Using HyspIRI at the Land/Sea Interface to Identify Phytoplankton Functional Types

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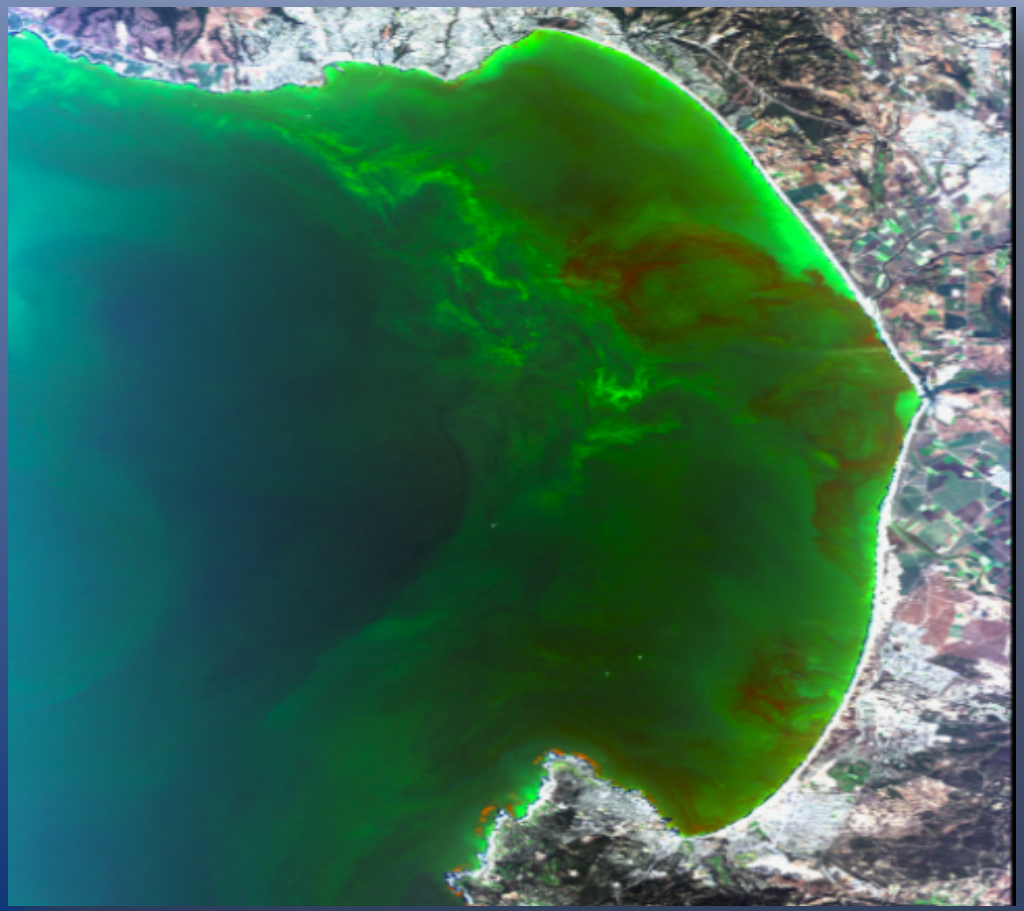

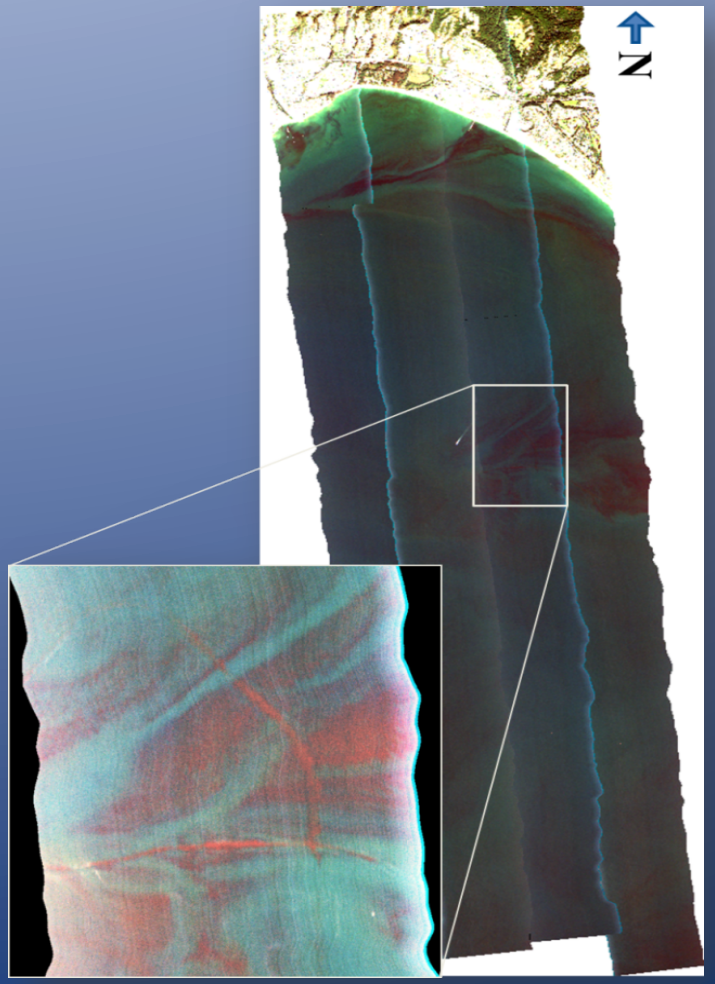

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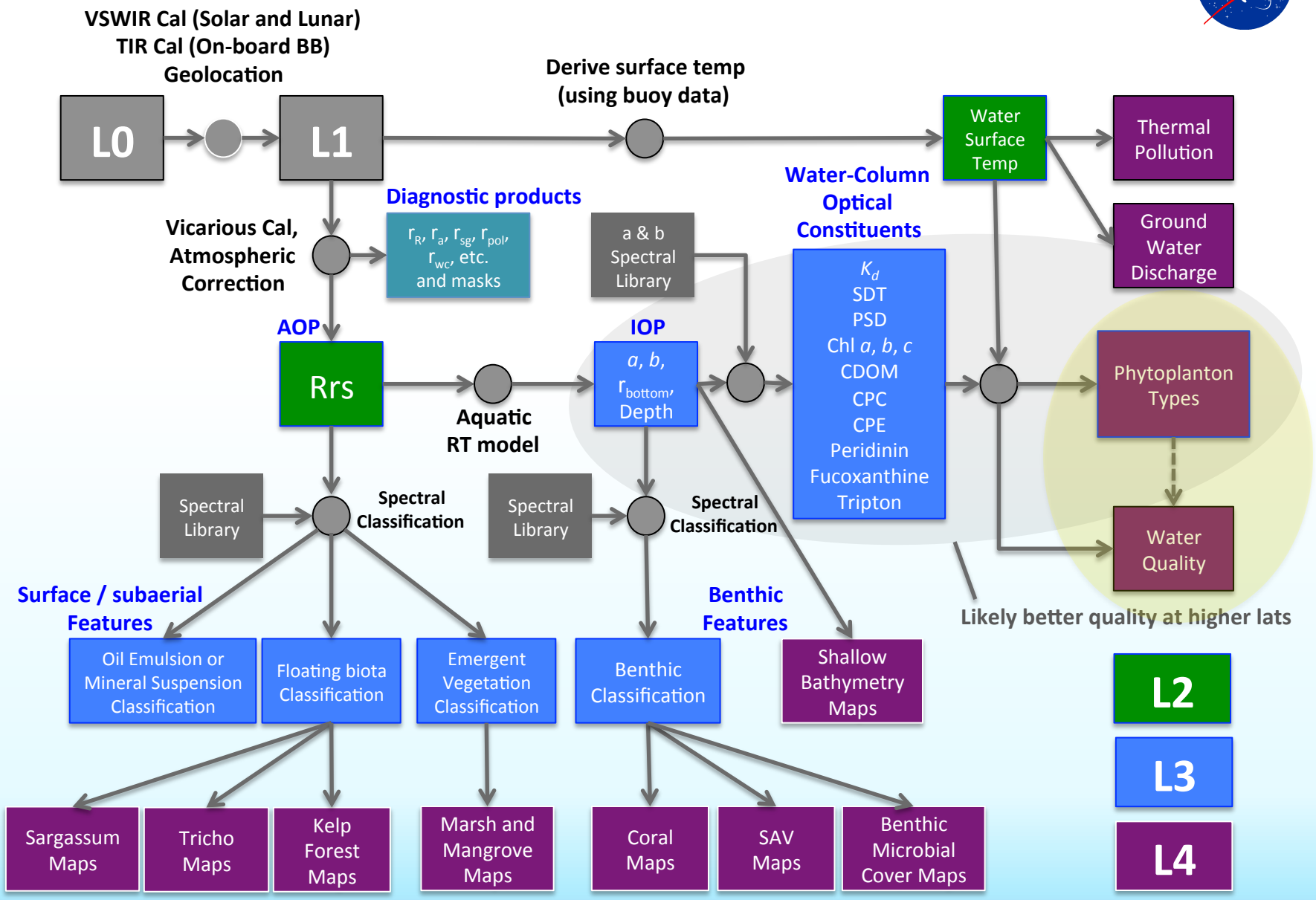
Objectives/Significance

- **Our primary goal is to demonstrate the utility of an airborne HyspIRI simulation to address the biological properties of coastal California, within the context of the long-term monitoring programs ongoing in the area**

1) The development and improvement of algorithms and models for the detection and prediction of HABs
2) Provide PFTs for inland water bodies such as lakes and reservoirs
3) Provide PFTs for the coastal ocean to assess ecosystem health and water quality (focusing on HABs and red tides)

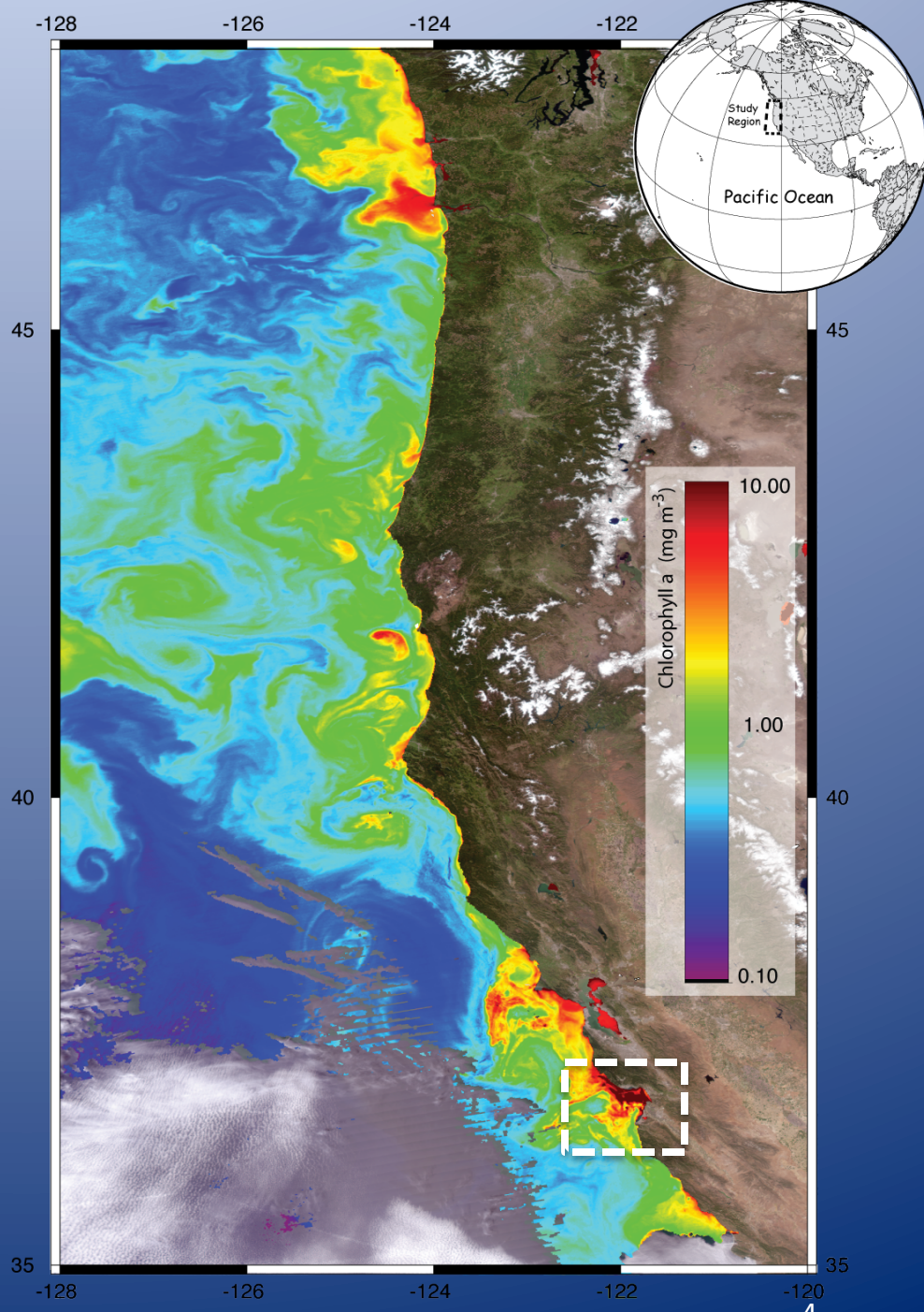
Aquatic Applications and Product Hierarchy



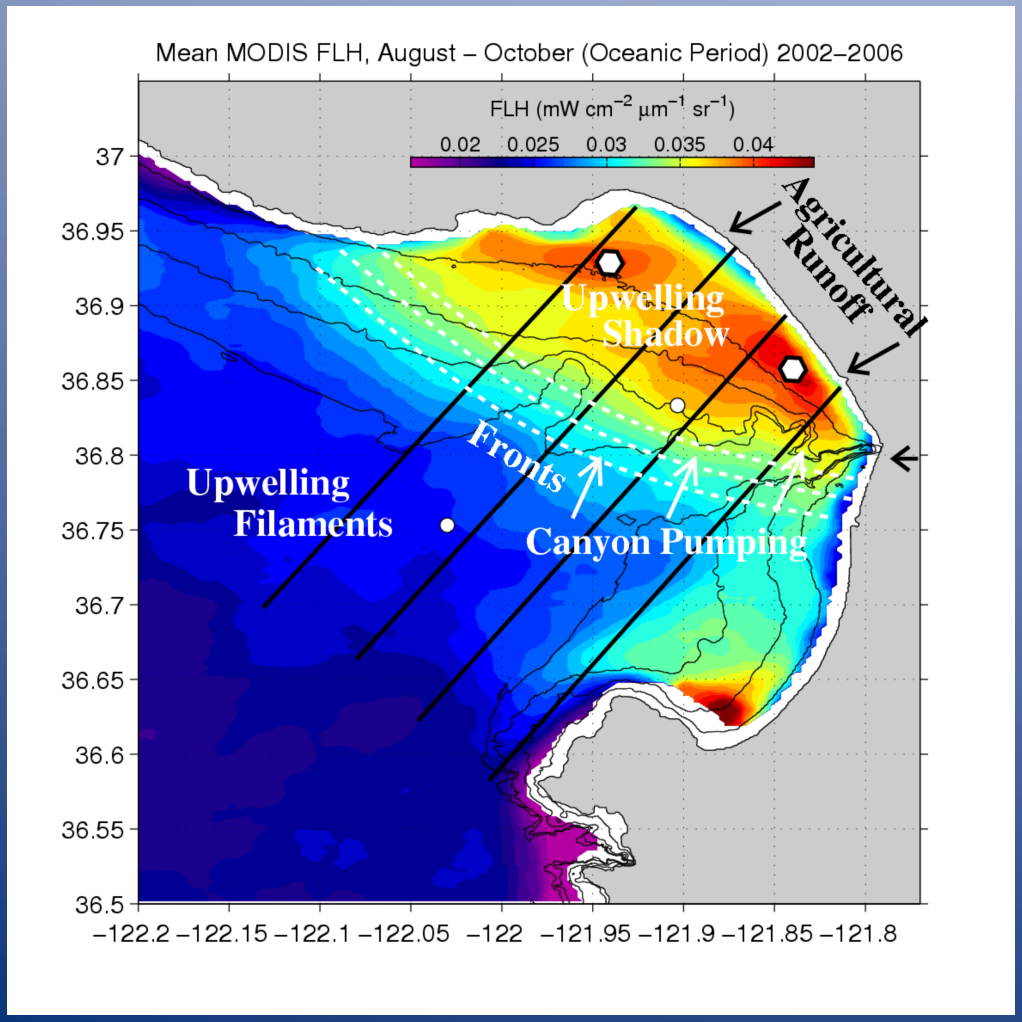
Kevin's Slide

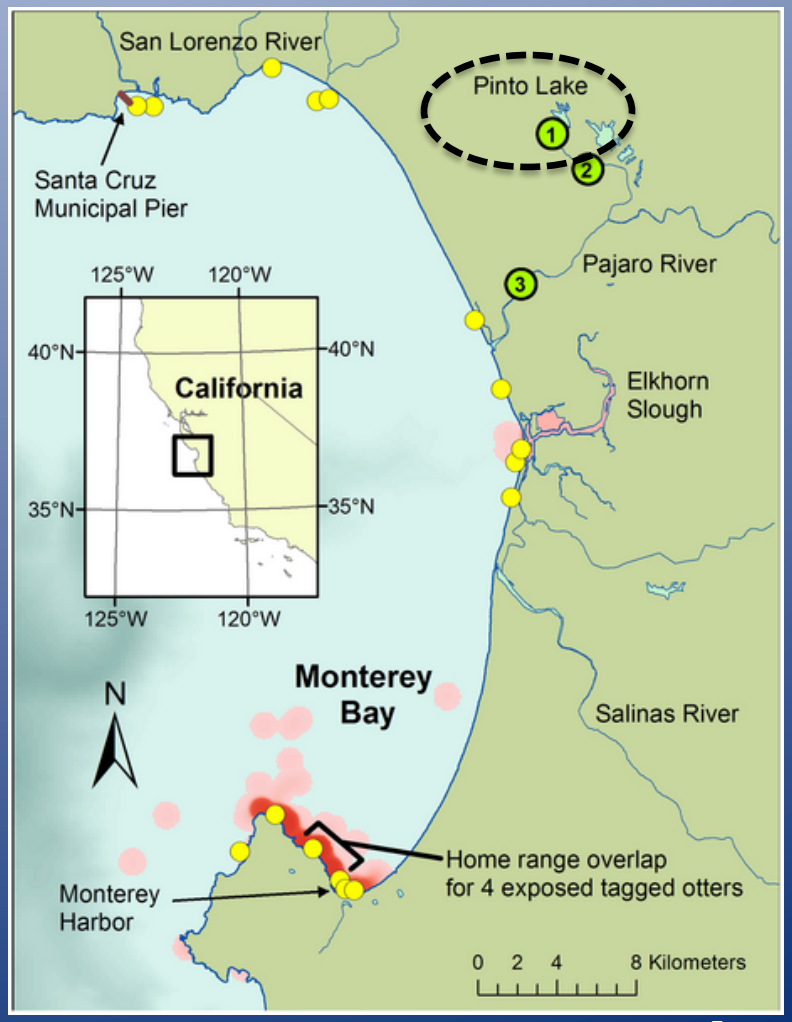
Monterey Bay as a Testbed

- Monterey Bay has been used for COAST 2006 (PHILLS 2 sensor), COAST-HOPE 2011 (Headwall and C-AIR sensors), PRISM (2012), SARP (MASTER, 2010), and GLIMMER (2012) as well as numerous AVIRIS overflights
- Ongoing time-series by UCSC, MLML, MBARI, with moorings and shore stations
- Features include Elkhorn Slough, Case 1 & 2 waters, red tides, kelp beds, river plumes

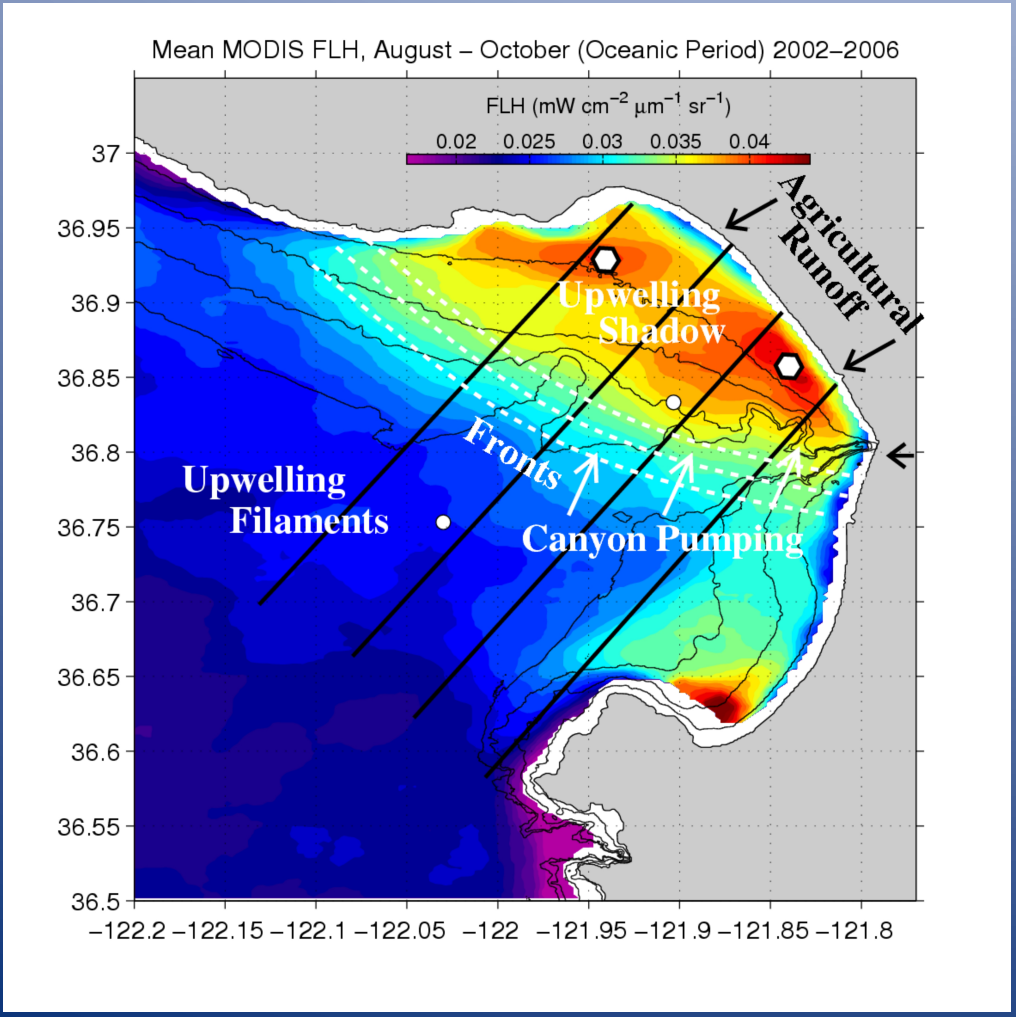


Field Sites


Mean MODIS FLH, August – October (Oceanic Period) 2002–2006
FLH (mW cm^{-2} µm^{-1} sr^{-1})
0.02 0.025 0.03 0.035 0.04
Upwelling Shadow
Agricultural Runoff
Fronts
Upwelling Filaments
Canyon Pumping
37
36.95
36.9
36.85
36.8
36.75
36.7
36.65
36.6
36.55
36.5
−122.2 −122.15 −122.1 −122.05 −122 −121.95 −121.9 −121.85 −121.8


San Lorenzo River
Pinto Lake
1
2
Santa Cruz Municipal Pier
3
Pajaro River
125°W 120°W
40°N
40°N
California
35°N
35°N
125°W 120°W
Elkhorn Slough
N
Monterey Bay
Salinas River
Home range overlap for 4 exposed tagged otters
Monterey Harbor
0 2 4 8 Kilometers

Field Sites – Flight Timing



Spring (March), Summer (July), and Fall (October) maximize the likelihood of data collection days, minimize cloud cover (for collection of satellite data), and provide a range of scientifically interesting features, including tidal exchange with Elkhorn Slough, red tides, fall transition, upwelling versus oceanic conditions, and, potentially, a "first flush" rain event.

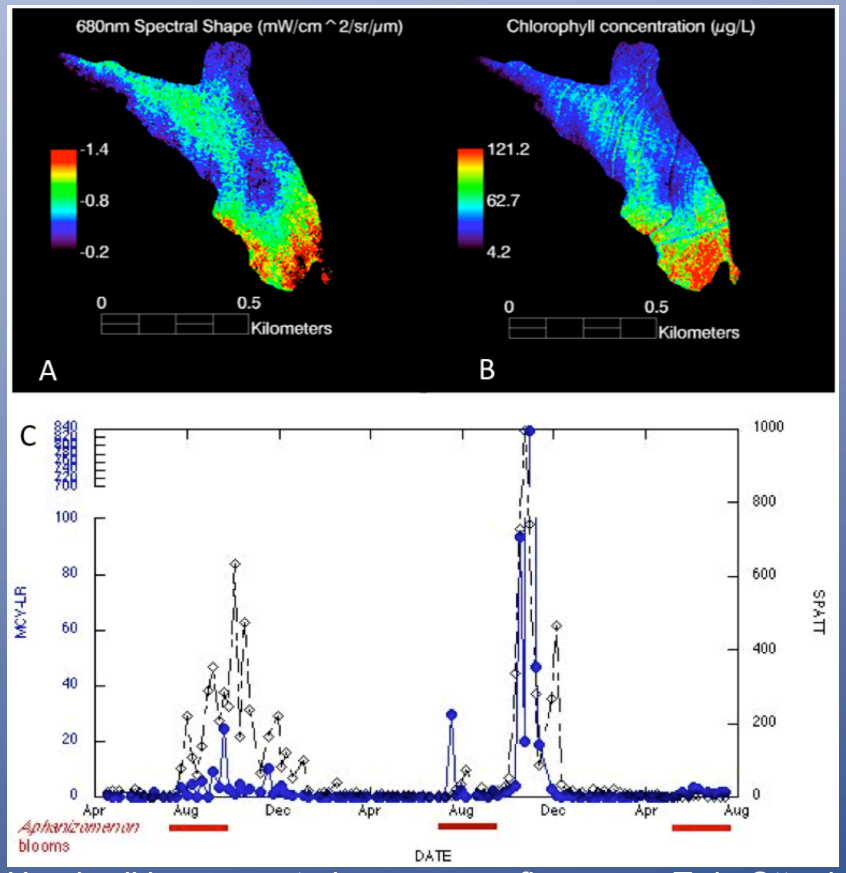
Seasonality in Monterey Bay can be delineated by

- upwelling (April-August),
- oceanic (September-October), and
- Davidson (November-March) seasons.

Having up to three AVIRIS overflights may enable capturing some of this seasonality.

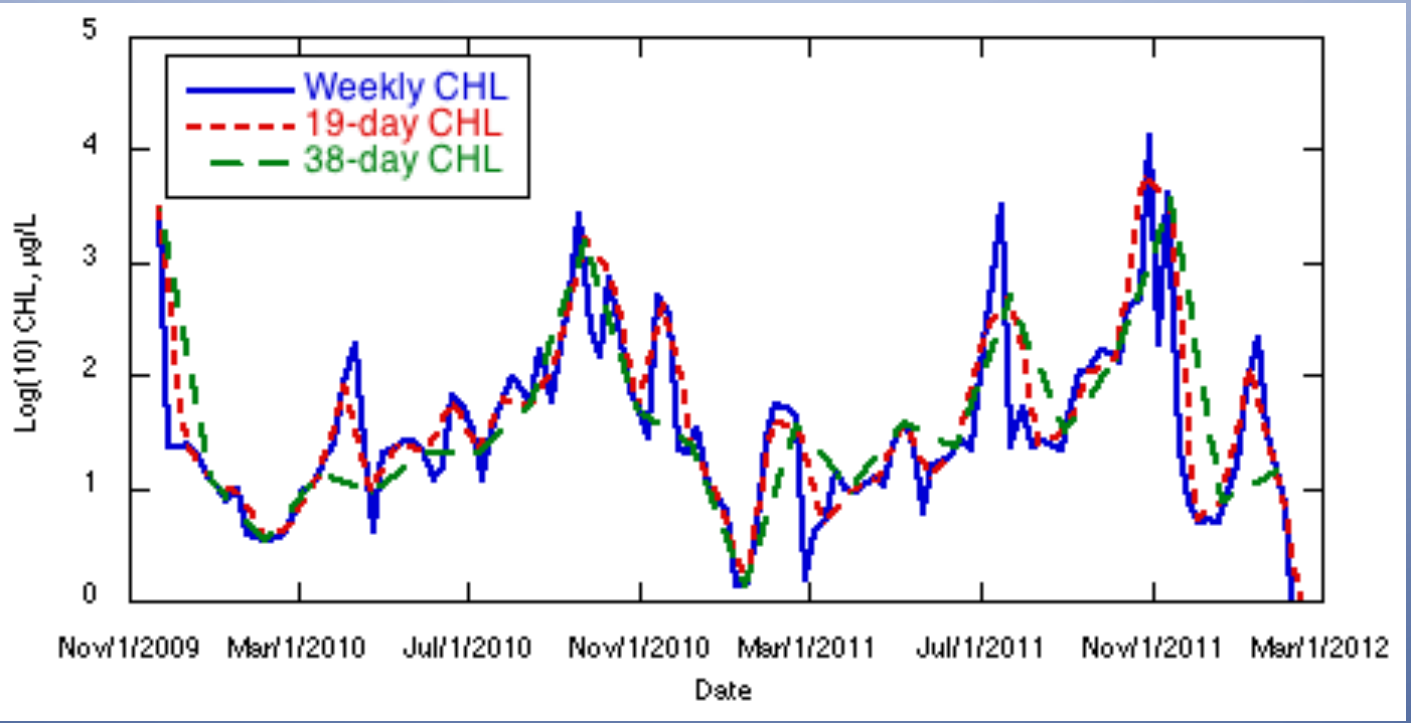
Pinto Lake

Meso-eutrophic lake, dominated by cyanos in summer with clear seasonal species succession



A Headwall hyperspectral sensor was flown on a Twin Otter in October 2010 over Pinto Lake. A spectral shape algorithm (A) and a band-ratio chlorophyll *a* algorithm (B) were applied. Sampling confirmed the presence of an extensive *Microcystis* bloom (with extremely elevated toxin levels) and chlorophyll concentrations. Toxin data from grab and time-integrated (SPATT) samples are shown (C) for 2010–2012. A separate spectral shape algorithm applied to HICO data in 2011 (not shown) successfully identified blooms dominated by *Aphanizomenon* (indicated with red bars) versus *Microcystis* from in-water spectra and HICO data.

Pinto Lake



Chlorophyll (and toxin) samples have been collected weekly for ~3 years from Pinto Lake, CA. Weekly CHL data are plotted after degrading to 19- and 38-day repeat cycles.

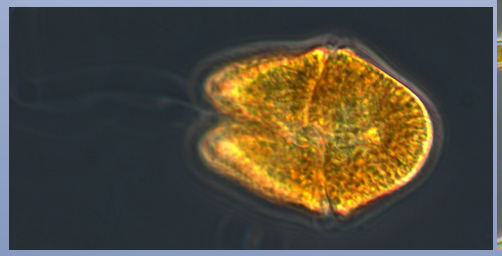
Pinto Lake has also been used as a site for airborne data collection in 2010, 2011, 2012, and 2013, and there are historical bio-optical and reflectance data available for comparison

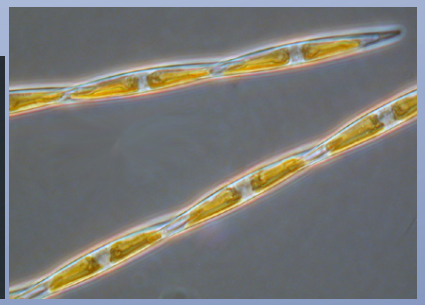
Phytoplankton Functional Types (PFTs)

- For oceanic waters, using PHYDOTax (Palacios 2012). This is an inversion model based on signature spectra (similar approach to CHEMTAX, but uses reflectance data). Solves for 6 functional types. Signature library developed using large-volume cultures (a, bb, c) and HydroLight
- For Pinto Lake, we have been using spectral shape algorithms with Headwall, MASTER, and HICO

PHYDOTax – Signature Library Taxa

dinoflagellate





diatom

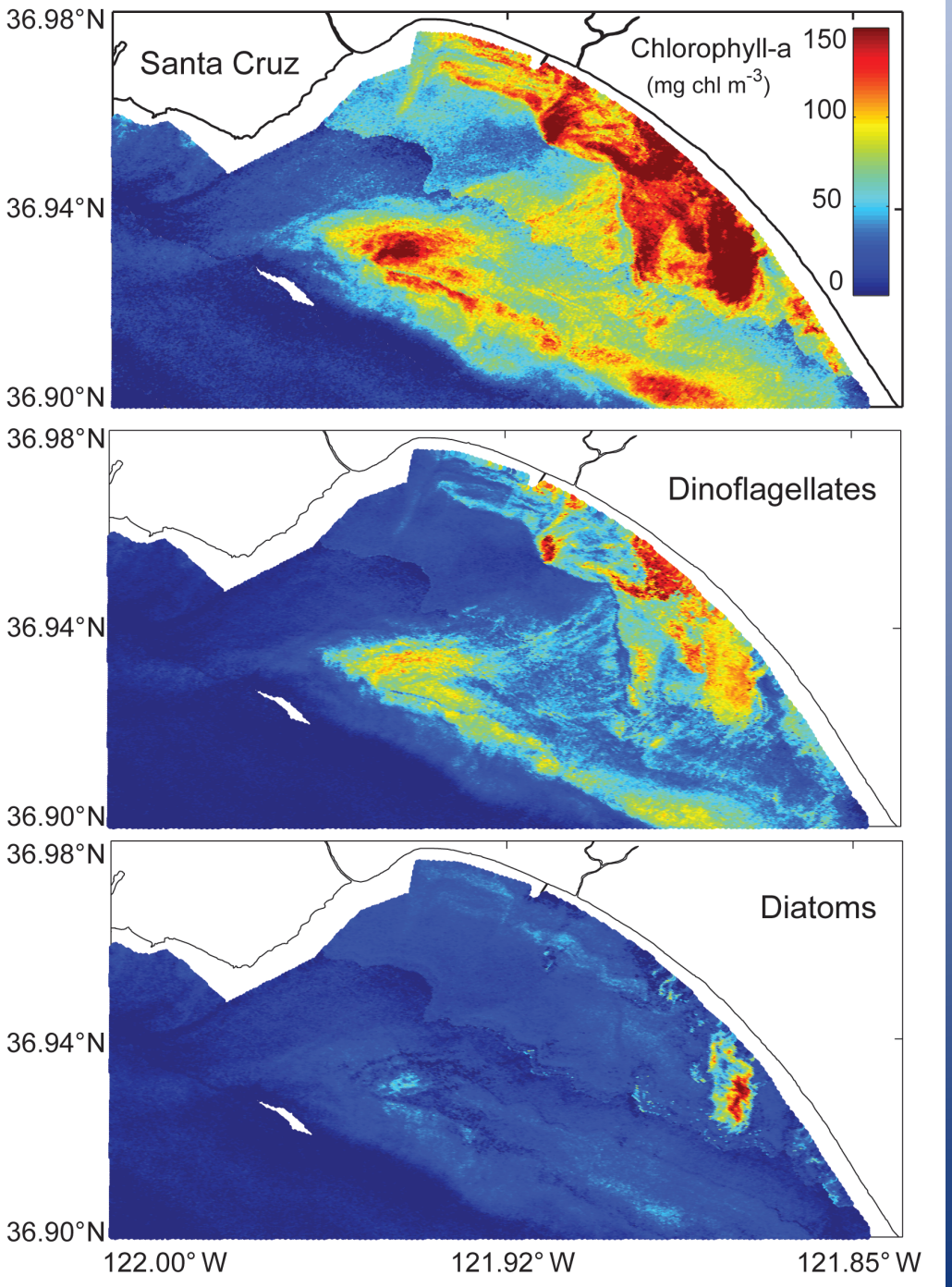
cryptophyte

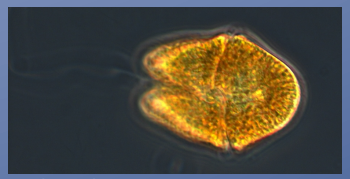
haptophyte

chlorophyte

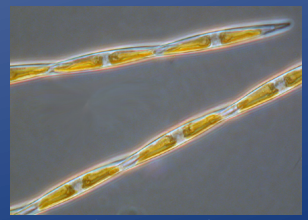
cyanobacterium

PHYDOTax Predictions





Akashiwo sanguinea



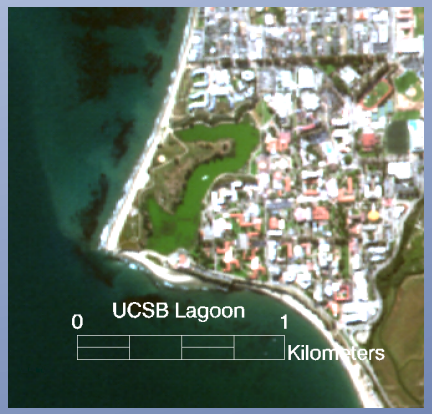
Pseudonitzschia sp.

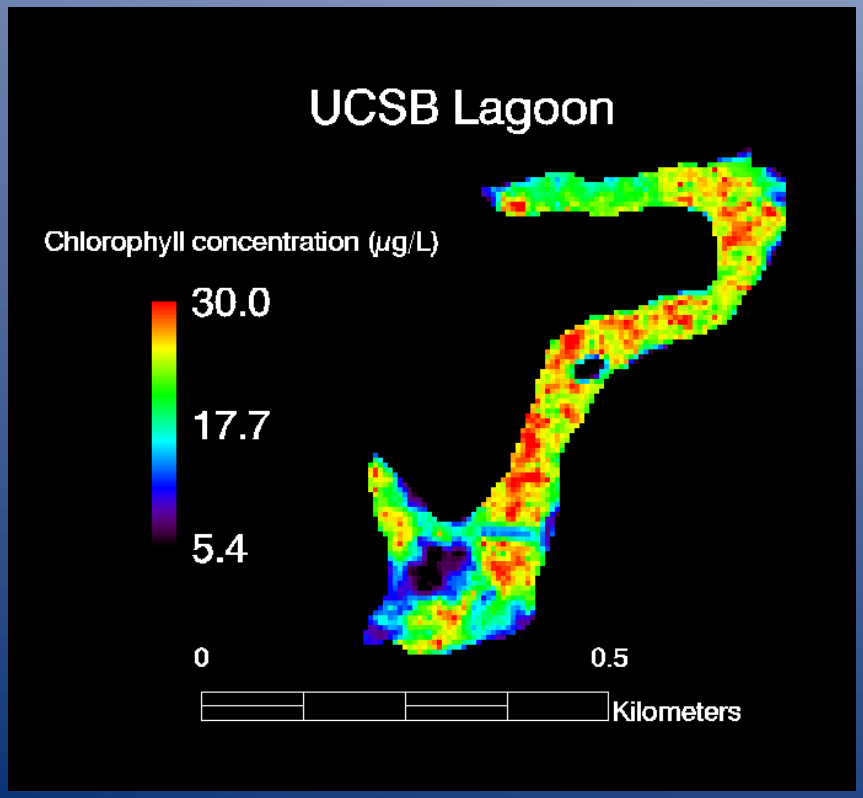
MSLH – Index to detect the cyanobacterium *Microcystis*

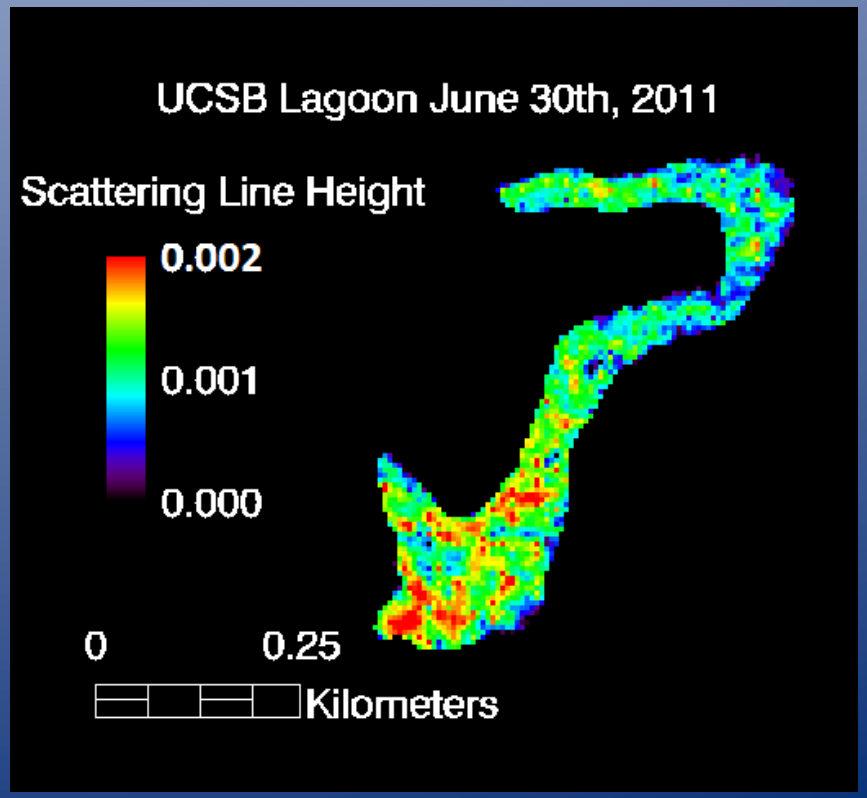
Vessicles in *Microcystis* exhibit unique scattering characteristics

Index similar to FLH

MSLH=MASTER Scattering Line Height



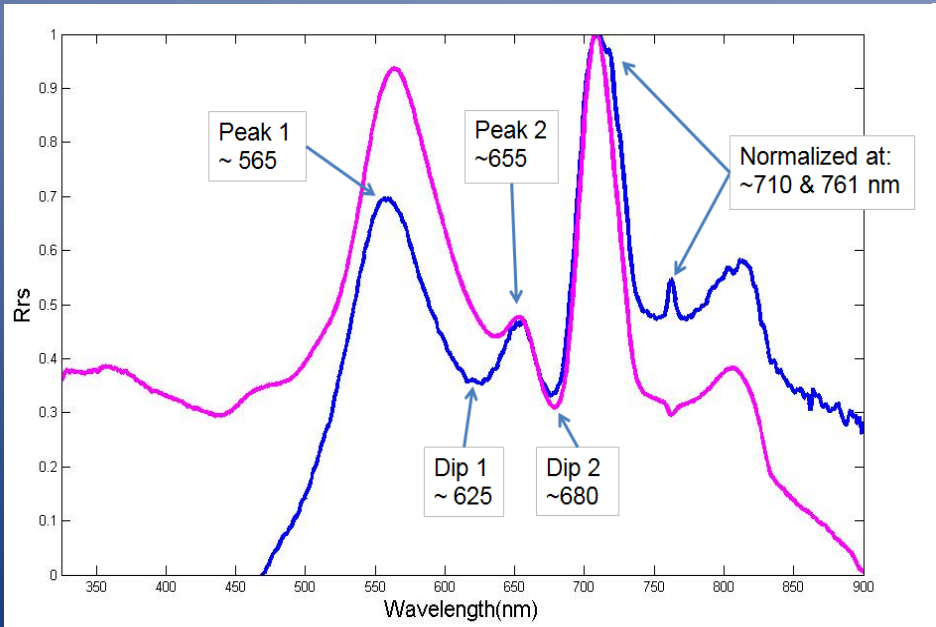


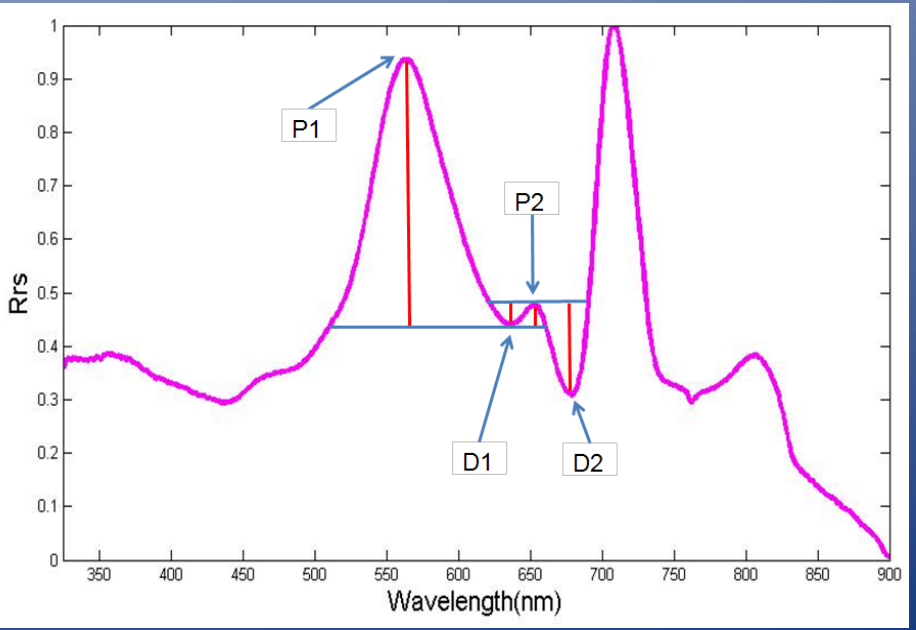


Santa Barbara 2011 MSLH, David Austerberry

Creation of indices & use on library species

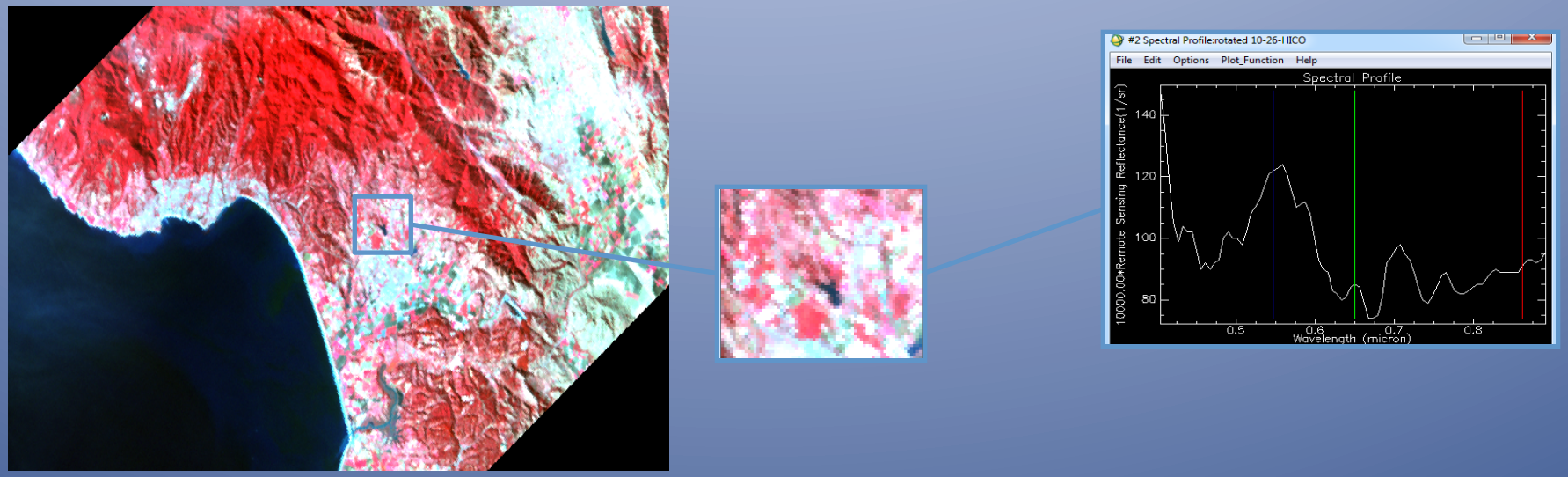
- Identification of key spectral features
- Feature x-value, y-value, height, width, area
- Ex. index, (peak 1 height/peak 2 height) = $\frac{(R565 - R625)}{(R655 - R625)}$





Pinto Lake 2012, Spectral Shape, Emma Accorsi

Indices applied to HICO match field data



- Indices applied 10/26/2011 HICO data suggest high biomass mixed bloom, consistent with 10/23 and 10/29 field data

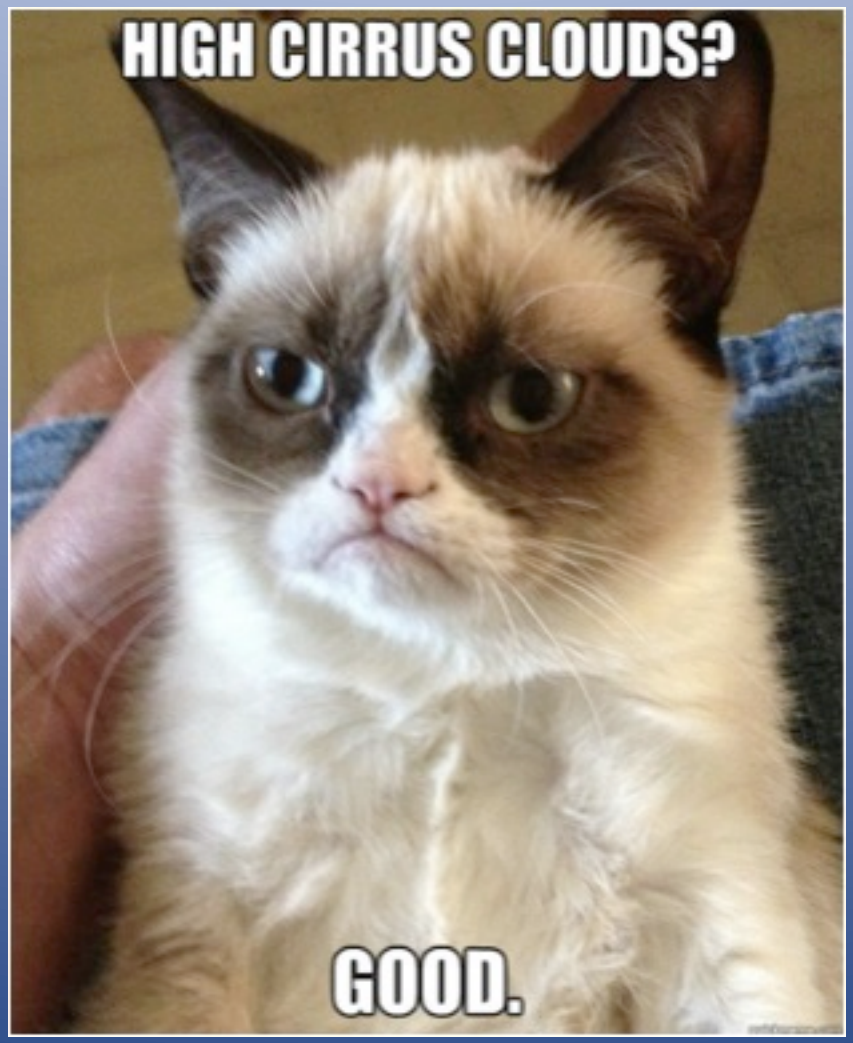
HyspIRI Airborne Flight Planning
Science Requirements – Coastal Ocean

- **Goal: Demonstrate the utility of an airborne HyspIRI simulation to address the biological properties of coastal California, within the context of the long-term monitoring programs ongoing in the area.**

1) Dates: March, July, October are best weather windows
2) Sun elevation of 30-45 deg is optimal along with flying into and out of the sun to avoid sun glint
3) Flight line timing over water to meet best weather and sun elevation will vary through the seasons (Spring, Summer, Fall)
4) Repeat flight lines at varying sun elevations will be a nice test of sun glint algorithms
5) Recommend use of HyspIRI look angle from AVIRIS to simulate HyspIRI, another good test for algorithms
6) Request that SB and Monterey Bay flights are not scheduled on consecutive days so that field teams and instruments can participate in field activities for both sites

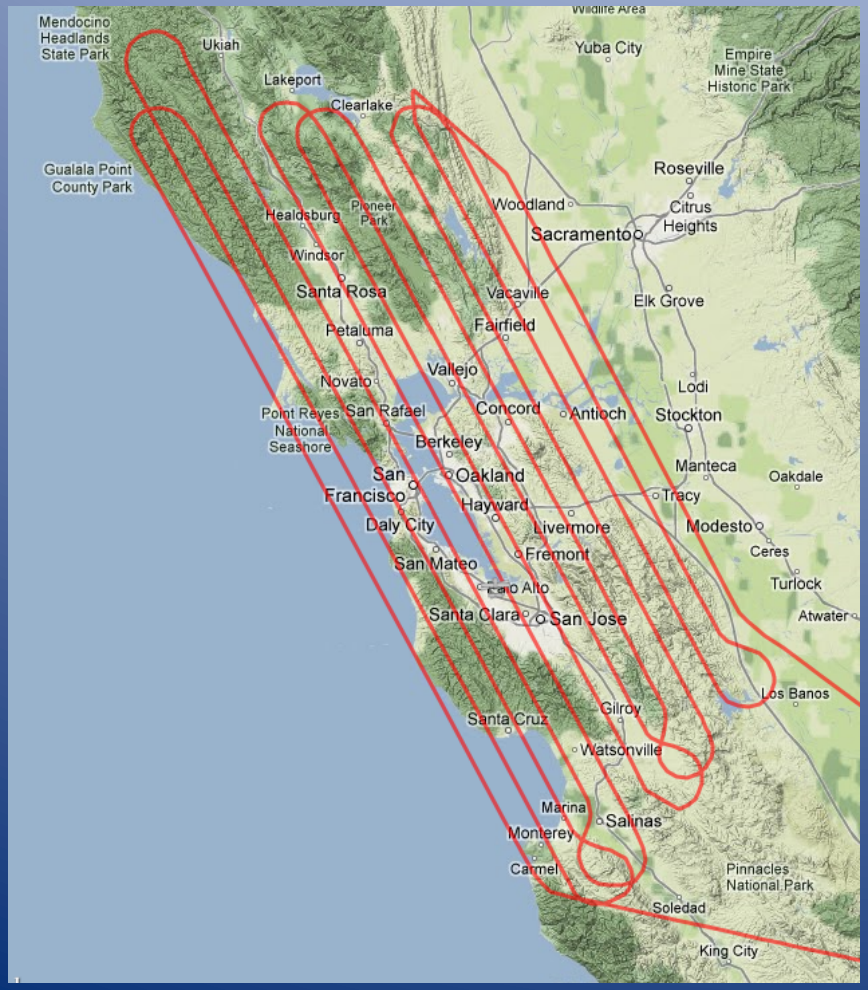
Spring 2013 Overflights

Ian McCubbin Deserves an Award!

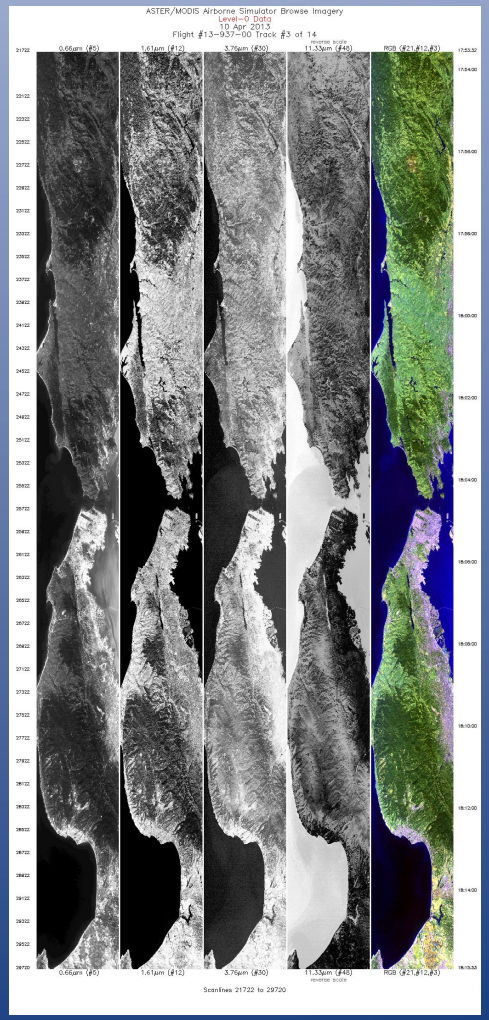

HIGH CIRRUS CLOUDS?
GOOD.

San Francisco Bay Over-flights
10 April 2013

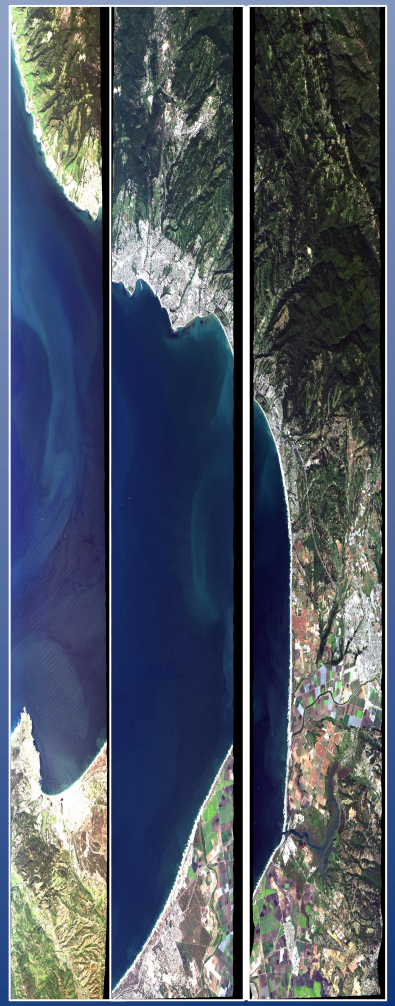
Flight Lines



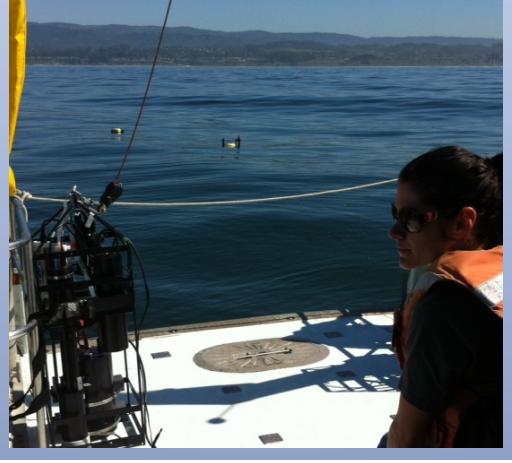
MASTER



AVIRIS (subset)



Field Collection 10 April 2013



Data Products?

Ship-based Measurements

- Underway T, S, Fluorescence
- At each station:
  - Size fractionated chlorophyll
  - CDOM, absorption spectra, nutrients
  - Satlantic HyperPro cast
    - Water-leaving radiance, profile data
  - Backscattering/ac-s casts
  - ASD surface reflectance

When will the data be available?

- Awaiting AVIRIS imagery from JPL
- Timeline for ground-truth data
  - 2013: data collection, processing, cataloging
  - 2014 & 2015: processing, analysis, distribution
- Data distribution – SeaBASS and CoastColour.org

What about sun glint?

HysplRI Airborne Flight Planning
Science Requirements – Coastal Ocean

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