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.
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
Sensors

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

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

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.
\[ L_w = L_w^w + L_w^b + L_w^f + L_w^R \]

Armstrong, et al., 2012

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

### Station Details

<table>
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<tr>
<th>Station</th>
<th>Reef</th>
<th>Bottom Type</th>
<th>Depth (m)</th>
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<td>Media Luna</td>
<td>Sand/Coral</td>
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<td>Seagrass</td>
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<td>Mario Deep</td>
<td>Mud</td>
<td>18.0</td>
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<td>5</td>
<td>Enrique West</td>
<td>Seagrass</td>
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<tr>
<td>6</td>
<td>Enrique East</td>
<td>Sand</td>
<td>1.5</td>
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</tbody>
</table>
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 $r^2 = 0.95$
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

Legend
Processing
Data/Imagery

Draft Benthic Habitat Maps

Accuracy Assessment
- Overall accuracy
- Kappa coefficient
- Tau coefficient

Ground Validation (Spatial Join)

AVIRIS / WV2 Image
- AVIRIS
- WV2

Benthic Habitat Maps
- AVIRIS
- WV2
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.
Findings

- Confusion matrix (Jensen, 1996)

- Overall Accuracy
  - AVIRIS classification = 63.55%
  - WV2 classification = 64.81%.

- Our study area
  - ~168 Km²

- 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.
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- Digital Globe® for the WV2 imagery.

QUESTIONS?

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BACK UP SLIDES