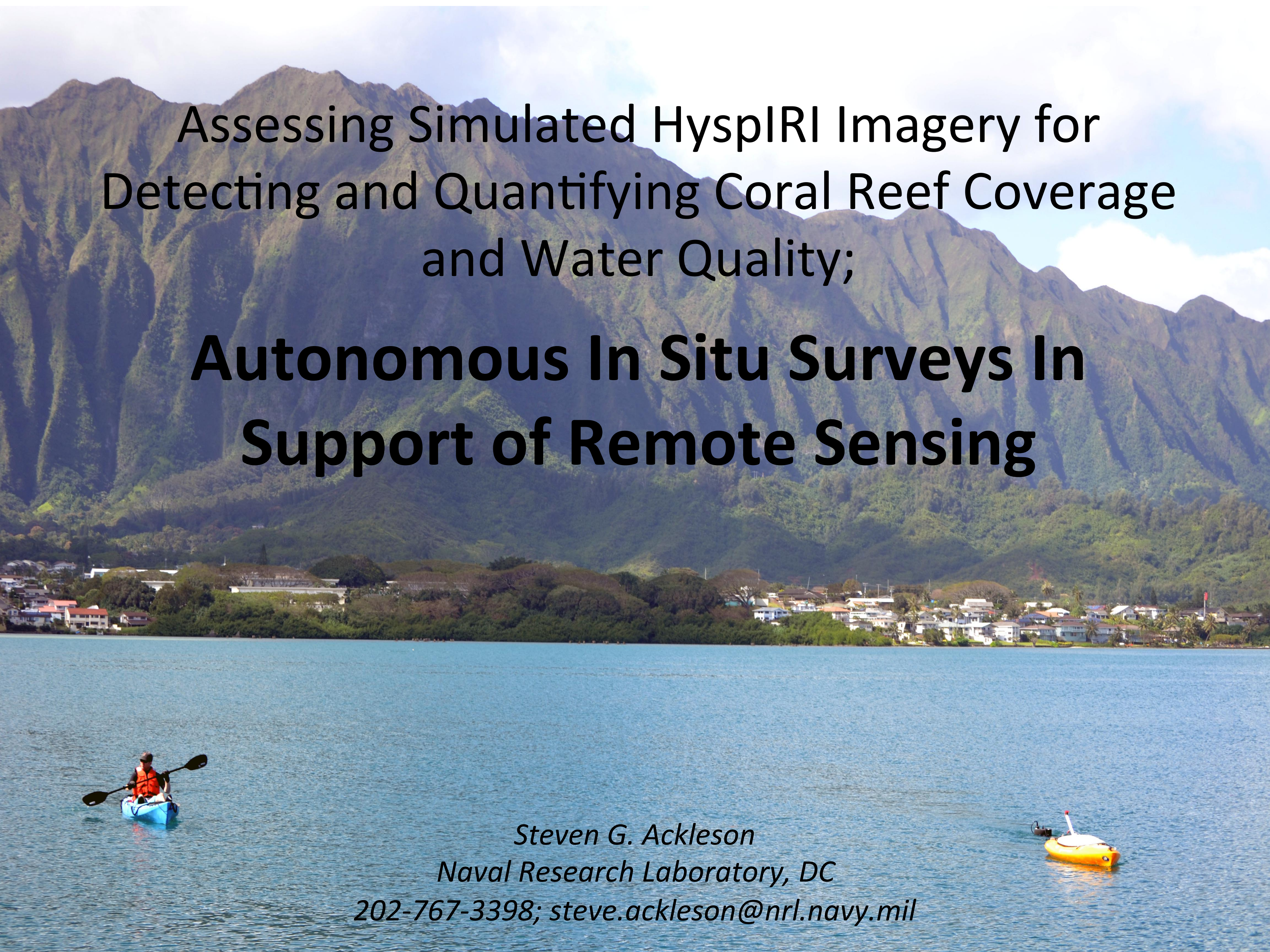
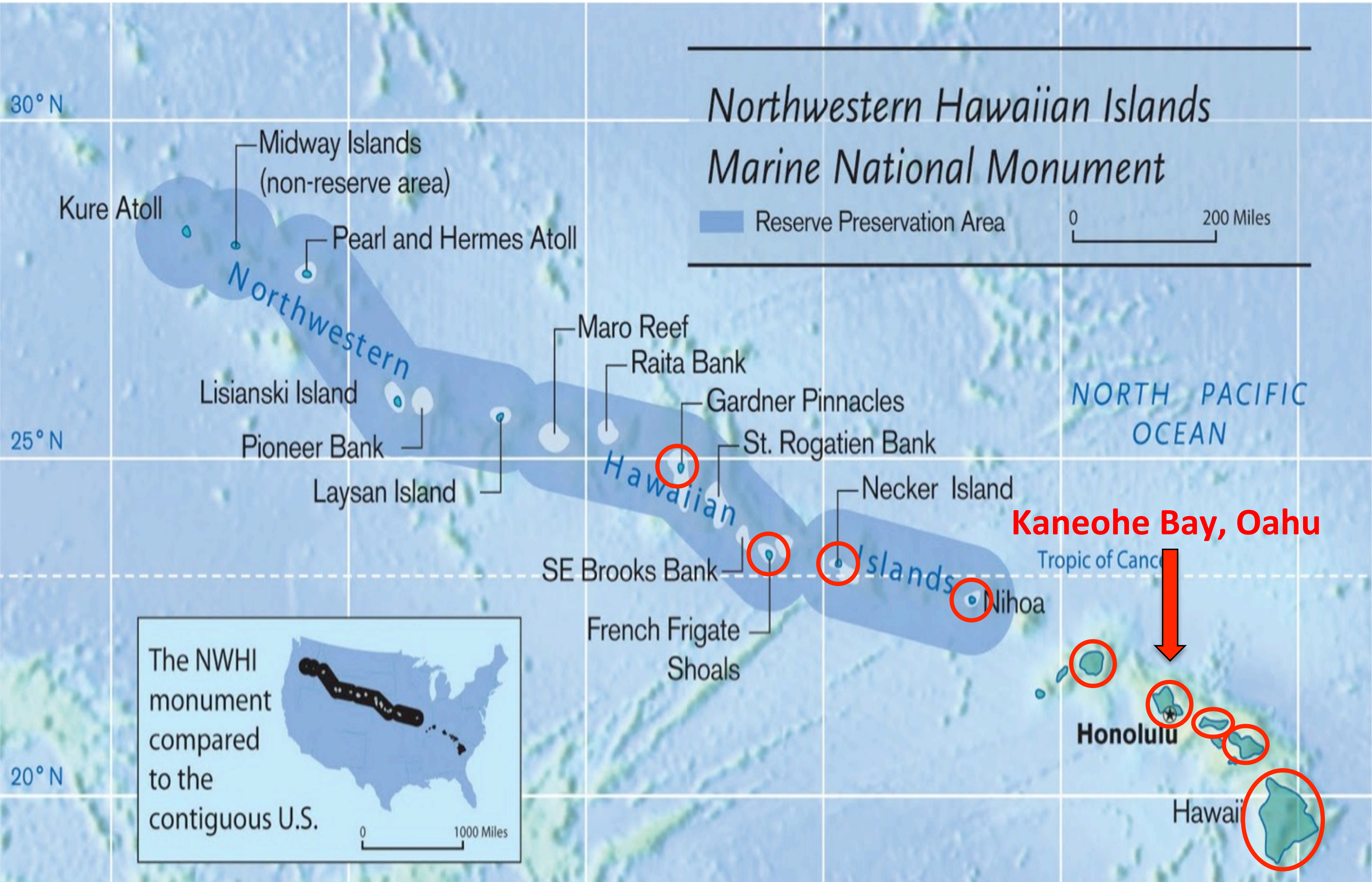


Assessing Simulated HyspIRI Imagery for Detecting and Quantifying Coral Reef Coverage and Water Quality;

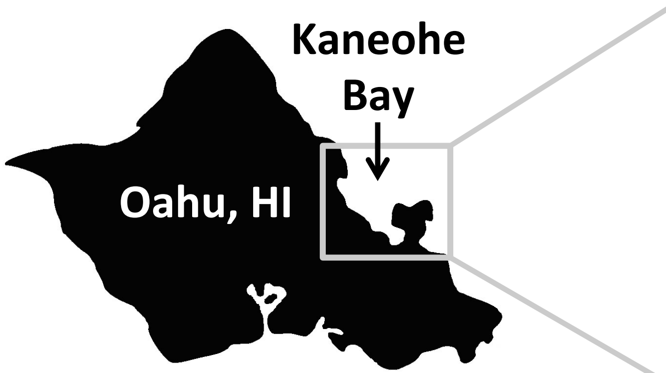
Autonomous In Situ Surveys In Support of Remote Sensing

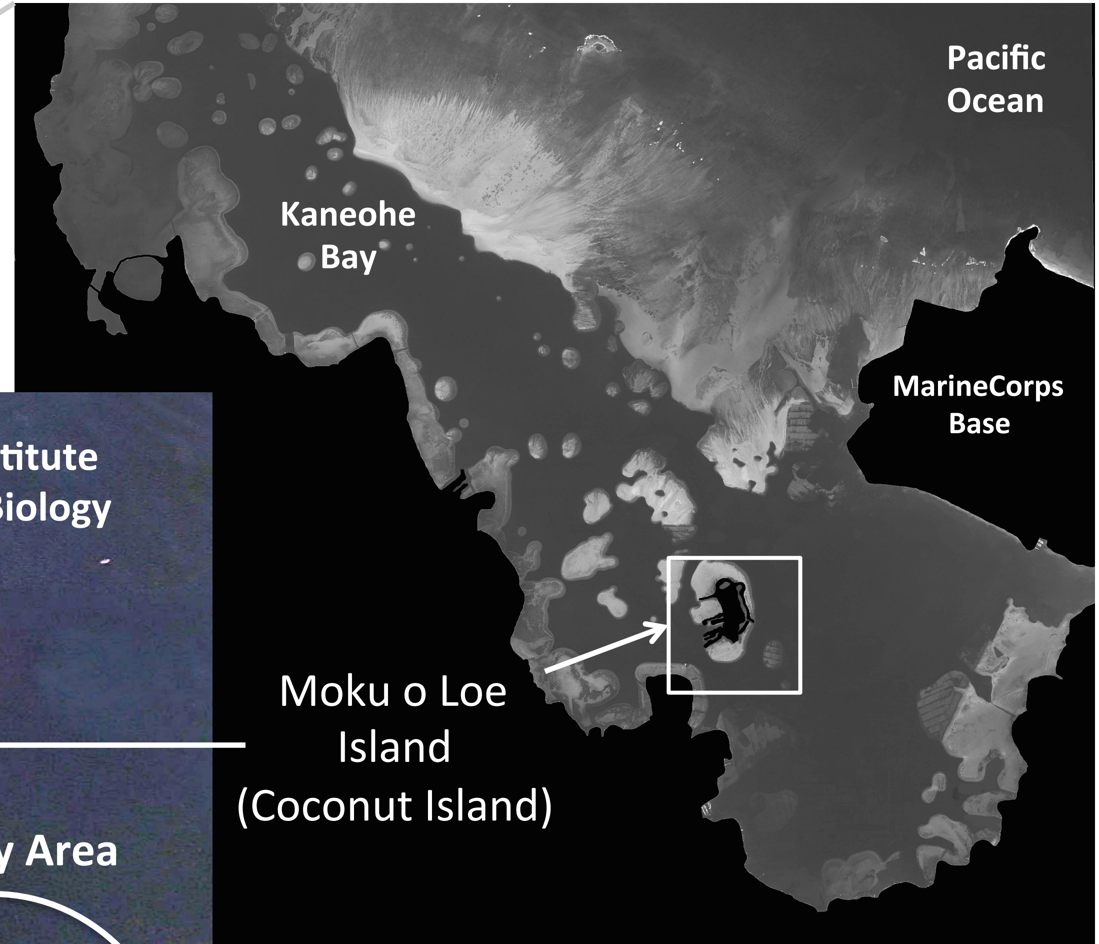
Steven G. Ackleson
Naval Research Laboratory, DC
202-767-3398; steve.ackleson@nrl.navy.mil

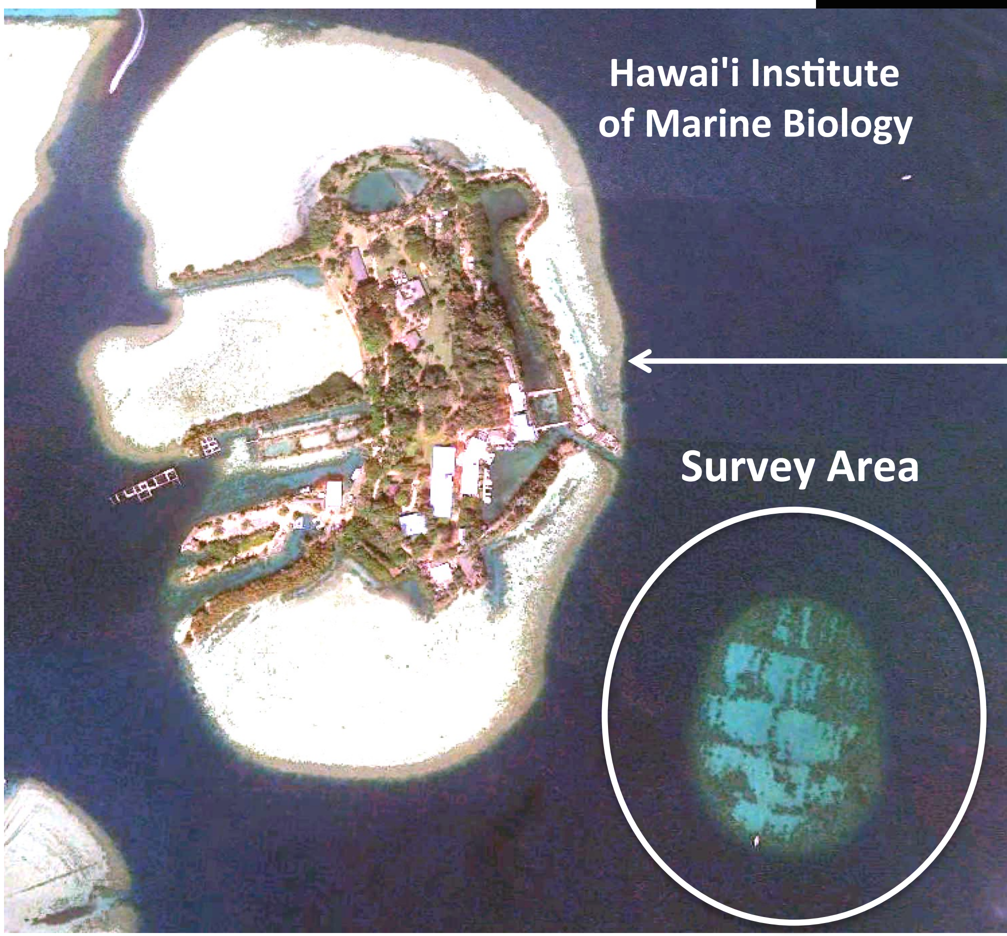
HyspIRI Coral Field Campaign
12 January - 3 March 2017



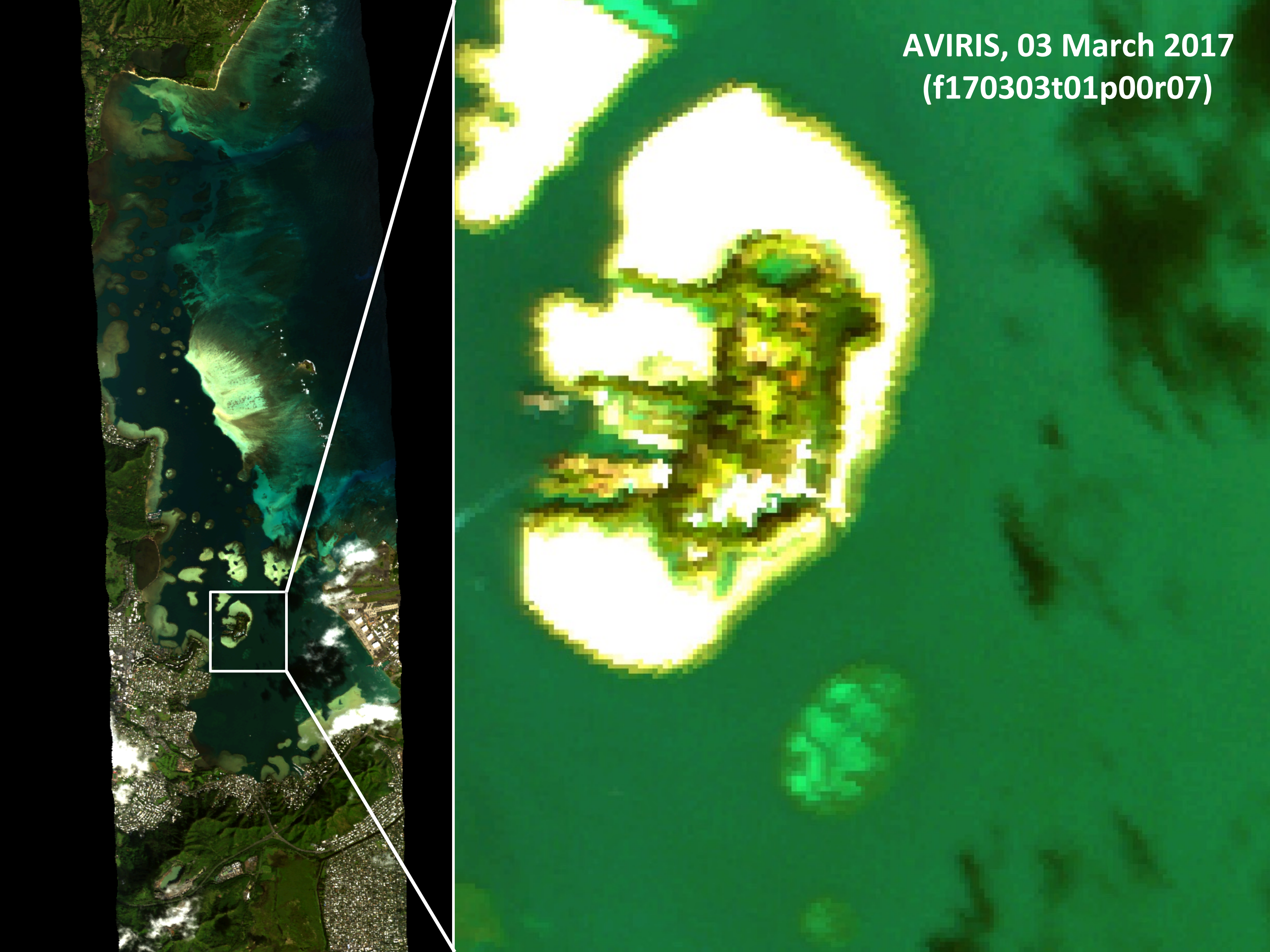
Primary Study Site



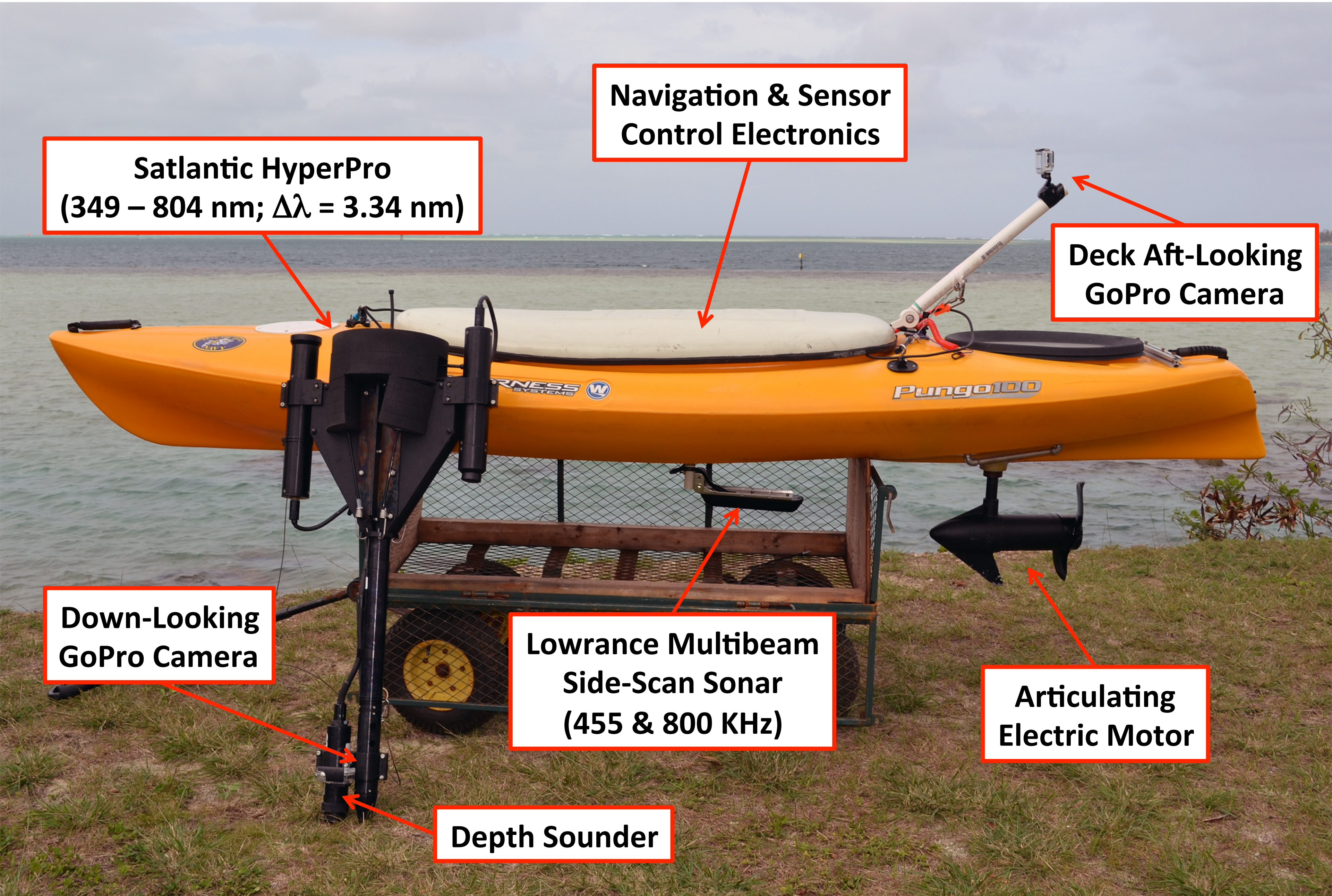




- Patch reef dredged during WWII
- Average Depth ≈ 4 m
- Reef Surveys: 12 & 18 February 2017
- AVIRIS Overflights:
  Jan 27, Feb 7,8 & 22, and Mar 3.

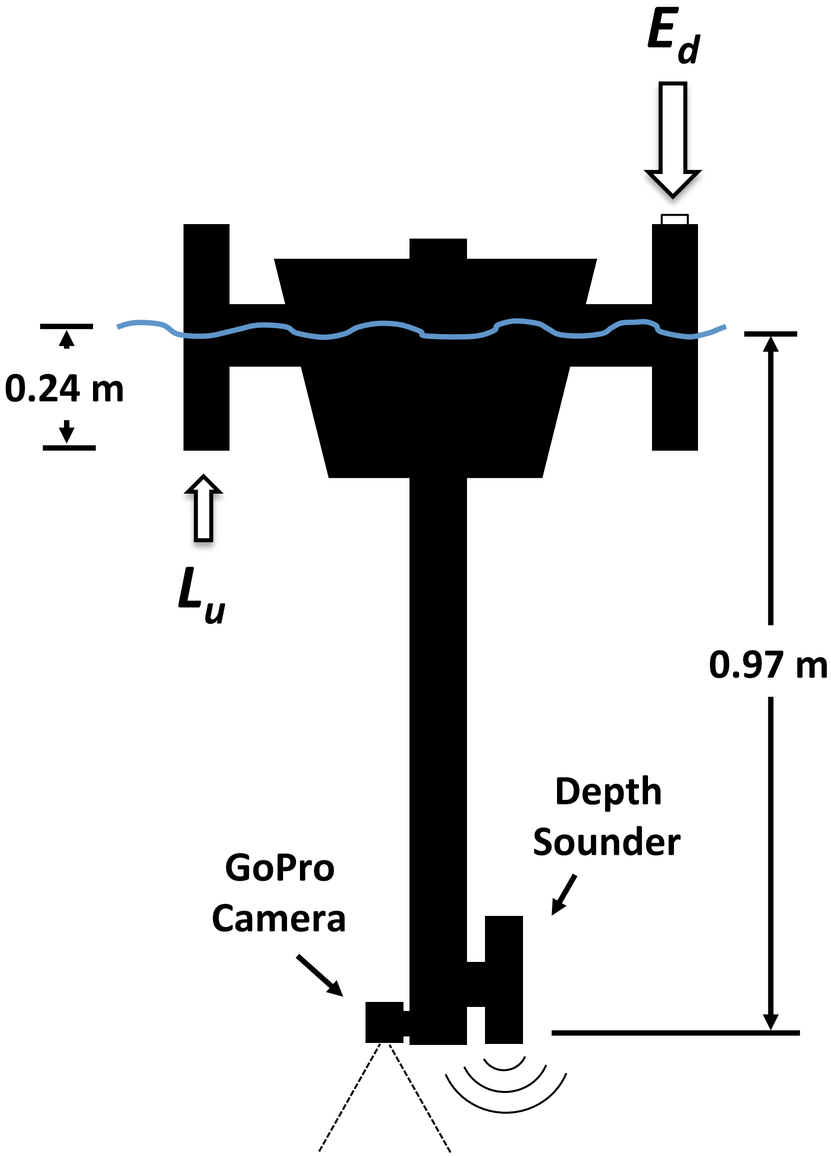

AVIRIS, 03 March 2017
(f170303t01p00r07)

Autonomous Kayak and Sensors



Towed Hyperspectral Radiometer System

Measurements



Computations

$$R_w = R_{od}\,(1 - e^{-KD}) + \frac{\rho_b}{\pi}\,e^{-KD}$$

R_w = water column reflectance
R_{od} = Optically deep water reflectance
D = water depth (m)
$K = K_d + K_u$
ρ_b = Bottom reflectance

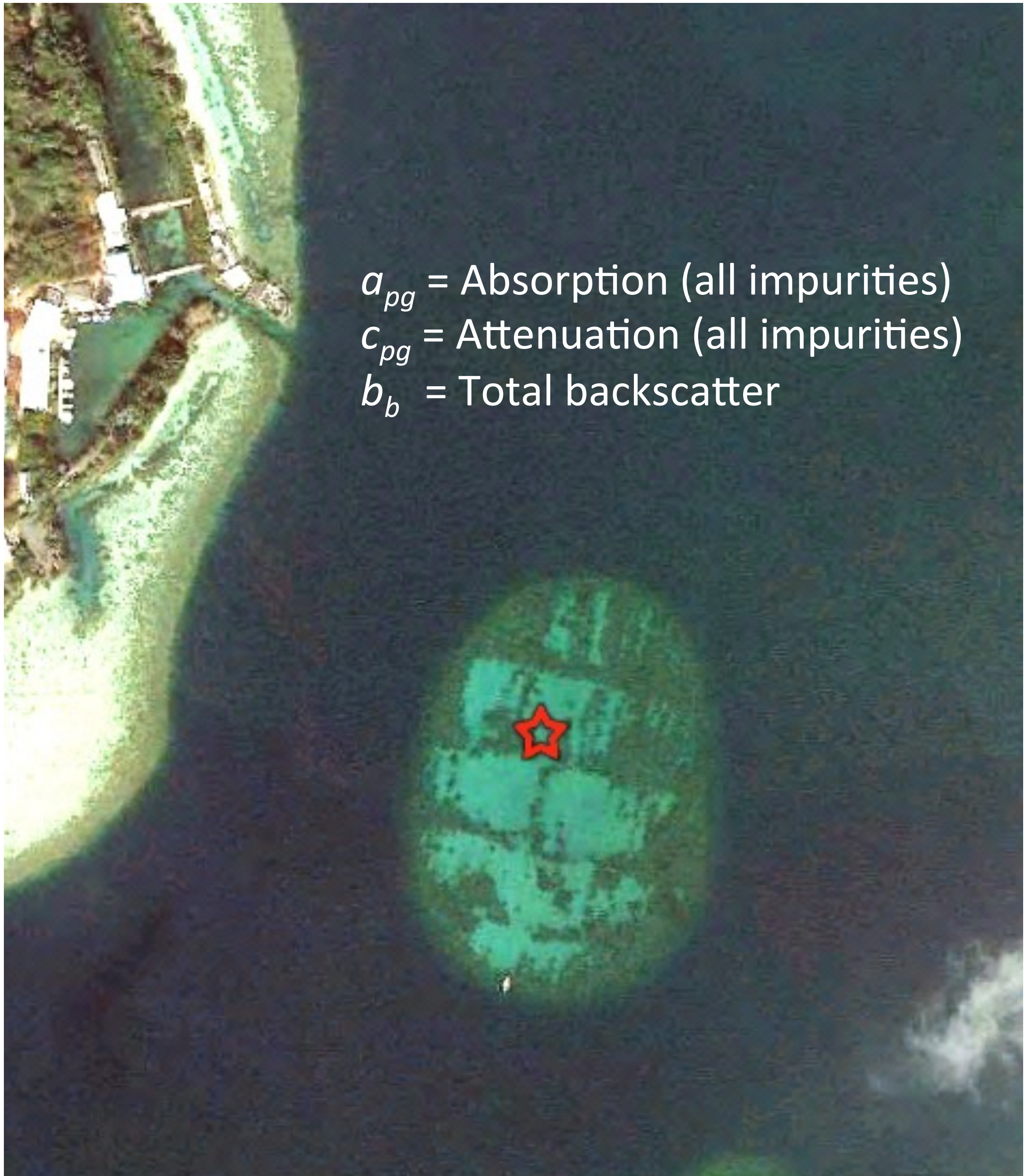
- Propagate E_d through water surface and down to 0.24 m using modeled values of K_d.
- Compute r_{rs} and invert the shallow-water equation for ρ_b.

$$\rho_b = \pi\,e^{KD}\left[R_w - R_{od}\,(1 - e^{-KD})\right]$$

- Compute R_{rs}.

In Situ Water Optical Properties: 17 February 2017

(B. Russell, UCONN)



Computations

- **Total absorption and scatter:**

$$a = a_{pg} + a_w$$
$$b = c_{pg} - a_{pg} + a_w$$

- **Diffuse Attenuation:**

$$K_\mu = \frac{b}{\mu}\left[1 + (0.425\,\mu - 0.19)\frac{b}{a}\right]^{1/2}$$

μ = average cosine

(Kirk, 1984)

- **Water Column Reflectance:**

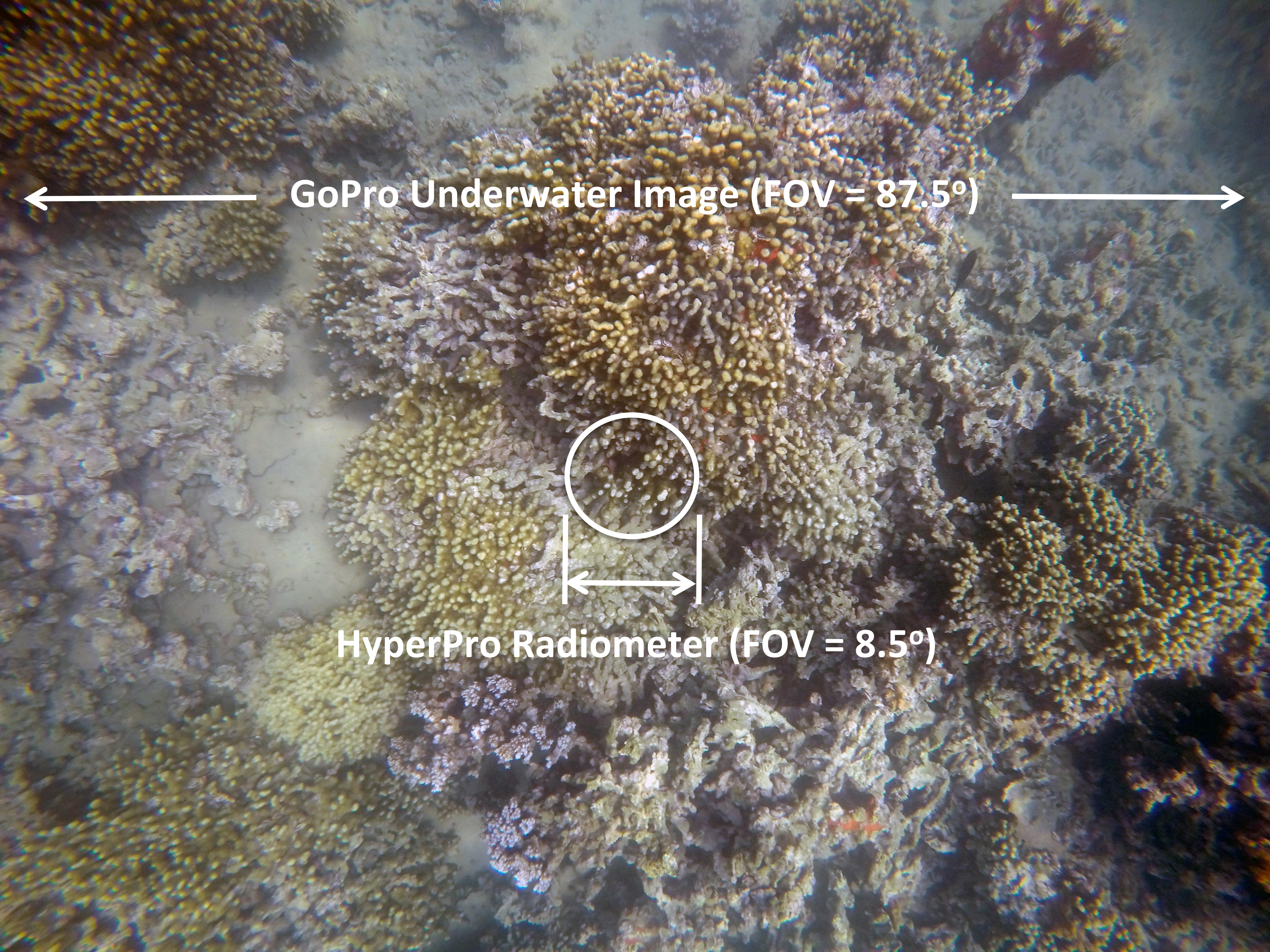
$$r_{rs} = \sum_{i=1}^{2} g_i \left(\frac{b_b}{a + b_b} \right)^i$$

$g_1 = 0.0949$; $g_2 = 0.0794$

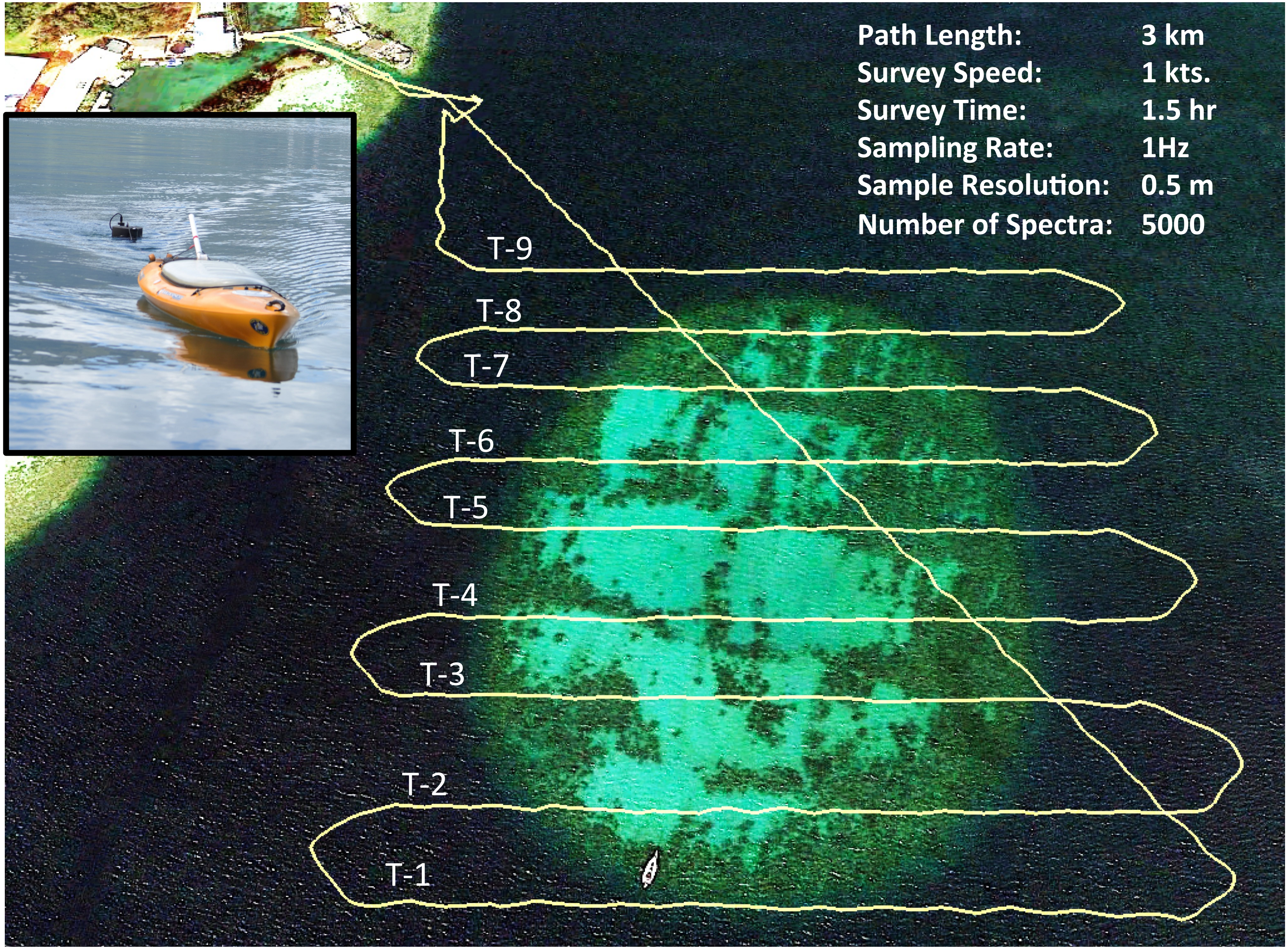
(Gordon et al., 1988)

- **Remote Sensing Reflectance:**

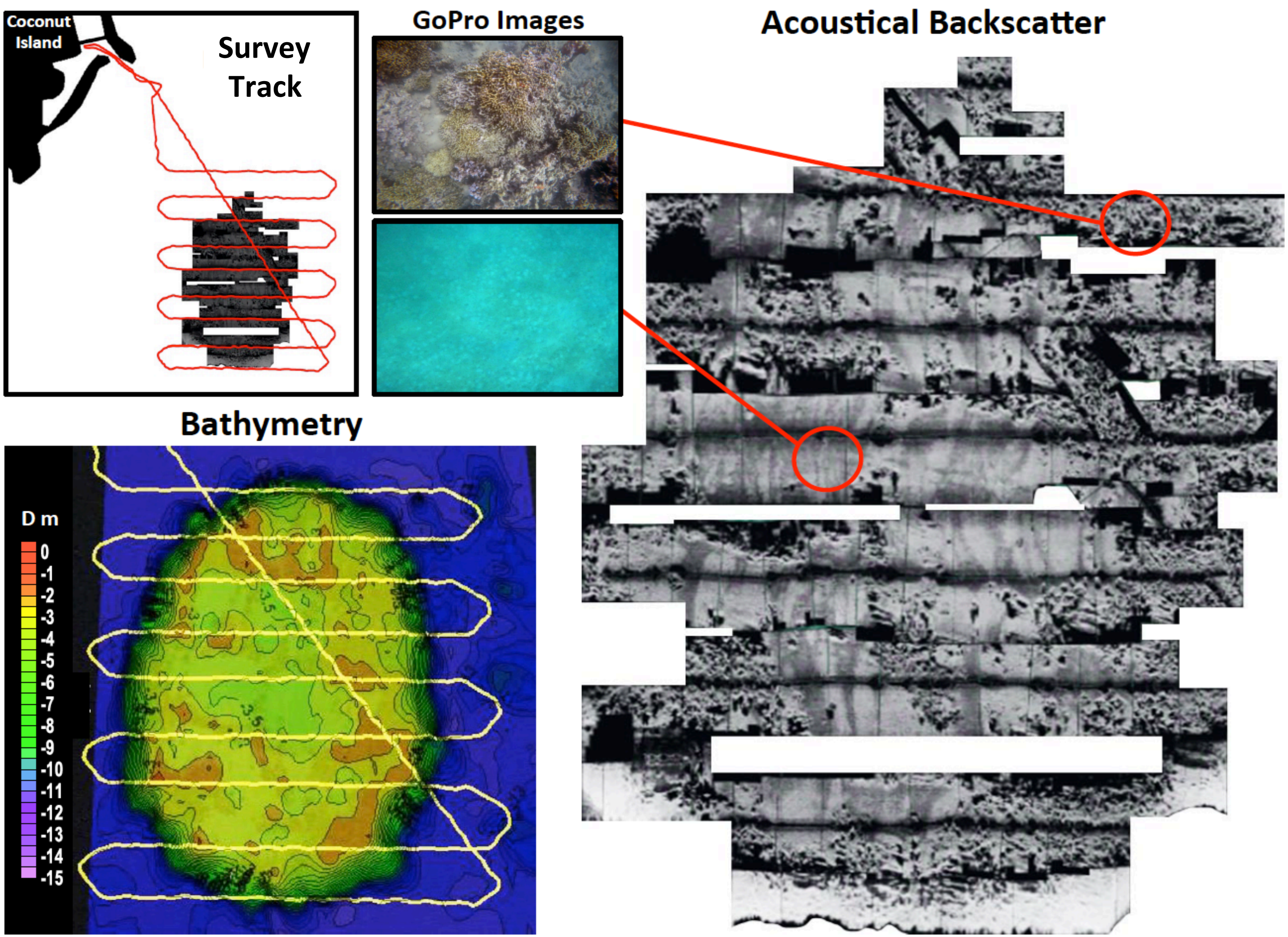
$$R_{rs} = \frac{0.52\, r_{rs}}{1 - 1.7\, r_{rs}}$$


GoPro Underwater Image (FOV = 87.5º)
HyperPro Radiometer (FOV = 8.5º)

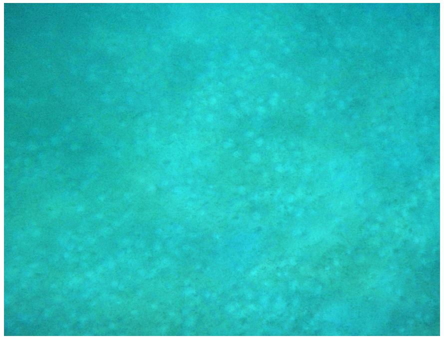
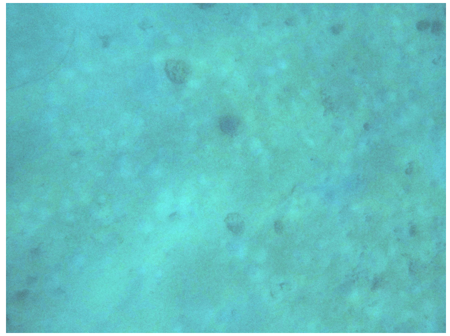
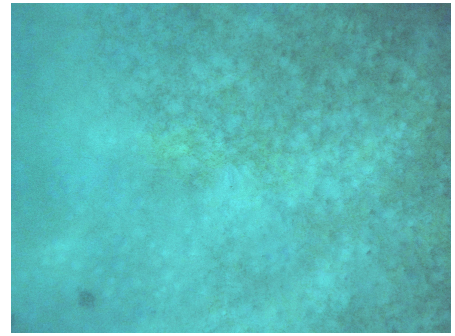
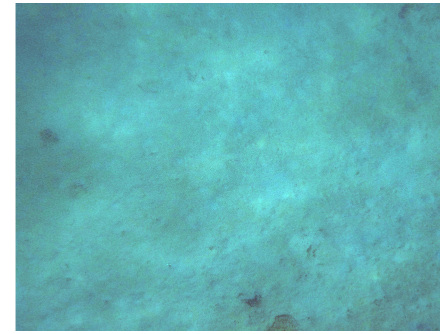
Survey Track: 12 February 2017



Bathymetric Information



Example Spectra: Sand

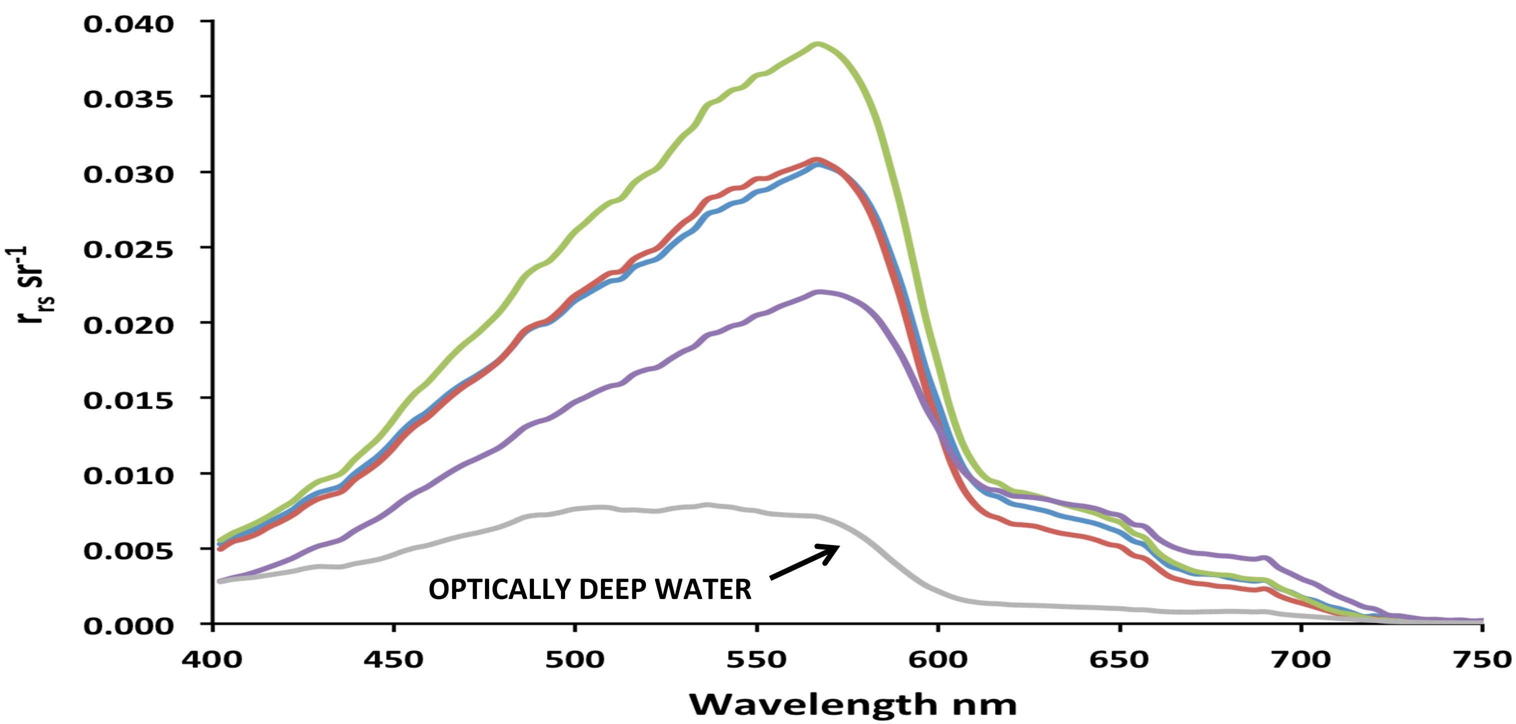





GoPro: 43431
Depth: 3.5 m

GoPro: 43500
Depth: 4.0 m

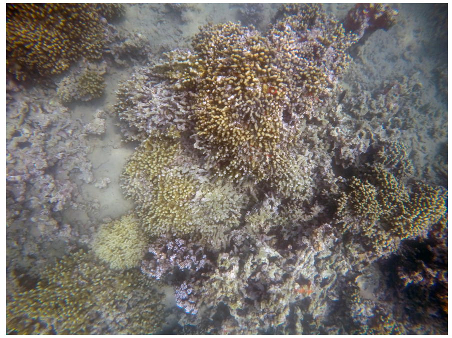
GoPro: 43537
Depth: 3.8 m

GoPro: 43602
Depth: 3.8 m

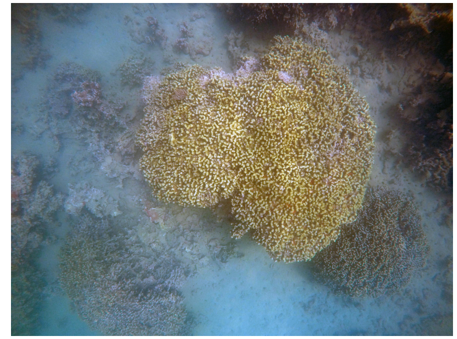


Example Spectra: Coral

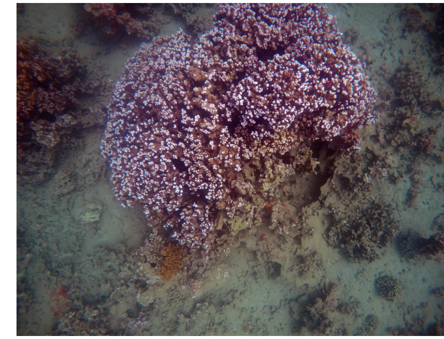
GoPro: 43348
Depth: 2.5 m



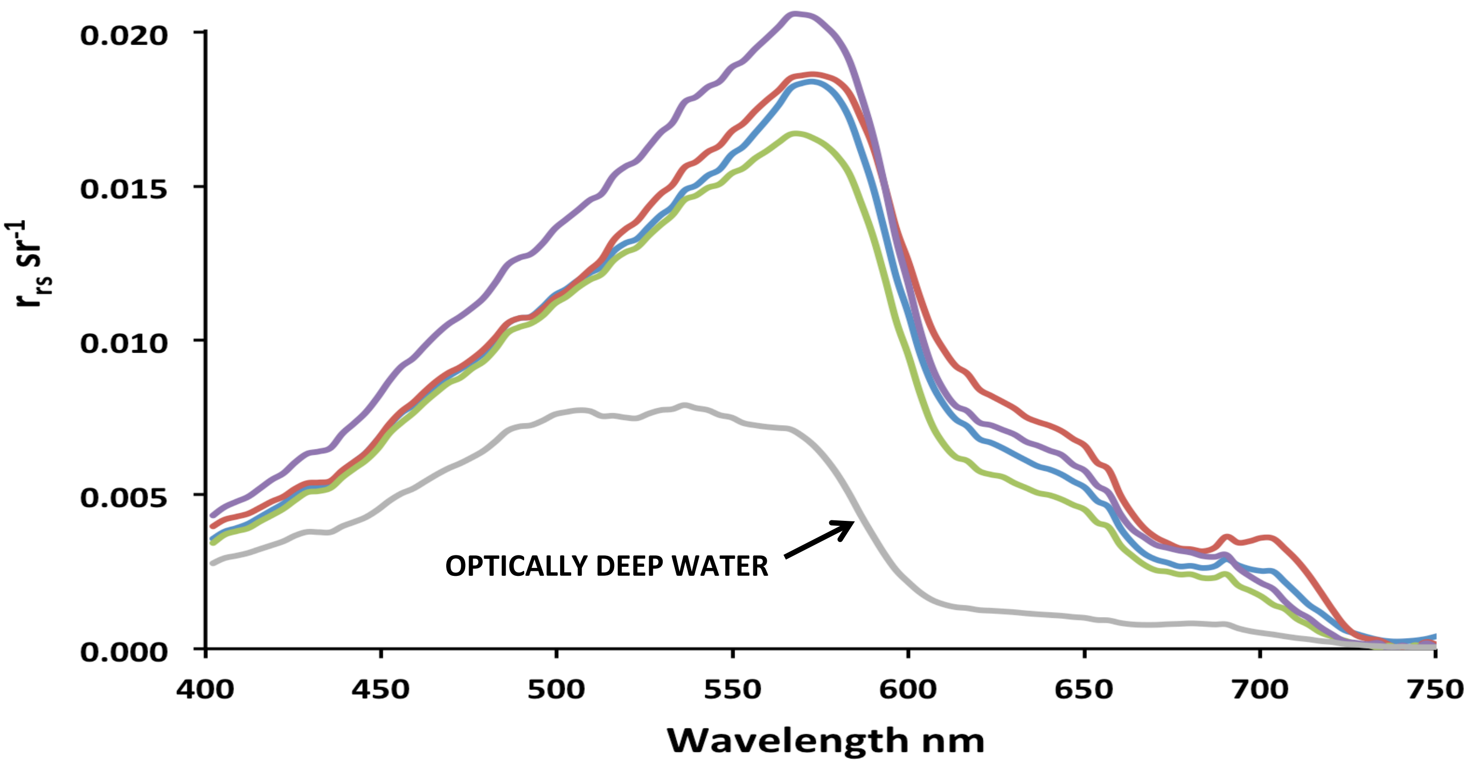
GoPro: 43386
Depth: 2.1 m



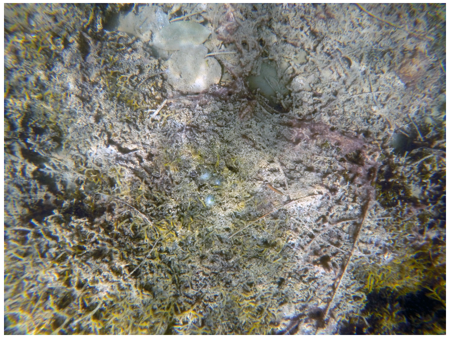
GoPro: 43571
Depth: 2.6 m



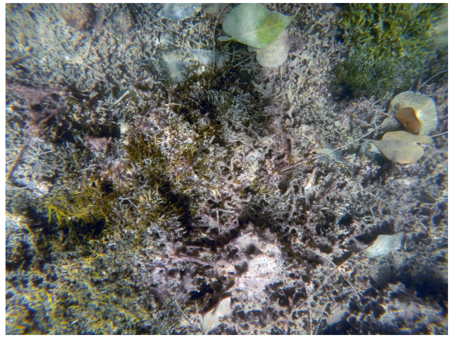
GoPro: 43648
Depth: 2.7 m



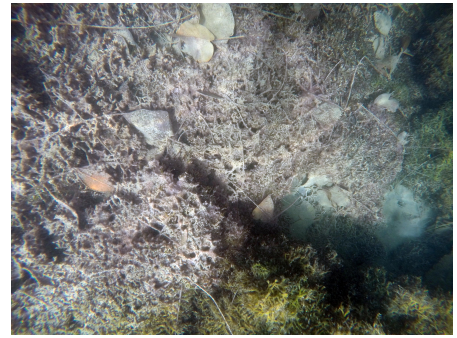
Example Spectra: Turf Algae



GoPro: 42803
Depth: 2.7 m

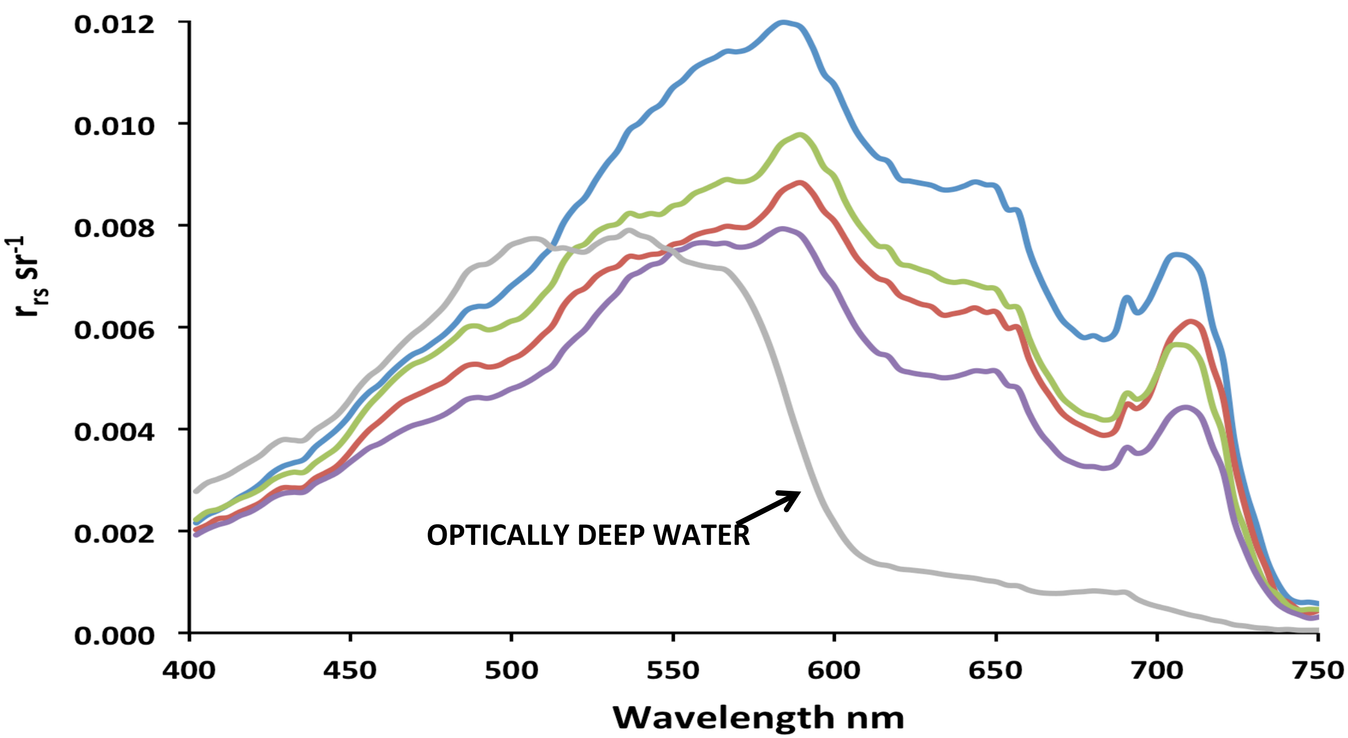


GoPro: 42807
Depth: 2.8 m

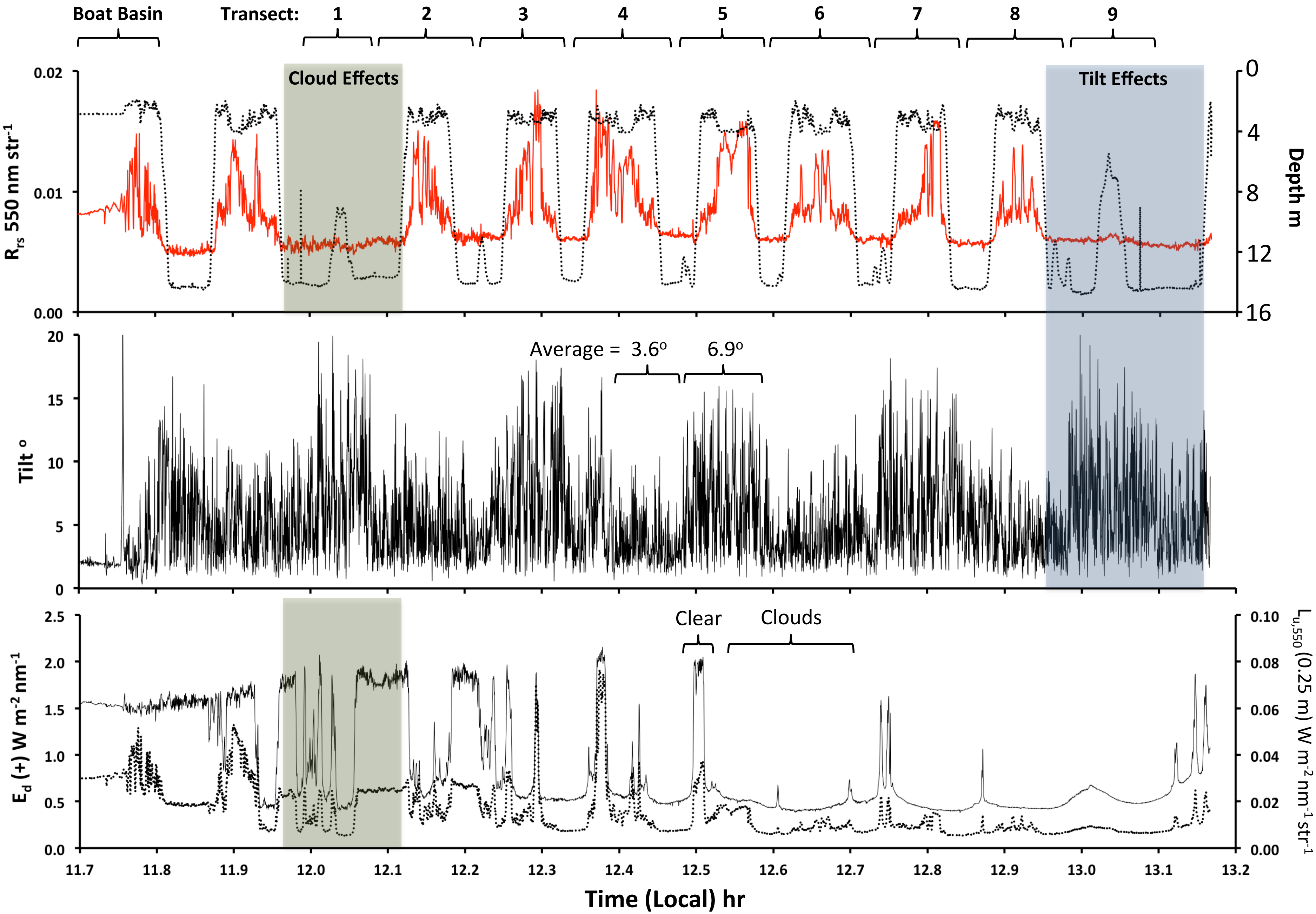


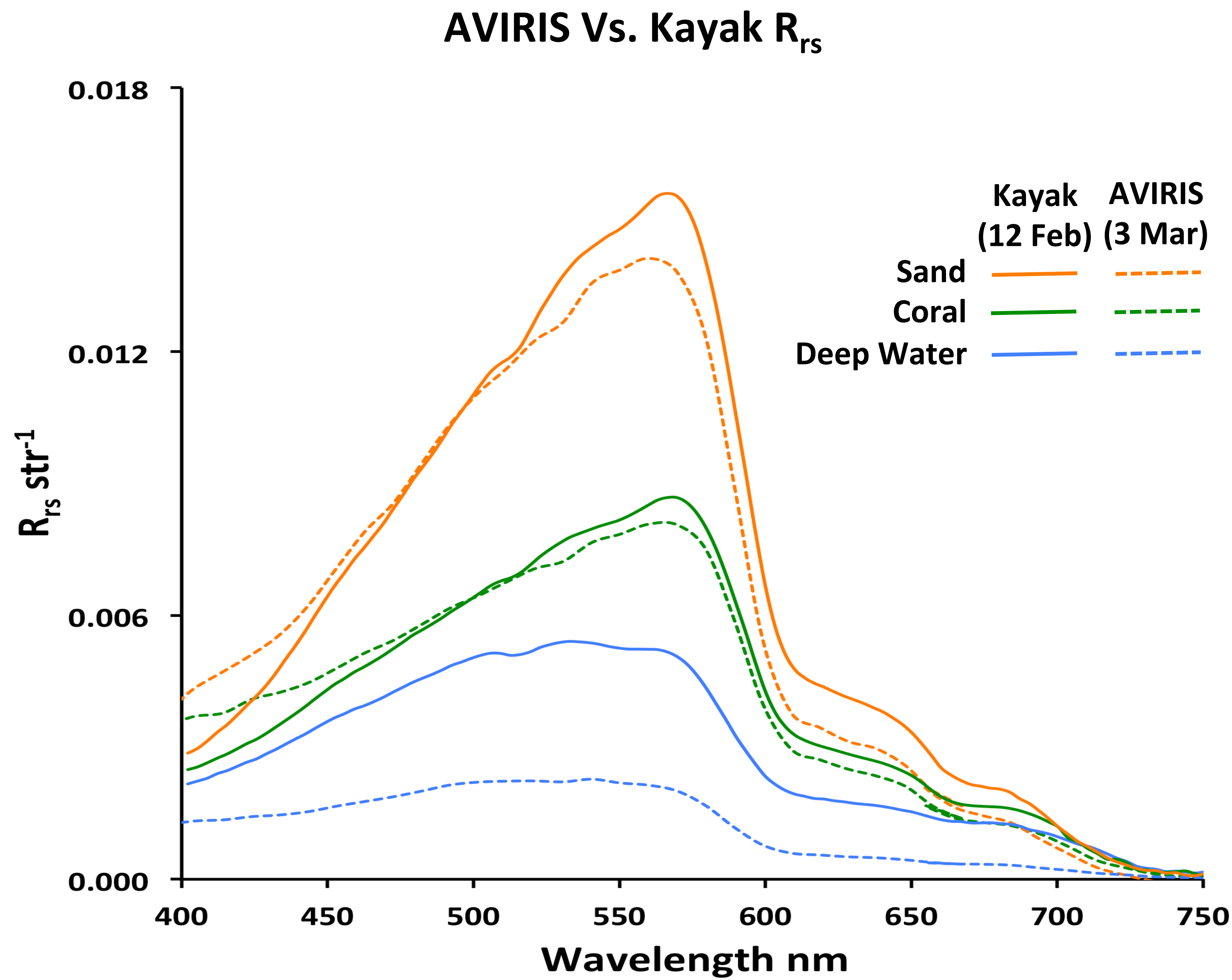
GoPro: 42811
Depth: 3.1 m

GoPro: 42820
Depth: 2.7 m



Effects of Buoy Orientation and Clouds?

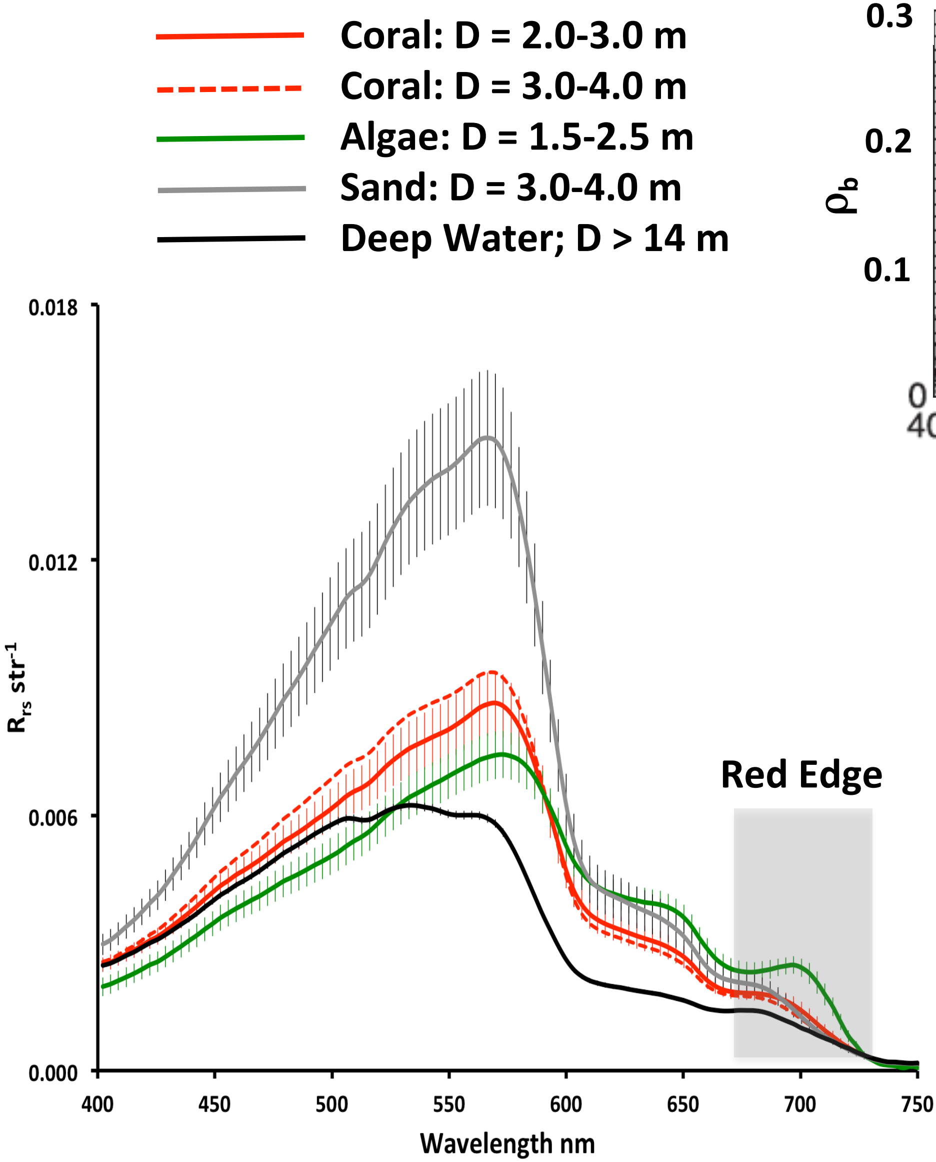




AVIRIS Vs. Kayak R_{rs}
0.018
0.012
0.006
0.000
R_{rs} str^{-1}
Kayak (12 Feb)
AVIRIS (3 Mar)
Sand
Coral
Deep Water
400
450
500
550
600
650
700
750
Wavelength nm

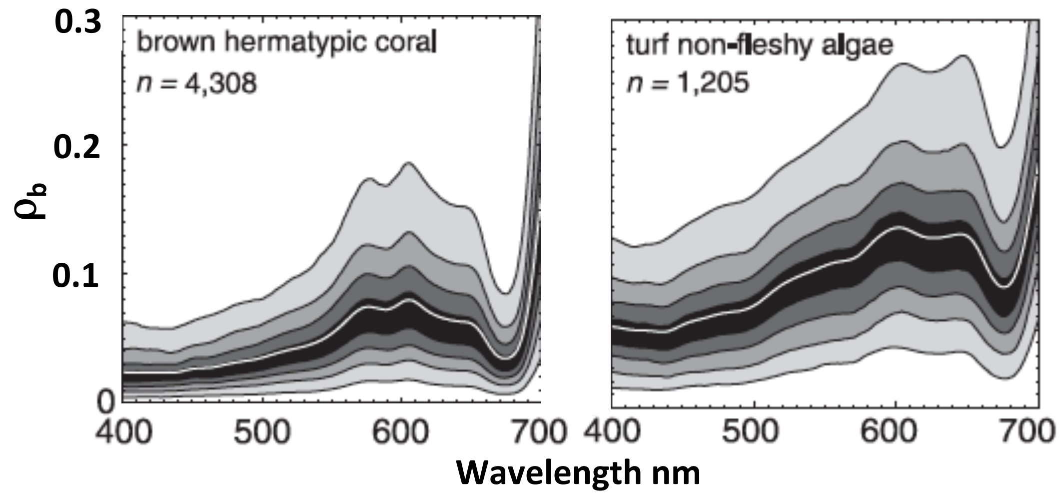
Red Edge Signal

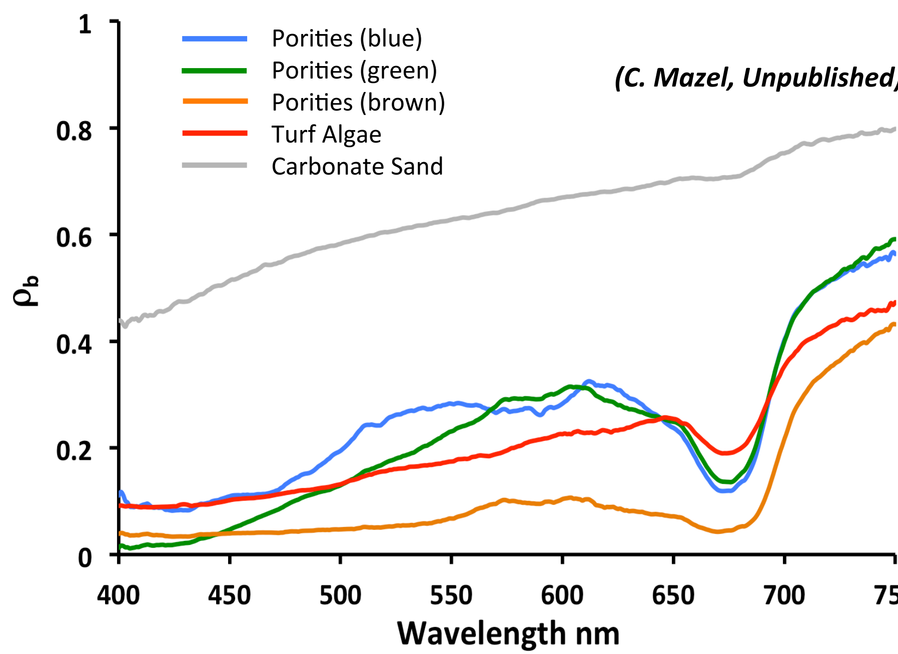
In Situ: Coconut Reef



Benthic Reflectance

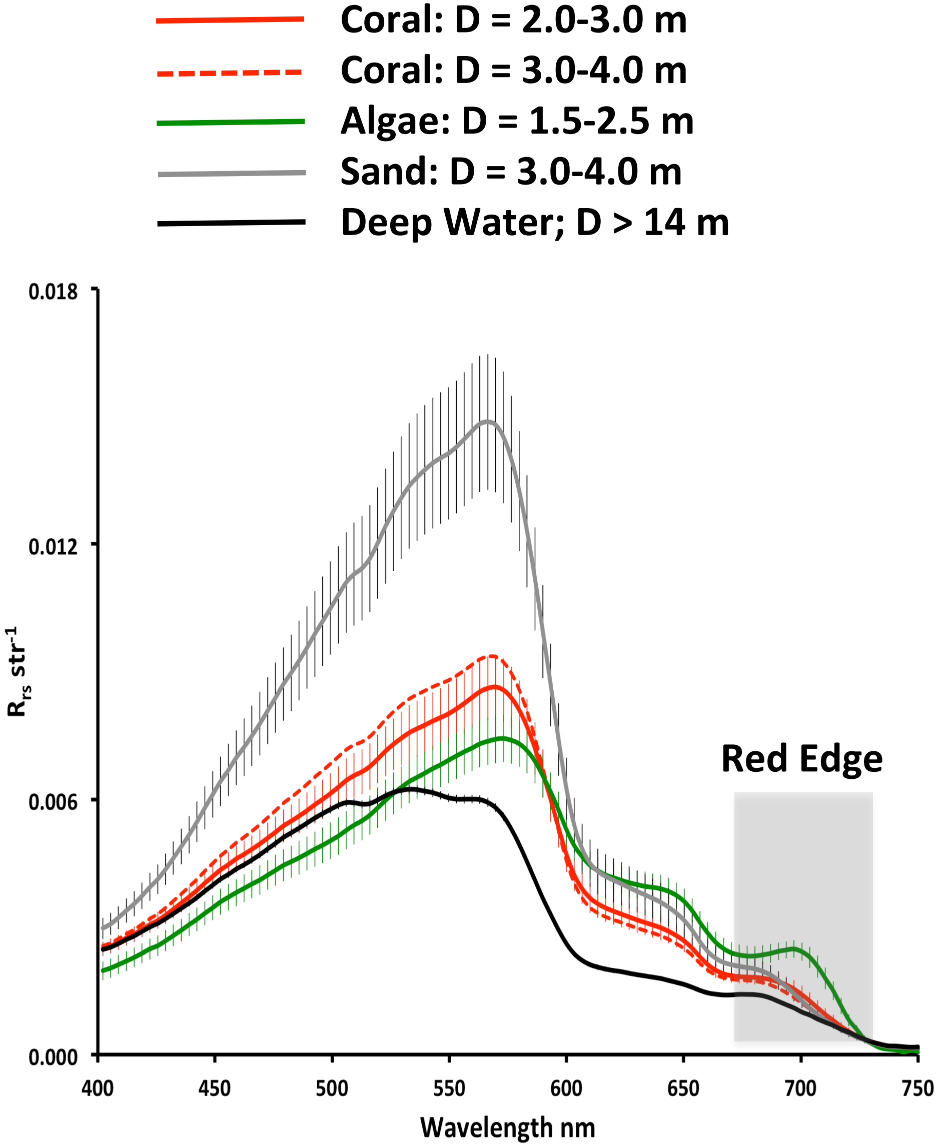
(Hochberg et al., 2003)



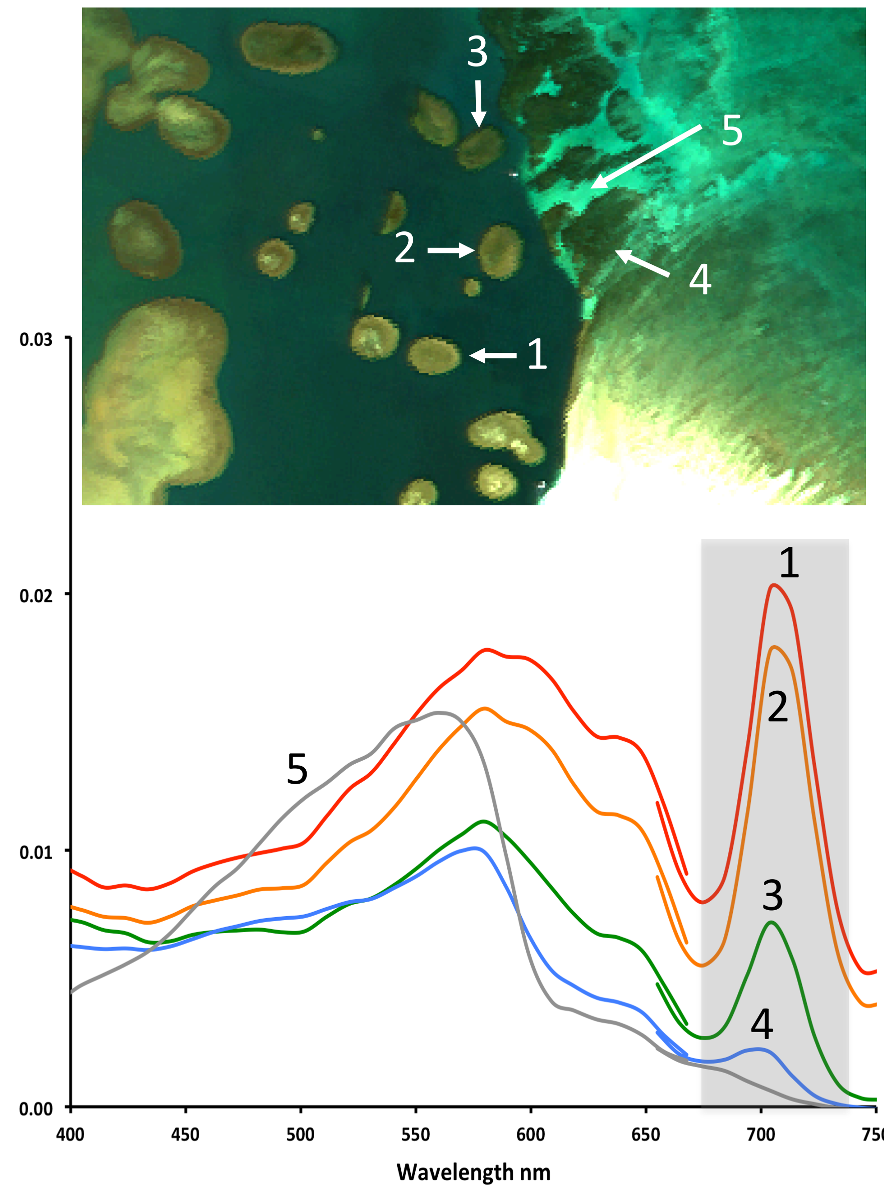


Red Edge Signal

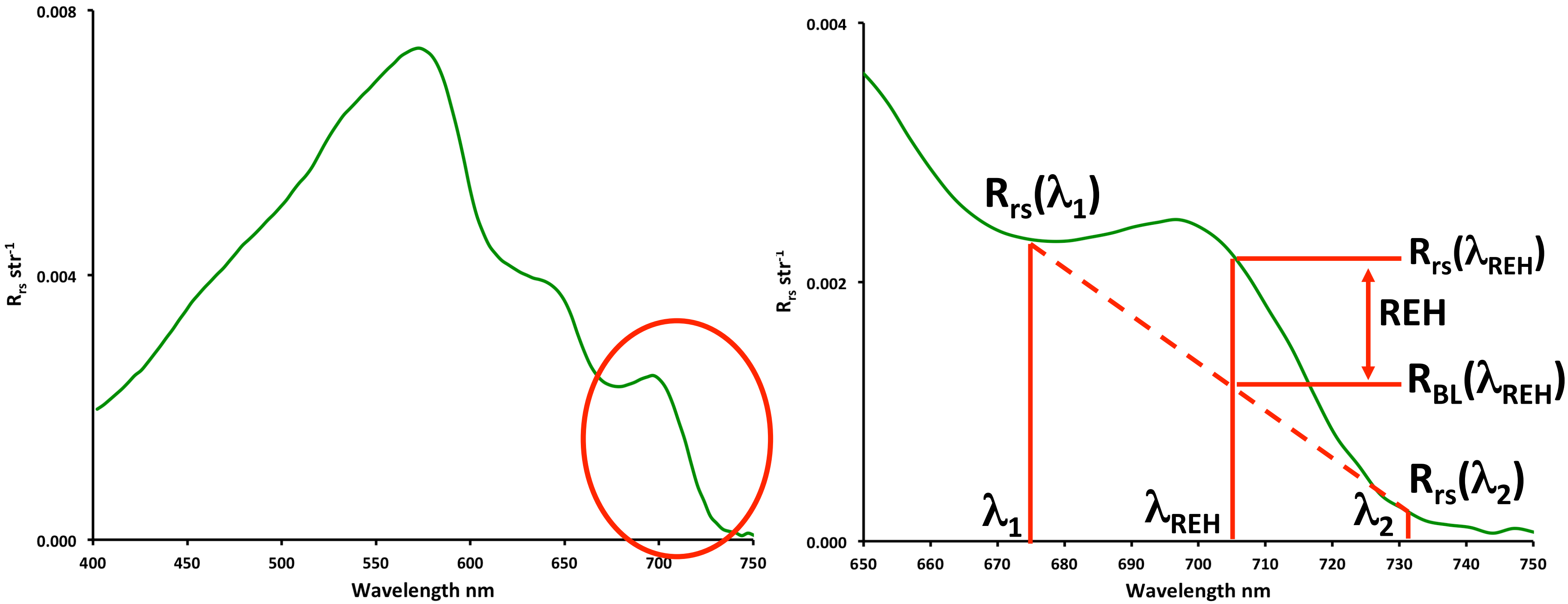
In Situ: Coconut Reef



AVIRIS: Patch Reefs



The Red Edge Height Computation

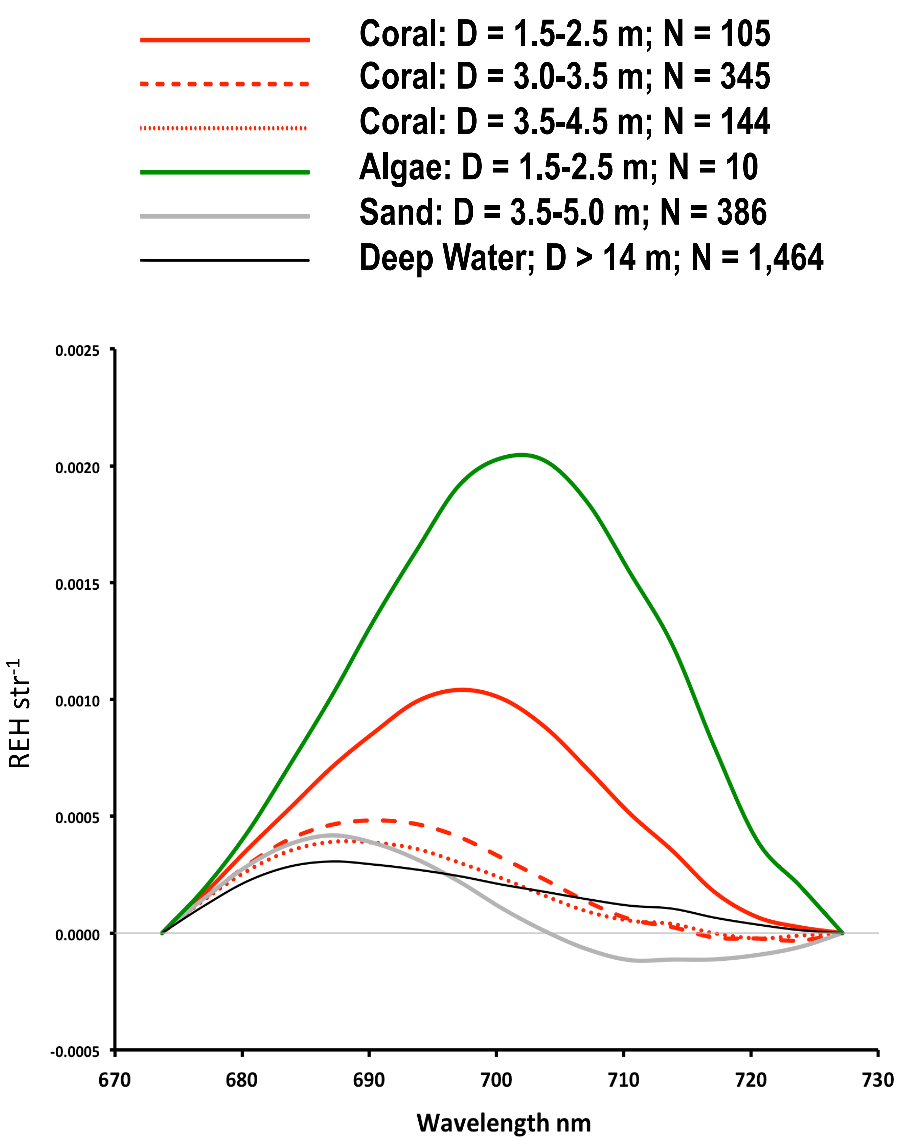


$$REH = R_{rs}(\lambda_{REH}) - R_{BL}(\lambda_{REH})$$

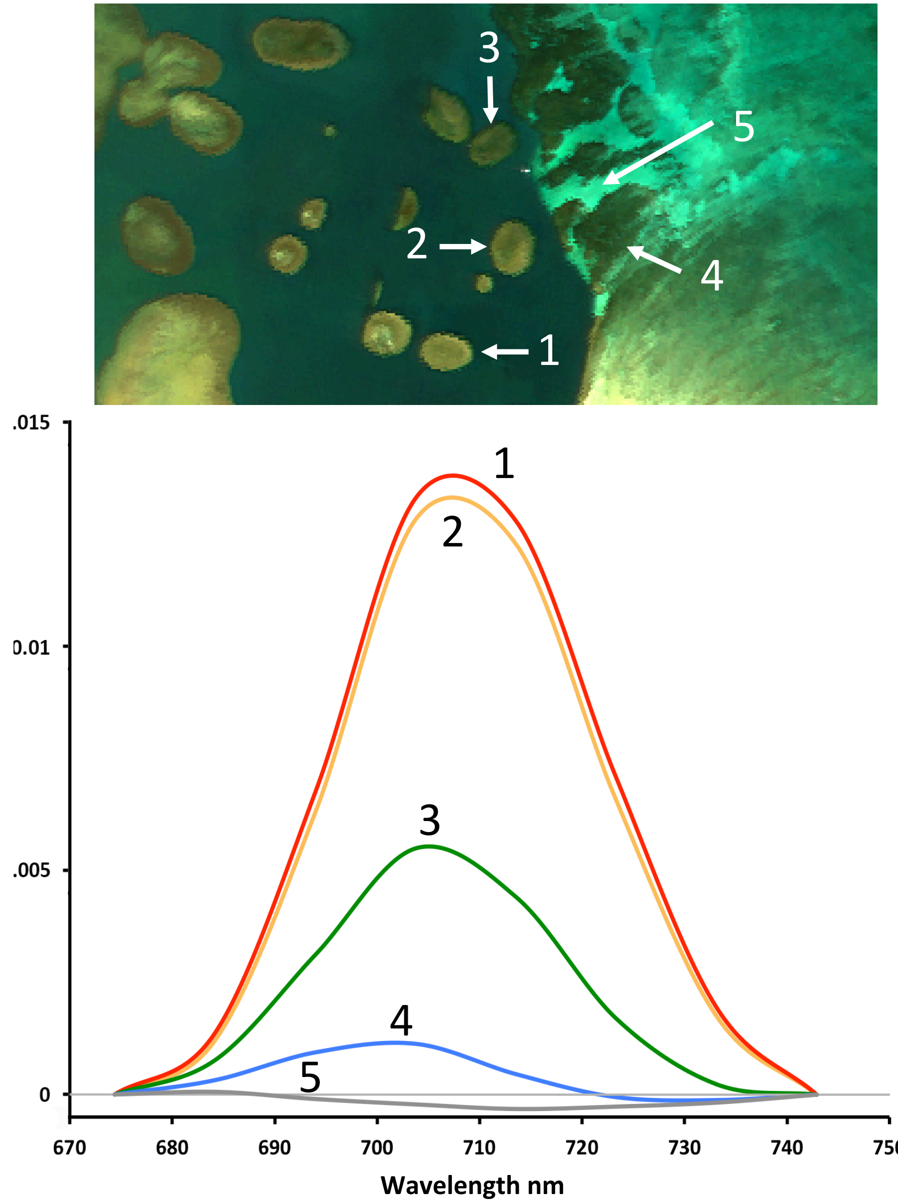
$$R_{BL}(\lambda_{REH}) = \frac{r_{rs}(\lambda_2) - r_{rs}(\lambda_1)}{\lambda_2 - \lambda_1} \bullet (\lambda_{REH} - \lambda_1) + R_{rs}(\lambda_1)$$

Red Edge Height

In Situ: Coconut Reef



AVIRIS: Patch Reefs



Concluding Remarks

- **Autonomous approaches to collecting in situ observations over shallow coastal environments (e.g., coral reefs) in support of remote sensing are emerging rapidly.**
- **The diversity of conditions represented within autonomous data sets allows many more questions to be asked within the context of remote sensing including vicarious calibration, sources of uncertainty, and empirical approaches to algorithm development.**
- **In situ reflectance does not appear to be significantly impacted by radiometer orientation or cloud cover.**
- **A preliminary comparison between AVIRIS and in situ reflectance is quite good in both magnitude and spectra.**