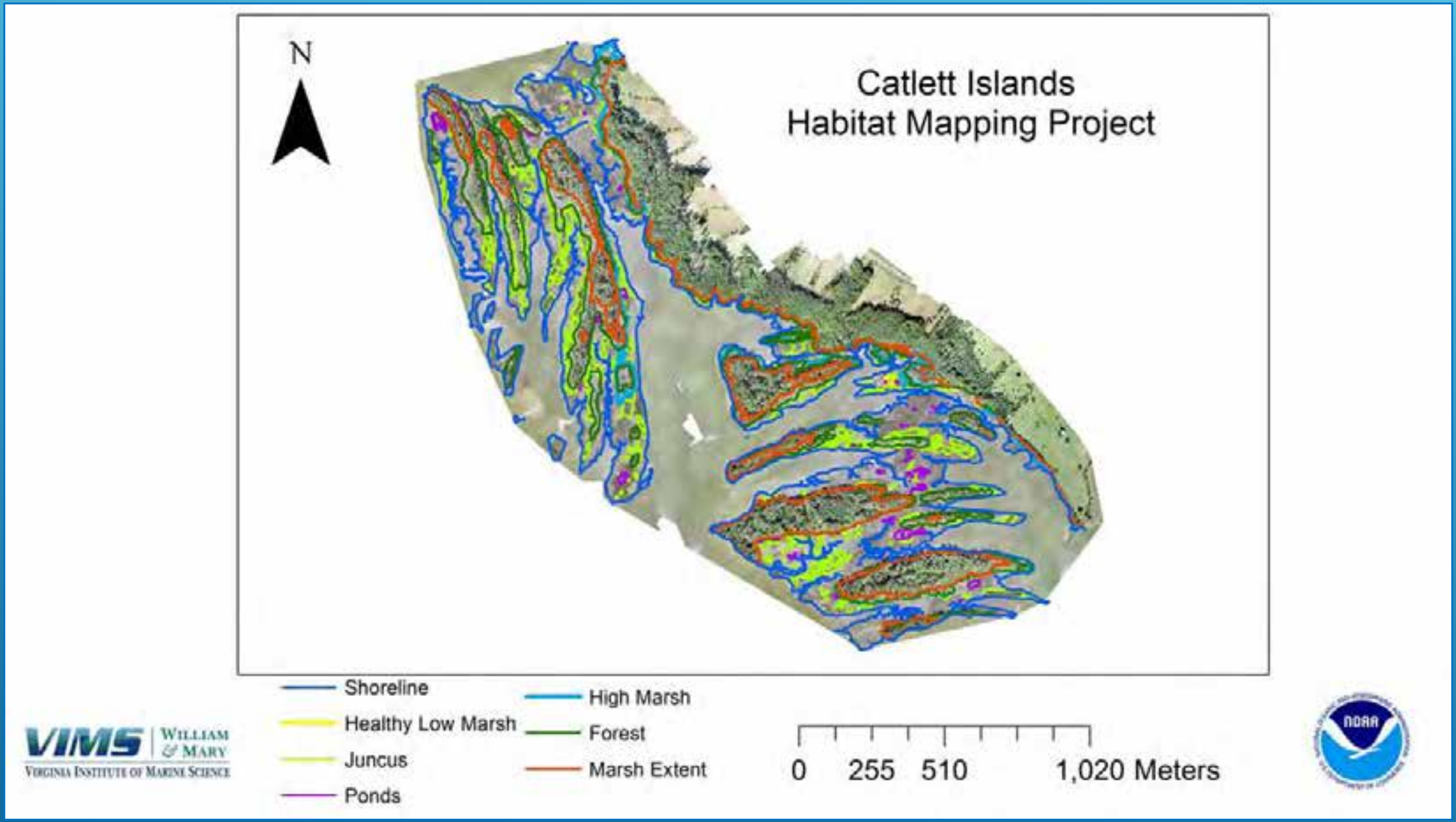
Habitat Mapping and Characterization



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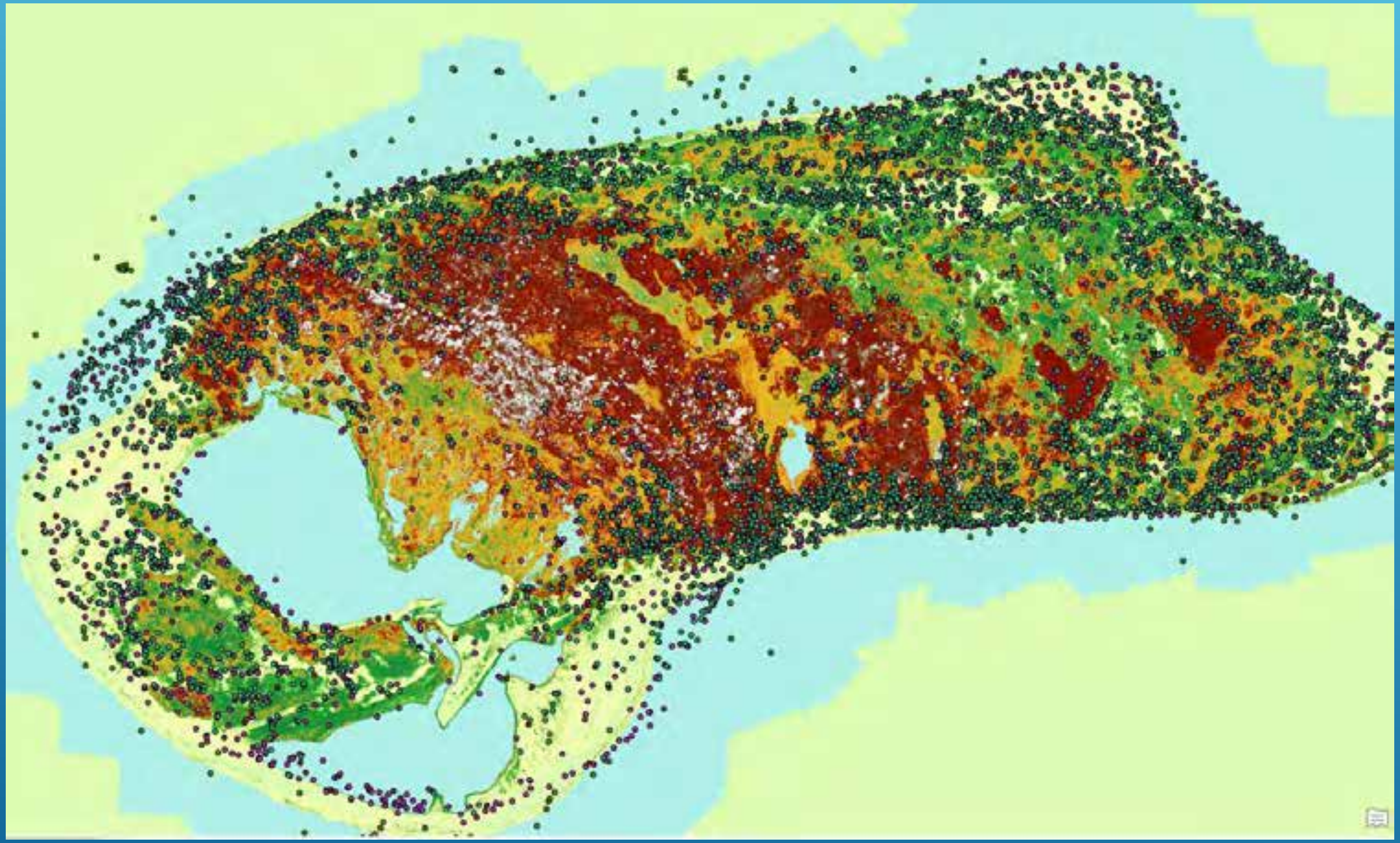
Habitat Mapping and Characterization



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Salmon Habitat Mapping

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Enforcement

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Enforcement

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Emergency Response

Unmanned Tech for Ocean Protection

Emergency Response

Unmanned Tech for Ocean Protection

Maritime Heritage

Unmanned Tech for Ocean Protection

Marine Debris

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Marine Debris

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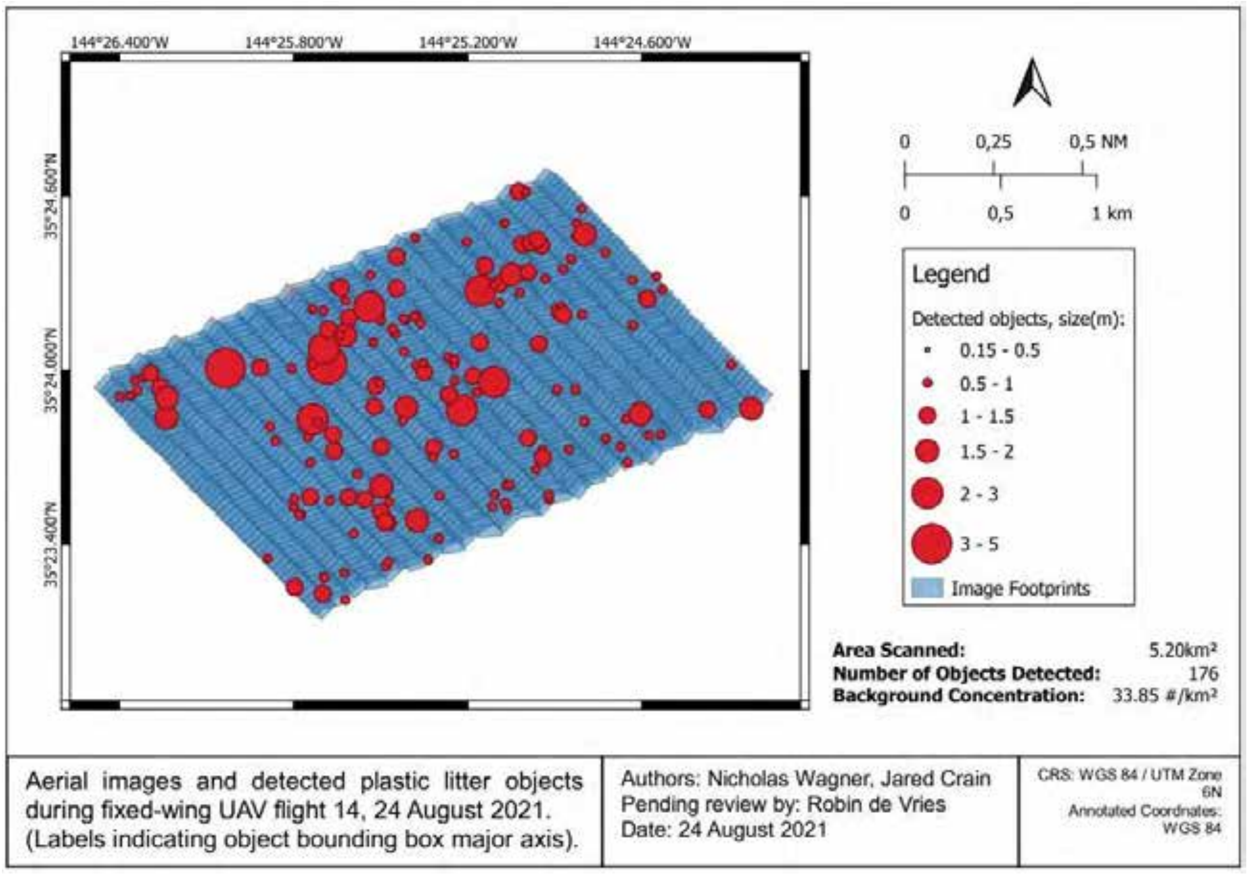

Bringing Tech to Ocean Protection

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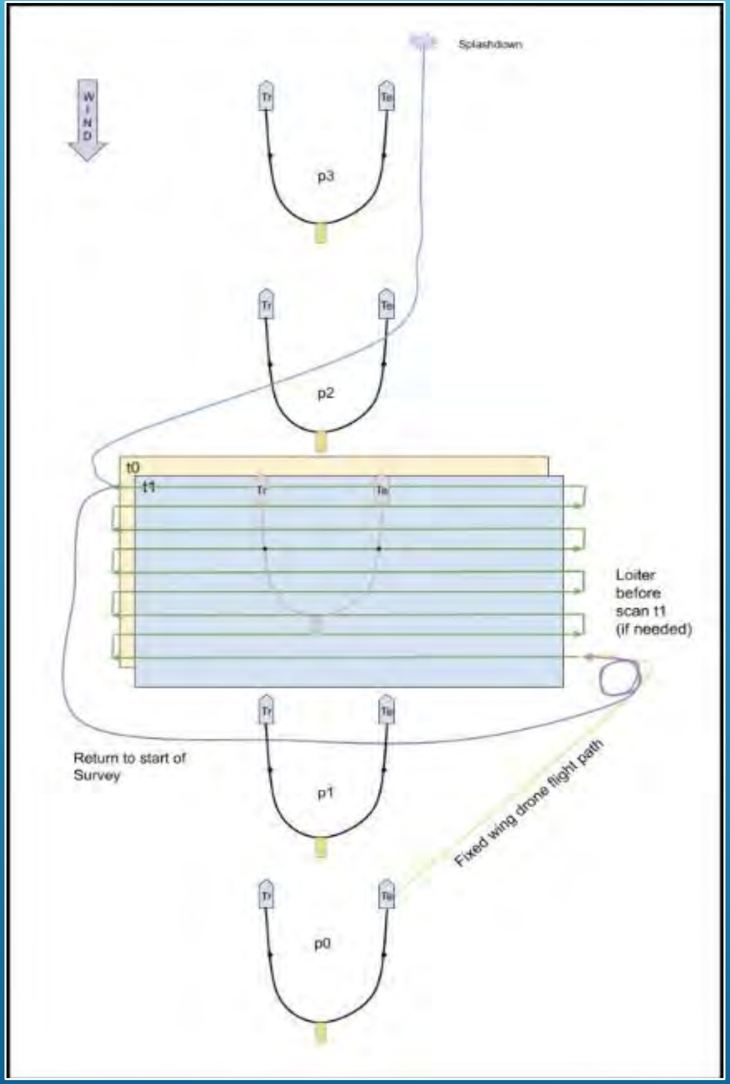

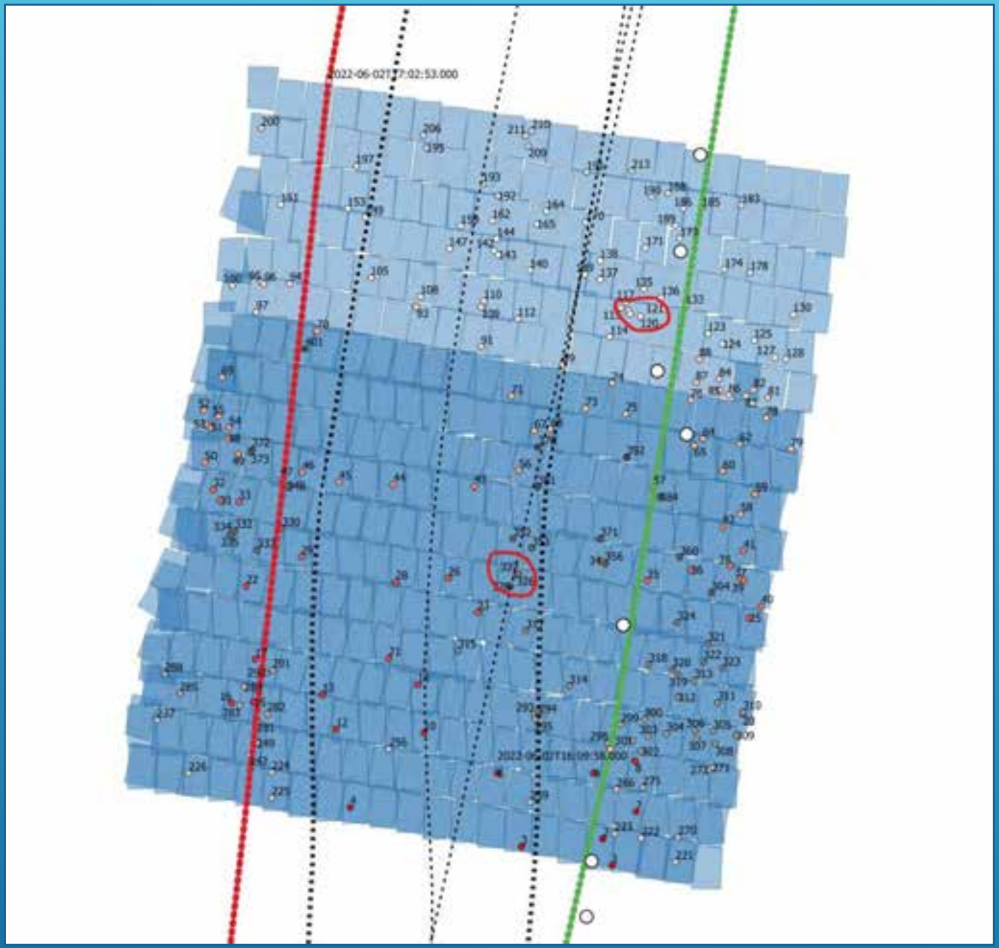

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Coastal Mapping for Nautical Charts

Unmanned Tech for Ocean Protection

freeFLY
DRONE RESPONSE TEAM

The freeFLY program is a volunteer network of trained drone operators to support marine mammal entanglement response efforts

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Conservation • Education • Protection

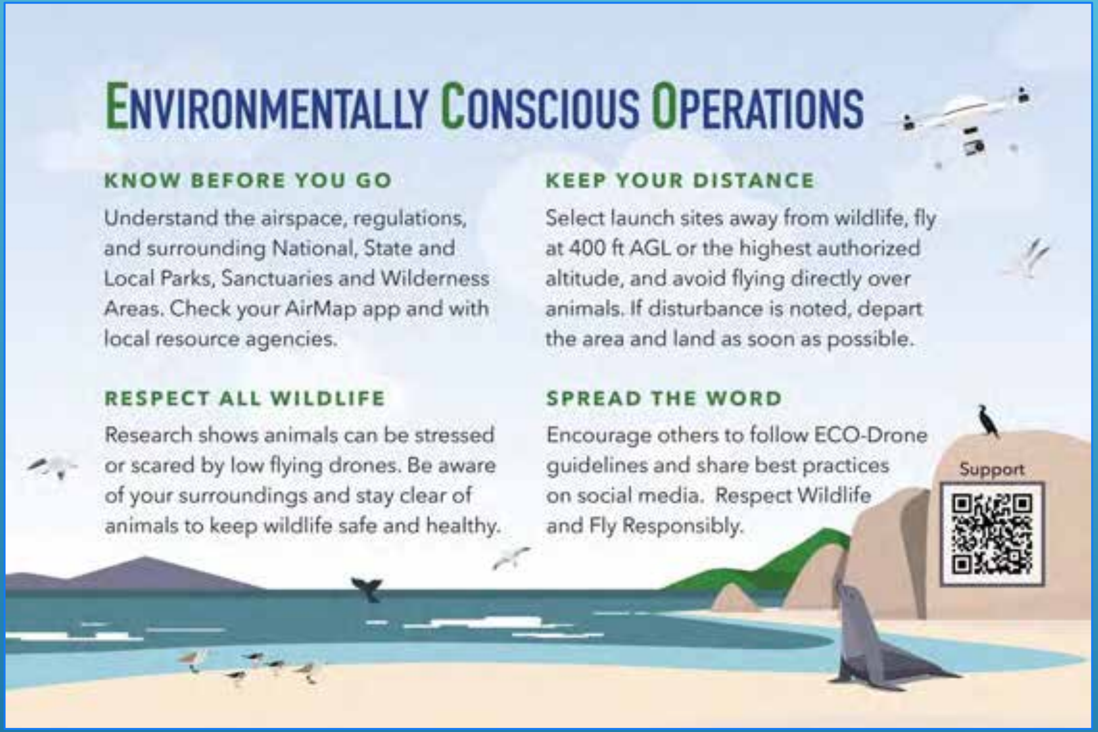
freeFLY
DRONE RESPONSE TEAM

The freeFLY program is a volunteer network of trained drone operators to support marine mammal entanglement response efforts

ECO-Drone

Environmentally Conscious Operations

The mission of ECO-Drone™ is to advance and encourage Environmentally Conscious Operations of recreational drones to protect and limit disturbances to wildlife resources



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ECO-Drone

Environmentally Conscious Operations

Questions / Discussion

Incorporating drone-based multispectral mapping in long-term saltmarsh monitoring at the North Inlet – Winyah Bay National Estuarine Research Reserve

Erik Smith & Brittany Morse

North Inlet-Winyah Bay National Estuarine Research Reserve
Baruch Institute for Coastal and Marine Sciences, University of South Carolina

NERRS Long-term emergent marsh vegetation monitoring

National goal: Understanding impacts of changing sea level and tidal inundation on marsh habitats to inform management, mitigation and restoration strategies

A key question: What are the current distributions of vegetated communities with respect to tidal range, and how sensitive are these distributions to changes in tidal inundation and sea level rise?

→ Vertical accretion
→ Horizontal migration

NERRS Long-term emergent marsh vegetation monitoring

Approach: permanent sampling plots along fixed transects spanning the marsh platform's elevation gradient

Sampling: standard non-destructive vegetation metrics (species composition, % cover, stem density, canopy height) as a function of marsh elevation

NI-WB NERR vegetation monitoring

Limitation of sampling design: resolution of spatial and temporal data

Question: Can we utilize drone-derived image products to expand the spatial and temporal resolution of our marsh monitoring efforts?

Initial focus of drone work:

→ *Spartina alterniflora*

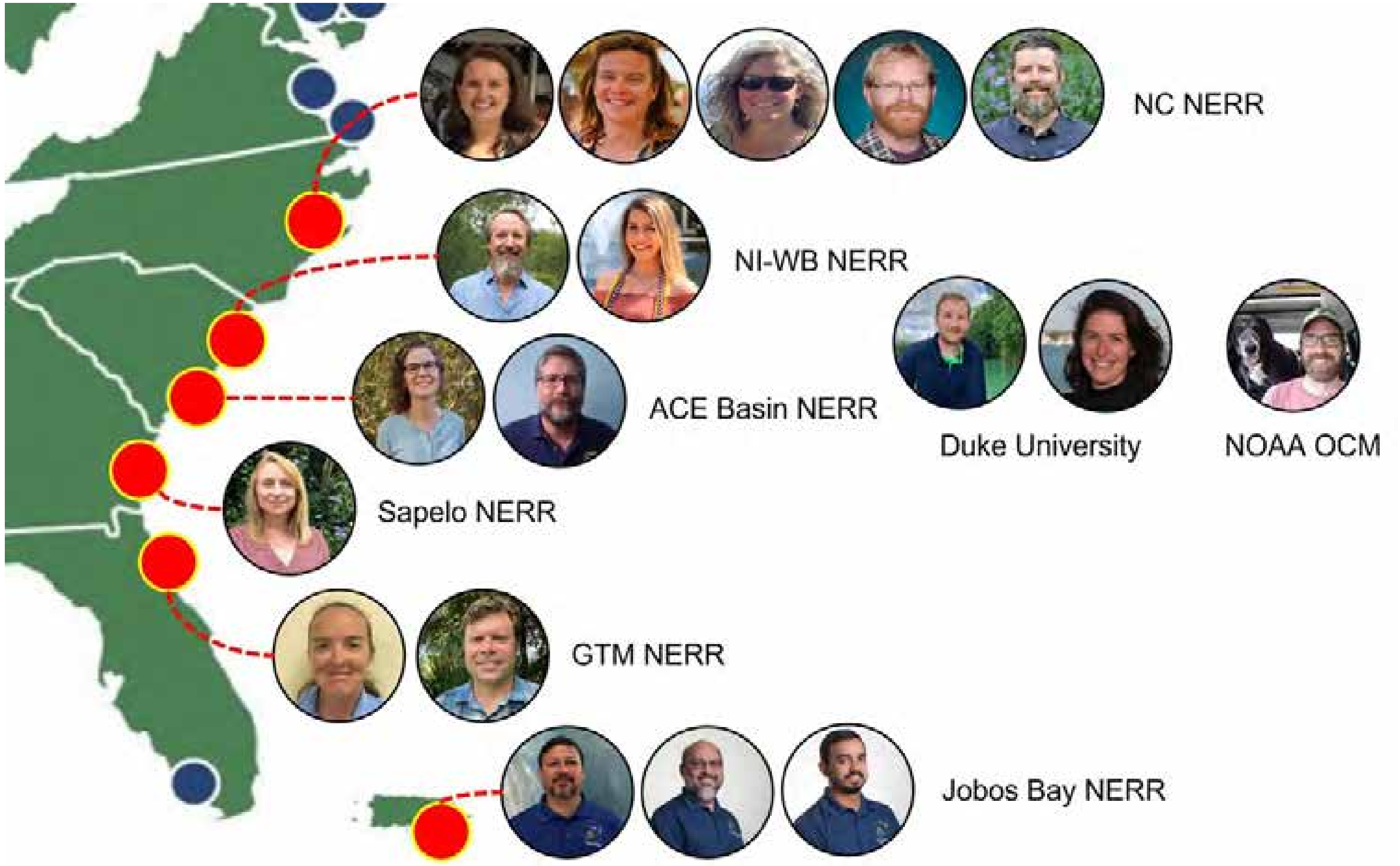
- Aboveground live biomass
- Percent cover

→ Spatial patterns and their change over time

Assessing the utility of drones for monitoring coastal wetlands

National Estuarine
Research Reserve System
Science Collaborative

Project leads:
- Brandon Puckett, NC NERR
- Whitney Jenkins, NC NERR
- Justin Ridge, Duke University

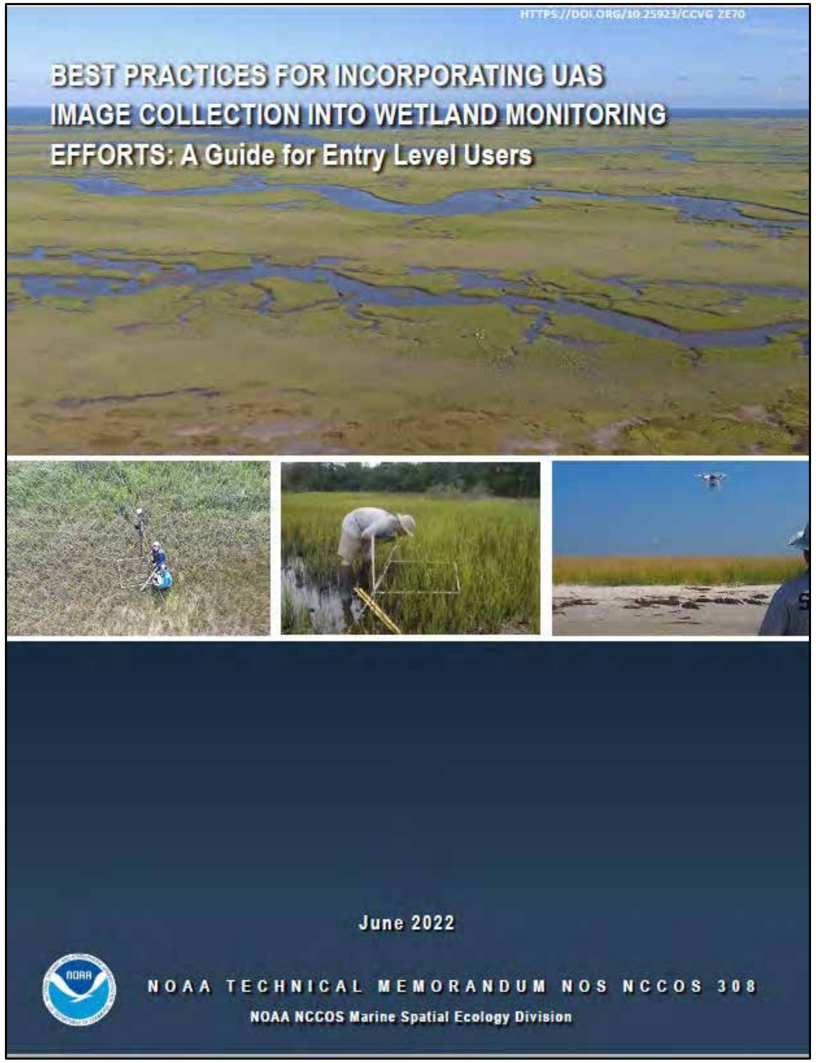


Project outcome:
"A Protocol for Monitoring Coastal Wetlands with Drones: Image Acquisition, Processing, and Analysis Workflows"

Available at:
https://nerrssciencecollaborative.org/project/Puckett20

Operationalizing the Use of UAS in Wetland Monitoring

Collaboration between NCCOS Marine Spatial Ecology Division, NC NERR, NI-WB NERR, and Duke University.
Funding from: NOAA Office of Atmospheric Research, Unmanned Aircraft Systems Program



BEST PRACTICES FOR INCORPORATING UAS IMAGE COLLECTION INTO WETLAND MONITORING EFFORTS: A Guide for Entry Level Users

June, 2022

Authors:

Jenny Davis[1], Ryan Giannelli[2], Cristiana Falvo[3], Brandon Puckett[4*], Justin Ridge[3], Erik Smith[5]

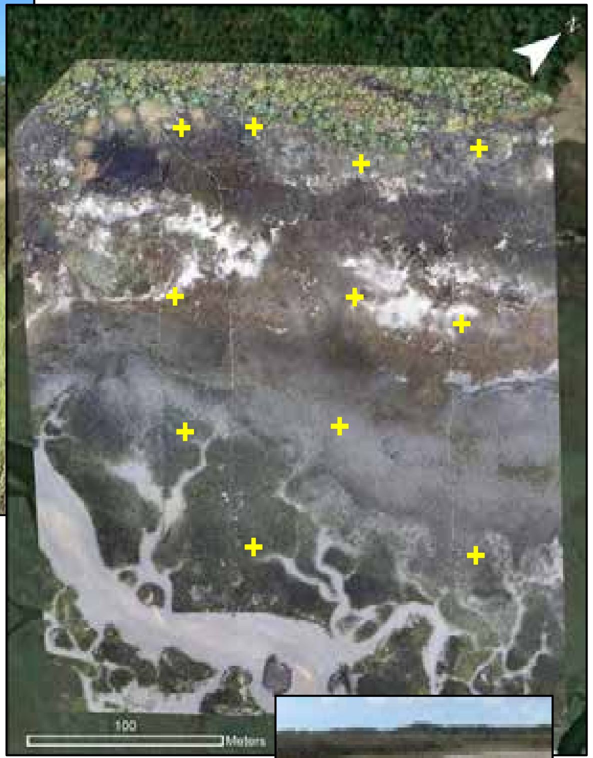
[1] NOAA National Ocean Service, National Centers for Coastal Ocean Science, Marine Spatial Ecology Division, Beaufort, NC
[*] current affiliation
[2] Consolidated Safety Services, Inc. under contract to NOAA
[3] Duke University Marine Laboratory, Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Beaufort, North Carolina
[4] North Carolina National Estuarine Research Reserve, Beaufort NC
[5] North Inlet – Winyah Bay National Estuarine Research Reserve & University of South Carolina, Baruch Institute, Georgetown, SC

Available at:

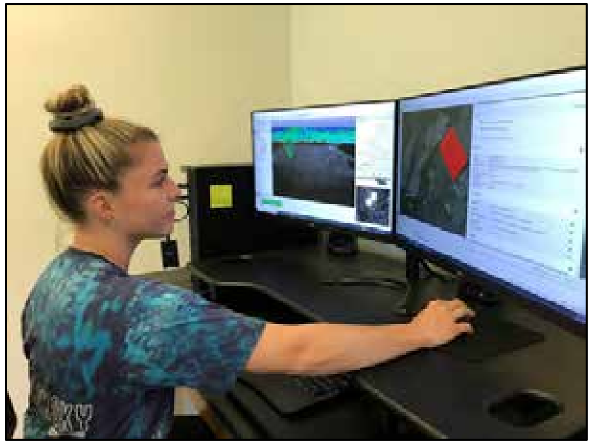
https://doi.org/10.25923/ccvg-ze70

Standardized Repeated UAS surveys at NI-WB NERR

- **Flights**
  - → Sensor = MicaSense Altum
    - 5 bands: B, G, R, “rededge” (717nm), NIR (842 nm)
    - Radiometric calibration
    - 1 flight ≈ 700 images / band
  - → Airframe = DJI Matrice 200 v2
  - → Flights at morning low tides (every 2 weeks)
  - → 50m altitude; GSD ≈ 2.3 cm
  - → permanent ground control (≈ 2/ha)



- **Data processing**
  - → Pix4DMapper: image processing
  - → ArcGIS Pro: data manipulation & analysis



Standardized Repeated UAS surveys at NI-WB NERR

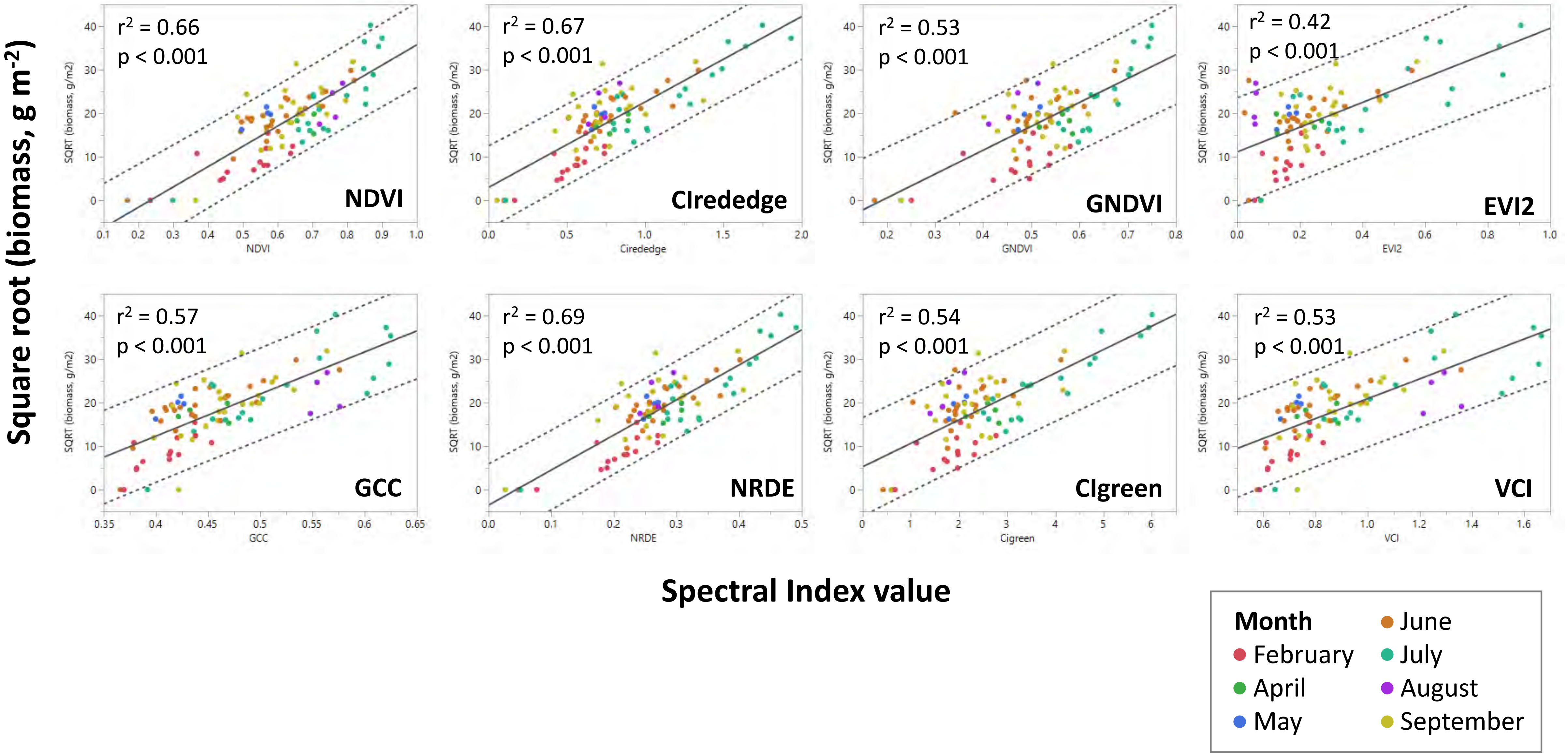
- **Ground-truth data collection**

  → *S. alterniflora* biomass (g dry weight m^{-2})

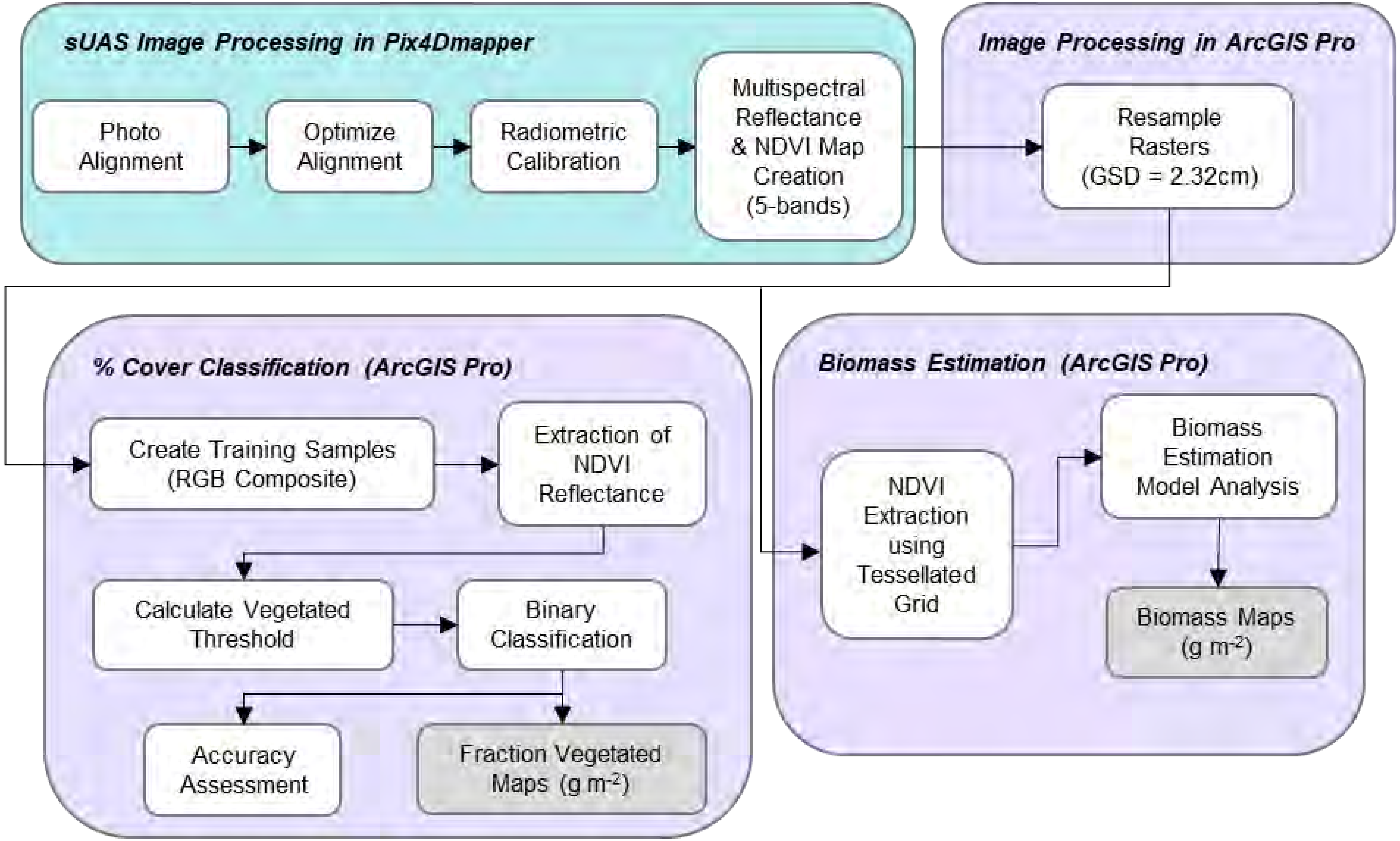
  - $0.25\ m^2$ clipped plots, sorted as live vs. dead, washed, dried (60 °C), and weighed.
  - Sampling seasonally in both marsh segments

  → RTK-GPS for ground control and biomass plots

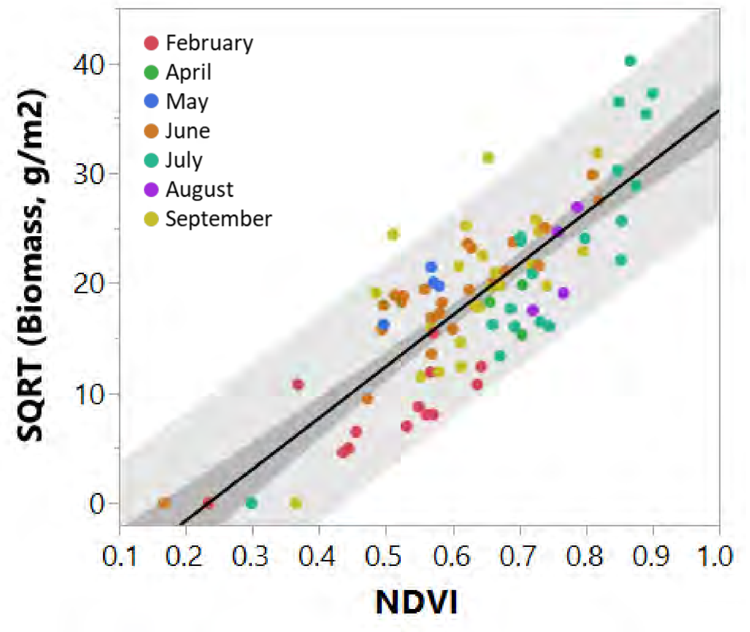
*A*boveground biomass vs. Vegetation Indices



Routine image processing workflow



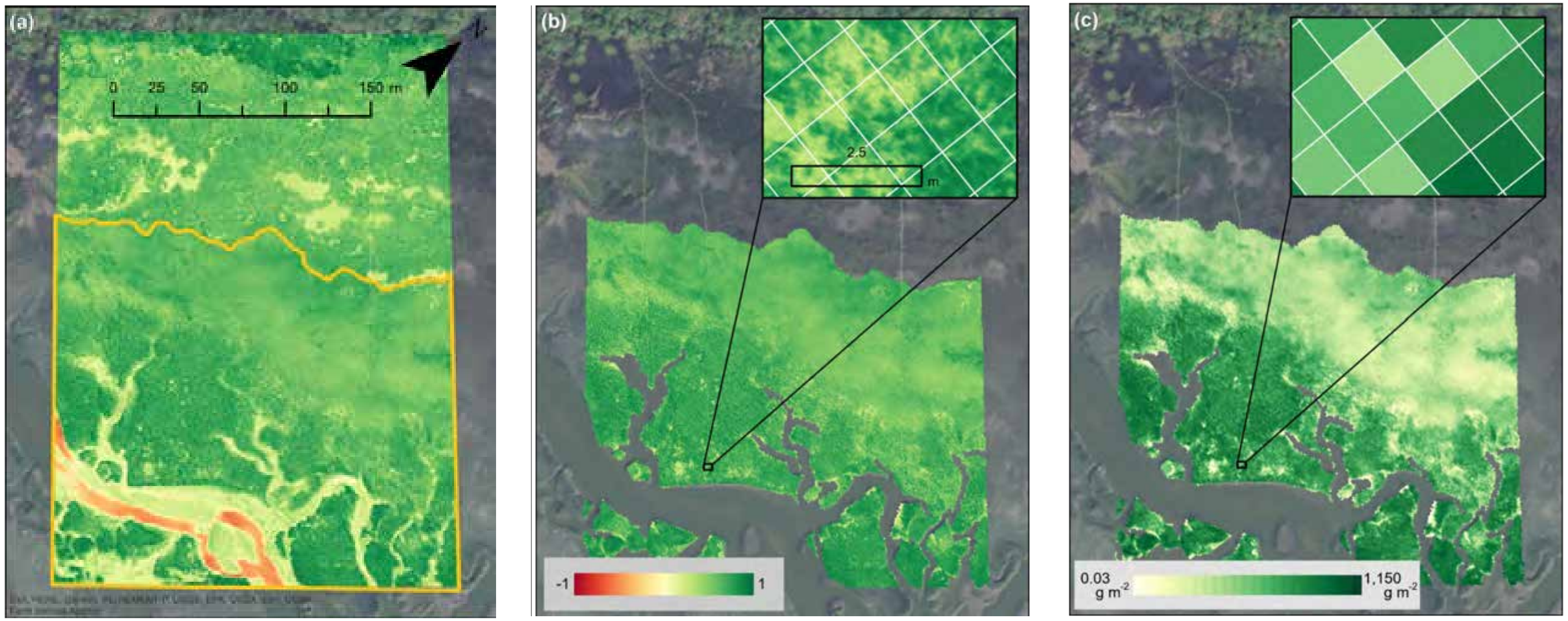
Converting NDVI to *S. alterniflora* aboveground biomass



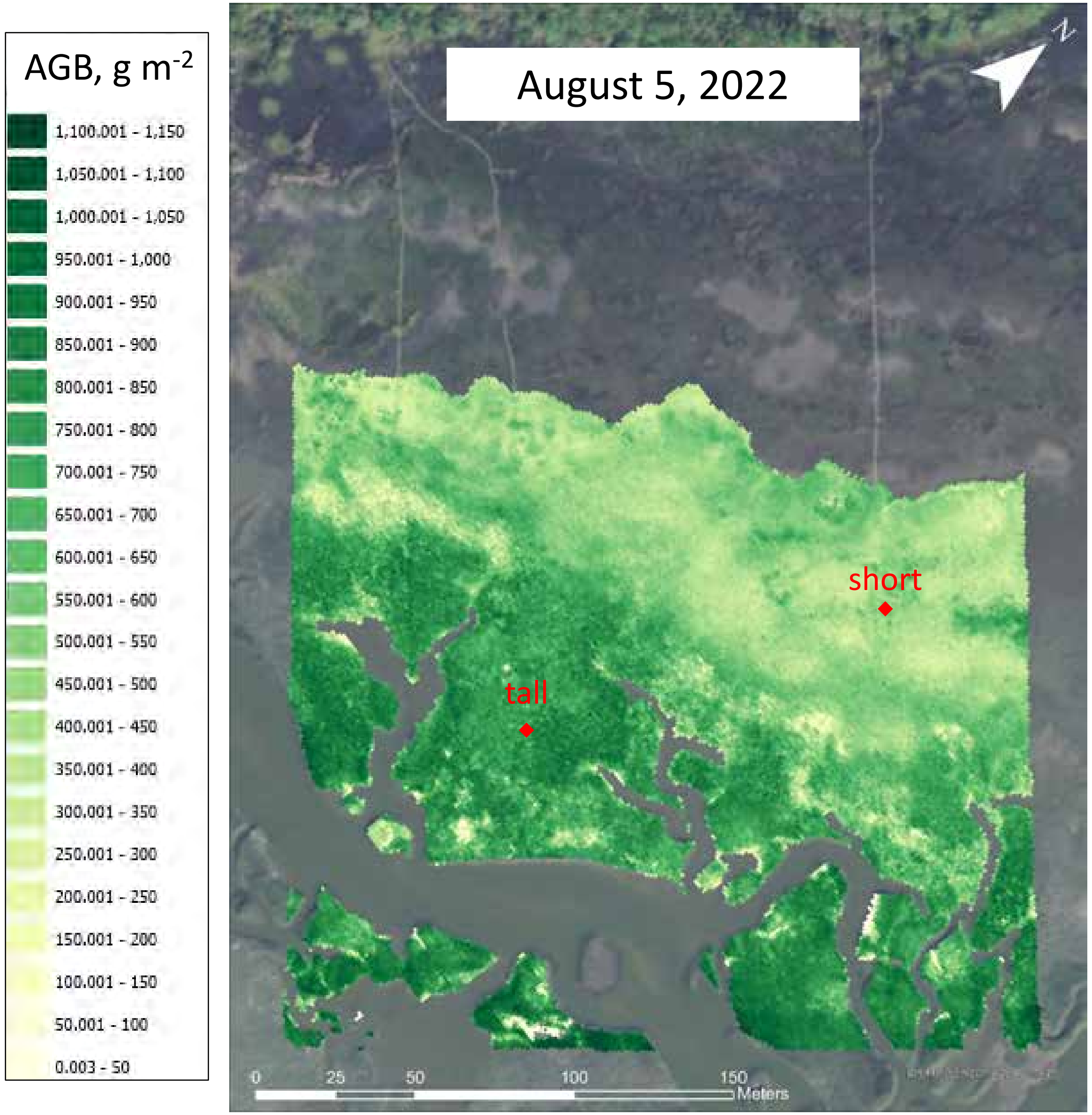
Square Root of Biomass (g m^{-2}) = 46.65*NDVI – 10.92

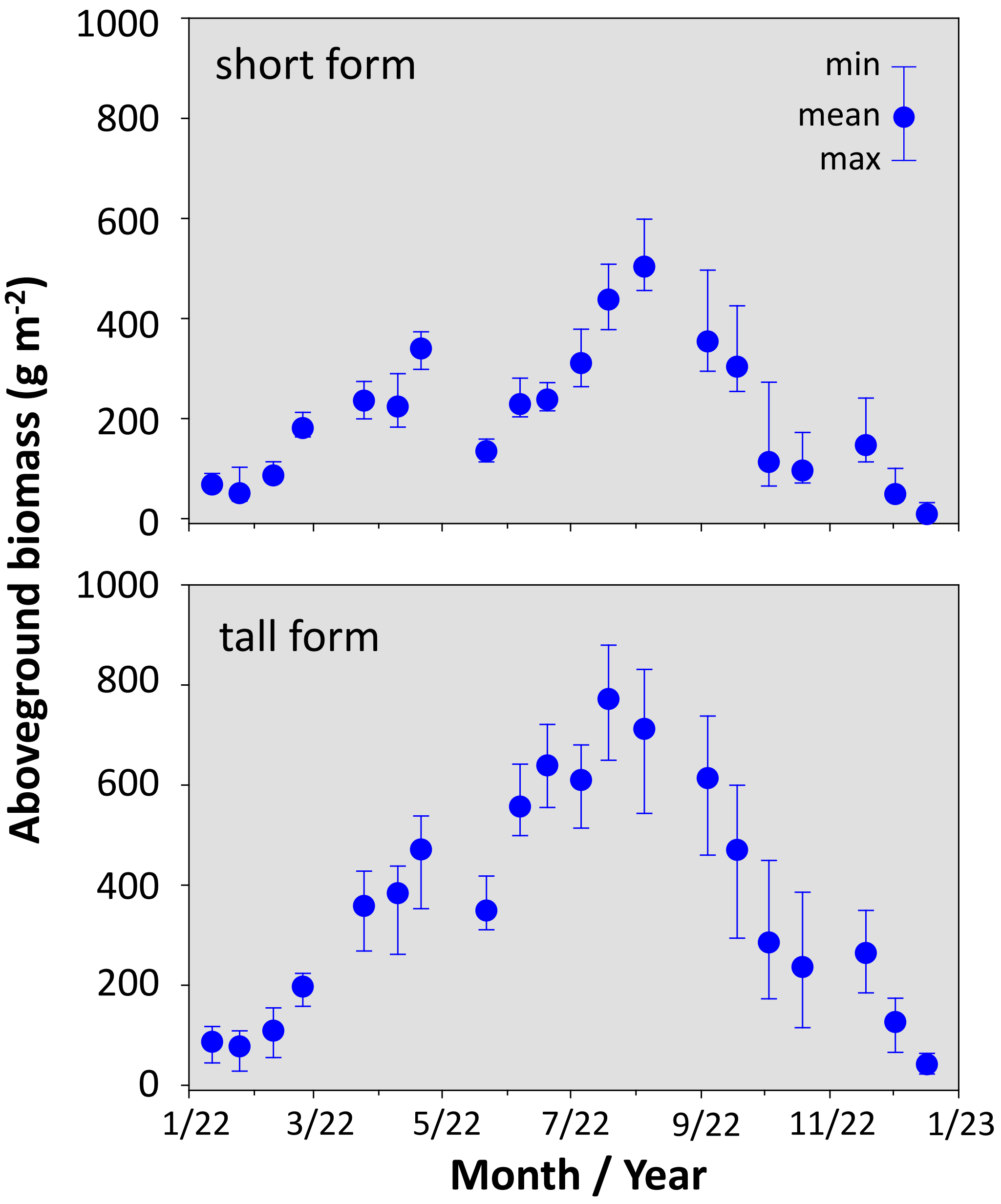
0.023 x 0.023 m pixels
NDVI

1 x 1 m pixels
g m^{-2}

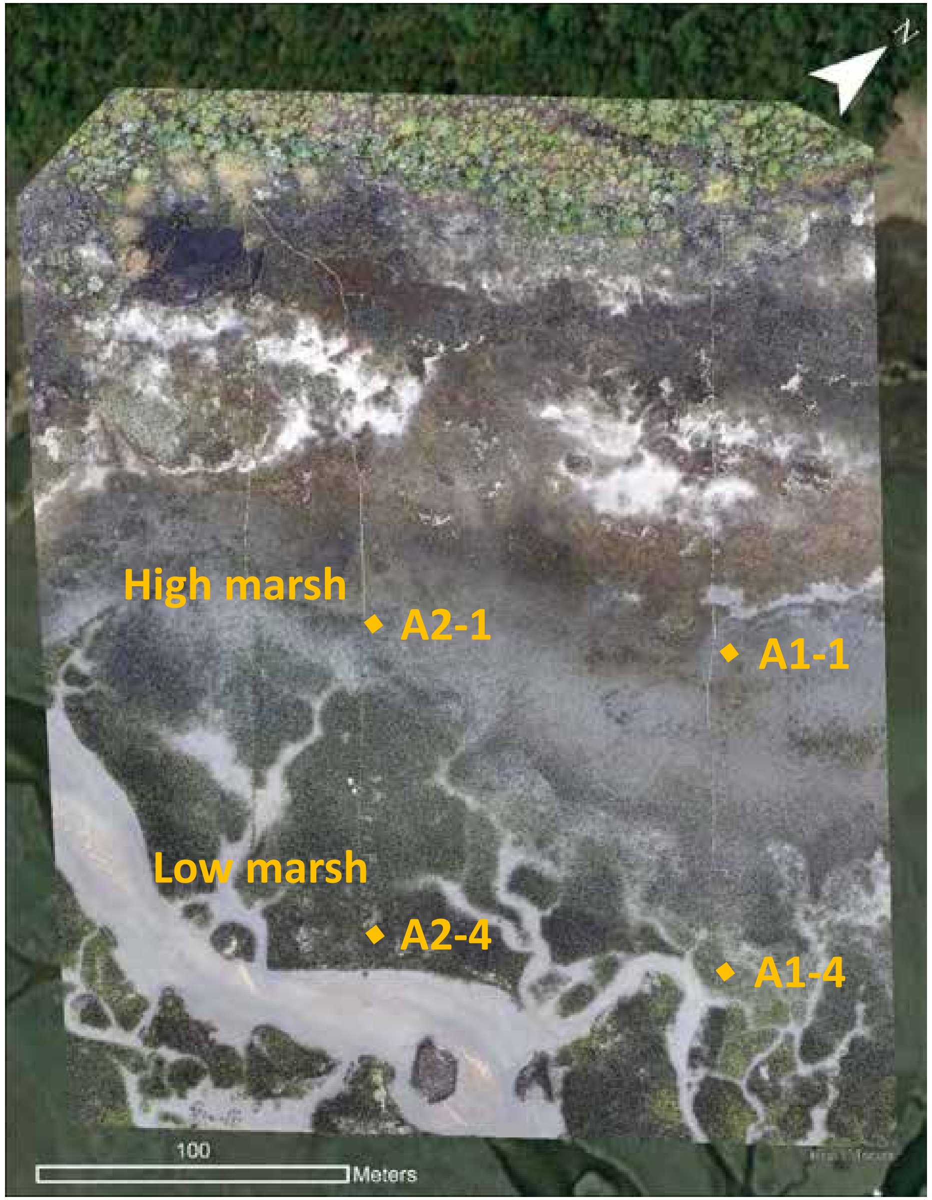


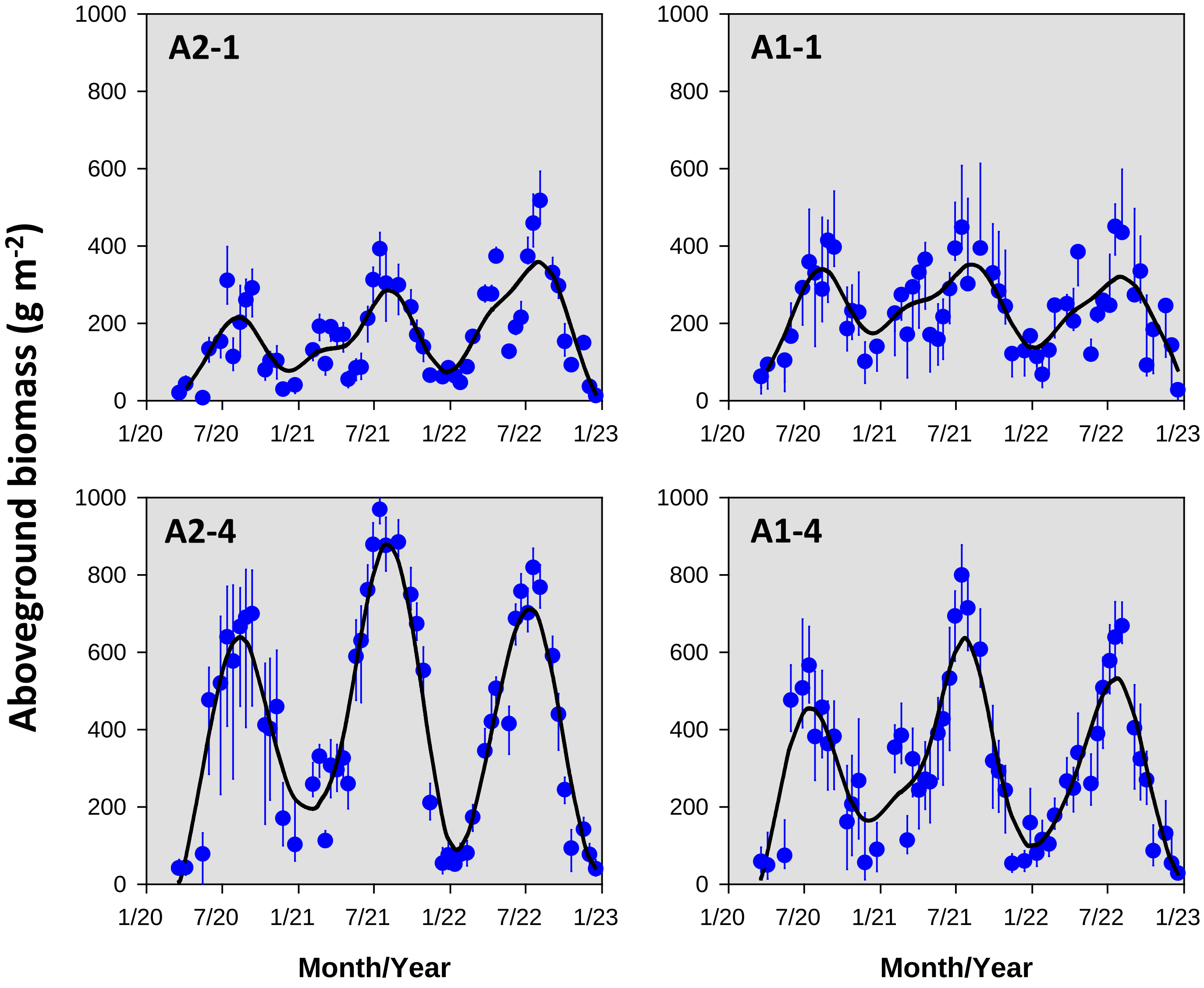
Segment A 2022 biomass time-series



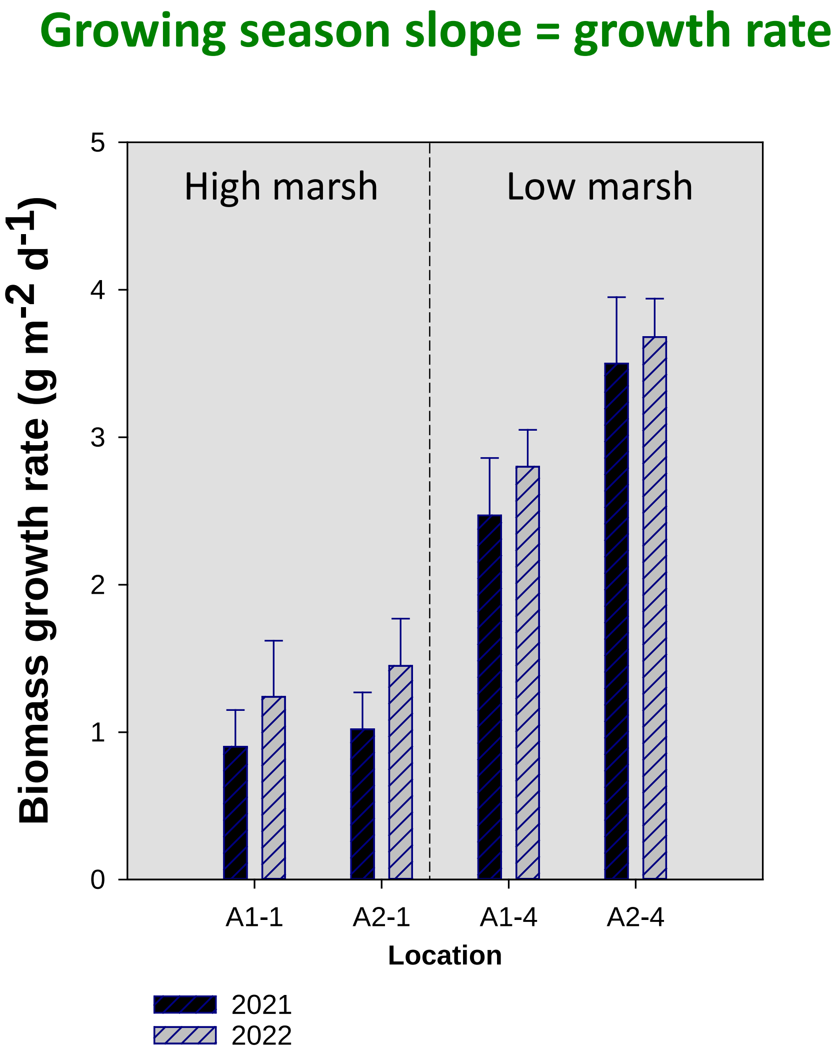


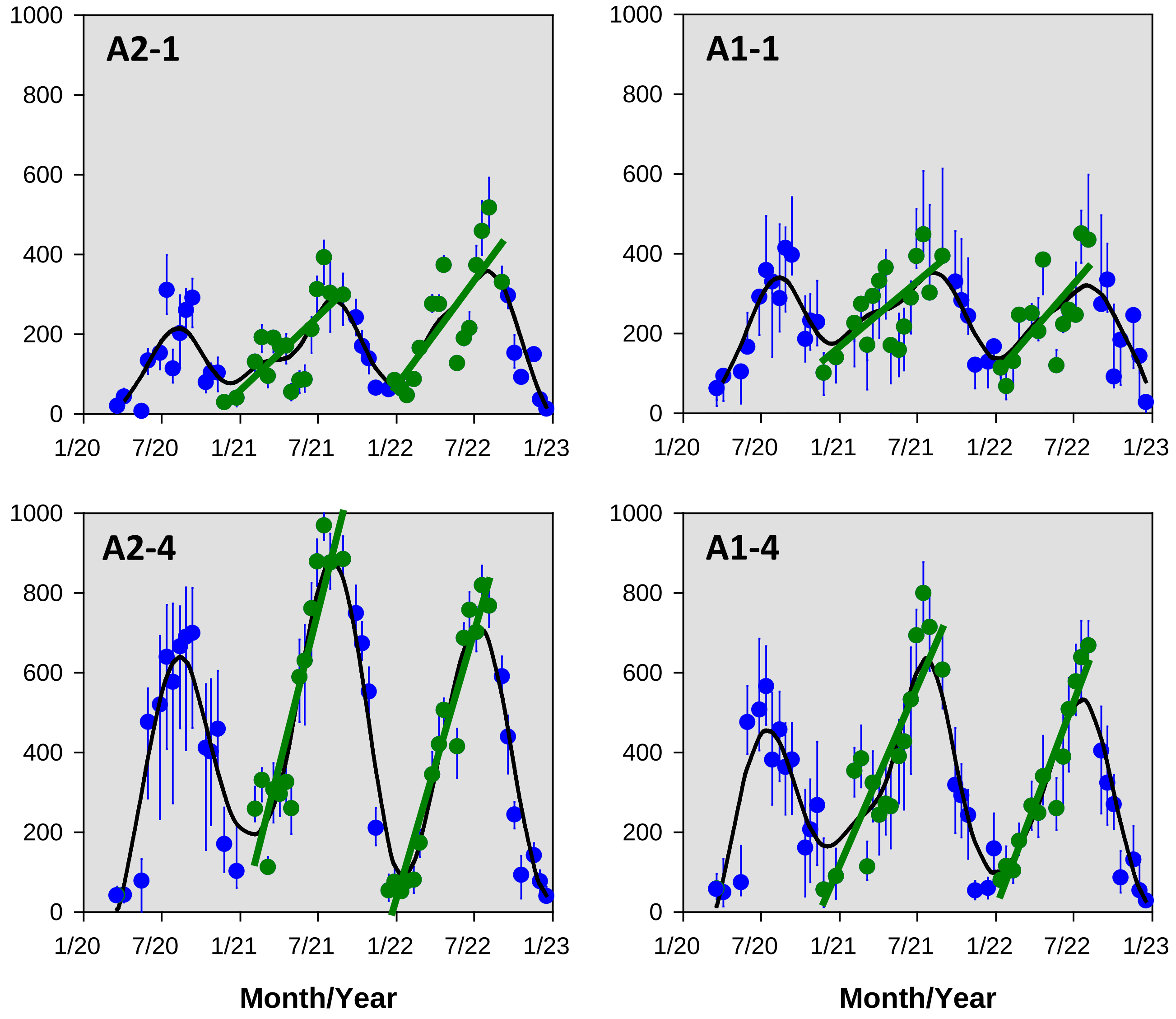
Segment A 2022 biomass time-series





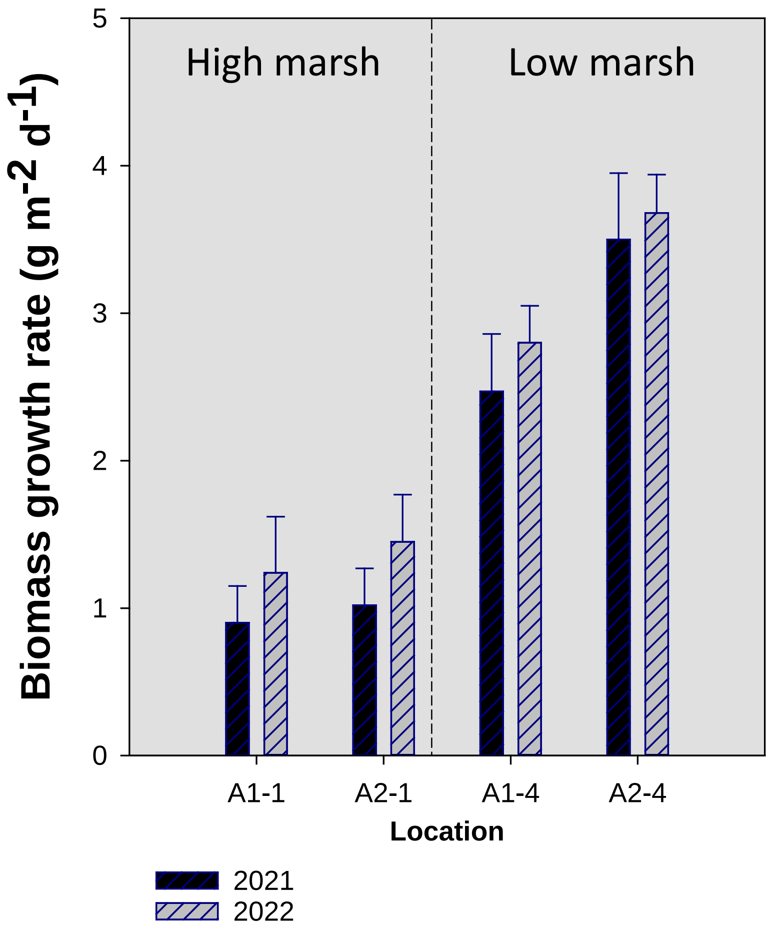
Spatial variability in seasonal mean growth rate





Spatial variability in seasonal mean growth rate

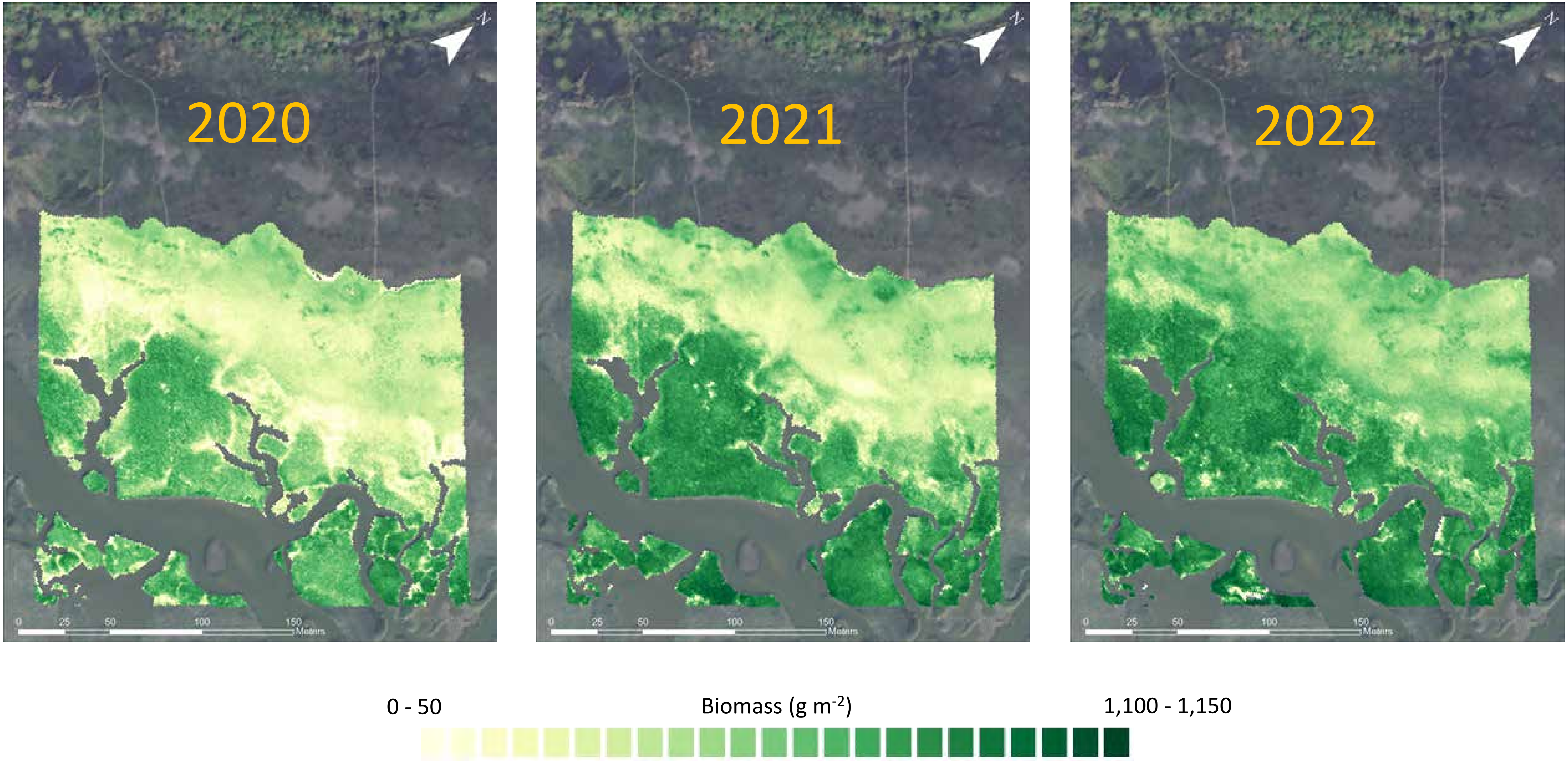
Growing season slope = growth rate



J. T. Morris's monthly plant census model for estimating annual production in North Inlet generates a monthly growth rate term:

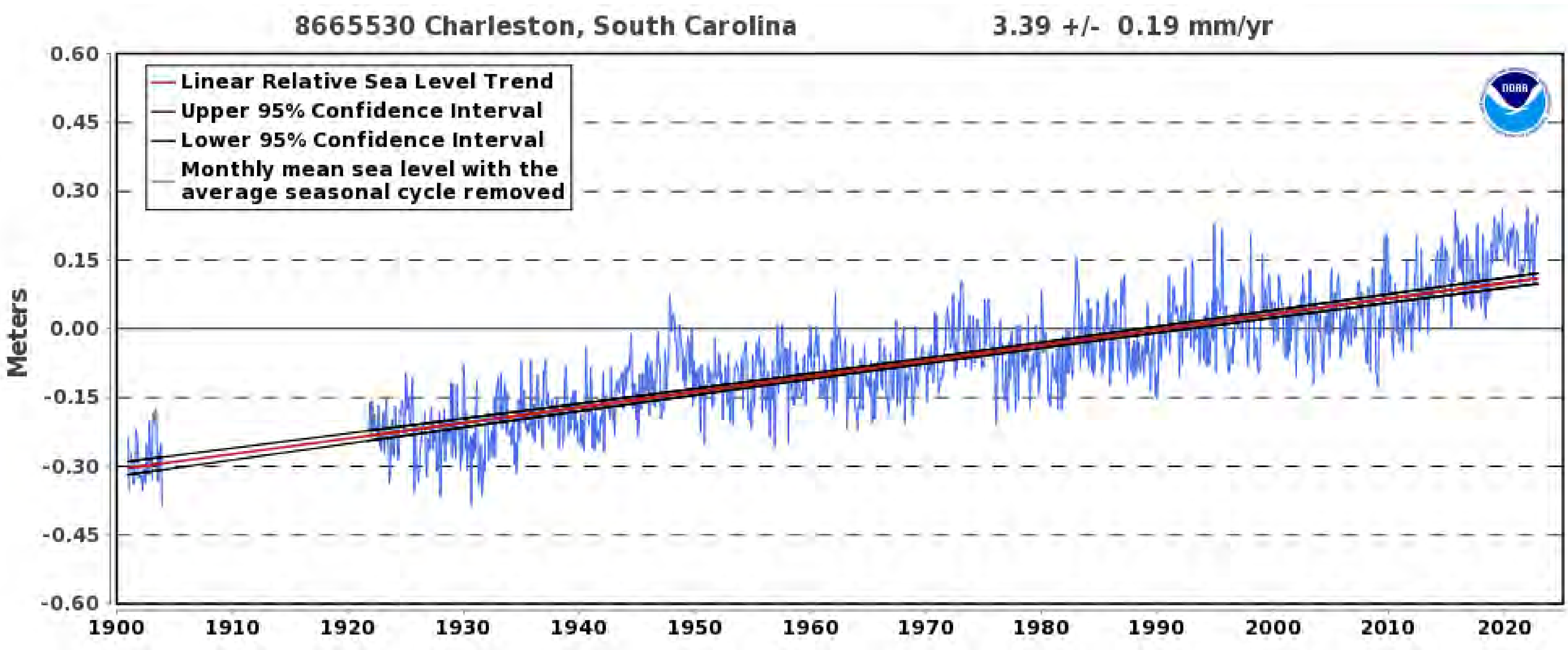
Site	Year	g m^{-2} d^{-1}
OL High marsh	2021	2.67
OL High marsh	2022	2.94
OL Low marsh	2021	4.59
OL Low marsh	2022	3.82

Peak biomass across years



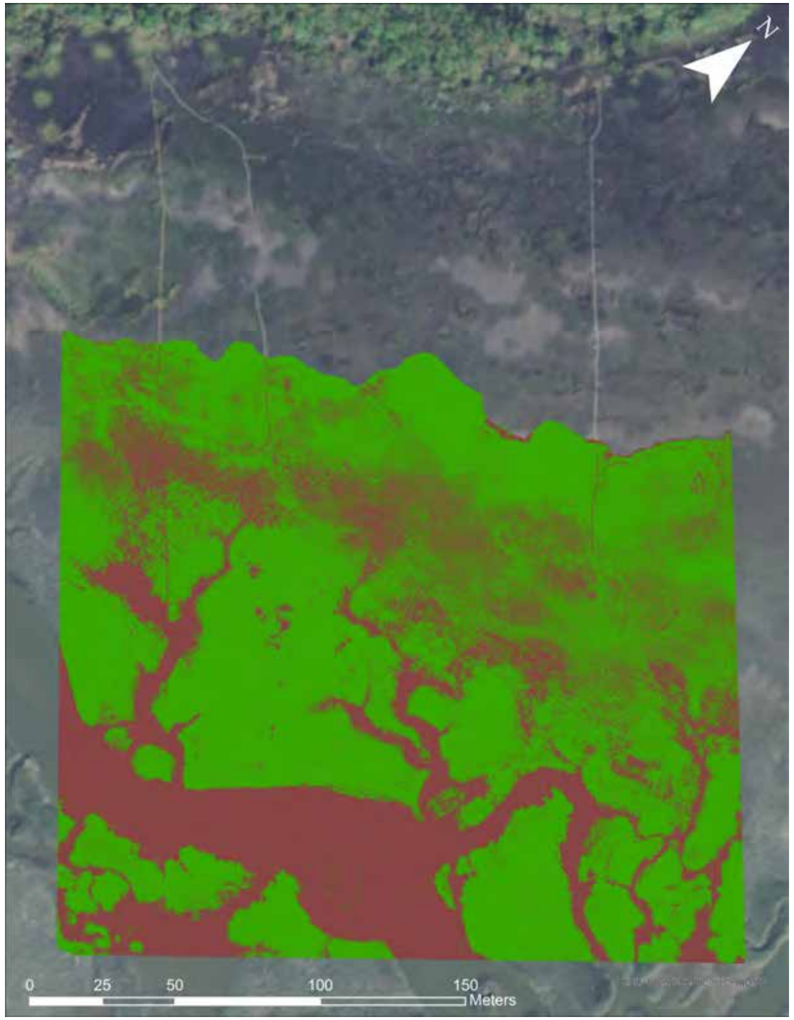
Sea level trends

(and relative [temporary] lack of trend over 2020 – 2023)



Calculating fraction vegetated from NDVI maps

0.023 x 0.023 m pixel classification



Pixel-level classification of vegetated or non-vegetated

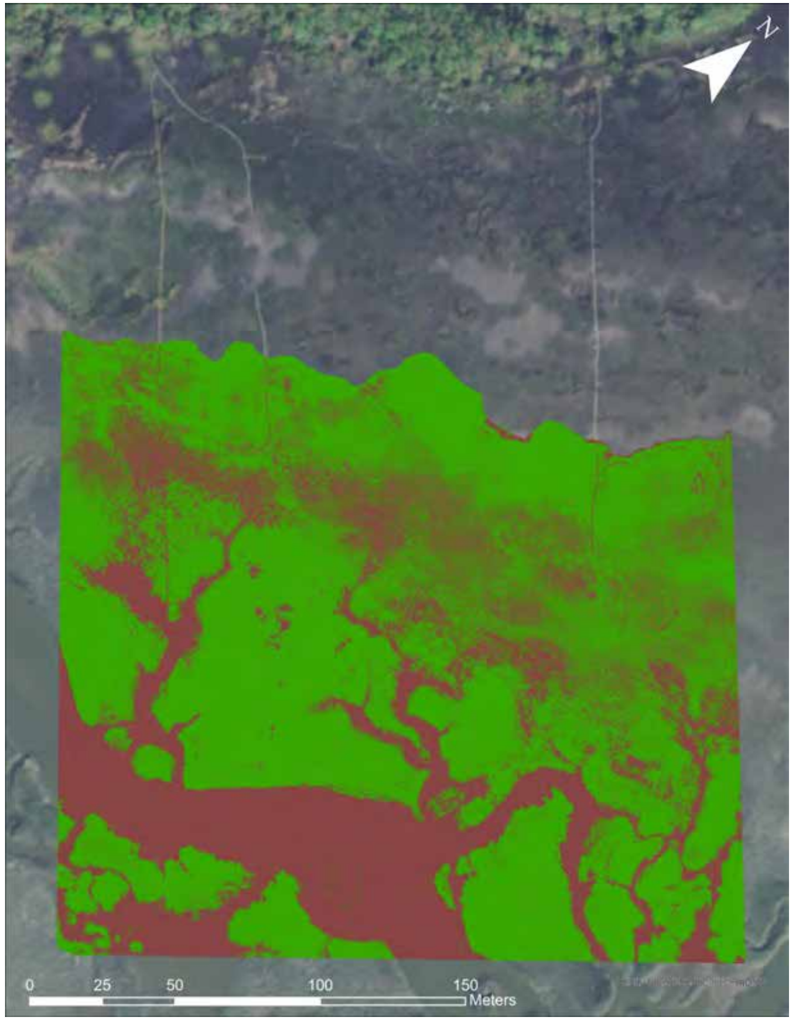
- Dynamic NDVI threshold approach to binary pixel classification
  → determined for each flight
- Training samples: 30 vegetated points; 30 ground points
- Threshold = [min($NDVI_{veg}$) + max($NDVI_{ground}$)]/2
- Pixels reclassified as veg or non-veg based on threshold value
- Accuracy assessment: 150 vegetated points; 150 ground points

OBJECTID	ClassValue	C_unveg	C_veg	Total	U_Accuracy	Kappa
1	C_unveg	125	25	150	0.83	0.00
2	C_veg	12	138	150	0.92	0.00
3	Total	137	163	300	0.00	0.00
4	P_Accuracy	0.91	0.85	0.00	0.88	0.00
5	Kappa	0.00	0.00	0.00	0.00	0.75

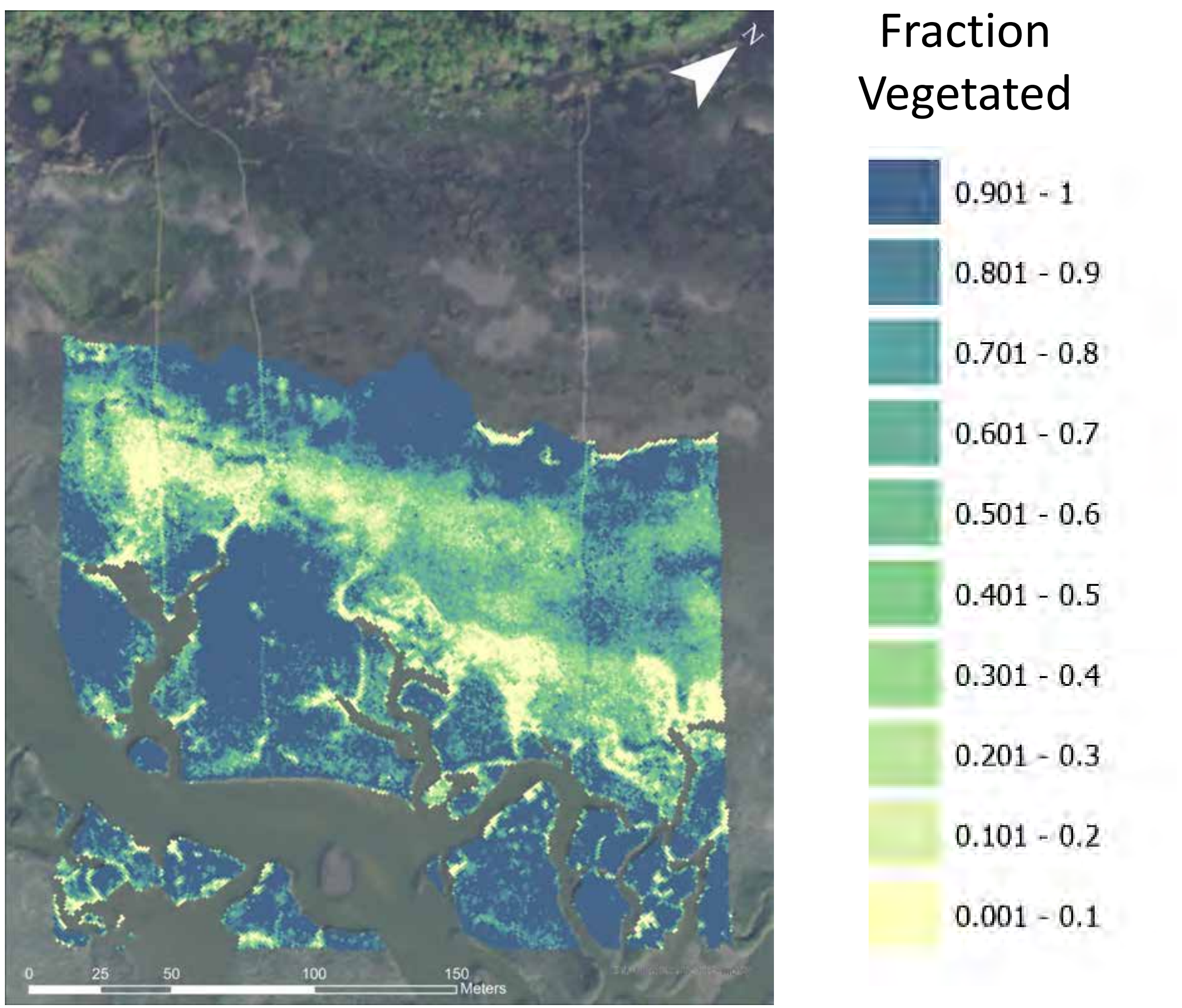
Overall classification accuracy ranges from 76 – 91 %

Calculating fraction vegetated from NDVI maps

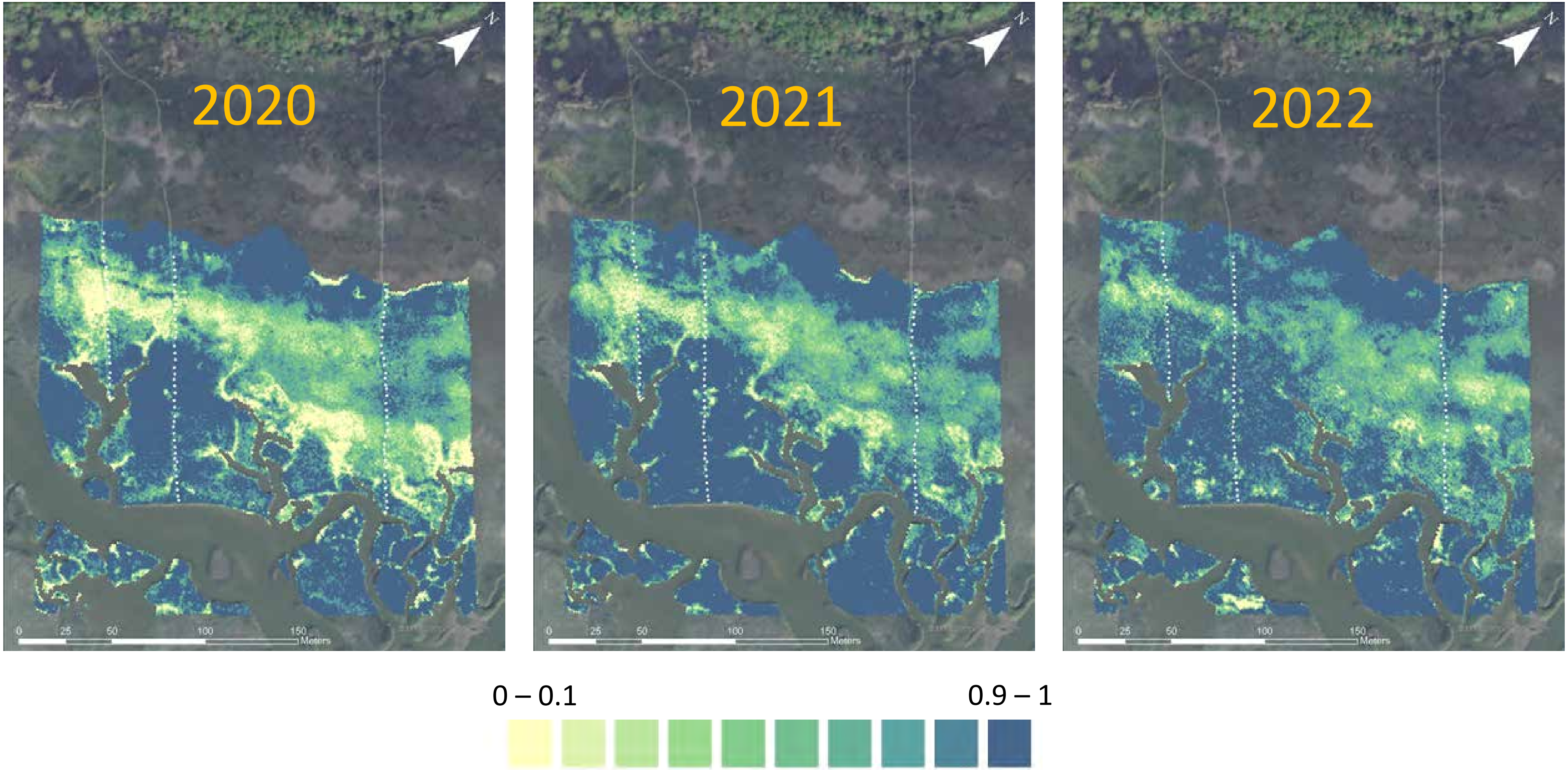
0.023 x 0.023 m pixel classification



1 x 1 m fraction vegetated



Fraction vegetated at peak biomass: variability among years



Summary

The use of UAS allows us to routinely and reliably monitor changes in vegetation biomass and cover.

- Multispectral imagery is a robust predictor of live aboveground biomass of *S. alterniflora.*

  → can use a single model across time and location

- Pixel-level classification allows robust estimates of *S. alterniflora* % cover.
- Repeat flights demonstrated distinct spatial and inter-annual variability in seasonality of biomass growth.

Next steps:

- Continue time-series
- Classification of additional marsh plant communities
- Expand marsh elevation surveys (e.g., drone-based LiDAR)


Thanks!
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