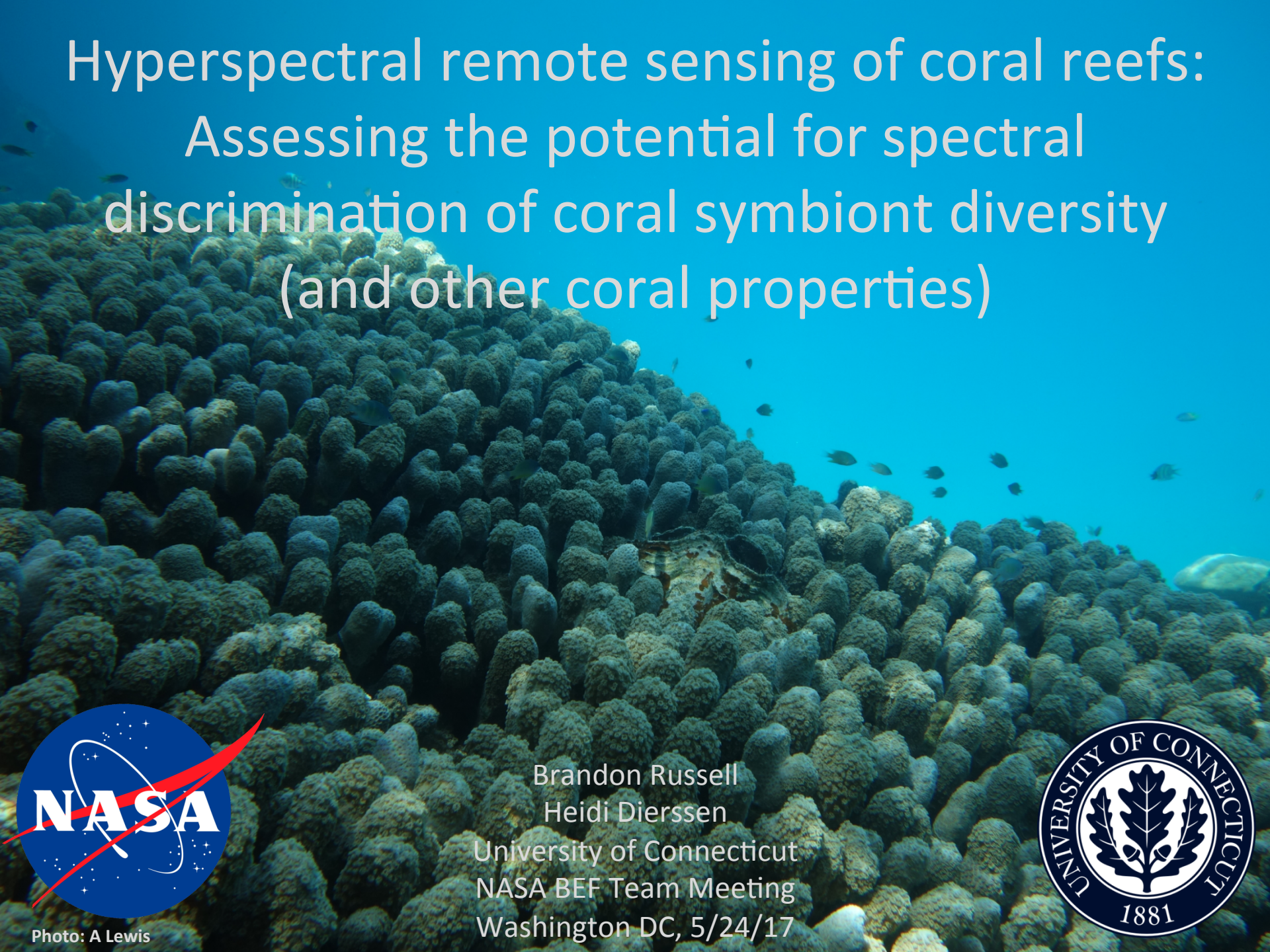
Hyperspectral remote sensing of coral reefs: Assessing the potential for spectral discrimination of coral symbiont diversity (and other coral properties)



Brandon Russell
Heidi Dierssen
University of Connecticut
NASA BEF Team Meeting
Washington DC, 5/24/17

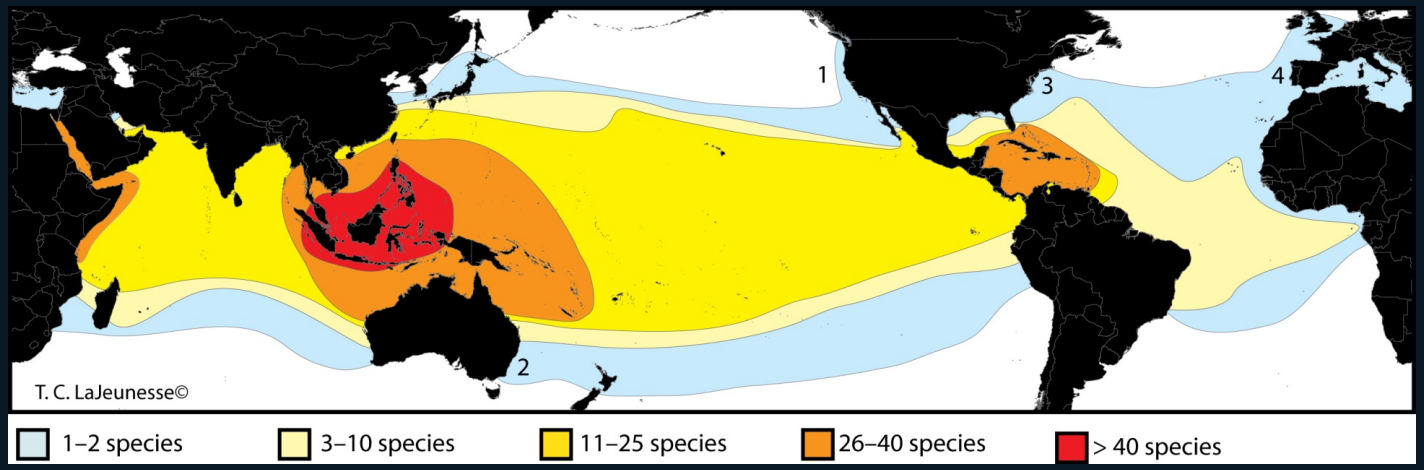
Photo: A Lewis

Research Questions

How coral reflectance varies and how this variability influences the uncertainties in *Rrs* in response to:

- Diversity of host and symbiont species (intact associations)
- Concentration and type of pigment in both host and symbiont
- Coral morphology
- Environmental variability: temperature, nutrients, water clarity

Symbiont Diversity



Cnidarian/dinoflagellate symbiosis

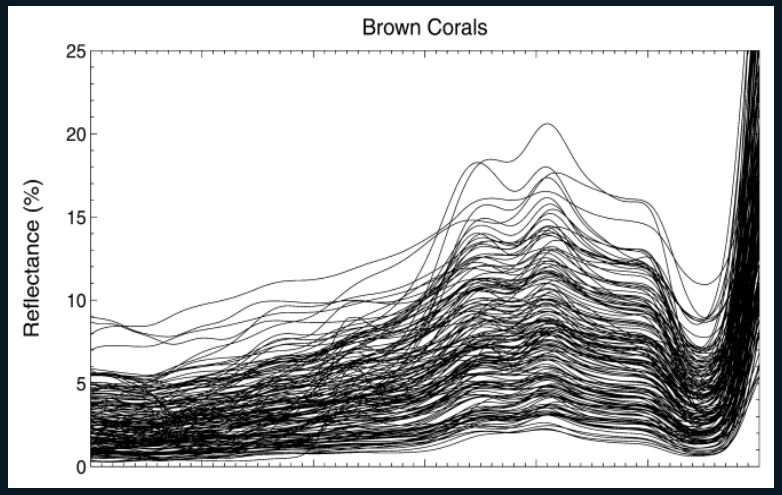
Eight genetic lineages, clades
Multiple subtypes/species

Variability in tolerance of host/symbiont assemblage to environmental stress

R(λ) driven by combination of algal and host pigments

Spectral Discrimination of Corals

- Globally coral reflectance is very similar, including “tri-peak,” brown /blue mode
- Some success discriminating coral species, pigment content through $R(\lambda)$
- Discrimination of coral from other benthic types



Hochberg 2004

Remote Sensing
ISSN 2072-4292
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Article

Hyperspectral Distinction of Two Caribbean Shallow-Water Corals Based on Their Pigments and Corresponding Reflectance

Juan L. Torres-Pérez [1,*], Liane S. Guild [2] and Roy A. Armstrong [3]

PLOS | ONE

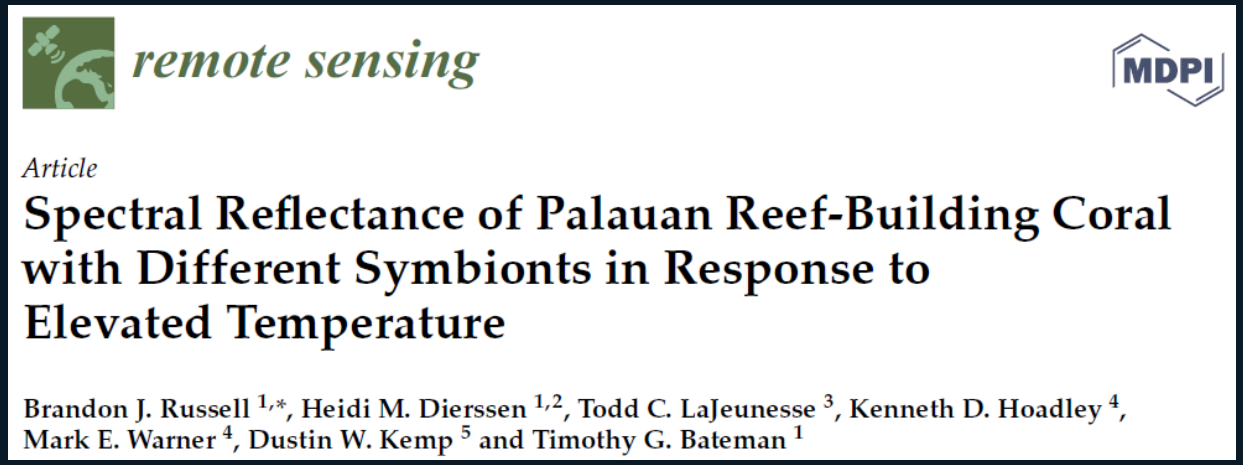
RESEARCH ARTICLE

Relative Pigment Composition and Remote Sensing Reflectance of Caribbean Shallow-Water Corals

Juan L. Torres-Pérez[1]*, Liane S. Guild[2], Roy A. Armstrong[3], Jorge Corredor[4], Anabella Zuluaga-Montero[5], Ramón Polanco[6]

CORAL
COral Reef Airborne Laboratory

Symbionts?



remote sensing

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Article

Spectral Reflectance of Palauan Reef-Building Coral with Different Symbionts in Response to Elevated Temperature

Brandon J. Russell [1,*], Heidi M. Dierssen [1,2], Todd C. LaJeunesse [3], Kenneth D. Hoadley [4], Mark E. Warner [4], Dustin W. Kemp [5] and Timothy G. Bateman [1]

Current spectral endmember library based on coral species, but associated symbionts unknown

Symbionts?

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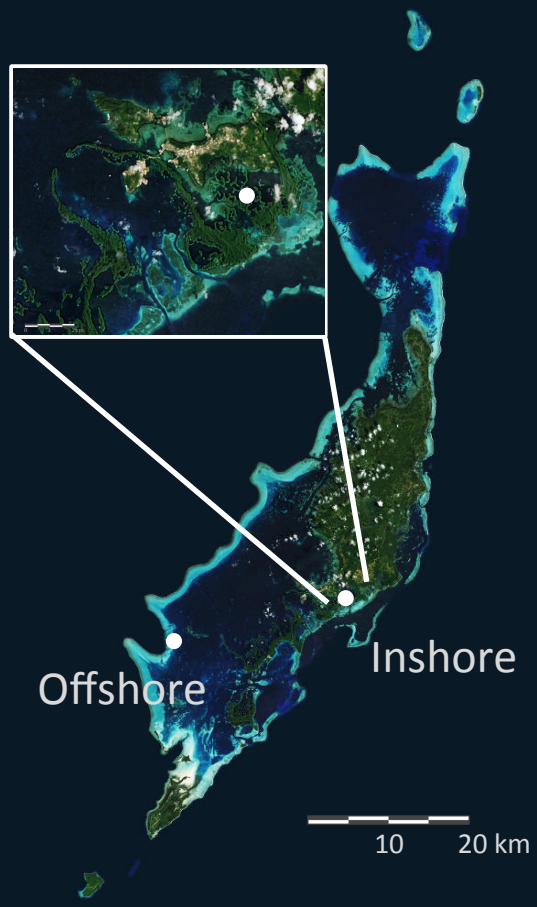

Current spectral endmember library based on coral species, but associated symbionts unknown

Examined *R*(λ) of corals of the same species with symbionts adapted to different environments:

- *Symbiodinium trenchii* – opportunistic generalist
- *Symbiodinium* Clade C – oceanic type

Symbionts?

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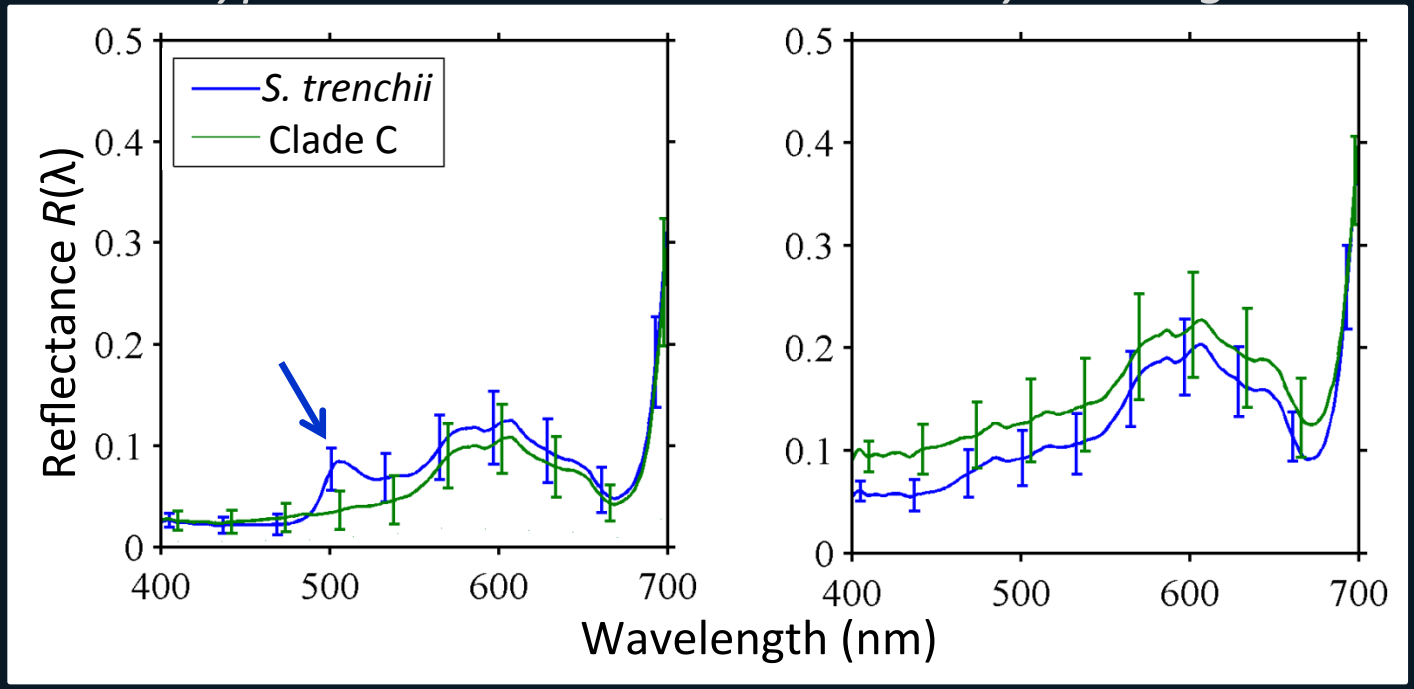

Symbionts?

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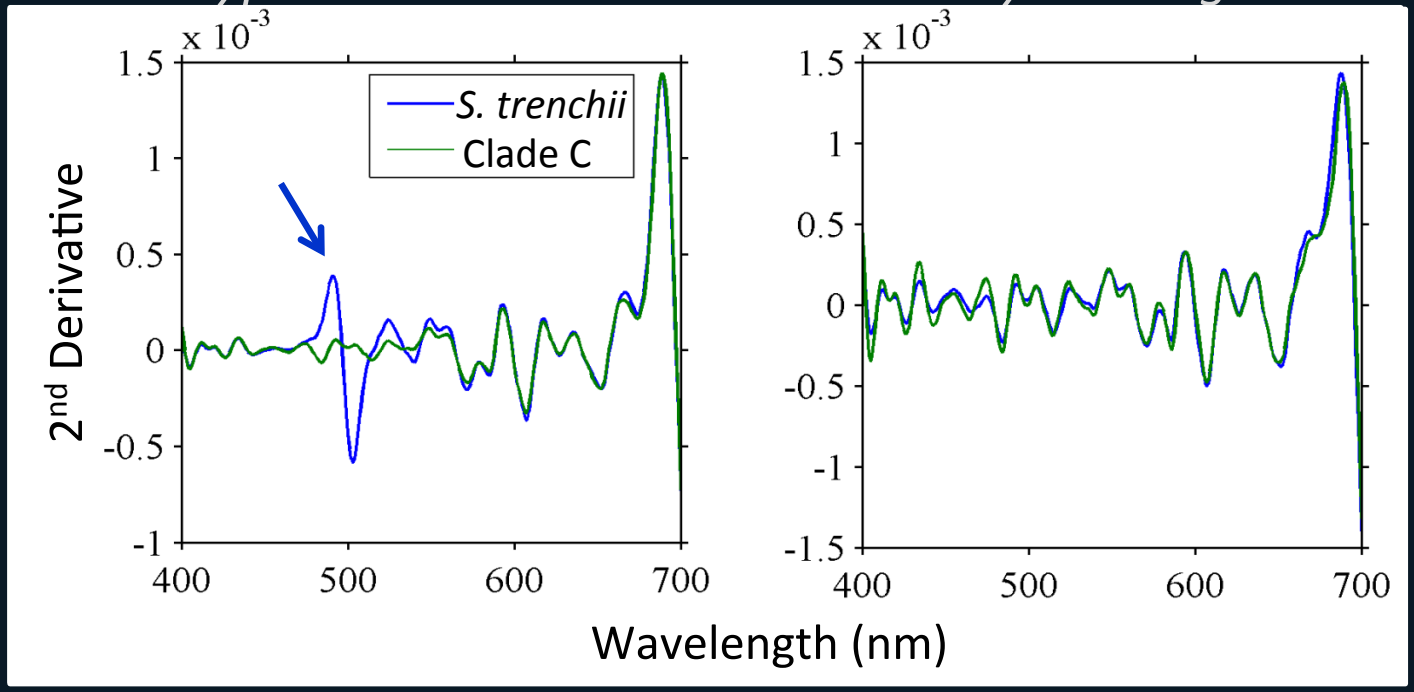

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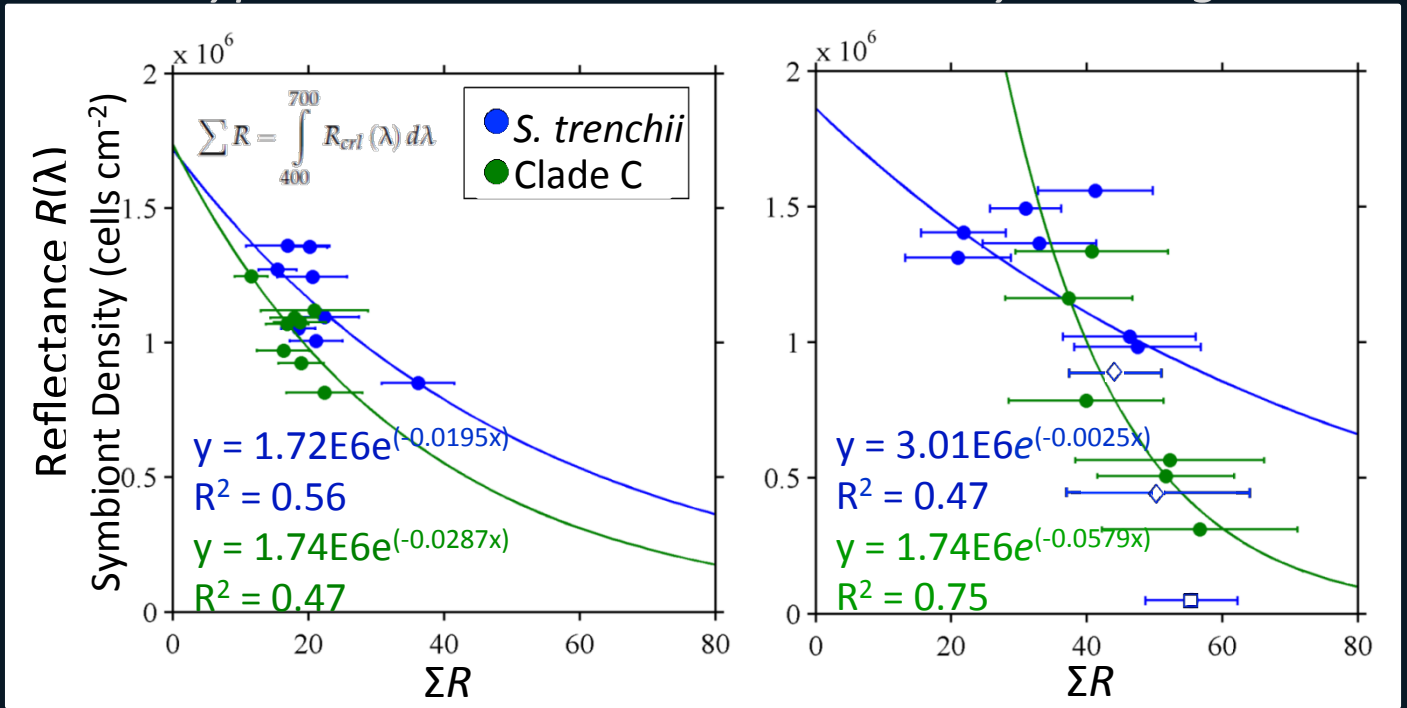


Going Forward?

Lack of spectral signature to differentiate clades of symbionts within the same host suggests symbionts may not be differentiated spectroscopically

Consistency in coral reflectance indicates that a single endmember could be used in remote sensing models independent of symbiont

Species-specific relationships between reflectance and *Symbiodinium* density may be useful to assess symbiont concentration and initiation of bleaching, if benthic $R(\lambda)$ is retrieved with adequate accuracy

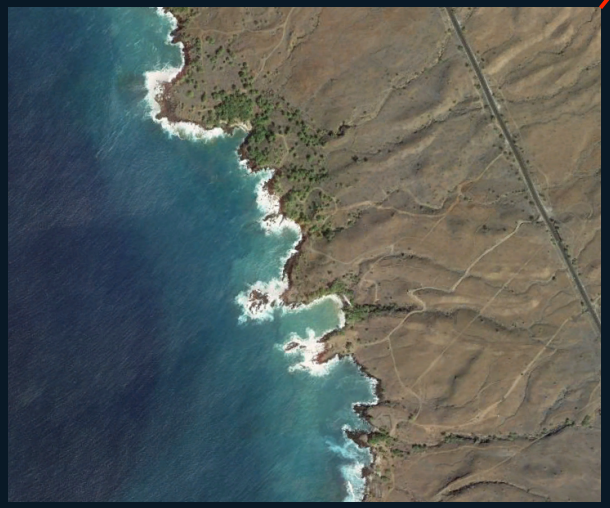
Variability in coral reflectance with morphology, depth, water column optics, etc. remains poorly constrained

Field Work – HyspIRI Hawaii Feb 2017

Field Work – HyspIRI Hawaii Feb 2017

Collection of live coral samples across multiple locations, water types, depths, species

Field Work – HyspIRI Hawaii Feb 2017



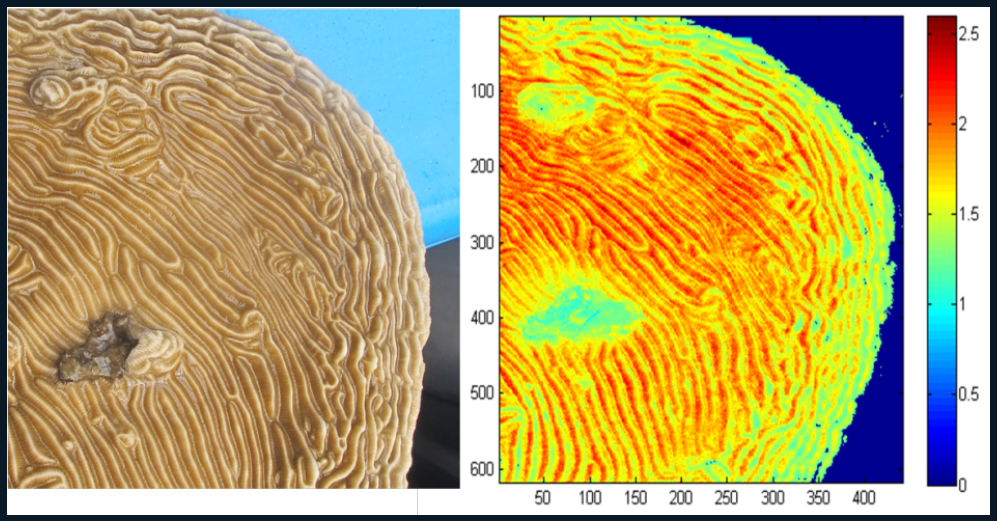
Field Work – HyspIRI Hawaii Feb 2017

Porites lobata

Porites compressa

Montipora capitata

Field Work – HyspIRI Hawaii Feb 2017



Reflectance

- Hyperspectral imaging of large coral samples, preserving morphology

Genetics/HPLC

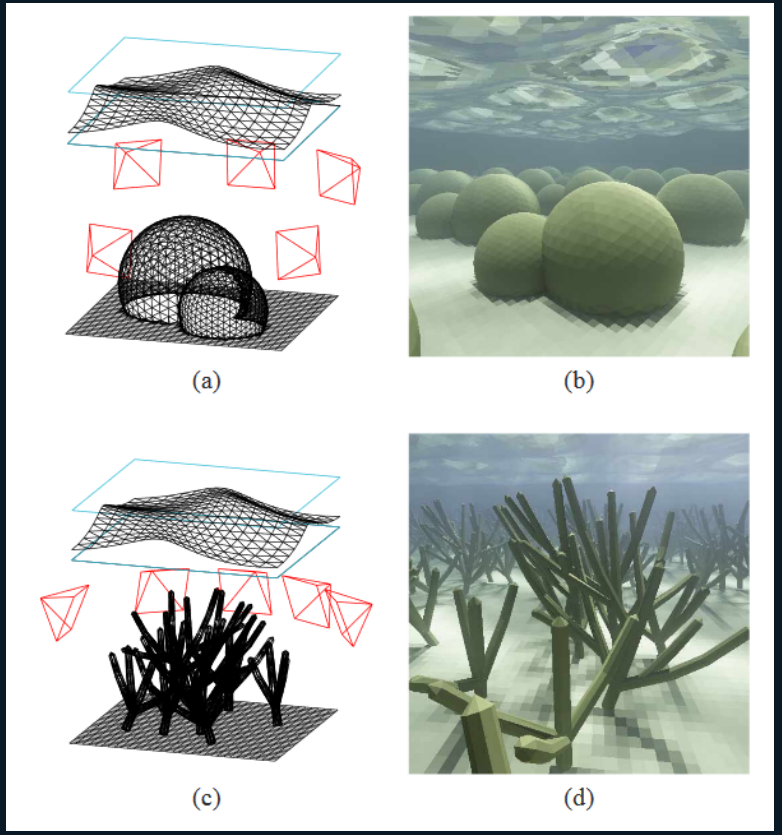
- Symbiont identity/diversity
- Pigment concentrations

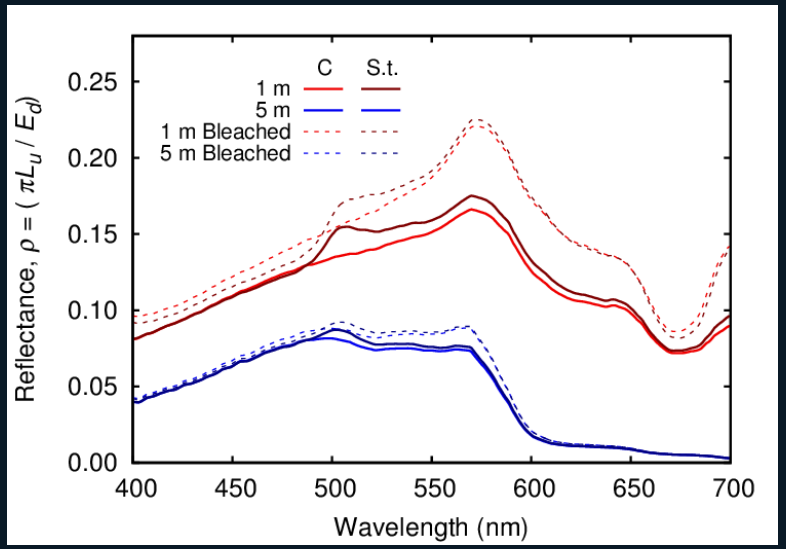
Modeling

Hyperspectral inversion modeling

- Multiple coral morphologies, relative angles to nadir, $R(\lambda)$, IOPs, depths, etc.
- Uncertainty development and propagation integrating field measurements
- Sensitivity analysis with inversion model to determine water depth, clarity at which spectral changes in coral reflectance could be differentiated using hyperspectral remote sensing

Software - John Hedley, Environmental Computer Science Ltd.





Spectral discrimination of symbiont types may not be challenging, but further study needed

Symbiont density can be assessed spectrally, with characterization

Sources of variation in coral reflectance may lead to uncertainties in remotely sensed products. Recently collected field data can be integrated with modeling studies