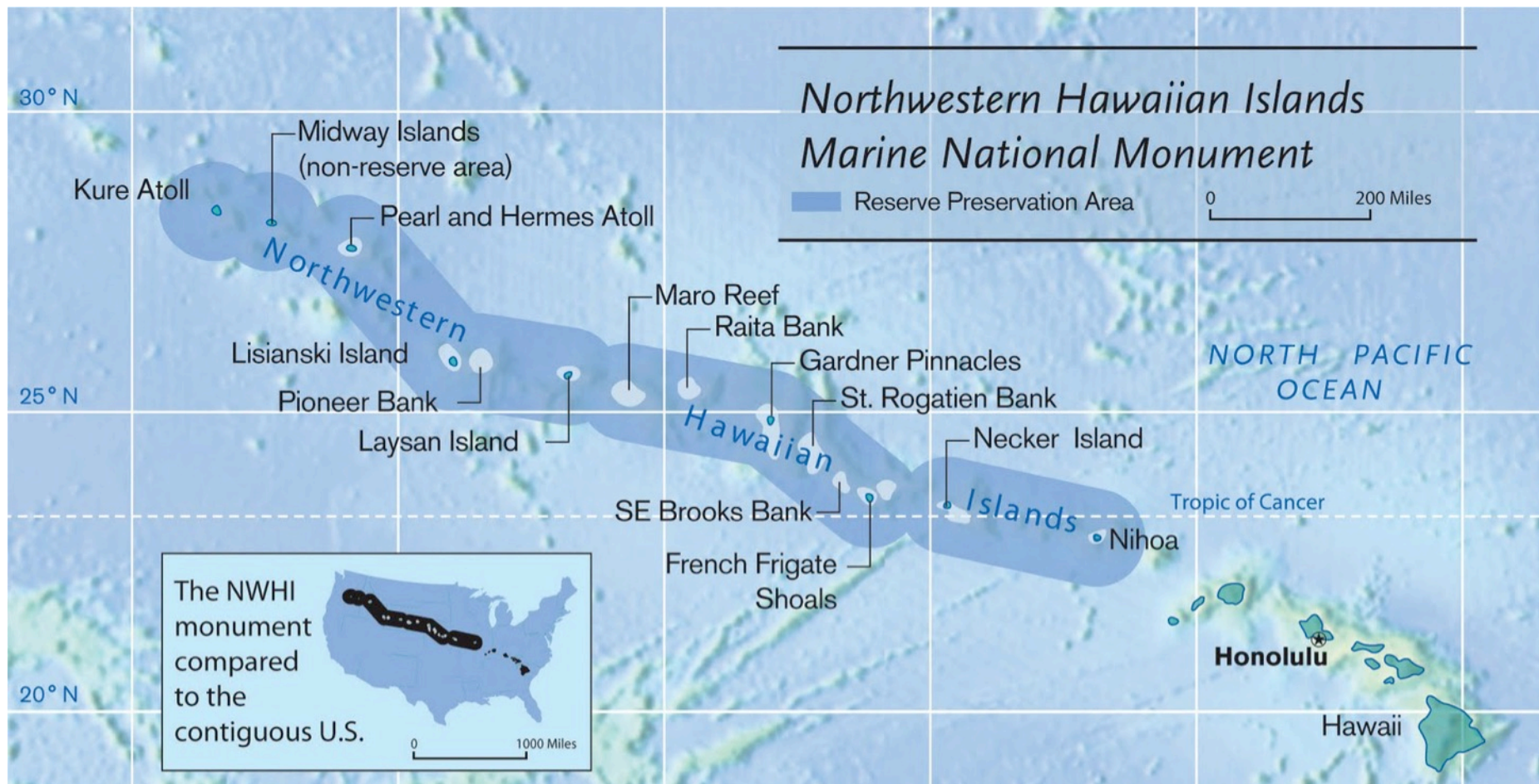# Assessing Simulated HyspIRI Imagery for Detecting and Quantifying Coral Reef Coverage and Water Quality Using Spectral Inversion and Deconvolution Methods

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Overarching Hypothesis: expected HyspIRI data will yield meaningful coral and water quality signals of relevance to modern concepts of coral reef health and resilience.

Northwestern Hawaiian Islands
Marine National Monument

30° N

Kure Atoll

Midway Islands (non-reserve area)

Pearl and Hermes Atoll

Northwestern

Reserve Preservation Area

0   200 Miles

NORTH PACIFIC OCEAN

Lisianski Island

Pioneer Bank

25° N

Laysan Island

Maro Reef
Raita Bank
Gardner Pinnacles
St. Rogatien Bank
Necker Island

Hawaiian

SE Brooks Bank

French Frigate Shoals

Islands

Nihoa

Tropic of Cancer

The NWHI monument compared to the contiguous U.S.

0   1000 Miles

Honolulu

20° N

Hawaii

Primary Objectives
- Assess anticipated HyspIRI data properties for discriminating between primary reef ecological regimes.
- Estimate sub-pixel variability and classification uncertainty.
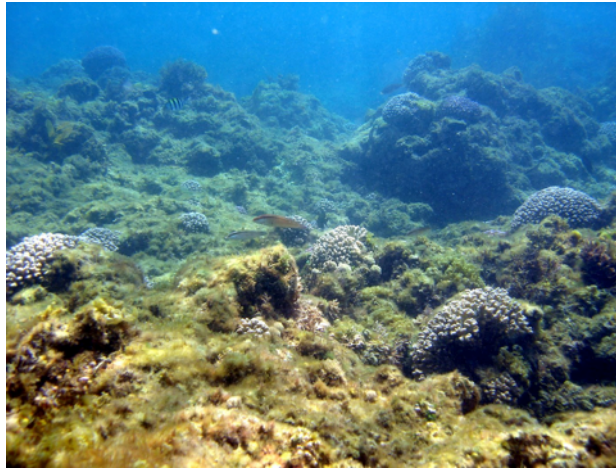
Secondary Objectives
- Expand mission coverage using other data sets, e.g., HICO and Landsat-8
- Investigate potential human impacts on derived spatial and temporal gradients.
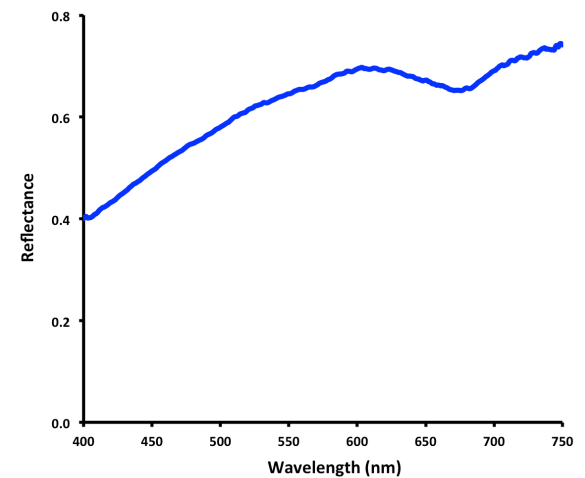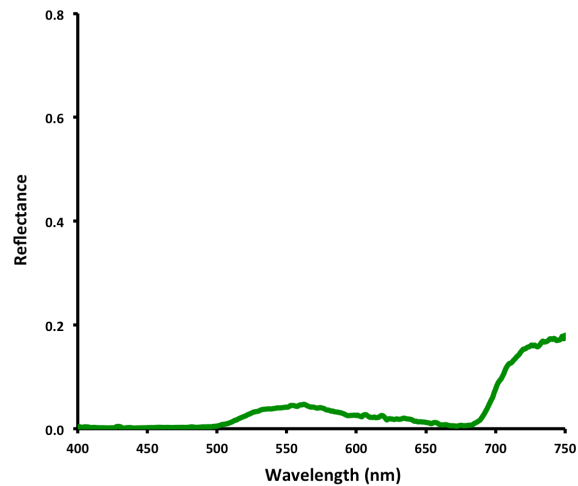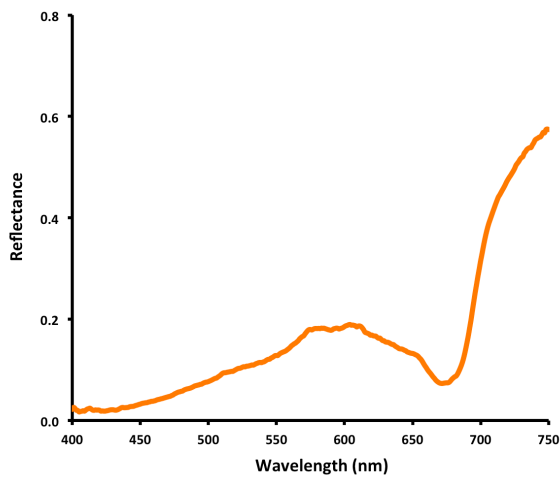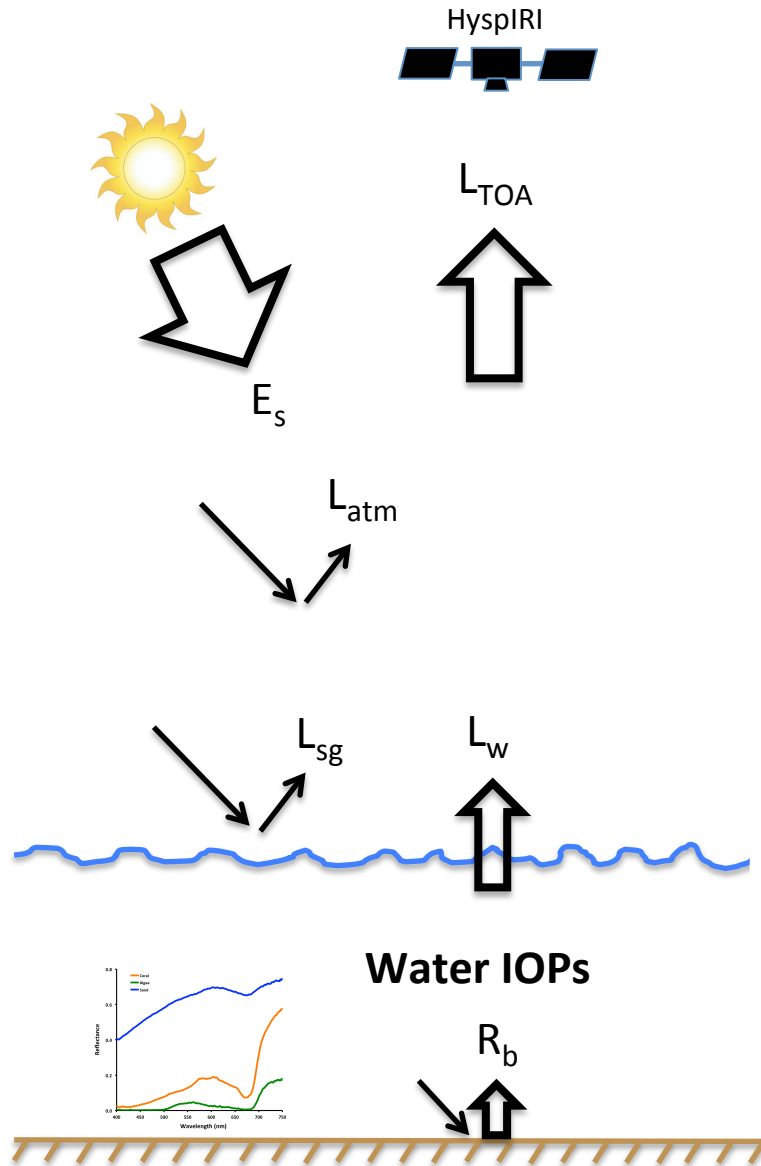
Coral Reef Ecological Regimes

Environmental Uncertainty and System Noise

HyspIRI

L_{TOA}

E_s

L_{atm}

L_{sg} L_w

Water IOPs

R_b

Top of Atmosphere Signal

Legend:
- **Coral**
- **Coral + Noise**
- **Coral - Noise**
- **Algae**
- **Algae + Noise**
- **Algae - Noise**
- **Sand**
- **Sand + Noise**
- **Sand - Noise**

Y-axis: **TOA Signal** (0, 2, 4, 6, 8, 10)
X-axis: **Wavelength (nm)** (400, 450, 500, 550, 600, 650, 700, 750)

Image Inversion

Environmental Parameter Values

- **Phytoplankton**
- **Sediment**
- **CDOM**
- **Depth**
- **Bottom Spectra**

Hydrolight

Spectral Matching Procedure

Spectral Reflectance Library

1. Parameters, $R_{sw}(\lambda)$
2. Parameters, $R_{sw}(\lambda)$
4. Parameters, $R_{sw}(\lambda)$
⋮
N. Parameters, $R_{sw}(\lambda)$

Calibrated, Atmosphere-Corrected Radiance

Image Inverted for Parameter of Interest

CWST match

measured

R_{RS}

Wavelength (nm)

Parameter
0.0 - 0.5
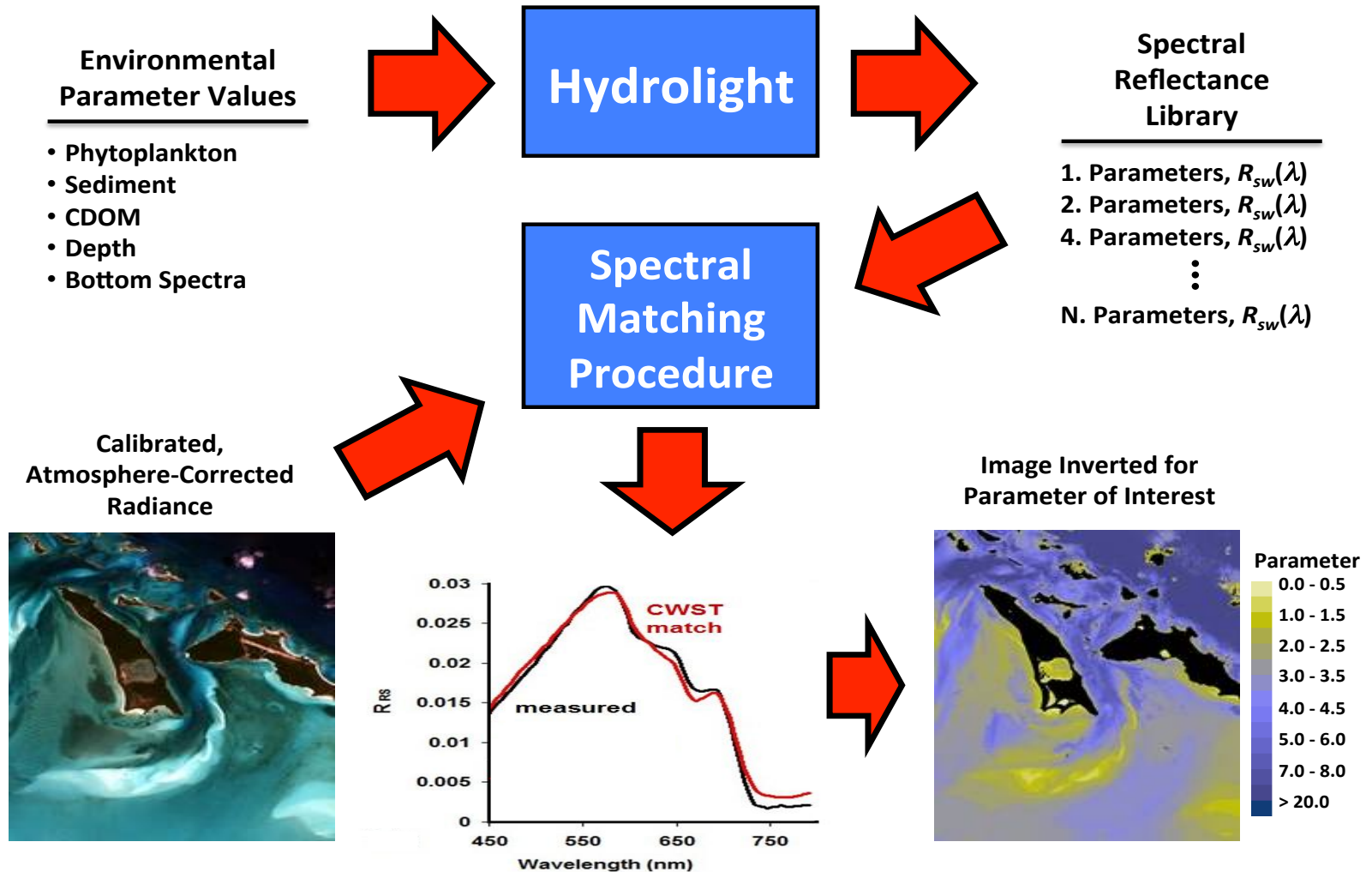1.0 - 1.5
2.0 - 2.5
3.0 - 3.5
4.0 - 4.5
5.0 - 6.0
7.0 - 8.0
> 20.0
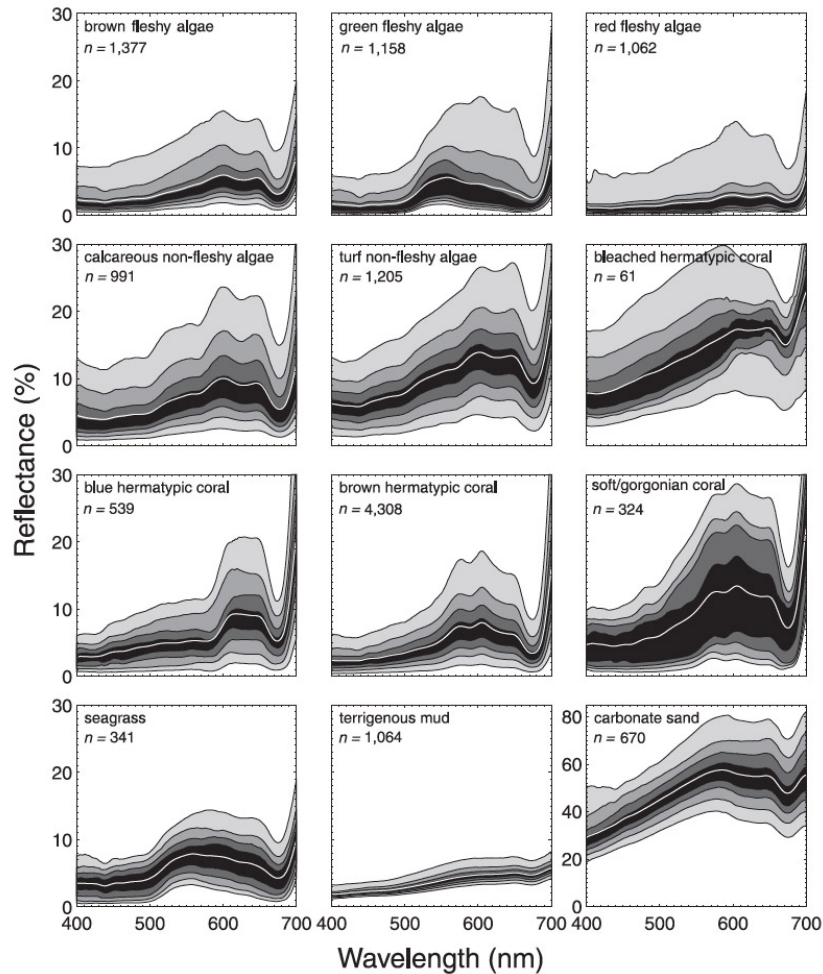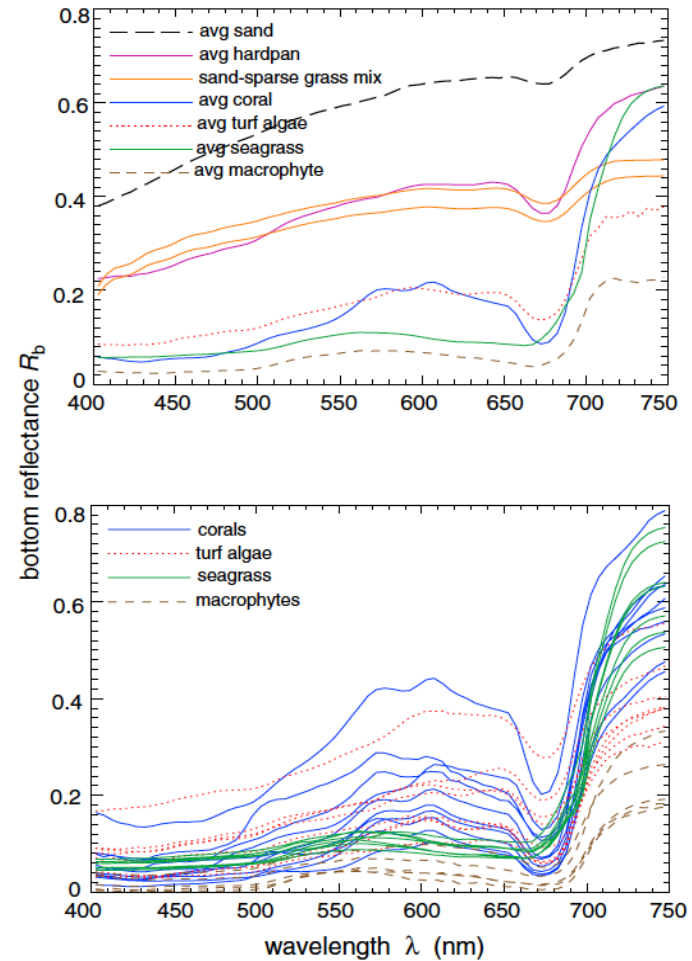
Existing In Situ Data

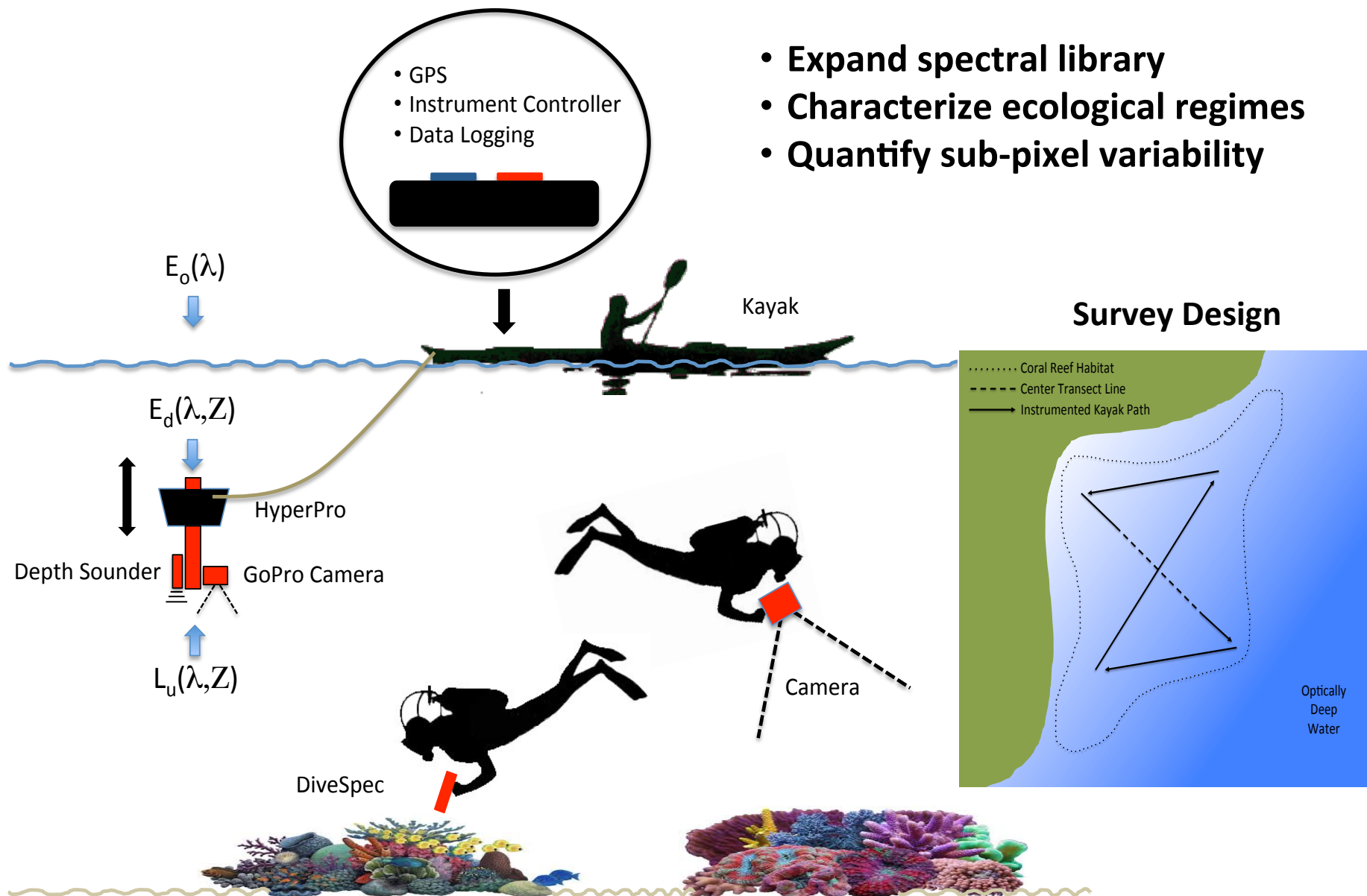**Hochberg et al., 2003**
(Hawaii)

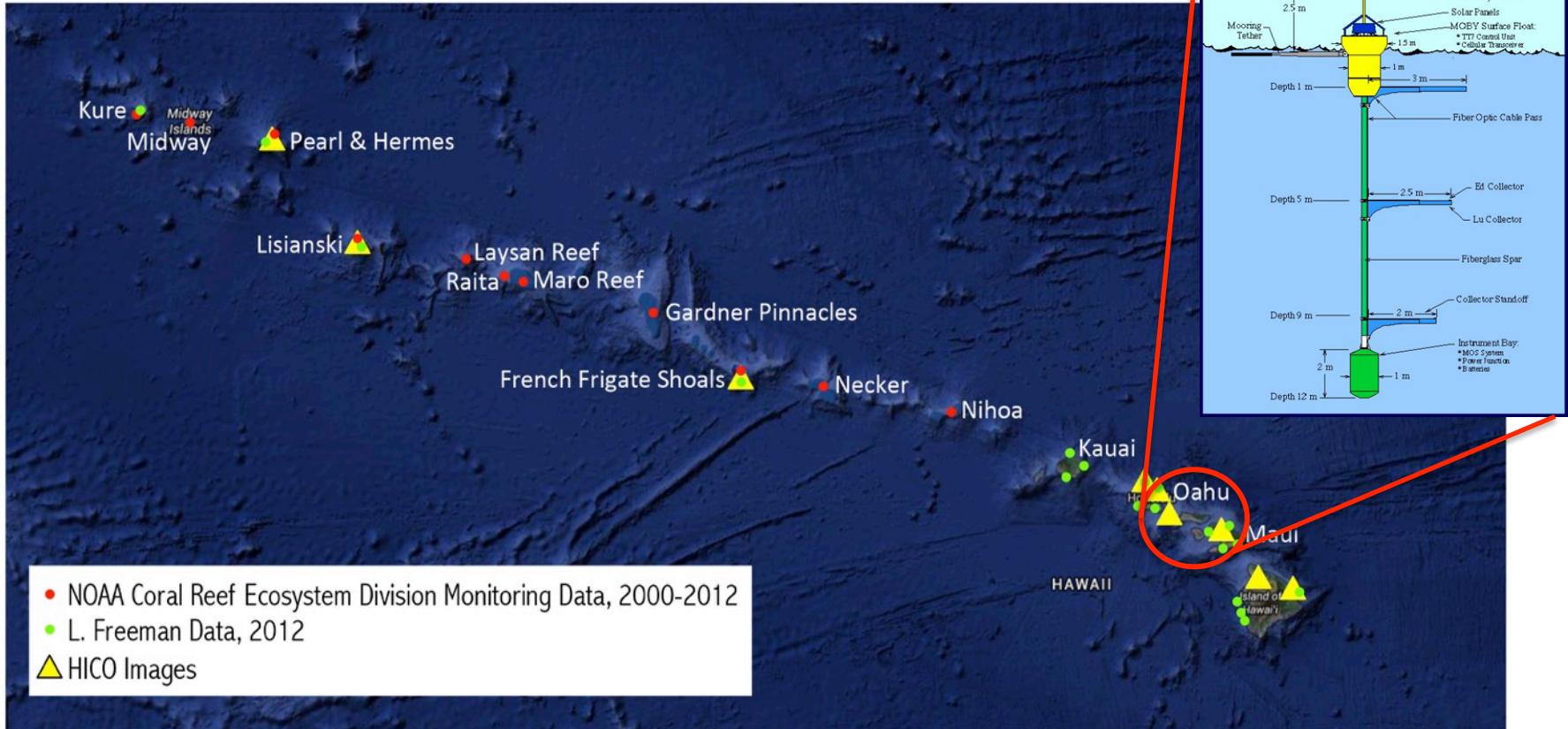**Lesser & Mobley, 2007, 2003**
(Bahamas)

In Situ Observations

- GPS
- Instrument Controller
- Data Logging

- **Expand spectral library**
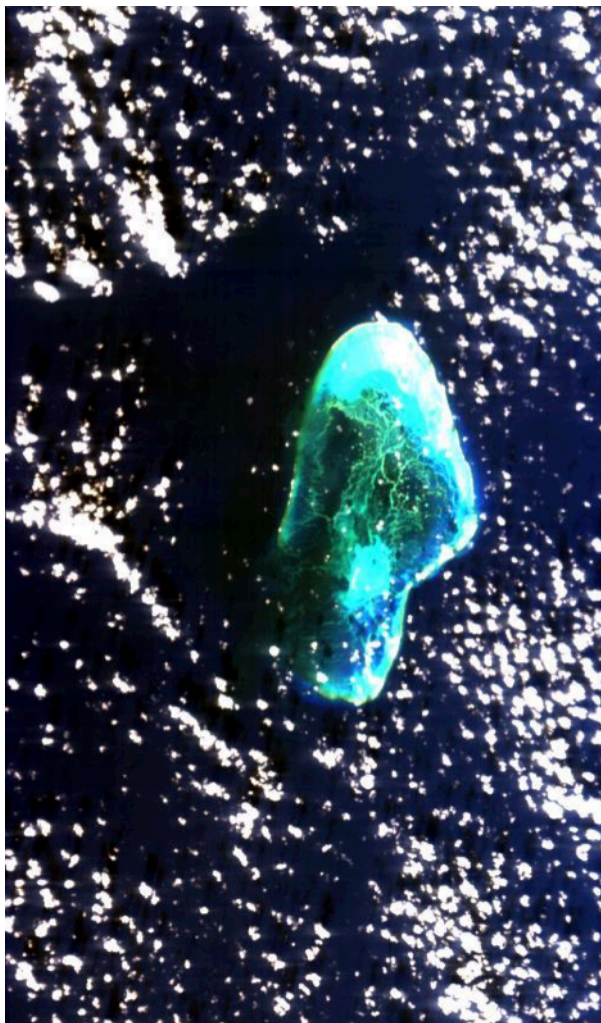- **Characterize ecological regimes**
- **Quantify sub-pixel variability**

$E_o(\lambda)$

Kayak

Survey Design

$E_d(\lambda,Z)$

HyperPro

Depth Sounder   GoPro Camera

$L_u(\lambda,Z)$

Camera

DiveSpec

······· Coral Reef Habitat
- - - Center Transect Line
→ Instrumented Kayak Path

Optically
Deep
Water

Other Supporting Data

- NOAA Coral Reef Ecosystem Division Monitoring Data, 2000-2012
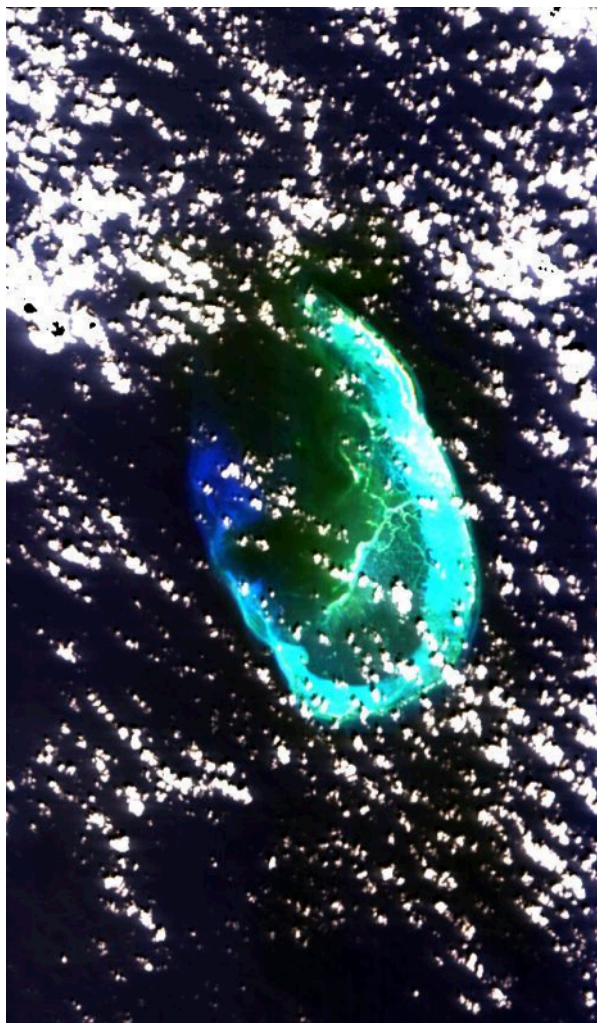- L. Freeman Data, 2012
- HICO Images

Expand Mission Coverage: HICO Images

Pearl & Hermes Atoll

French Frigate Shoals

Oahu

Summary

- Assessment of HyspIRI simulator data for detecting and mapping primary reef ecosystem regimes.

- Earth system approach to modeling remotely sensed signals with environmental uncertainty and sensor noise.

- Image inversion for reef regime coverage and water quality.

- In situ validation of remotely sensed signals and assessments of sub-pixel variability.

- Combined HyspIRI simulator and historical data to investigate magnitude and causes of spatial and temporal gradients in regime cover.