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 ~3 days
  - Phytoplankton doubling time (1-8 doublings d^{-1})

- HyspIRI will be useful for process studies

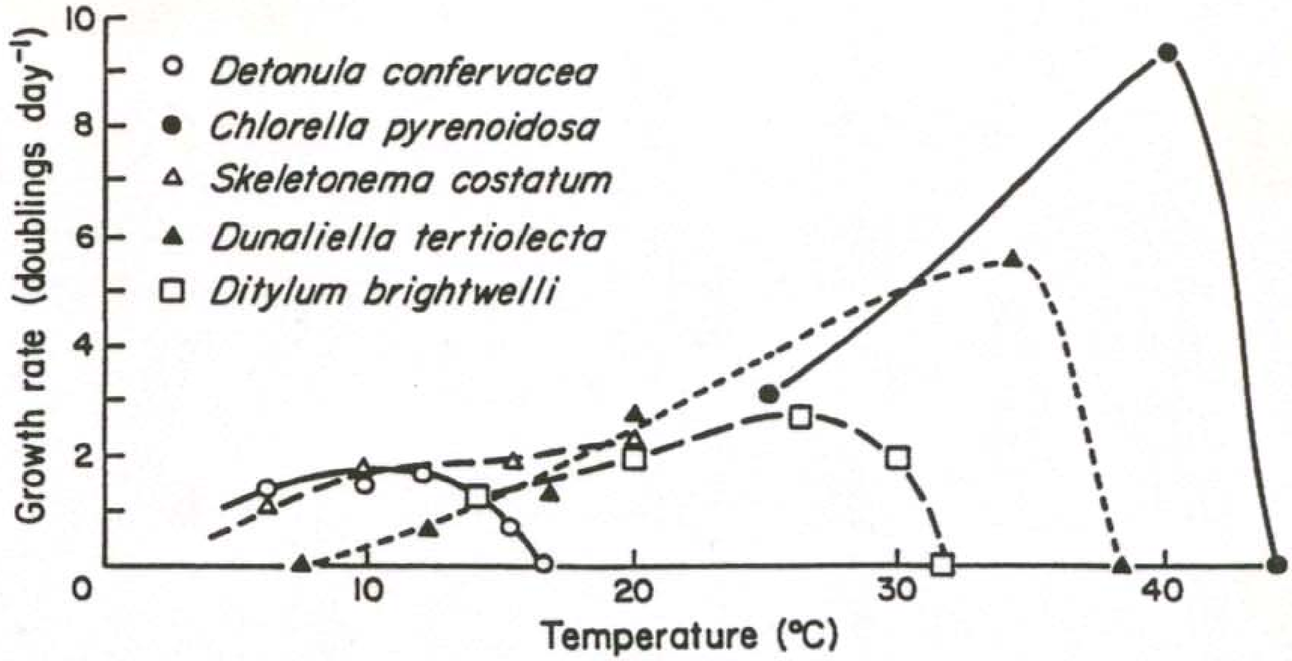
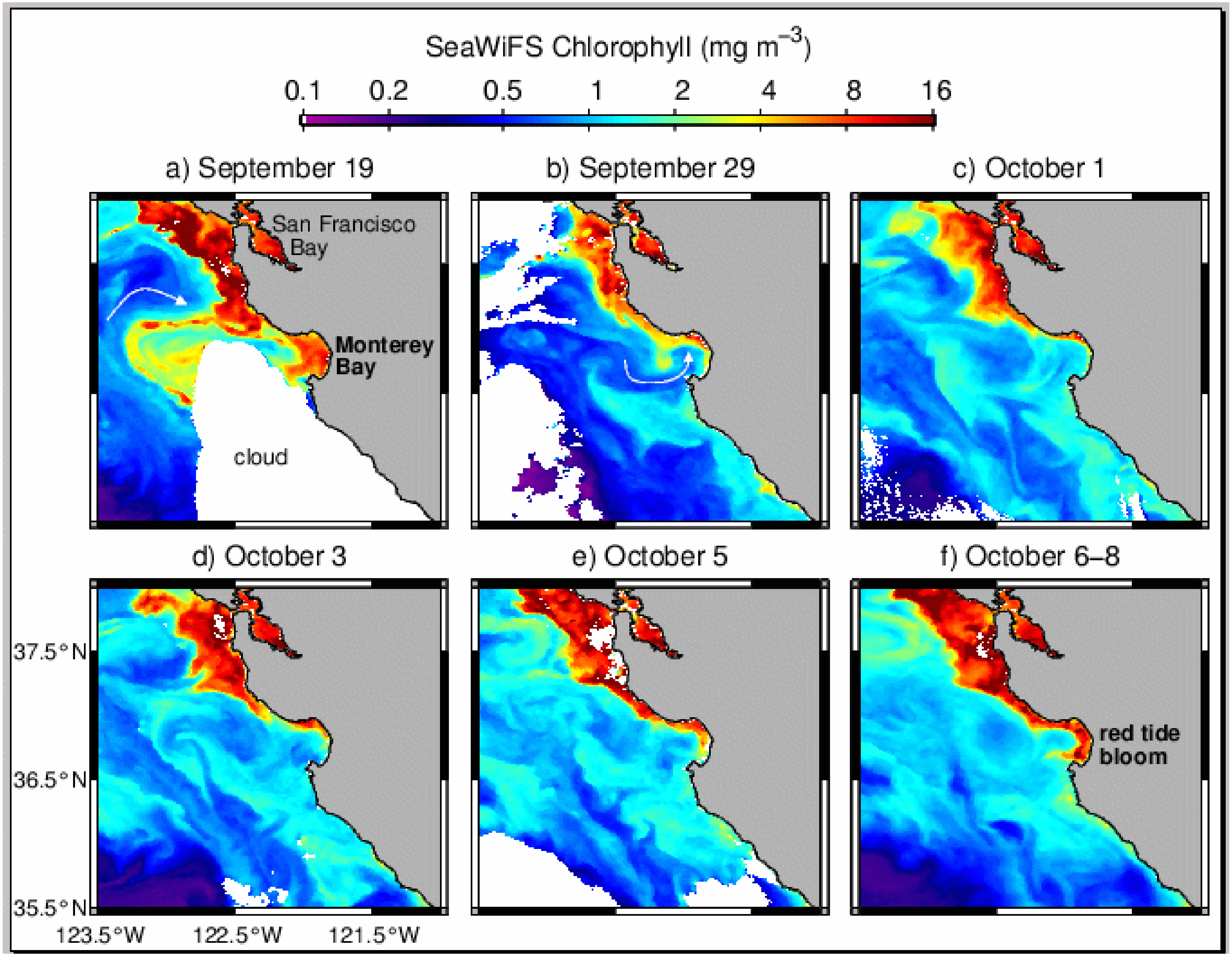
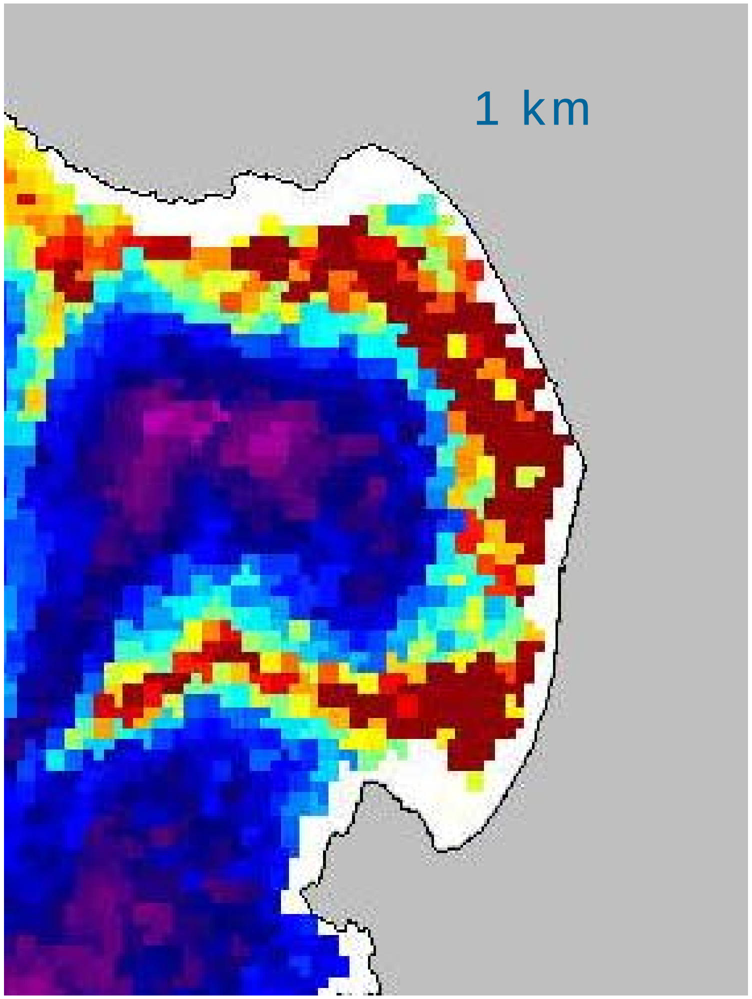


FIGURE 2-32. Growth rate of several phytoplankton species under differe temperatures. Adapted from Eppley (1972).

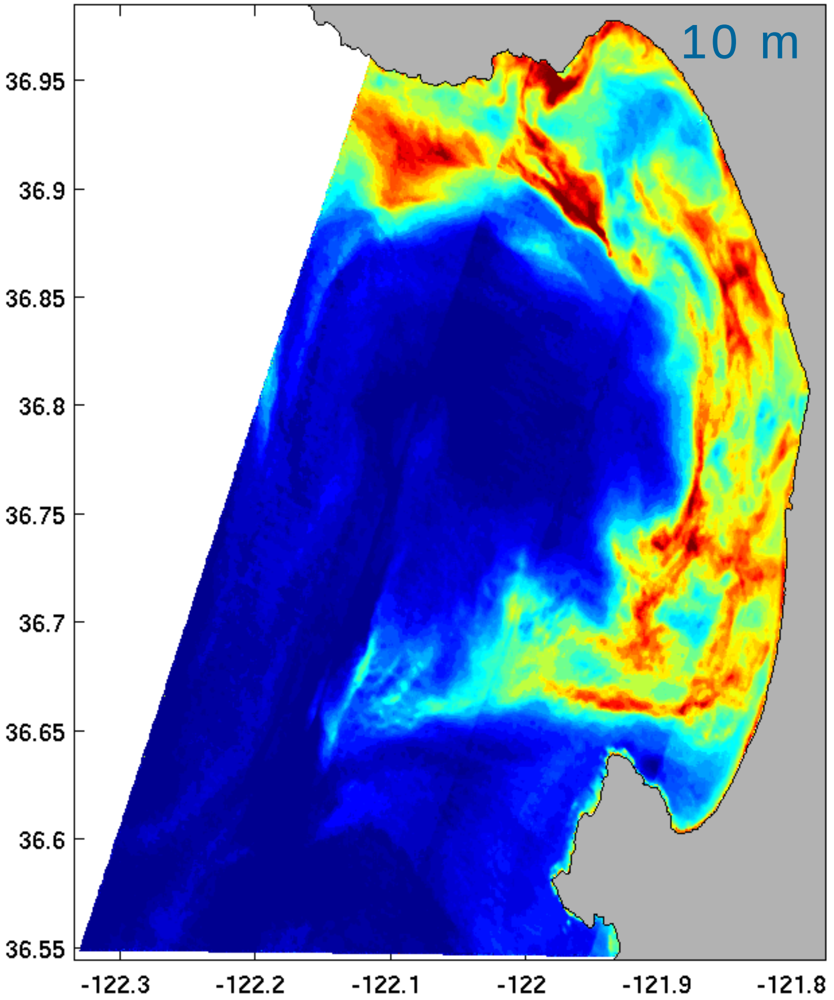

SeaWiFS Chlorophyll (mg m^{-3})
0.1
0.2
0.5
1
2
4
8
16
a) September 19
b) September 29
c) October 1
d) October 3
e) October 5
f) October 6–8
San Francisco Bay
Monterey Bay
cloud
red tide bloom
37.5°N
36.5°N
35.5°N
123.5°W
122.5°W
121.5°W

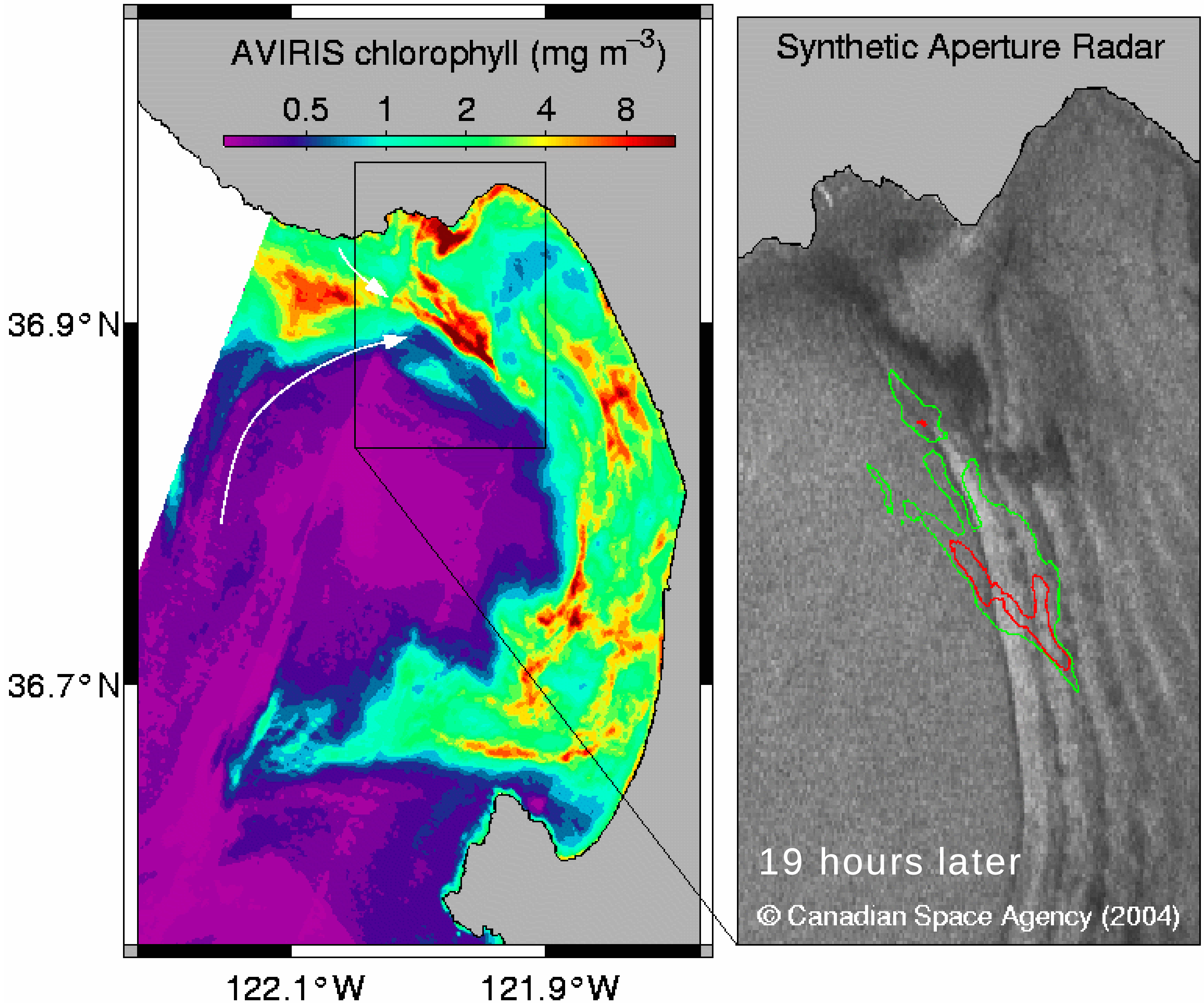
Imaging "Red Tides" in Monterey Bay

SeaWiFS



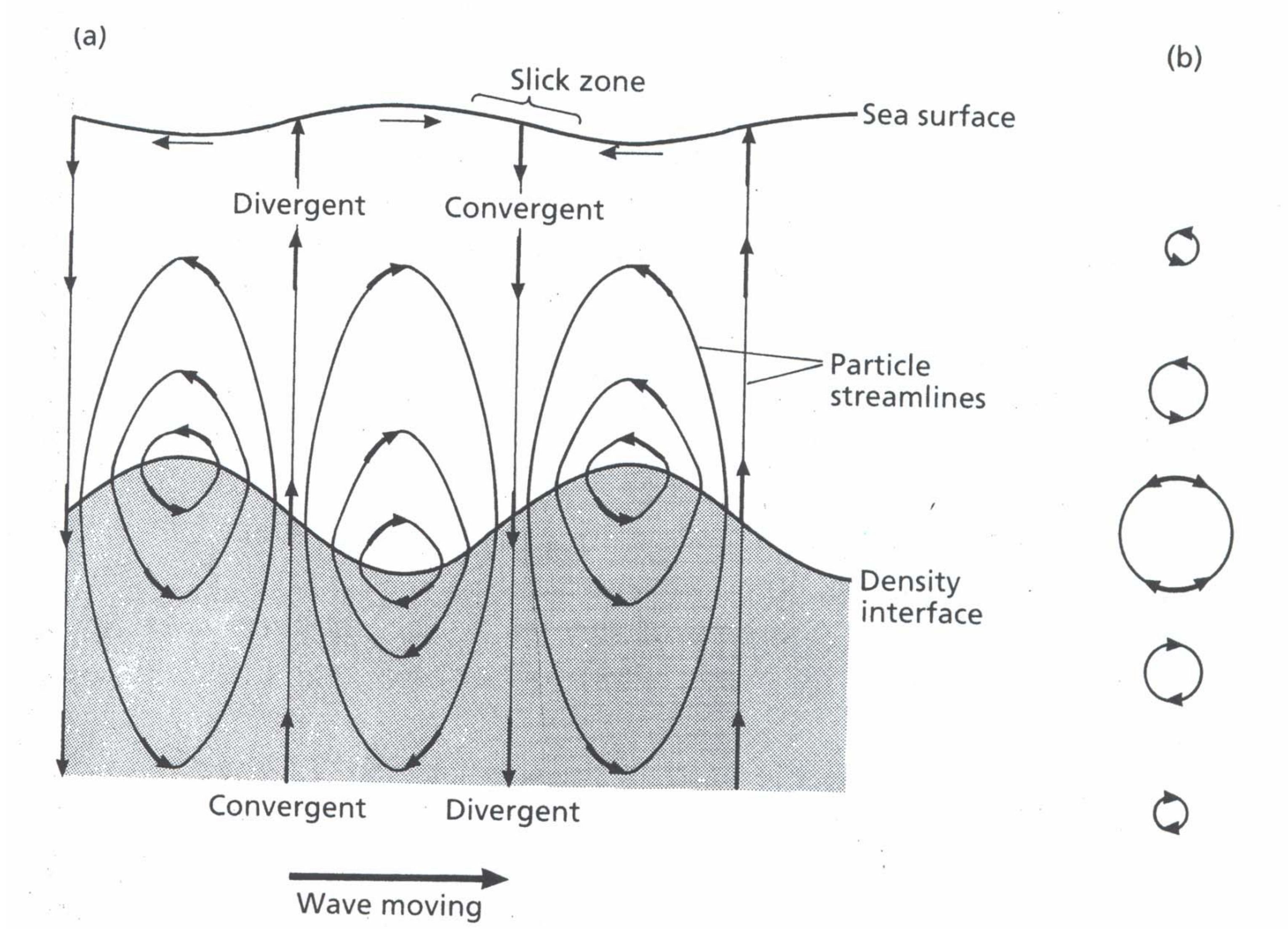
AVIRIS

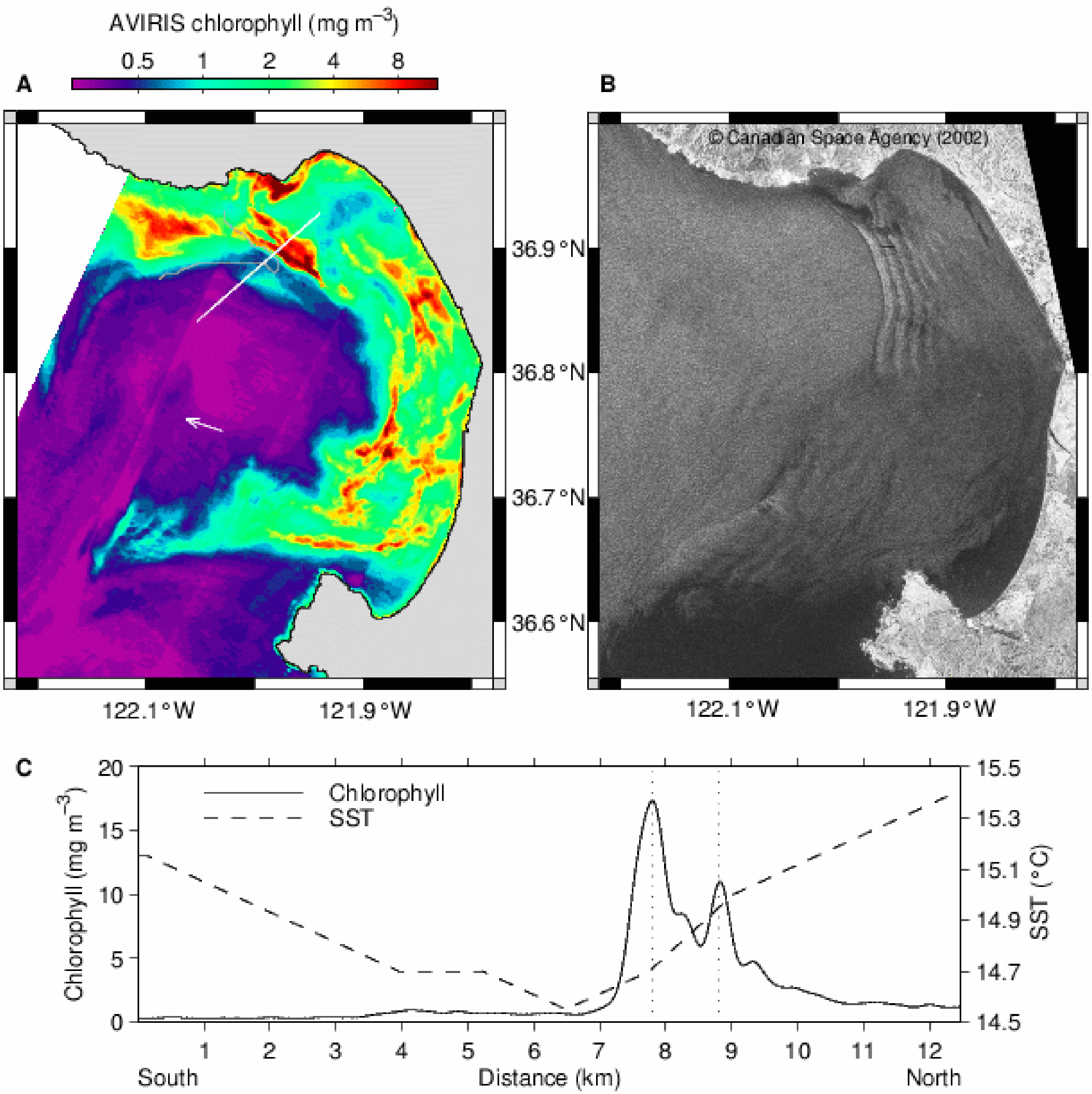




AVIRIS chlorophyll (mg m^-3)
0.5
1
2
4
8
36.9° N
36.7° N
122.1° W
121.9° W
Synthetic Aperture Radar
19 hours later
© Canadian Space Agency (2004)

Internal Waves cause convergence zones





AVIRIS chlorophyll (mg m^{-3})
0.5
1
2
4
8
A
B
© Canadian Space Agency (2002)
36.9°N
36.8°N
36.7°N
36.6°N
122.1°W
121.9°W
122.1°W
121.9°W
C
Chlorophyll
SST
Chlorophyll (mg m^{-3})
SST (°C)
20
15
10
5
0
15.5
15.3
15.1
14.9
14.7
14.5
1
2
3
4
5
6
7
8
9
10
11
12
South
Distance (km)
North

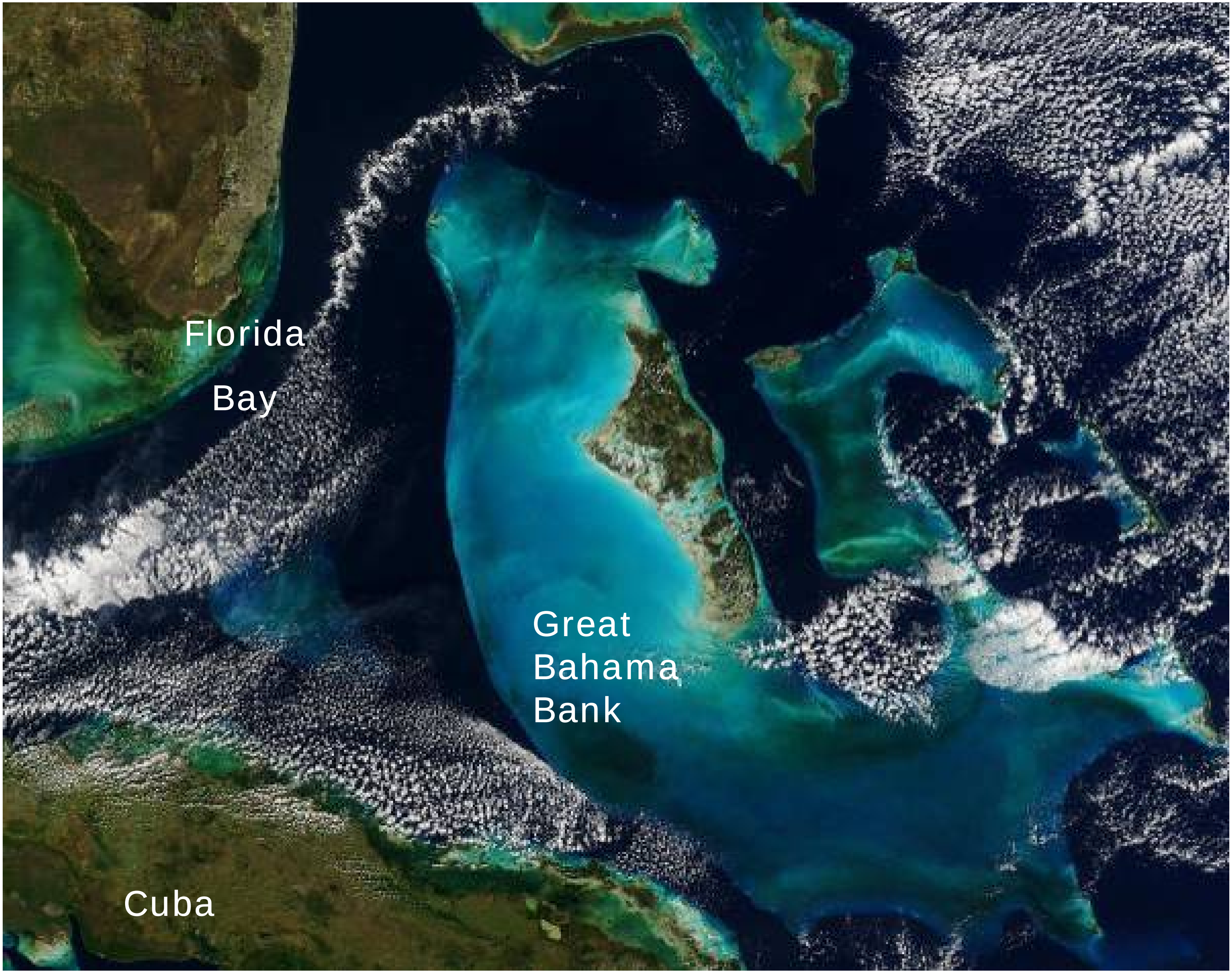
Coastal Bloom Products

- 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

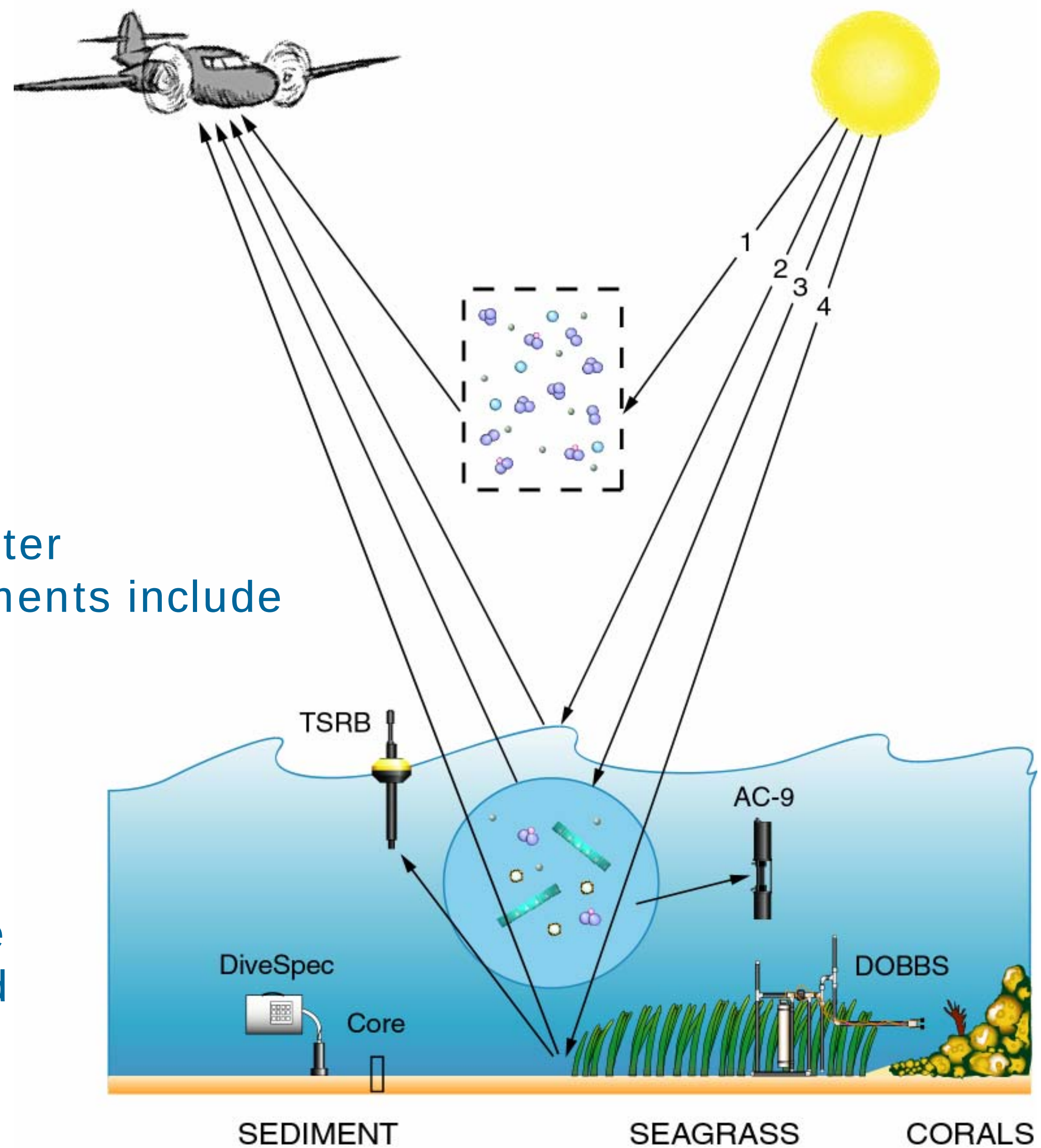
- What are the ecological mechanisms for distributions and response to environmental forcing?


Florida
Bay
Great
Bahama
Bank
Cuba

Methods –
Wet Remote Sensing

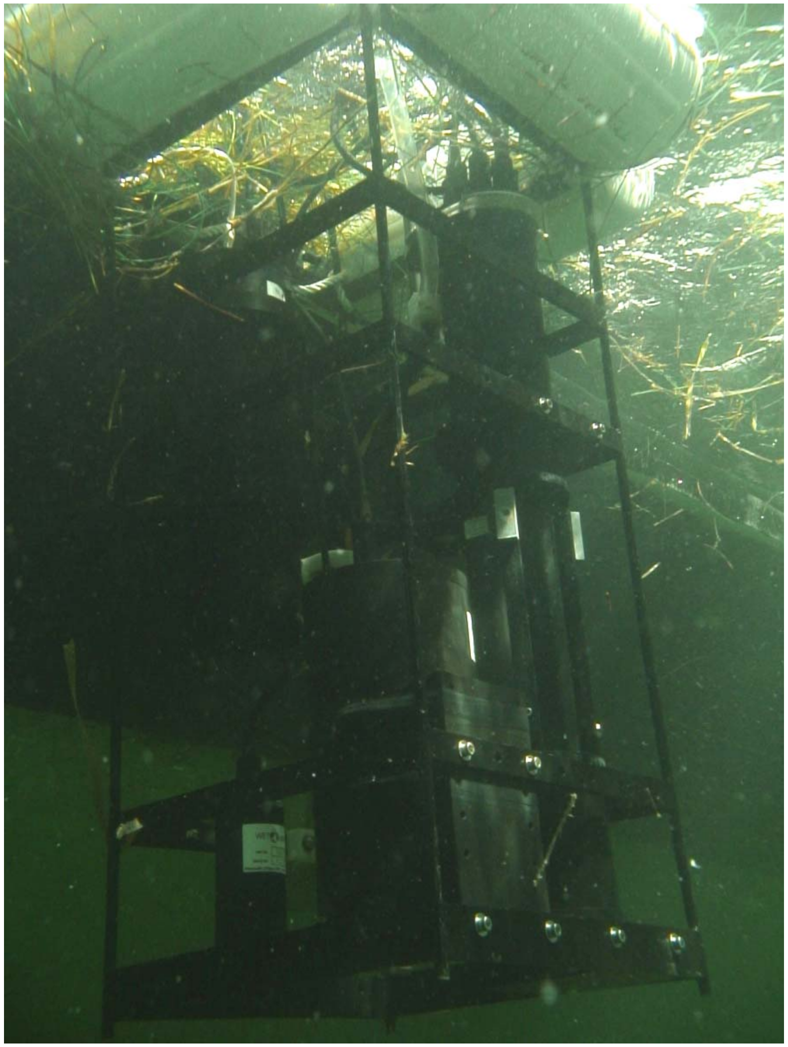
Above-water measurements include glint

Below-water measurements require extrapolation to 0^- and across air-water interface

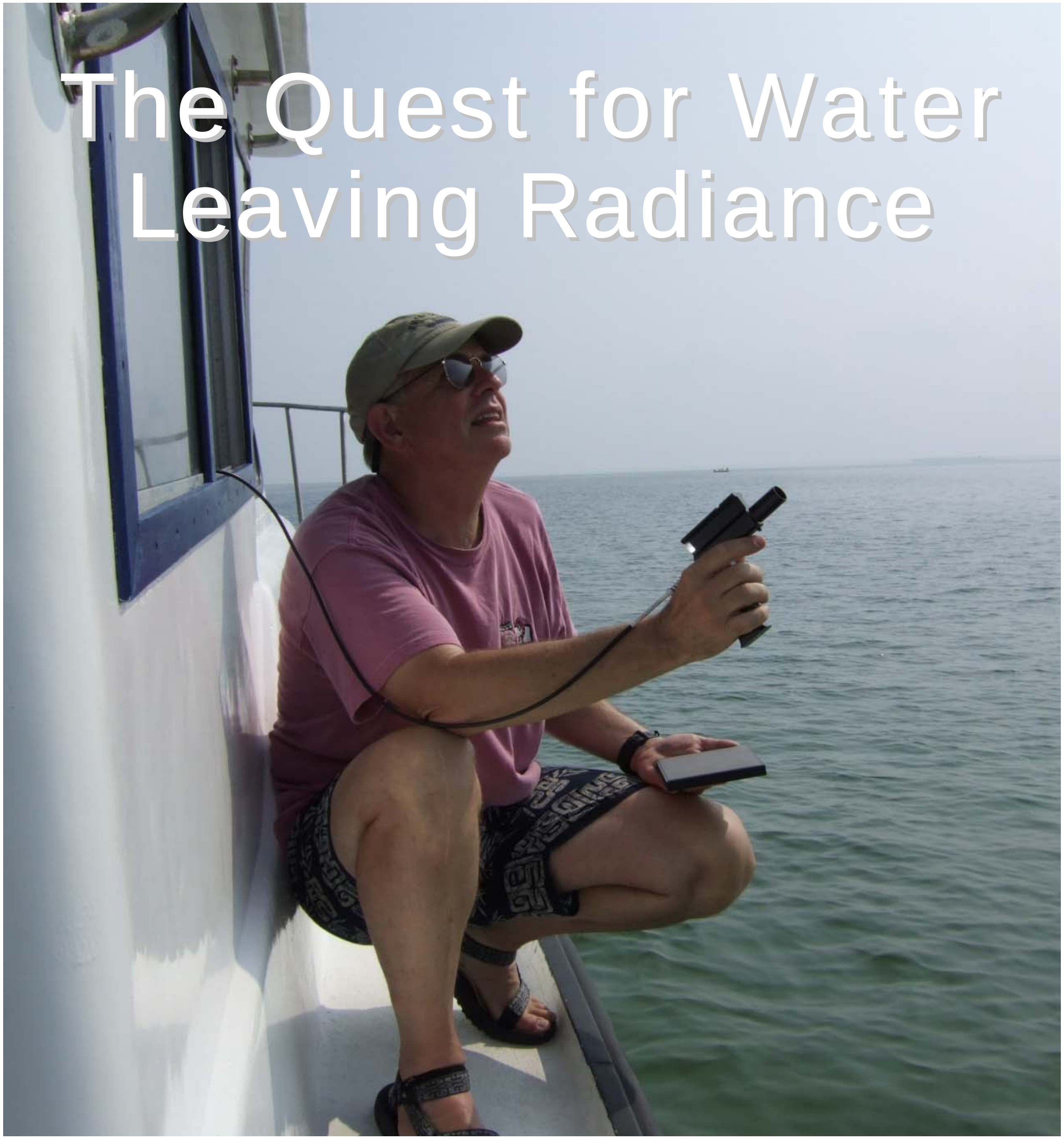


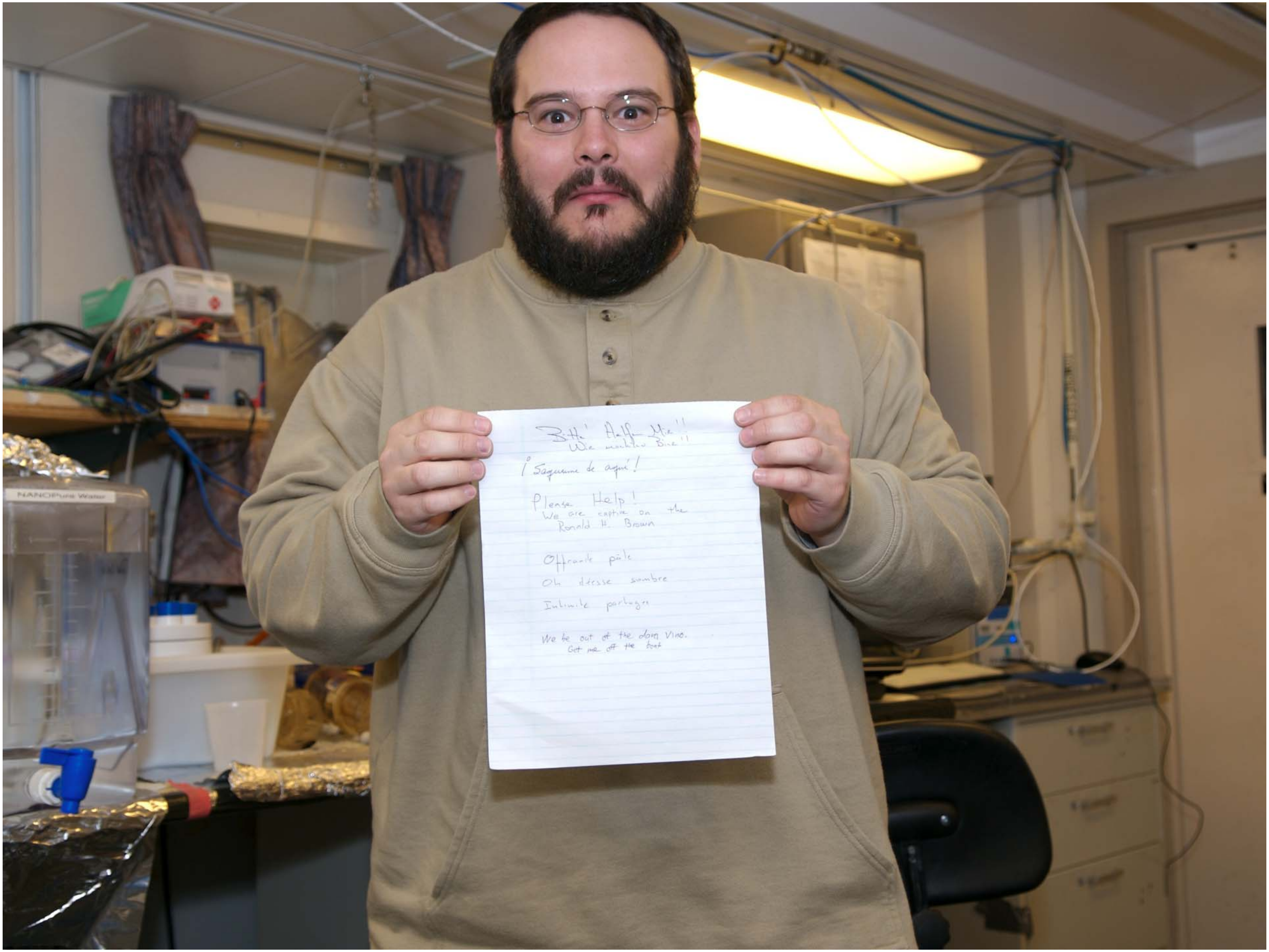
Water column properties

- *ac*-9 package
- eco-VSF
- CTD
- fluorometers
- (Chl, CDOM, phycoer.)



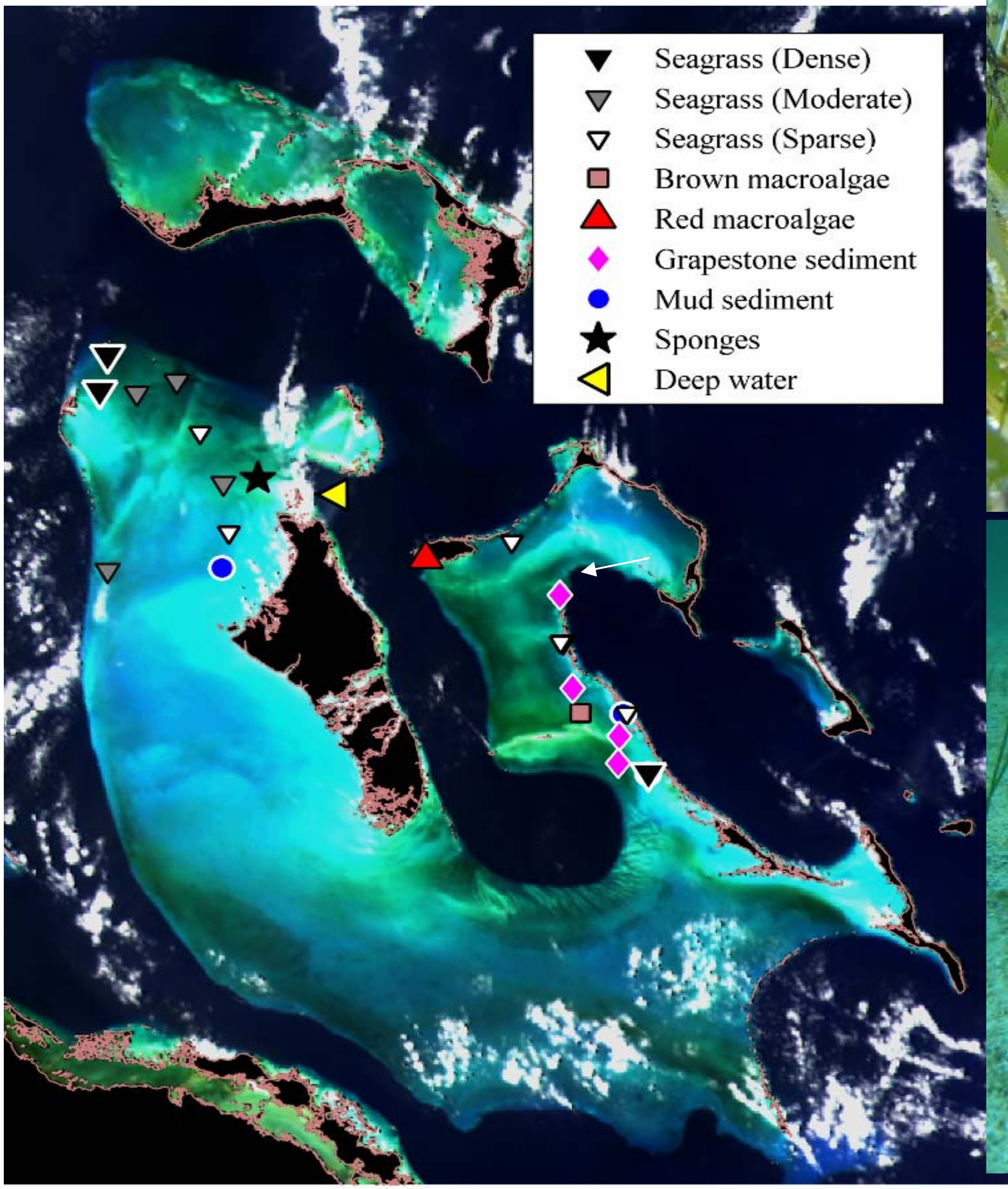
The Quest for Water Leaving Radiance




Bitte! Helfen Mir!!
¡Saquenme de aquí!
Please Help!
We are captive on the
Ronald H. Brown
Offrande pâle
Oh deesse sombre
Intimite partagee
We be out of the darn Vino.
Get me off the boat


Hooters
34A

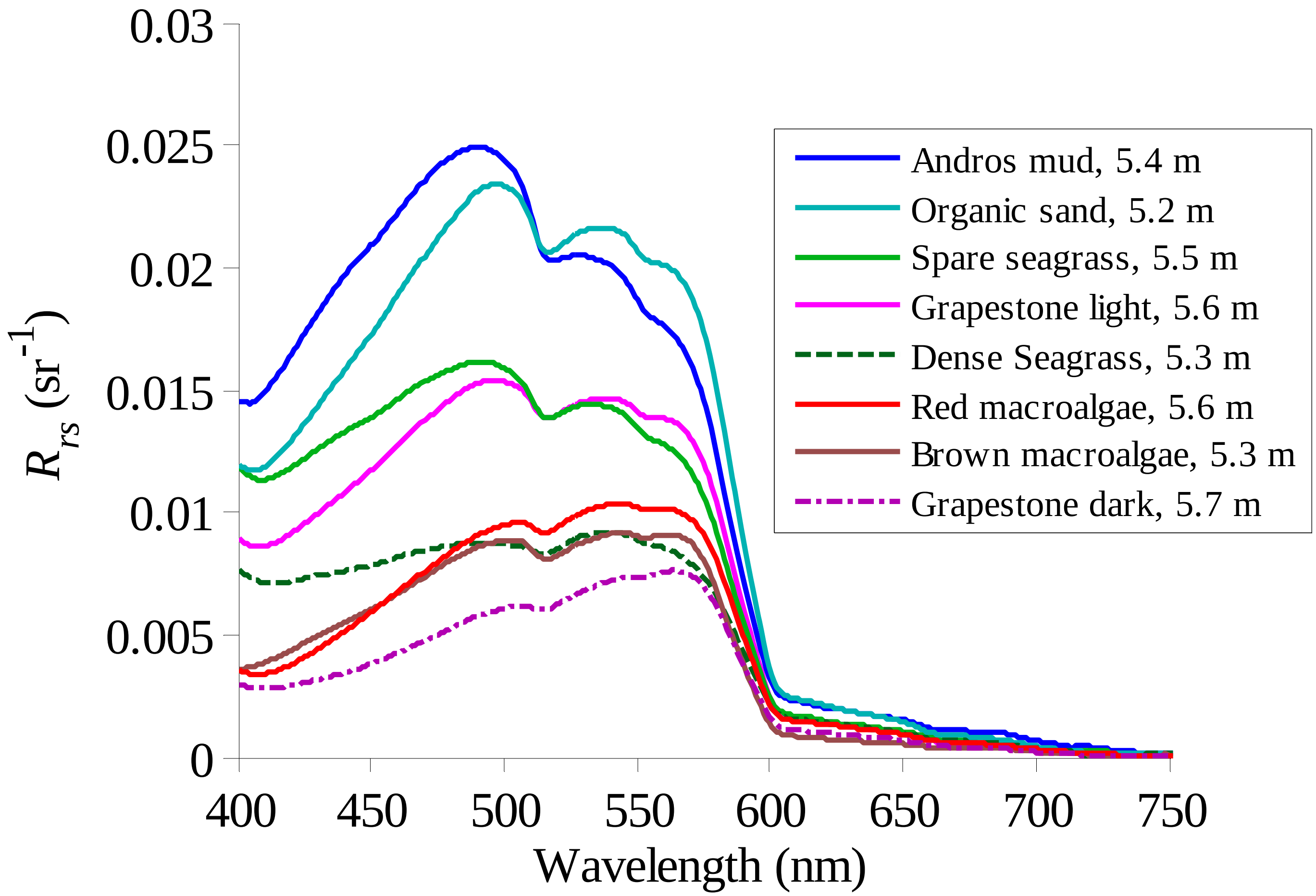
- Seagrass counts



Seagrass (Dense)
Seagrass (Moderate)
Seagrass (Sparse)
Brown macroalgae
Red macroalgae
Grapestone sediment
Mud sediment
Sponges
Deep water

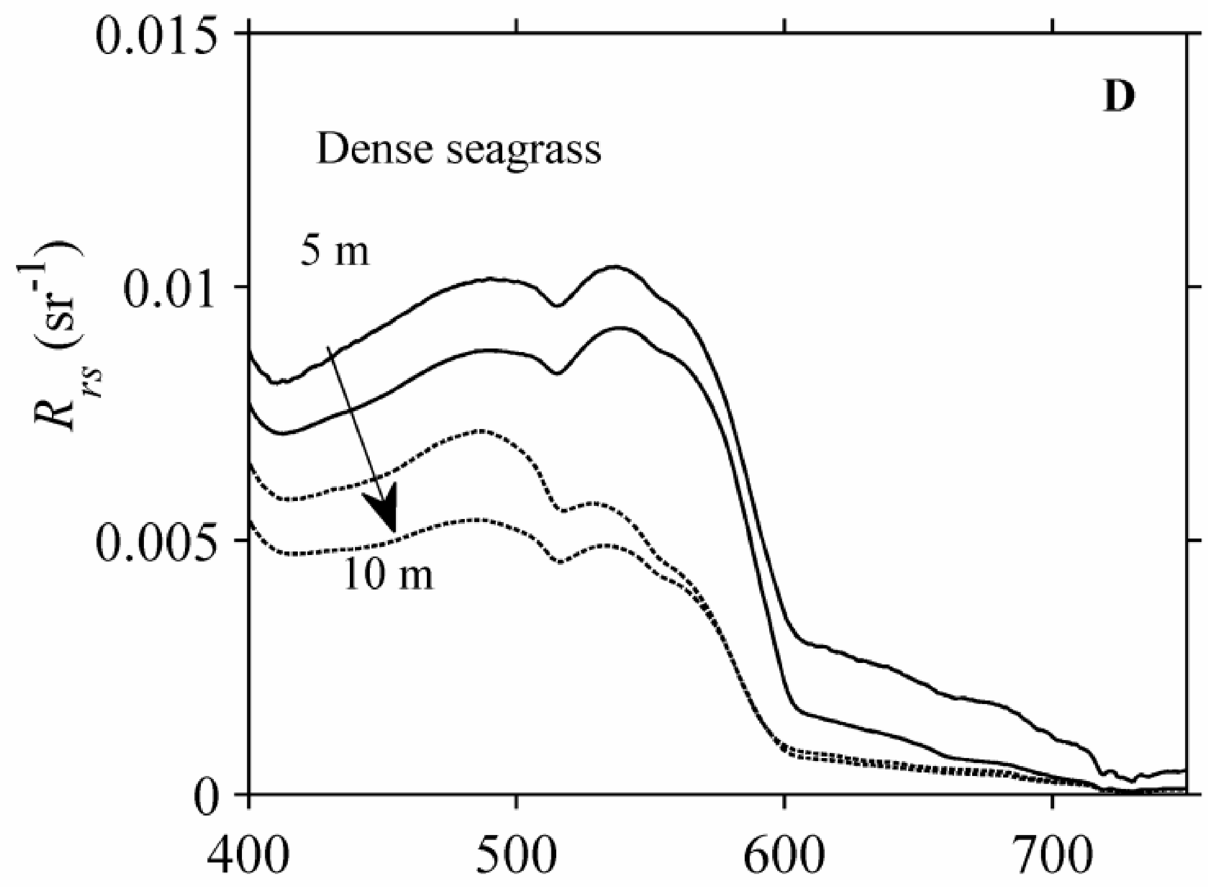
Tutrtlegrass

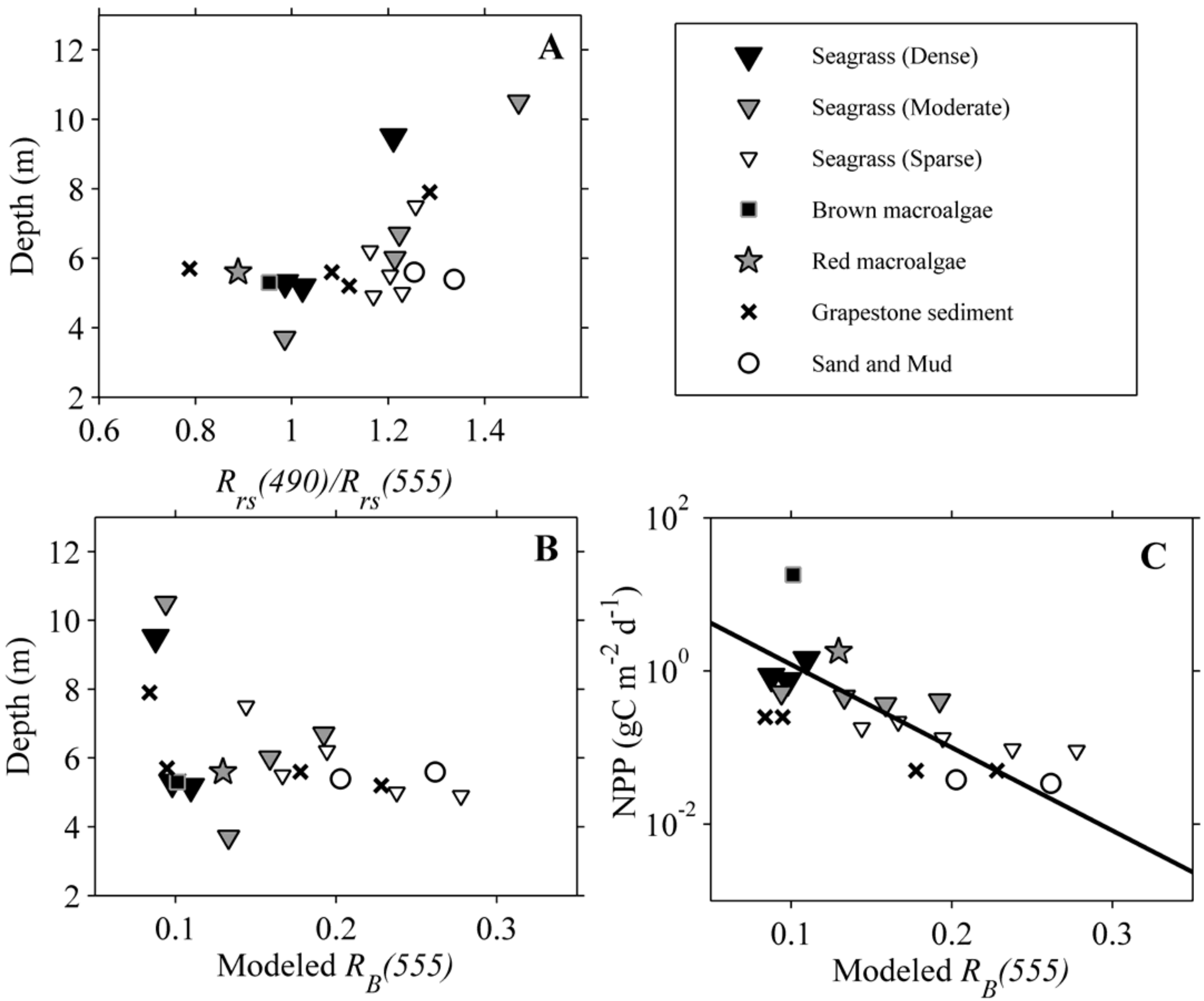
UConn


0.03
0.025
0.02
0.015
0.01
0.005
0
R_{rs} (sr^{-1})
400
450
500
550
600
650
700
750
Wavelength (nm)
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

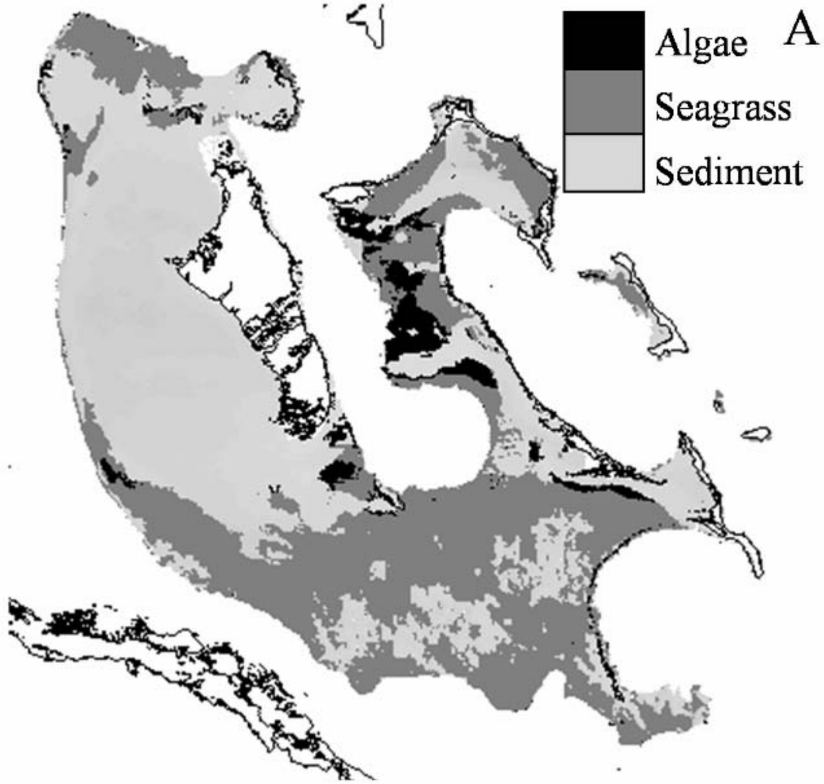
UConn

With depth, the spectrum changes from green-to blue- dominated





A
Depth (m)
$R_{rs}(490)/R_{rs}(555)$
Seagrass (Dense)
Seagrass (Moderate)
Seagrass (Sparse)
Brown macroalgae
Red macroalgae
Grapestone sediment
Sand and Mud
B
Depth (m)
Modeled $R_B(555)$
C
NPP ($gC\ m^{-2}\ d^{-1}$)
Modeled $R_B(555)$

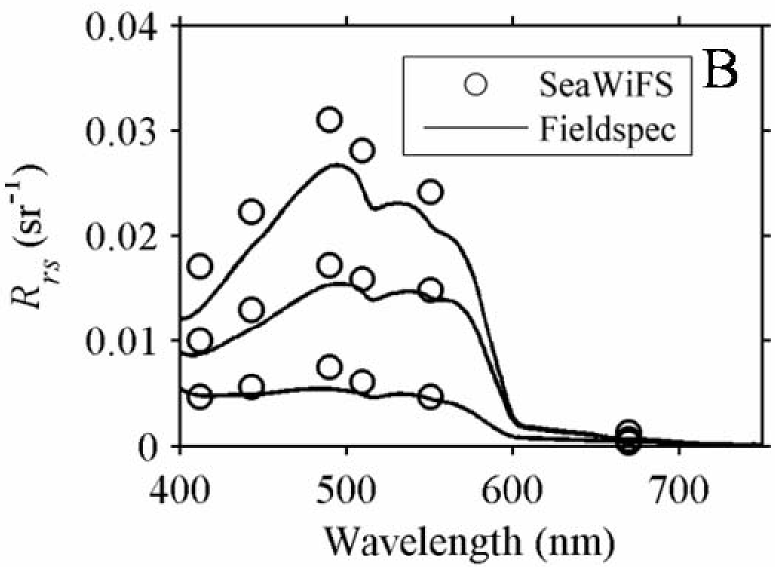


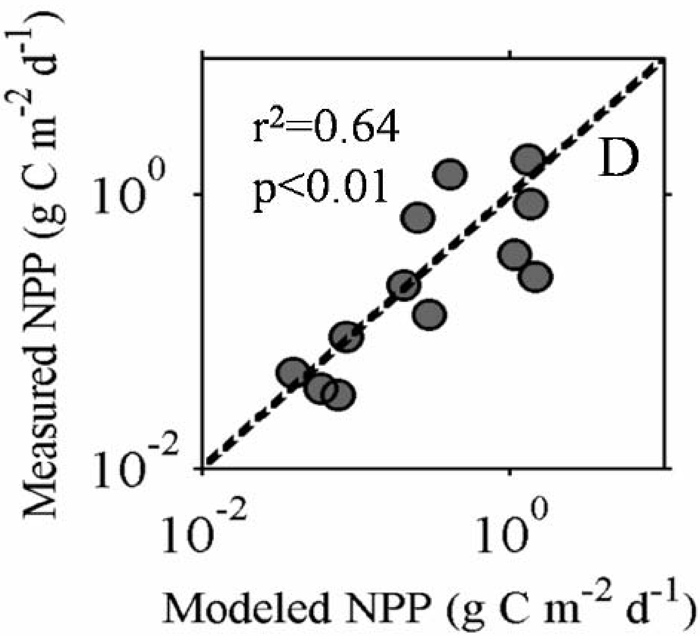
B

Classification Accuracy Matrix

Measured \ Modeled	Seagrass	Algae	Sediment
Seagrass	**5**	0	2
Algae	1	**2**	1
Sediment	2	0	**10**

Atmospheric Correction

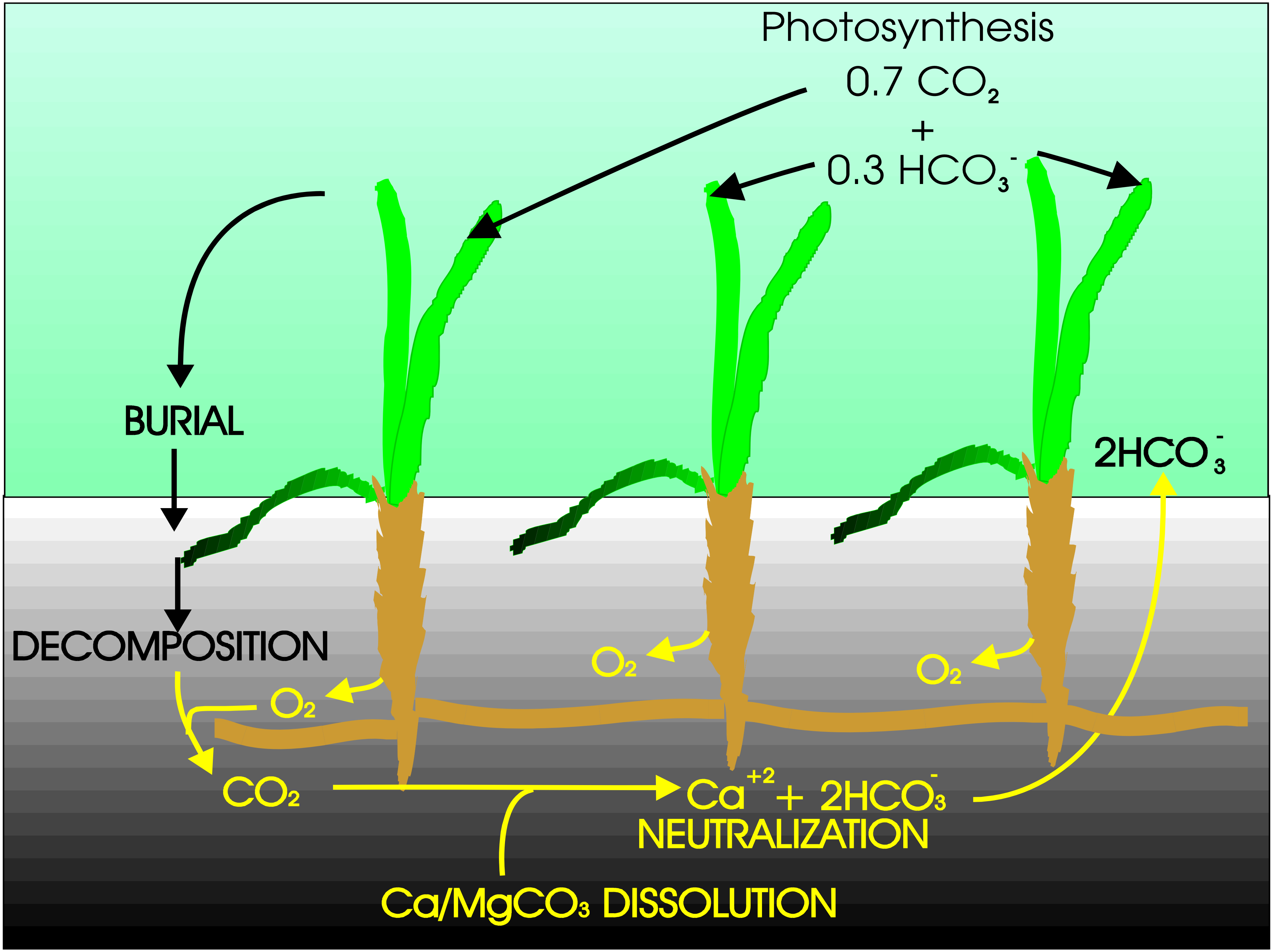




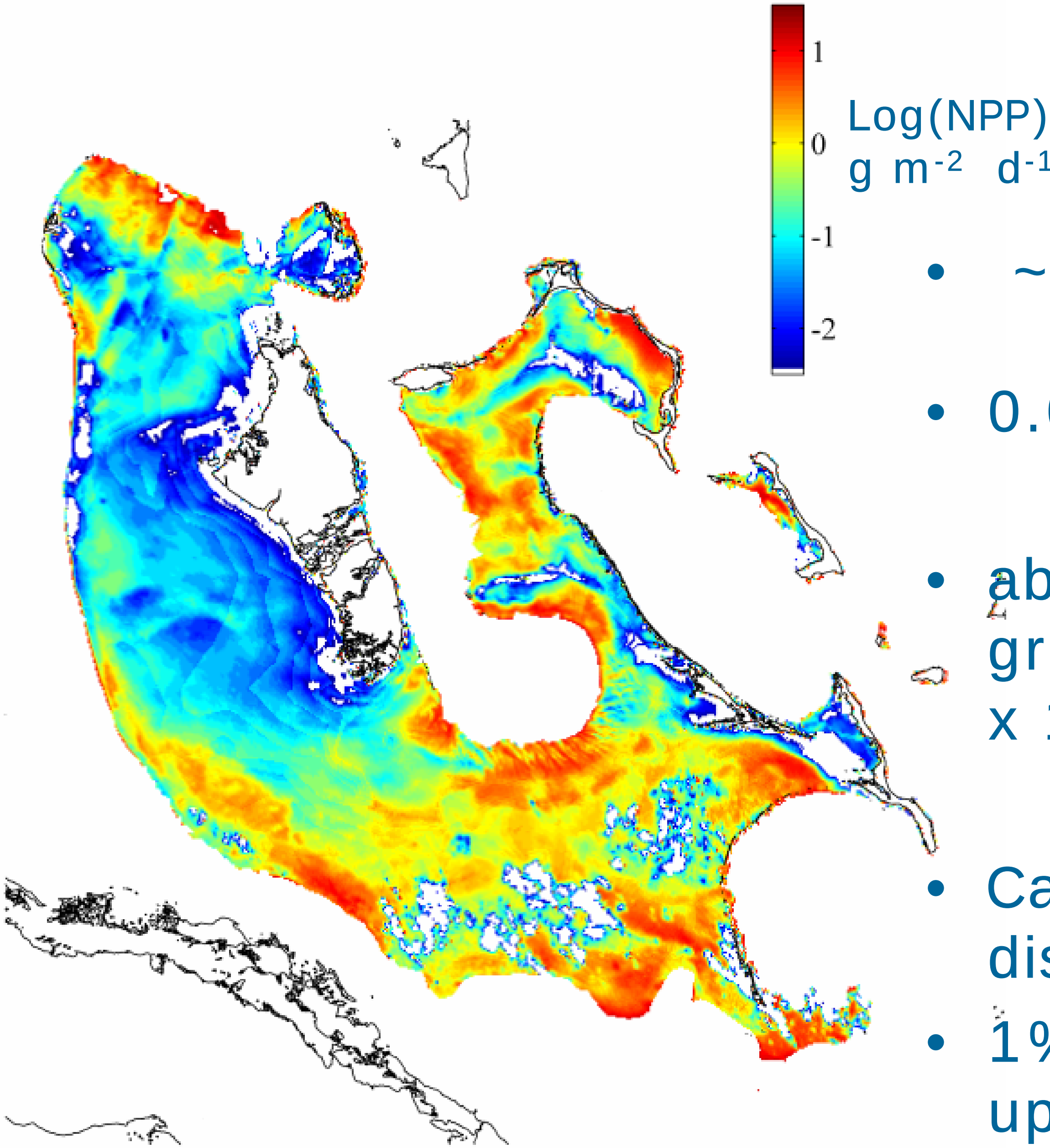
Carbonate Sediment Geochemistry

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

  - Burdige & Zimmerman, *Limnol. Oceanogr*. 2002. **47**: 1751-1763



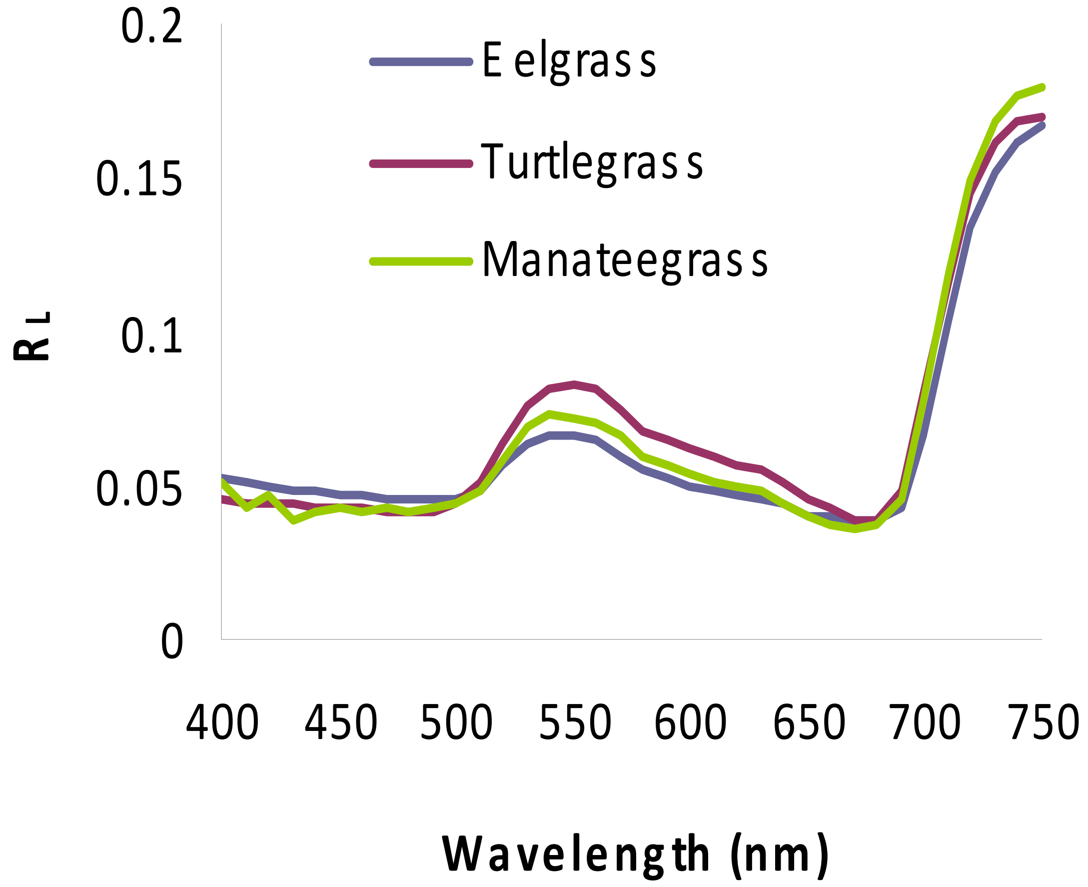
Photosynthesis
$0.7\ CO_2$
+
$0.3\ HCO_3^-$
BURIAL
DECOMPOSITION
O_2
O_2
O_2
CO_2
$Ca^{+2} + 2HCO_3^-$
NEUTRALIZATION
$2HCO_3^-$
$Ca/MgCO_3$ DISSOLUTION



- ~2 x 10^{13} g C y^{-1}
- 0.04% global NPP
- above- and below-ground carbon (2.4 x 10^{13} g C y^{-1})
- Carbonate dissolution
- 1% oceanic net CO2 uptake

Greater Florida Bay

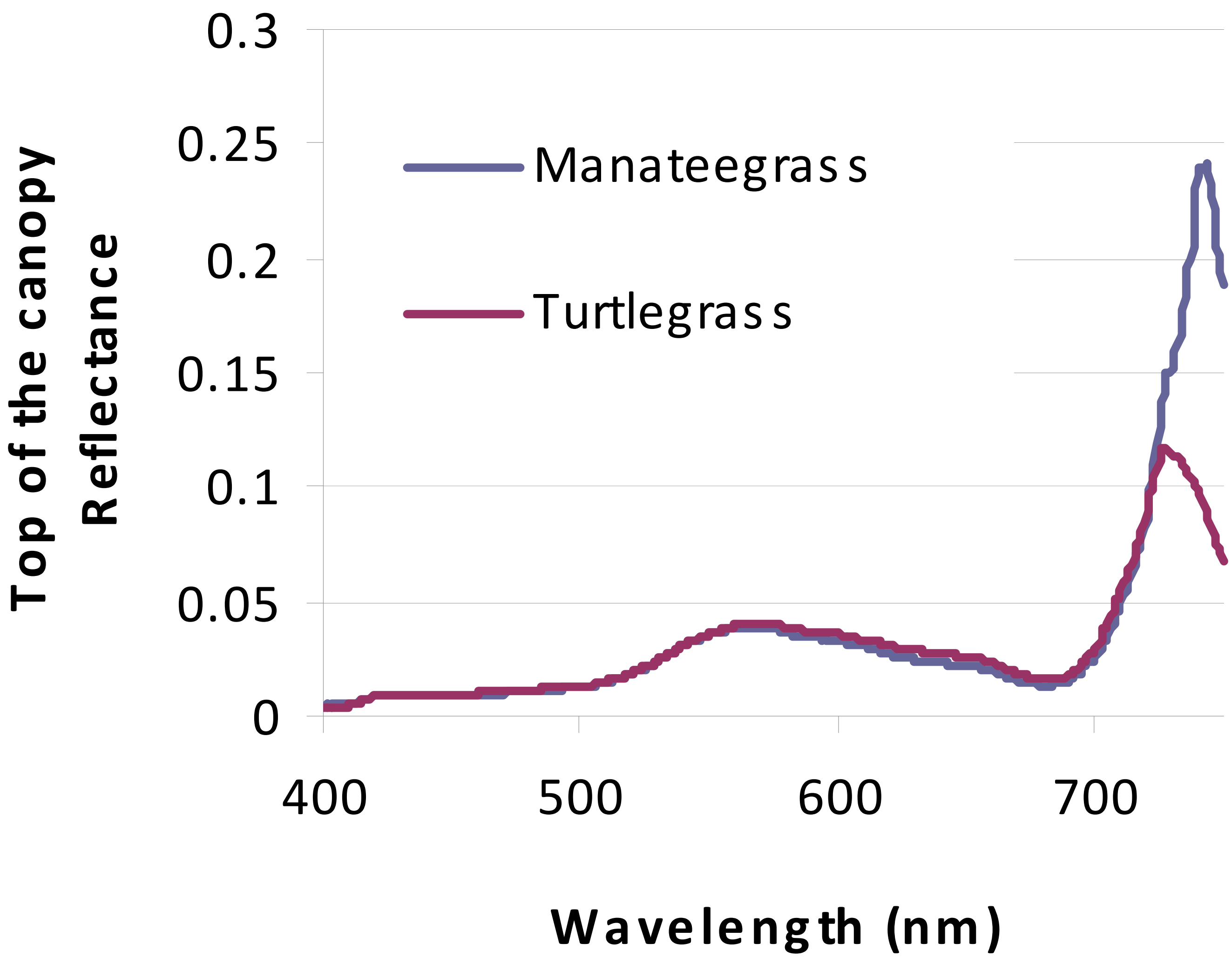
Differentiating seagrass species



- Similar leaf reflectance

Measuring Seagrass Canopy Reflectance

Different canopy reflectance



Fate of the carbon

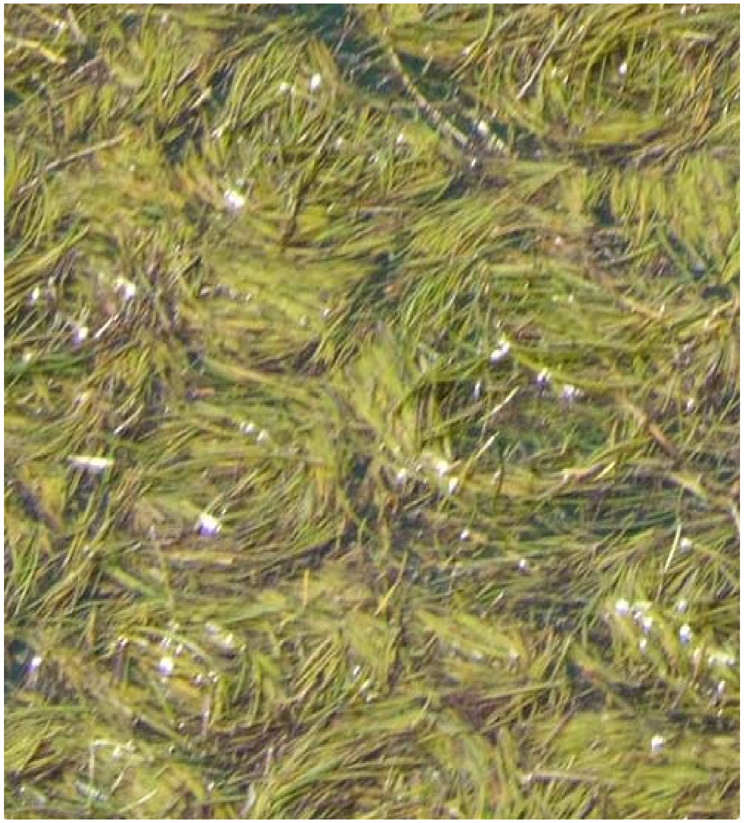
- Different seagrass species play different ecological roles
- Turtlegrass leaves decompose in the beds

Manateegrass

- Buoyant leaves, exported carbon

Fate of the carbon

- Different seagrass species play different ecological roles



Relevance to Hyspiri

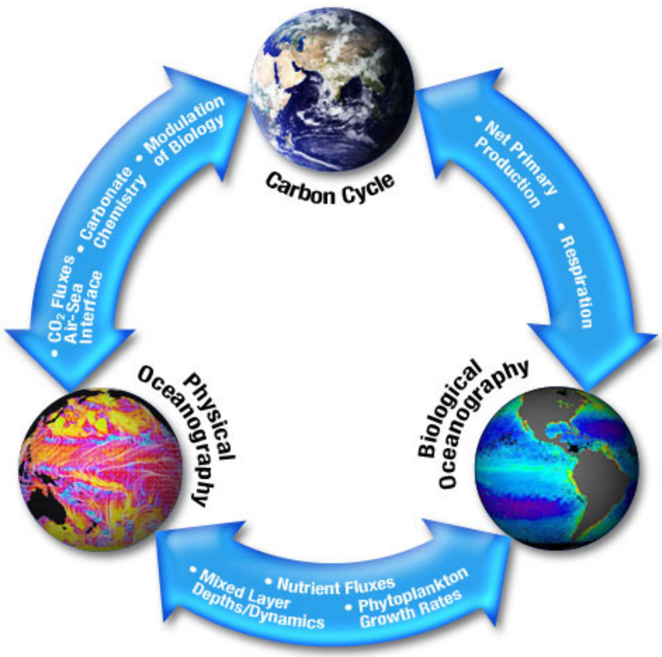
- Spatial resolution -
  - 60 m will resolve many benthic features on large carbonate banks like Florida Bay and Bahamas

- 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



GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L04602, doi:10.1029/2008GL036188, :

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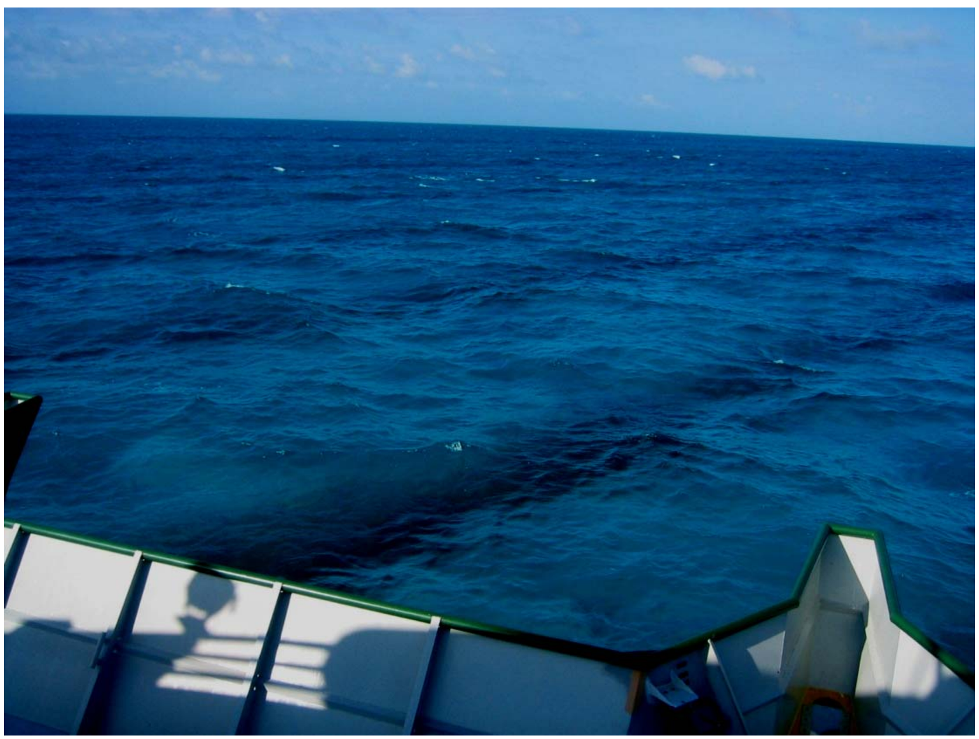
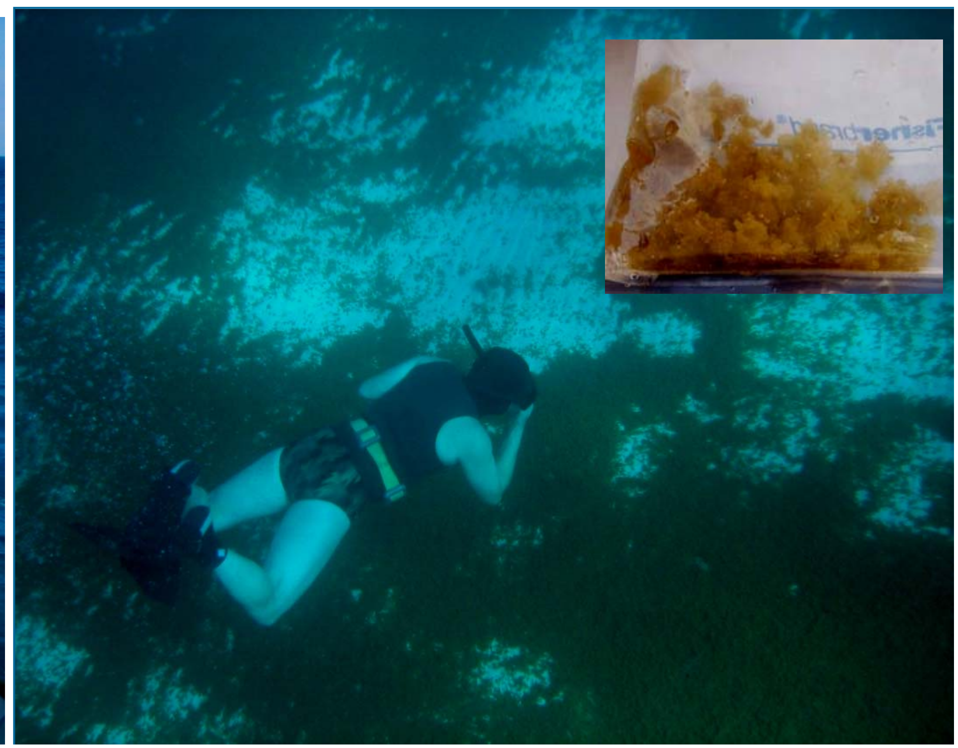
Potential export of unattached benthic macroalgae to the deep sea through wind-driven Langmuir circulation

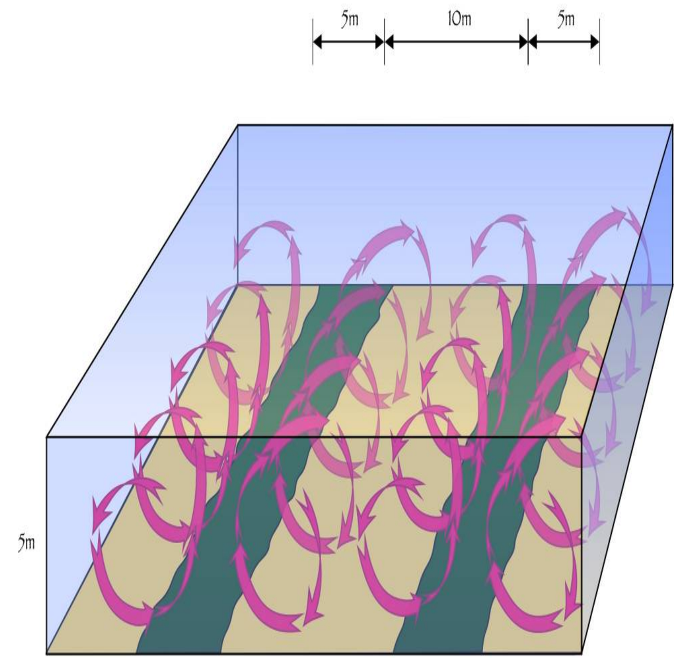
H. M. Dierssen,[1] R. C. Zimmerman,[2] L. A. Drake,[2,3] and D. J. Burdige[2]



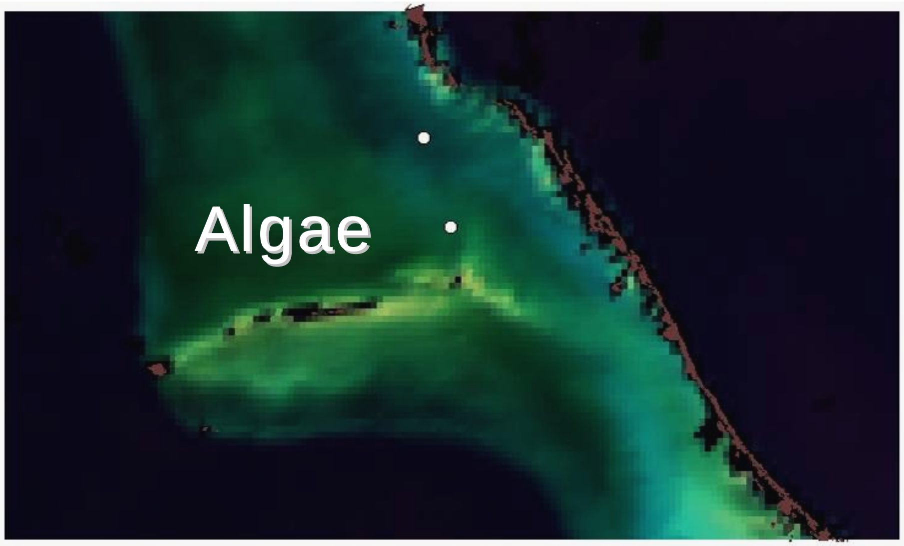


Langmuir "supercells" could be a mechanism

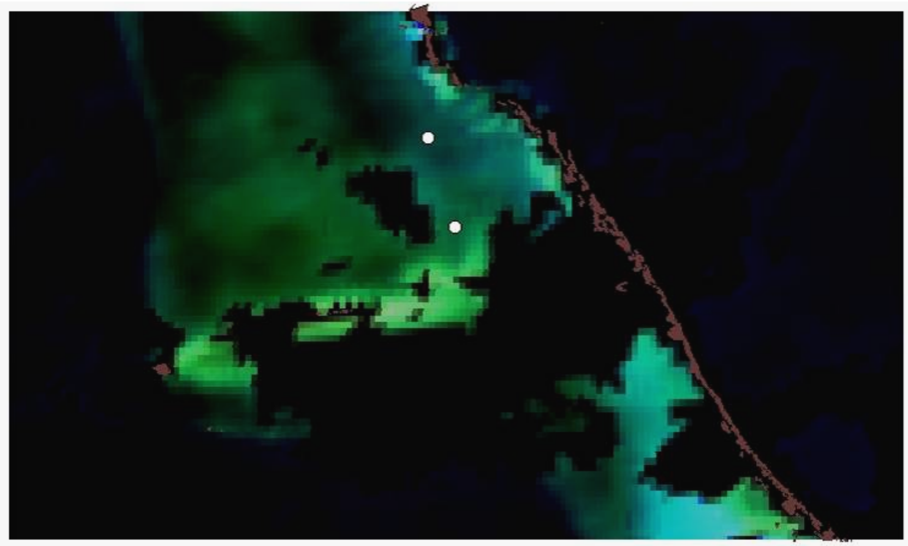
- Langmuir cells observed on the Banks
- Consistent with periodicity in optics
- Historic descriptions of "digits" and "roiling"
- Seasonality of whitings consistent with wind patterns



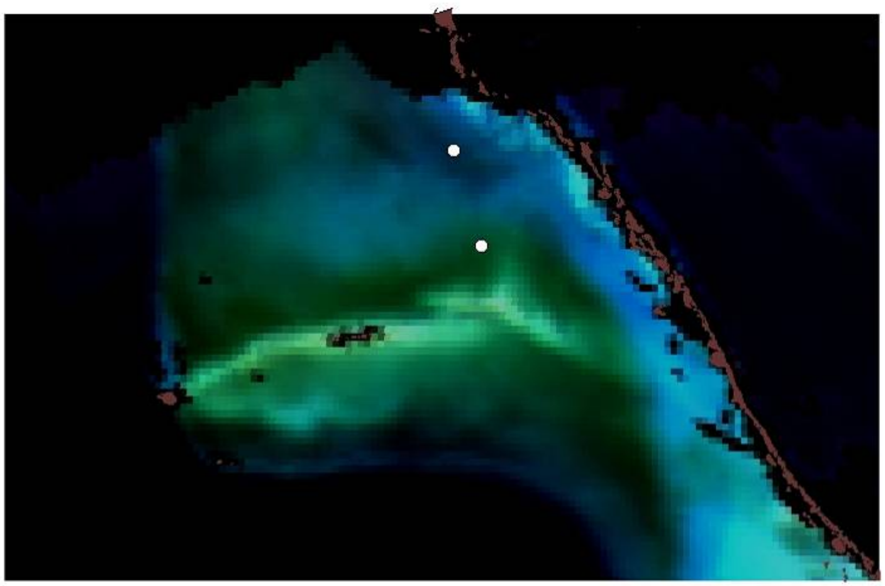
6 March 2004



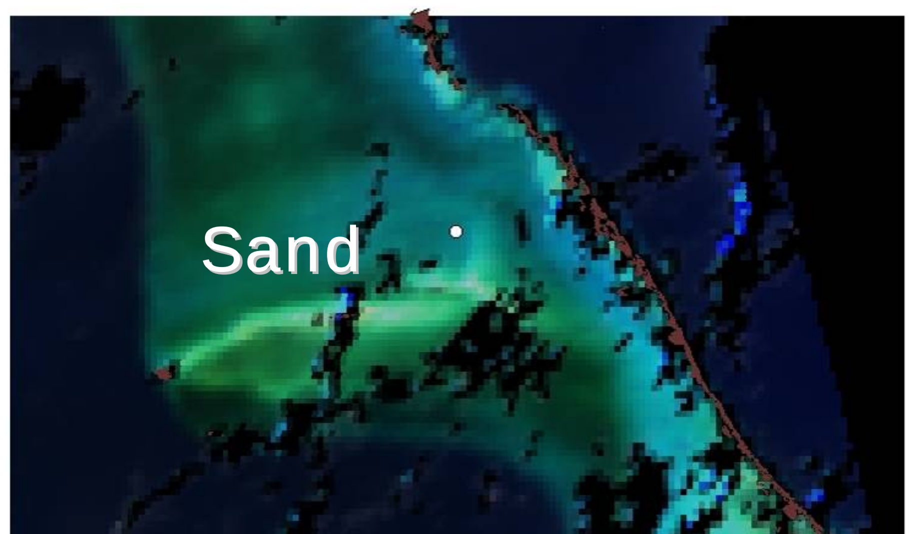
7 March 2004



16 March 2004 → 19 March windrow



22 March 2004



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 7×10^{10} g carbon
  - Equivalent to daily export flux of phytoplankton in the tropical North Atlantic

Biogeosciences, 6, 1–13, 2009
www.biogeosciences.net/6/1/2009/
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Biogeosciences

Optics and remote sensing of Bahamian carbonate sediment whitings and potential relationship to wind-driven Langmuir circulation

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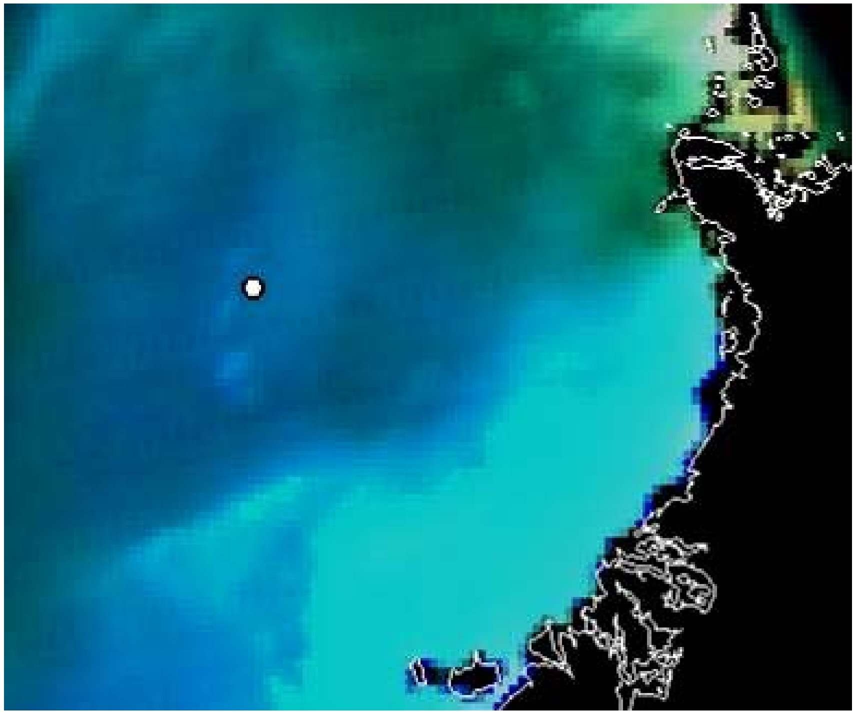
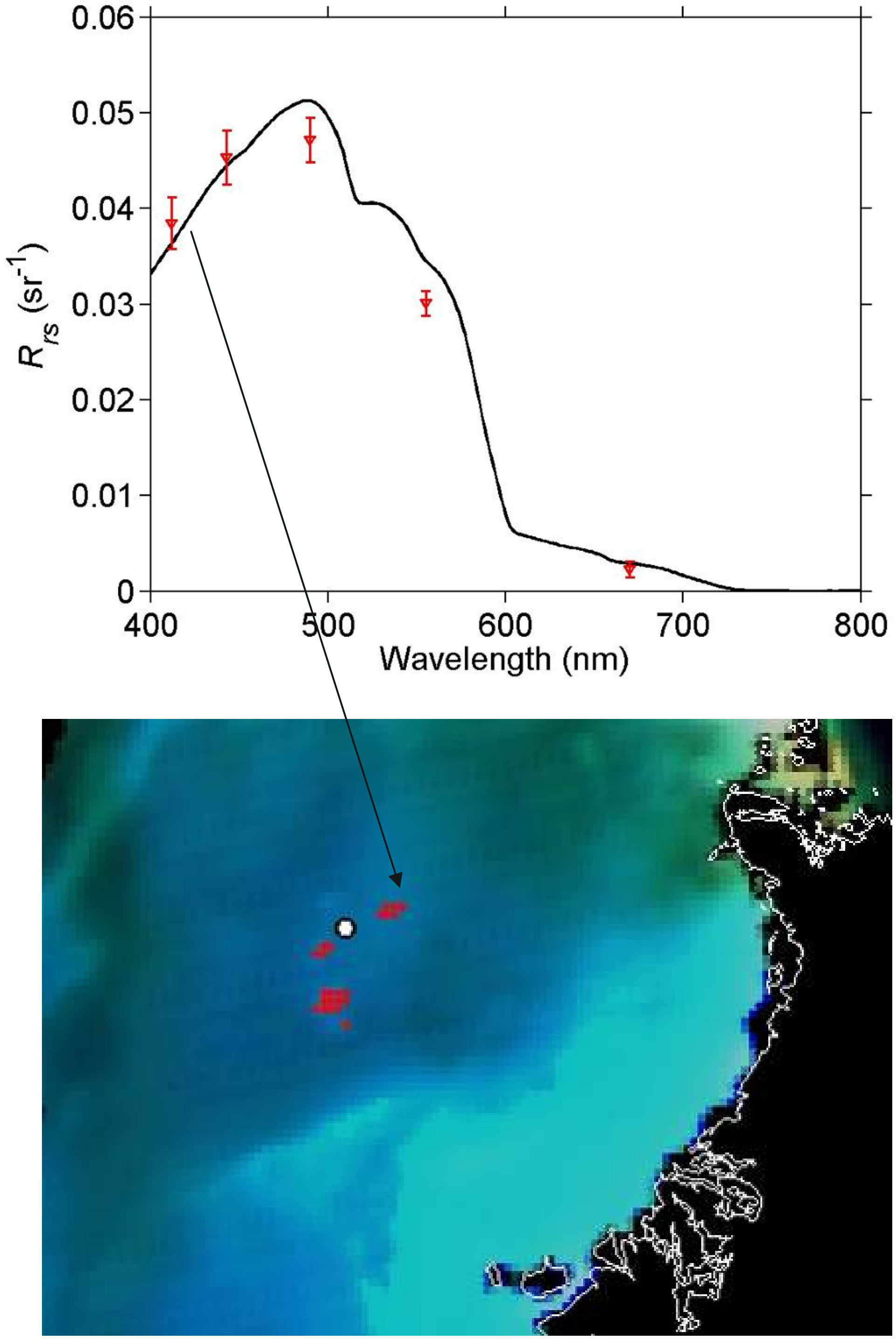
[2]Department of Ocean, Earth & Atmospheric Sciences, Old Dominion Univ., 4600 Elkhorn Ave., Norfolk VA 23529, USA





Resuspensed sediment can serve as a nucleus for carbonate precipitation and growth of sediment particles

~18 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) $m^2\ m^{-2}$
  - Net primary productivity $g\ C\ m^{-2}\ d^{-1}$
  - Rates of carbonate dissolution
  - Rates of carbonate precipitation (resuspended sediment)
  - Bottom albedo for heat budgets


NOAA
CICORE
CICORE (SEA-core) acronym
1. Center For Integrative Coastal Observation, Research and Education.
NSF
ONR
Office of Naval Research
NASA