Remote Sensing of Red tides and the Seafloor:

Heidi Dierssen,
University of Connecticut
Go Huskies!
• **HyspIRI**

  Will not be useful for routine monitoring of ocean plumes and blooms (19 day revisit)
  
  – Water residence time in Monterey Bay is \( \sim 3 \) days
  
  – Phytoplankton doubling time (1-8 doublings \( d^{-1} \))

• HyspIRI will be useful for process studies
Figure 2-32. Growth rate of several phytoplankton species under different temperatures. Adapted from Eppley (1972).
SeaWiFS Chlorophyll (mg m\(^{-3}\))

- a) September 19
- b) September 29
- c) October 1
- d) October 3
- e) October 5
- f) October 6–8

- San Francisco Bay
- Monterey Bay
- cloud
- red tide bloom
Imaging “Red Tides” in Monterey Bay

SeaWiFS

AVIRIS

1 km

10 m
19 hours later
Internal Waves cause convergence zones
Coastal Bloom Products

- High resolution snapshots of algal blooms show patches at 60 m resolution

- Useful for process studies to evaluate mechanisms of bloom formation

- Analyses not possible with 1 km
Benthic Questions

• How do benthic producers on large banks influence the carbon cycle and climate?
  – Net primary production
  – Carbonate dissolution
  – Heat budgets

• What are the ecological mechanisms for distributions and response to environmental forcing?
Methods – Wet Remote Sensing
Above-water measurements include glint

Below-water measurements require extrapolation to 0° and across air-water interface
Water column properties

- ac-9 package
- eco-VSF
- CTD
- fluorometers
  - (Chl, CDOM, phycoer.)
The Quest for Water
Leaving Radiance
"Hi! All you!!
We vote to bust!!
Sign our petition!

Please Help!
We are working on the Ronald H. Break

Affirmative plea
Old dense zombie
Initiate parliment

We be out of the city nice.
Set me at the bar."

Graduate students
• Seagrass counts
Grapestone sediment

Turtlegrass

Seagrass (Dense)
Seagrass (Moderate)
Seagrass (Sparse)
Brown macroalgae
Red macroalgae
Grapestone sediment
Mud sediment
Sponges
Deep water
Andros mud, 5.4 m
Organic sand, 5.2 m
Spare seagrass, 5.5 m
Grapestone light, 5.6 m
Dense Seagrass, 5.3 m
Red macroalgae, 5.6 m
Brown macroalgae, 5.3 m
Grapestone dark, 5.7 m
With depth, the spectrum changes from green-to blue-dominated.
Atmospheric Correction

**Figure B**: Graph showing the relationship between $R_{rs}$ (sr$^{-1}$) and Wavelength (nm) for SeaWiFS and FieldSpec data.

**Figure D**: Scatter plot of Measured NPP (g C m$^{-2}$ d$^{-1}$) vs. Modeled NPP (g C m$^{-2}$ d$^{-1}$) with a linear regression line. The correlation coefficient $r^2 = 0.64$ and p-value $< 0.01$.
Carbonate Sediment Geochemistry

- Turtlegrass oceanic sink for carbon
  - Shallow water “biological pump”
  - Decomposition in sediments
  - Carbonate sediment dissolution

Photosynthesis

0.7 CO₂ + 0.3 HCO₃⁻ → O₂ + Ca²⁺ + 2HCO₃⁻

DECOMPOSITION

Buryal

Ca/MgCO₃ DISSOLUTION
- $\sim 2 \times 10^{13} \text{ g C yr}^{-1}$
- 0.04% global NPP
- above- and below-ground carbon ($2.4 \times 10^{13} \text{ g C yr}^{-1}$)
- Carbonate dissolution
- 1% oceanic net CO2 uptake
Greater Florida Bay
Differentiating seagrass species

- Similar leaf reflectance
Measuring Seagrass Canopy Reflectance
Different canopy reflectance
Fate of the carbon

- Different seagrass species play different ecological roles
- Turtlegrass leaves decompose in the beds
Manateegrass

- Buoyant leaves, exported carbon
Fate of the carbon

• Different seagrass species play different ecological roles
Relevance to Hyspiri

• Spatial resolution -
  – 60 m will resolve many benthic features on large carbonate banks like Florida Bay and Bahamas

• Spectral resolution
  – Differentiate benthic producers
  – Differentiate seagrass species from canopy-level NIR effects
  – Potentially detect export flux
Implications

• Improved understanding of role of shallow banks and bays on carbon cycle and climate

• Improved understanding of ecology and environmental forcing
Potential export of unattached benthic macroalgae to the deep sea through wind-driven Langmuir circulation

H. M. Dierssen,¹  R. C. Zimmerman,²  L. A. Drake,²,³  and D. J. Burdige²
Langmuir “supercells” could be a mechanism

- Langmuir cells observed on the Banks
- Consistent with periodicity in optics
- Historic descriptions of “digits” and “roiling”
- Seasonality of whitings consistent with wind patterns
Carbon Export to Deep Sea

- Phytoplankton only considered in models
  - Carbon not consumed and respired back

- Negatively buoyant macroalgae sinks rapidly and could be a potential missing sink of export carbon

- Pulsed export $7 \times 10^{10}$ g carbon
  - Equivalent to daily export flux of phytoplankton in the tropical North Atlantic
Optics and remote sensing of Bahamian carbonate sediment whitings and potential relationship to wind-driven Langmuir circulation

H. M. Dierssen\textsuperscript{1}, R. C. Zimmerman\textsuperscript{2}, and D. J. Burdige\textsuperscript{2}

\textsuperscript{1}Department of Marine Sciences and Geography, Univ. of Connecticut, 1080 Shennecossett Road, Groton, CT 06340, USA
\textsuperscript{2}Department of Ocean, Earth & Atmospheric Sciences, Old Dominion Univ., 4600 Elkhorn Ave., Norfolk VA 23529, USA
Resuspended sediment can serve as a nucleus for carbonate precipitation and growth of sediment particles

$\sim 18 \text{ km}^2$
HyspIRI Benthic Products

• Products we may get
  – Mapping broad benthic types across Bahamas and similarly clear banks and bays
  – Seasonal shifts in motile benthic cover
  – Resuspended sediment on banks

• Potential Products
  – Leaf area index (LAI) $\text{m}^2 \text{m}^{-2}$
  – Net primary productivity $\text{g C m}^{-2} \text{d}^{-1}$
  – Rates of carbonate dissolution
  – Rates of carbonate precipitation (resuspended sediment)
  – Bottom albedo for heat budgets