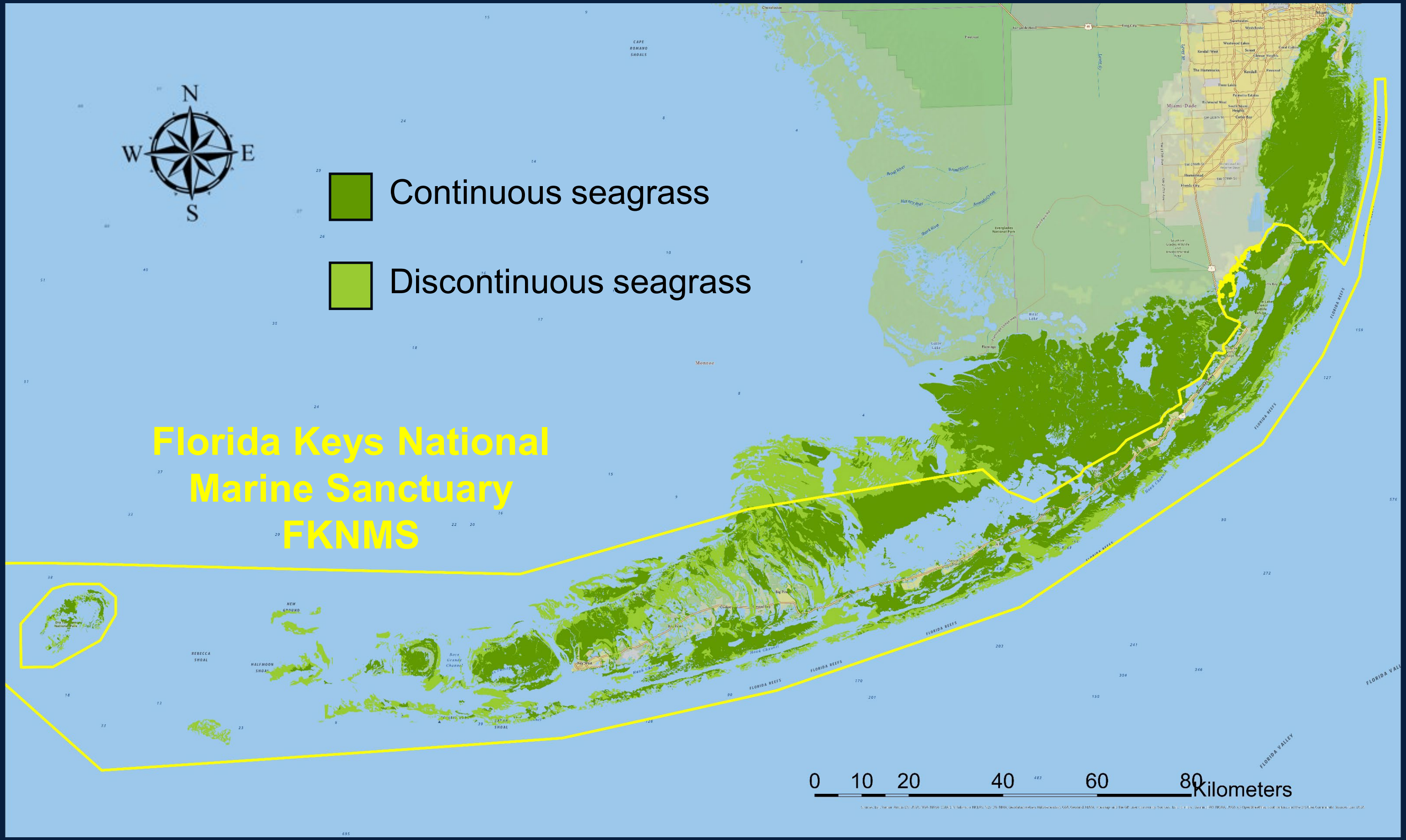
Mapping Seagrass-Coral Reef Mosaics Using Satellite Imagery to Quantify Seascape Structure in the Florida Keys

Marianna Coppola
Florida International University
October 30th, 2025

Seagrass Meadows of the Florida Keys Reef Tract

- Biodiversity hotspot
- Nursery habitats
- Foraging grounds
- Carbon sequestration



Seagrass habitat are poorly represented in conservation planning worldwide

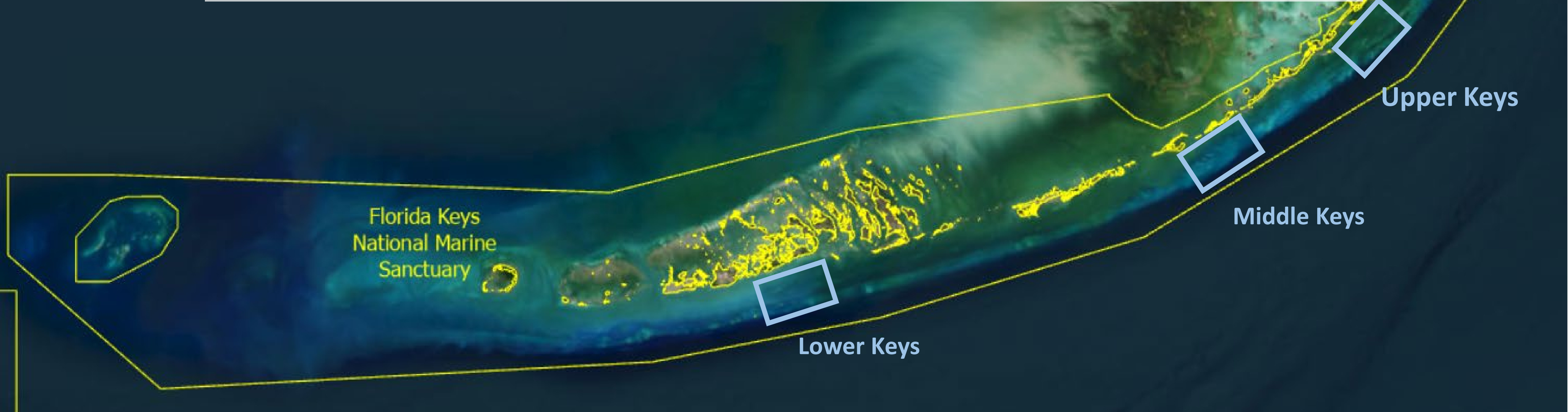
Fish In Seagrass Habitats: Seascape Connectivity Across Protected Ecosystems

GAPS:

In the FKNMS, no-take zones contain only a small area of seagrass

OBJECTIVES:

Determine how much seagrass is necessary to support foraging for different reef fishes based on habitat configuration and how this might change over time



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Inter-disciplinary approach

FISHSCAPE integrates multiple approaches:

- Seascape mapping
- Acoustic telemetry to track fish movements
- Laboratory experiments measuring energetic costs
- Mesocosm Experiment On Mesopredatory fish Foraging Efficiency
- Stable Isotope Analyses and Mesopredators diet
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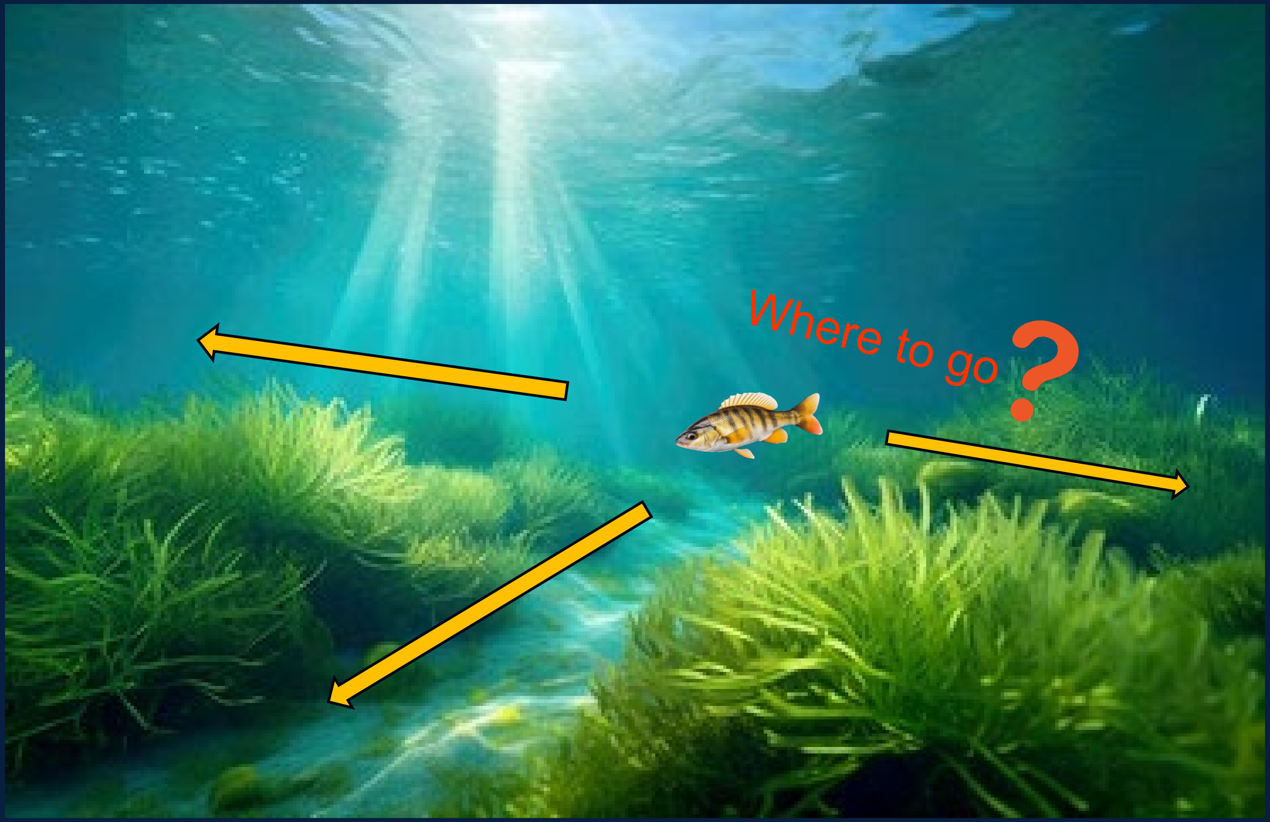
Putting the “scape” in FISHSCAPE project!

Seascape Characterization

SEAGRASS SPATIAL STRUCTURE INFLUENCES:

- Predation risk
- Prey Density
- Fish movements
- Patch reef – seagrass connectivity



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How are reef and seagrass habitats spatially arranged across the Florida Keys Reef Tract?

Let’s map the seascape!

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Mapping Workflow

DATA ACQUISITION

***In Situ* data**

- Quadrat pictures
- GPS data

Manually digitized points

TOA Satellite Data

DATA PROCESSING

Classification Scheme → **Training data**

SR Satellite Data

Additional layers:

- Bathymetry
- Hardbottom
- Spectral Indices
- Depth-invariant indices

→ **Raster stack**

DATA ACQUISITION

Classification Models

Predict categorical classes

Seascape maps

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planet. imagery applications in seagrass mapping

PlanetScope constellation:

- Launched in 2016
- 3 m pixel resolution
- 8 spectral bands
- 180+ microsatellites in orbit
- Daily revisit

Chapter

Assessment of PlanetScope images for benthic habitat and seagrass species mapping in a complex optically shallow water environment

By Pramaditya Wicaksono, Wahyu Lazuardi

Book [Fine Resolution Remote Sensing of Species in Terrestrial and Coastal Ecosystems](#)

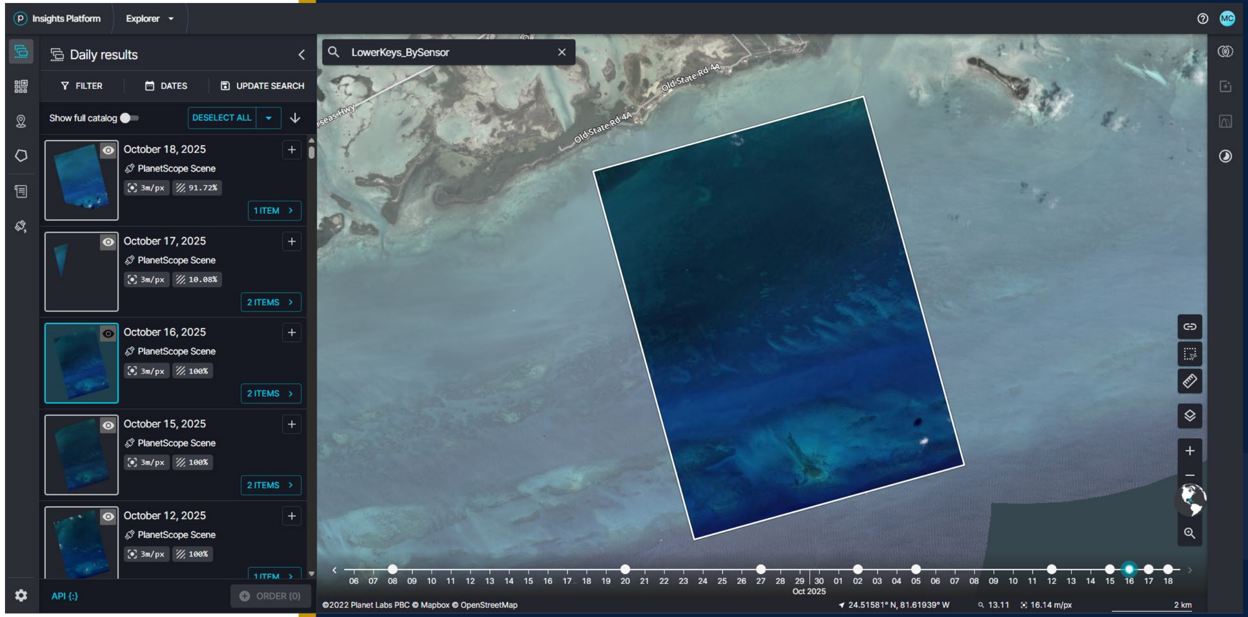
Edition 1st Edition

First Published 2021

esa

Mapping the National Seagrass Extent in Seychelles Using PlanetScope NICFI Data

by C. Benjamin Lee [1,*], Lucy Martin [2,3], Dimosthenis Traganos [1], Sylvanna Antat [4], Stacy K. Baez [5], Annabelle Cupidon [6], Annike Faure [7], Jérôme Harlay [4], Matthew Morgan [6], Jeanne A. Mortimer [6,8], Peter Reinartz [9] and Gwilym Rowlands [2]



Research Articles

Consistency assessment of multi-date PlanetScope imagery for seagrass percent cover mapping in different seagrass meadows

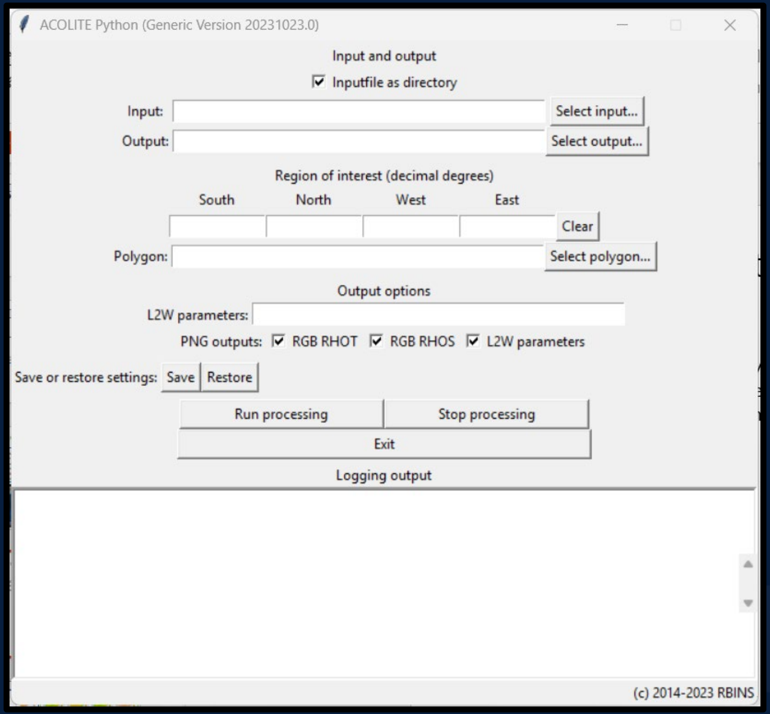
Pramaditya Wicaksono, Amanda Maishella, Wahyu Lazuardi & Faaris Hizba Muhammad

Pages 15161-15186 | Received 19 Dec 2021, Accepted 24 Jun 2022, Published online: 06 Jul 2022

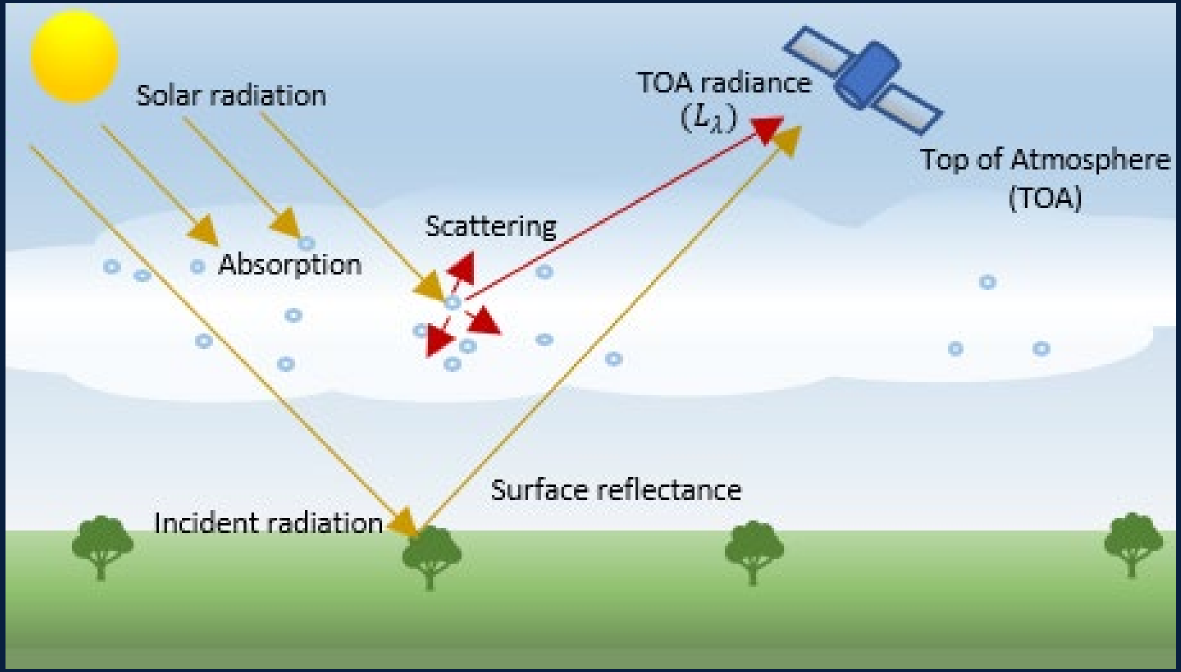
Atmospheric correction

ACOLITE

processor developed by the REMSEM* team for atmospheric correction and processing of satellite imagery for coastal and inland water applications.



ACOLITE GUI



Acolite atmospheric correction options:

- **Dark spectrum fitting DSF**
- Adjacency aware processing RadCor
- Exponential extrapolation EXP

*The REMSEM team at the Royal Belgian Institute of Natural Sciences is dedicated to advancing ocean colour remote sensing science and applications

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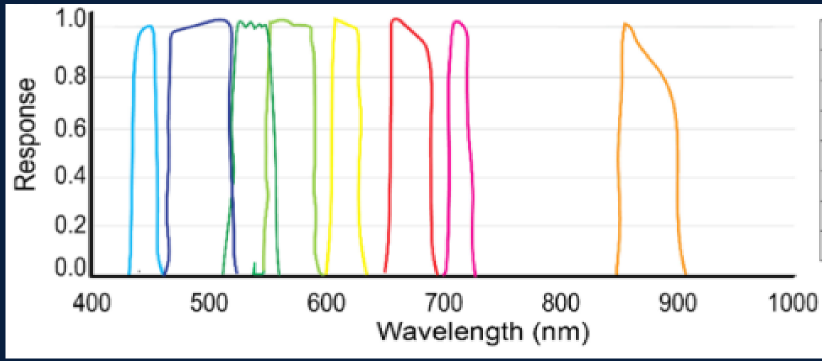
Image data processing



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Blue	465–515
Green	513–549
Green II	547–583
Yellow	600–620
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RE I	697–713
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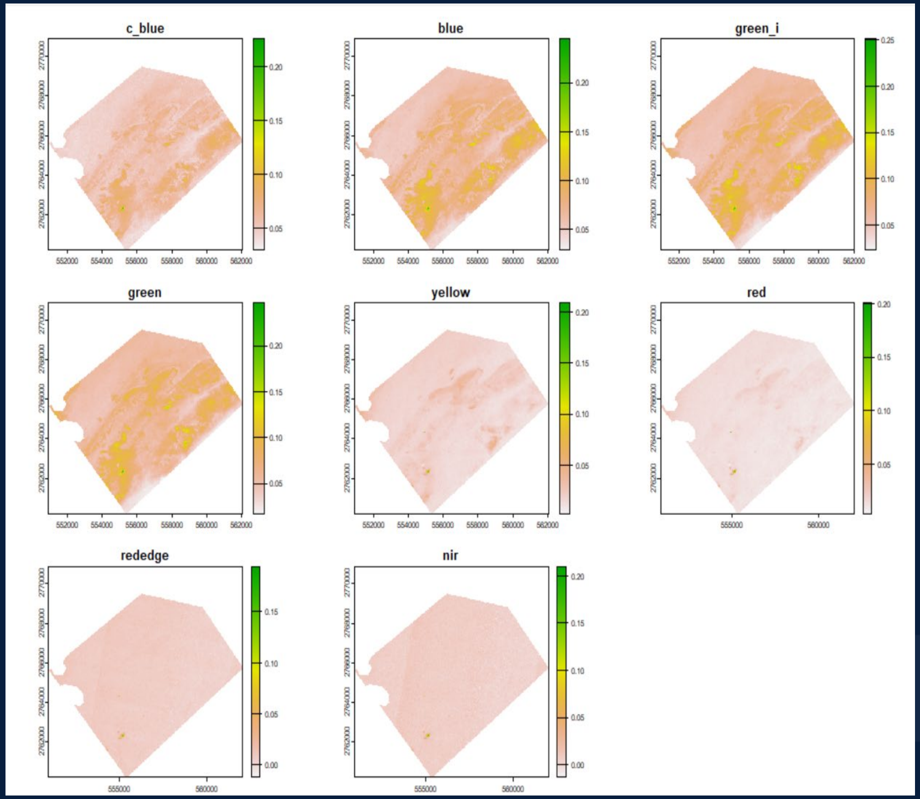
PlanetScope spectral bands

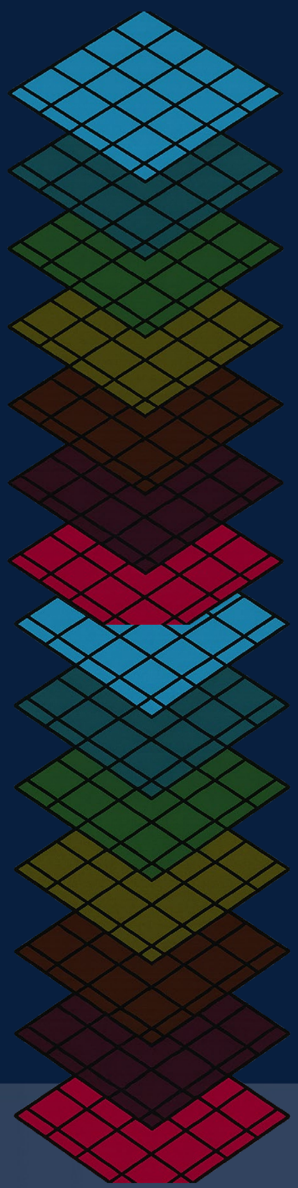


Spectral indices
- **Pearson correlation**
- **Previous seagrass literature**

Depth-invariant indices
- **Lyzenga et al. 2006**

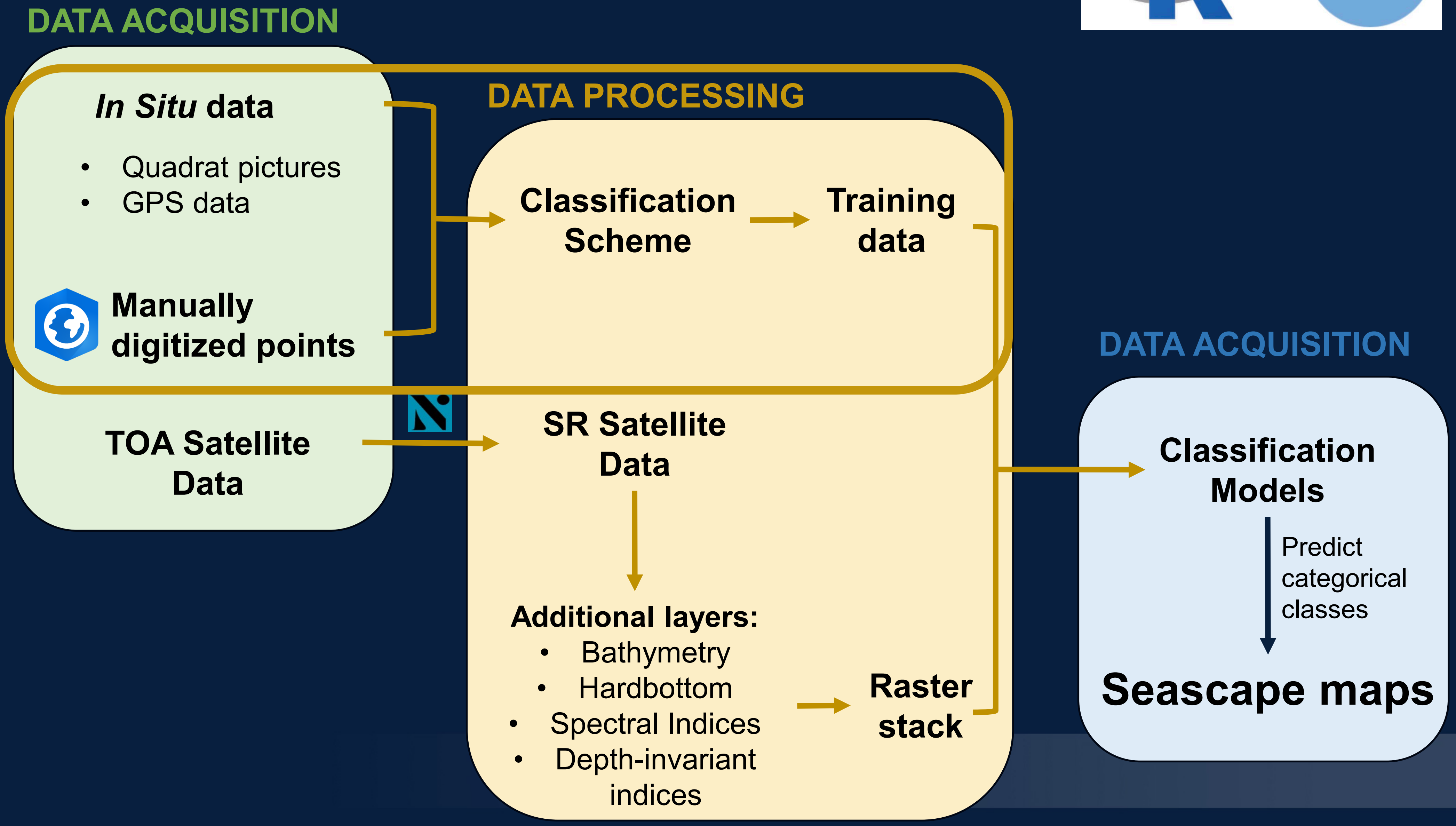
	MeanDecreaseGini
c_blue	5.646619
blue	7.421766
green_i	5.464639
green	4.777225
yellow	4.86004
red	5.11954
rededge	4.393521
nir	3.86765
depth	8.126005
ind24	4.641086
NDWI	4.144928
WAVI	4.590362
depth_c_blue	4.467628
depth_blue	4.183981
depth_green_i	4.040031
depth_green	4.278456
depth_yellow	6.164899
cbg	4.484608
cbgi	4.065593
cbg2	4.791752
cby	8.964488
bgi	10.10831
bgr	13.76476
gig	10.50227
giy	10.9073
gy	9.609247
gr	8.127678
yr	3.632081
Hardbottom	12.08598

29 layers



Lyzenga at al., 2006; Rowan & Kalaska 2020

Mapping Workflow



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In situ data acquisition

GNSS receiver

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In situ datasets

Dense Seagrass

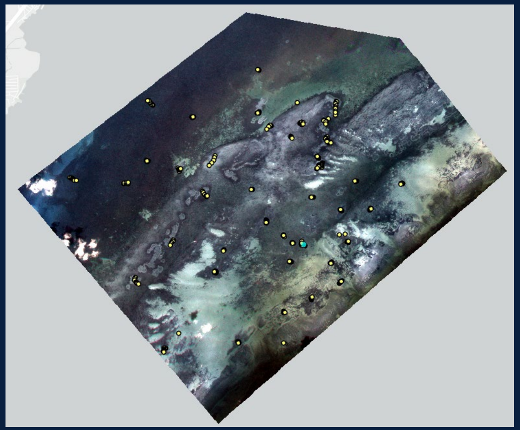
Sparse Seagrass

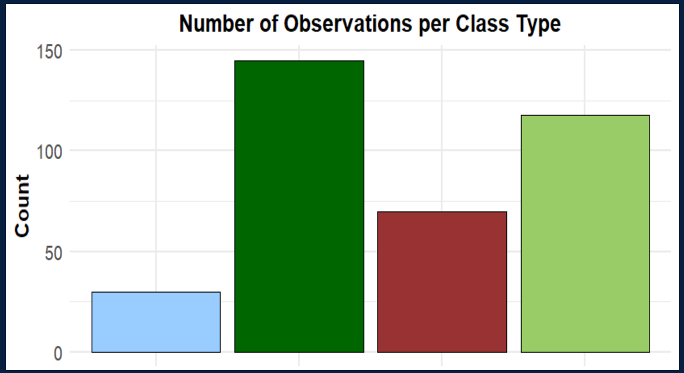
Patch Reef

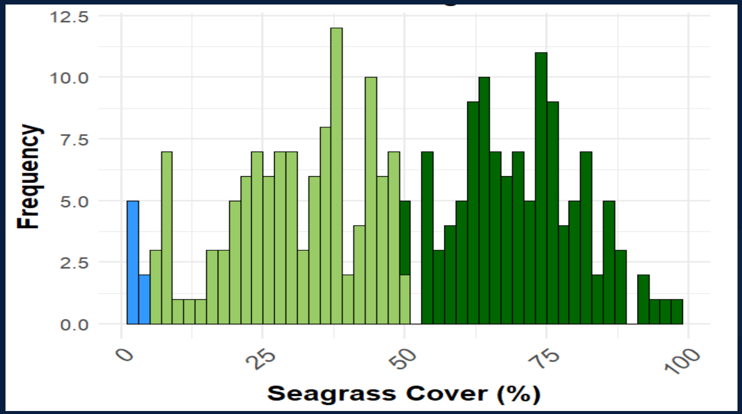
Colonized Pavement

Algal-dominated hardbottom

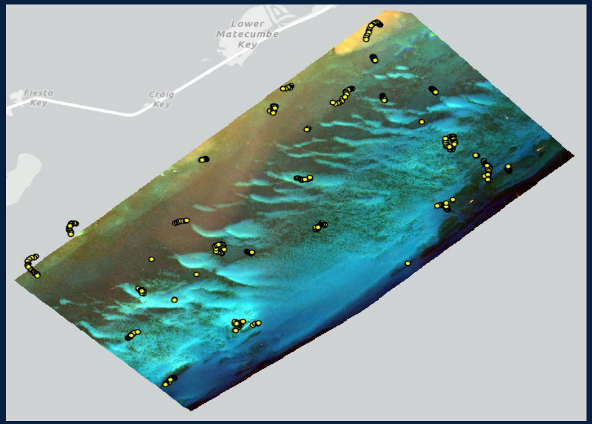
Upper Keys

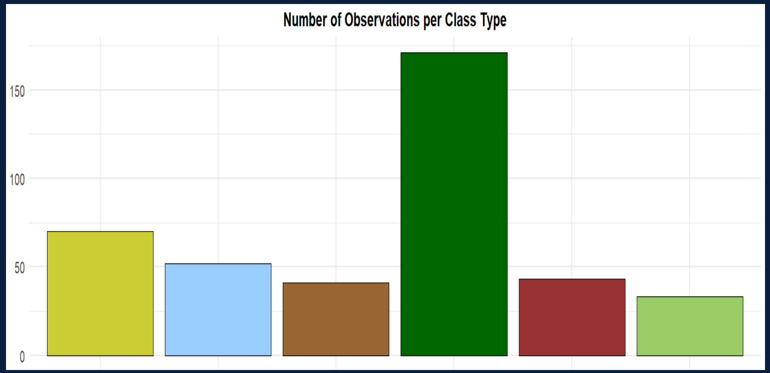


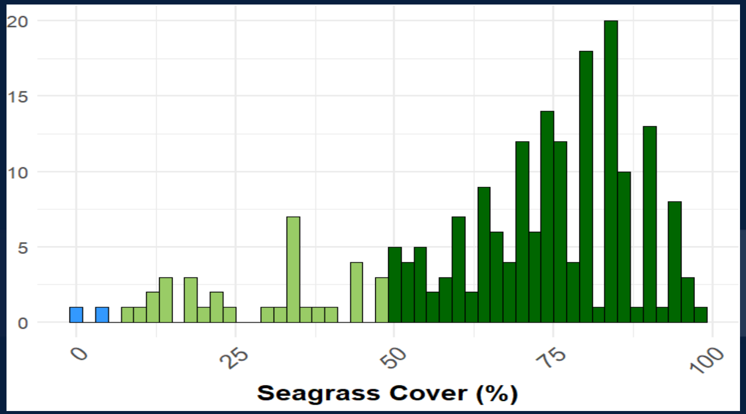




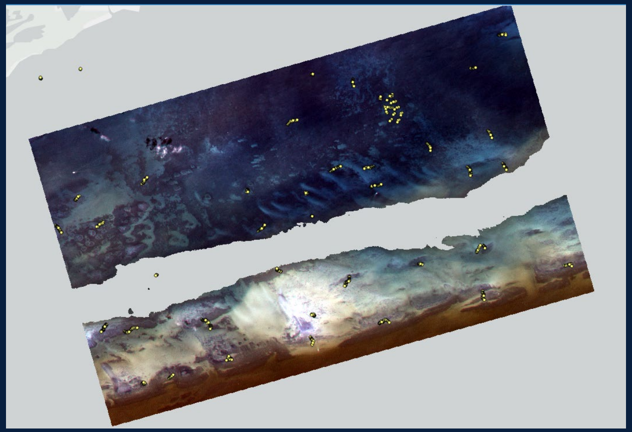
Middle Keys

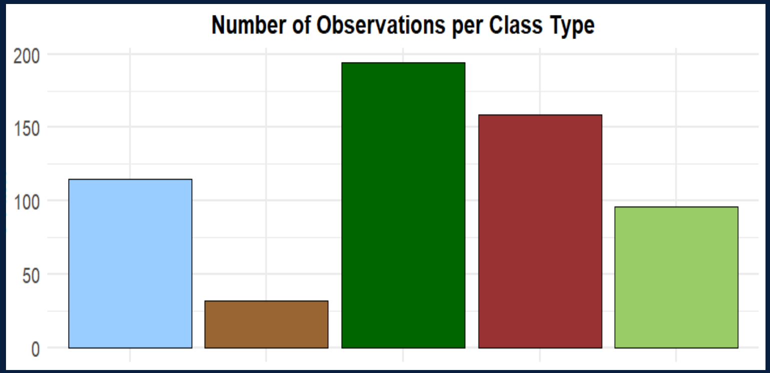


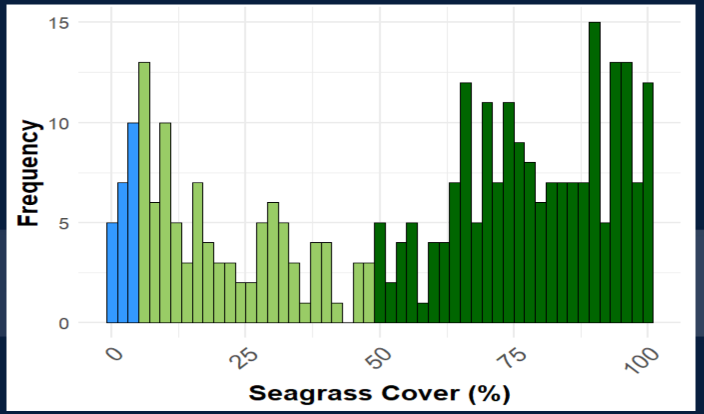




Lower Keys







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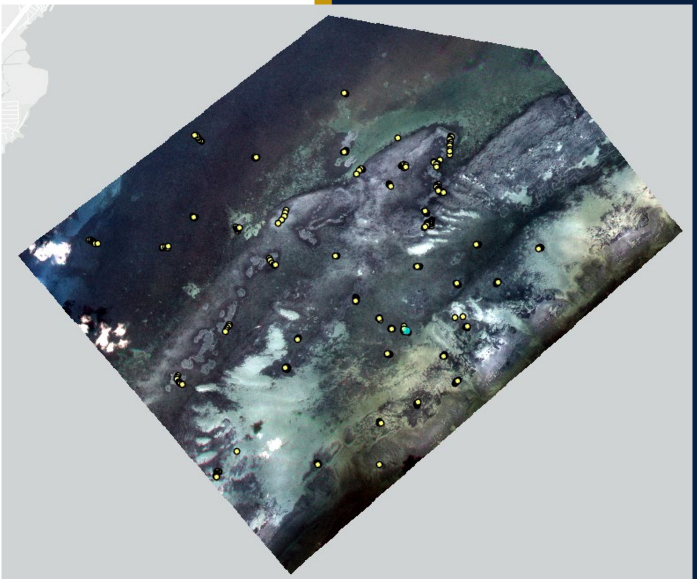
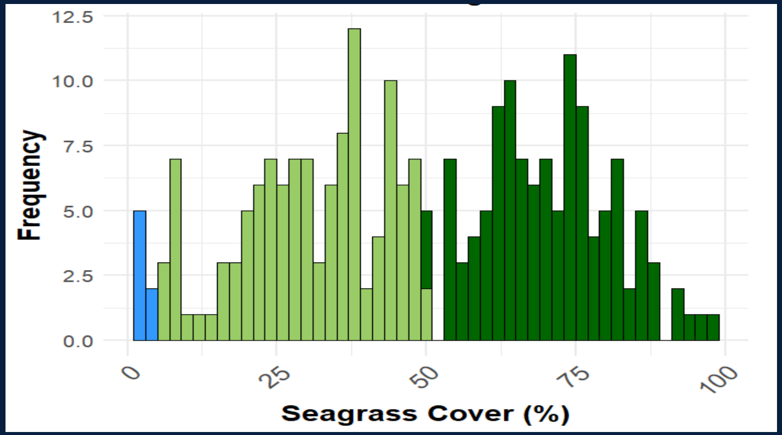
Classification Scheme





Medoids – Total seagrass cover

- Cluster1 TOT 35.30
- Cluster2 TOT 0.00
- Cluster3 TOT 72.25

Class thresholds

- Lower threshold = (0 + 35.30) / 2 = 17.65
- Upper threshold = (35.30 + 72.25) / 2 = 53.78

Seagrass classification scheme

0 < Bare < 17.65 < Sparse < 53.78 < Dense

Random Forest Classification

Model-based Error

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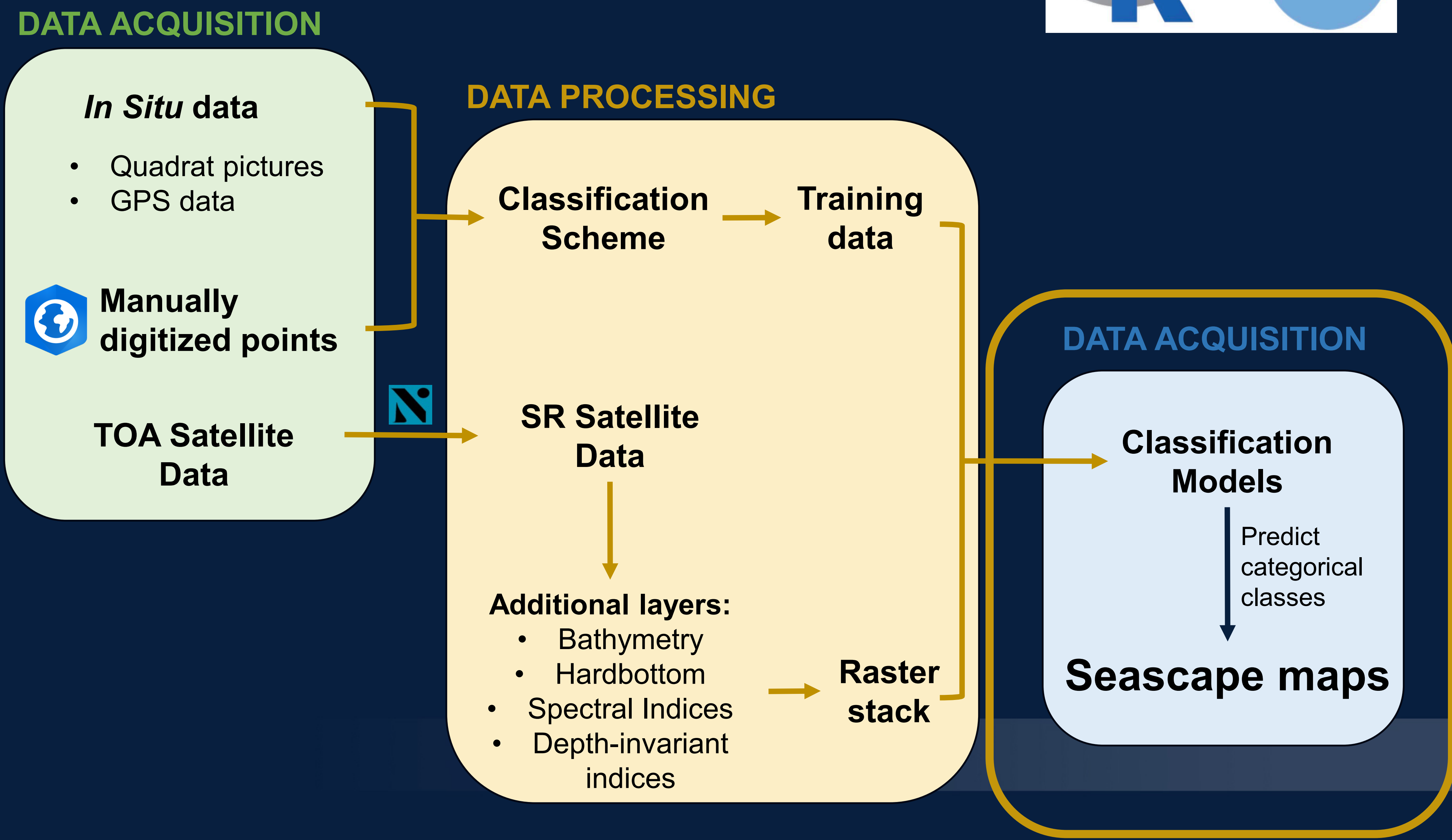
Mapping Workflow



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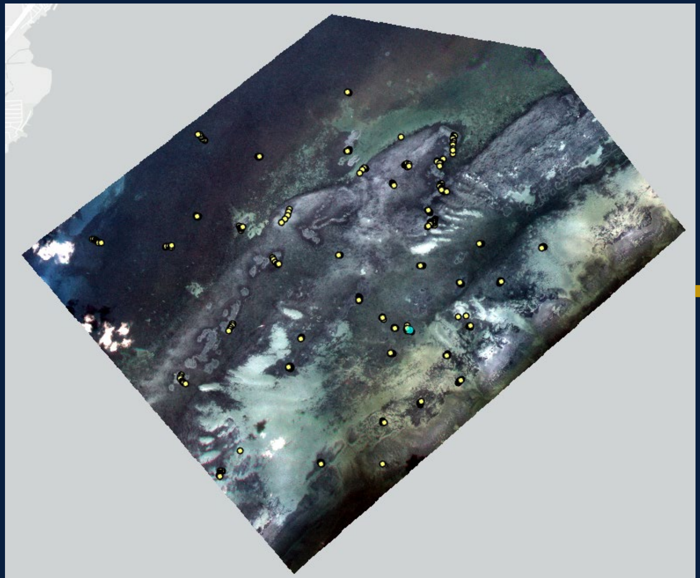
Best seagrass classification scheme

0 < Bare < 5 < Sparse < 50 < Dense



Extract spectral values across bands for each class

Machine Learning
-Random Forest-

Classification models
70-75% accurate

Seascape Maps

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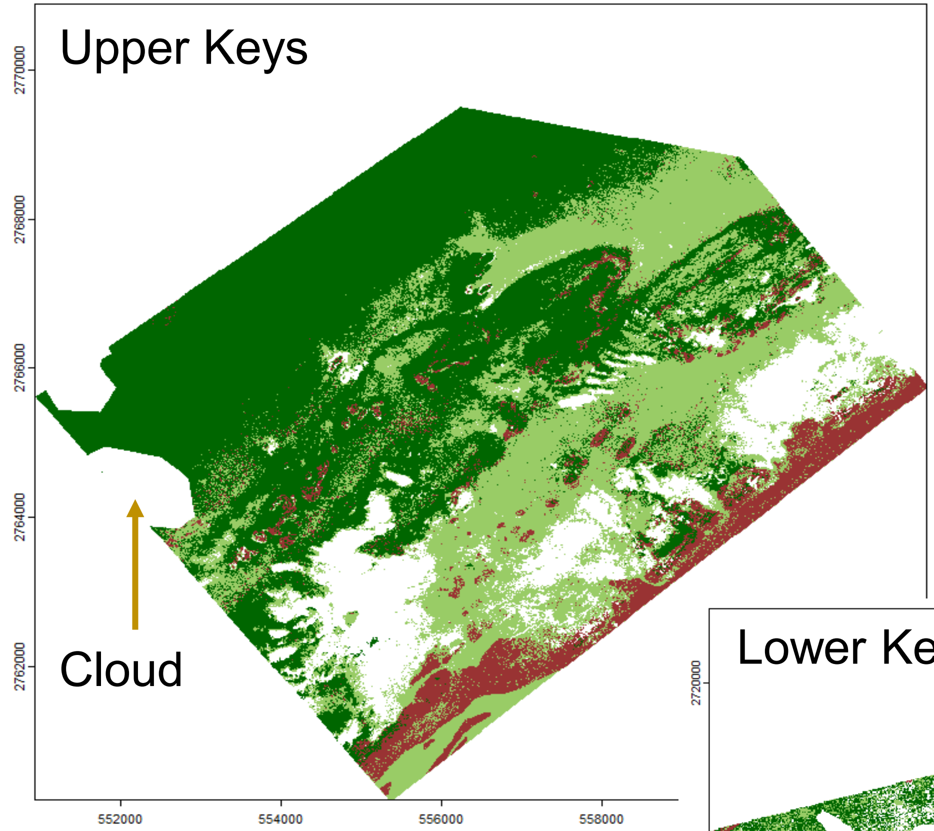
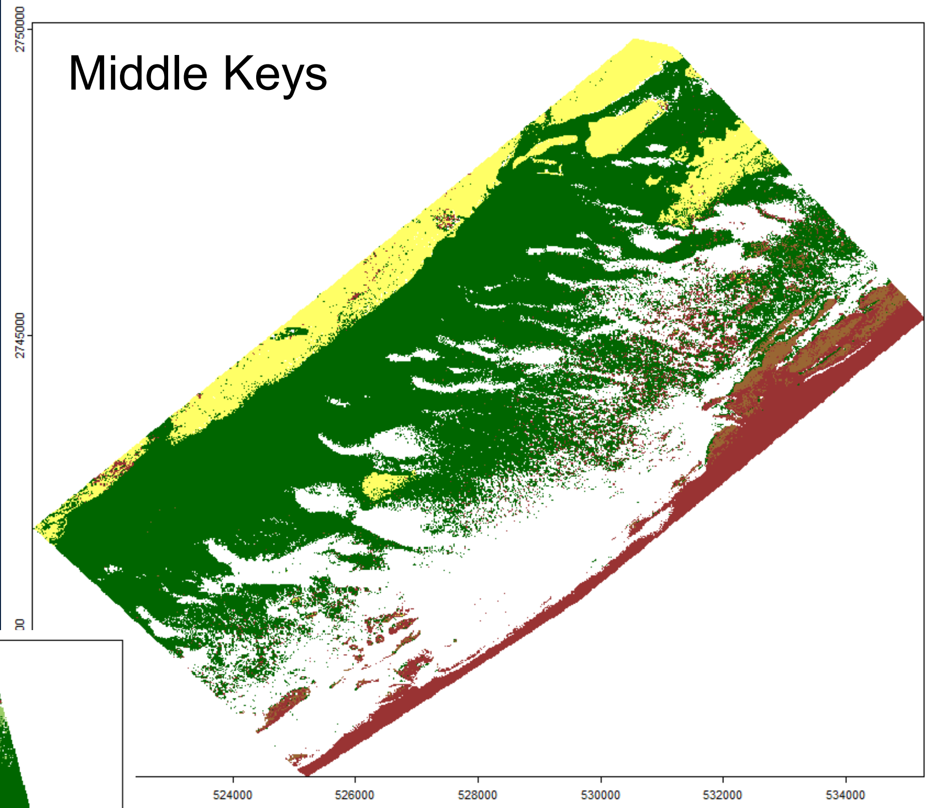
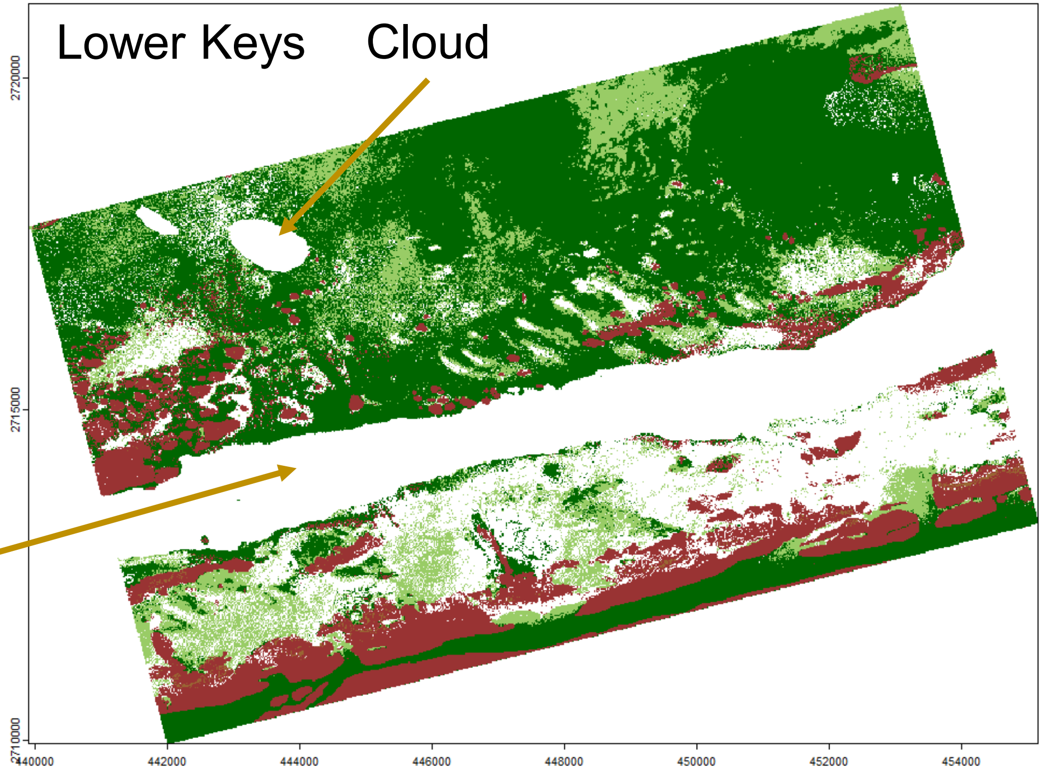


- Dense Seagrass > 50%
- Sparse Seagrass 5 – 50%
- Patch Reef
- Colonized Pavement
- Algal-dominated hardbottom





Hawk Channel

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Fish In Seagrass Habitats: Seascape Connectivity Across Protected Ecosystems

GAPS:
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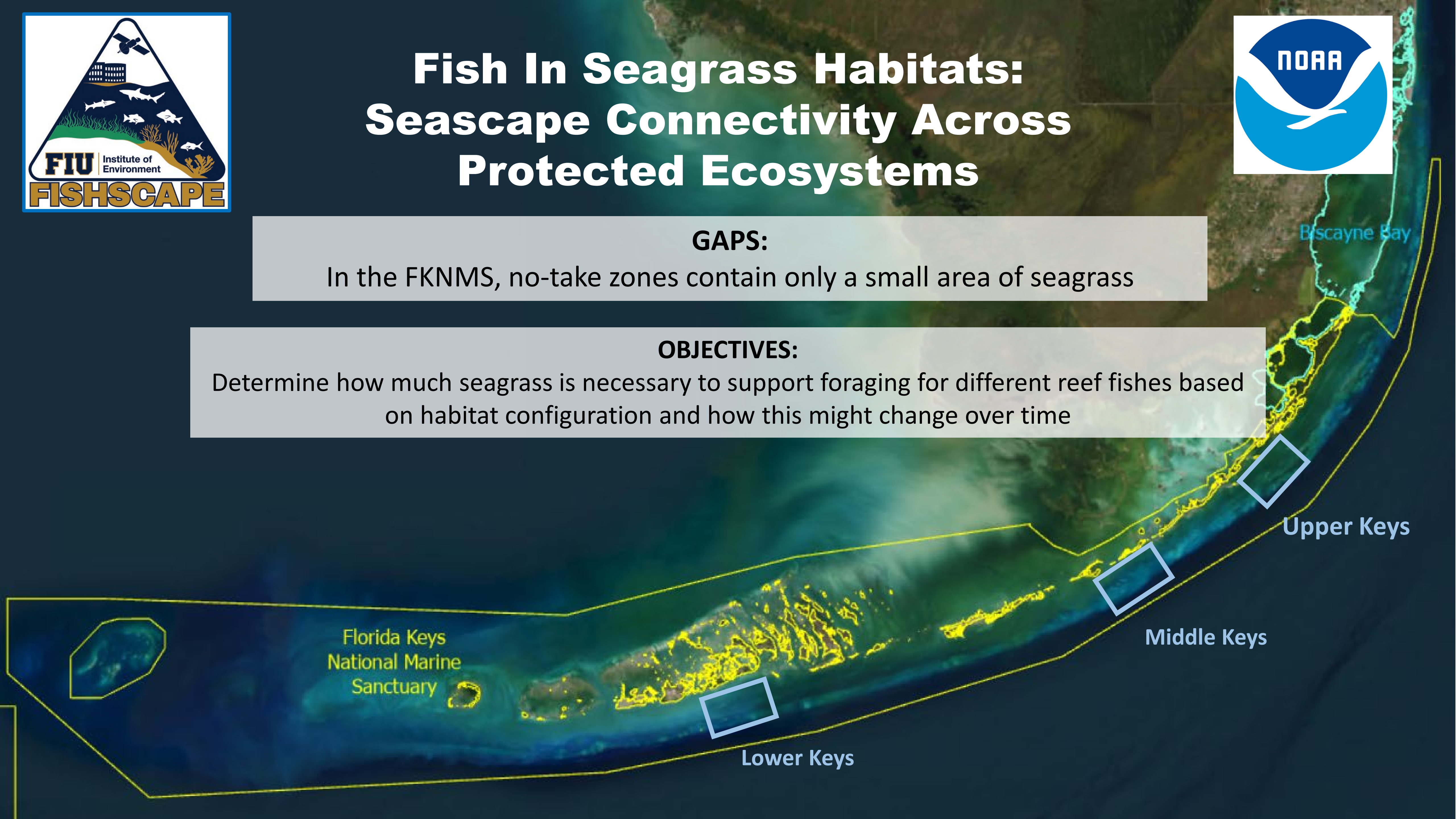
OBJECTIVES:
Determine how much seagrass is necessary to support foraging for different reef fishes based on habitat configuration and how this might change over time



Seagrass-Patch Reef Arrangement

1. Patch Reef Point Layer
2. Buffer 250 m radius
3. Calculate landscape metrics

- **Percent of Landscape (pland)**

-Amount of habitat per unit area-

- **Edge Density (ed)**

-Proportion of edge habitat, shape complexity-

- **Fragmentation Index** (Santos et al. 2011)

-level of meadow continuity/patchiness-

- **Simpson Evennes Index**

-Habitat Type richness-

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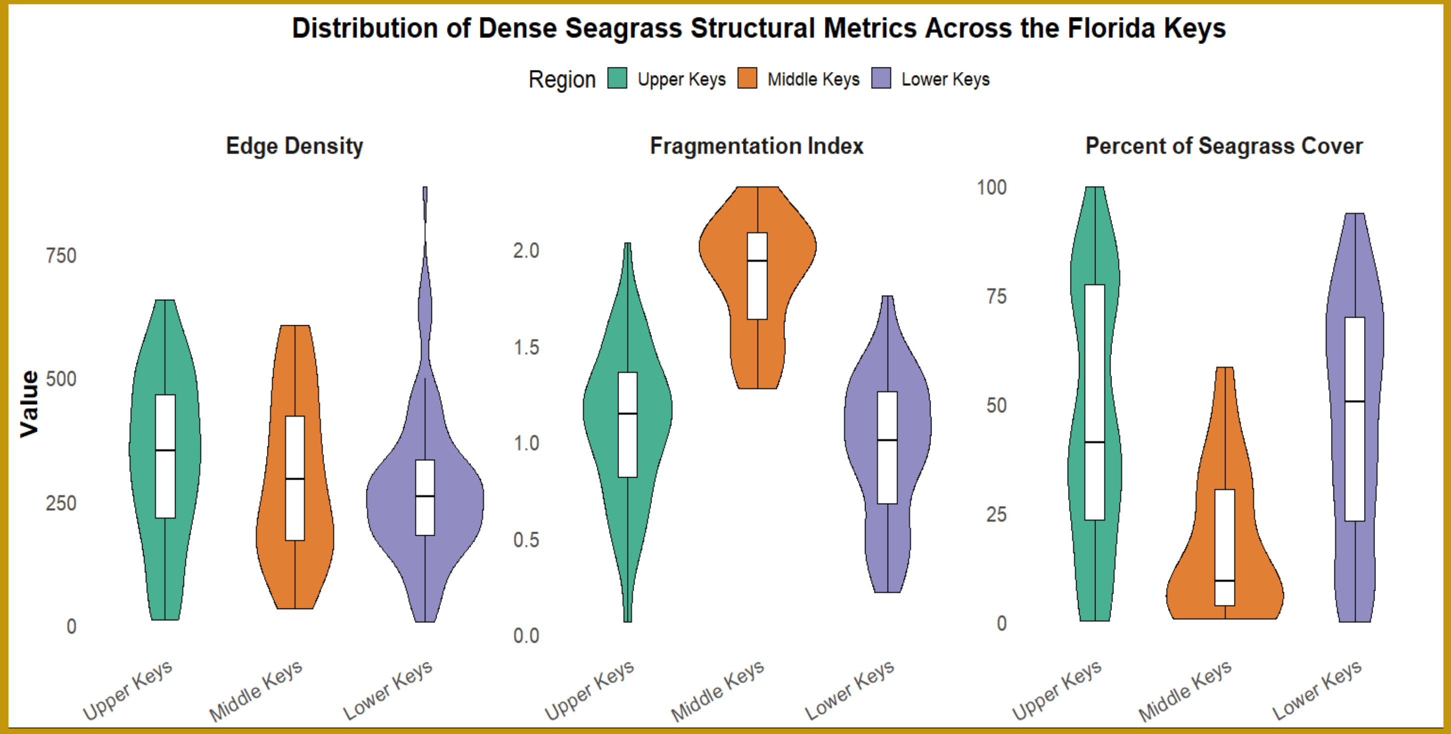
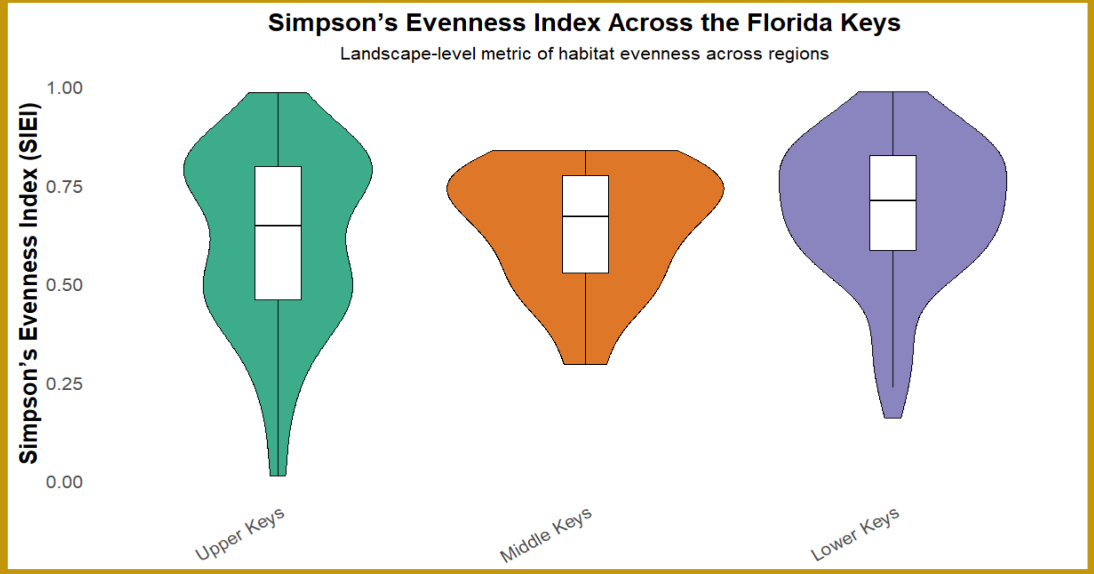
Hesselbarth et al., 2019

Results





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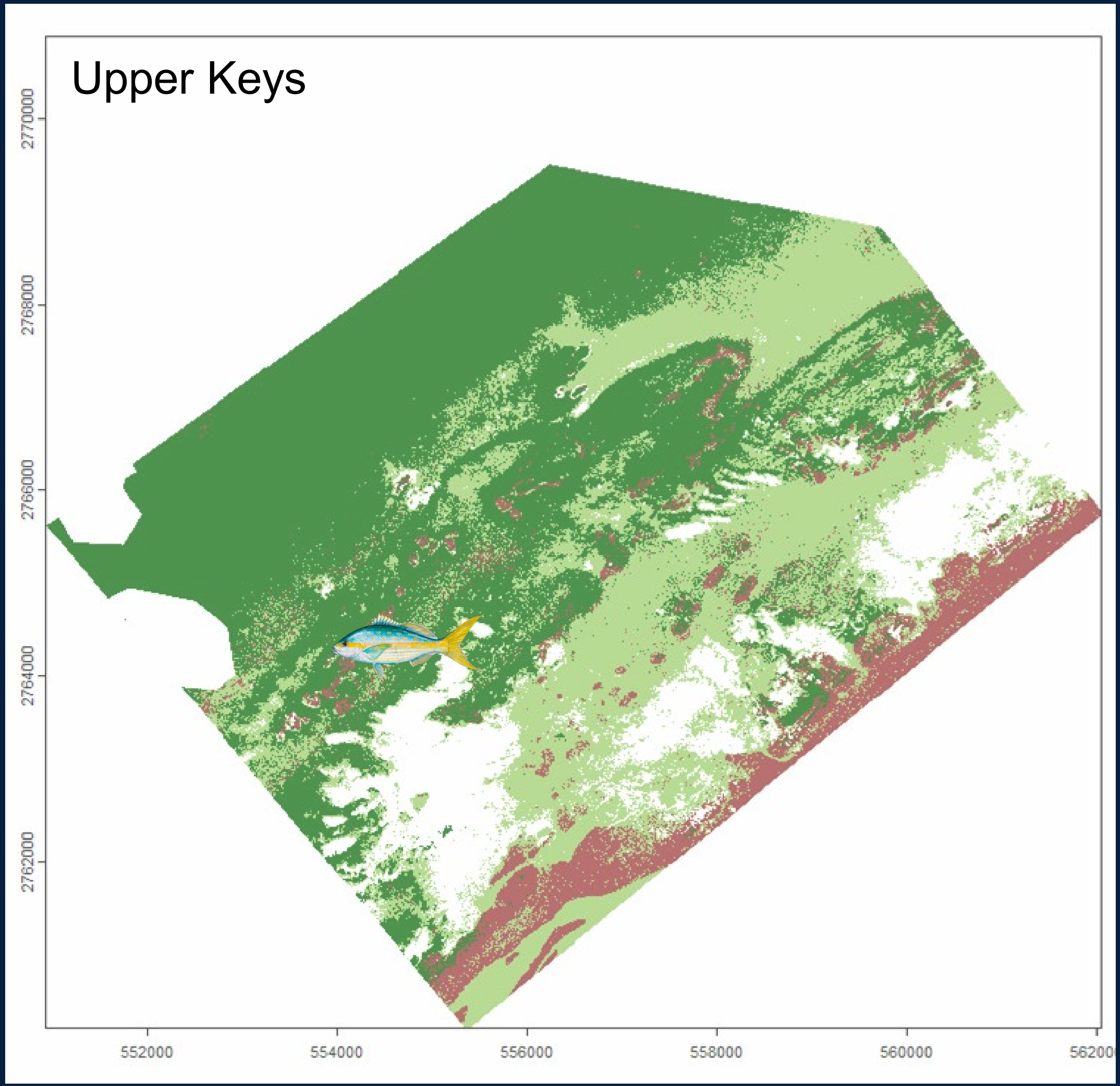
Conclusions

- **Dense seagrass meadows display high proximity and contiguity to patch reef in the Upper Keys and Lower Keys**
- **Patch reefs in the Middle Keys are more isolated from dense seagrass beds**



Highly connected dense seagrass – patch reef mosaics are priority targets for MPA design in the Florida Keys

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Next steps

- Upscale seascape maps to Sentinel2 data across time-series images
- Measure seagrass structural dynamics across the Florida Keys seascape mosaics

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- Christine Nation
- Sofia Garcia
- Jonathan Rodemann
- Justin Lesser

Rehage Lab

The FISHSCAPE Team

The Seakeepers Foundation

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

FIU Institute of Environment
FISHSCAPE

SANTOS SEASCAPE ECOLOGY LAB

FLORIDA INTERNATIONAL UNIVERSITY
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FULBRIGHT
Italy

Thank you!

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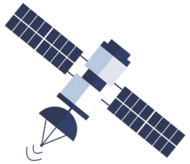
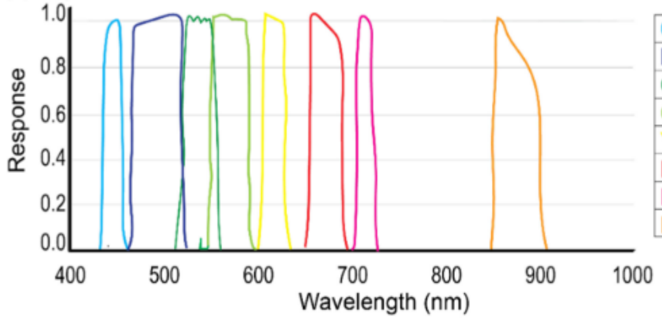
SEAGRASS MEADOWS

Biodiversity hotspot
Nursery habitats
Foraging grounds
Carbon sequestration
Poorly represented in conservation planning worldwide

Image data processing





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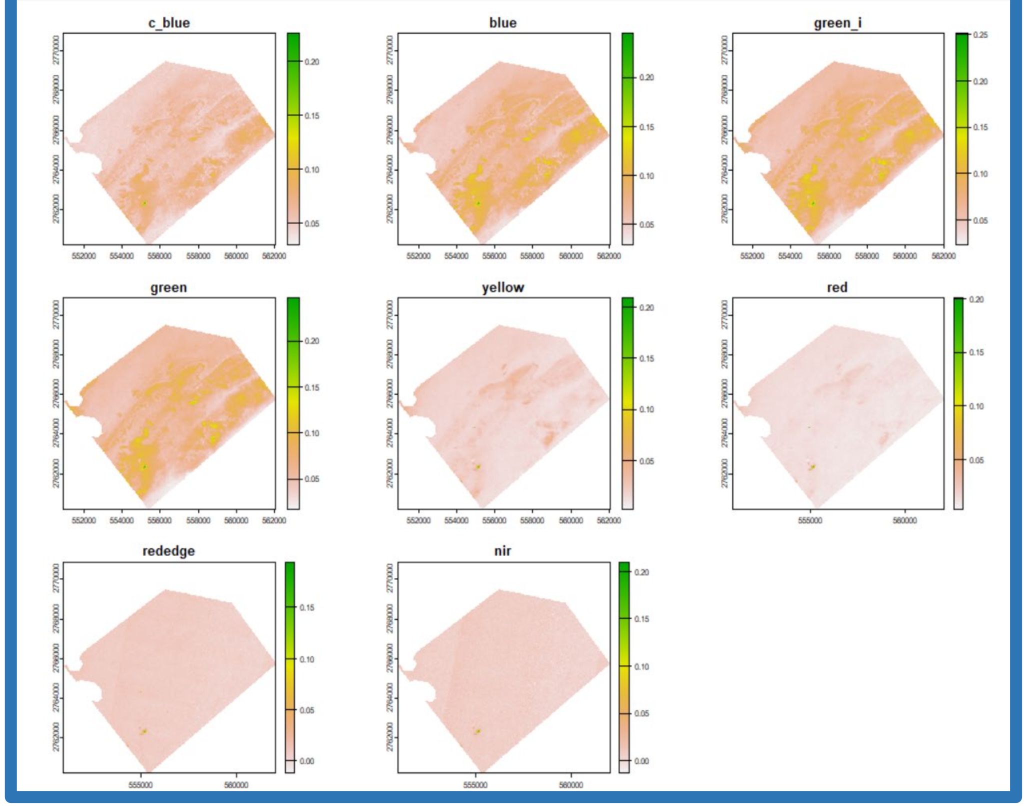
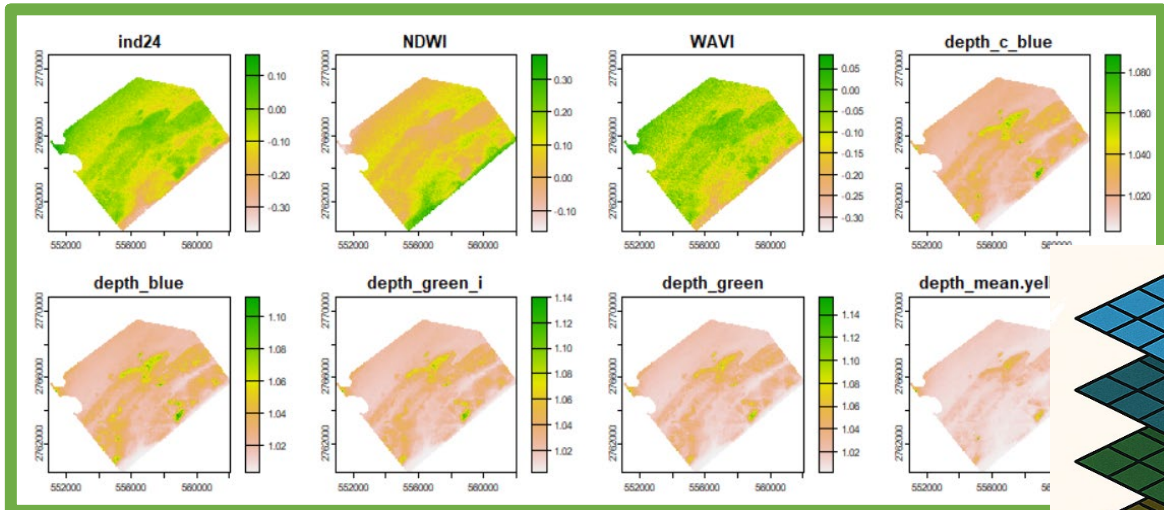
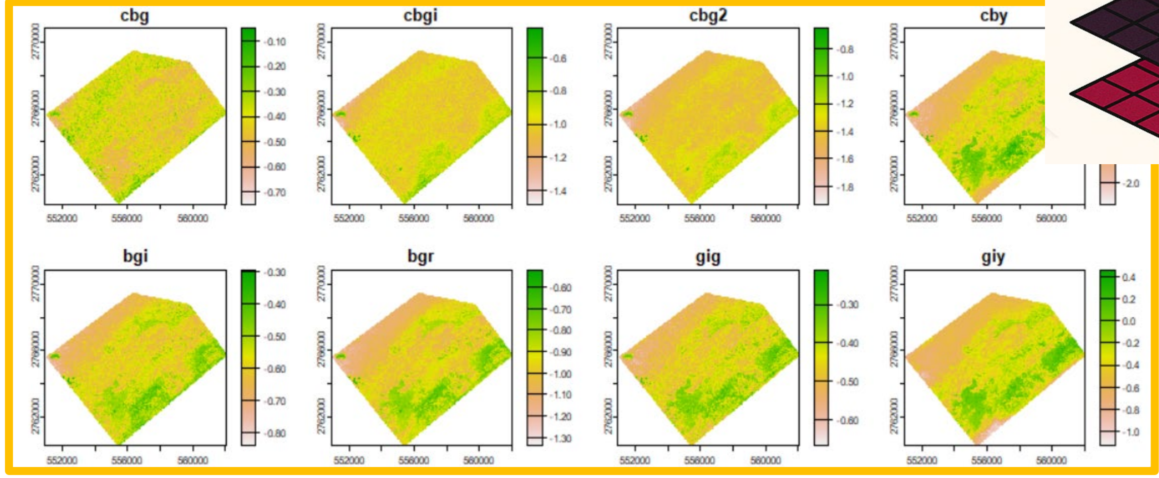
PlanetScope spectral bands

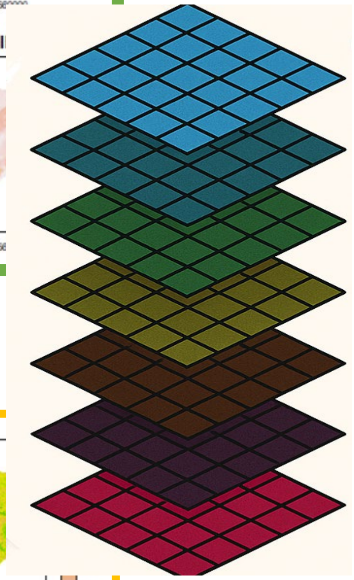


Spectral indices - correlation analysis and previous literature



Depth- invariant indices – Lyzenga et al. 2006

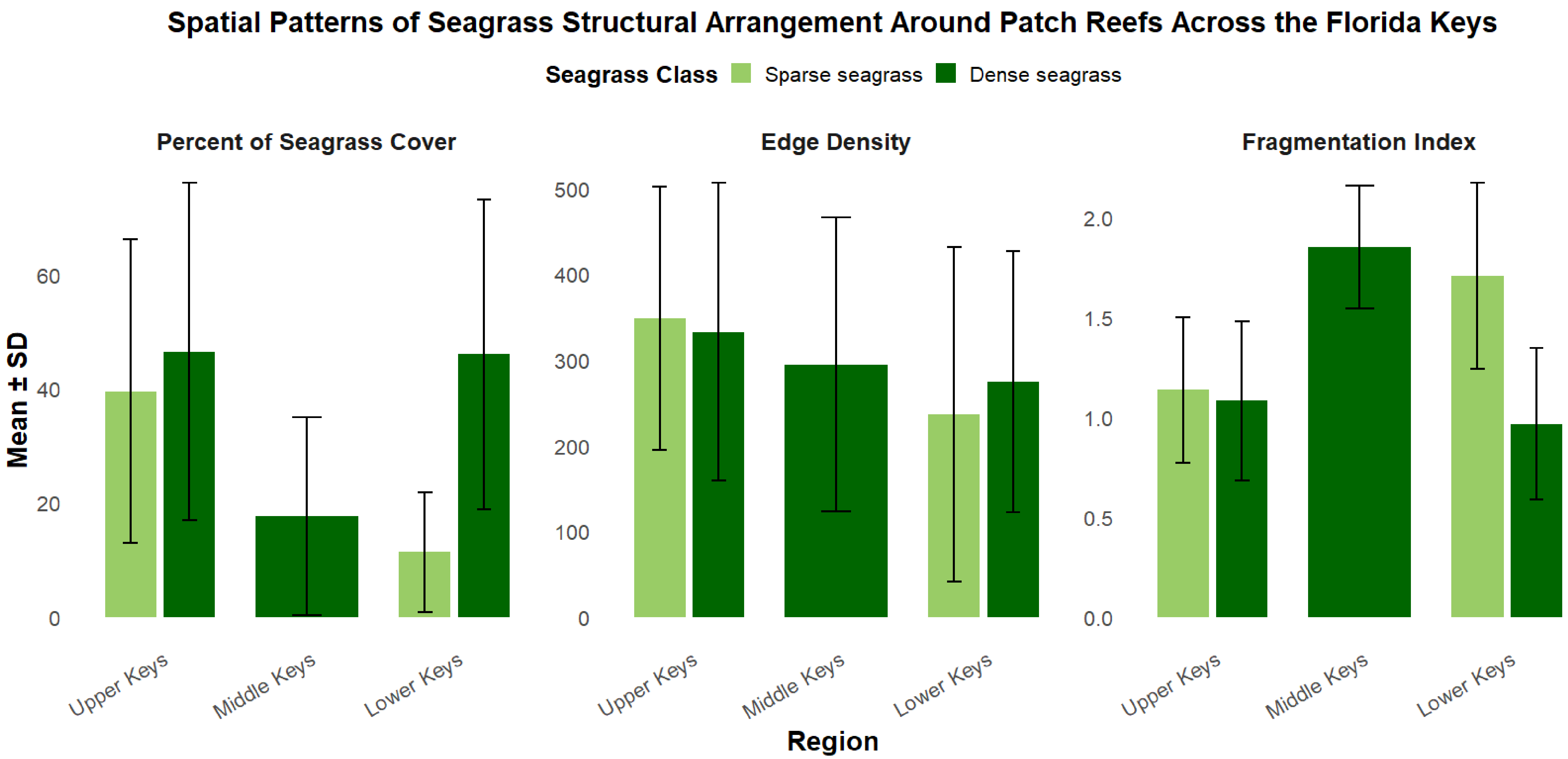




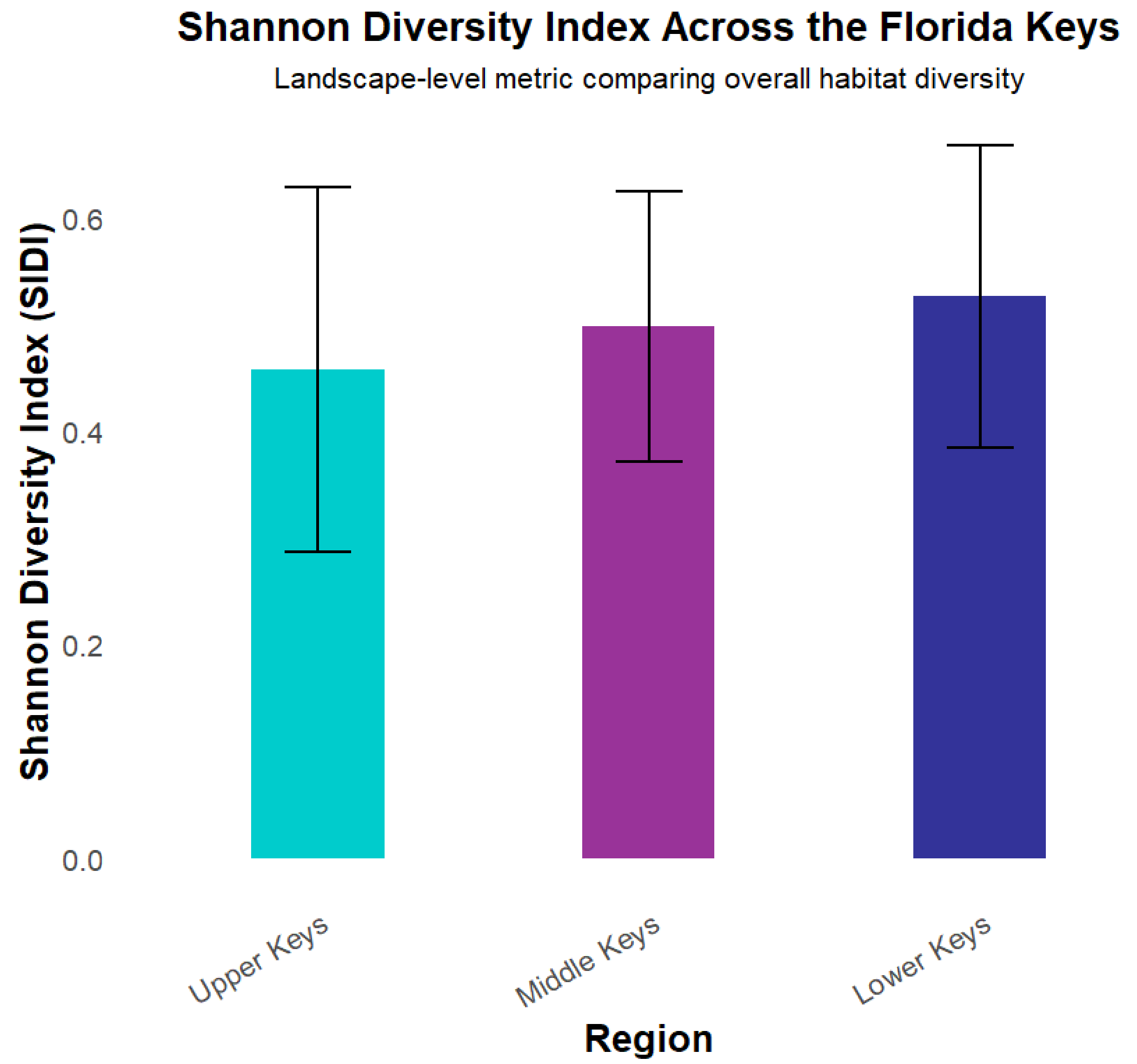
Around 30 layers

Lyzenga at al., 2006; Rowan & Kalaska 2020

Results


Spatial Patterns of Seagrass Structural Arrangement Around Patch Reefs Across the Florida Keys
Seagrass Class
Sparse seagrass
Dense seagrass
Percent of Seagrass Cover
Edge Density
Fragmentation Index
Mean ± SD
0
20
40
60
0
100
200
300
400
500
0.0
0.5
1.0
1.5
2.0
Upper Keys
Middle Keys
Lower Keys
Region

Results


Shannon Diversity Index Across the Florida Keys
Landscape-level metric comparing overall habitat diversity
Shannon Diversity Index (SIDI)
0.6
0.4
0.2
0.0
Upper Keys
Middle Keys
Lower Keys
Region