High-resolution bottom albedo images and benthic habitat classification to develop baseline management tools in Natural Reserves

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Outline

- Introduction
  - Remote Sensing
  - Study Area
  - Challenges
  - Sensors (Active/Passive)
1. High Resolution Bottom Albedo and Water Optical Characterization of La Parguera Reserve from Active and Passive
2. Benthic Habitat Map of La Parguera Reserve using Passive and Active Remote Sensing

- Conclusions

Introduction

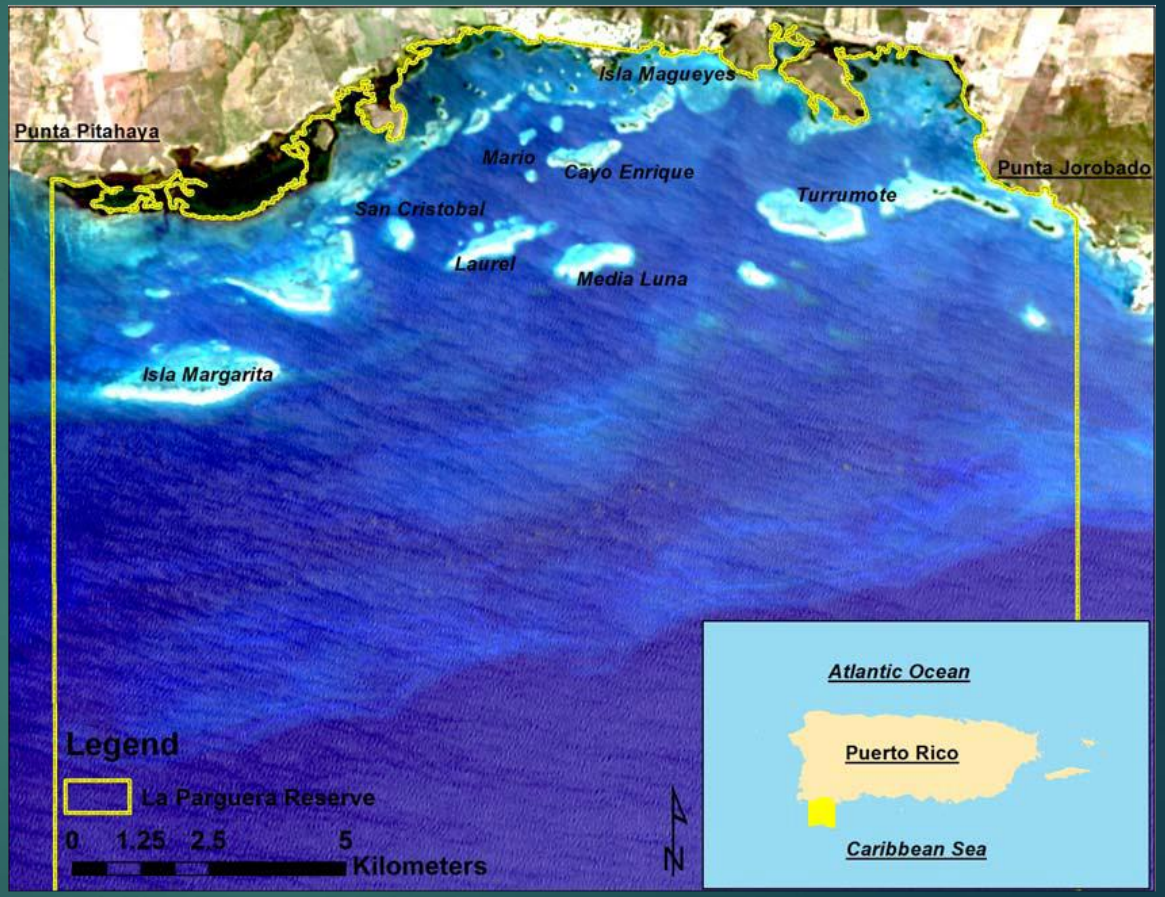
Coastal areas

- Important resources for NOAA mission
  - Healthy and resilient ecosystems resources and communities.
- Ecosystems affected by human-based and natural factors.
- However, little is known about benthic habitats and water properties.

http://gers.uprm.edu/images/bahia.jpg

Study Area

- La Parguera
  - DNR Natural Reserve
  - Aprox. 12,500 acres
  - Unique habitats
  - ~ Depth 18 meters
  - Variable substrate
- Use of Remote Sensing Techniques



Sensors

- AVIRIS (Airborne Visible Infrared Imaging Spectrometer)
- December 2005
- 224 Bands (370-2500 nm)
- Hyperspectral
- Visible range: 400-700 nm

  (32 bands)
- 10 nm bandwidth
- High signal to noise ratio (~1,000:1)
- Spatial resolution: ~3m

AVIRIS mosaic

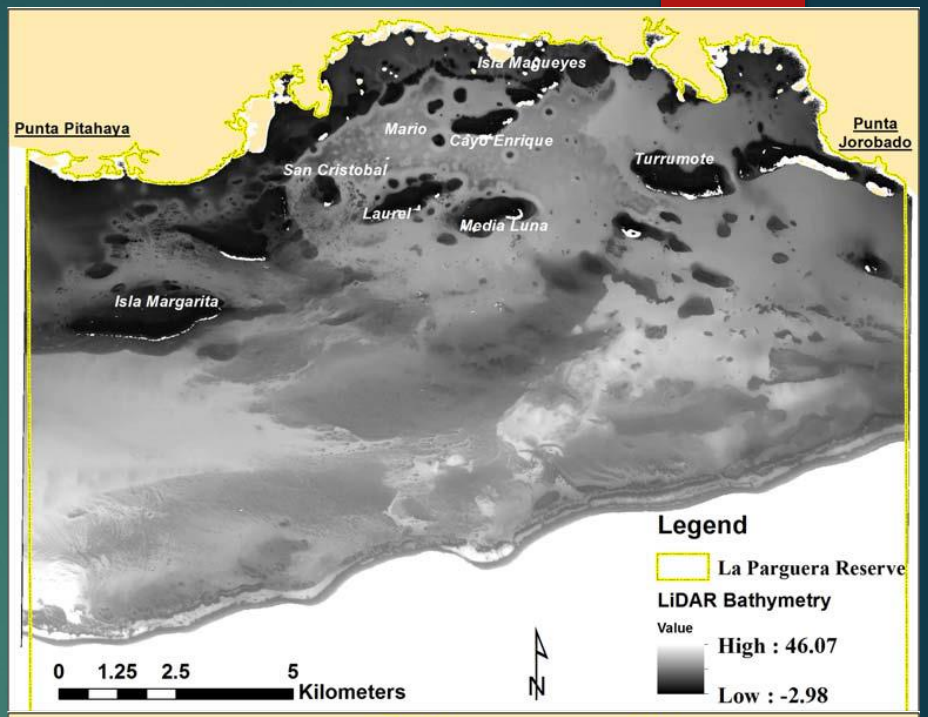
Sensors

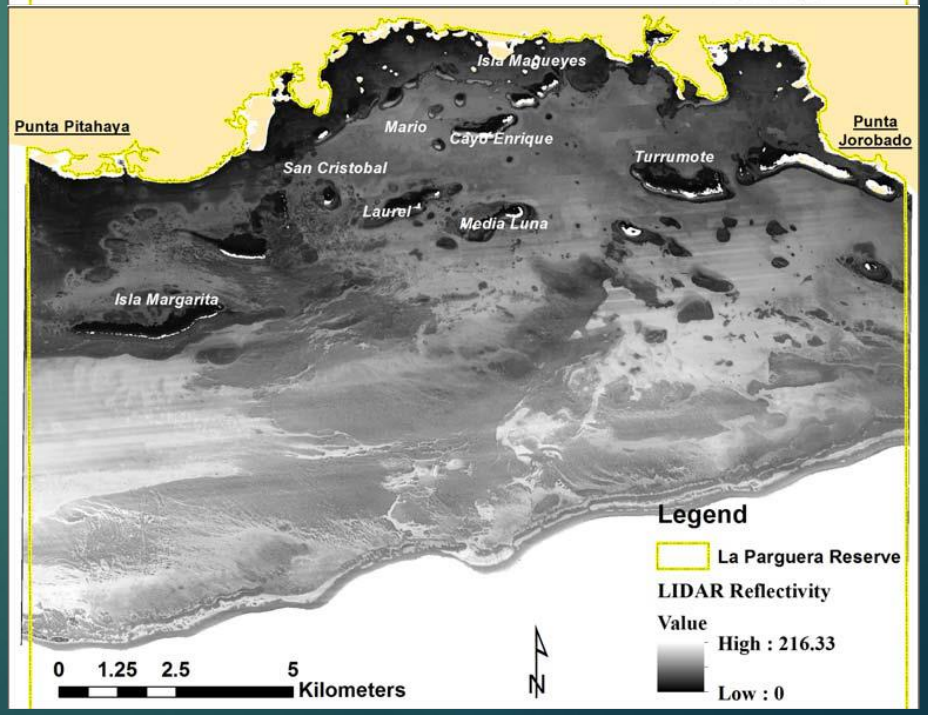
- Worldview 2 (WV2)
- December 2011
- 8 bands, 5 visible
- Multispectral
- ~2 m spatial resolution
- "Coastal band" (425nm)

WV2 Imagery

Sensors

- LiDAR SHOALS
  - 2006
  - (LADS) Mk II Airborne System.
  - Infrared beam (1064 nm)
  - Green beam(532nm)
  - 4 x4 meters bathymetry surface
  - 5x5 meters intensity surface

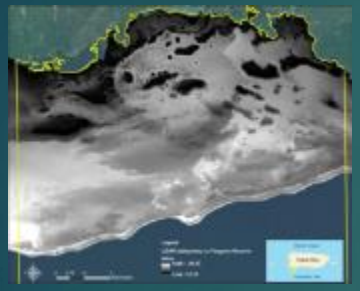




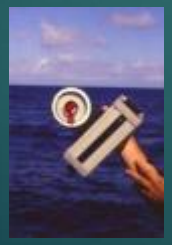
METHODS

AVIRIS image

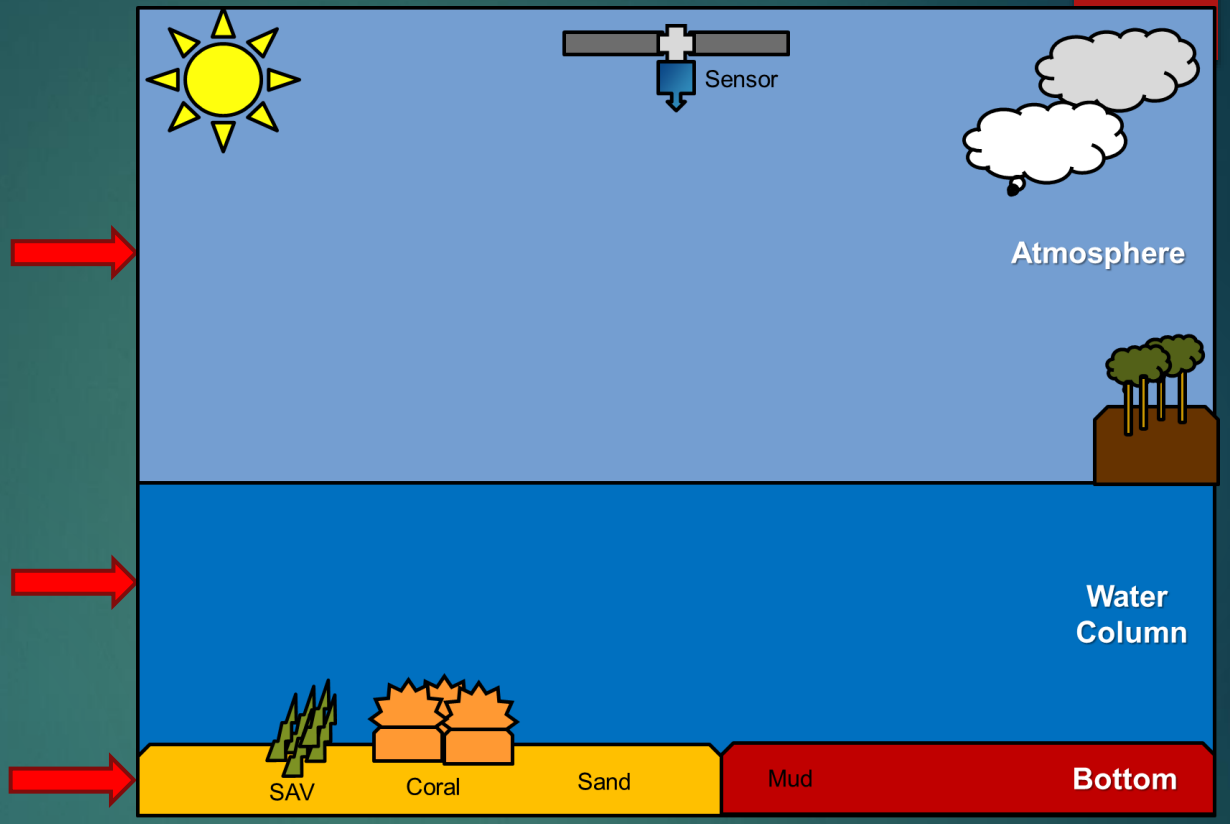
WV2 image



LiDAR SHOALS



Bio-optical sampling



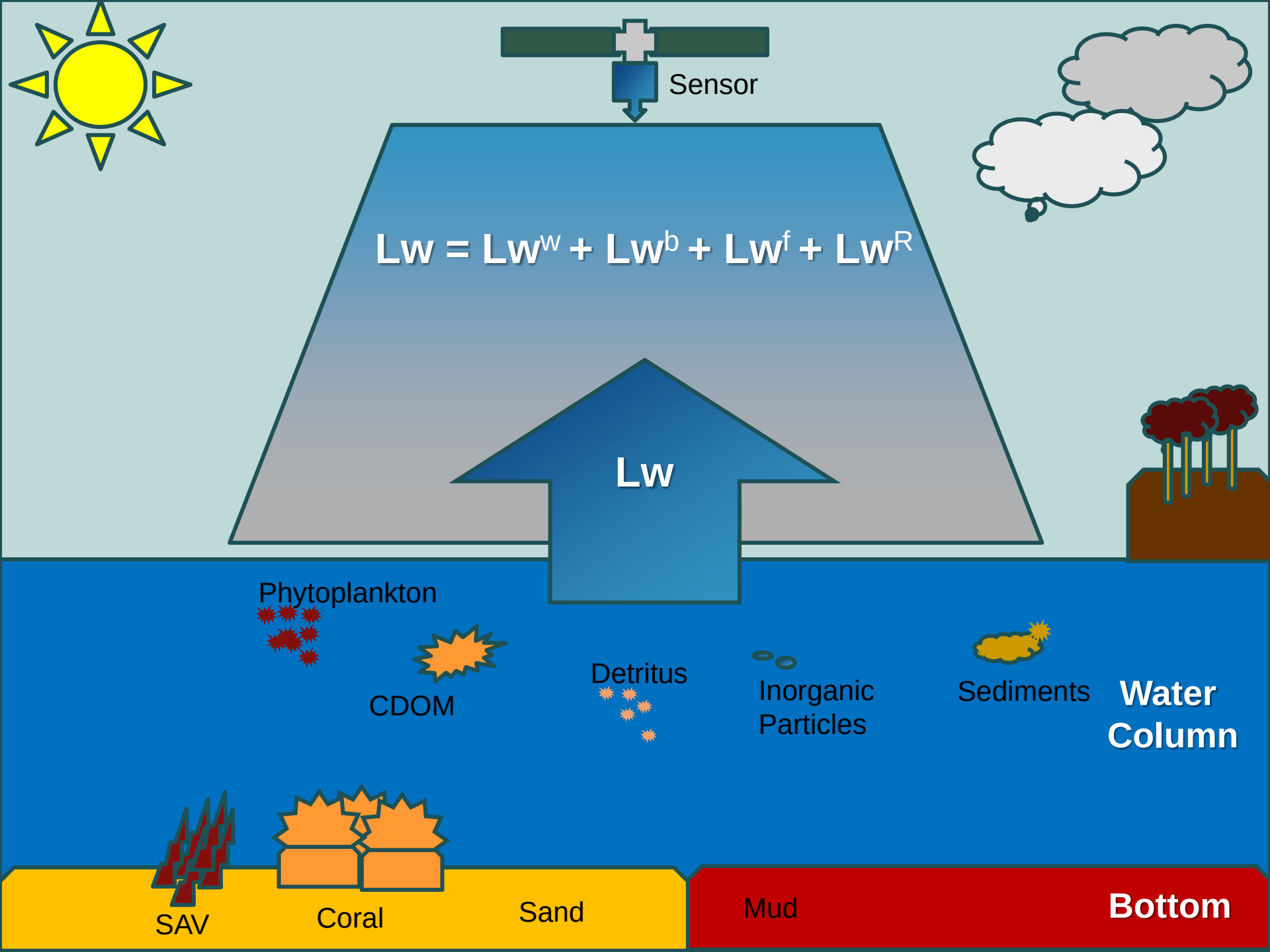
Pre-processing Steps (co-registration, landmask)

- High Resolution Bottom Albedo and Water Optical Characterization of La Parguera Reserve from Active and Passive Sensors
- Benthic Habitat Map of La Parguera Reserve using Passive and Active Remote Sensing

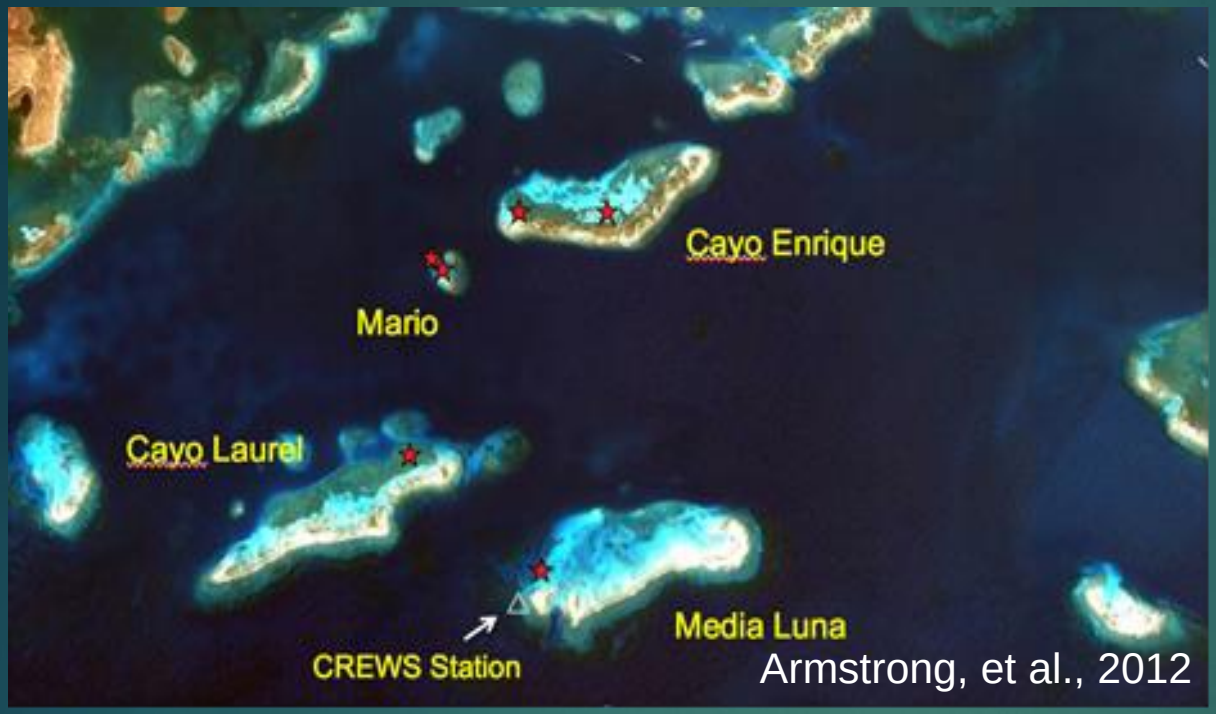
High Resolution Bottom Albedo and Water Optical Characterization of La Parguera Reserve from Active and Passive Sensors

Objectives

- Characterization of optical properties of La Parguera Reserve.
  - Inherent Optical Properties (IOP)
  - Apparent Optical Properties (AOP)
- Image derived IOP's/AOP's from both multispectral (WV2) and hyperspectral (AVIRIS) sensors.
  - Validate image derived with *in situ* values.
- Water column correction of imagery from IOP/AOP .
  - Lee's inversion model- QAA (Lee et al., 1999, 2001).
- Bottom albedo images from AVIRIS and WV2.


Sensor
$Lw = Lw^w + Lw^b + Lw^f + Lw^R$
Lw
Phytoplankton
CDOM
Detritus
Inorganic Particles
Sediments
Water Column
SAV
Coral
Sand
Mud
Bottom

Bio-Optical Sampling Monthly Campaign (May-2007--September-2009)



Armstrong, et al., 2012

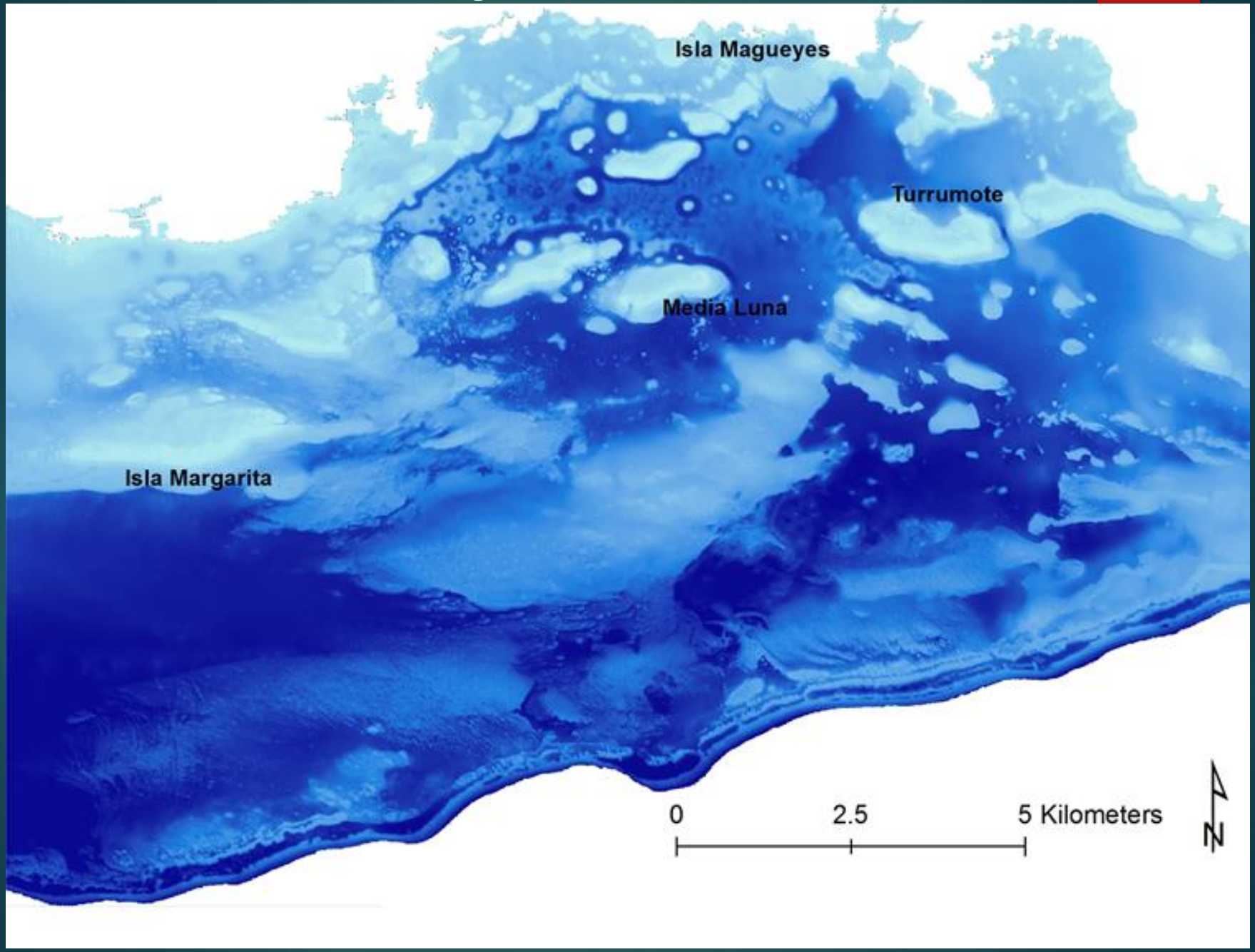

Bio-optical sampling

Measurements

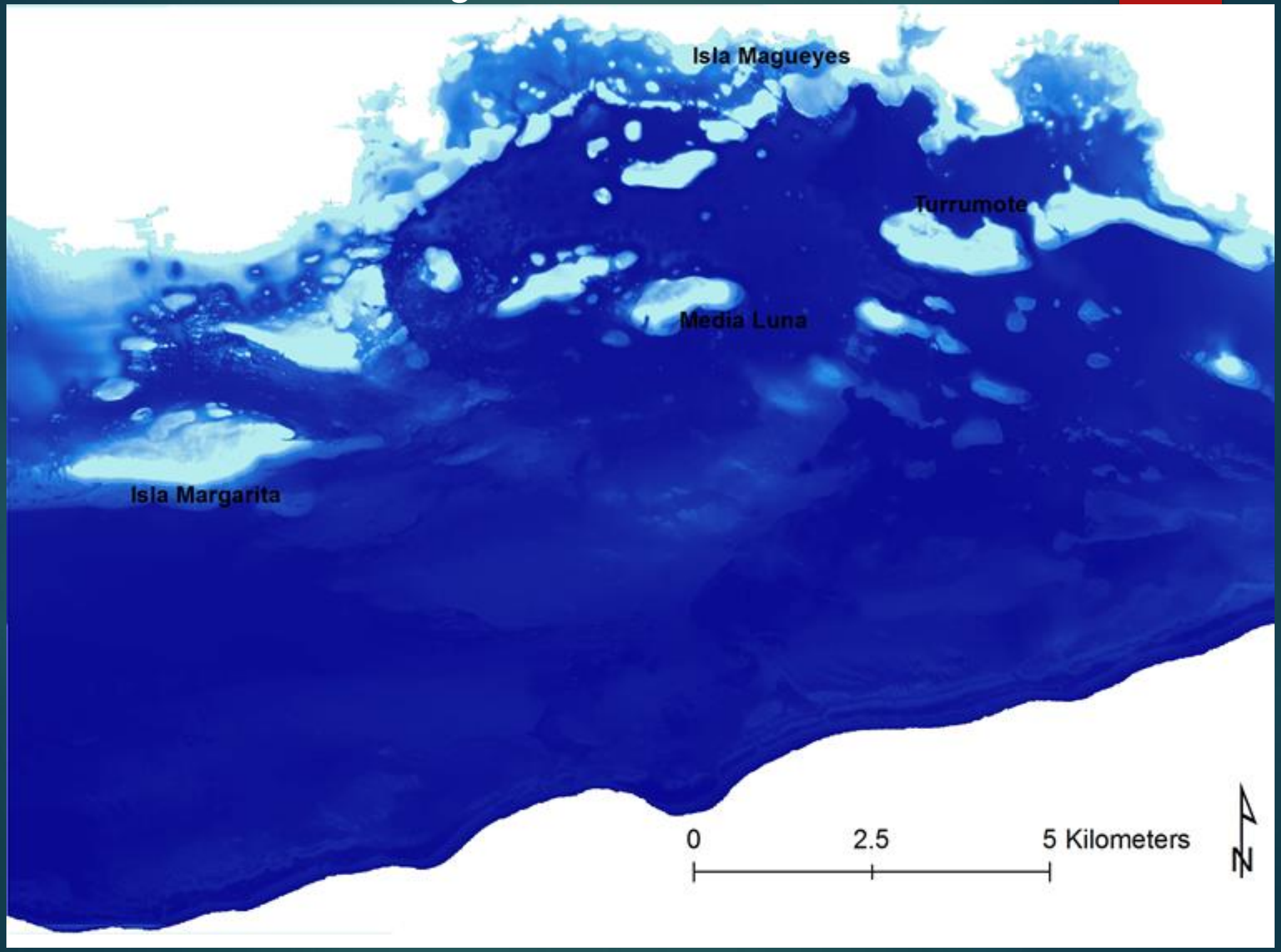
- Absorption (AC-9)
- Attenuation (AC-9)
- Backscattering (AC-9)
- CTD (Seabird)
- Rrs (GER-1500)

Station	Reef	Bottom Type	Depth (m)
1	Media Luna	Sand/Coral	3.0
2	Laurel	Seagrass	2.0
3	Mario Shallow	Sand/Coral	4.5
4	Mario Deep	Mud	18.0
5	Enrique West	Seagrass	2.0
6	Enrique East	Sand	1.5

AVIRIS Bottom Albedo Image

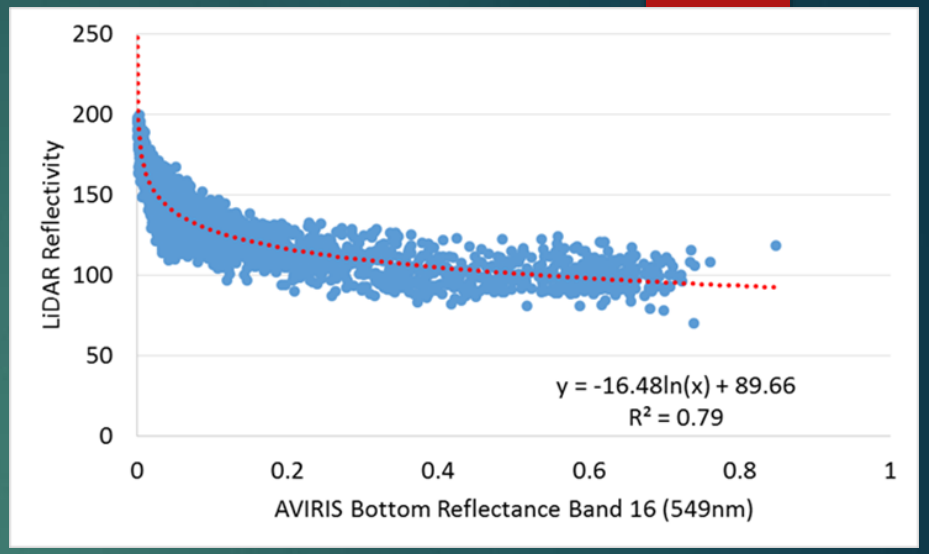


WV2 Bottom Albedo Image

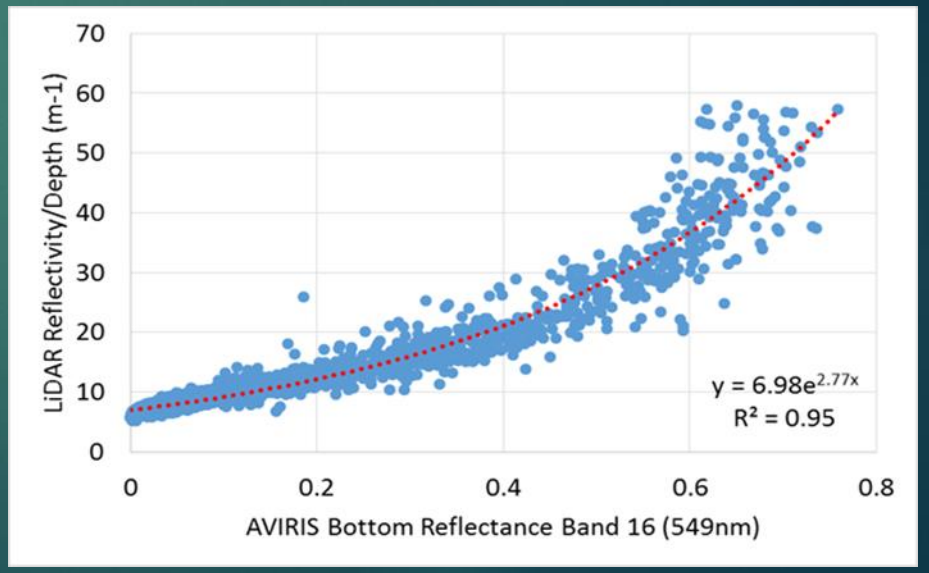


Bottom Albedo vs Lidar Reflectivity

- Correlation LiDAR reflectivity vs Bottom Albedo bands (*AVIRIS-band 16, 549nm and WV2-band 3, 545nm)*.
- LiDAR intensity surface was highly correlated with the LiDAR bathymetric surface.
- De-correlated the depth influence of LiDAR targets.
- Improvement
  - $r^2 = 0.79$ to and $r^2 = 0.95$



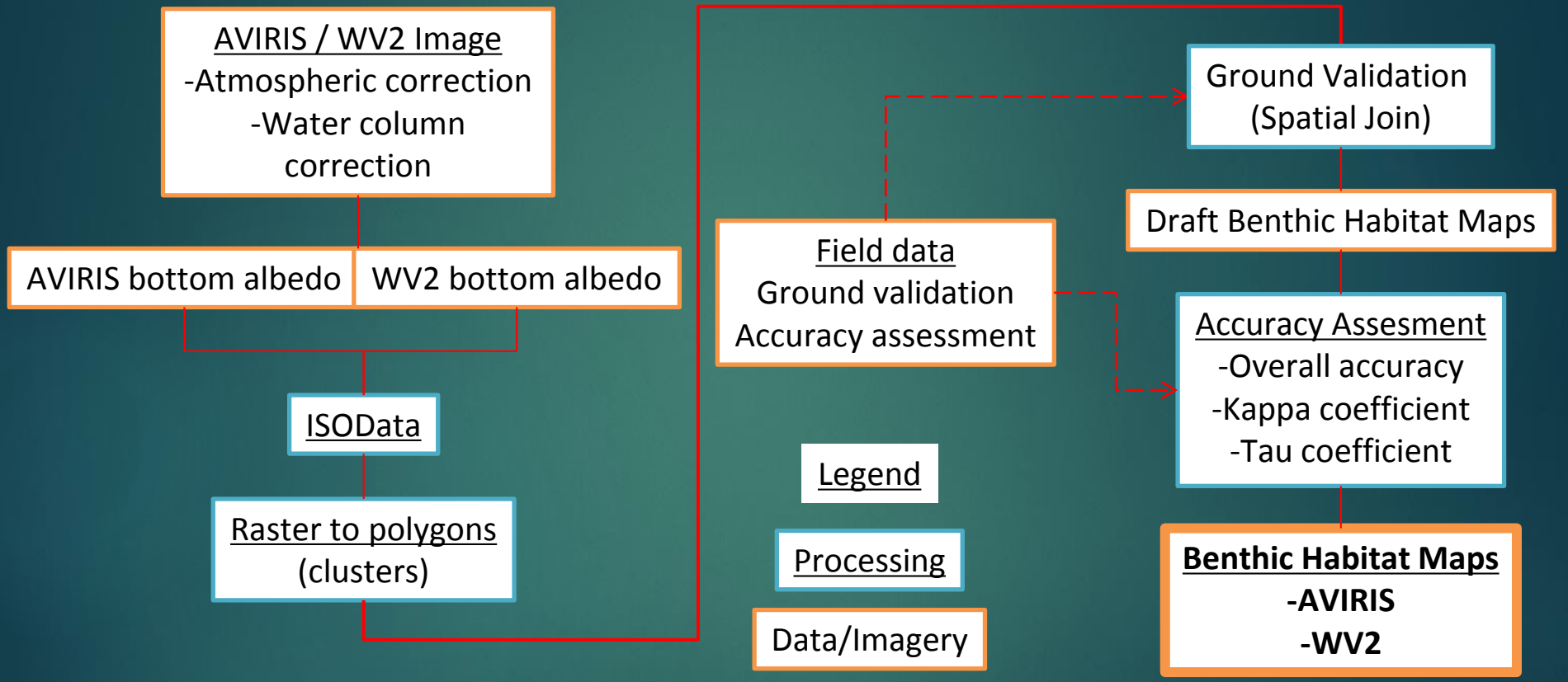
After Decorrelation of Depth



Benthic Habitat Mapping

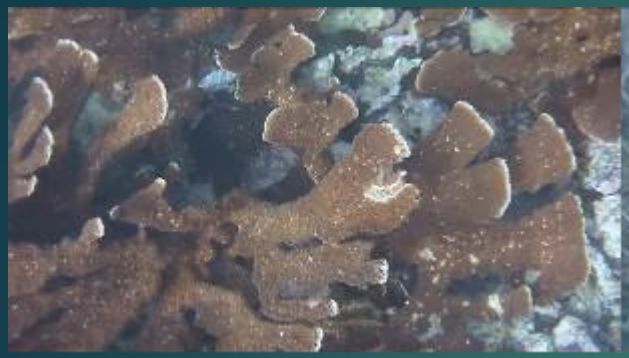
- Goals
  - Develop a high-resolution benthic habitat map
    - AVIRIS and WV2 modeled bottom albedo
  - Identify ecologically important habitats in La Parguera for scientific and management purposes.
  - Improve the methods for developing objective-based classifications from high-resolution satellite imagery.

Methods


AVIRIS / WV2 Image
-Atmospheric correction
-Water column correction
AVIRIS bottom albedo
WV2 bottom albedo
ISOData
Raster to polygons (clusters)
Field data
Ground validation
Accuracy assessment
Ground Validation (Spatial Join)
Draft Benthic Habitat Maps
Accuracy Assesment
-Overall accuracy
-Kappa coefficient
-Tau coefficient
Benthic Habitat Maps
-AVIRIS
-WV2
Legend
Processing
Data/Imagery

Benthic habitat classification scheme

(1) Coral Reefs



(2) Seagrass

(3) Hardbottom

(4) Mix: Sand/ Hardbottom/Coral

(5) Mud

(6) Sand

(7) Sand with Benthic Algae

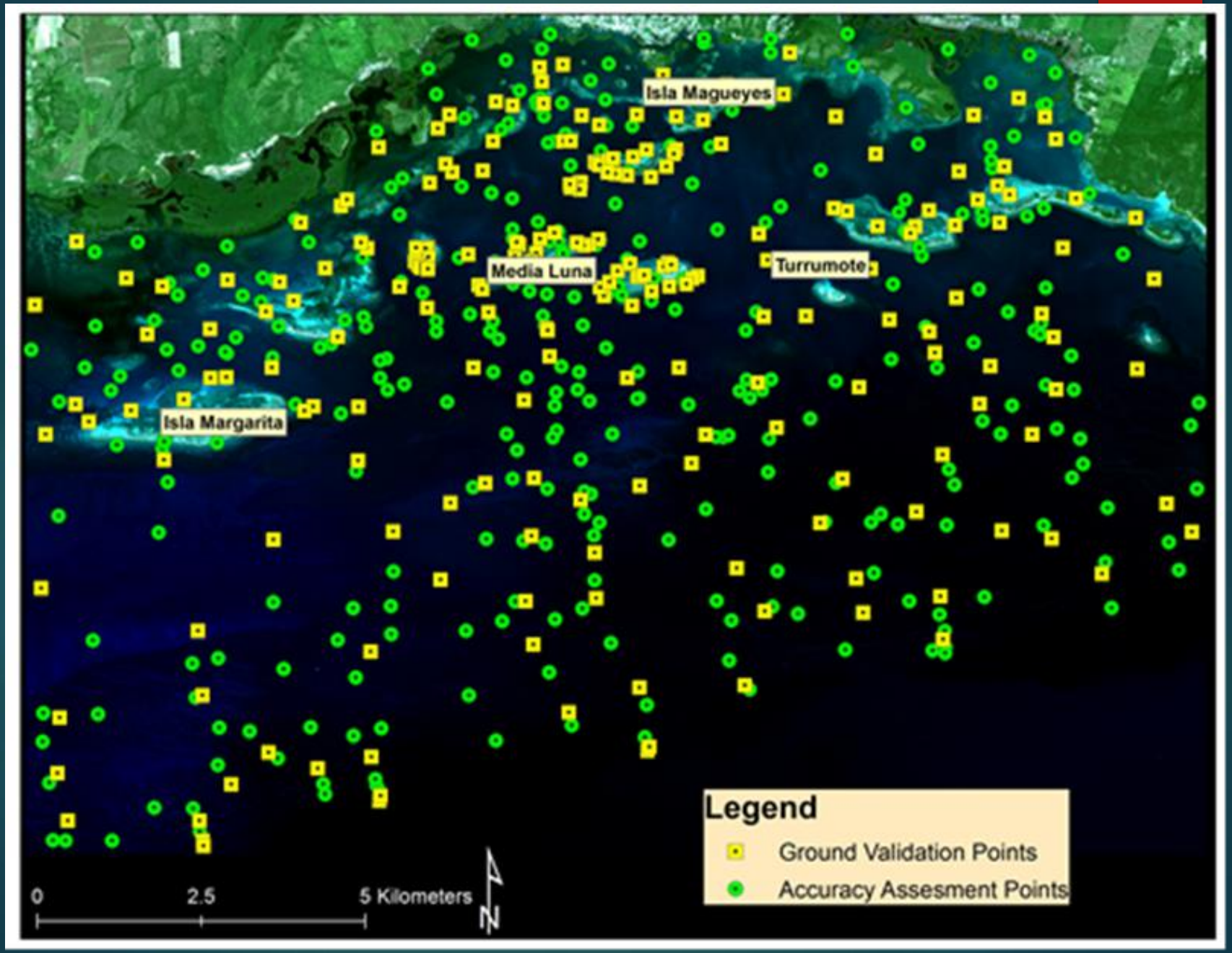
Sampling Sites

- Delta Vision Pro
  - Drop Camera HD Video (1080p)
  - 10-second video collected
  - DVR

- Trimble Juno GPS
  - 10-second averaging
  - dGPS
  - 2 meters

- Synchronized GPS and video

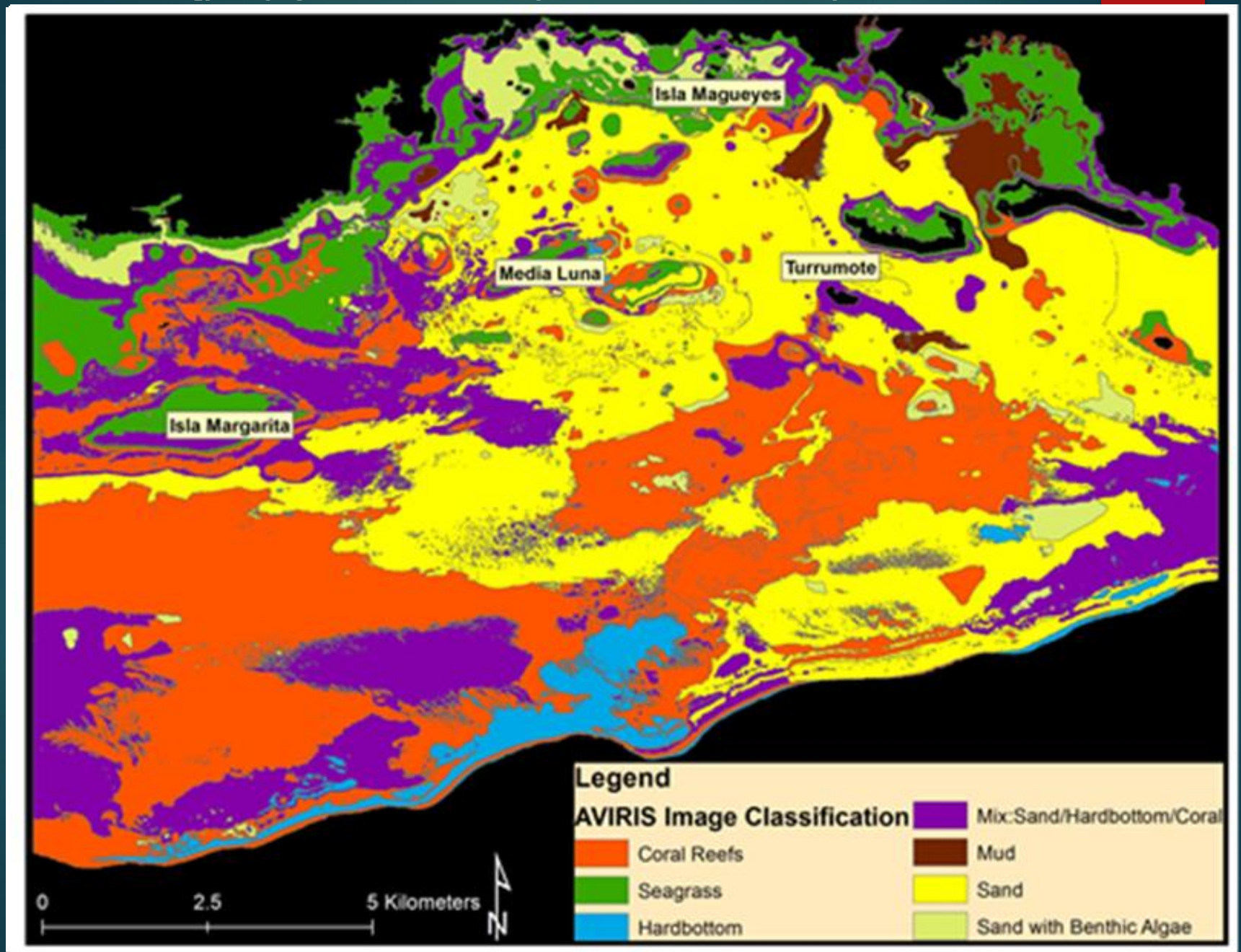
Ground Validation and Accuracy Assessment Points



Classification

- Clusters obtained from ISODATA classification
  - 150 clusters with 5 iterations
  - Identified multiple class / benthic habitat (confused pixels)
- Converted to polygons in ESRI ArcMap 10.3.
- Spatial Join Tool
  - Polygons assigned to a class based on ground validation.
  - Joining based on spatial location.
  - Attribute of the nearest point is collected and a distance value is recorded.
  - Dissolve Tool from ESRI ArcMap 10.3.

AVIRIS (after water column correction)



Findings

- Confusion matrix (Jensen, 1996)
- Overall Accuracy
  - AVIRIS classification = 63.55%
  - WV2 classification = 64.81%.
  - Our study area
    - ~168 Km^2
    - depth range from 0-41 meters (average depth = ~18 meters).
- Kappa coefficient
  - AVIRIS (55%) and WV2 (57%). "Moderate" classification (Landis and Koch 1977)
- Tau coefficient
  - AVIRIS (59%) and WV2 (60%).

Findings

- Image acquisition dates.
  - Massive bleaching event occurred during the AVIRIS image acquisition followed by a coral reef mass-mortality (Eakin et al. 2010).
  - Detrimental to *Montastraea (Orbicella) annularis* complex resulting in mortalities in the order of 50% (Garcia-Sais et al. 2008).
  - These factors may explain the difference in the total area covered of the coral reef class between the AVIRIS image (50.32 km^2) and the WV2 (22.89 Km^2).

Conclusions and Remarks

- From top-of-atmosphere (TOA) to bottom albedo.
  - Atmospheric and water column corrections improve benthic habitat mapping.
- Benthic habitat maps developed from bottom albedo images of both AVIRIS and WV2 sensors.
- Change detection
  - Reduction in the coral reefs class total
- Development of benthic habitat mapping tools for La Parguera Reserve.

Web Mapping Application

Acknowledgements

- NOAA Cooperative Remote Sensing Science and Technology Center (CREST) program under grant number NA11SEC4810004.
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- Dr. Liane Guild (NASA) for AVIRIS imagery
- Digital Globe® for the WV2 imagery.

QUESTIONS?

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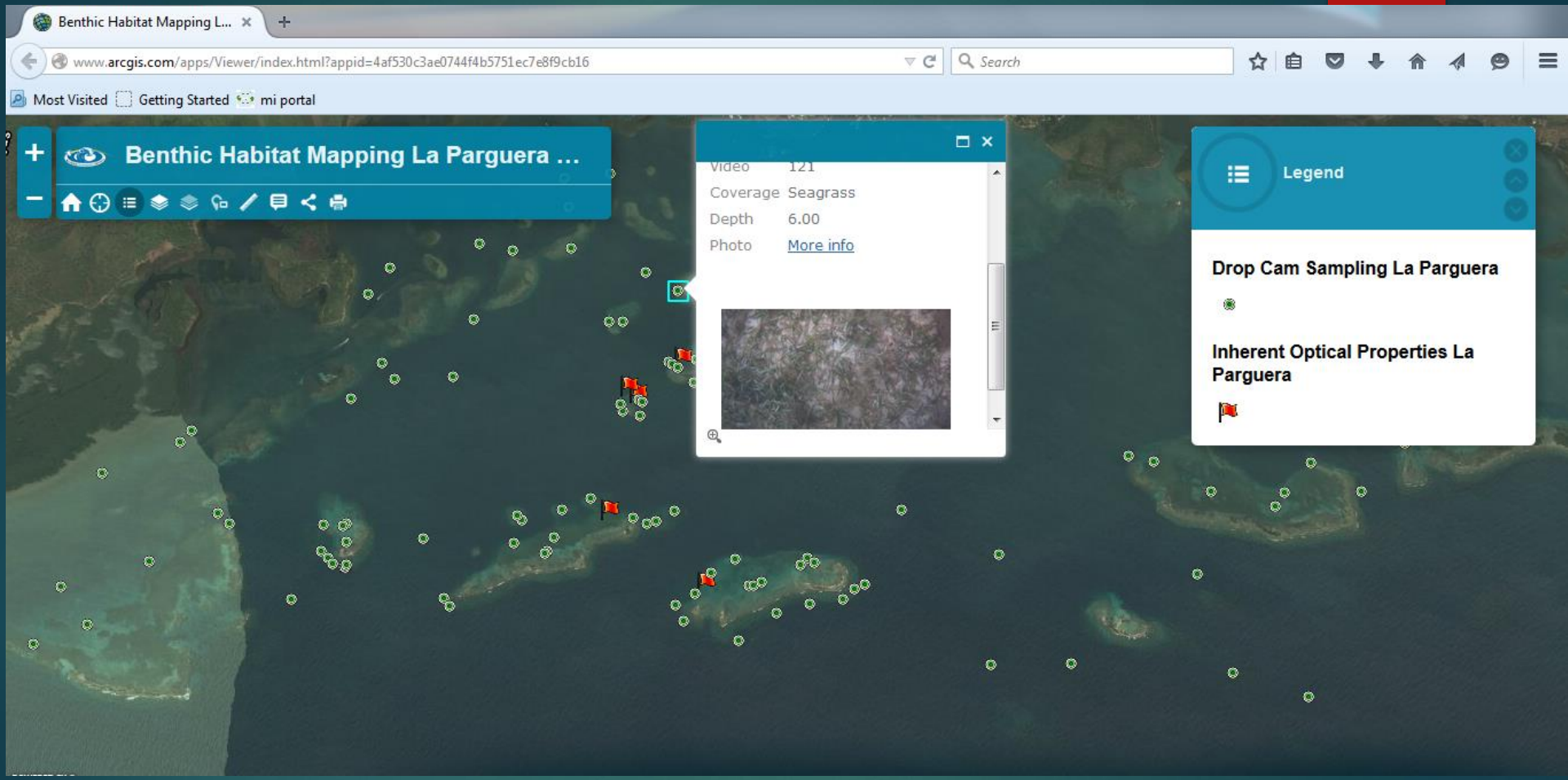
BACK UP SLIDES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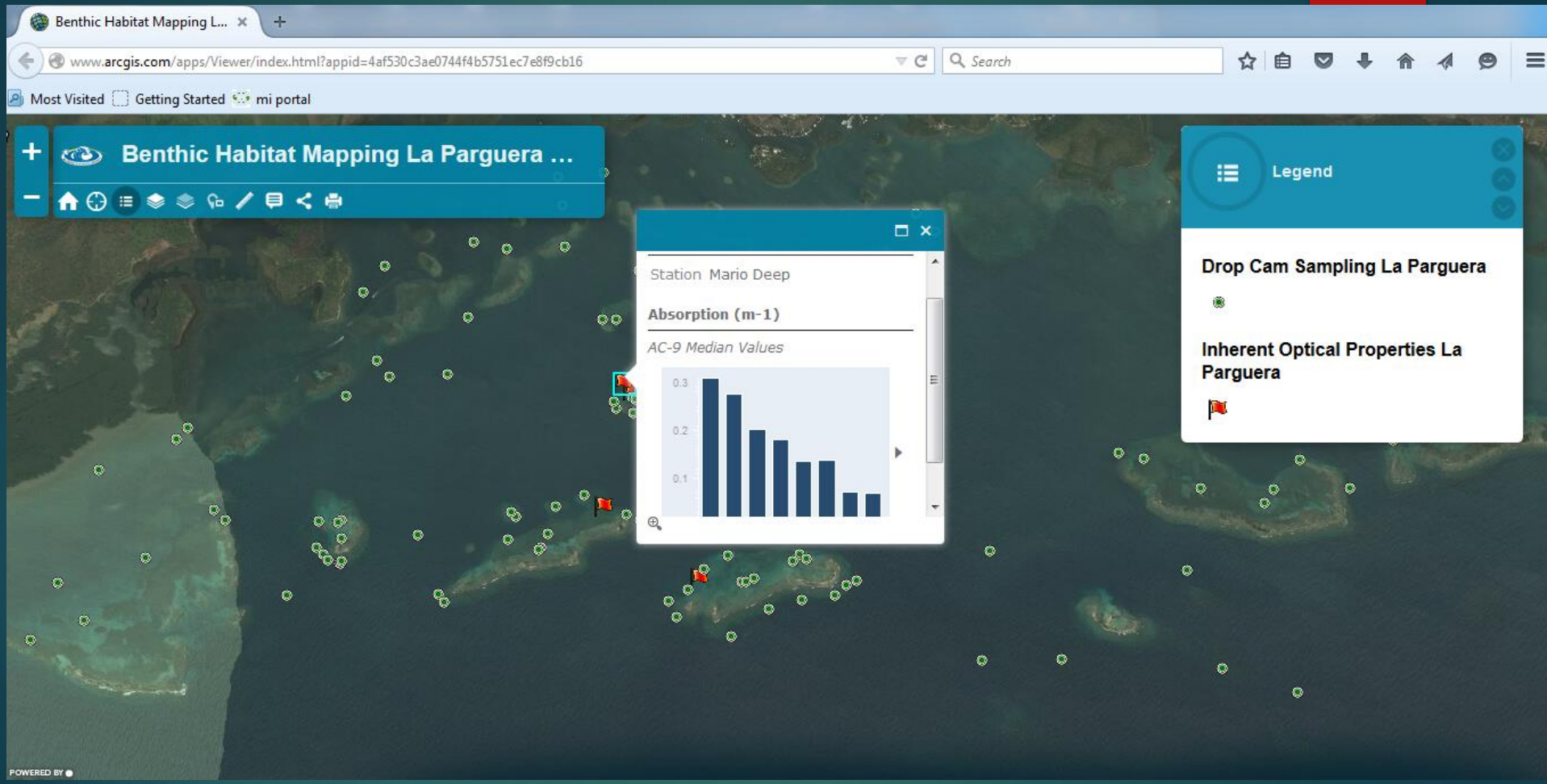
Coverage Seagrass
Depth 6.00
Photo More info
Legend
Drop Cam Sampling La Parguera
Inherent Optical Properties La Parguera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Station Mario Deep
Absorption (m-1)
AC-9 Median Values
0.3
0.2
0.1
Legend
Drop Cam Sampling La Parguera
Inherent Optical Properties La Parguera
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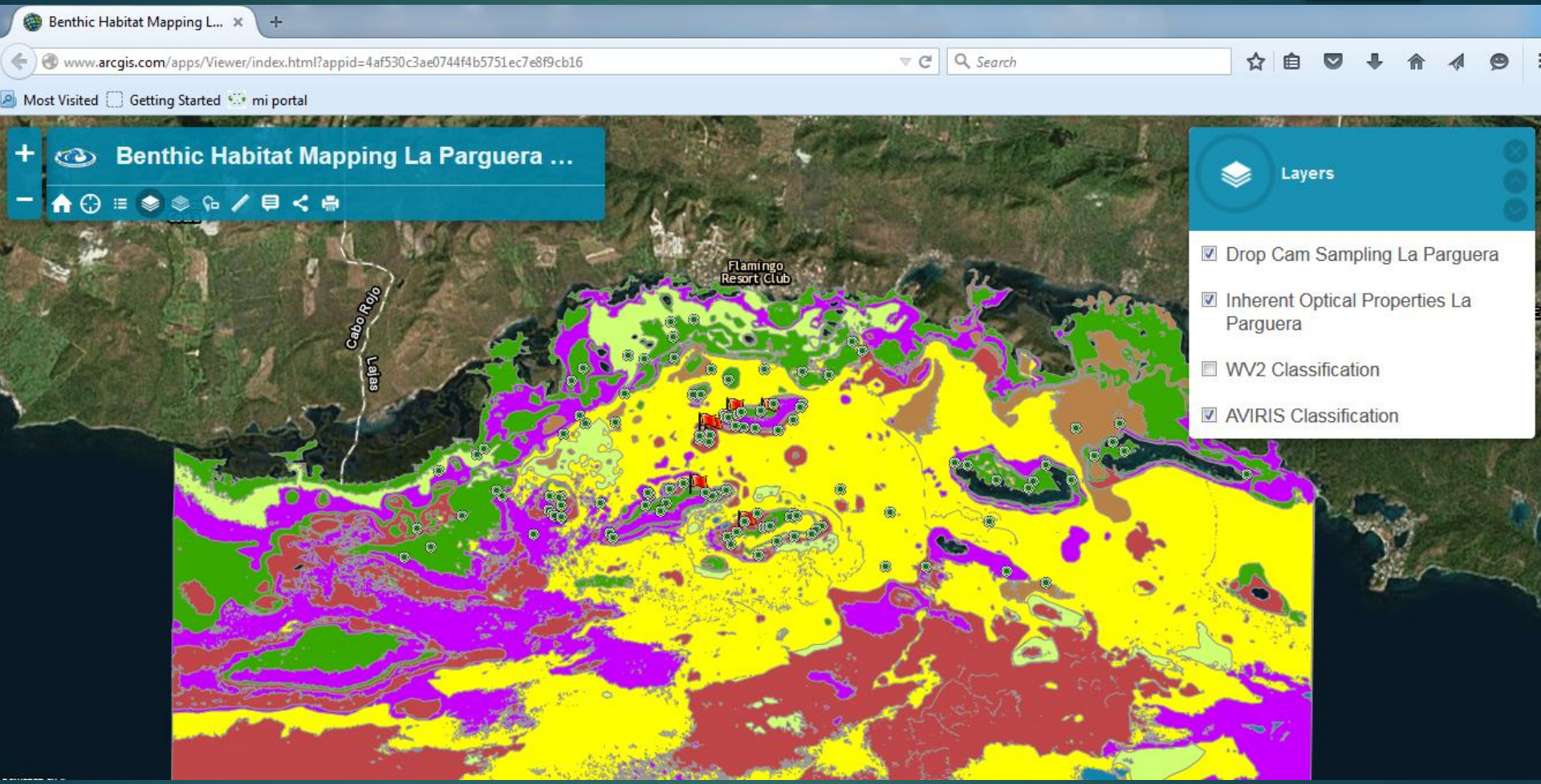
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