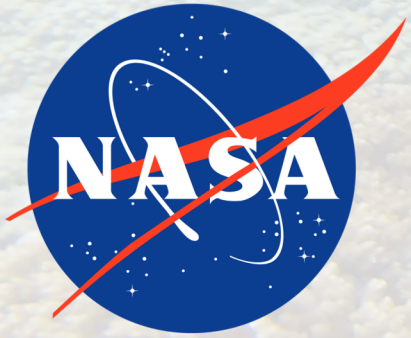
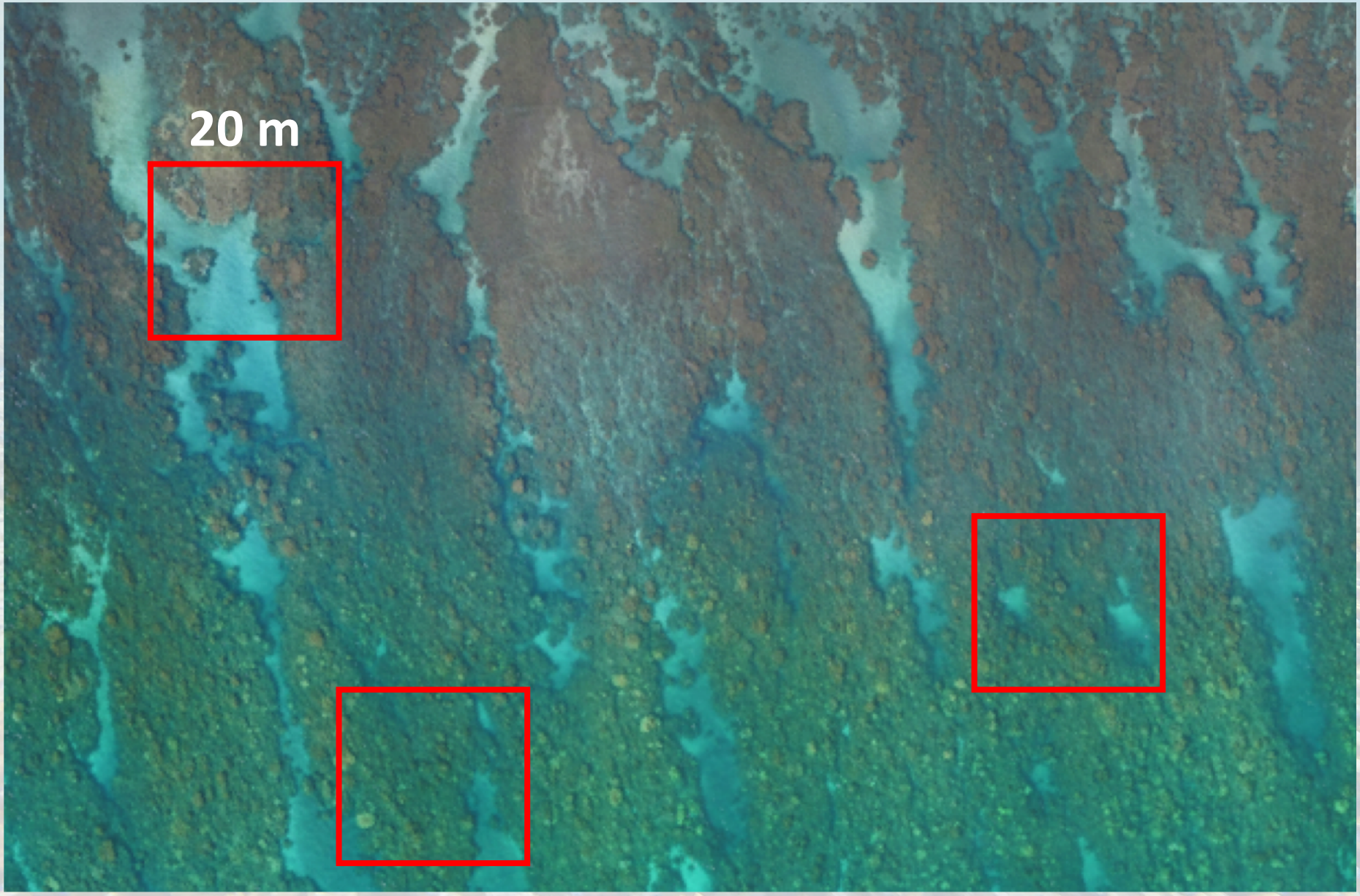
Using HysplRI to Identify Benthic Composition in Shallow Coral Reef Ecosystems

Tom Bell
PIs: Kyle Cavanaugh & Greg Okin




20 m

Overarching Project Goals

Will the spectral characteristics of HyspIRI-like data allow for the accurate retrieval of reef benthic composition?

1. **Simulation analysis** to characterize the practical limits of discrimination of coral reef benthic composition.

2. **Validation** of benthic fractions from AVIRIS imagery using field observations.

Questions – Simulation Analysis

1. Under what conditions can we expect good benthic discrimination?

2. Which benthic types are difficult to discriminate?

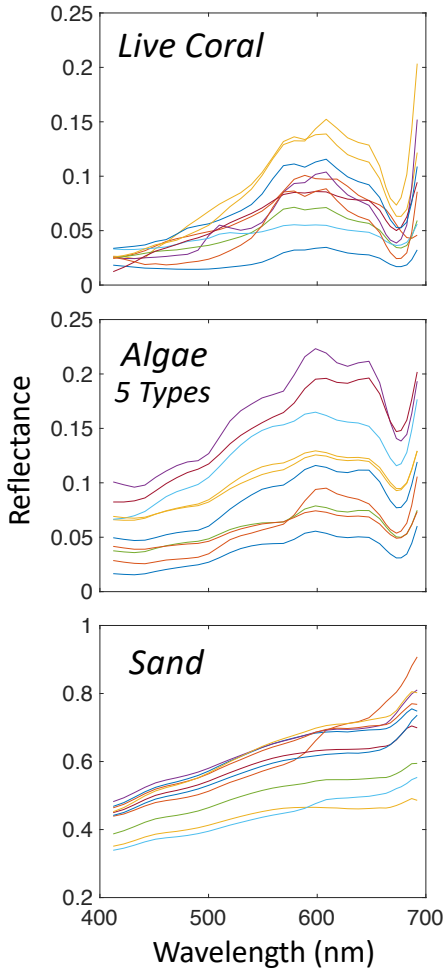
3. What is the minimum fraction of live coral we need for detection?

4. Does the use of **Multiple Endmember Spectral Mixing Analysis** (MESMA) improve our ability to distinguish live coral versus traditional **Spectral Mixing Analysis** (SMA)?

Answer these questions by examining errors related to spectral unmixing and water conditions.

Overview of Simulation Analysis

1 Use Spectral Endmembers to Build Spectral Mixture



Courtesy of Eric Hochberg

Overview of Simulation Analysis

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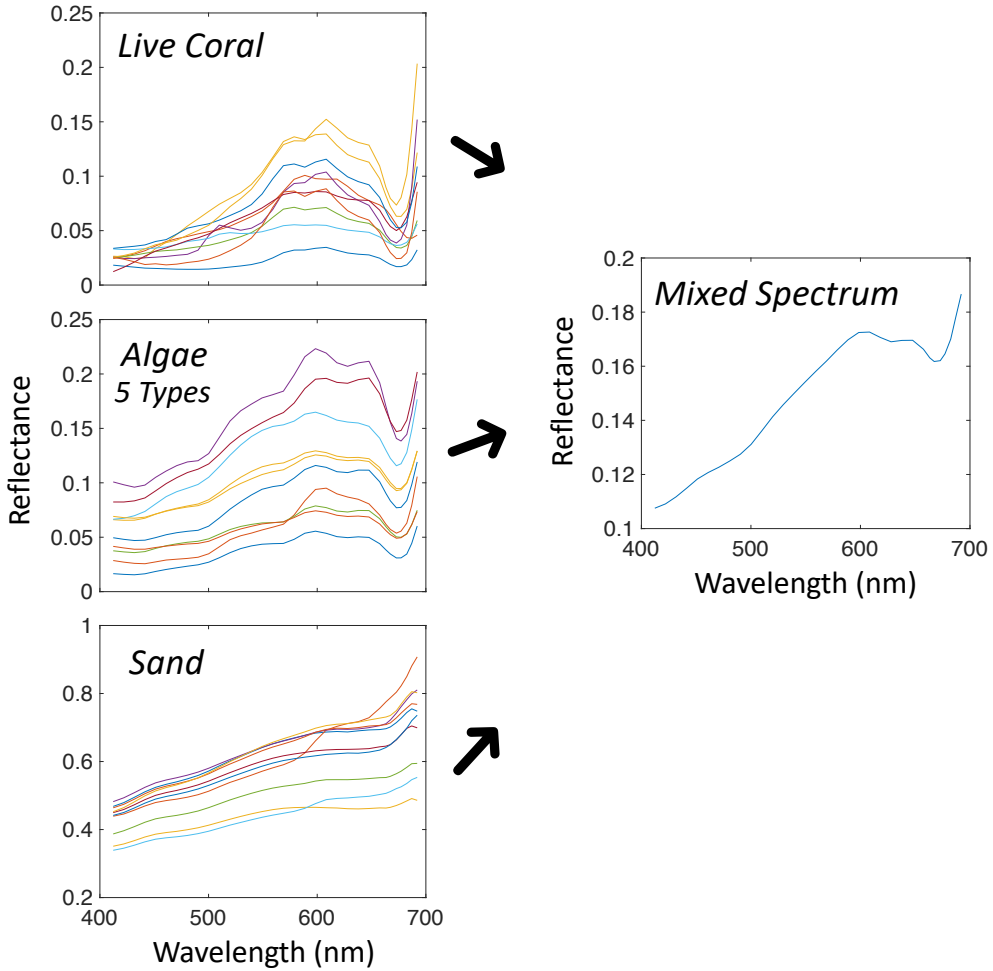
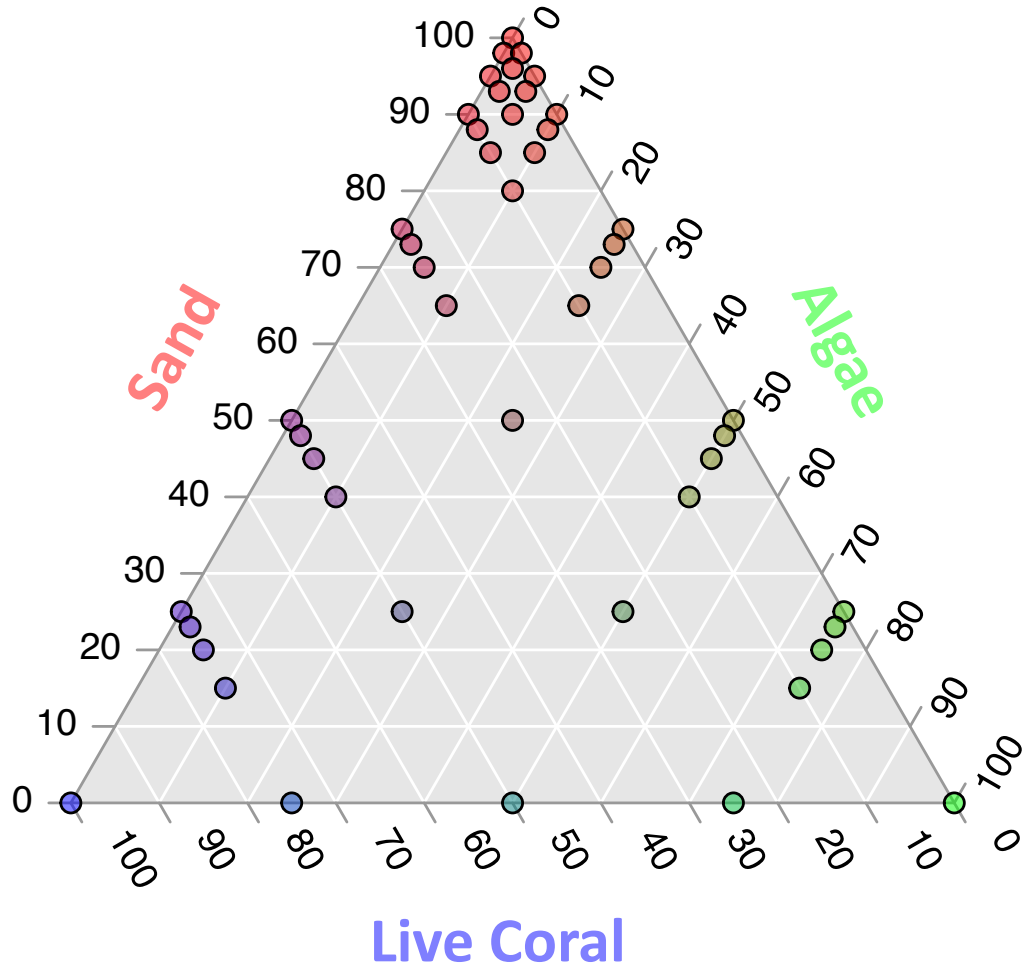


Courtesy of Eric Hochberg

48 Fractional Mixtures



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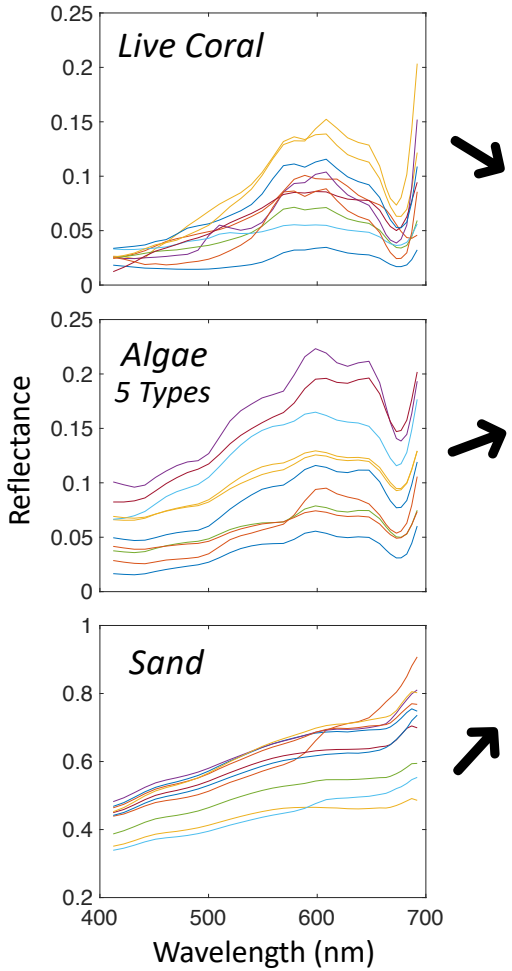
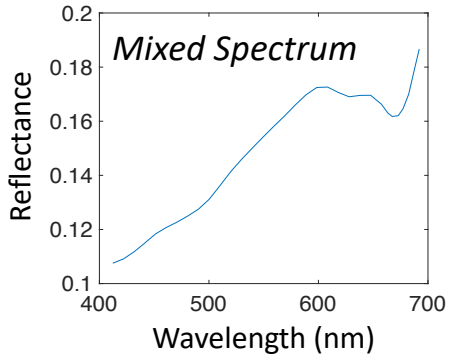
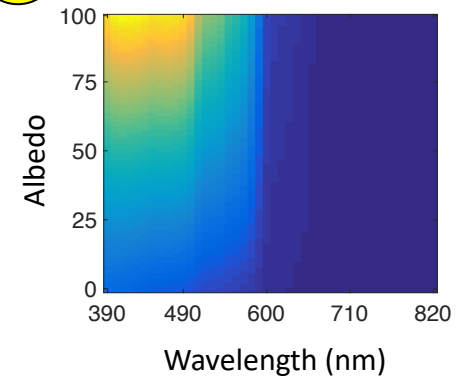


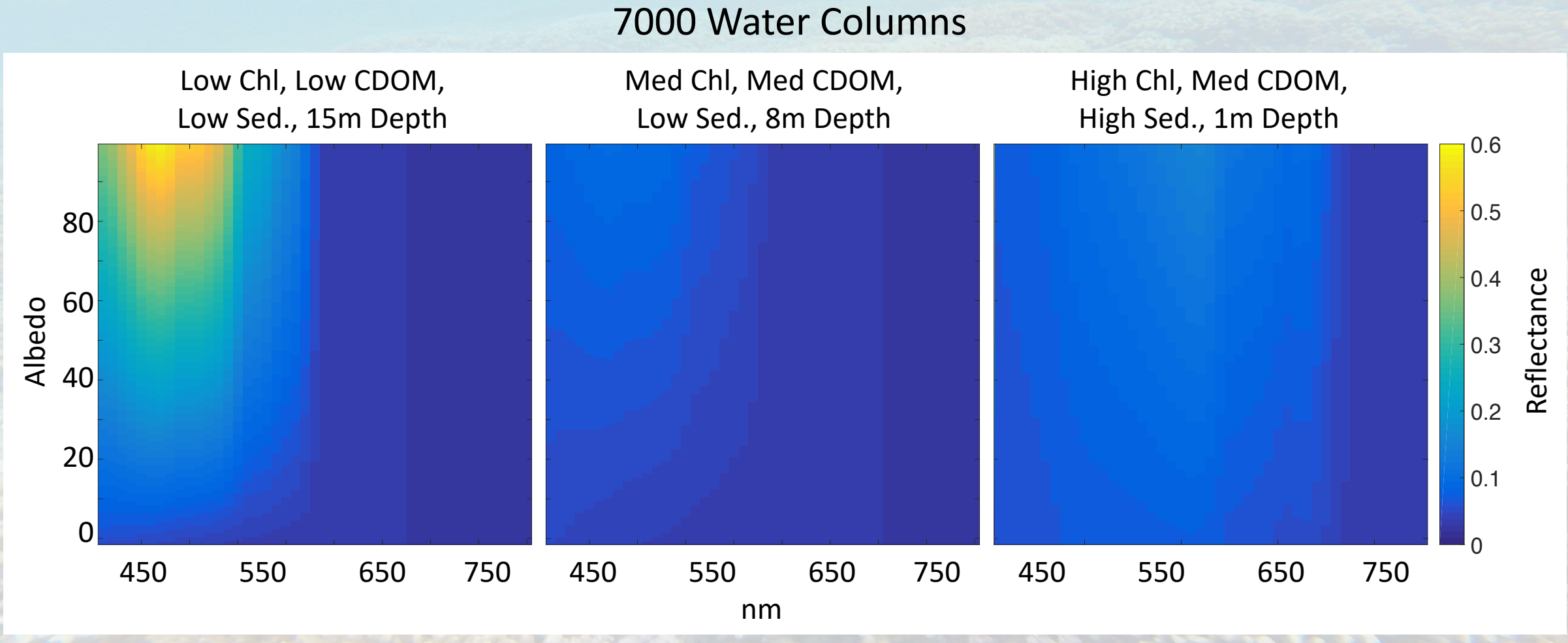


2 Pass Mixed Spectrum through Water Column



Courtesy of Eric Hochberg

Changes in Reflectance Due to Water Properties



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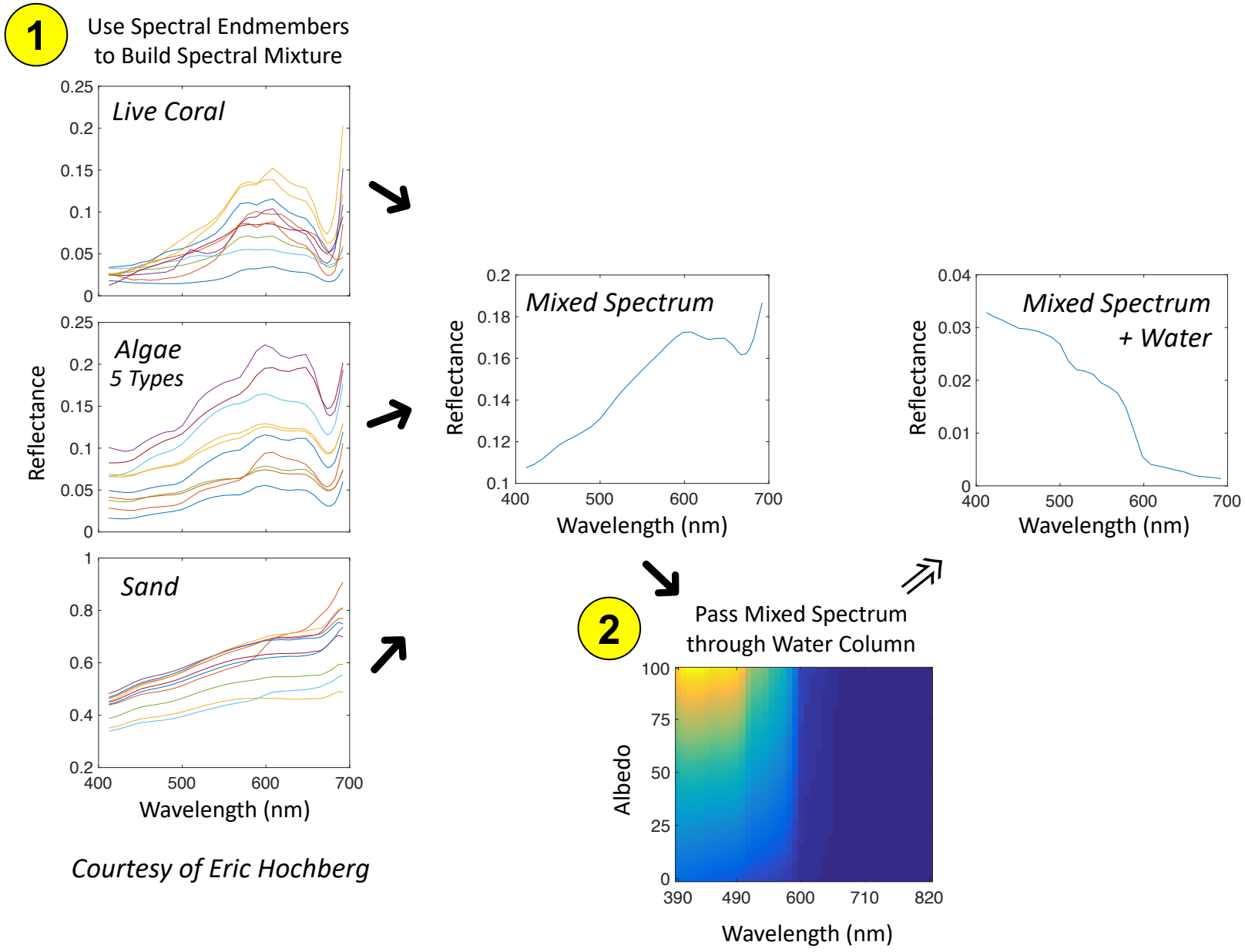

Courtesy of Eric Hochberg

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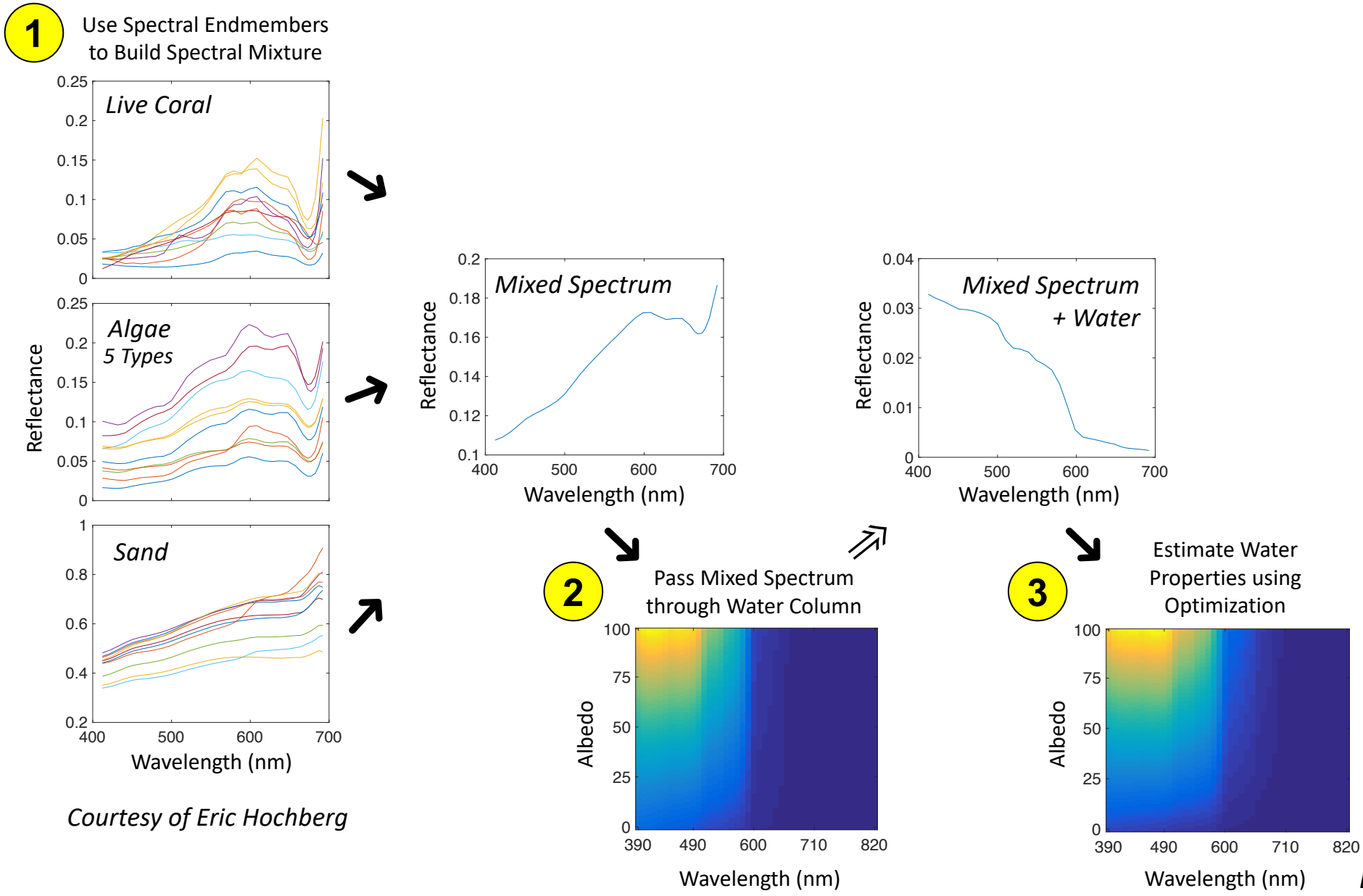
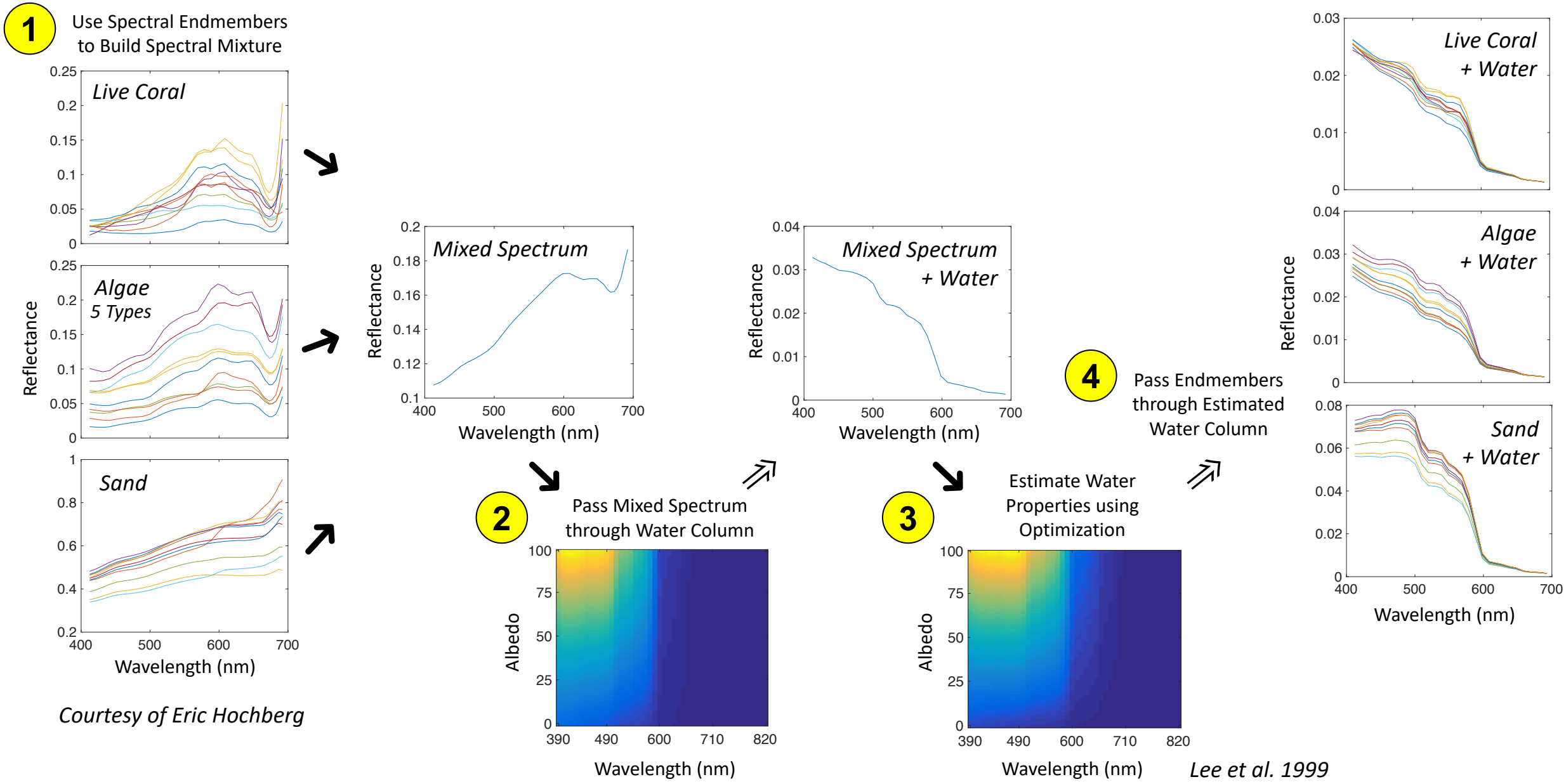


Courtesy of Eric Hochberg

Lee et al. 1999

Overview of Simulation Analysis



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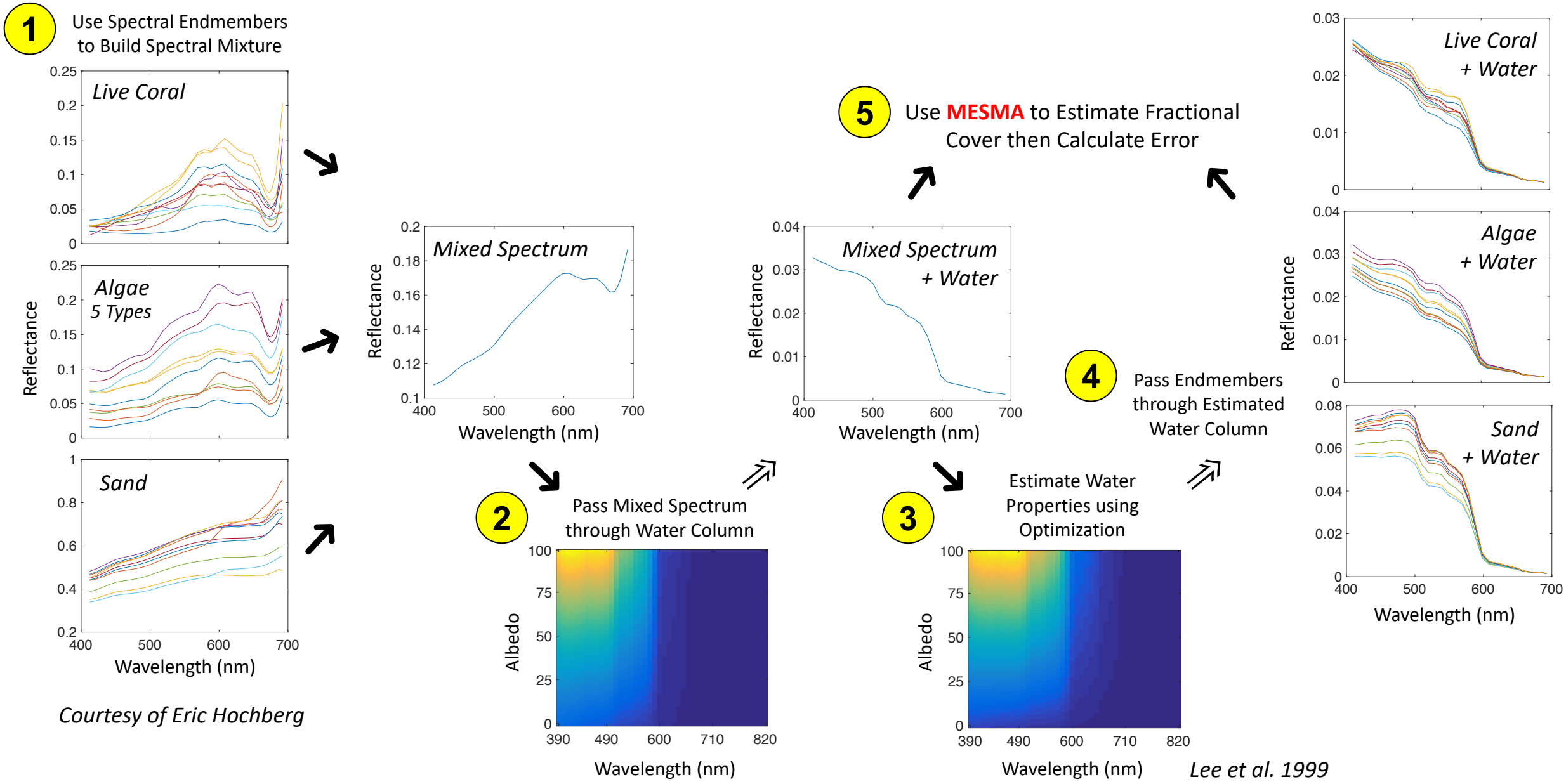


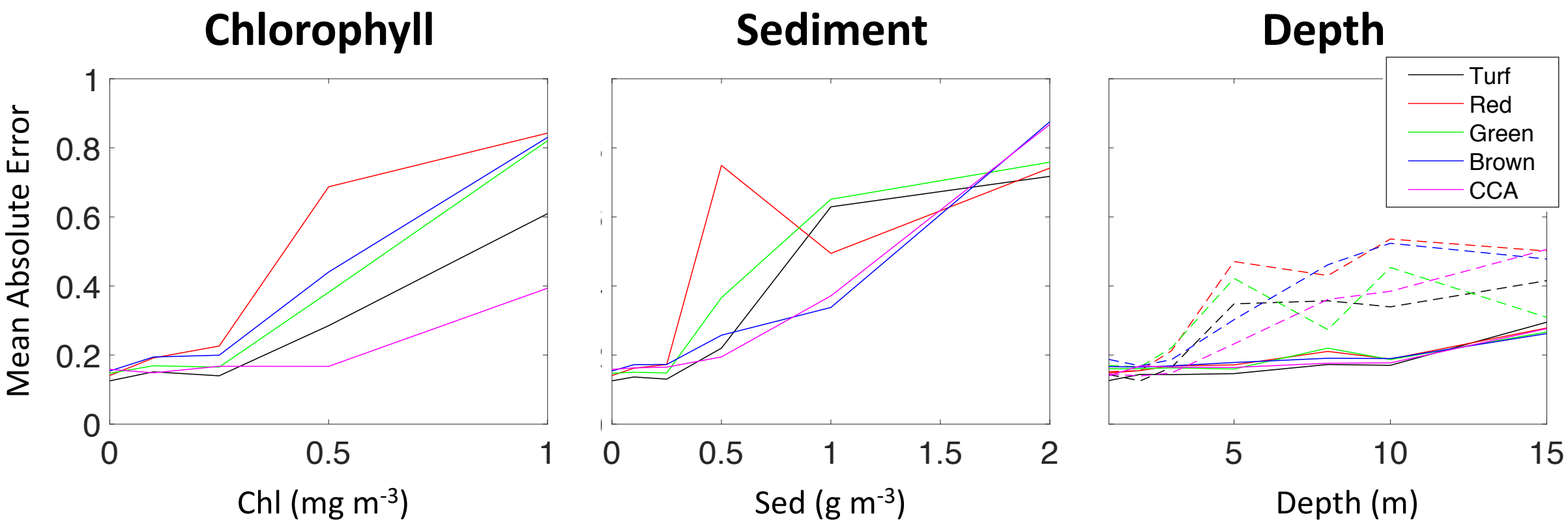
Measures of Error

1. Mean Absolute Error = $\frac{1}{n}\sum_{i=1}^{n} |f_i^{MESMA} - f_i^{actual}|$

2. Mean Error = $\frac{1}{n}\sum_{i=1}^{n} (f_i^{MESMA} - f_i^{actual})$

3. Mean Relative Error = $\frac{1}{n}\sum_{i=1}^{n} \frac{|f_i^{MESMA} - f_i^{actual}|}{f_i^{actual}}$

Increasing Chl, Sed, Depth Increase Error



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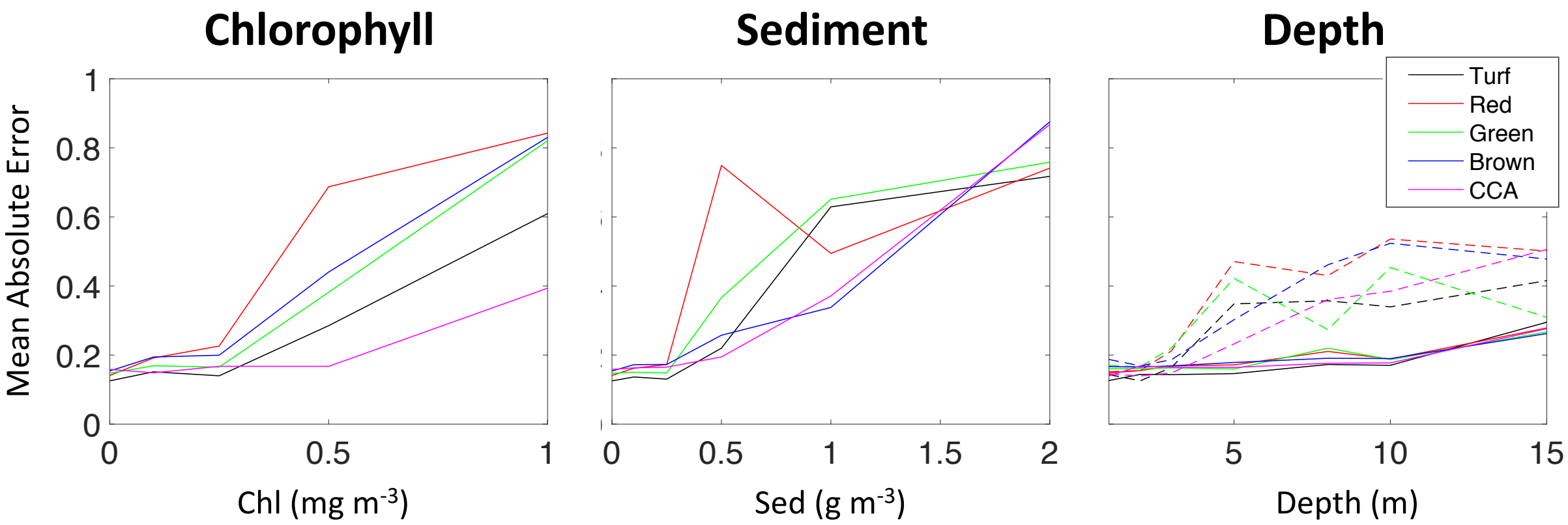
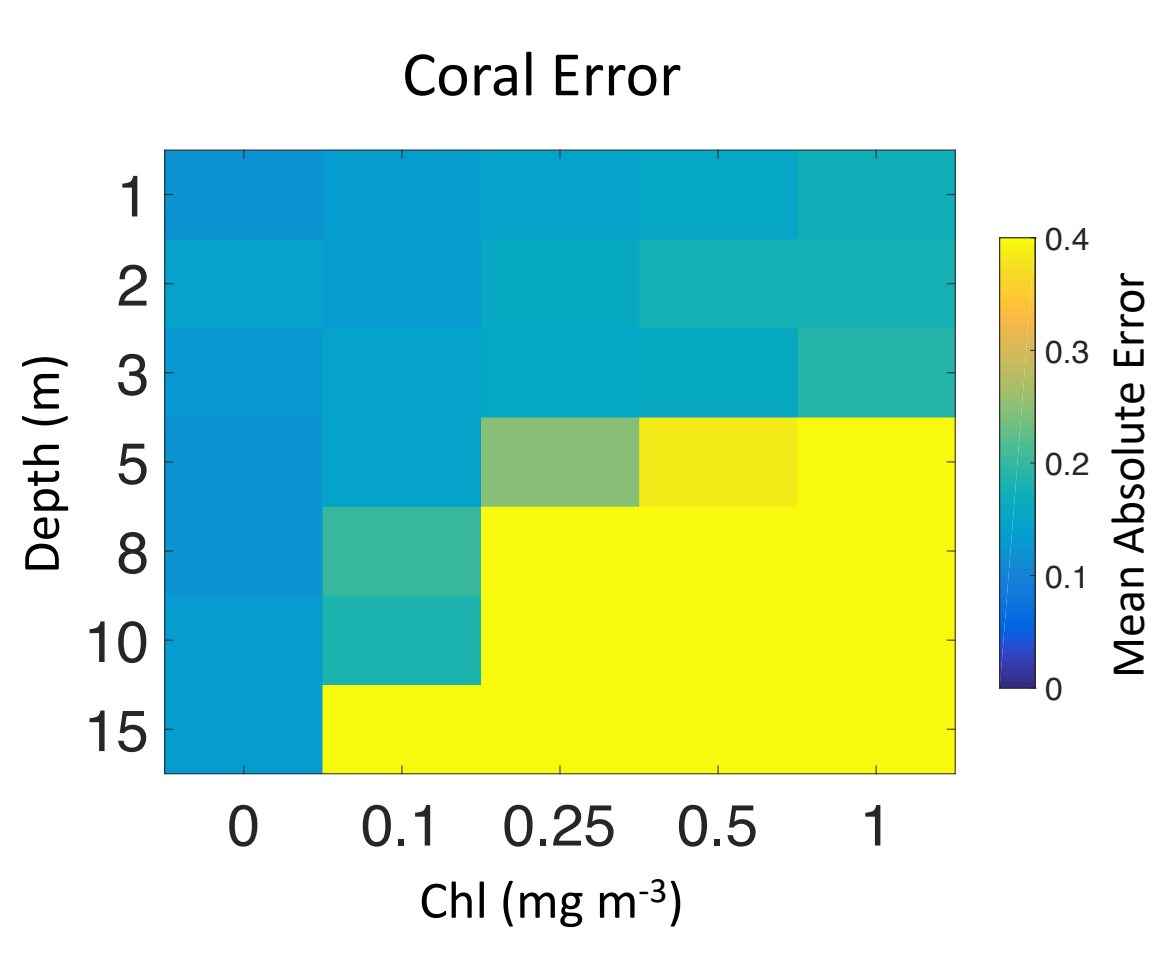
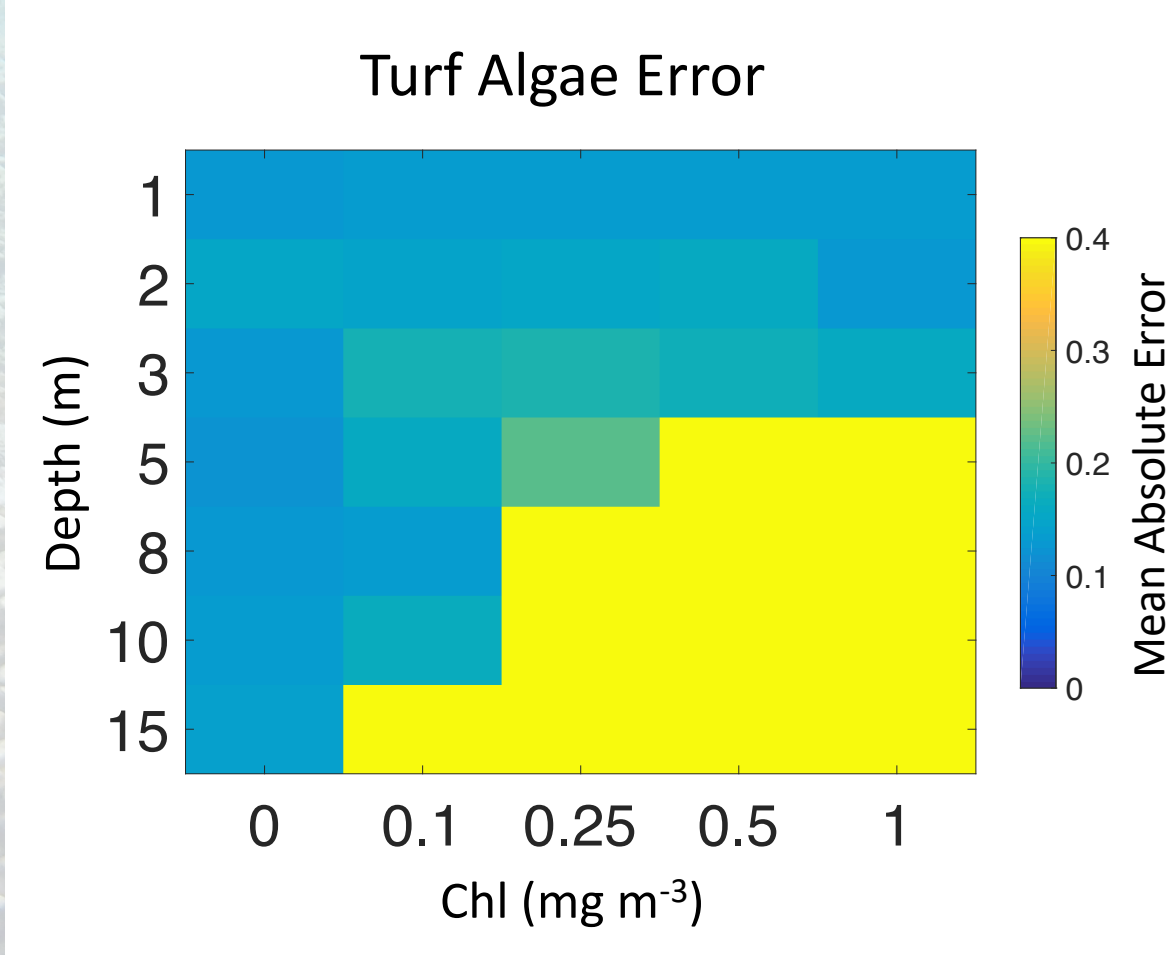
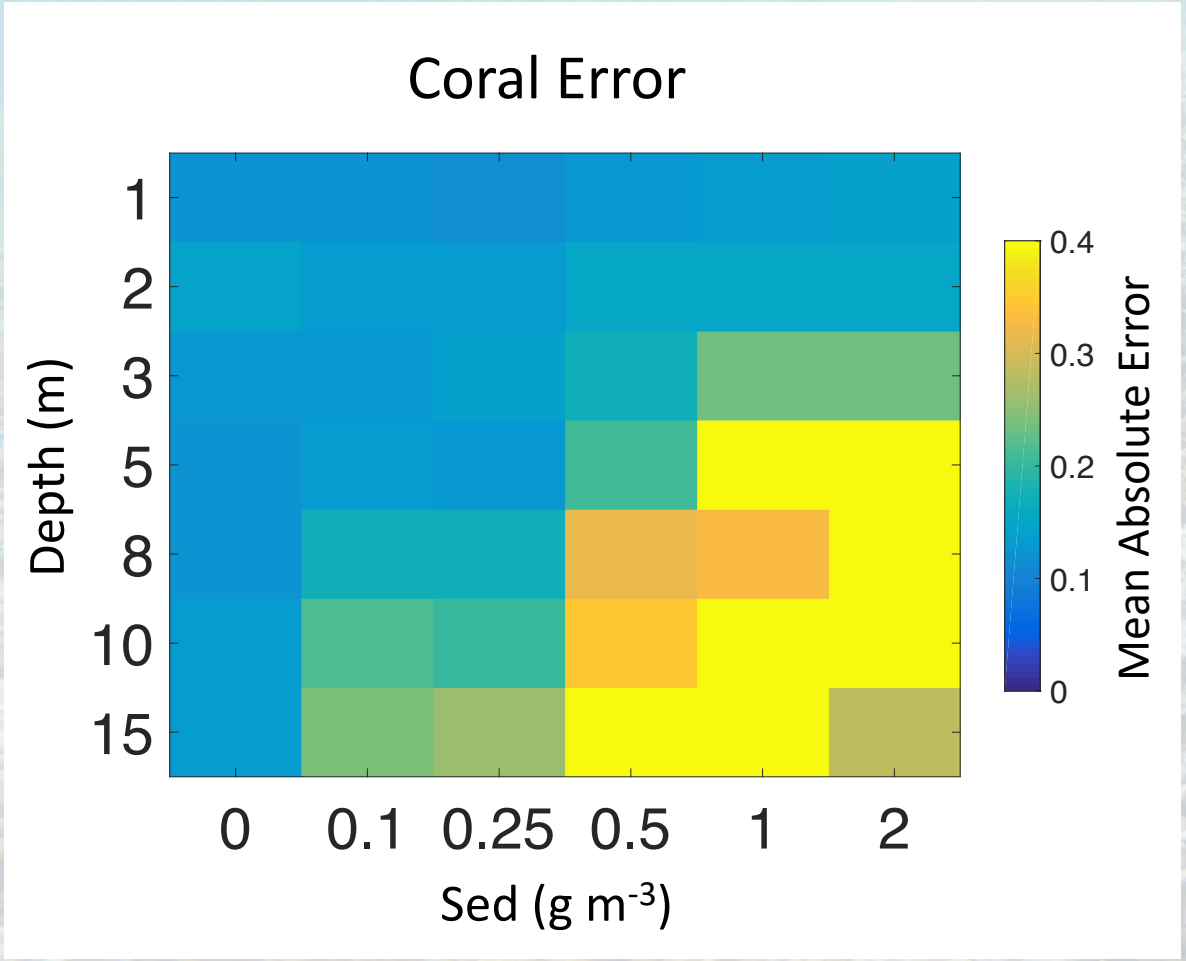


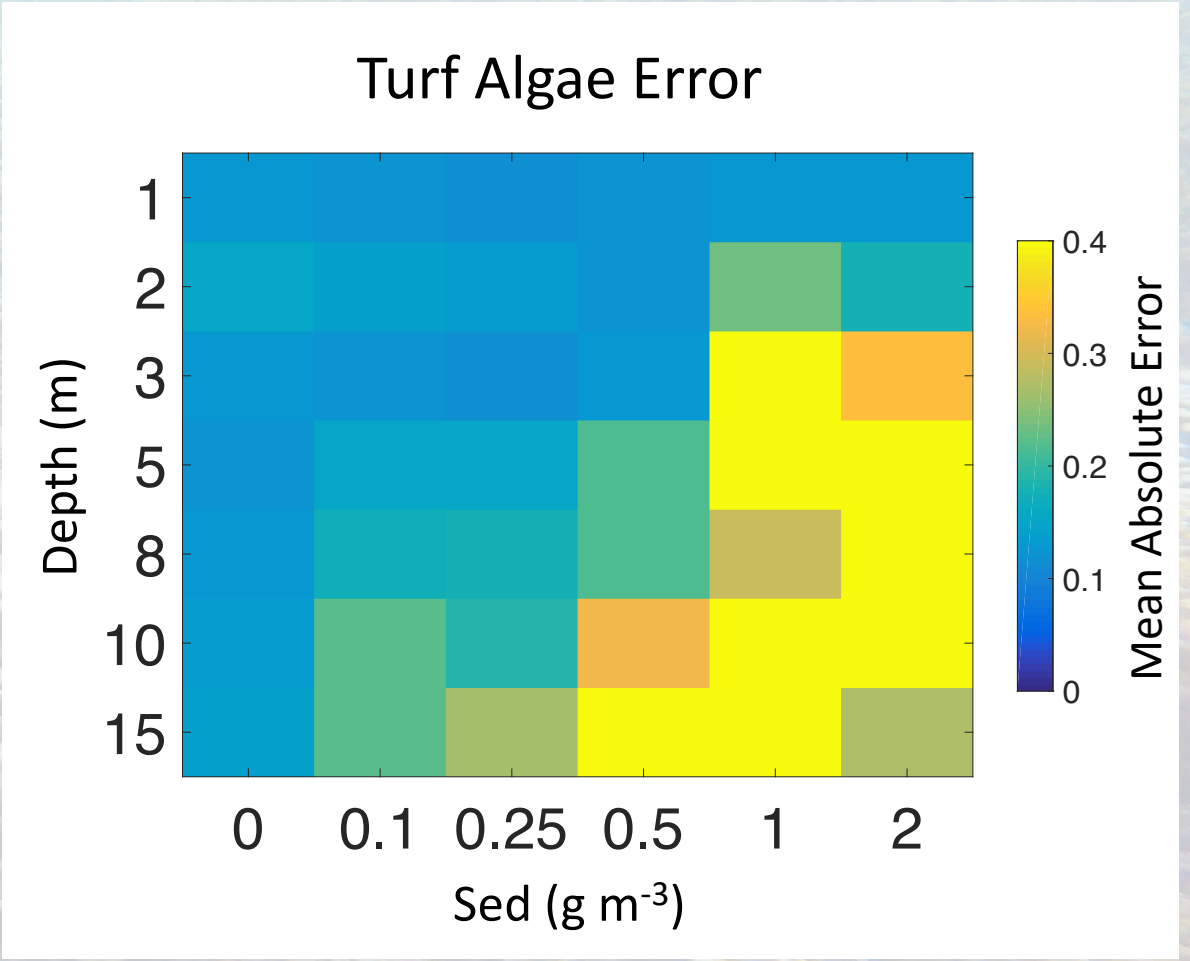
Reasonable Error Chl < 0.25 mg m^{-3}



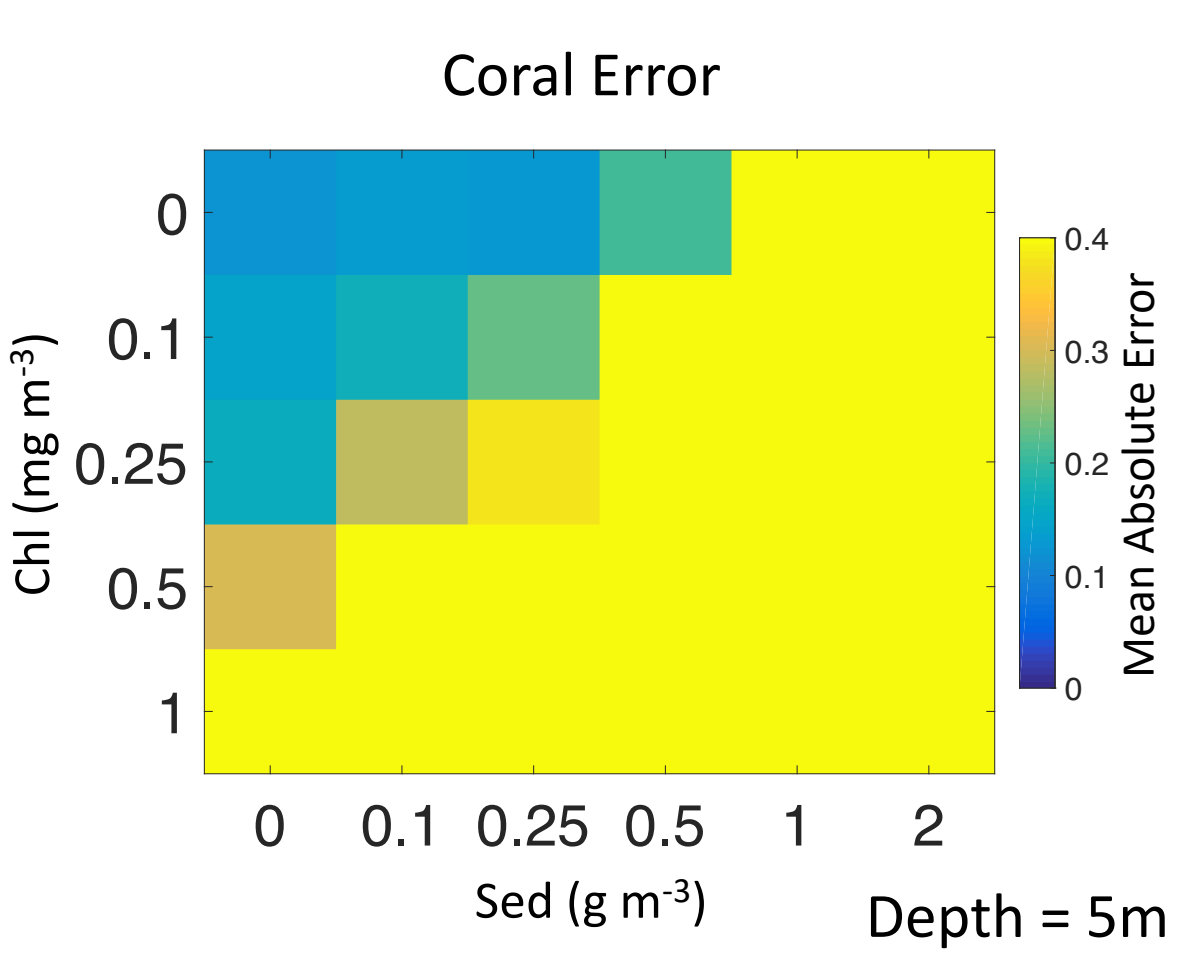


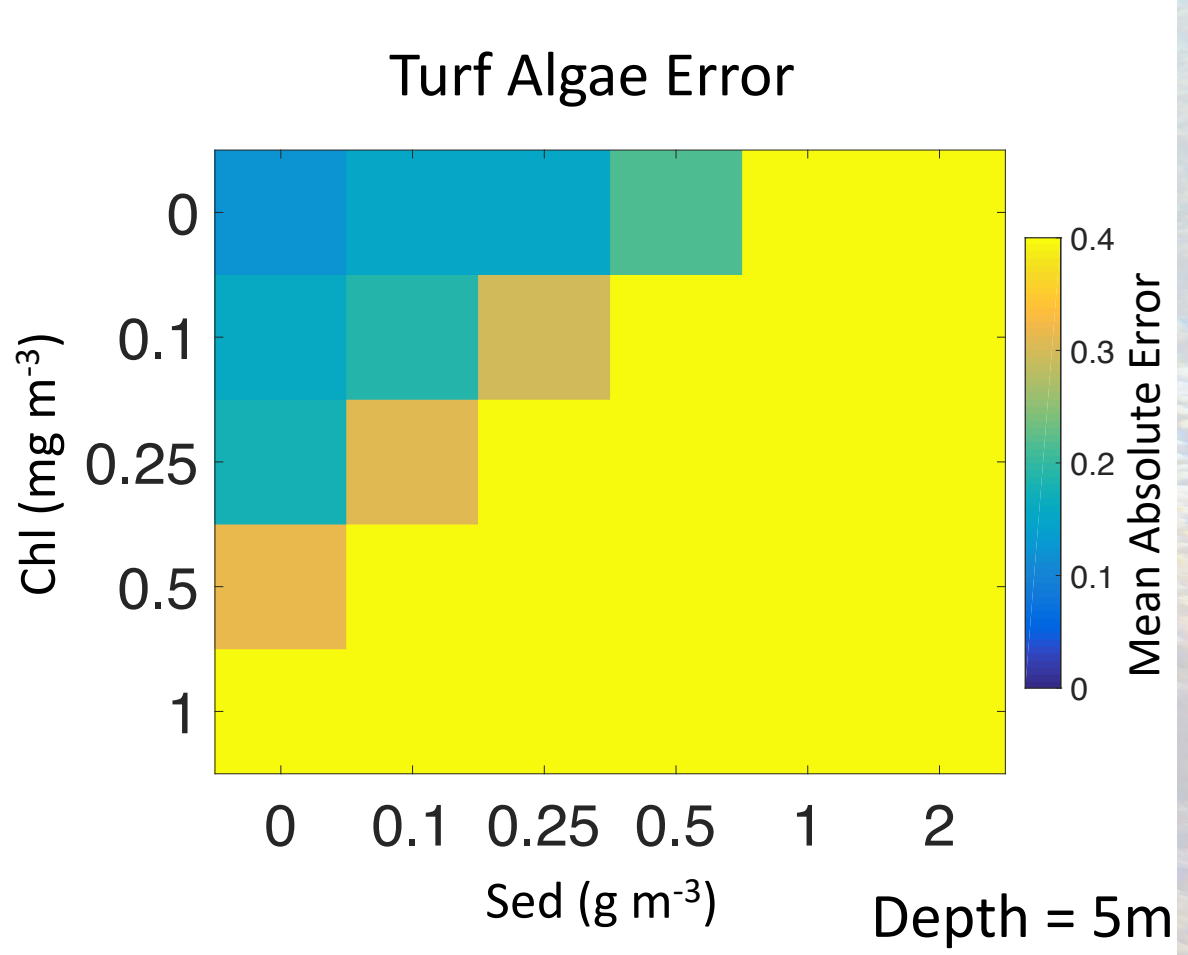
Reasonable Error Sed < 0.5 g m^{-3}



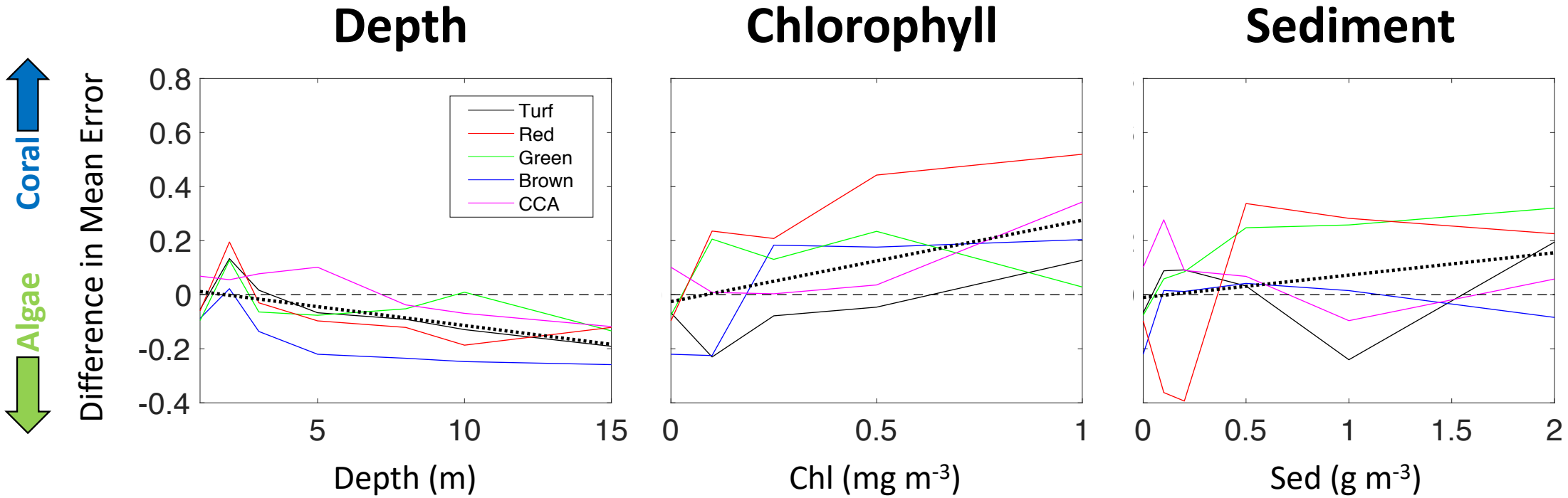


Strong Interactive Effect Between Chl and Sed

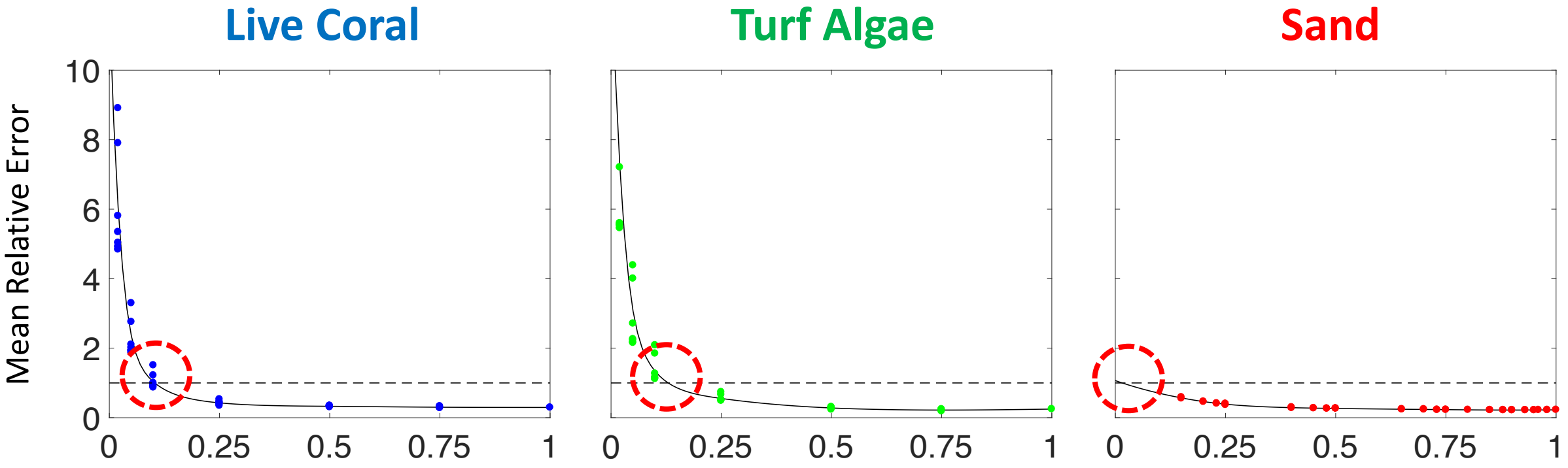




Confusion between Coral and Algae

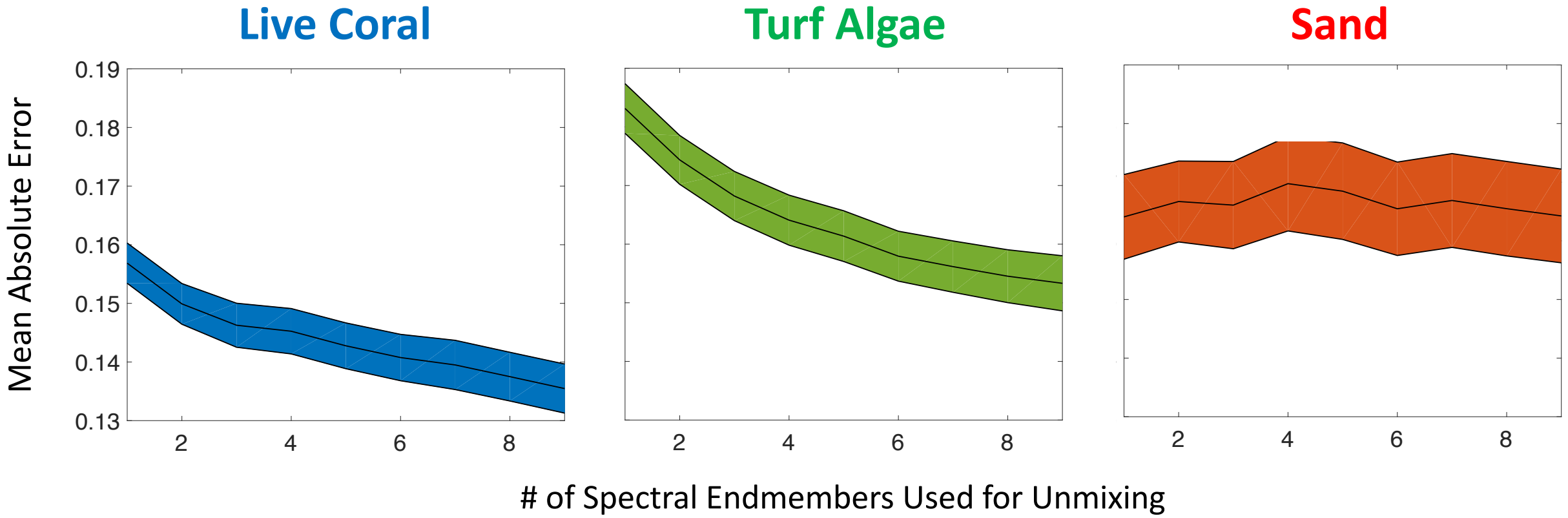


Minimum ~12% cover needed for Coral/Algae



Depth = 5m, clear water

MESMA Reduces Error Compared to SMA



Conclusions

- Clear water = good fractional estimates to 15m depth, but strong interactive effects between Chl and Sed increase error, esp ≥5m
- ⬆ Depth - coral confused for algae, ⬆ Chl - algae confused for coral
- Need minimum ~12% cover coral/algae inside a pixel
- MESMA reduces error for coral and algae compared to SMA

Validation of benthic fractions from AVIRIS imagery using field observations

<u>Simulation Analysis</u>
Best Classification Methods
Limits to Water Properties

AVIRIS Imagery

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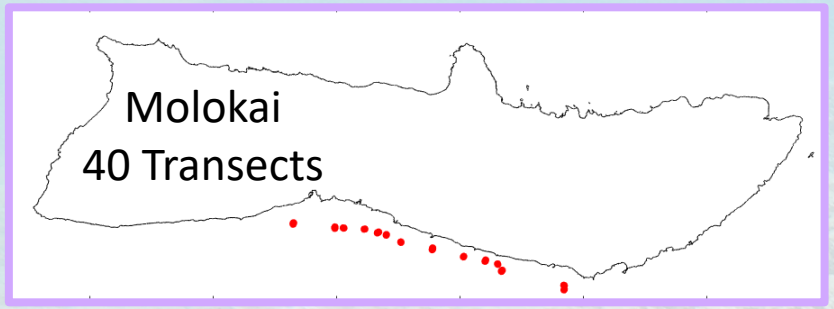
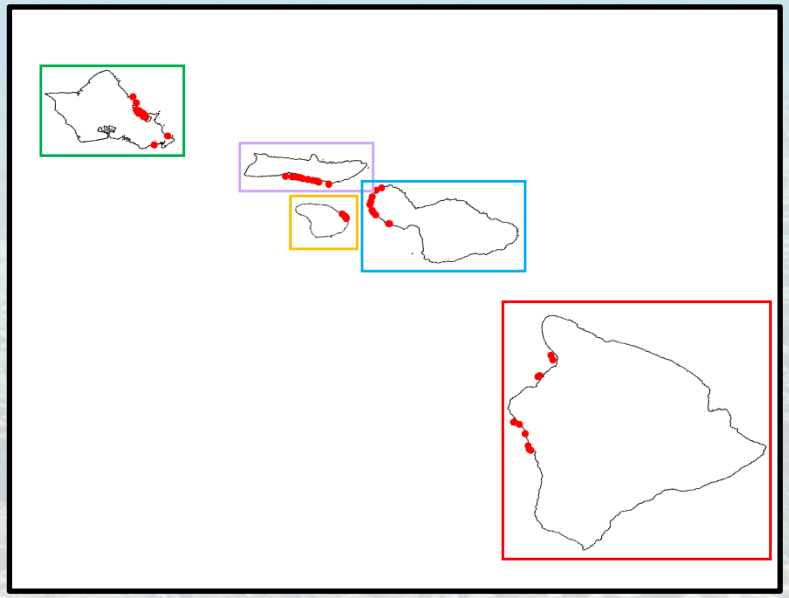
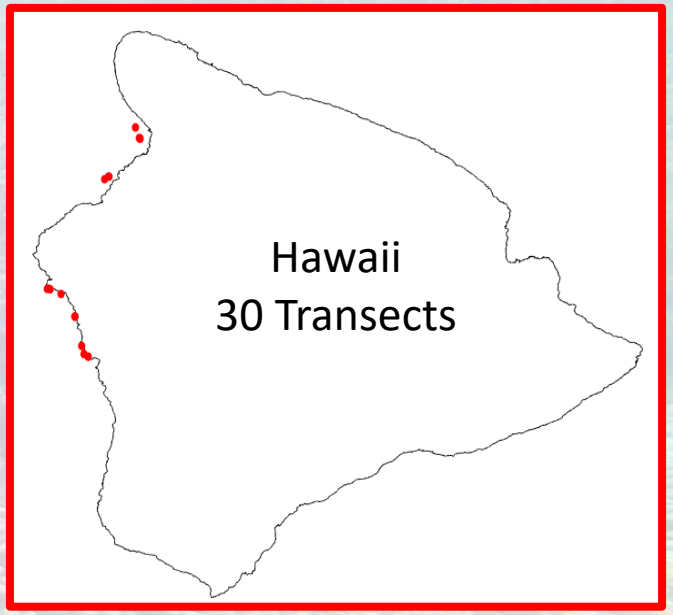
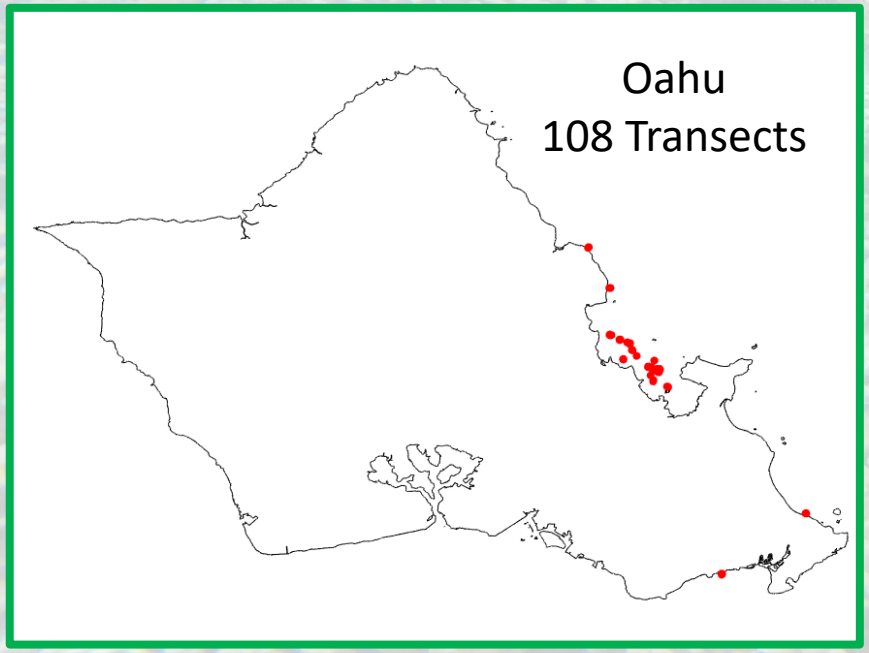
Field Surveys Conducted During AVIRIS Flights

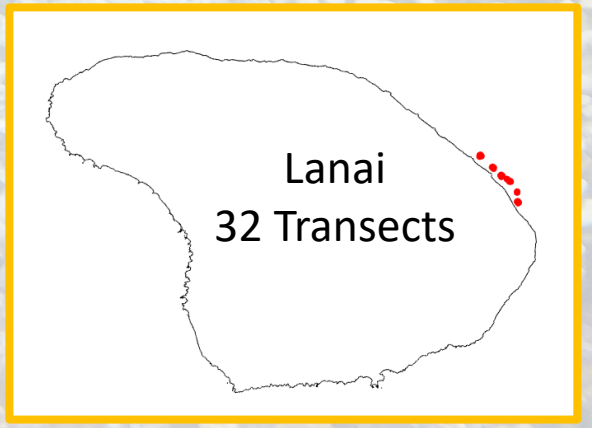
250 Phototransects Across 5 Hawaiian Islands

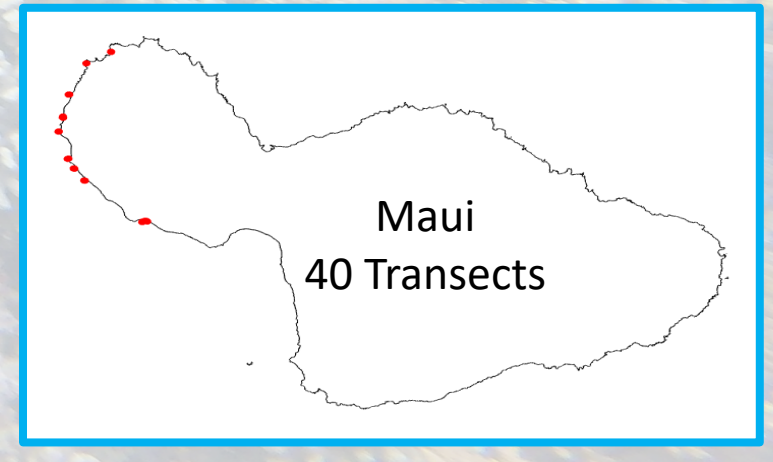




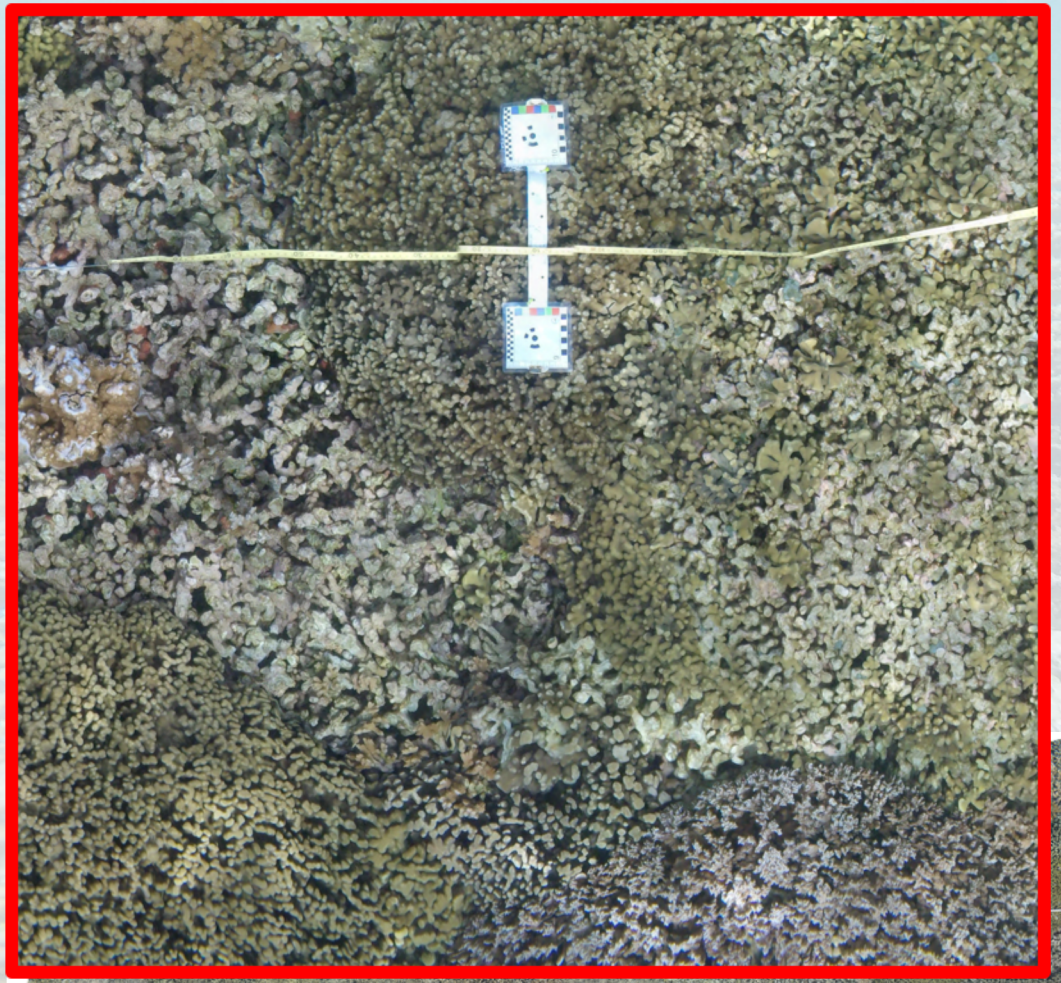




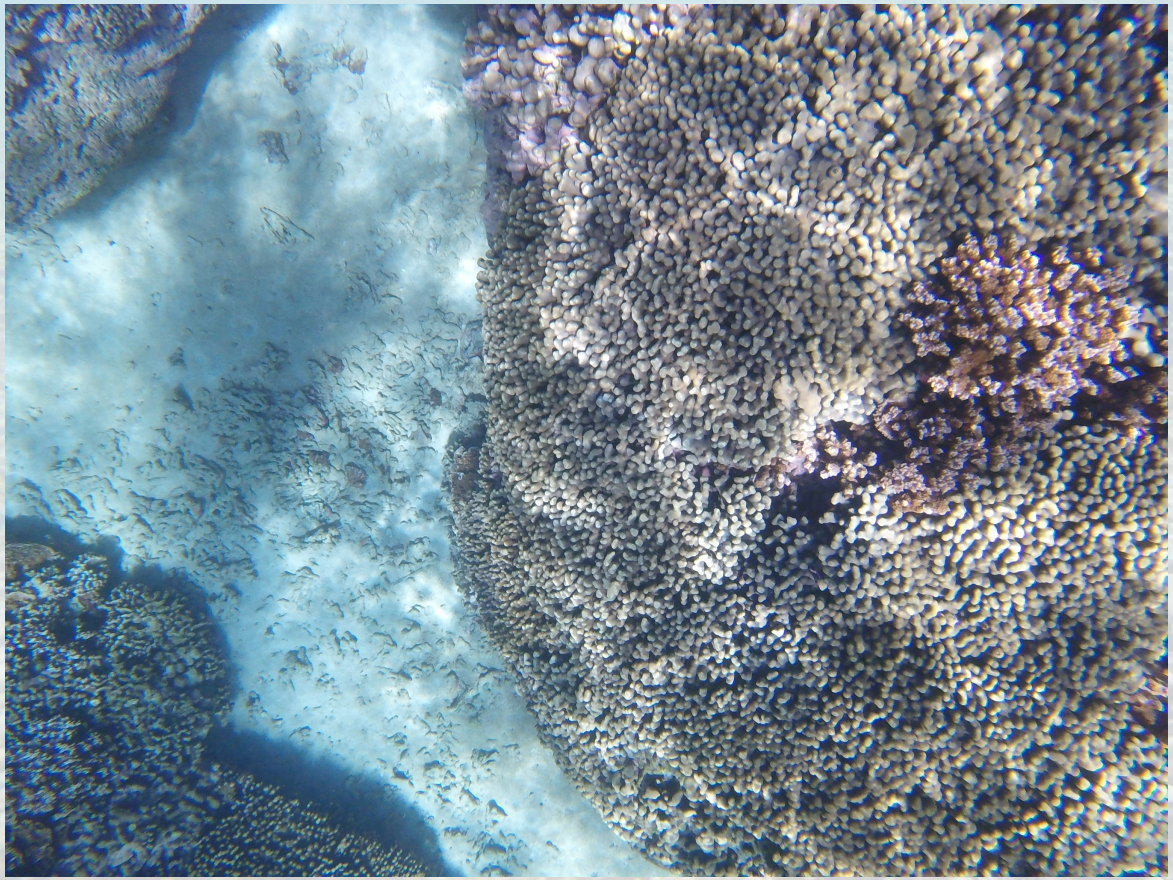




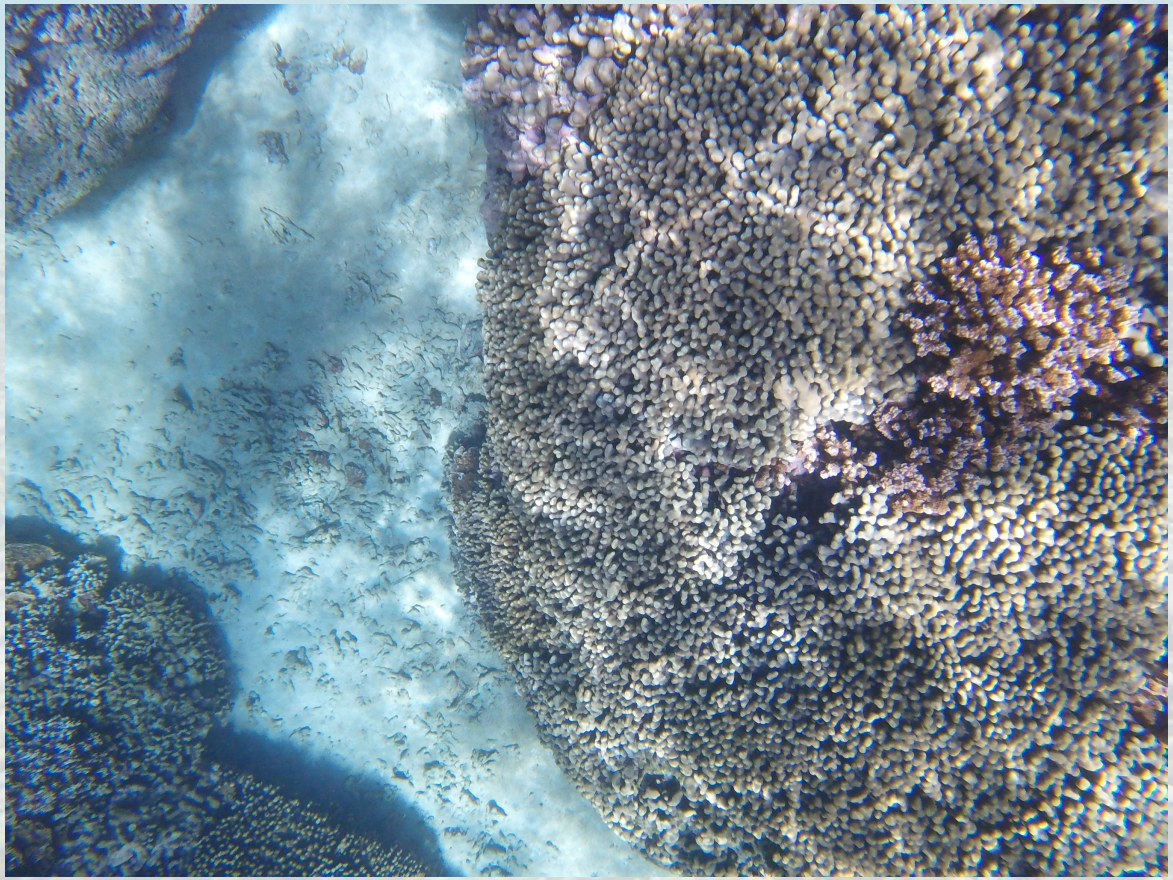
Phototransect Collection (250)

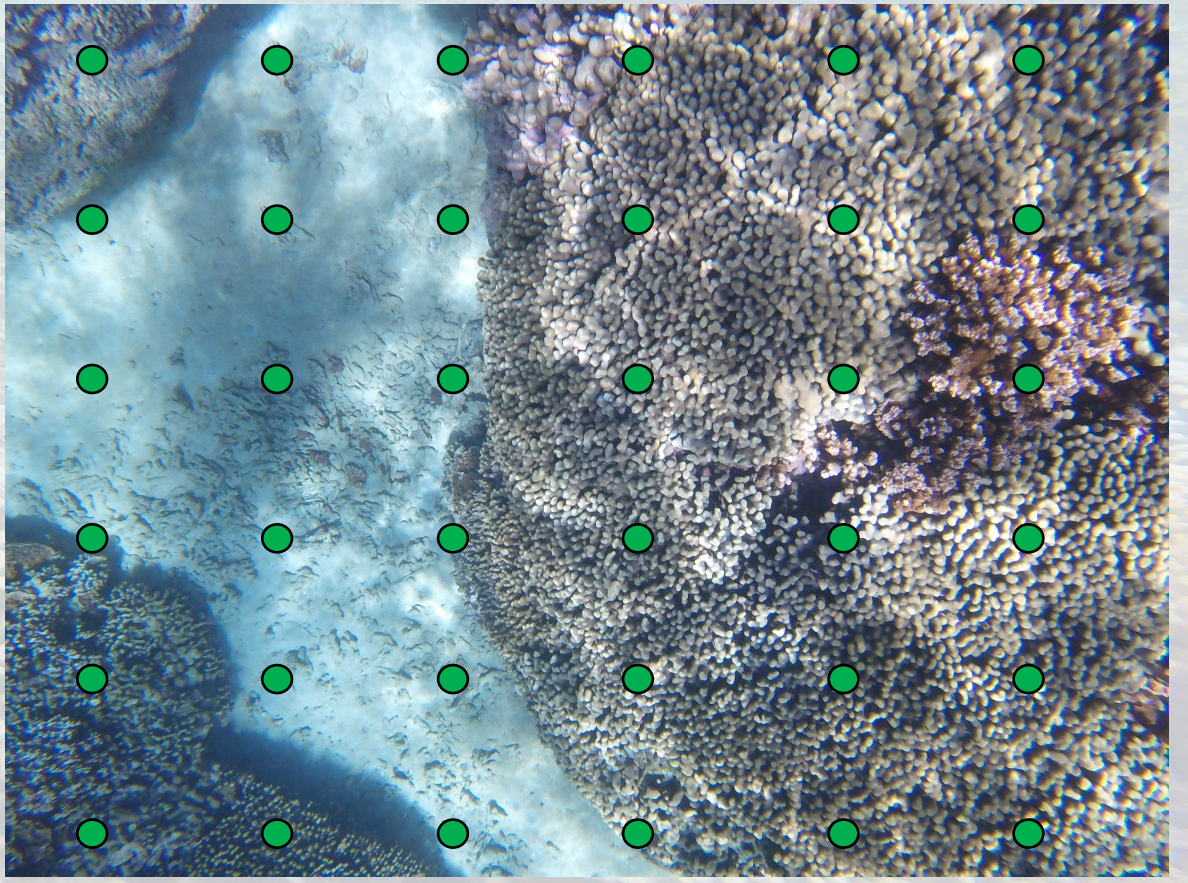


Classification of Orthomosaics



Point-based Classification





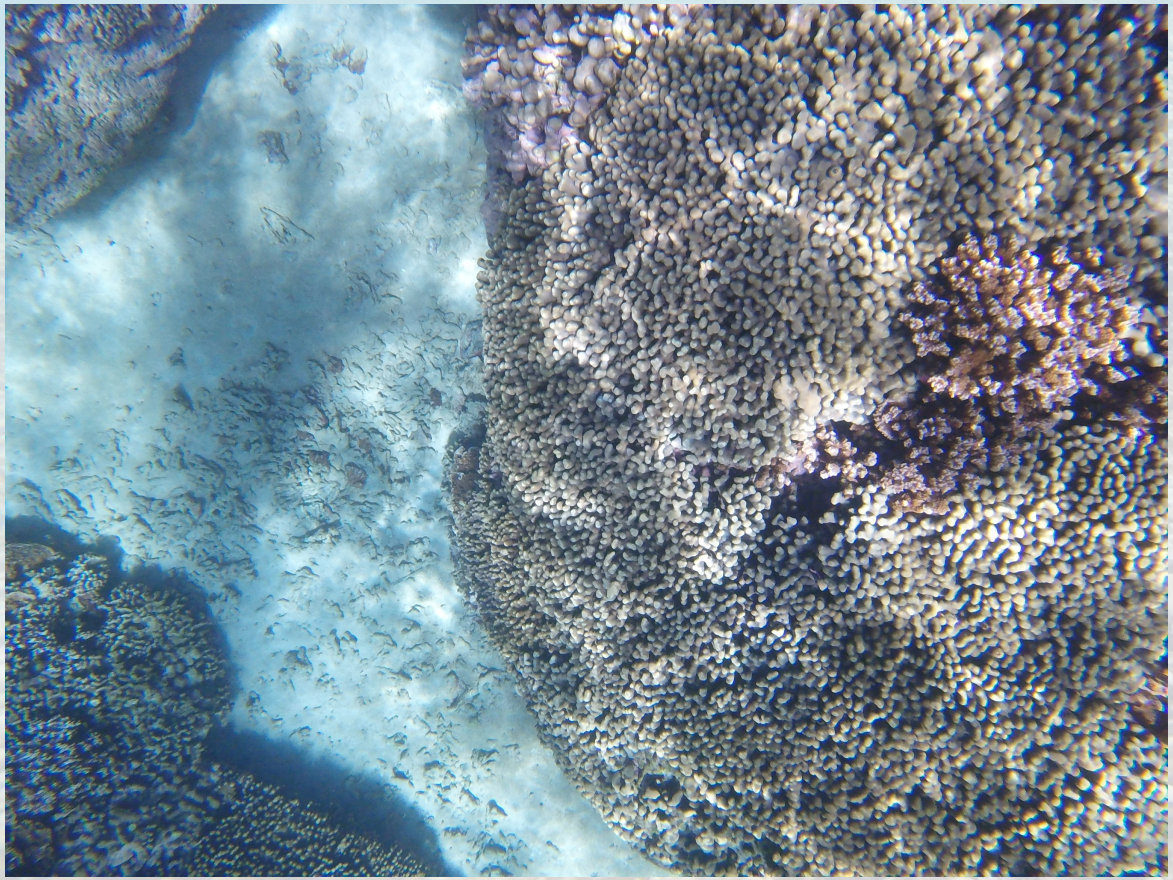
Classification Using Computer Vision Analysis

CORALNET BETA

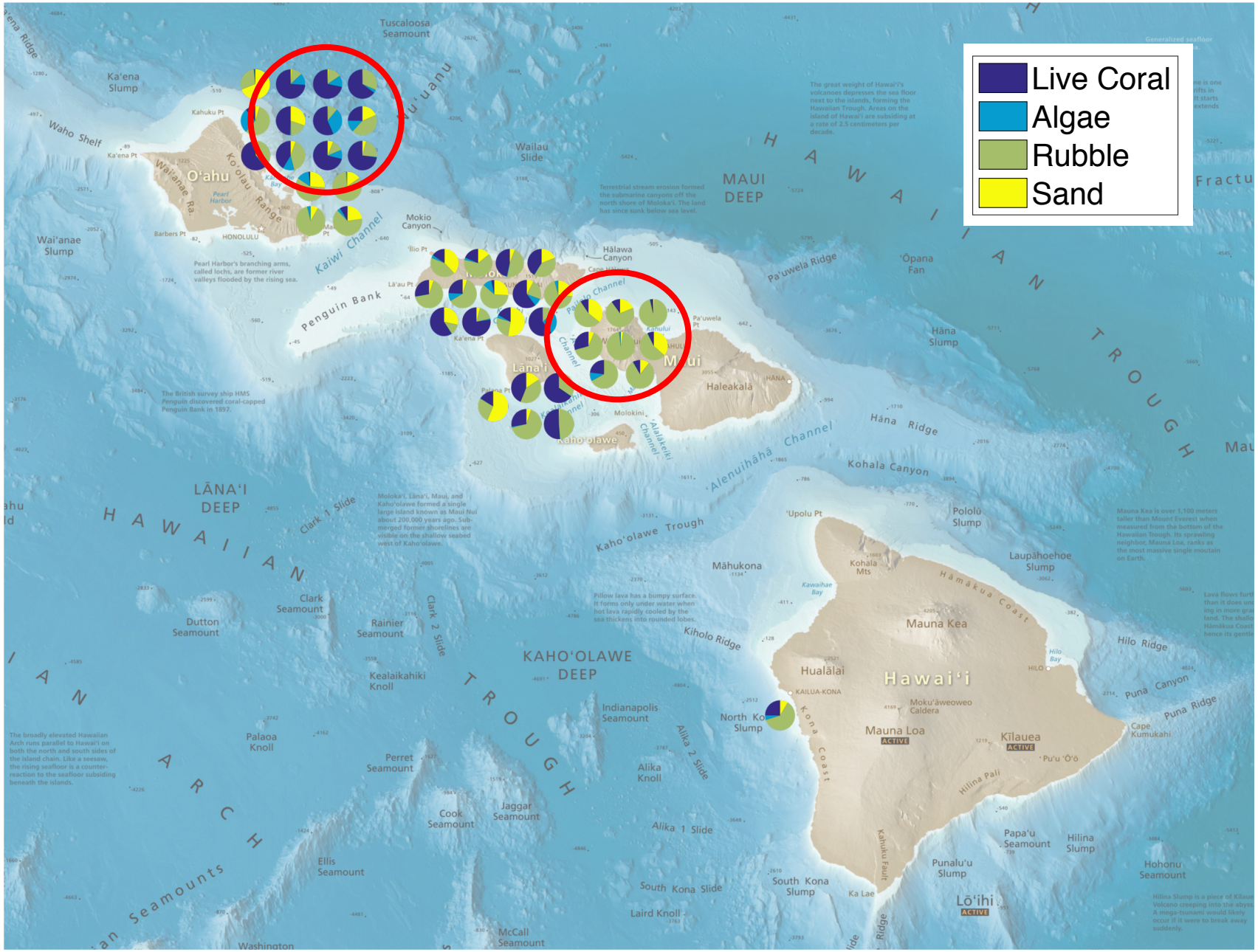
A WEB SOLUTION FOR CORAL REEF ANALYSIS

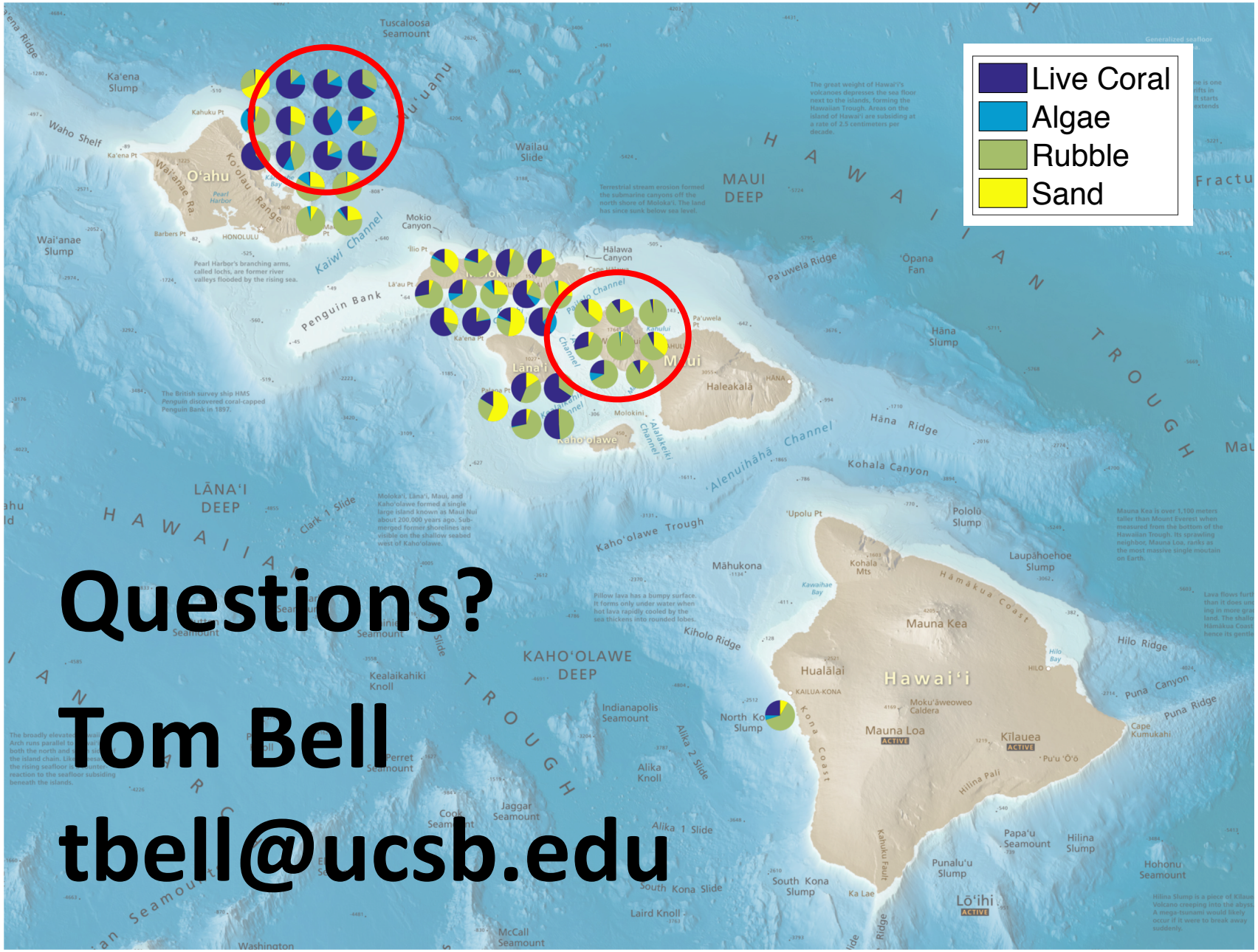
Upload coral reef images, organize and annotate images, and view annotation statistics.

Classification Using Computer Vision Analysis

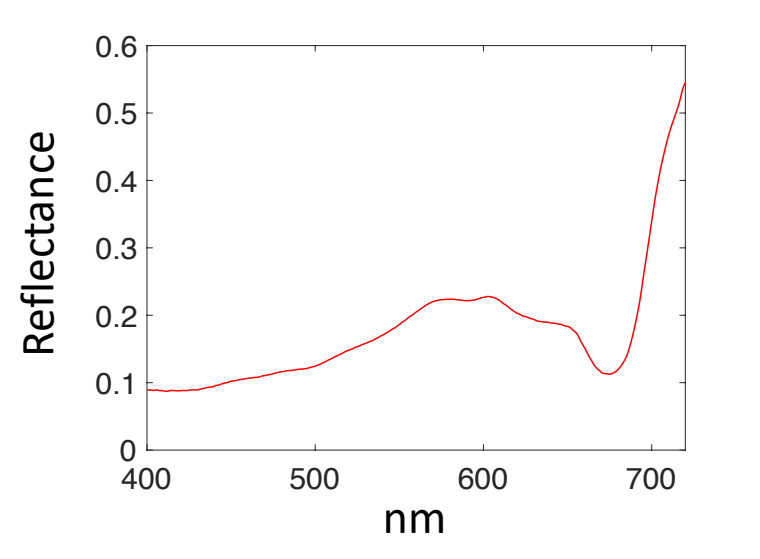


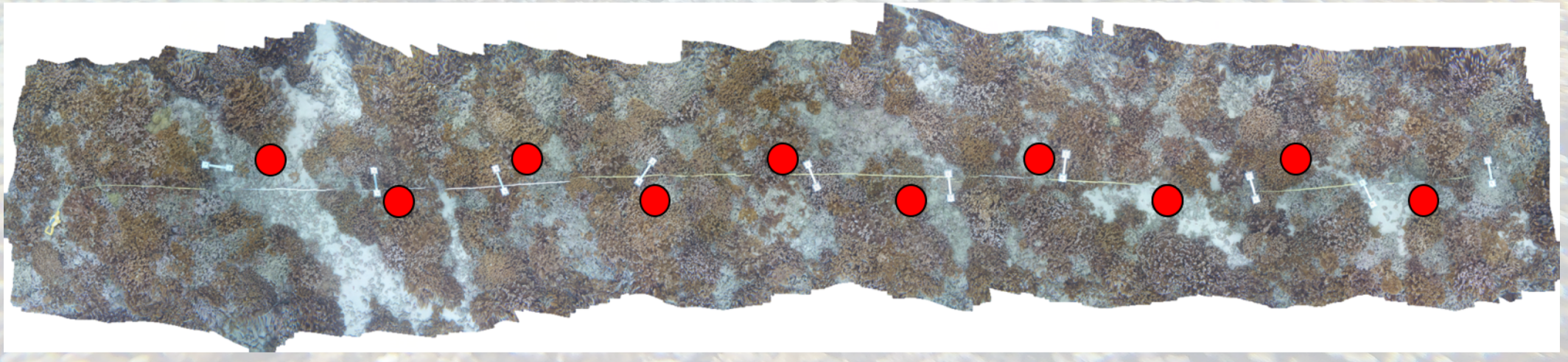
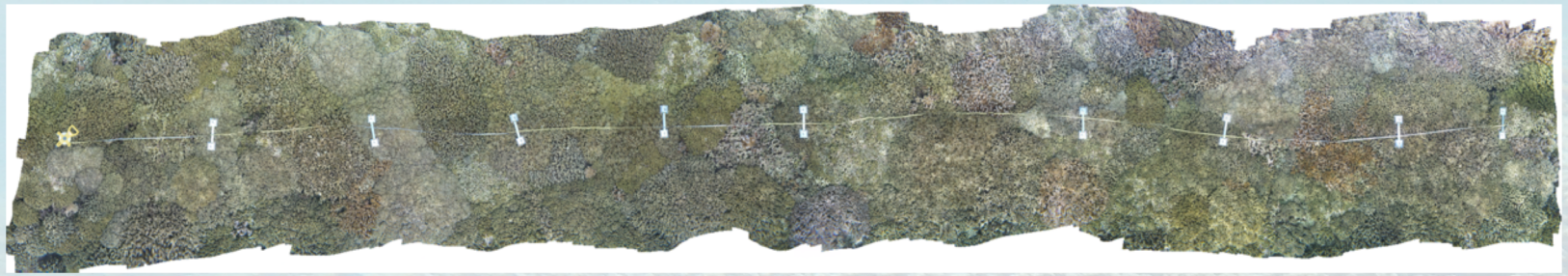
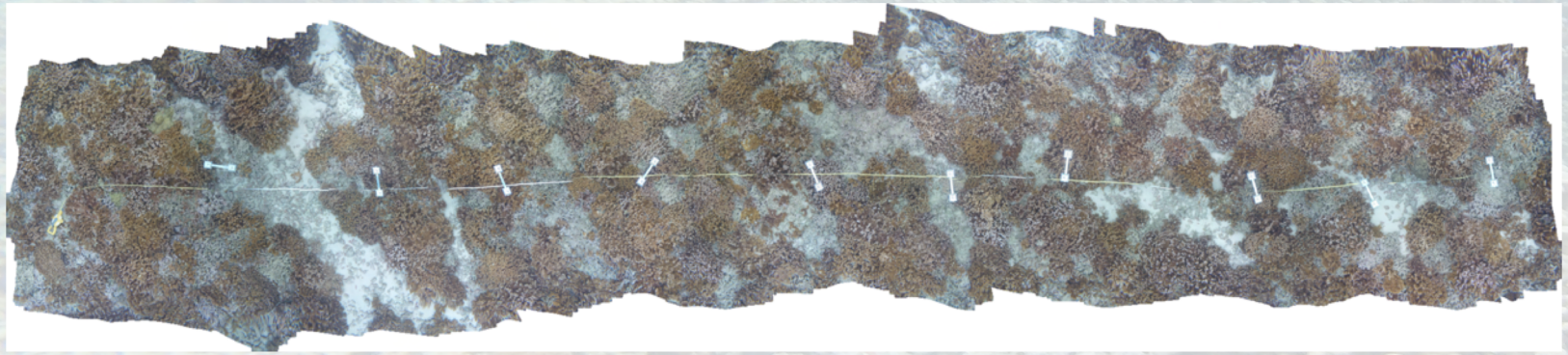
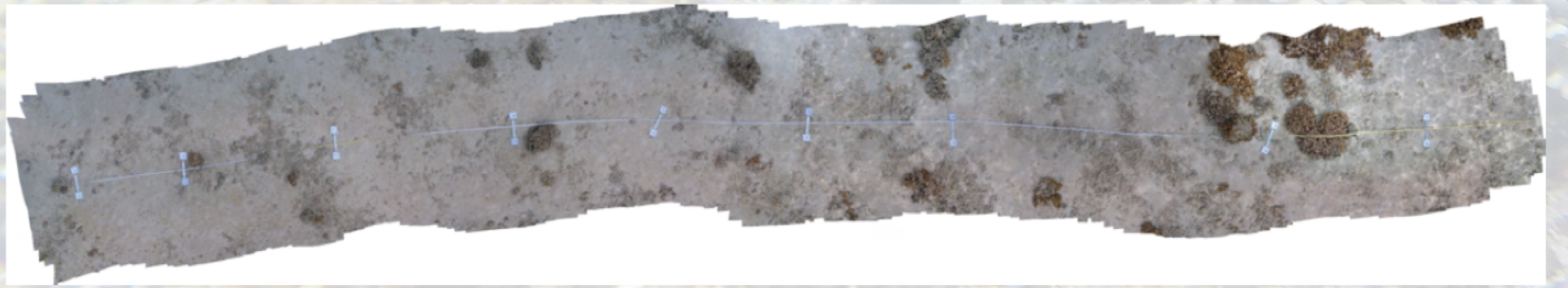
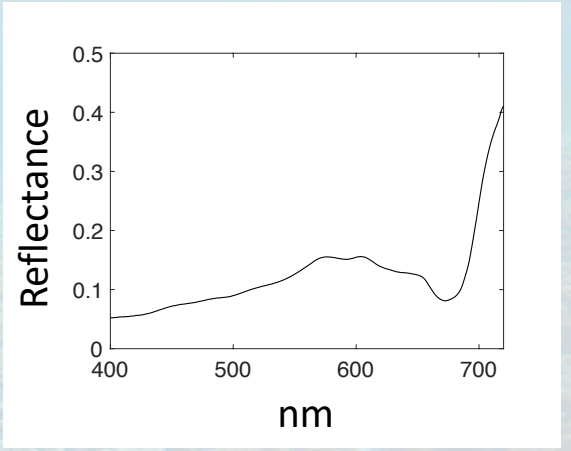
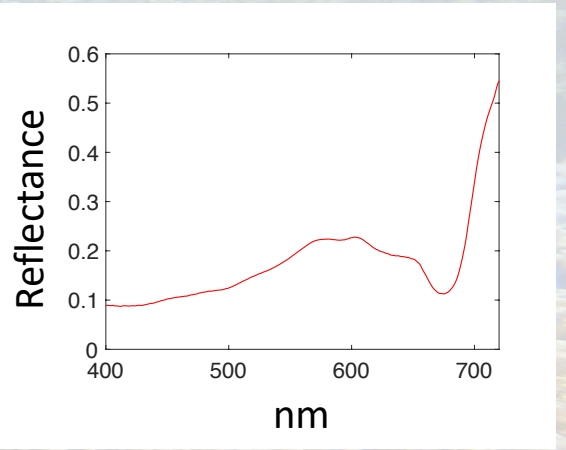
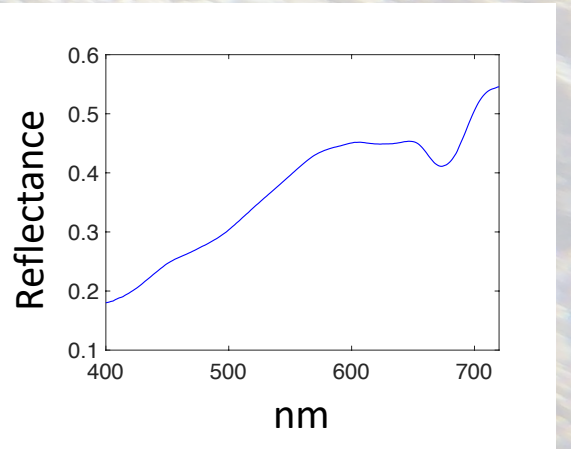
	Rubble	Live Coral	Sand	CCA
Rubble	**86**	**2**	**13**	**0**
Live Coral	**5**	**95**	**0**	**0**
Sand	**13**	**0**	**83**	**0**
CCA	**100**	**0**	**0**	**0**


Live Coral
Algae
Rubble
Sand
Tuscaloosa Seamount
Ka'ena Slump
Kahuku Pt
Waho Shelf
Ka'ena Pt
Wailau Slide
MAUI DEEP
HAWAIIAN TROUGH
O'ahu
Ko'olau Range
Wai'anae Ra.
Pearl Harbor
Barbers Pt
HONOLULU
Mokio Canyon
Wai'anae Slump
Kaiwi Channel
Hālawa Canyon
Penguin Bank
Pa'uwela Ridge
'Ōpana Fan
Hāna Slump
Pailolo Channel
Kahului
Maui
Haleakalā
HĀNA
Lāna'i
Molokini
Kaho'olawe
Alalākeiki Channel
Hāna Ridge
'Alenuihāhā Channel
Kohala Canyon
LĀNA'I DEEP
Clark 1 Slide
Kaho'olawe Trough
'Upolu Pt
Pololū Slump
Māhukona
Kohala Mts
Laupāhoehoe Slump
Hāmākua Coast
Mauna Kea
Kawaihae Bay
Clark Seamount
Dutton Seamount
Rainier Seamount
Clark 2 Slide
Kiholo Ridge
Hilo Ridge
Hilo Bay
HILO
Hualālai
Hawai'i
KAILUA-KONA
Moku'āweoweo Caldera
Puna Canyon
Puna Ridge
KAHO'OLAWE DEEP
Kealaikahiki Knoll
Indianapolis Seamount
North Kona Slump
Mauna Loa
ACTIVE
Kīlauea
ACTIVE
Pu'u 'Ō'ō
Cape Kumukahi
Kona Coast
Hilina Pali
Palaoa Knoll
Perret Seamount
Alika Knoll
Alika 2 Slide
Cook Seamount
Jaggar Seamount
Alika 1 Slide
Kahuku Fault
Papa'u Seamount
Hilina Slump
Punalu'u Slump
Hohonu Seamount
Ellis Seamount
South Kona Slide
South Kona Slump
Ka Lae
Lō'ihi
ACTIVE
Laird Knoll
McCall Seamount
Washington


Live Coral
Algae
Rubble
Sand
Questions?
Tom Bell
tbell@ucsb.edu

Spectral Transects (56/250)





Phototransects w/ Spectra