Field Validation of P R I S M: Portable Remote Imaging SpectroMeter

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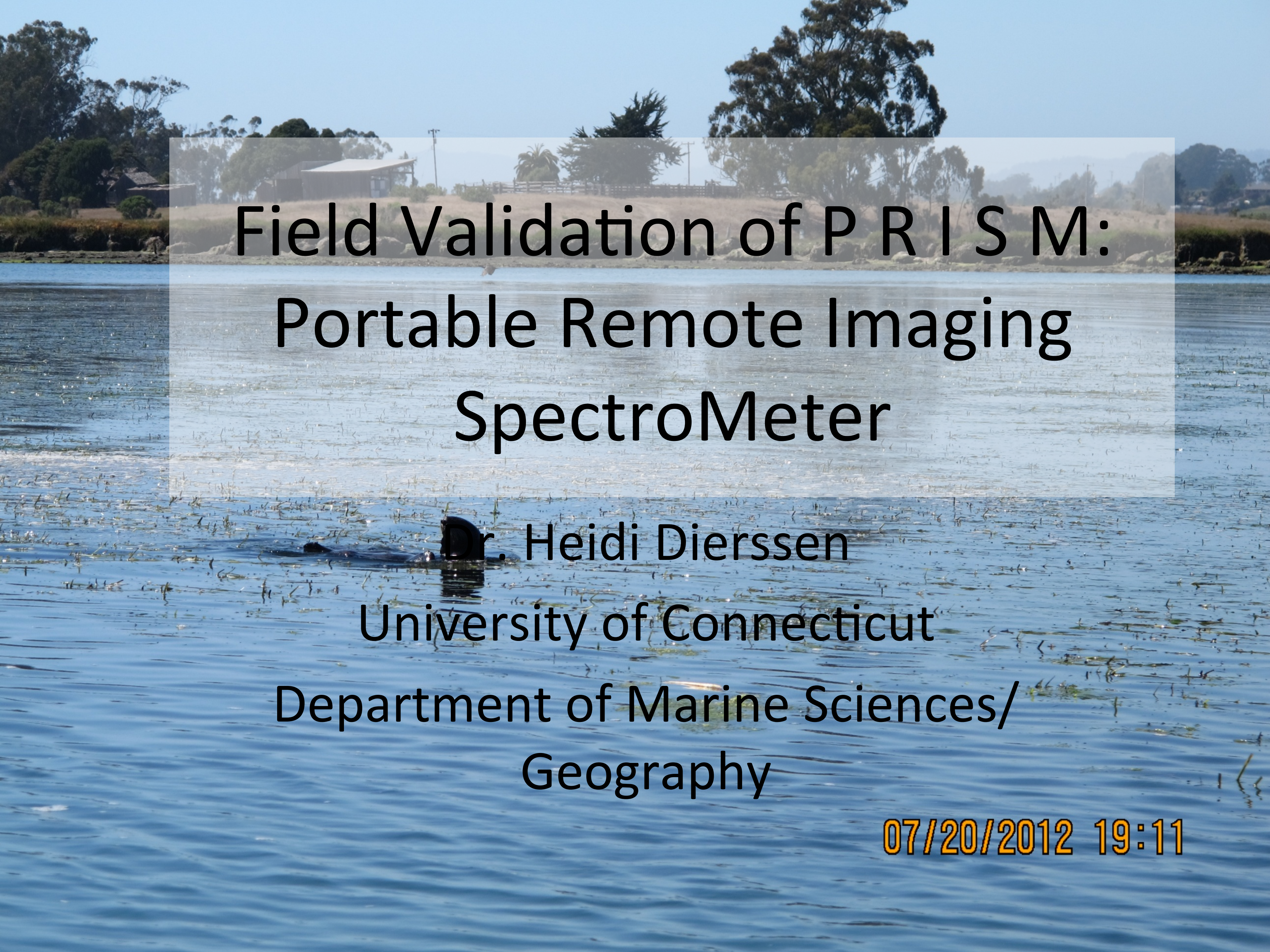


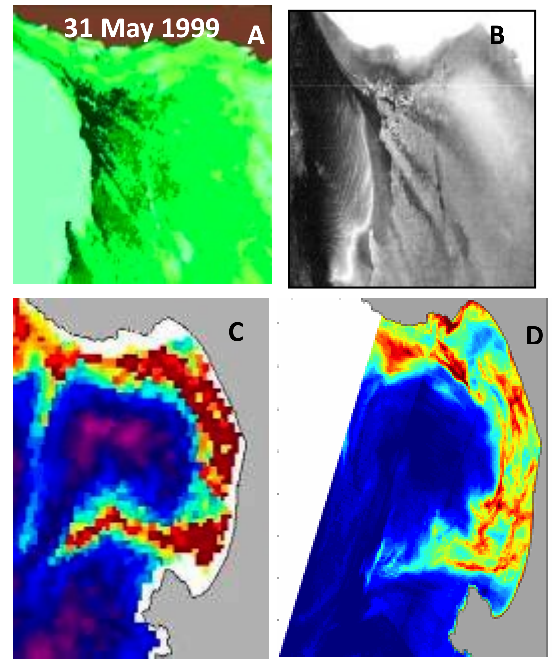
Earth's Living Ocean: 'The Unseen World'

An advanced plan for NASA's Ocean Biology and Biogeochemistry Research

2006

OBB Plan outlines:
Portable Sensors from Suborbital Platforms

- Imagery with spatial resolution of meters or less
- Mapping and tracking fine-scale features along coastal margins, including river plumes, flooded land regions, and seafloor features
- Hazardous and episodic events require repeat sampling on the order of hours and not days or weeks
- Water quality of inland lakes, rivers, and coastal estuaries



Seagrass Leaf Area Index (LAI) and B) shallow water bathymetry 0-6 m estimated from the PHILLS sensor at Lee Stocking Island, Bahamas.

A dense algal bloom or red tide in Monterey Bay measured from C) SeaWiFS satellite imagery at 1 km resolution and D) AVIRIS airborne imager at 30 m resolution

Timeline / Mission Themes	Immediate (1 – 5 Years)	Near-Term (5 - 10 Years)	Long-Term (10 - 25 Years)	Ecosystems	Biogeochemistry	Habitats	Hazards
Global Separation of In-water Constituents & Advanced Atmospheric correction	**Advanced radiometer & scattering lidar** • 5nm resolution from UV through visible • Ozone & extended NIR atmosphere bands • Atmosphere & subsurface particle scattering profiles	**Ocean radiance and atmosphere aerosols** • Advanced radiometer • Scattering lidar for aerosol speciation • Polarimeter for global aerosol coverage •500 m passive resolution	**Radiometry, aerosols, and physiology lidar** • Global radiometry system • Aerosol height & species • Midnight/noon obs of variable stimulated fluorescence				
High Spatial & Temporal Resolution Coastal	**Coastal carbon – GEO** **Support analysis of current satellite data** **Landsat DCM partnership** **Development of suborbital sensor systems**	**High-res coastal imager** • 20 bands from UV - NIR • 10 m res – 100 km swath **GEO carbon mission** **Deployment of suborbital systems**	**Constellation of imaging spectrometers** • High temporal res • LEO, MEO or GEO • Include SAR **Continued deployment of suborbital systems**				
Plant Physiology & Functional Composition	**Support analysis of global passive data** • Assess functional groups using hyperspectral data • Estimate algal carbon & chlorophyll to characterize physiology	**Support analysis of global & GEO data**	**Variable fluorescence lidar constellation** •Map physiological provinces at different times of day • Dawn/dusk variable fluorescence lidar • Noon/midnight lidar				
Mixed Layer Depth	**Synthesis/analysis of observational forecast fields & on orbit remote sensing** **Mixed layer model development**	**Prototype mixed layer sensor development** • field testing of novel approaches for remote detection of mixed layer depth & light availability	**Mixed layer depth mission** •Space-borne proof-of-concept mission for global mixed layer depth mapping				

Bold Green Text Represents Satellite Missions
Bold Blue Text Represents Development Activities leading to Missions
Cross-hatch indicates secondary contribution to Mission Theme

Top Priority Science Question	Color Code	Example of Benefits to Society
How are ocean ecosystems and the biodiversity they support influenced by climate or environmental variability and change, and how will these changes occur over time?		Improved management of ecosystem goods and services
How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do biogeochemical fluxes impact the ocean and Earth's climate over time?		Information based policy on greenhouse gas emissions and nutrient loading
How (and why) is the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well-being of human society?		Mapping and assessment of coastal habitats for future development plans and tourism
How do hazards and pollutants impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?		National security and improved forecasting of natural and human-induced hazards

NASA RFP Feb. 2008

2.1 Development of airborne instrument

NASA's Ocean Biology and Biogeochemistry program, in partnership with the Airborne Science Program within the Earth Science Division, is soliciting a project that seeks to develop a portable sensor from airborne (e.g., aircraft, Unmanned Aerial Systems (UAS),

Instruments proposed should be focused on radiometry to enable estimation of ocean biological and biogeochemical properties, specifically to encourage broad NASA ocean research community use. A field test plan of the instrument must be included in the proposed statement of work, along with a clearly defined plan for instrument calibration

Optical design of a coastal ocean imaging spectrometer

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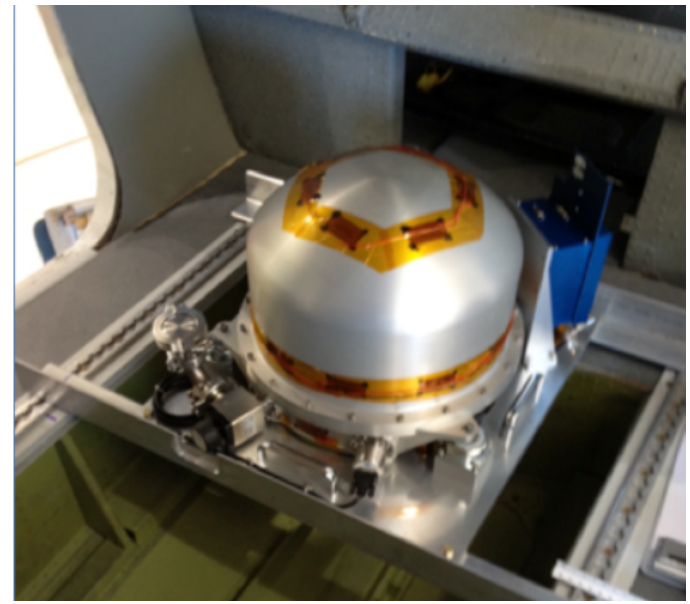
Abstract: We present an optical design for an airborne imaging spectrometer that addresses the unique constraints imposed by imaging the coastal ocean region. A fast (F/1.8) wide field system (36°) with minimum polarization dependence and high response uniformity is required, that covers the spectral range 350-1050 nm with 3 nm sampling. We show how these requirements can be achieved with a two-mirror telescope and a compact Dyson spectrometer utilizing a polarization-insensitive diffraction grating.

#94845 - $15.00 USD Received 8 Apr 2008; revised 28 May 2008; accepted 28 May 2008; published 4 Jun 2008

PRISM Sensor

- UV-NIR sensor
  - 350-1050 nm
- Approx. 3 nm spectral resolution
- Up to 30 cm spatial resolution
- Two-channel SWIR radiometer
- Zakos Mouroulis talk tomorrow



Objective

- First science flight of NASA's new PRISM sensor
  – Portable Remote Imaging Spectrometer
- July 17-28 2012
- Validate spectra obtained over diverse coastal targets


Photo by Eric Heupel

Field Validation was a Large Collaborative Effort

- UConn
- NASA JPL
- Naval Research Lab
  - Gao for atmospheric correction
- NASA Ames
  - Liane Guild and crew
- University of Santa Cruz
  - Raphael Kudela and crew
- Moss Landing Marine Labs
  - Jason Smith and Facilities
- Monterey Bay Aquarium Research Institute
  - John Ryan

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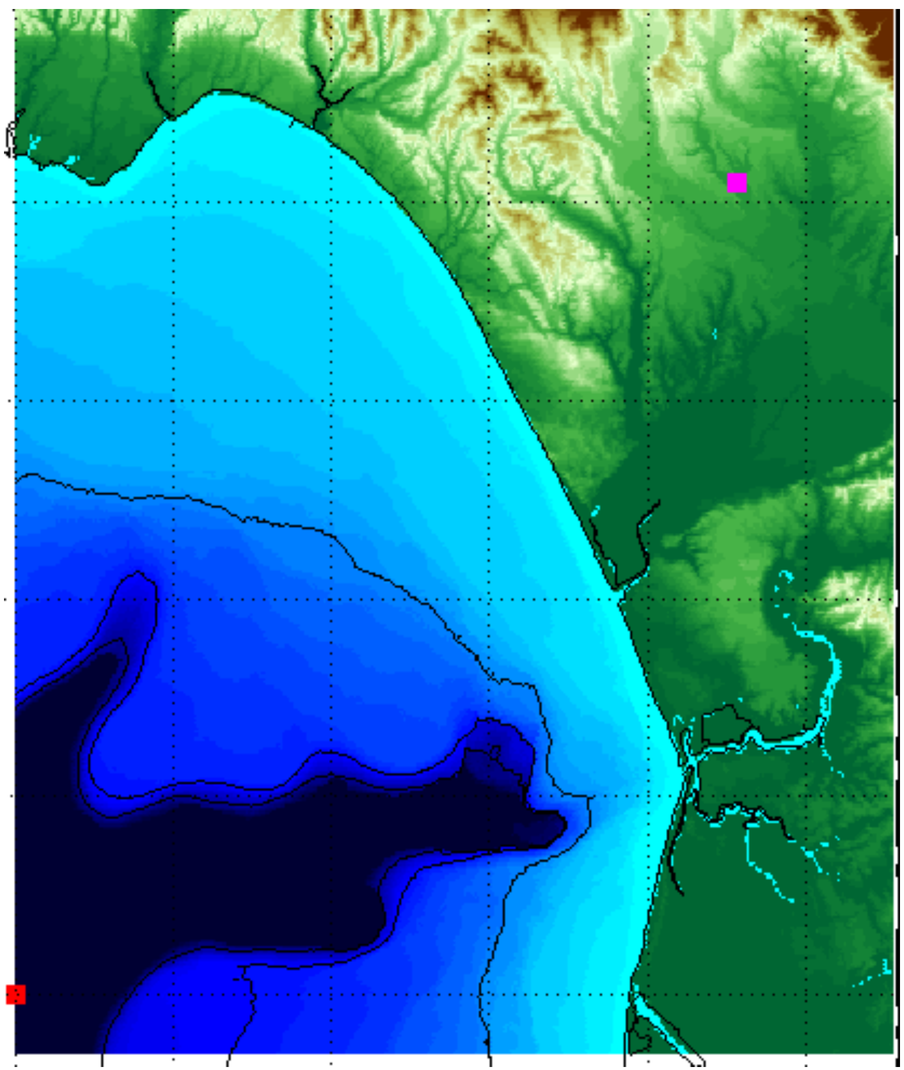
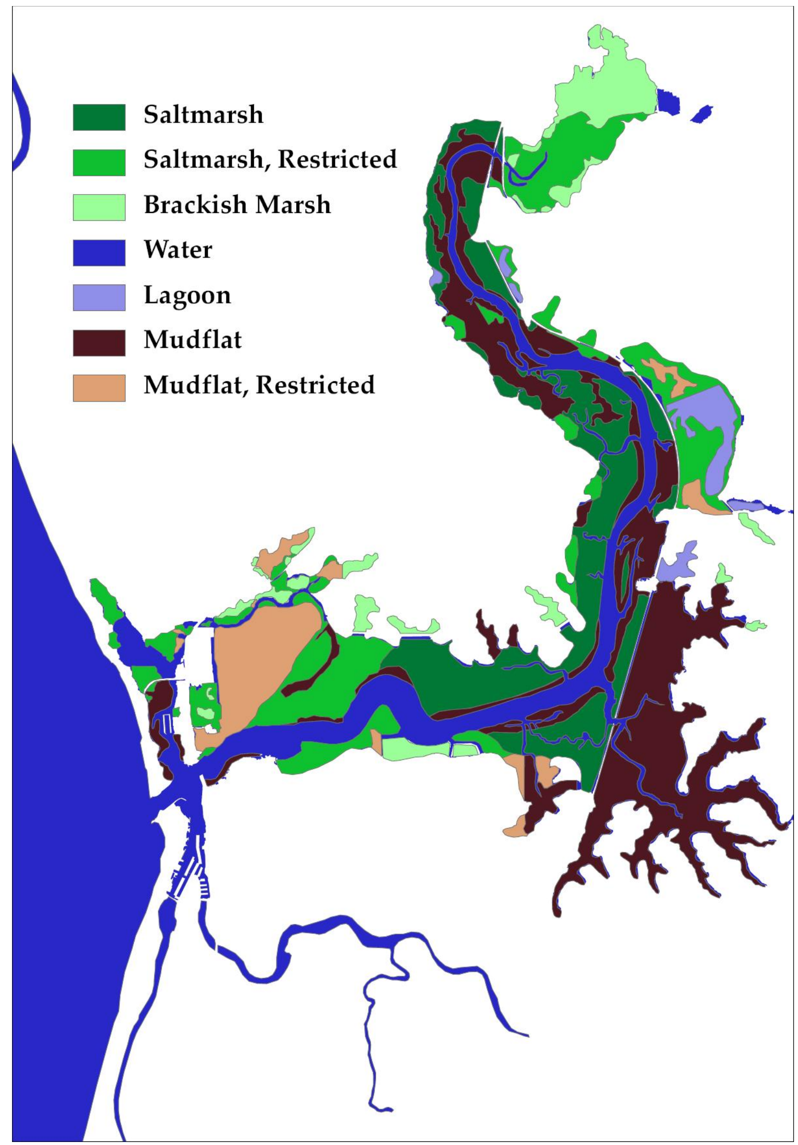
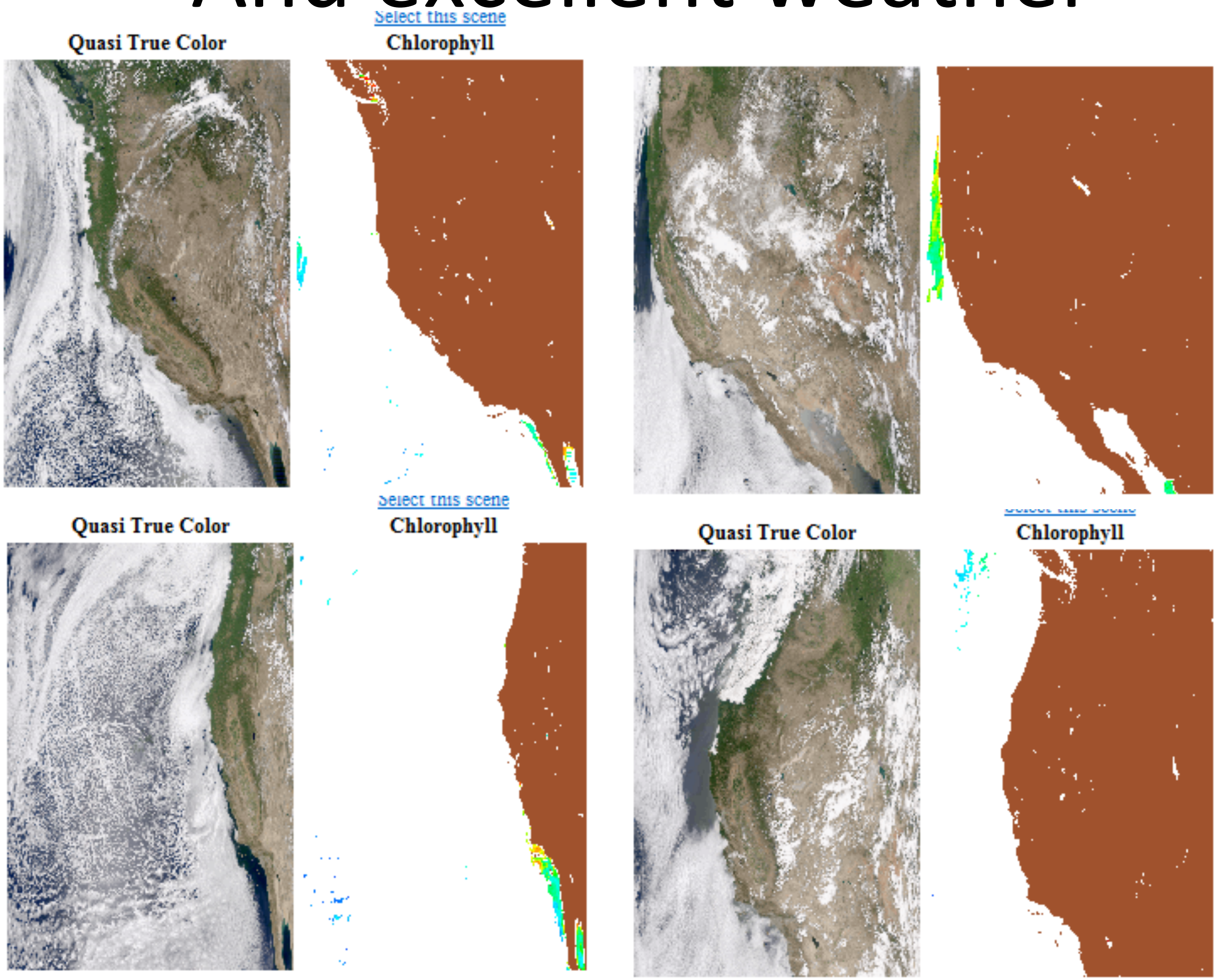
Site with Diverse Coastal Habitats





And excellent weather

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montrail

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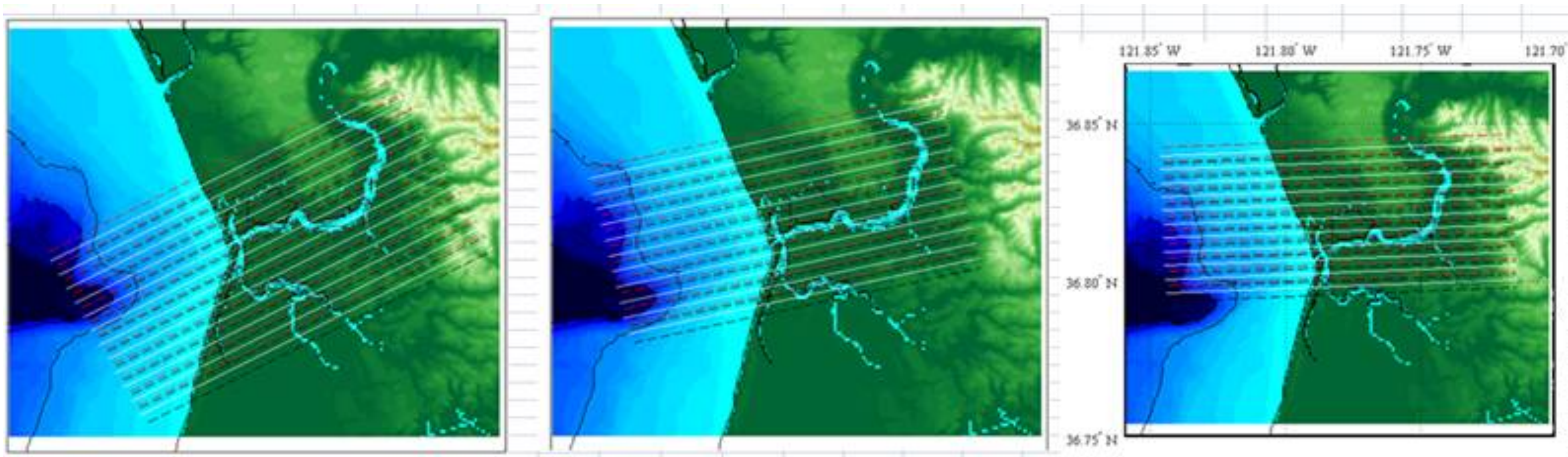
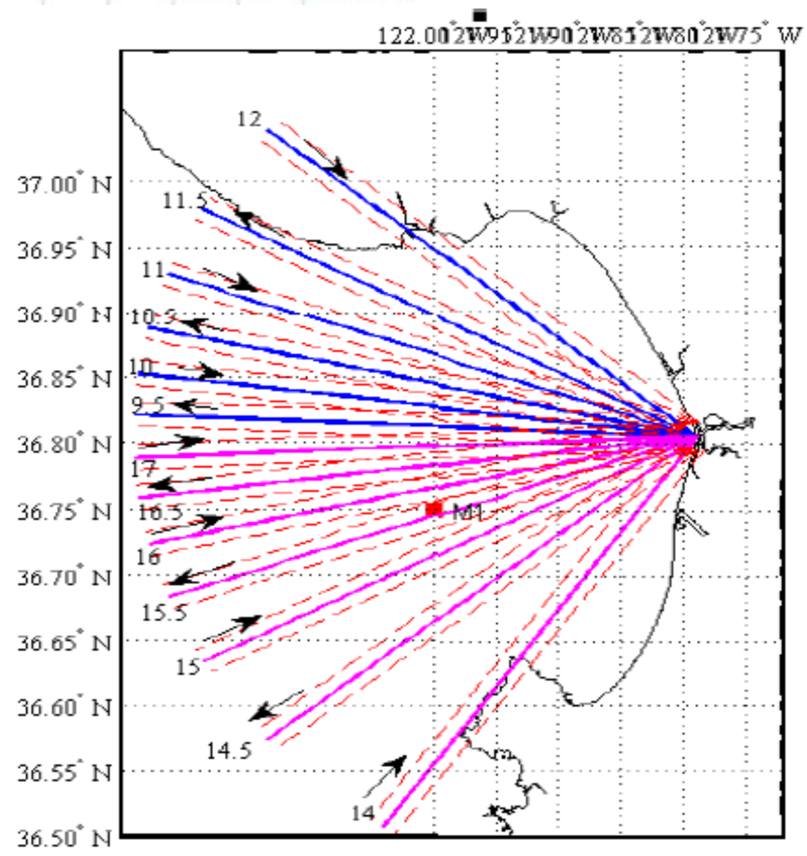
Quasi True Color

Chlorophyll



- Hourly flight lines oriented with sun

- Clearing in the afternoon

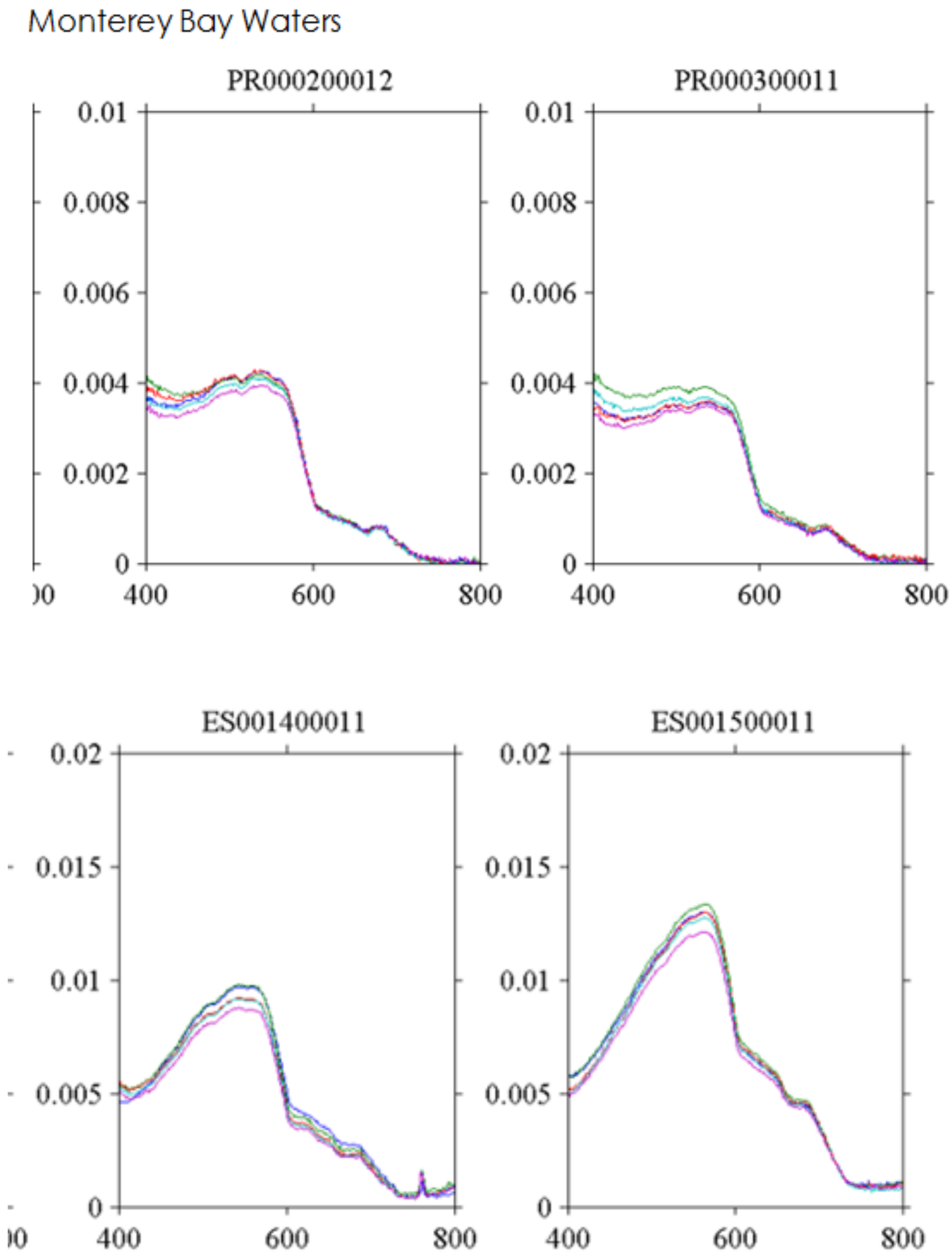


ASD

Dive Spec

LISST

Remote sensing Reflectance Spectra



Intercalibration of sensors

ASD


Heidi Dierssen
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Department of Marine Sciences
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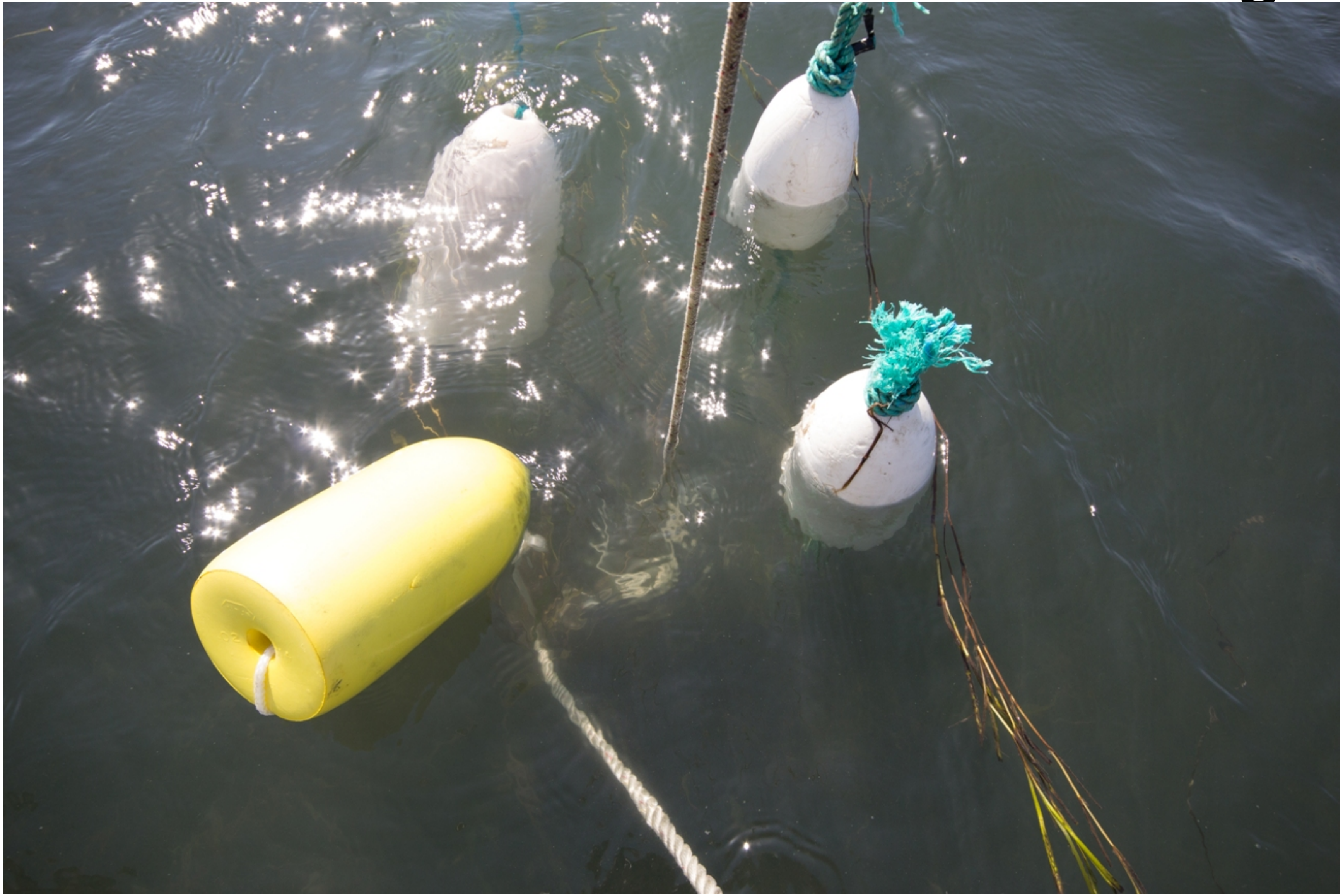
07/26/2012 14:46

Inherent Optical Properties (IOP) Package

IOP Package

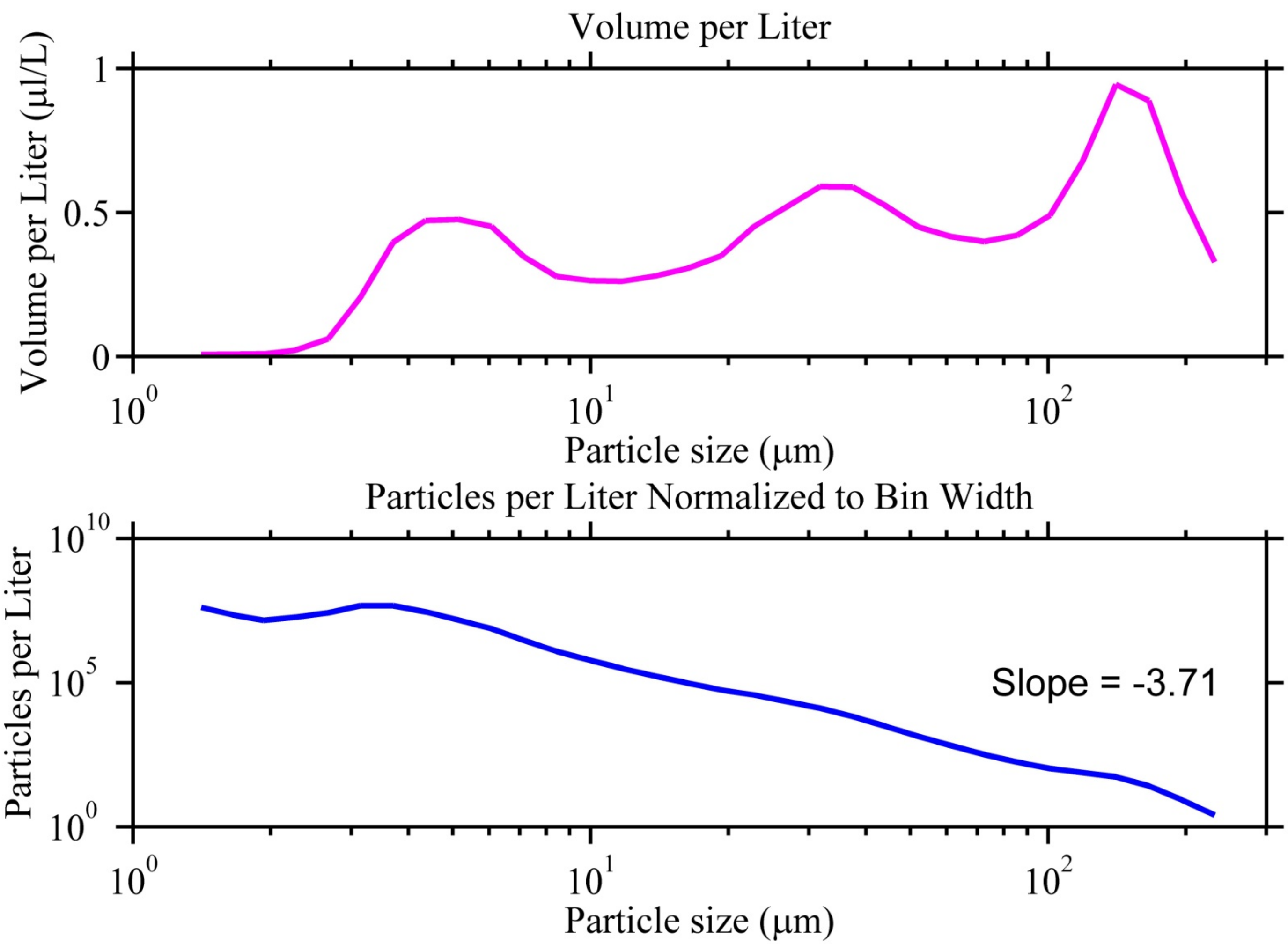


Lab Work

- Filters
  - Total suspended matter
  - HPLC Pigment analysis
  - *Chl-a* measurements
- Eelgrass leaf measurements

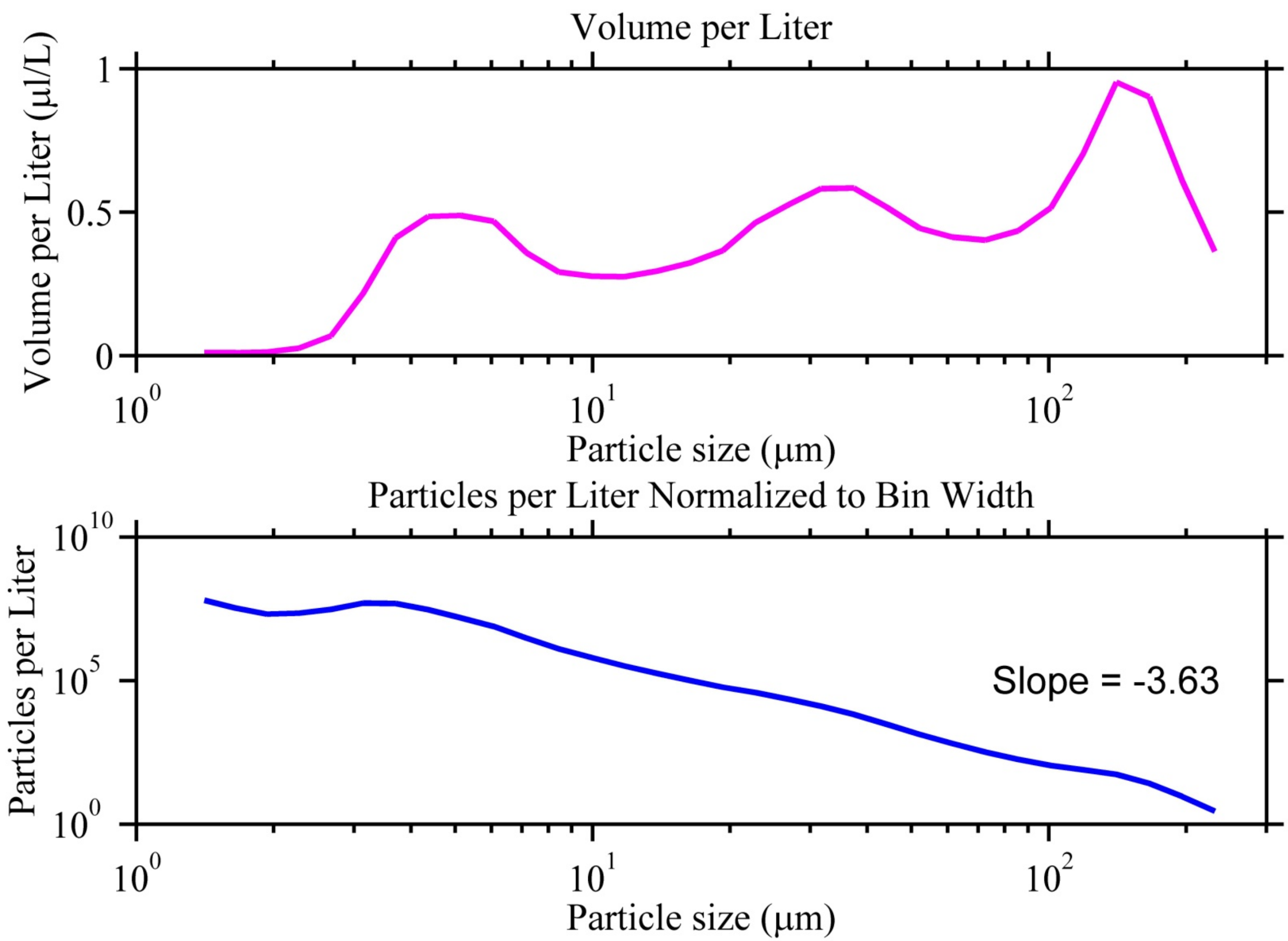
LISST

- Station 2, Monterey Bay



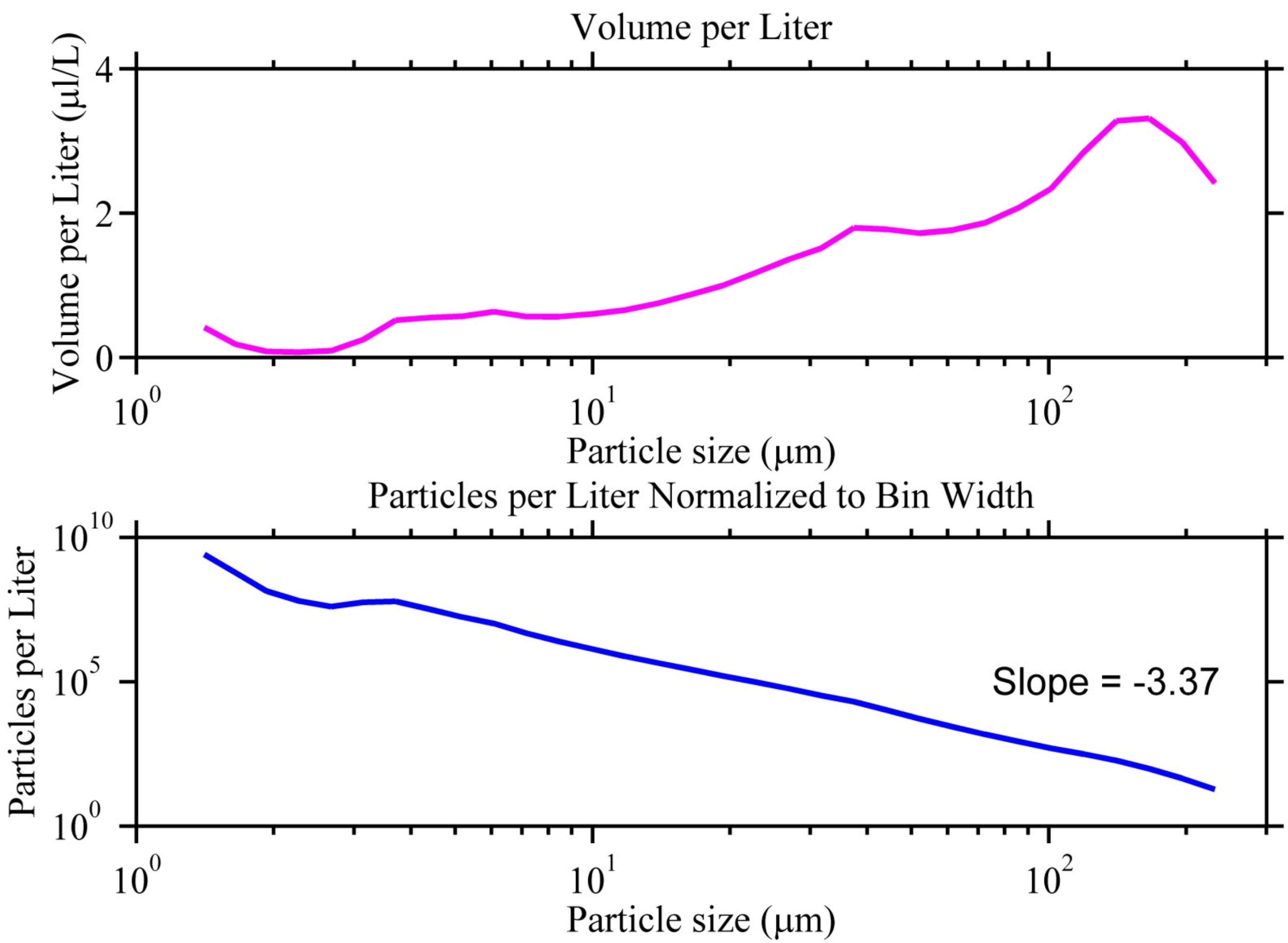
LISST

- Station 4, Monterey Bay



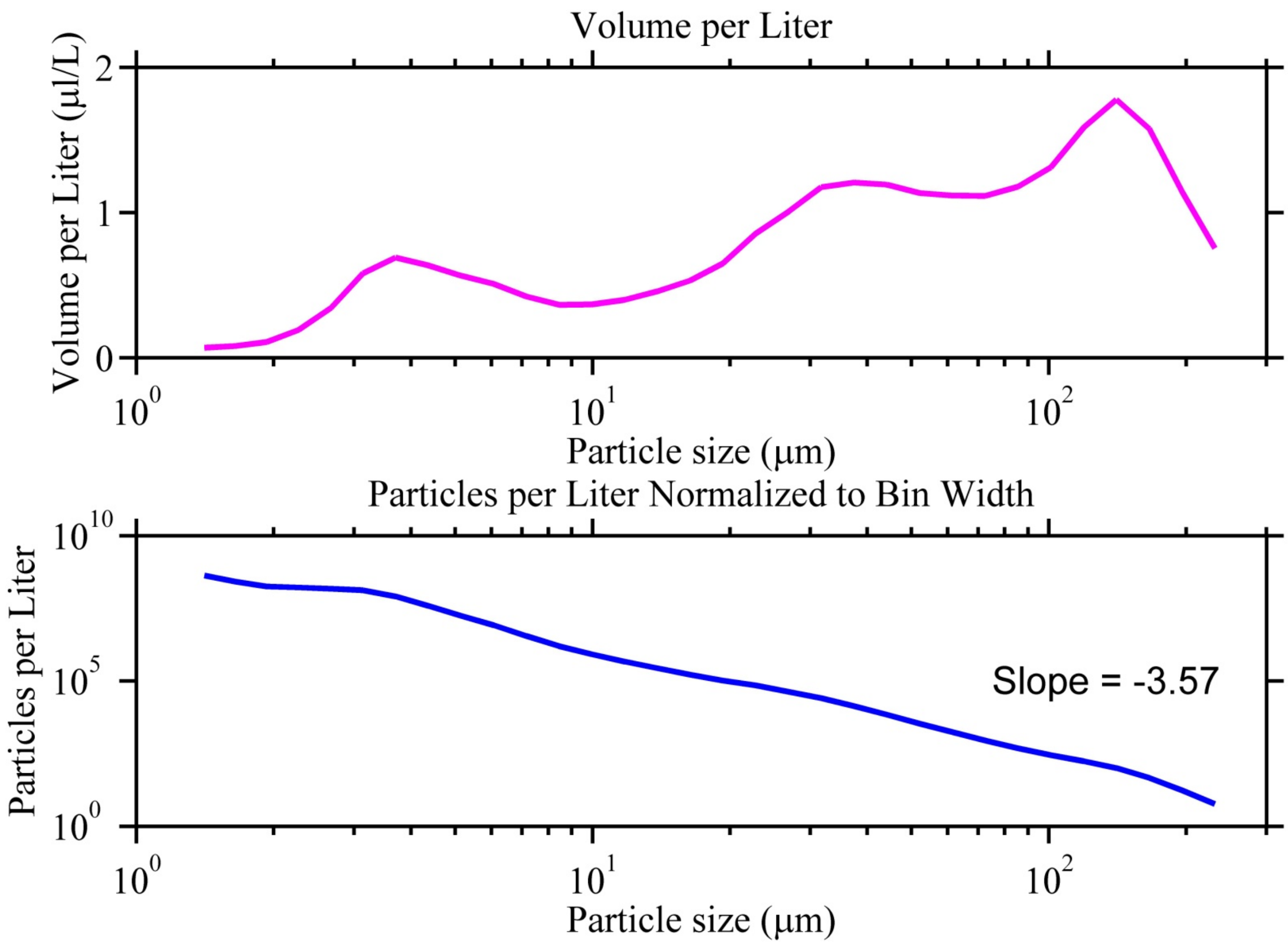
LISST

- Station 14, Elkhorn Slough, ebb tide

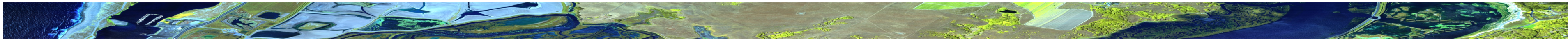


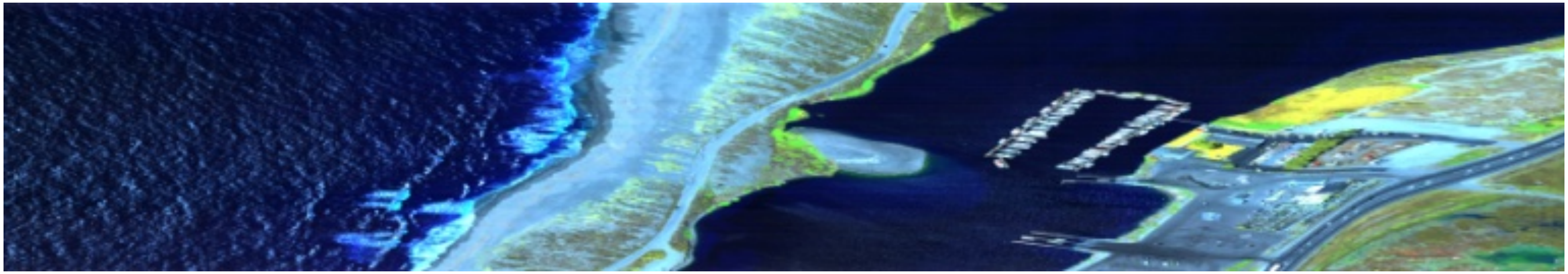
LISST

- Station 22, Elkhorn Slough, high slack



400GB of imagery was obtained





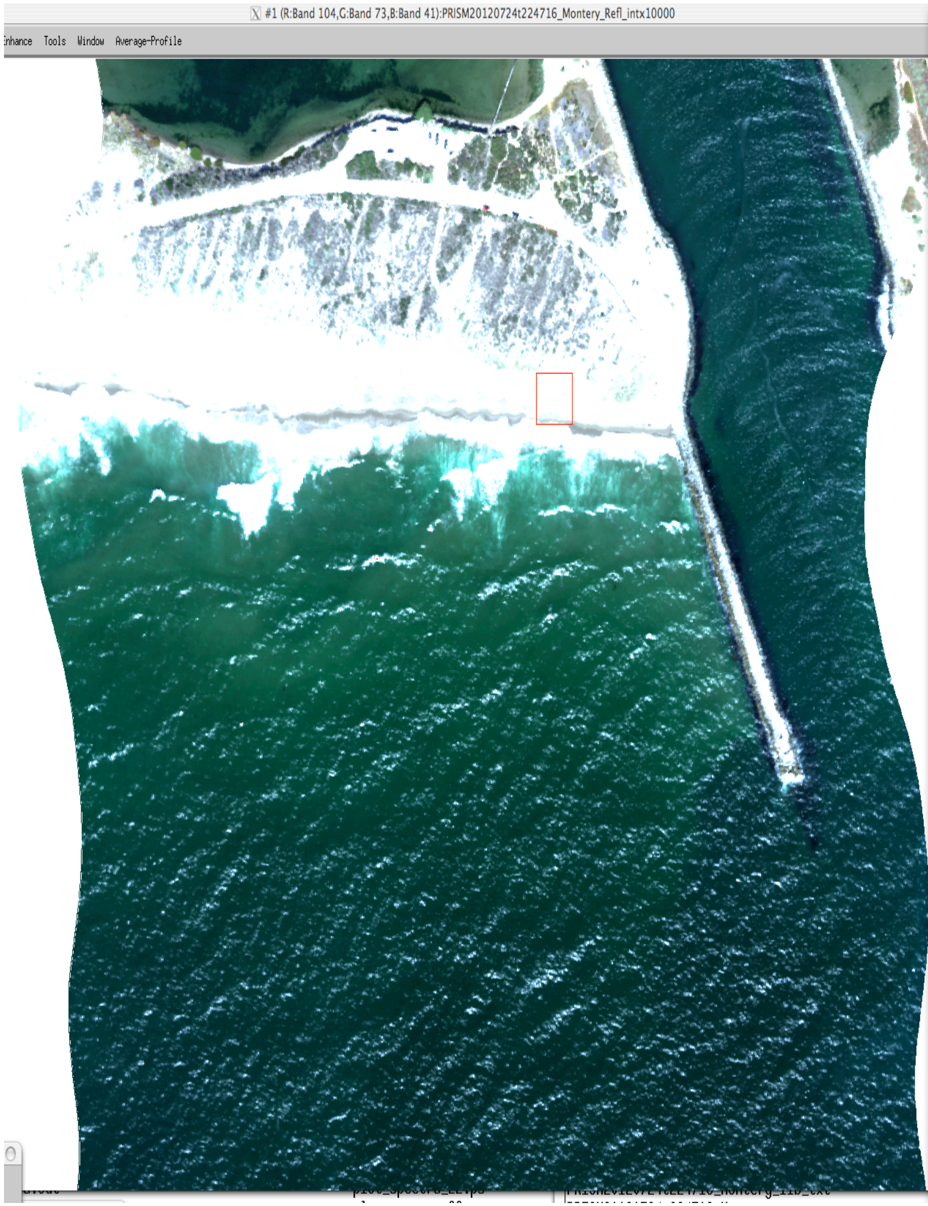
The PRISM sensor was integrated into a Twin Otter aircraft:

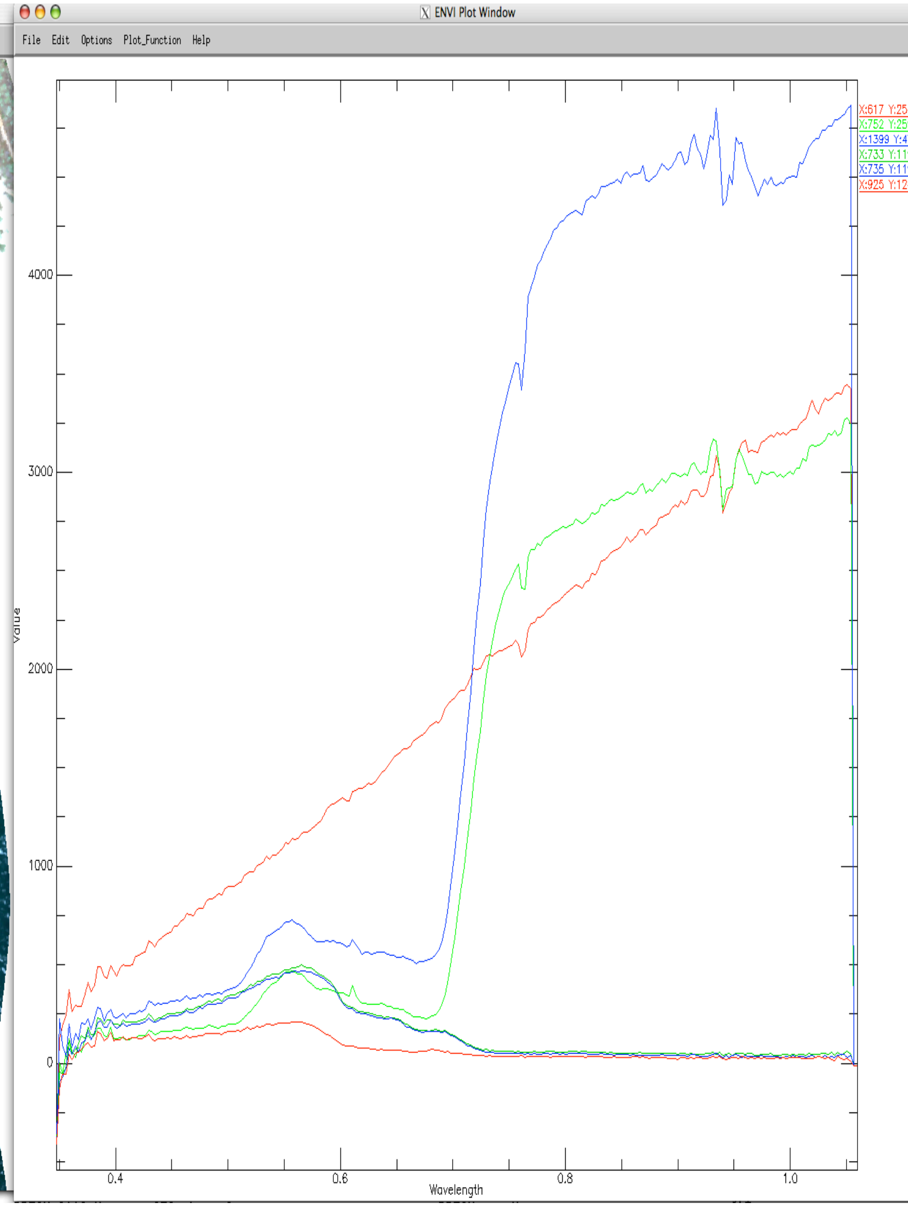
- 12 lines over Elkhorn Slough and the Monterey Bay shelf at 3,500 ft (~1m/pixel)
- 3 lines at 10,500 ft (~3m/pixel) extending 40 km into the bay and over the M1 mooring
- 5 lines over Pinto Lake at 3,500 ft

Preliminary Image Processing Atmospheric Correction

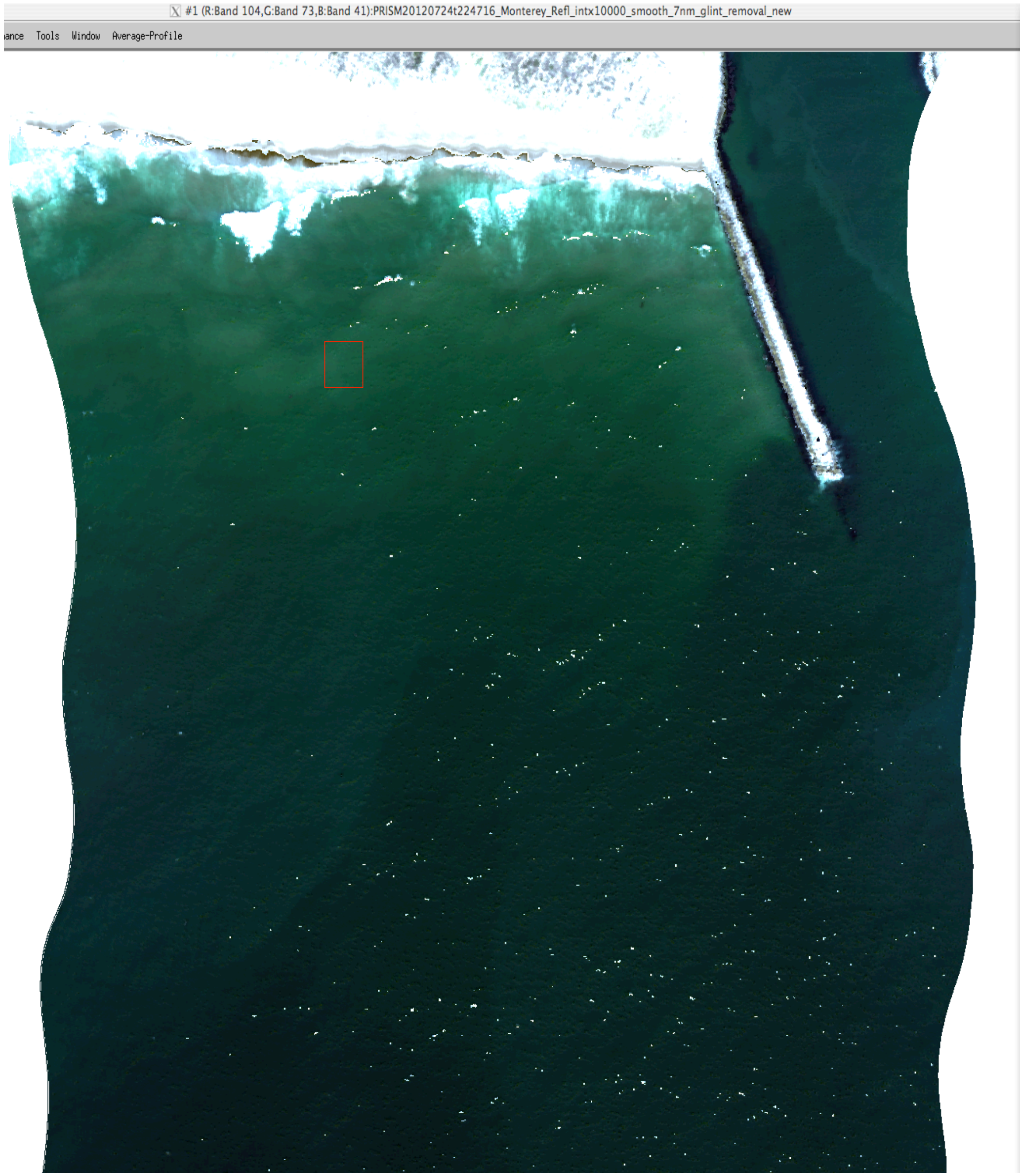
- Calibrated and 0rthorectified by JPL
- Bo-Cai Gao Naval Research Lab
- Modified ATREM model with sun glint and cloud removal.

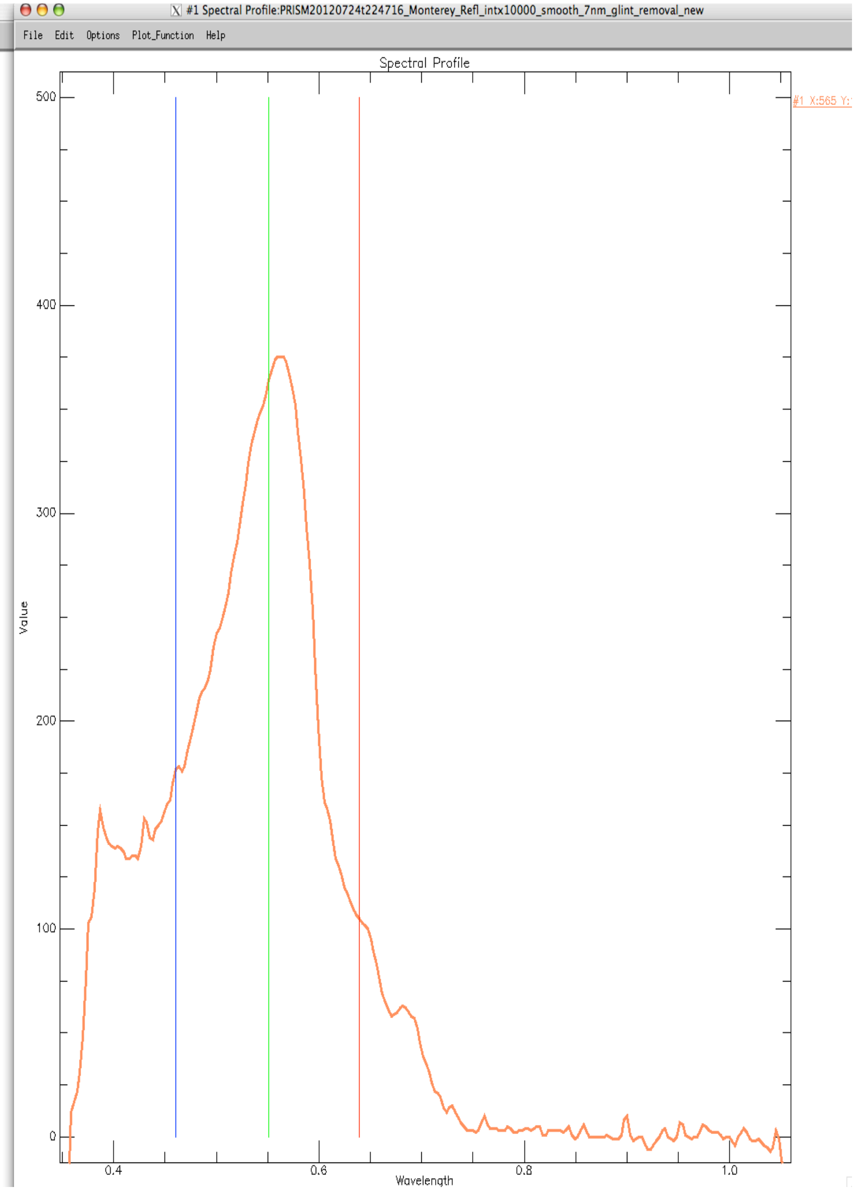
Sample Spectrum After 7-nm Smoothing, Sunglint + Cloud Removal – Green Water (the center pixel of the red box in the left image)





Sample Spectrum After 7-nm Smoothing, Sunglint + Cloud Removal – Green Water (the center pixel of the red box in the left image)

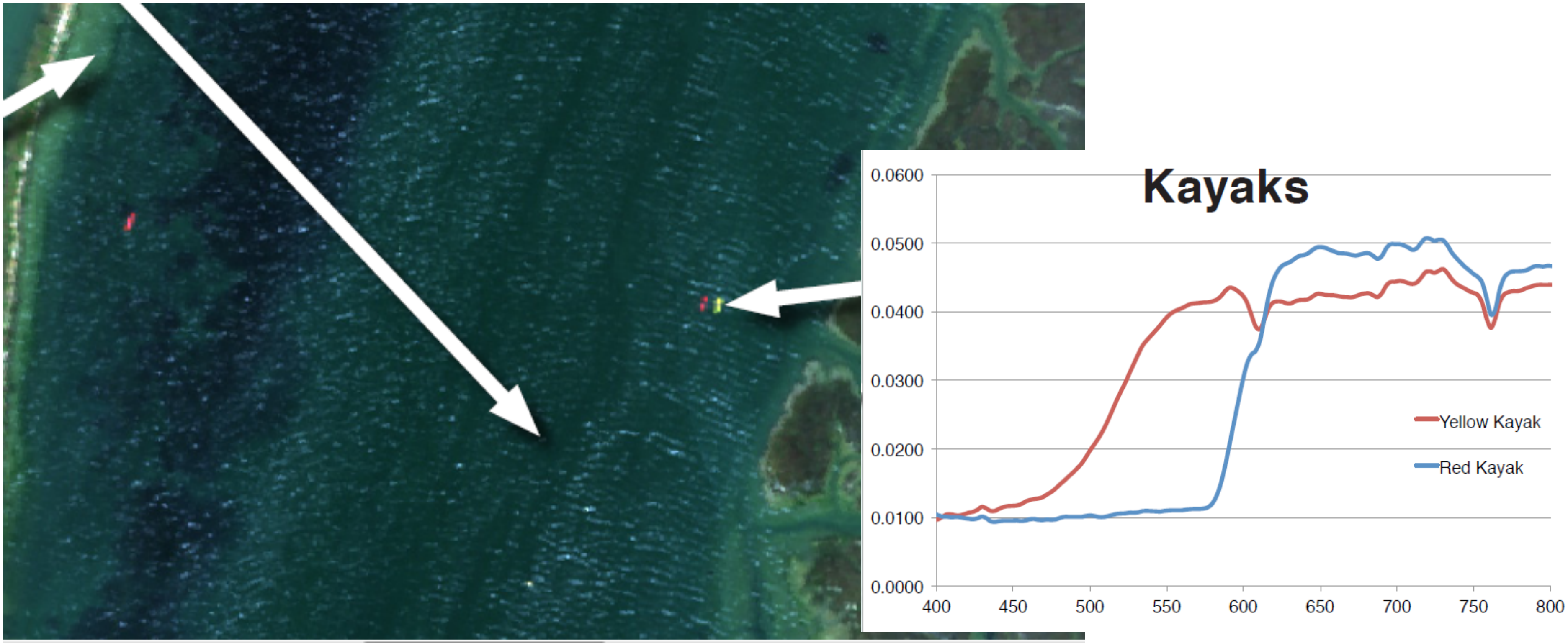




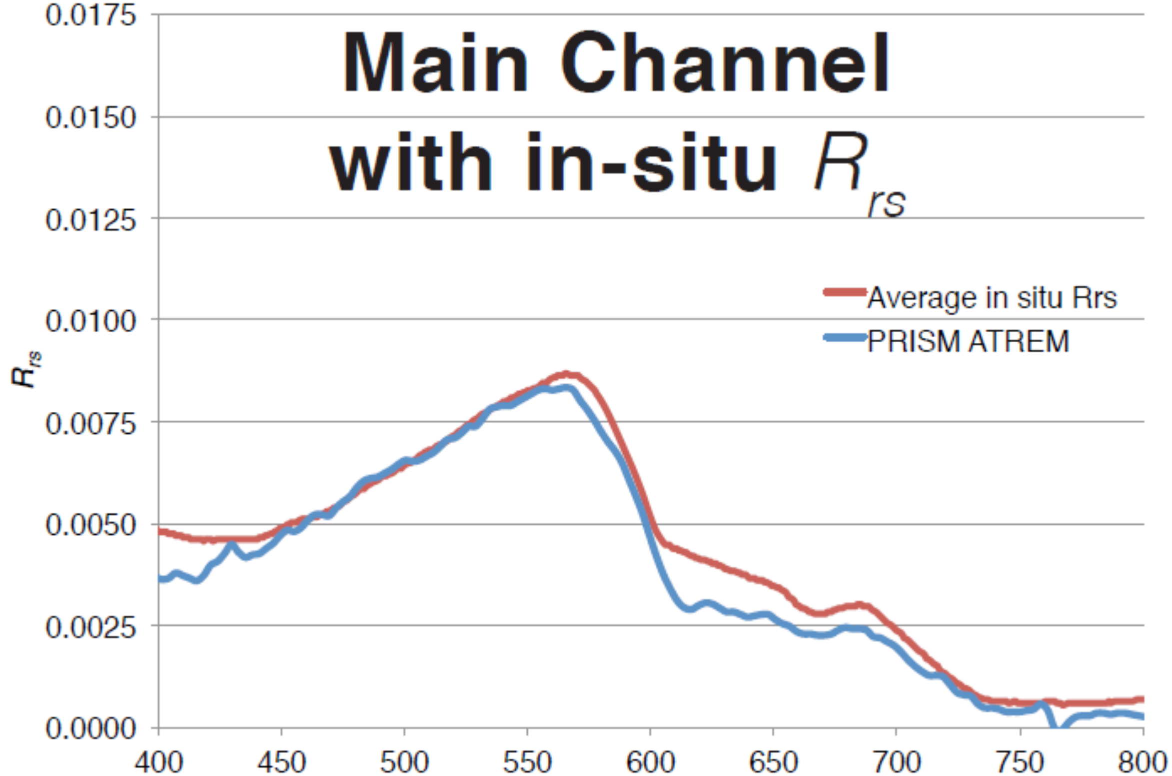
An Example of Sunglint + Cloud Effect Removal

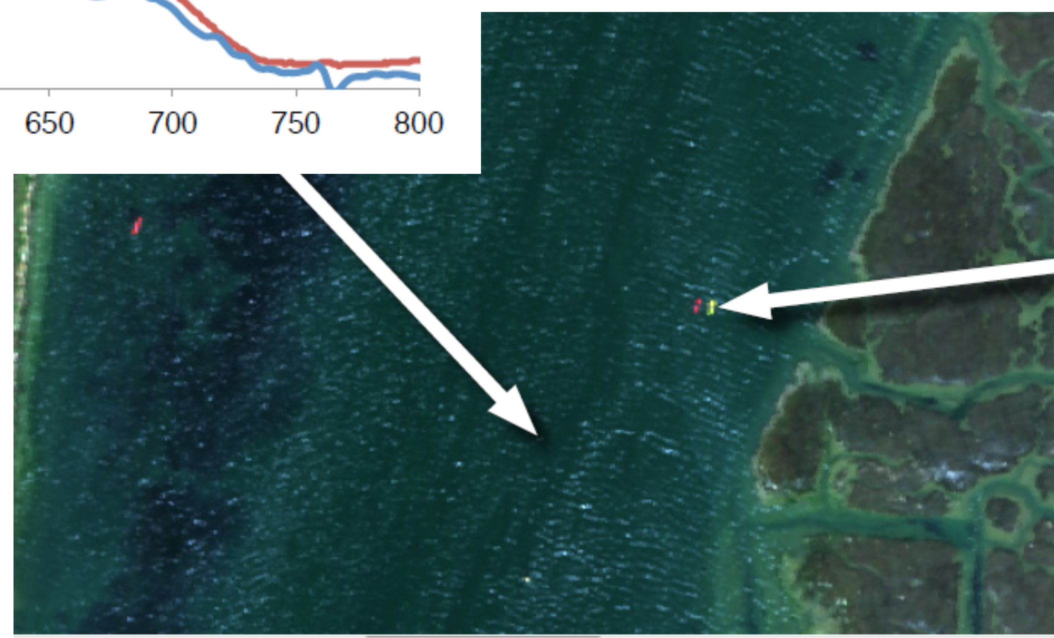
After – spatially contiguous water features are seen

Before

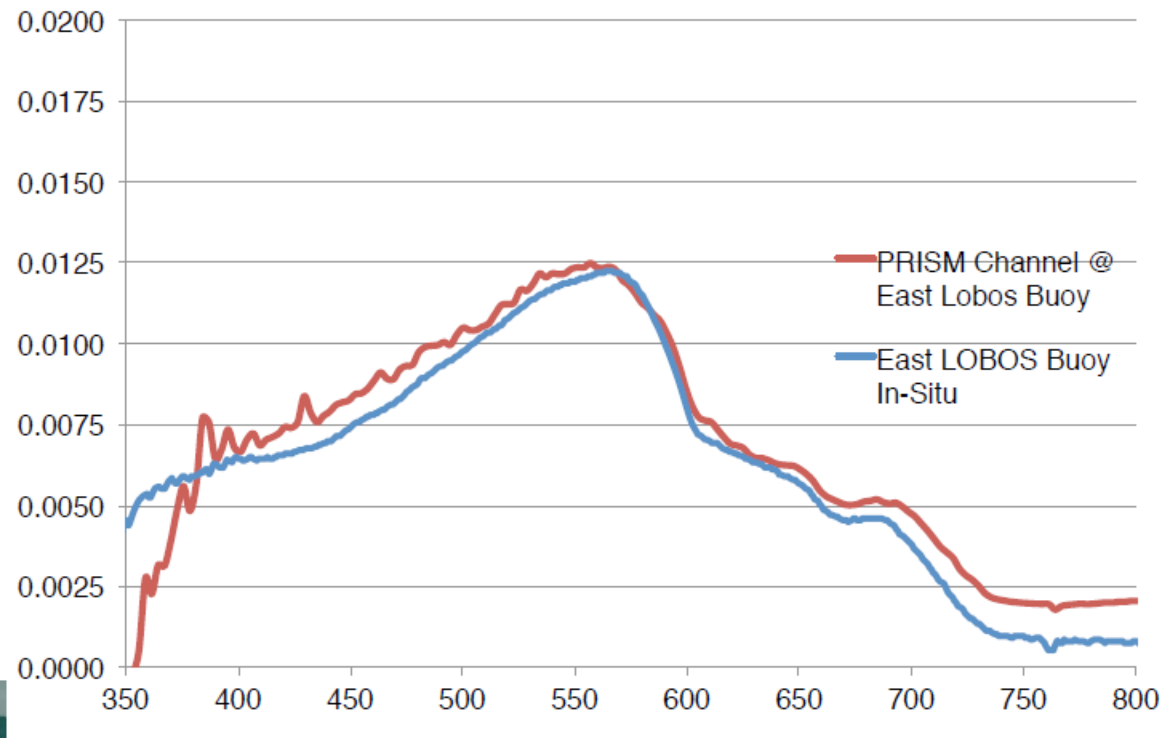

Kayaks
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
400
450
500
550
600
650
700
750
800
Yellow Kayak
Red Kayak

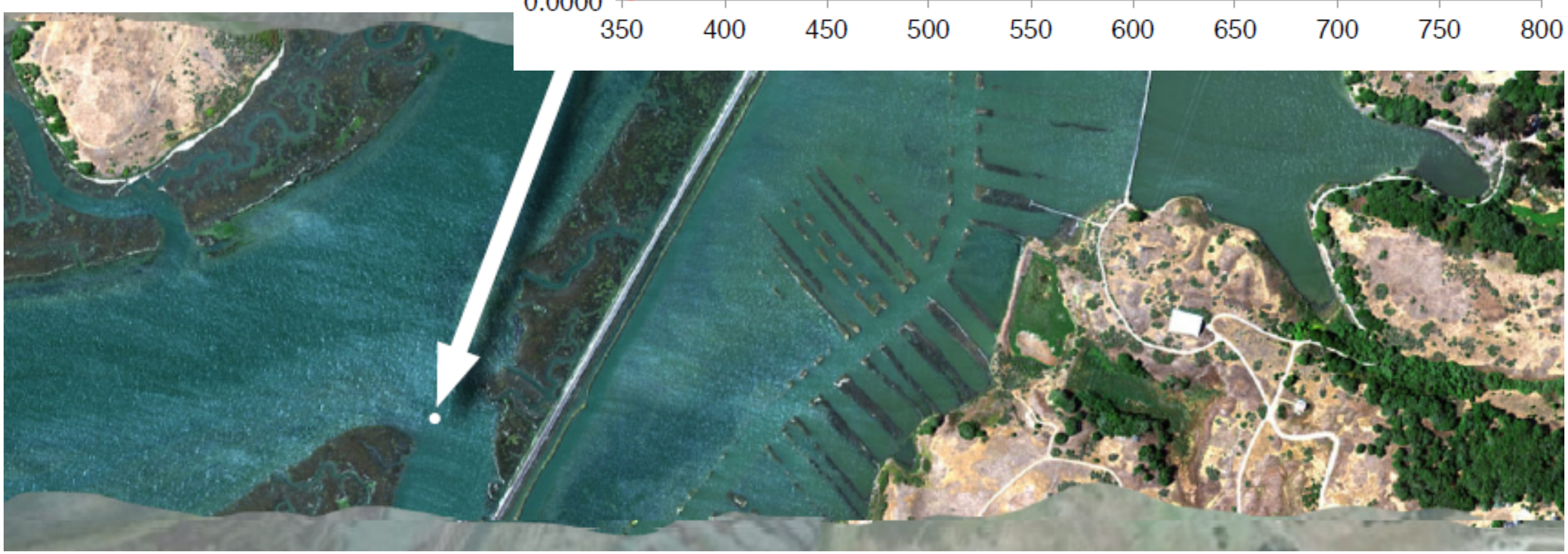
Main Channel with in-situ R_{rs}

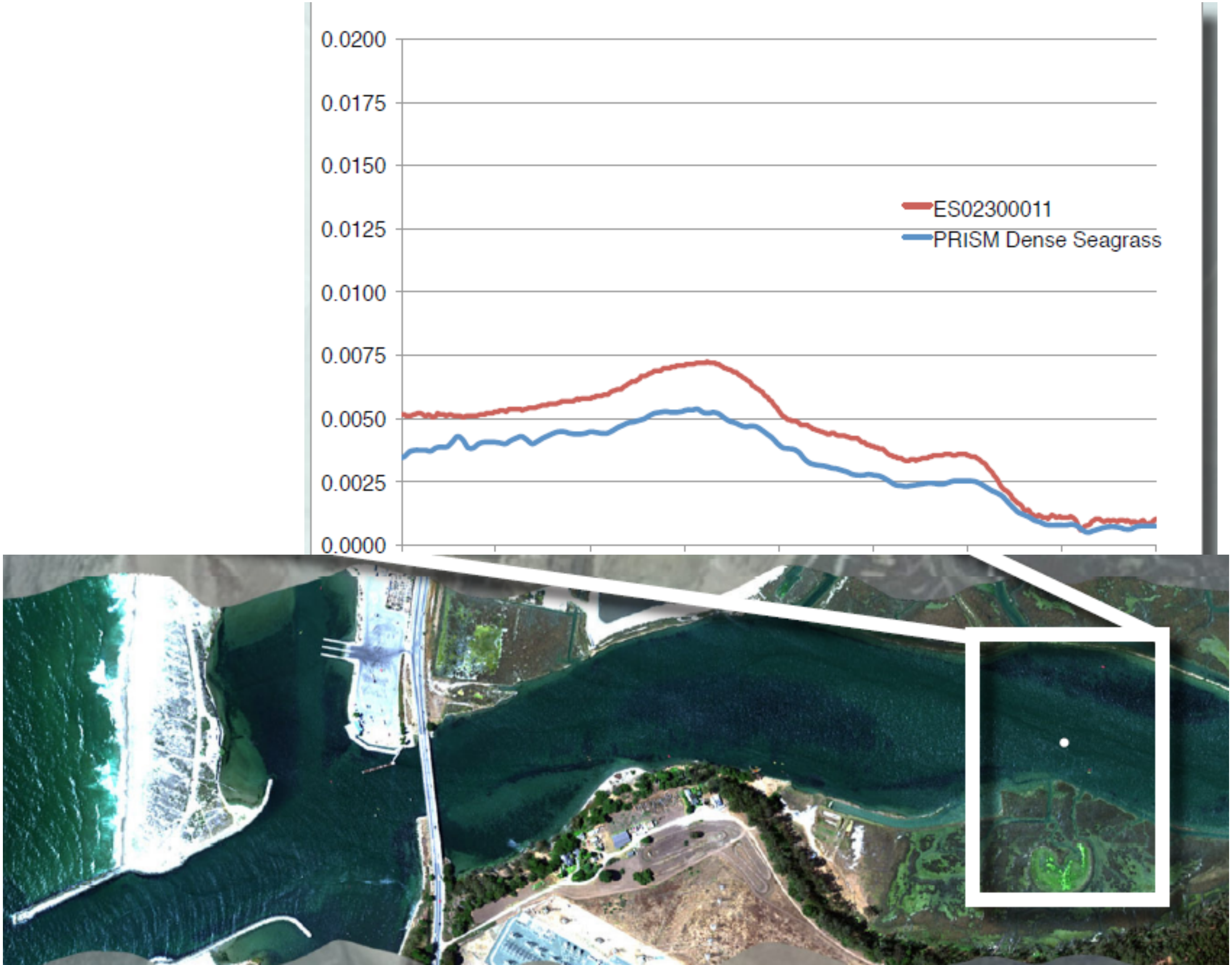




East Lobos Buoy






0.0200
0.0175
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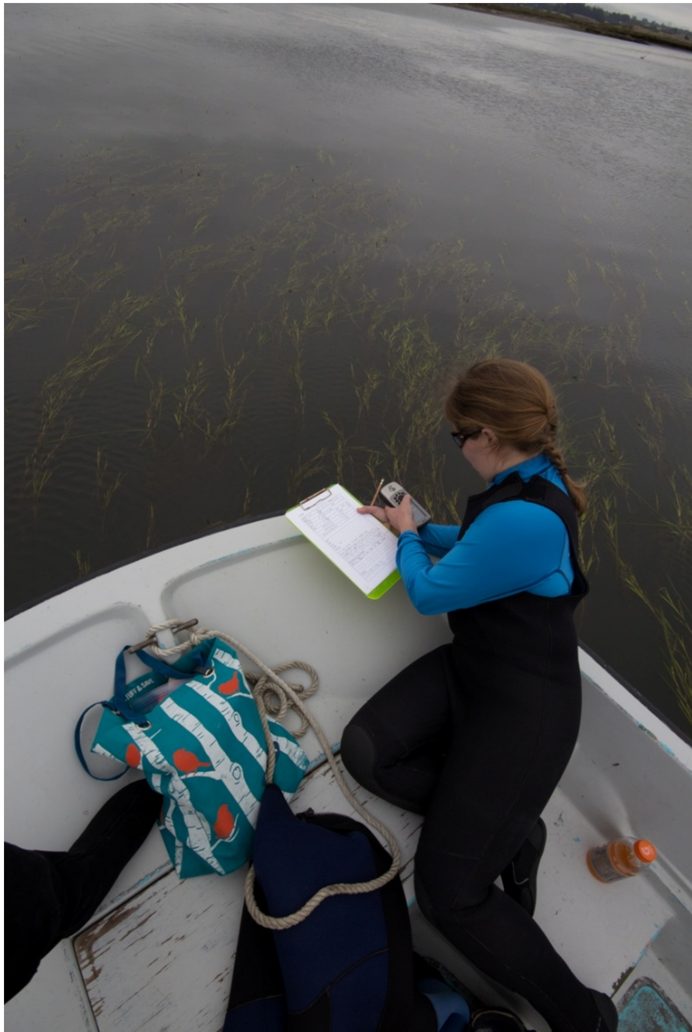
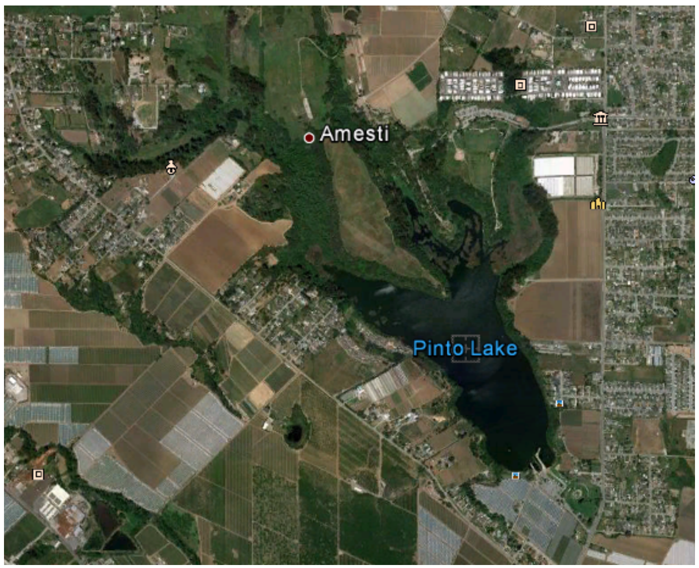
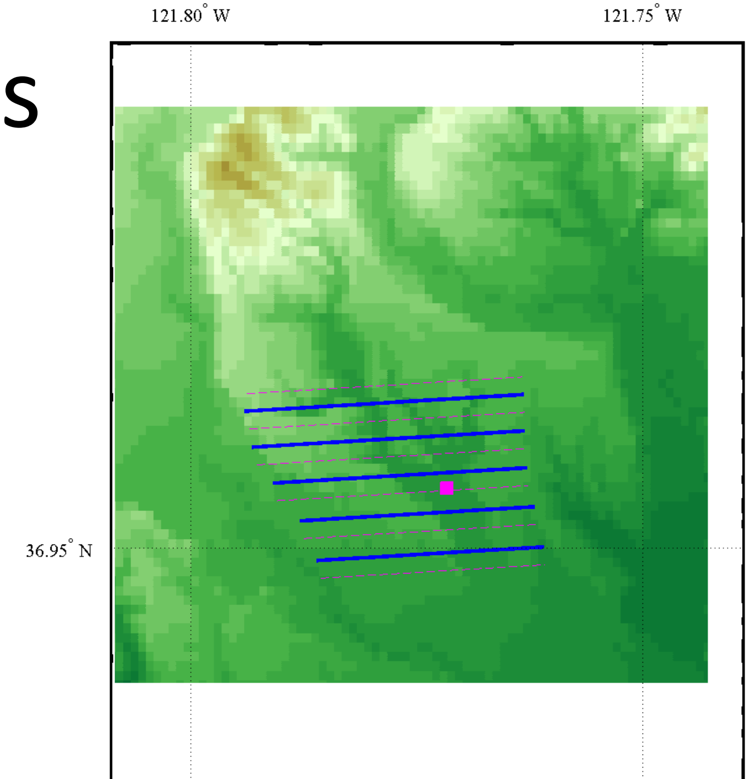
0.0100
0.0075
0.0050
0.0025
0.0000
ES02300011
PRISM Dense Seagrass

Validation Points



Dense Algal Blooms Pinto Lake





Date: 7/25/2012; GMT: 23.5-24.5; Local: 16.5-17.5

Line 1: [36.9636N, -121.7632W] to [36.9621N, -121.794W]; 2.74 km; Time 0.018 hr

Line 2: [36.9604N, -121.7631W] to [36.9589N, -121.7932W]; 2.68 km; Time 0.018 hr

Line 3: [36.9571N, -121.7629W] to [36.9557N, -121.7909W]; 2.49 km; Time 0.017 hr

Line 4: [36.9537N, -121.762W] to [36.9524N, -121.788W]; 2.31 km; Time 0.016 hr

Line 5: [36.9501N, -121.761W] to [36.9489N, -121.7861W]; 2.23 km; Time 0.015 hr

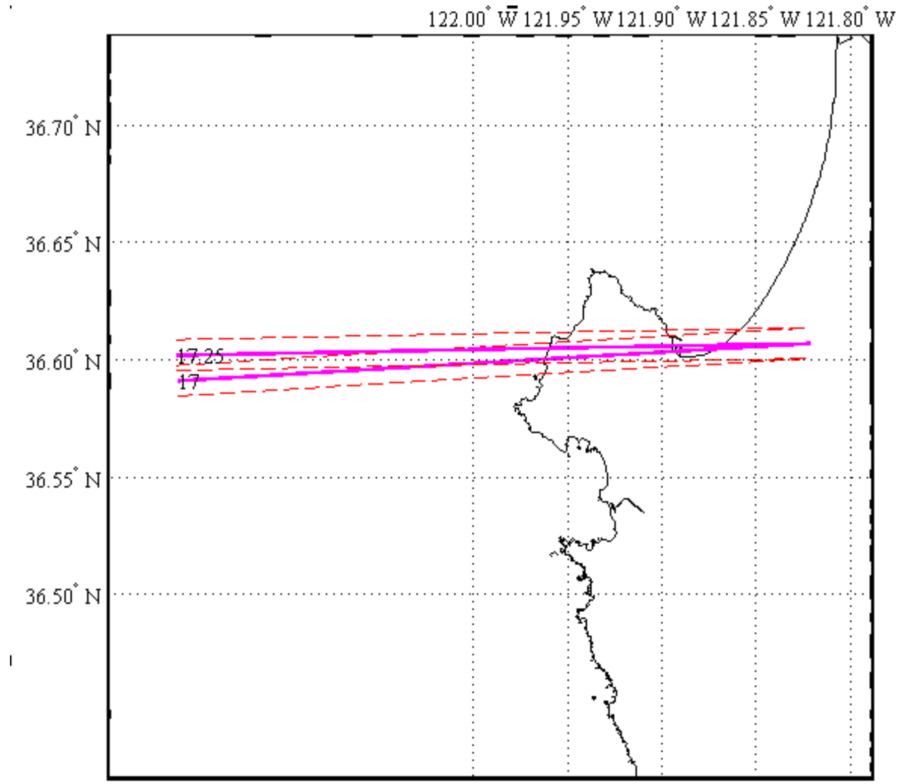
- Ongoing sampling by Raphael Kudela

Total Dist.: 15.32 km; Min. Time: 0.1; Azimuth: 267, SZA: 52.1

Toxic Algal Bloom *Pseudonitschia* which produces Domoic Acid

- Harbor in Monterey Wharf

- In collaboration with Jason Smith at MLML



Conclusions

- Field Validation Effort was a *Big Success*, thanks to all!
- Over 400 GB of imagery was collected
- Reflectance spectra and bio-optical properties of water and seafloor collected over diverse habitats
- Ongoing efforts to process imagery and produce habitat maps using a variety of algorithms
- Data and imagery will be available for others to play with