Deriving Shellfish Endmembers from Hyperspectral Imagery and Shellfish Spectral Variability

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Introduction

- Shellfish important both economically and ecologically.
- Greater anthropogenic impact to coastal ecosystem from non-point source pollution.
- The **main objective** of this research is to identify the spectral endmembers of shellfish, mud, water, sand, and vegetation from HyMap hyperspectral imagery.
- A **secondary objective** is the compilation of an in-situ spectral signature library of the five or more substrates from field collected data over the course of a year. This spectral library will then be compared to the extracted spectral endmembers.

Hypothesis and Justification

Problem: Difficult to distinguish shellfish from mud, sand, water, and vegetation using low spectral and spatial resolution remote sensing.

- Null Hypothesis
  - There is no difference between in-situ and imagery derived spectral endmembers of shellfish.
  - There is no spectral difference between mud and shellfish.
  - There is no spectral difference between sand and shellfish.

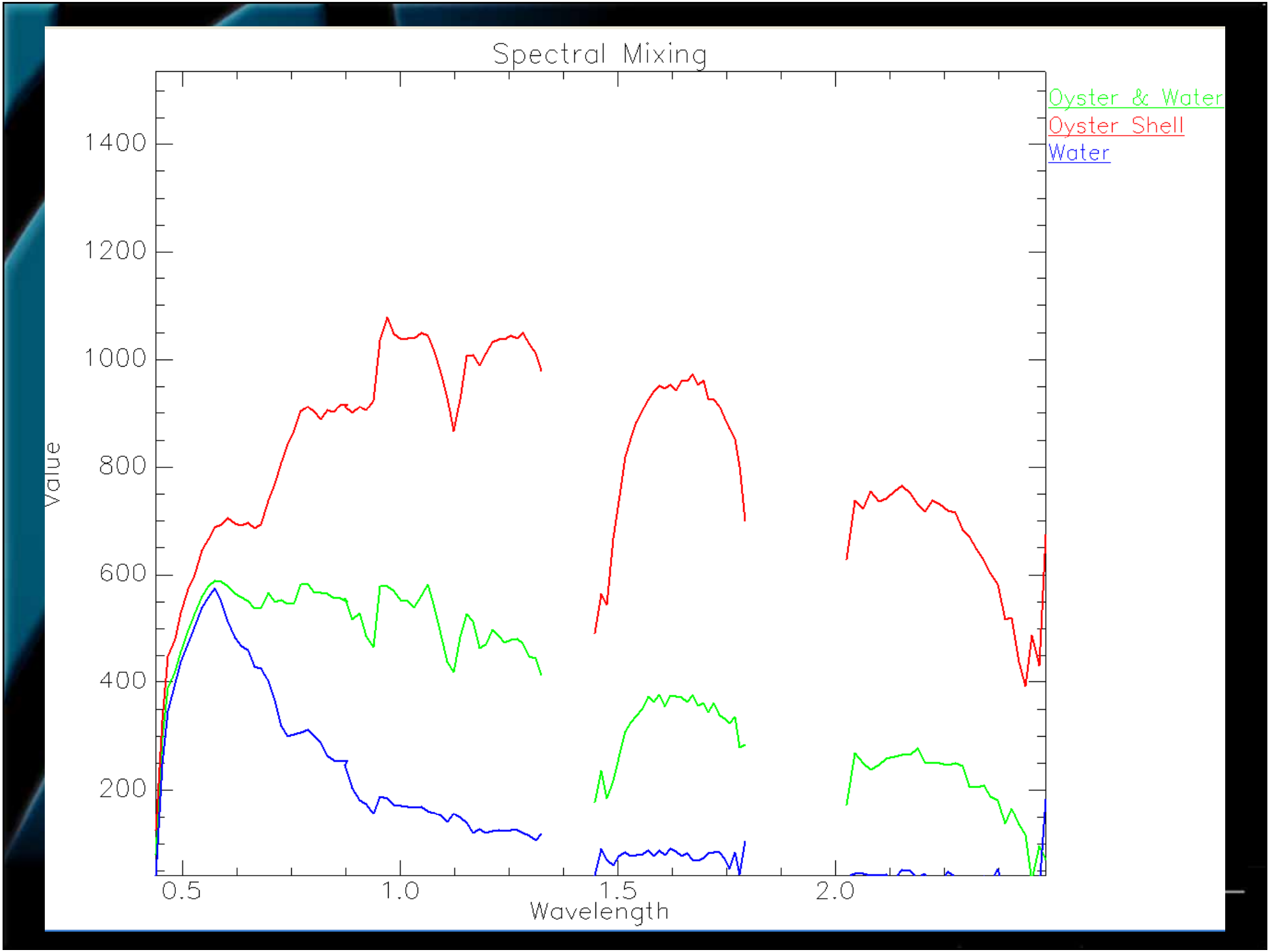
- Justification
  - Need for timely, repeatable, and (more) accurate spatial distribution of shellfish resources.
  - Baseline maps of resource distribution
  - Southeastern intertidal shellfish extensively studied but very little quantitative information exists (Coen et al. 2000: Grizzle, 1990)

Methodology - Overview

- Field and Image Analysis:
  1. In-situ data collection of shellfish spectra.
  2. Derive spectral endmembers from imagery and spectrally unmix.
  3. Using in-situ shellfish spectra spectrally unmix imagery.
  4. Derive shellfish maps, compare two methods and field verify.
- Incorporate LiDAR data.

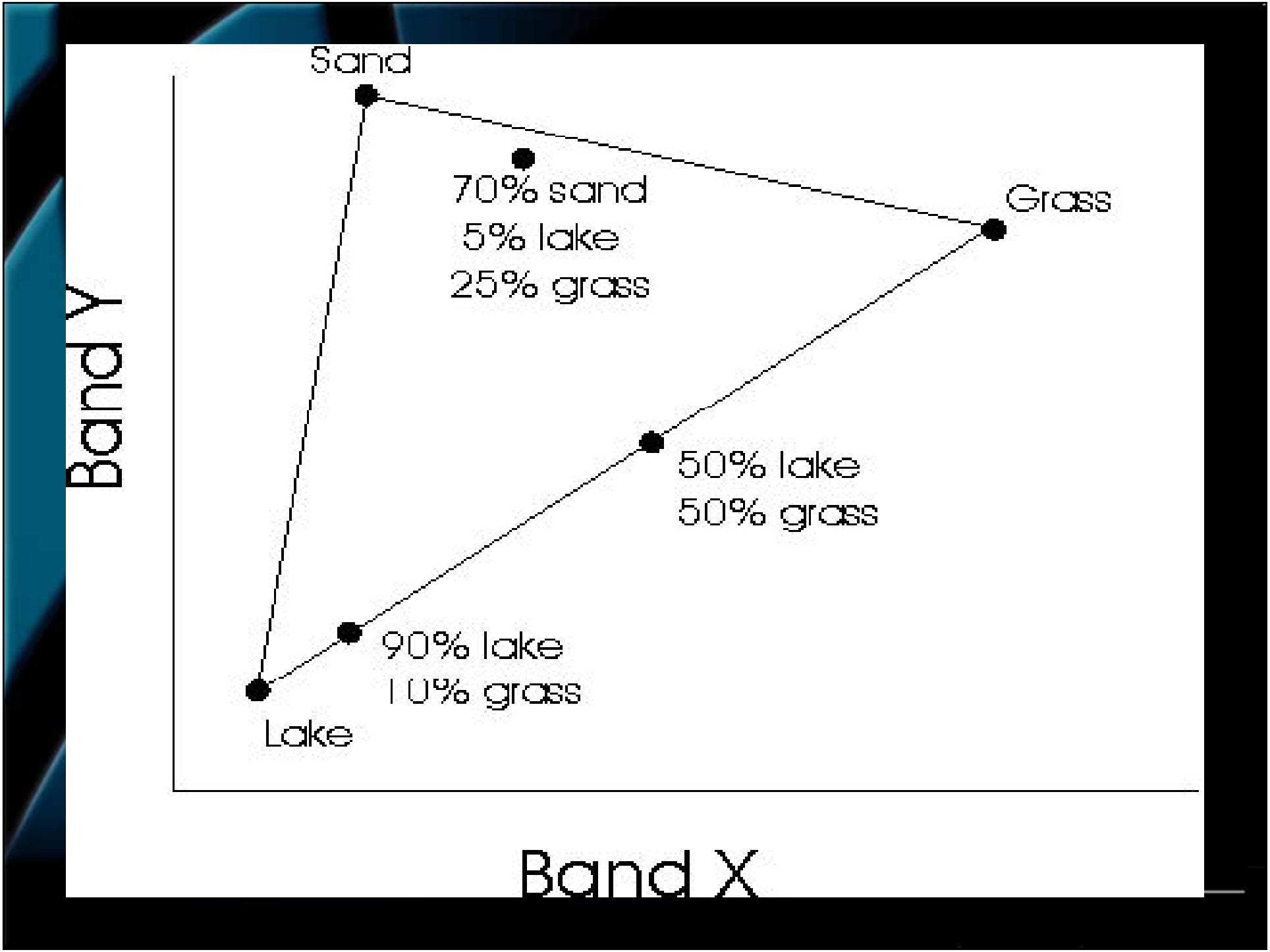
Spectral Mixture Analysis

- Performed in ENVI® as either a wizard or individual functions.
  - Technique for dividing earth materials contained within a pixel into its constituent components by the use of endmembers that are representative of the spectral signatures of the cover type, (Garcia-Haro, et al.1999).
  - Assumption: each pixel is a physical mixture of multiple components weighted by surface abundance and the spectrum of the mixture is the linear combination of the component spectra.
- Endmembers to isolate in imagery are:
  - Shellfish
  - Vegetation
  - Mud
  - Sand
  - Water
  - Shadow


Spectral Mixing
Oyster & Water
Oyster Shell
Water
Value
1400
1200
1000
800
600
400
200
0.5
1.0
1.5
2.0
Wavelength

Spectral Mixture Analysis – Process Overview

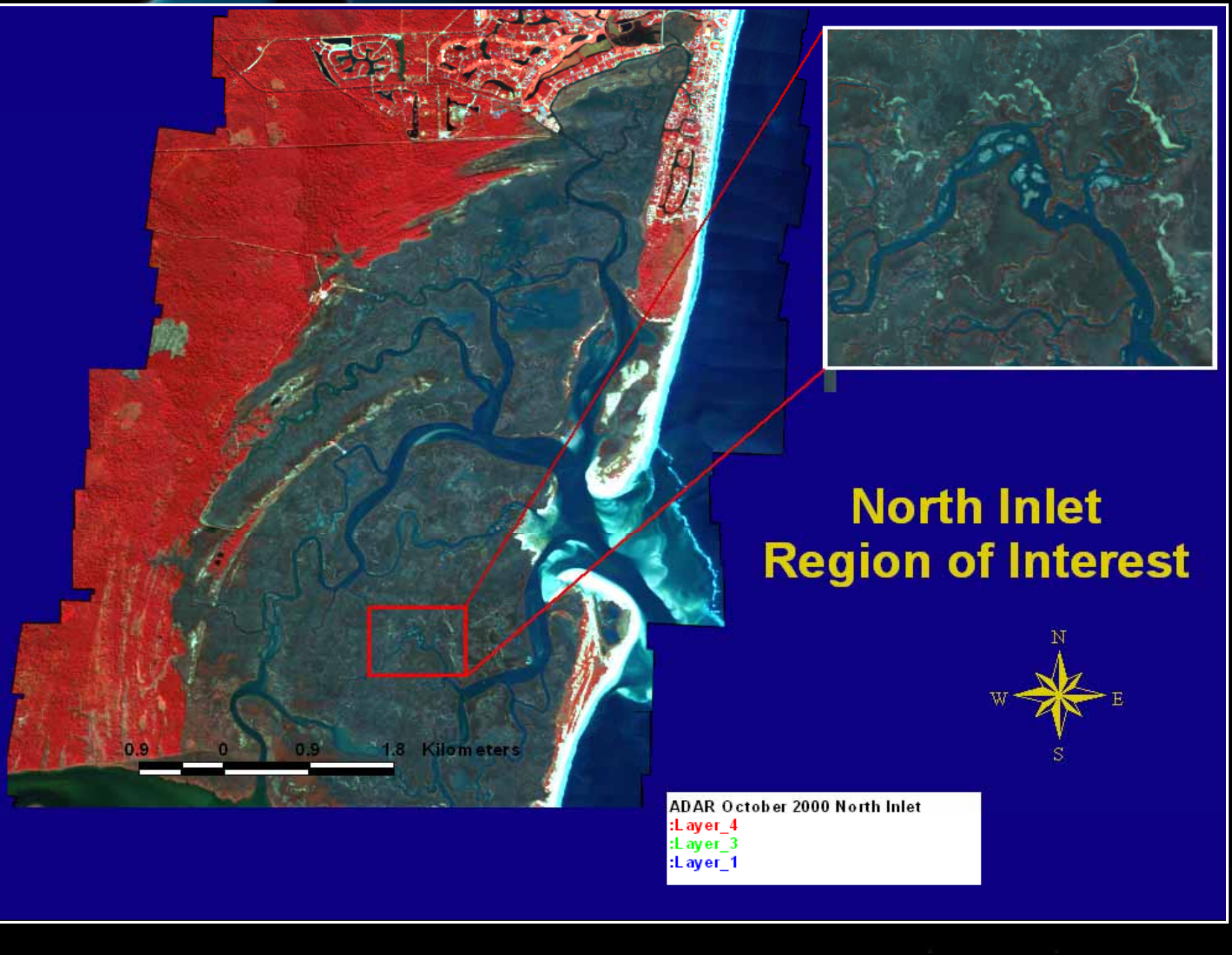
1. Reduce data dimensionality
   - Principal component analysis: Minimum Noise Transform
2. Derive endmembers from imagery or input user supplied endmembers.
   - Isolate spectrally pure or extreme endmembers of interest from imagery.
3. Spectrally unmix image.

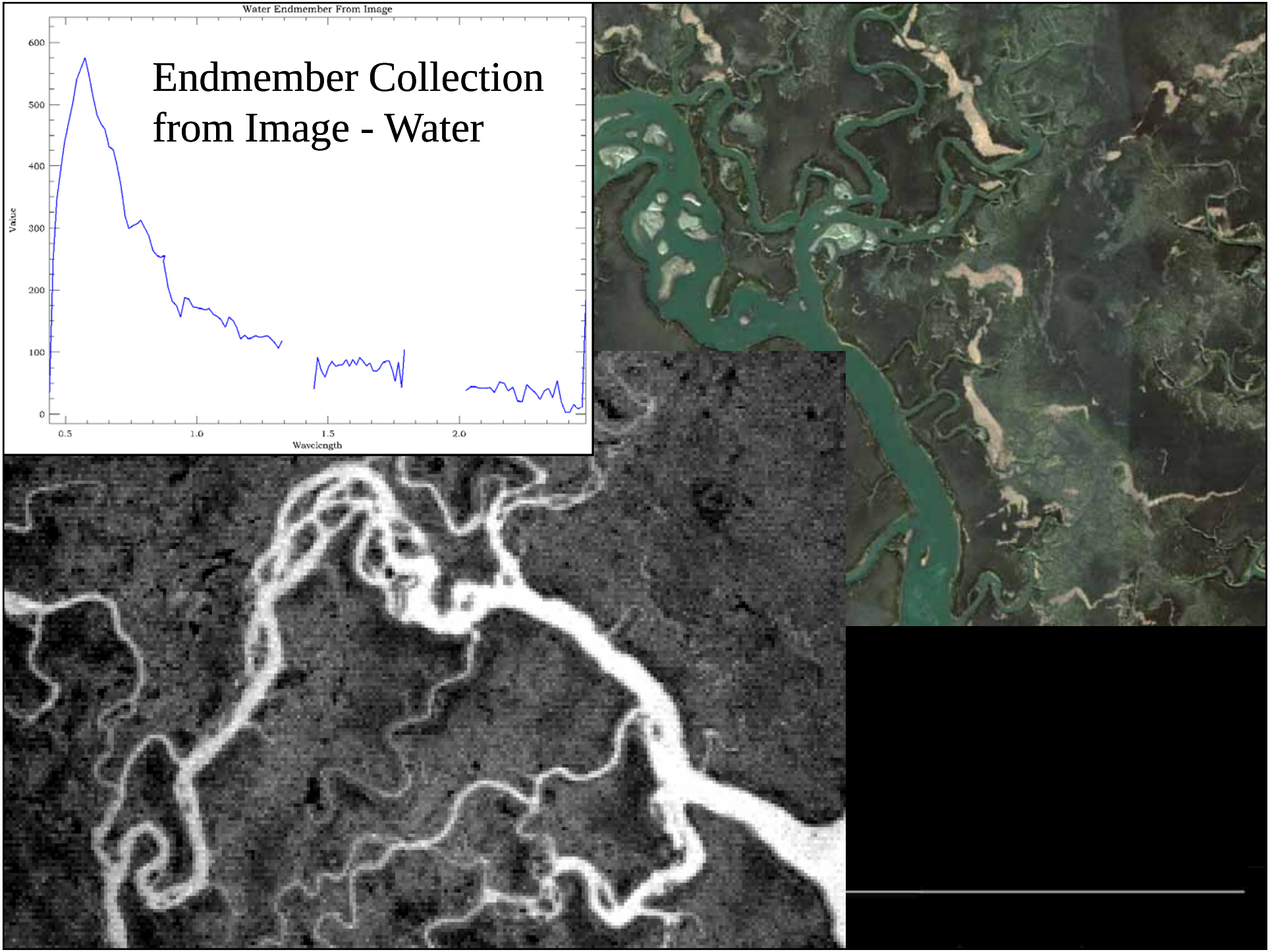

Sand
70% sand
5% lake
25% grass
Grass
50% lake
50% grass
90% lake
10% grass
Lake
Band Y
Band X

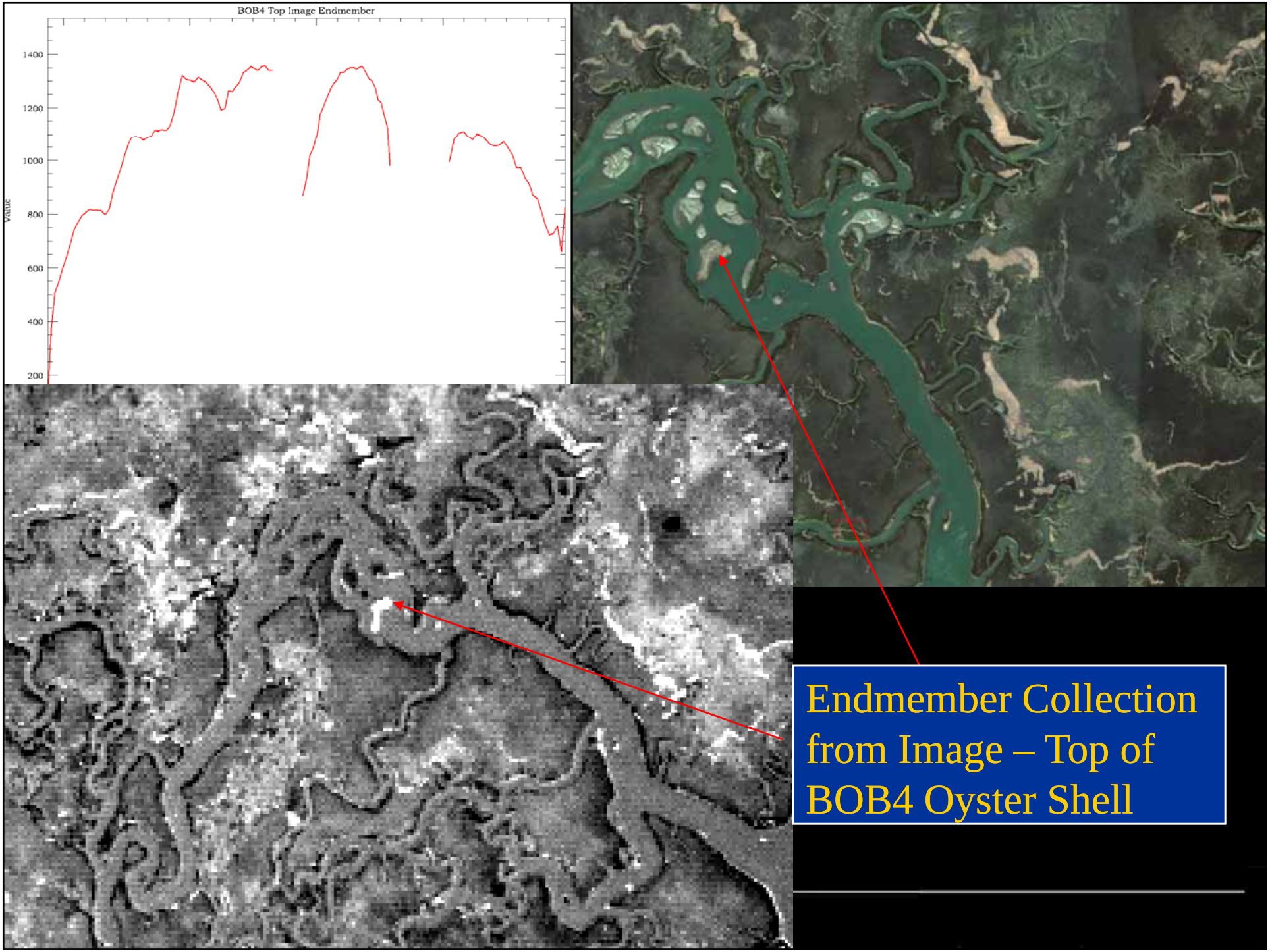
Imagery

- HyMap:
  - Airborne platform, 2 Km.
  - 126 contiguous bands: 439.0 – 2482.0 nm
  - Sampling interval is 15 nm
  - High signal to noise ratio (>500:1)
  - Spatial resolution is 4 X 4 meter.
  - Acquired October 2000

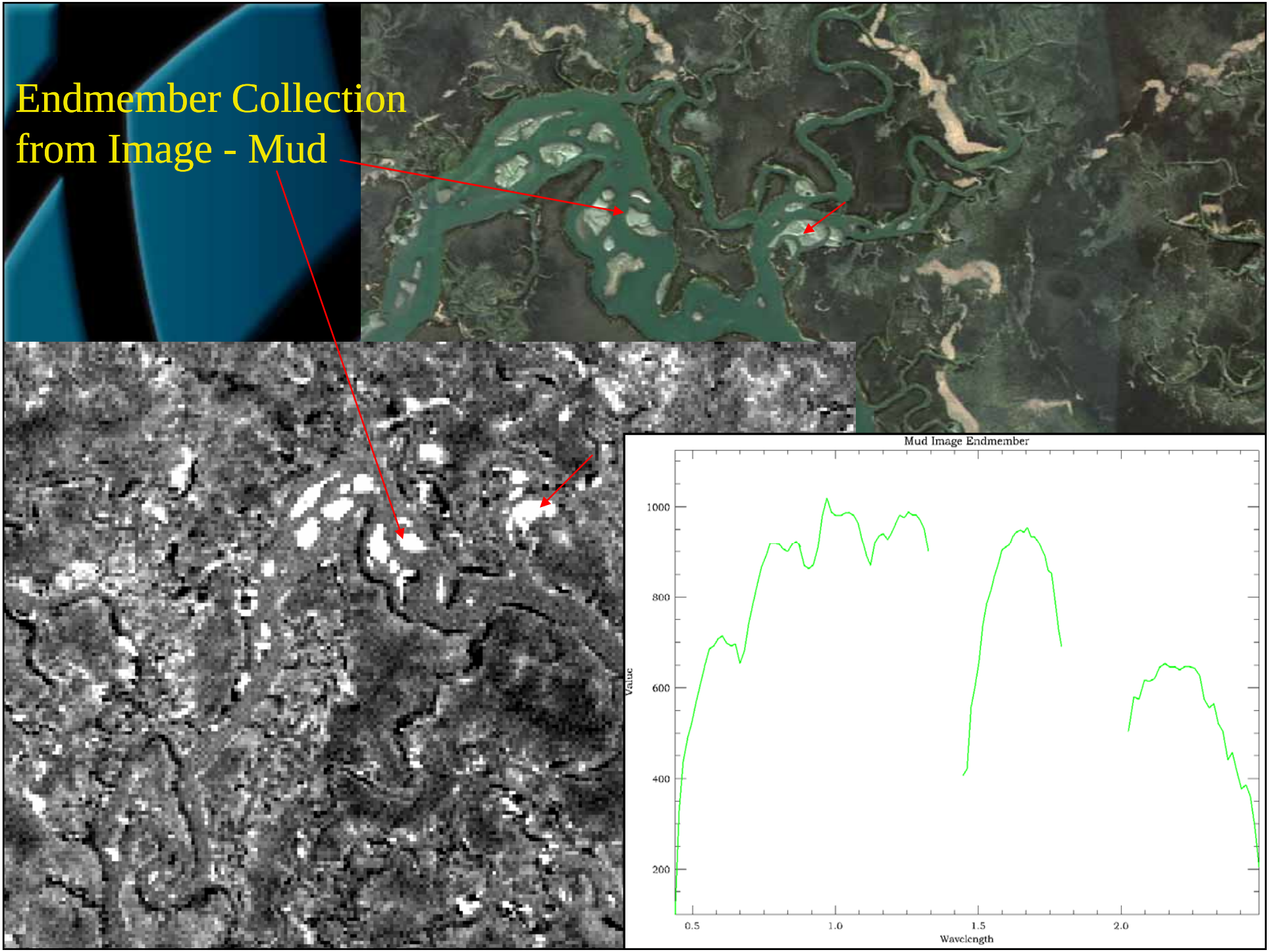
HyVista Corporation

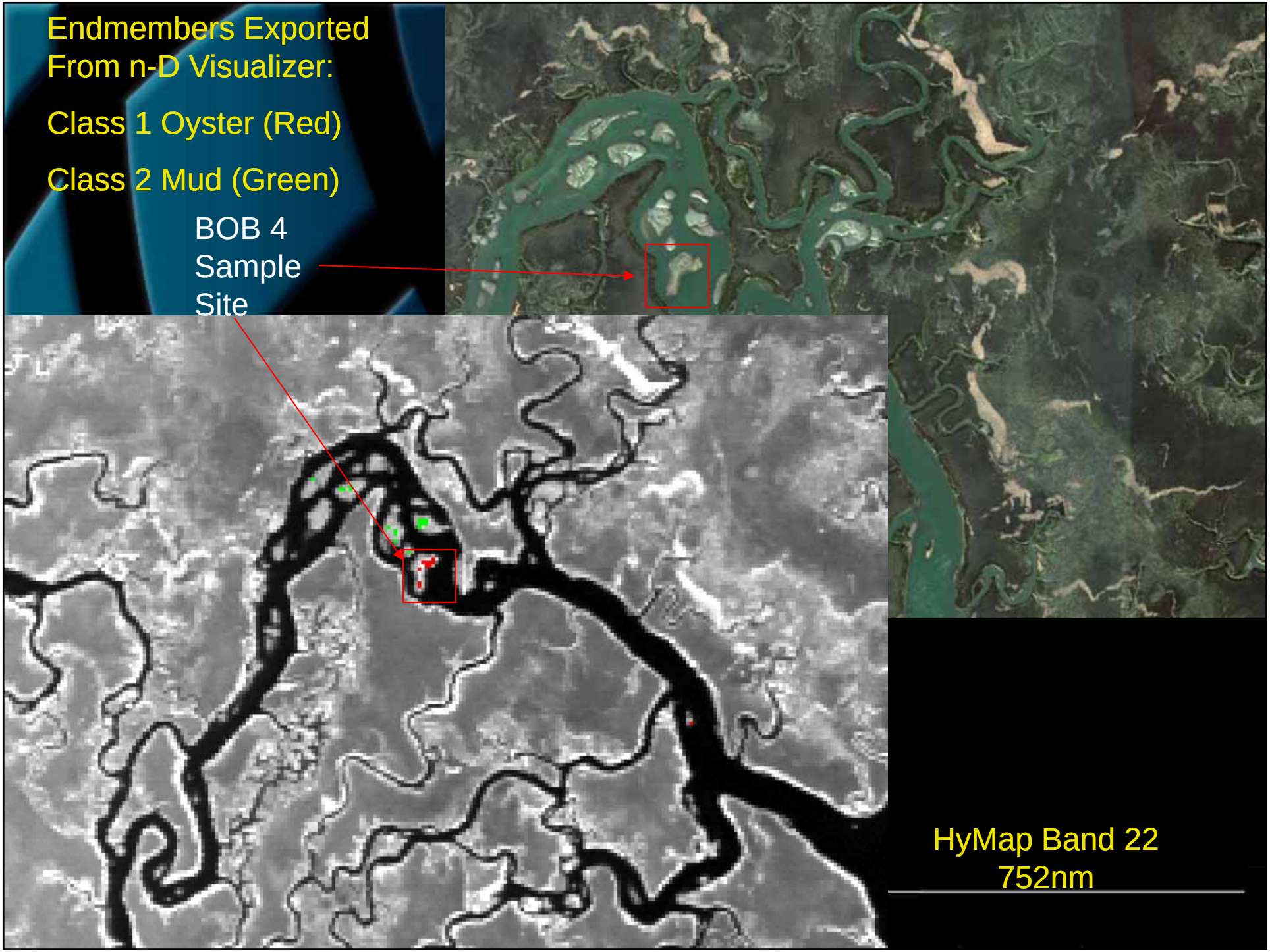

North Inlet
Region of Interest
N
W
E
S
0.9 0 0.9 1.8 Kilometers
ADAR October 2000 North Inlet
:Layer_4
:Layer_3
:Layer_1

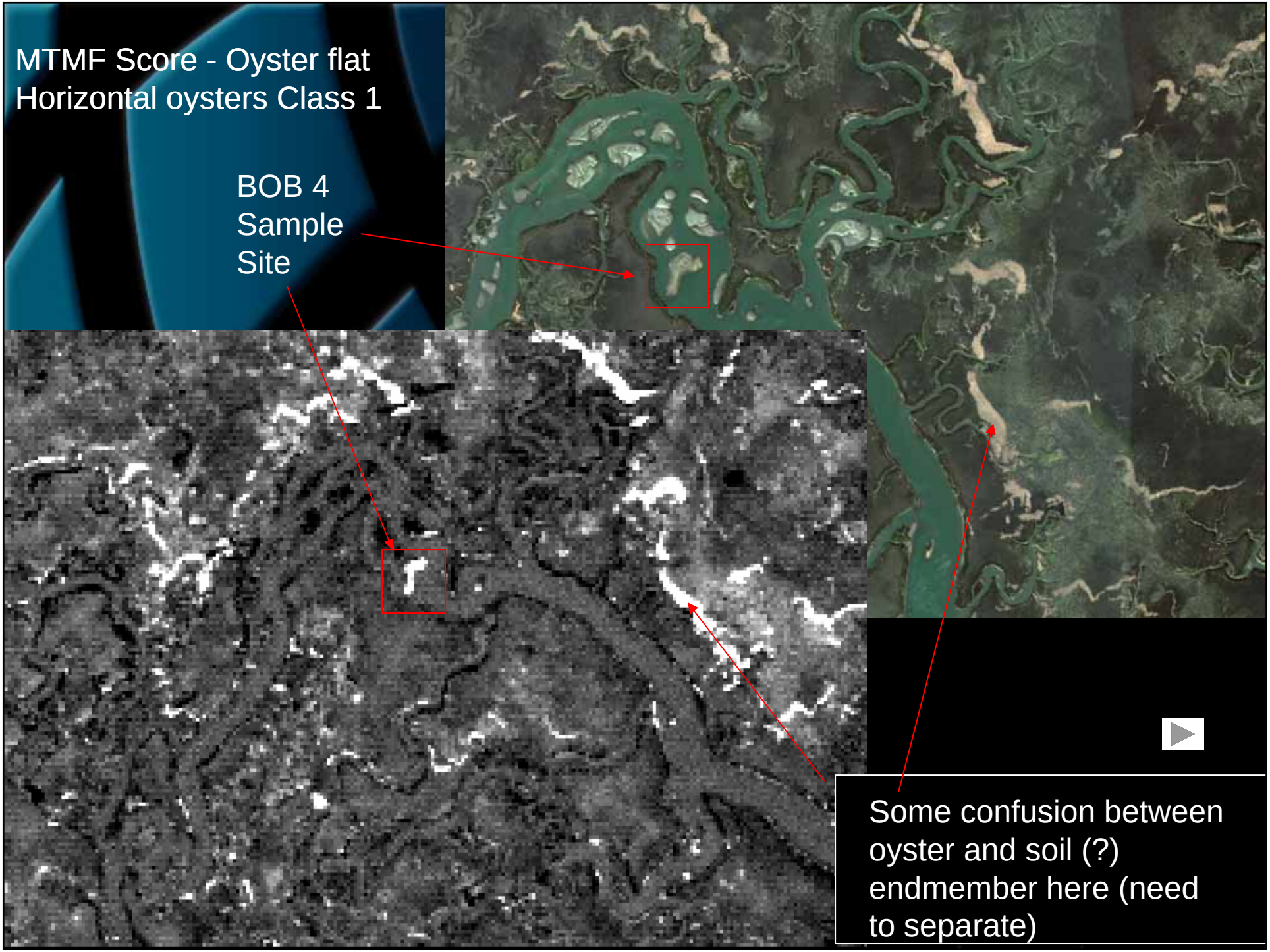

Water Endmember From Image
Value
Wavelength
0
100
200
300
400
500
600
0.5
1.0
1.5
2.0
Endmember Collection
from Image - Water


BOB4 Top Image Endmember
Value
1400
1200
1000
800
600
400
200
Endmember Collection from Image – Top of BOB4 Oyster Shell

Endmember Collection from Image - Mud

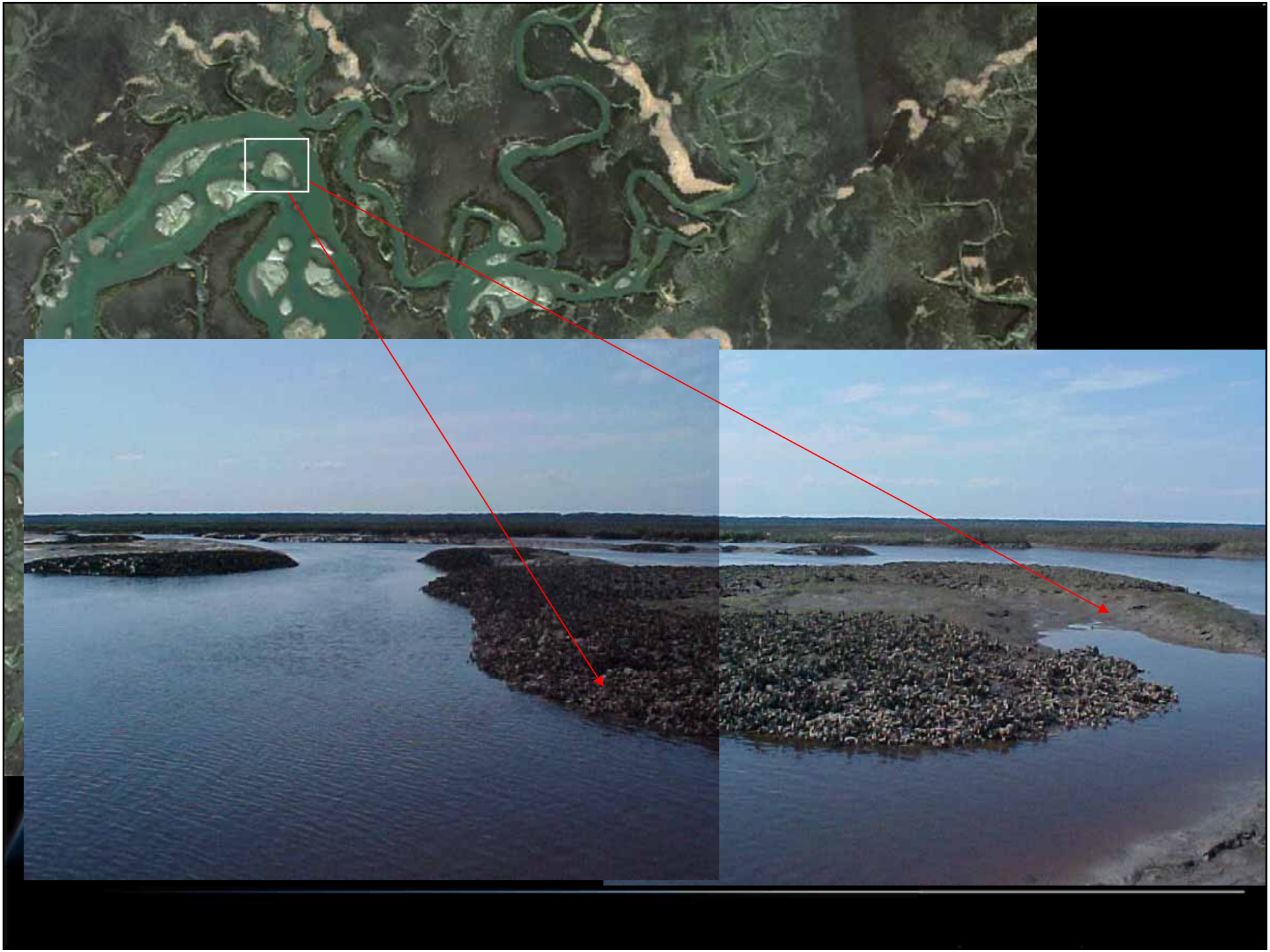


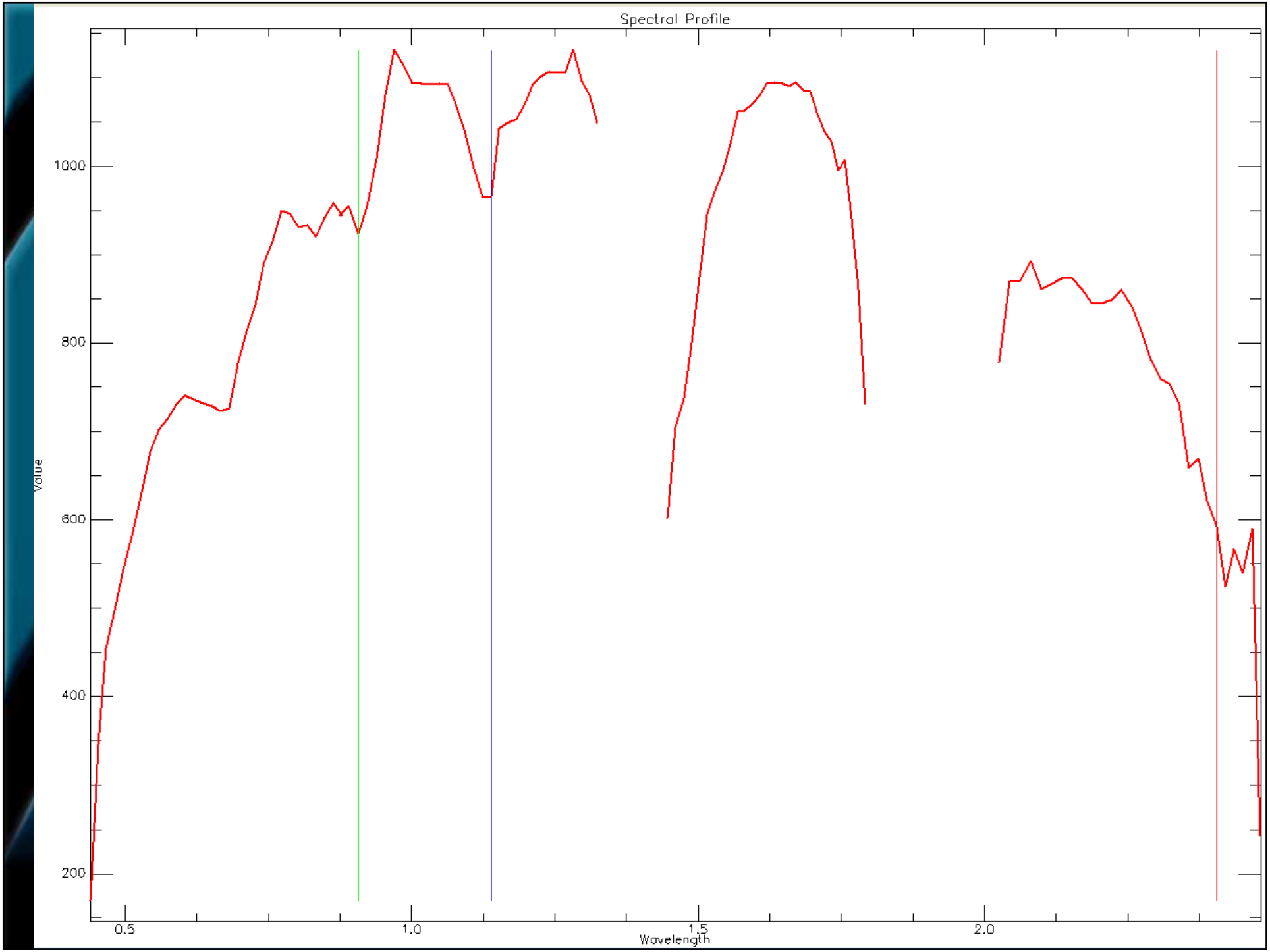

Endmembers Exported From n-D Visualizer:
Class 1 Oyster (Red)
Class 2 Mud (Green)
BOB 4 Sample Site
HyMap Band 22
752nm

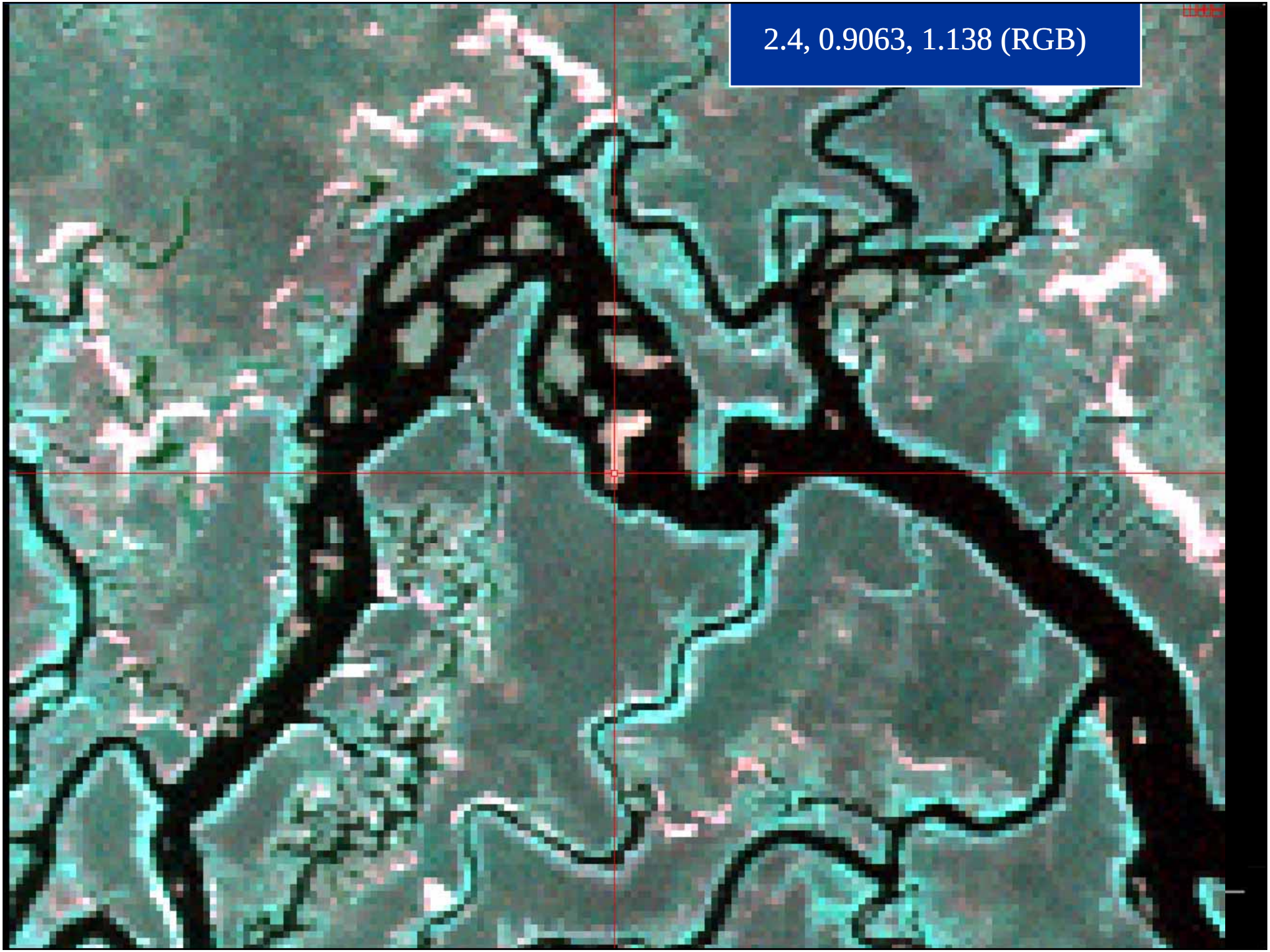

MTMF Score - Oyster flat
Horizontal oysters Class 1
BOB 4
Sample
Site
Some confusion between oyster and soil (?) endmember here (need to separate)

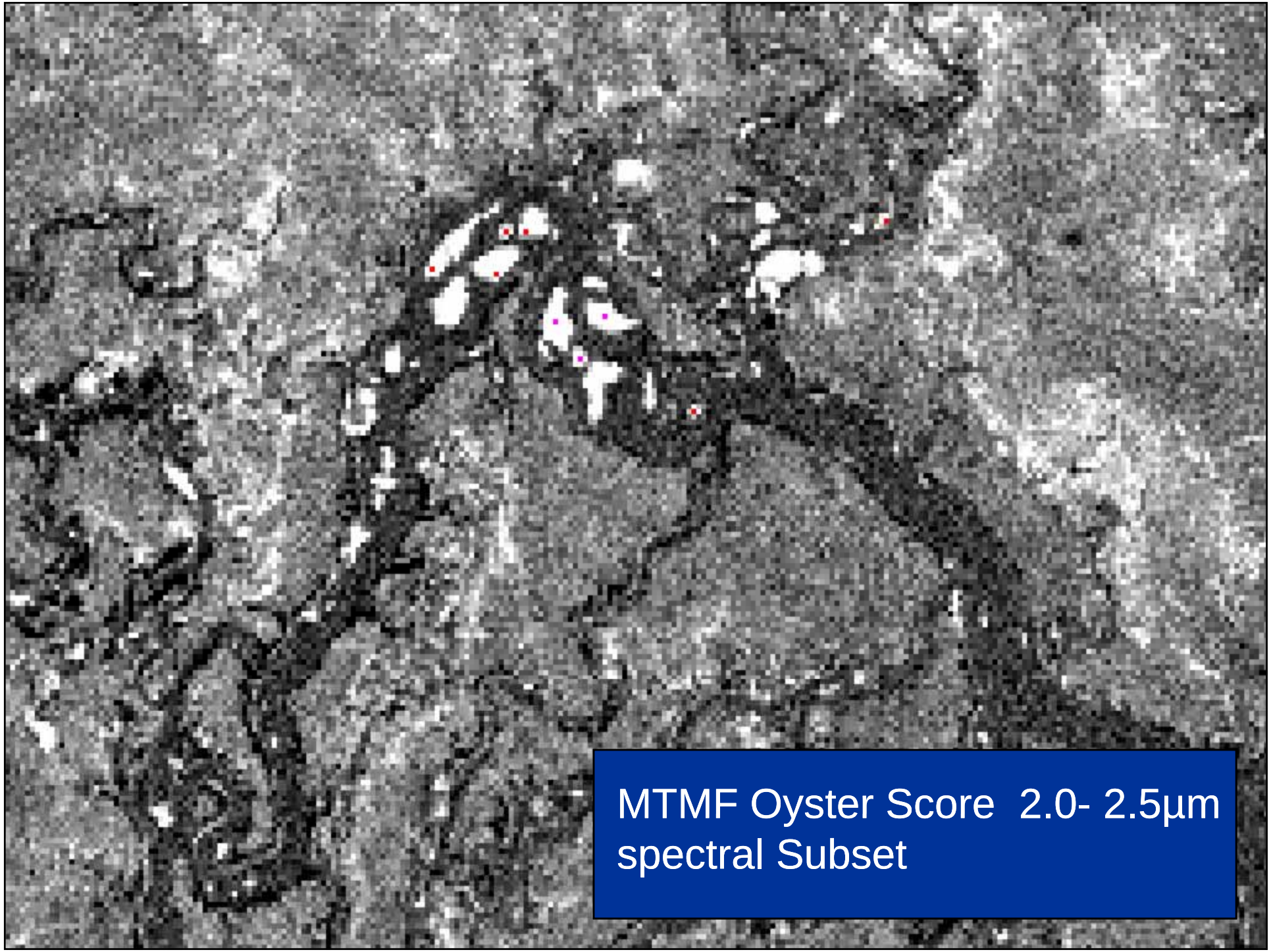
MTMF Score - Mud Endmember Class 2

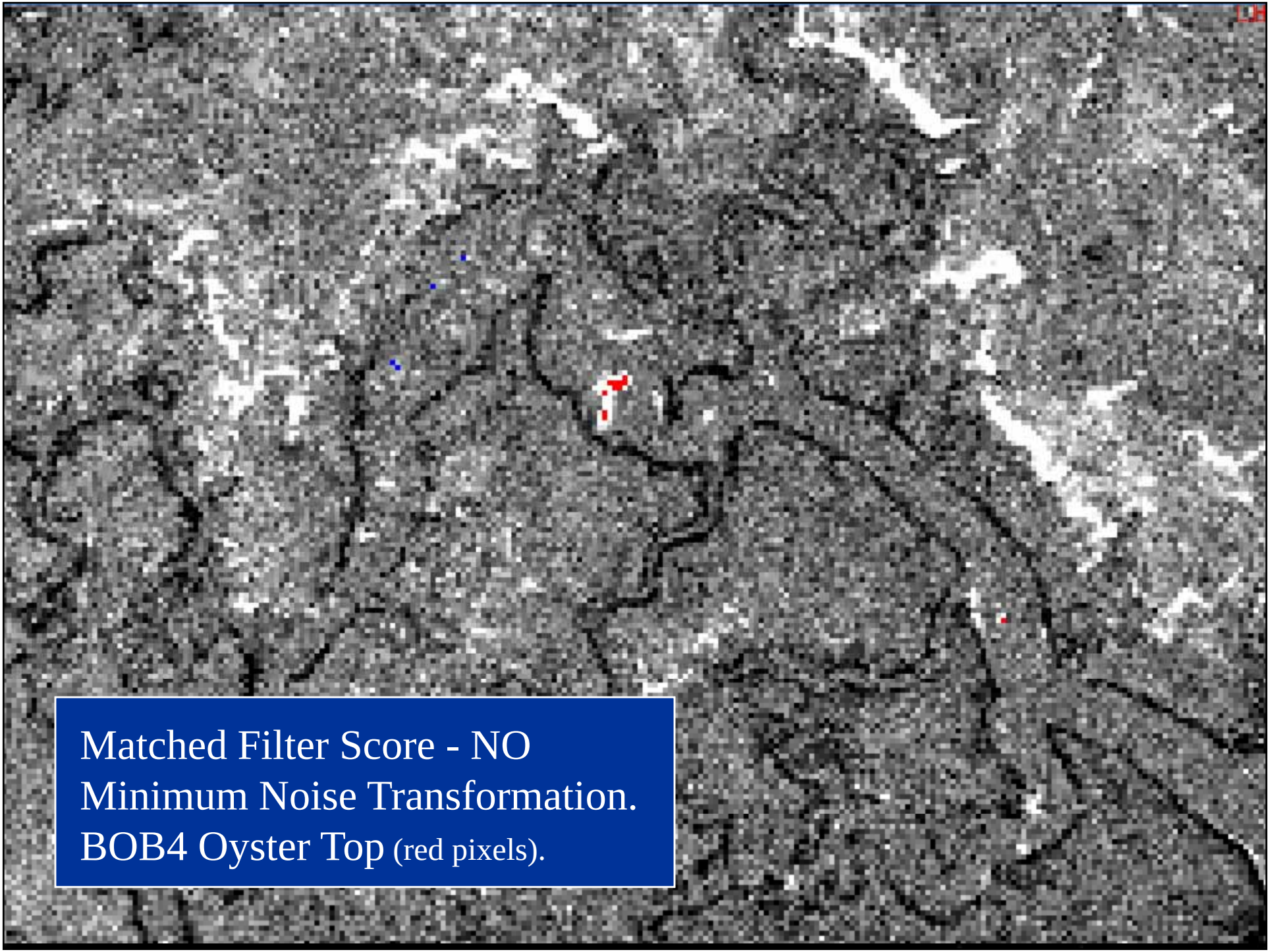
Mud / Oysters Flats – missing oysters.

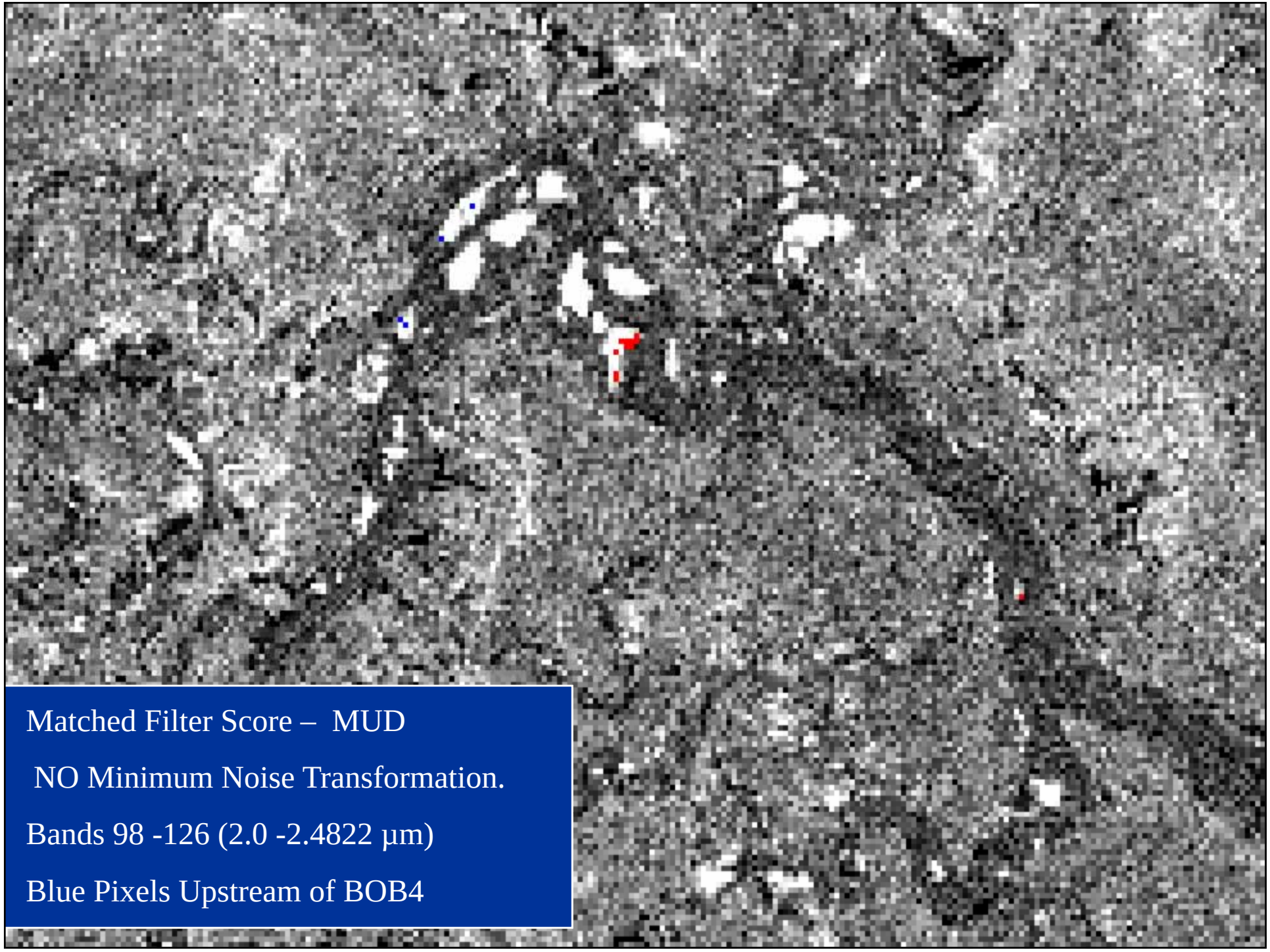



Spectral Profile
1000
800
600
400
200
Value
0.5
1.0
1.5
2.0
Wavelength


2.4, 0.9063, 1.138 (RGB)

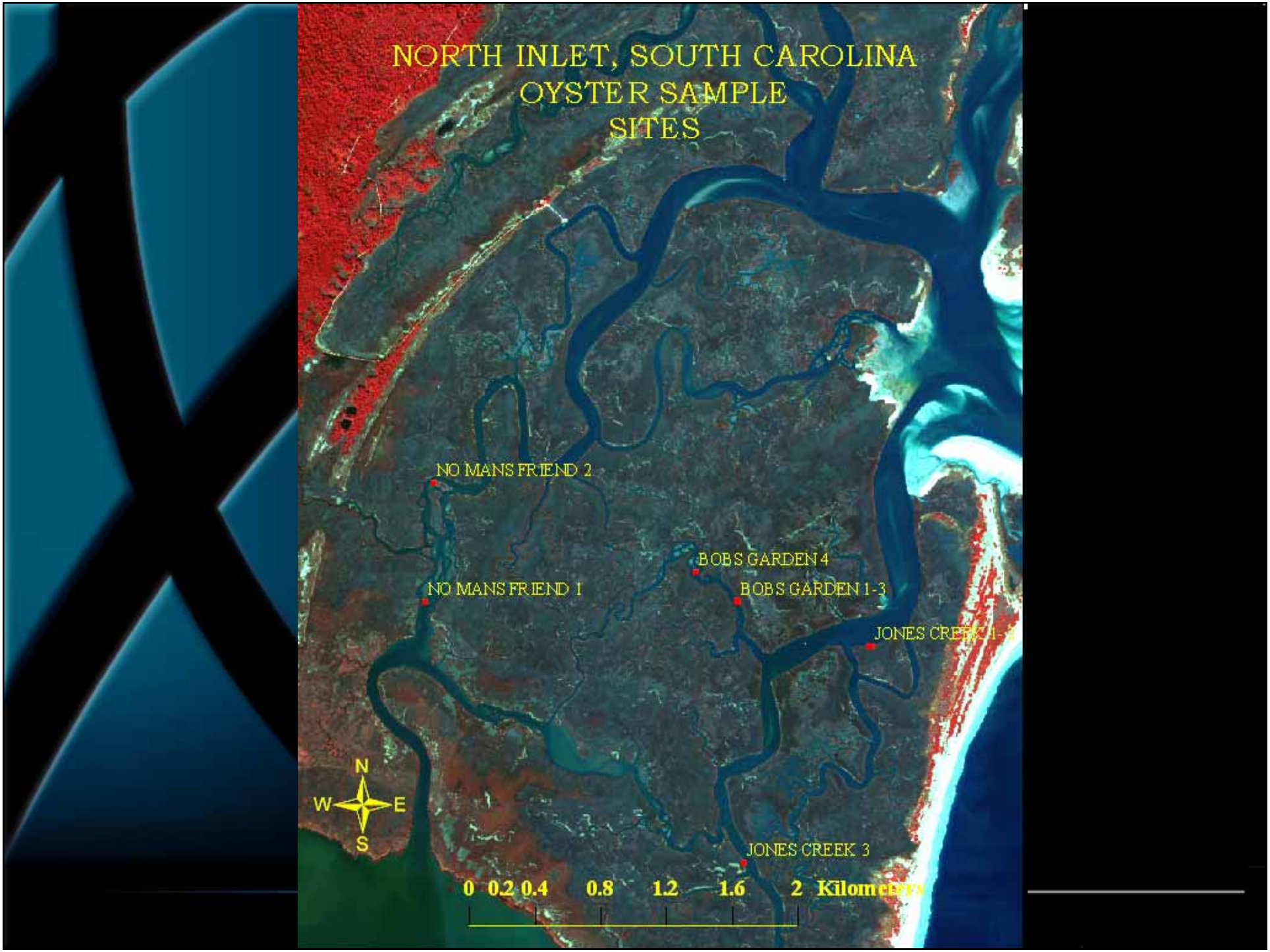

MTMF Oyster Score 2.0- 2.5µm
spectral Subset


Matched Filter Score - NO Minimum Noise Transformation. BOB4 Oyster Top (red pixels).

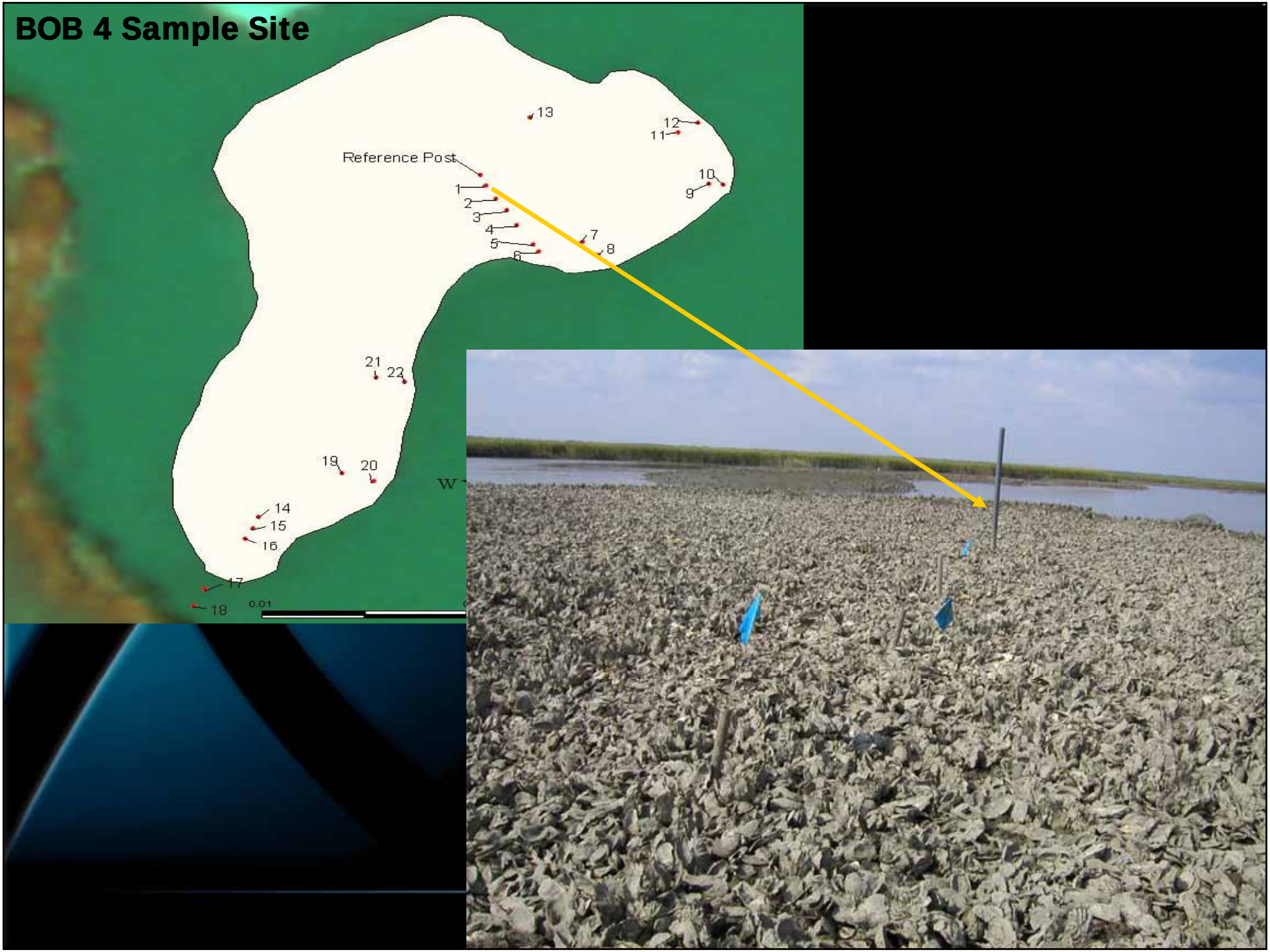

Matched Filter Score – MUD
NO Minimum Noise Transformation.
Bands 98 -126 (2.0 -2.4822 µm)
Blue Pixels Upstream of BOB4

Field Sample Sites

- Ten sample sites with each sample site having between 4 – 22 sample points.
- Sample points organized according to spatial clustering (densities) of shellfish to characterize shellfish spectral signature.
- Spectral samples taken dry, wet and submerged.
- Sampled once a month for twelve months.


NORTH INLET, SOUTH CAROLINA
OYSTER SAMPLE
SITES
NO MANS FRIEND 2
BOBS GARDEN 4
NO MANS FRIEND 1
BOBS GARDEN 1-3
JONES CREEK 1-2
N
W
E
S
JONES CREEK 3
0 0.2 0.4 0.8 1.2 1.6 2 Kilometers

BOB 4 Sample Site



No Man’s Friend Creek 1

Jones Creek 3

BOB Creek 1-3

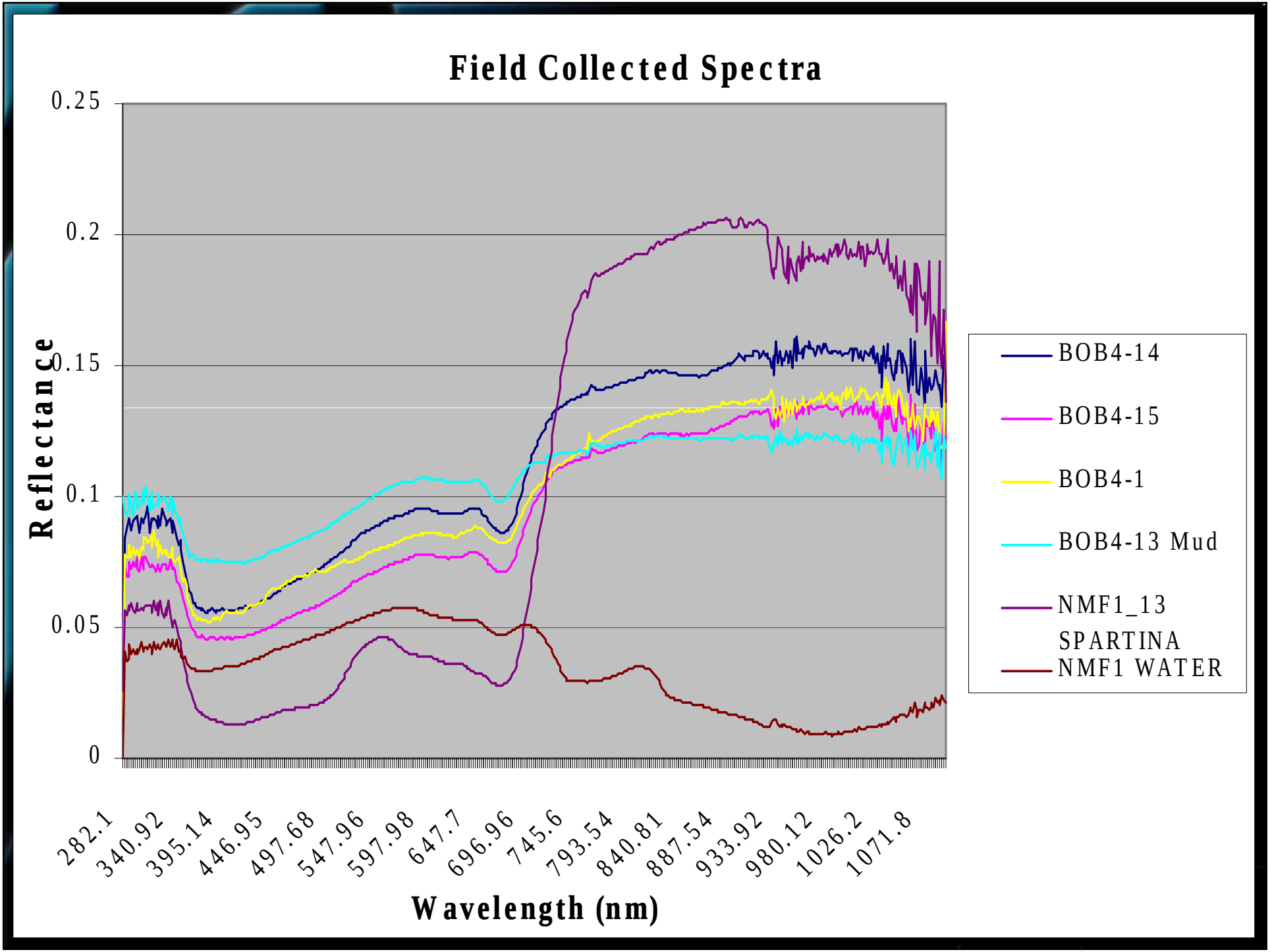
Jones Creek 1-2

No Man’s Friend 2

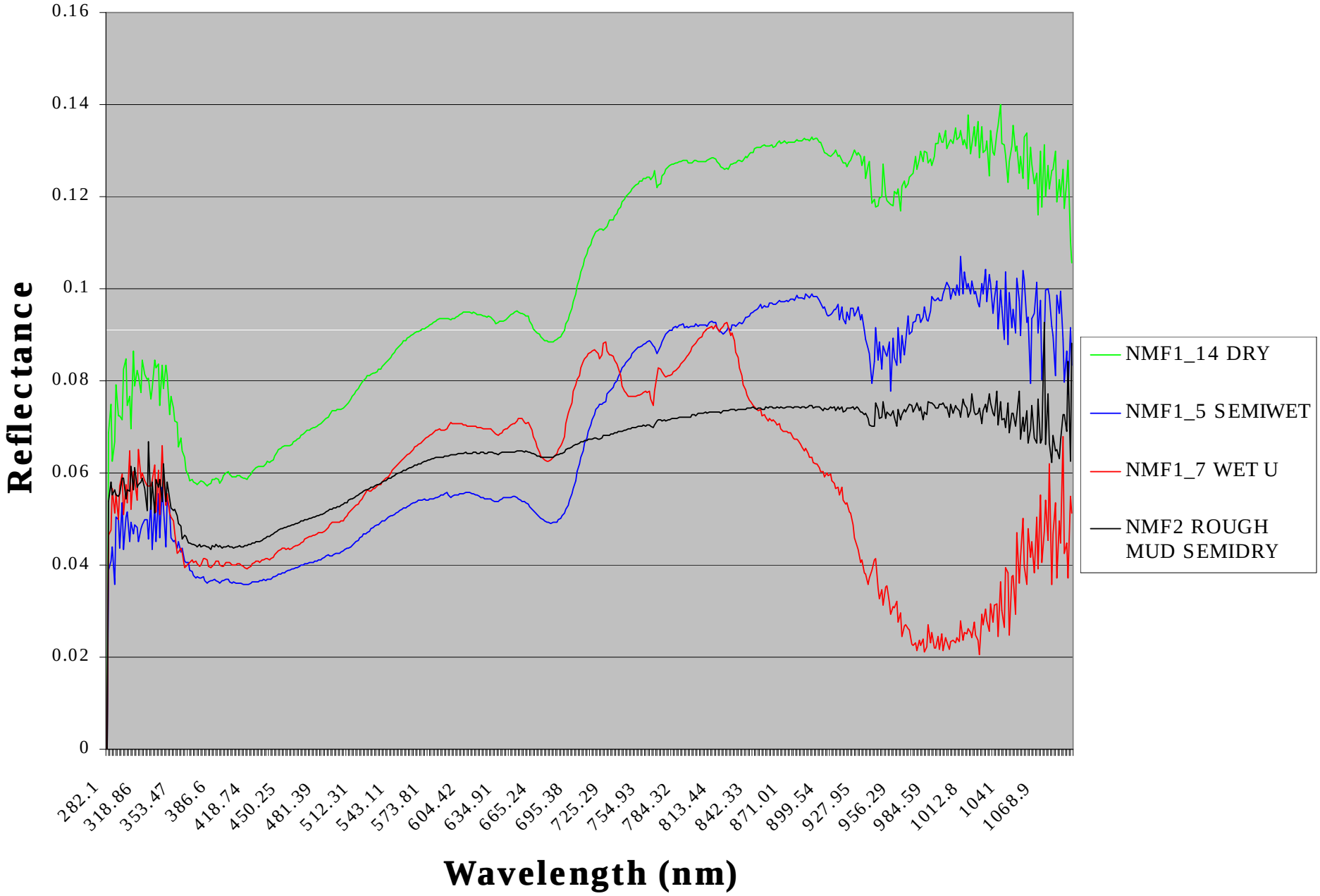
Spectroradiometer Sampling

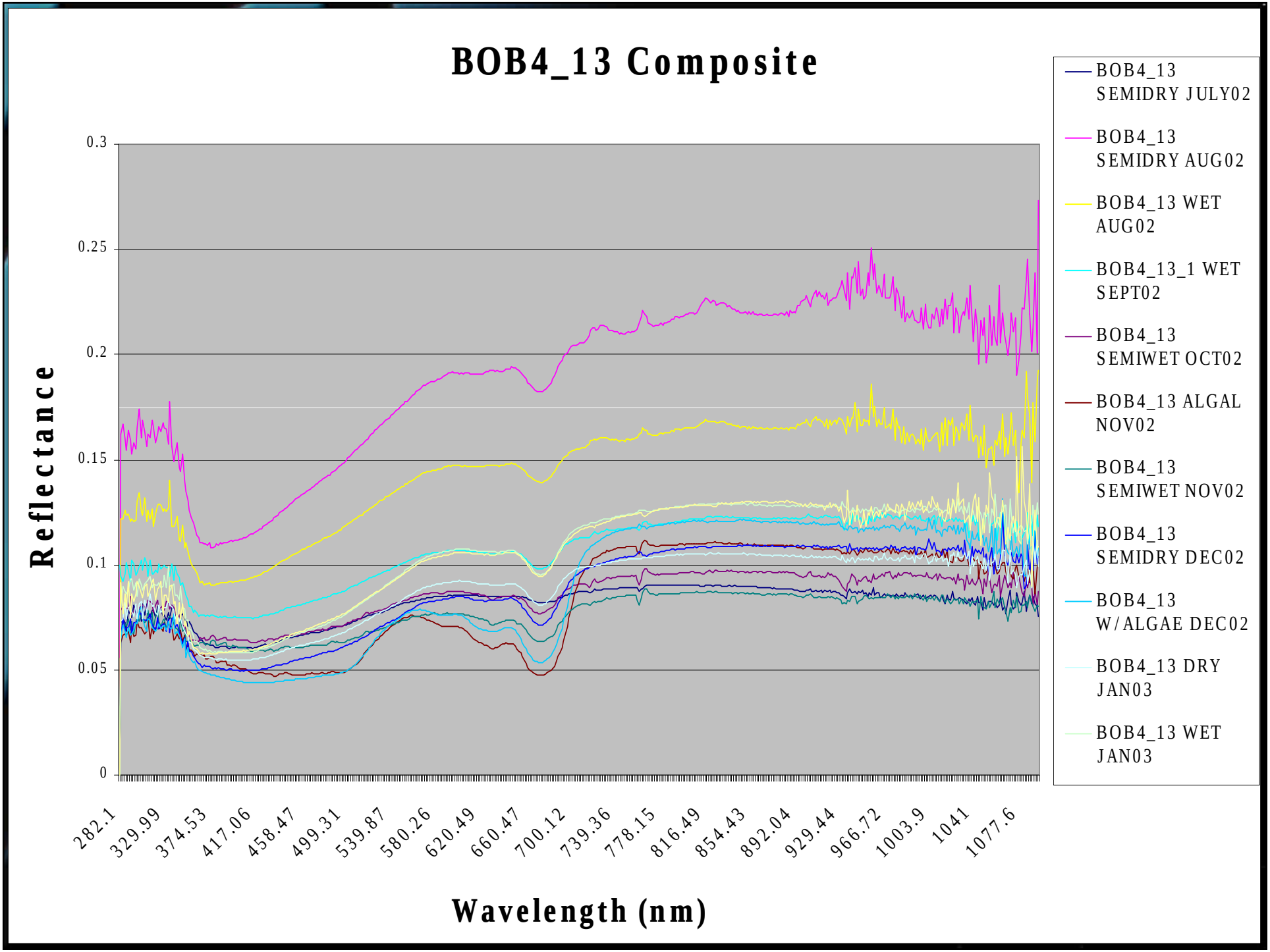
Building the Spectral Library:

- Field spectral measurements taken with GER 1500 spectroradiometer with 3° FOV.
- Spectroradiometer instrument calibration from 350 – 1095 nm.
- Reference shots taken as atmospheric conditions change or between shellfish groups.
- At each sampling point three target shots taken and averaged.
- Aggregated into like sample classes by month.

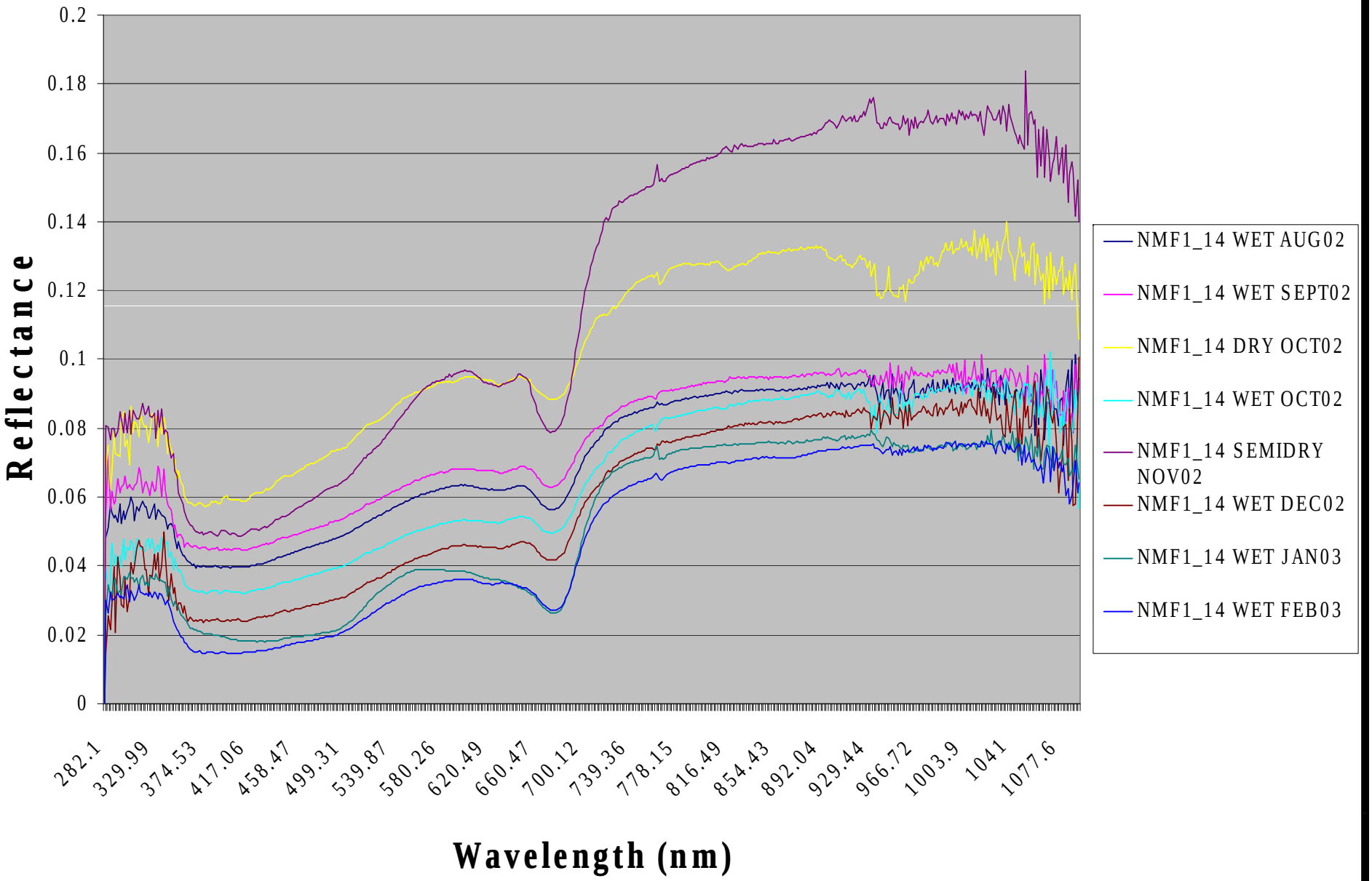

Field Collected Spectra
Reflectance
0.25
0.2
0.15
0.1
0.05
0
282.1
340.92
395.14
446.95
497.68
547.96
597.98
647.7
696.96
745.6
793.54
840.81
887.54
933.92
980.12
1026.2
1071.8
Wavelength (nm)
BOB4-14
BOB4-15
BOB4-1
BOB4-13 Mud
NMF1_13 SPARTINA
NMF1 WATER

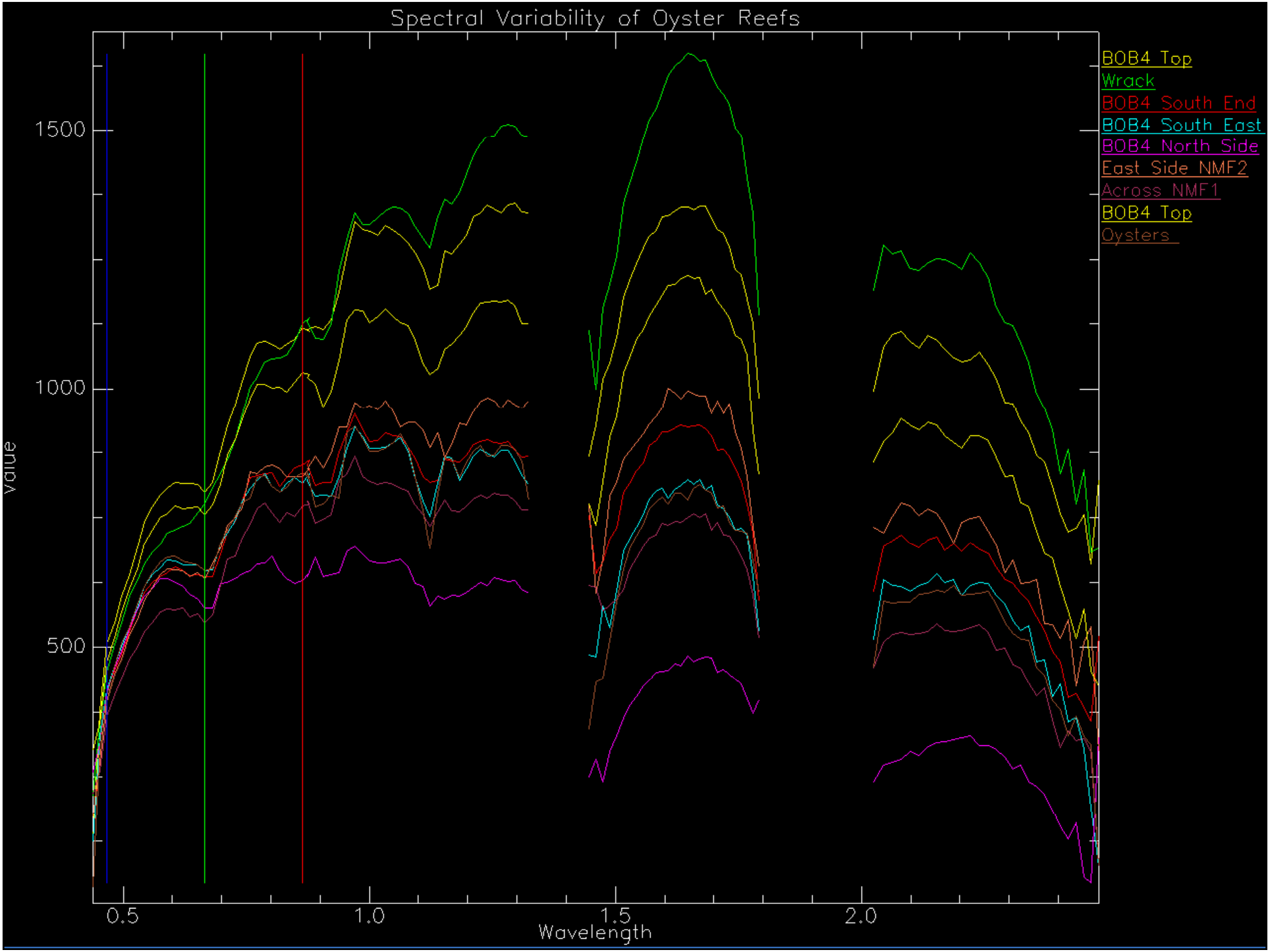
No Man's Friend One




BOB4_13 Composite
Reflectance
0.3
0.25
0.2
0.15
0.1
0.05
0
282.1
329.99
374.53
417.06
458.47
499.31
539.87
580.26
620.49
660.47
700.12
739.36
778.15
816.49
854.43
892.04
929.44
966.72
1003.9
1041
1077.6
Wavelength (nm)
BOB4_13 SEMIDRY JULY02
BOB4_13 SEMIDRY AUG02
BOB4_13 WET AUG02
BOB4_13_1 WET SEPT02
BOB4_13 SEMIWET OCT02
BOB4_13 ALGAL NOV02
BOB4_13 SEMIWET NOV02
BOB4_13 SEMIDRY DEC02
BOB4_13 W/ALGAE DEC02
BOB4_13 DRY JAN03
BOB4_13 WET JAN03

NMF1_14 Time Series Composite



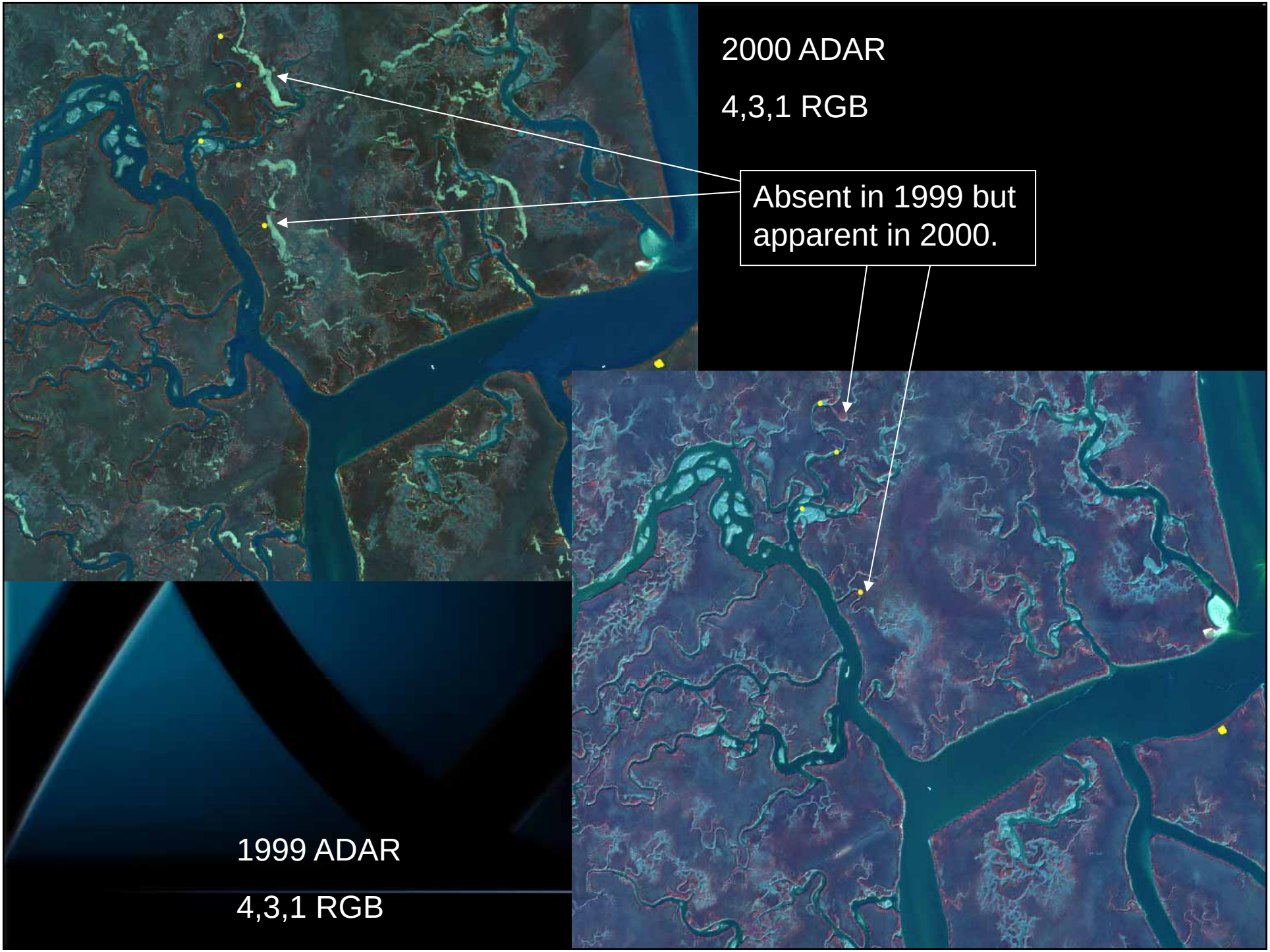

Spectral Variability of Oyster Reefs
BOB4 Top
Wrack
BOB4 South End
BOB4 South East
BOB4 North Side
East Side NMF2
Across NMF1
BOB4 Top
Oysters
1500
1000
500
value
0.5
1.0
1.5
2.0
Wavelength

Left To Do…

- Separate oyster-mud endmembers in flats.
- Reconcile soil-mud endmember with higher reflective oyster shells.
- Use field collected endmembers to unmix image and compare with image derived endmembers.

The End

Thank You For Your Time


2000 ADAR
4,3,1 RGB
Absent in 1999 but apparent in 2000.
1999 ADAR
4,3,1 RGB

Digital Photo Taken
June 9, 2003

2000 ADAR
4,3,1 RGB