Benthic Ecology from Space

Seagrass Production across the Bahamas Banks from MODIS

Heidi M. Dierssen[1] and Richard C. Zimmerman[2,]

[1]University of Connecticut, Department of Marine Science, Groton, CT, Email: heidi.dierssen@uconn.edu

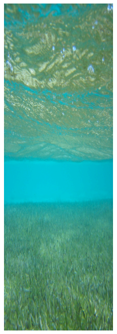
[2]Old Dominion University, Department Ocean Earth, Atmospheric Science, Norfolk, VA

Abstract

Seagrasses play a significant role in the biogeochemistry of the coastal and global oceans, but their global distributions remain elusive. We have previously developed algorithms to utilize high spatial and spectral resolution remote sensing imagery obtained from an aircraft to estimate seagrass leaf area index in a small region of the Bahamas Banks. Here, we modify and apply these techniques to coarser multi-channel SeaWiFS and MODIS imagery to quantitatively estimate seagrass distributions over the entire Bahamas Banks. Atmospheric correction of the Level 1A Local Area Coverage (LAC) data was obtained using a fixed aerosol model over the entire scene. Our preliminary results reveal that seagrass ecosystems integrated over the whole Bahamas Banks were responsible for 7.6 x 10^{13} g C y^{-1} or 0.2% of the total ocean productivity. Per area, the Bahamas Banks is many times more productive than the world's oceans and an important system for long-term carbon storage. To our knowledge, these are the first quantitative measures of seagrass primary production over an entire basin using remotely sensed data.

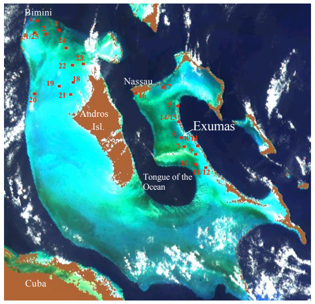
Funding for this project was provided by NASA (hmd) and NSF (rcz, db).

Field Validation



- R/V *Walton Smith*, March 2004
- Optical Data
  - *ac*-9, Eco-VSF, ctd
  - Hyperspectral TSRB
  - ASD spectrometer
- Bottom reflectance (ASD)
  - Sand
  - Seagrass leaves
  - Other red/brown algae
- Seagrass
- Leaf Area Index
  - Rhizome/shoot and dry weight
  - Primary productivity
    - 2 week Leaf growth rates
      - (Sta. 3 and 4)
    - Oxygen evolution
  - Epiphyte productivity
- Pore water and sediment biogeochemistry

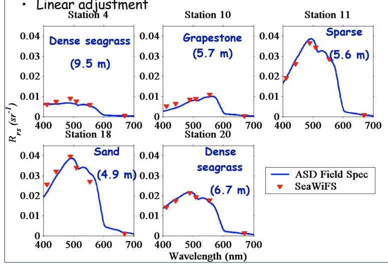
Bahamas Banks from Space



True-color SeaWiFS image of the Bahamas Banks from 6 March 2004. Locations of our sampling station are shown in red. Green regions indicate seagrass or algal sediment. Blue regions indicate sand.

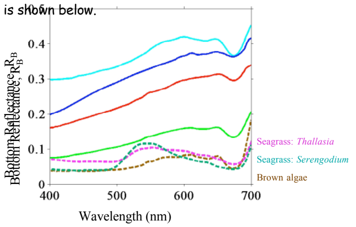
Atmospheric Correction

- Standard approach fails in optically shallow water
- Iterative scheme (SeaDAS Ver. 3)
  - Default multi-scattering model
  - Picked an aerosol optical depth and model representative of region
  - Reprocessed with fixed atmosphere
- Linear adjustment



Seafloor Reflectance

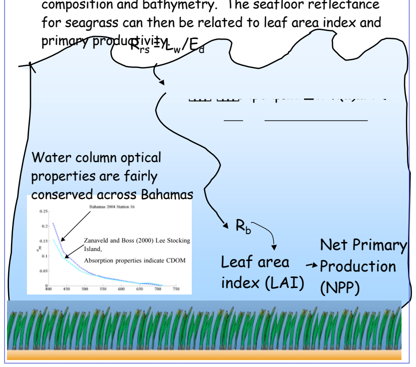
Sand across the Bahamas Banks has different reflective properties (Bottom Reflectance, R_B) due to the size of the sediment grains and the amount of algal material. In March 2004, we measured bottom reflectance over a wide geographic range of the Bahamas Banks. A summary plot is shown below.



- (cyan) The sediment to the west of Andros Island has the finest grain size and is a highly reflective white mud
- (blue) The sediment on the northern margins (Nassau and Bimini) contained more organic material and the second highest reflectance
- (red) The sediment along the Exumas is ooilitic in nature
- (green) Grapestone sediment which is very coarse and highly organic

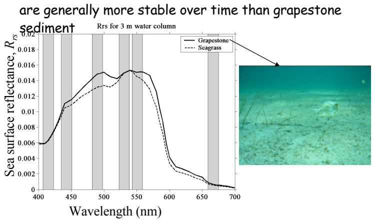
Water Column Modulation

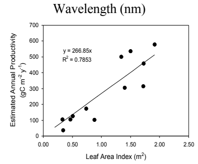
The water column scatters and absorbs light reflected off the seafloor. We use a radiative transfer model, *Hydrolight*, to simulate the light leaving the water surface (R_{rs}) of regions with different seafloor composition and bathymetry. The seafloor reflectance for seagrass can then be related to leaf area index and primary productivity.



Refining Algorithms

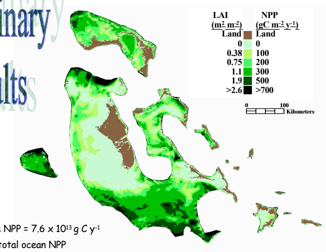
Grapestone sediment causes the water to appear green like seagrass blades. It will be a challenge to spectrally differentiate these "green" seafloors. Time series analysis may prove useful because seagrass beds are generally more stable over time than grapestone sediment





Modeling Seagrass Productivity from Leaf Area Index

Preliminary Results



Total System-wide NPP = 7.6 x 10^{13} g C y^{-1}

Represents 0.2% total ocean NPP

(48 x 10^{15} g C y^{-1})