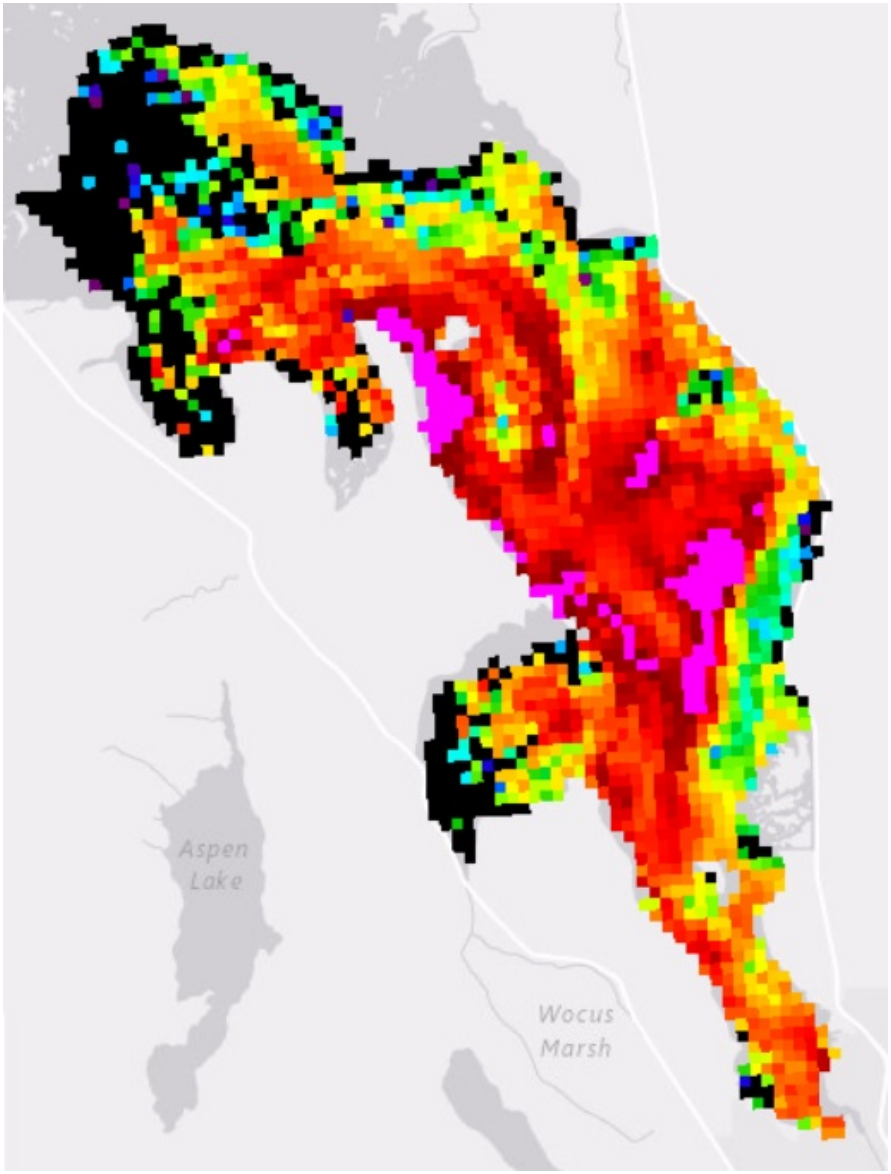


Remote Sensing of Cyanobacteria Blooms:

Next Steps in Utilizing Satellite Imagery

Randy Turner

San Francisco Estuary Institute

2018 Water Boards
Science Symposium
June 21, 2018

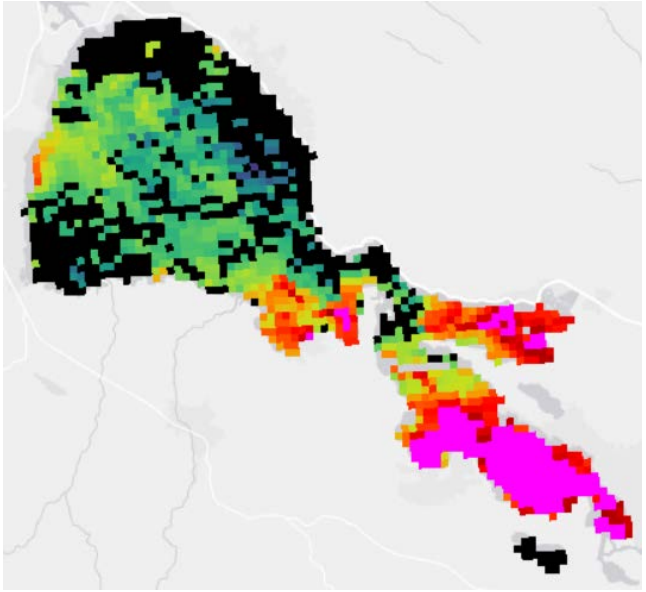
SAN FRANCISCO ESTUARY INSTITUTE
REGION-WIDE SCIENCE FOR ECOSYSTEM MANAGEMENT

Background and Challenges

- Cyanobacteria blooms and toxins natural
- Many factors/drivers influence blooms
- Landscape and climate change favor cyanobacteria blooms
  - ↑ Water temperature
  - ↑ N & P availability
  - ↓ Flows
- Bloom drivers vary by waterbody
- Managing blooms is a challenge

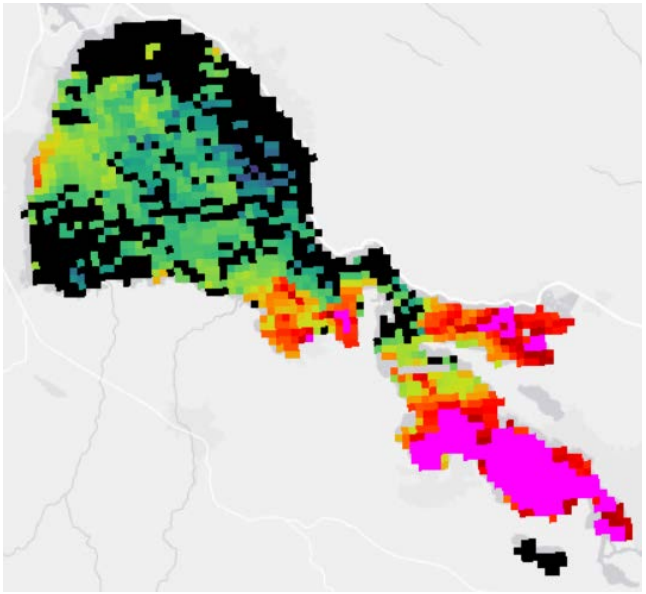
Satellite Project Goals

- Estimate cyanobacteria abundance in near-real time for large waterbodies



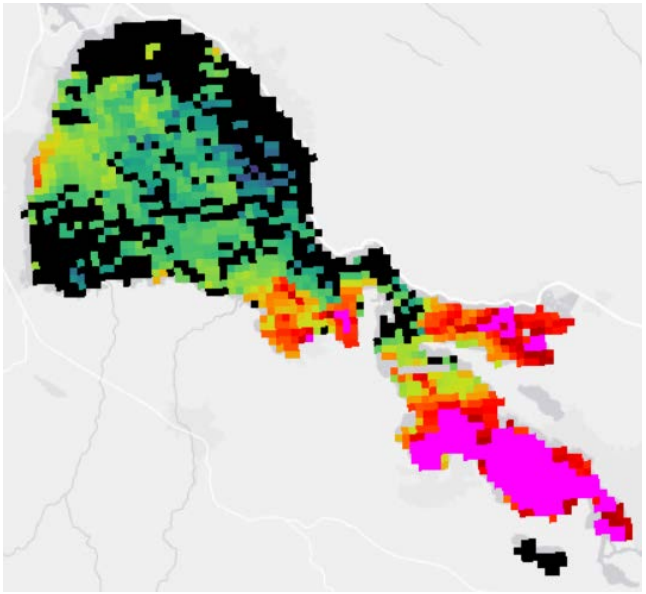
Satellite Project Goals

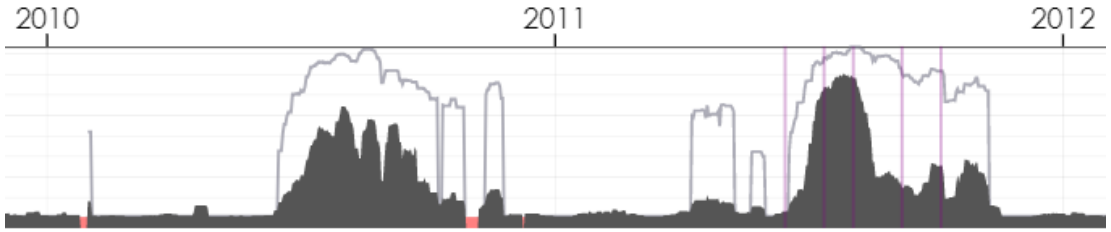
- Estimate cyanobacteria abundance in near-real time for large waterbodies
- Screening tool to guide public health sampling



Satellite Project Goals

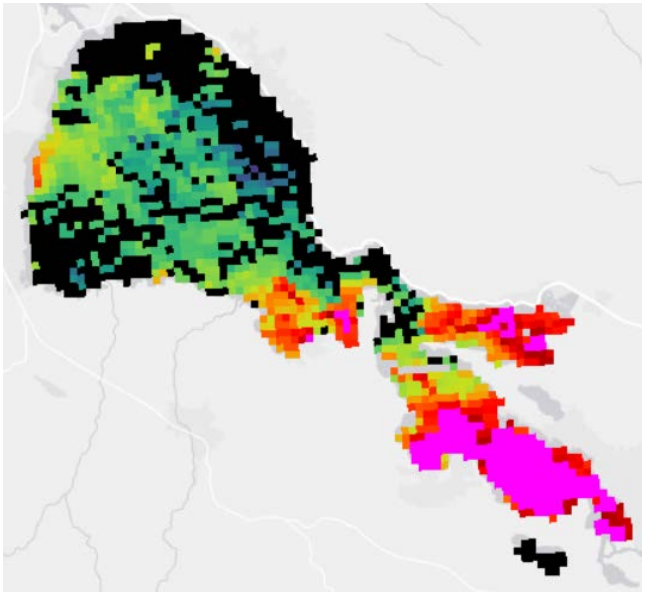
- Estimate cyanobacteria abundance in near-real time for large waterbodies
- Screening tool to guide public health sampling
- Evaluate spatial and temporal trends

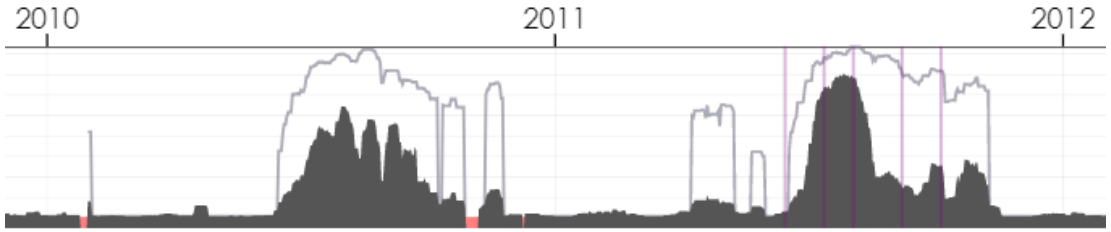




Satellite Project Goals

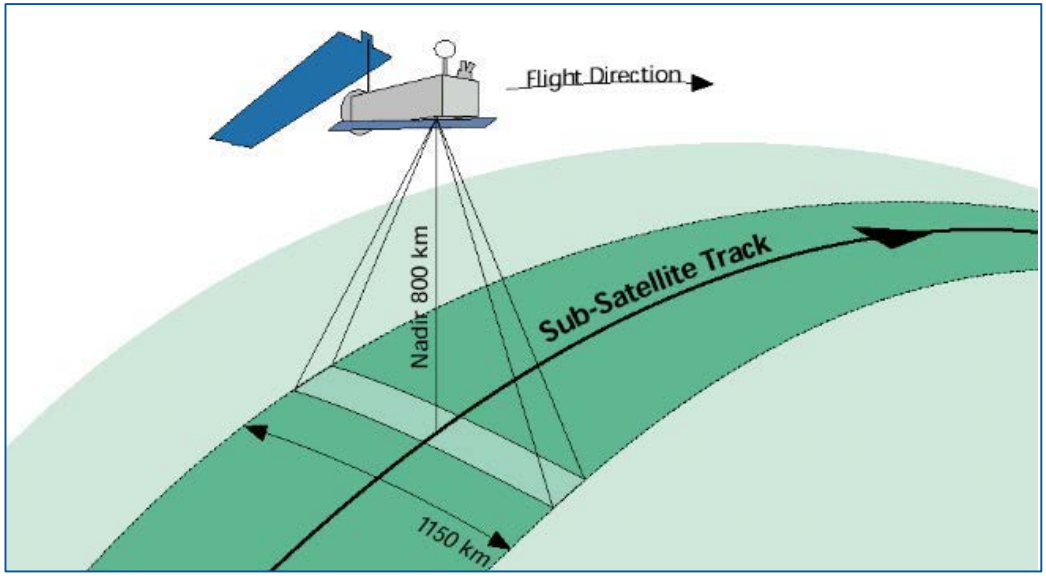
- Estimate cyanobacteria abundance in near-real time for large waterbodies
- Screening tool to guide public health sampling
- Evaluate spatial and temporal trends
- Dataset to assess other management questions

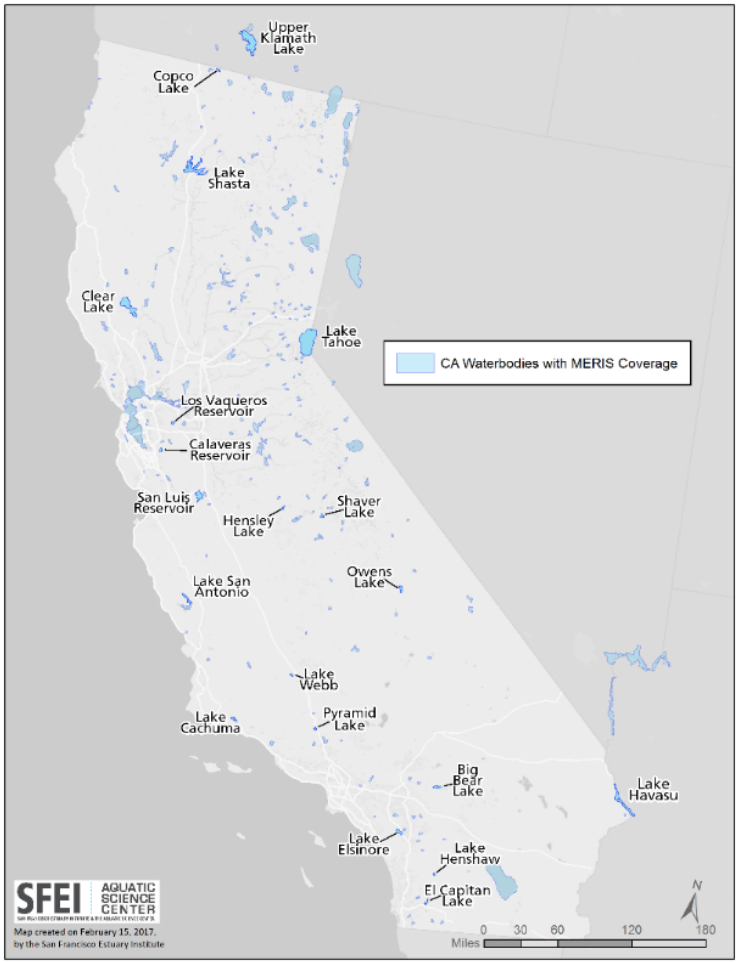




CA Surface Water Ambient Monitoring Program (SWAMP)

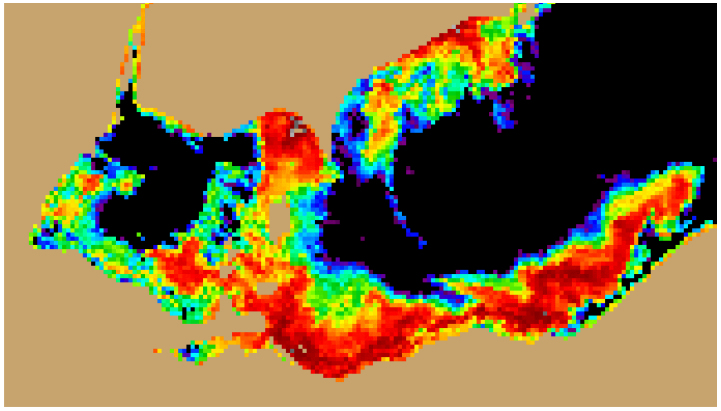
- Develop infrastructure to process and display imagery from two satellites
- Evaluate 255 waterbodies
  - Older data (2002-2012)
  - New data (Jan 2017 – Present)
- Email notifications when blooms develop

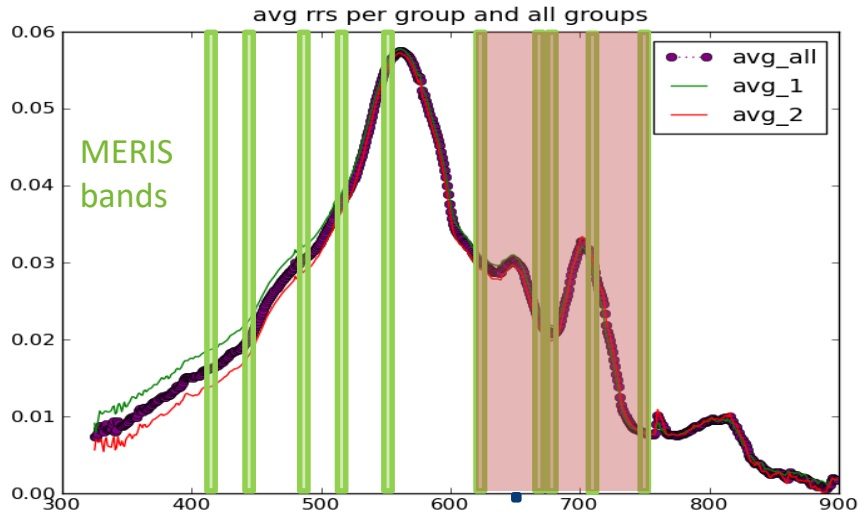




Satellite Imagery

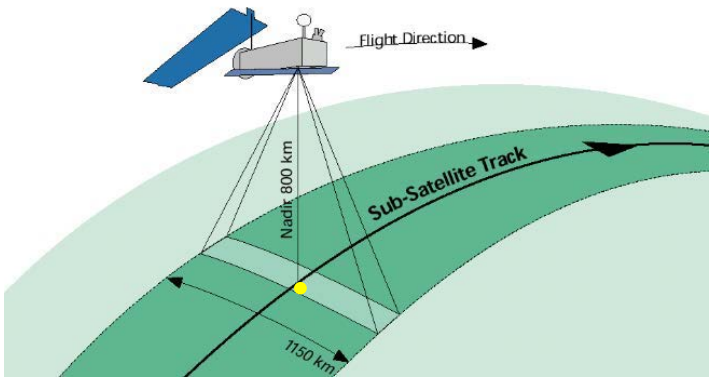
- Cyanobacteria blooms are observable
- Can distinguish from other algae
- Rapid turnaround- data available next day

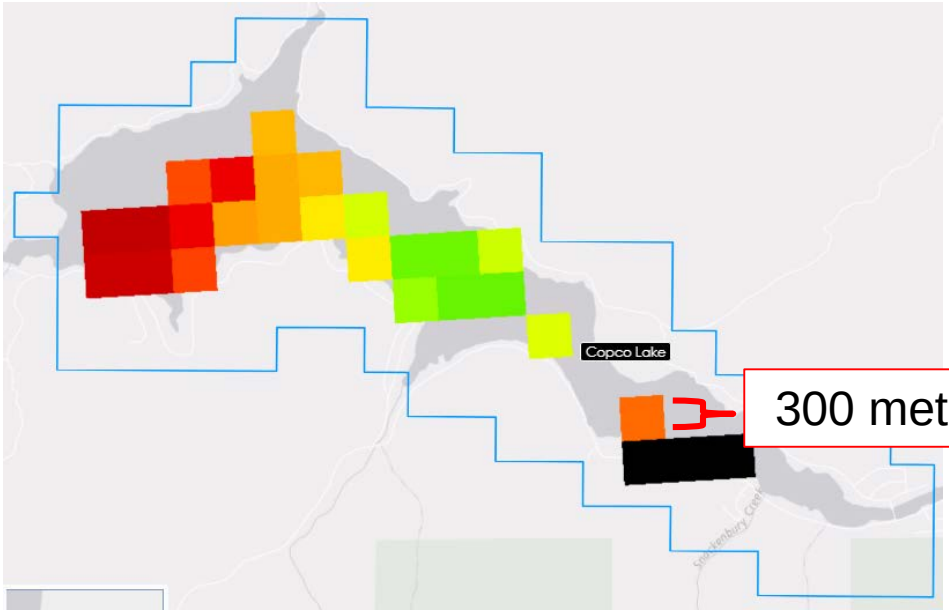


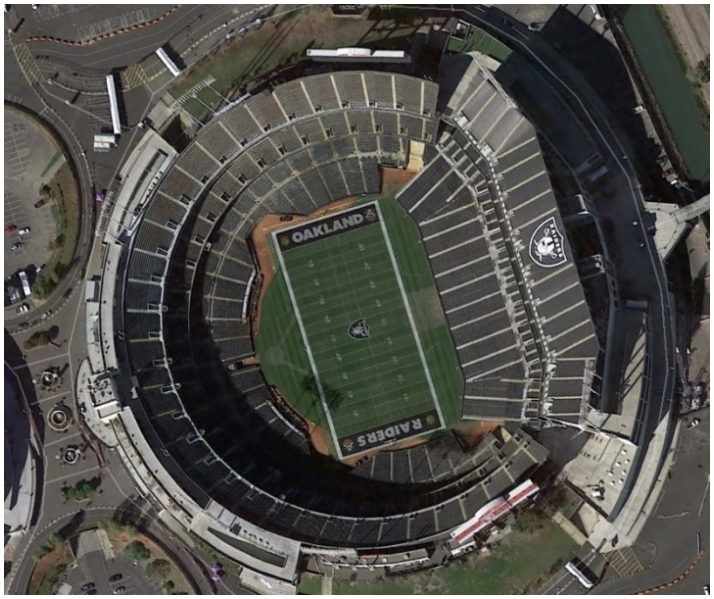


Pixels

- Pixel size is 300m x 300m
  - (~22 acres)
- Pixel location always the same

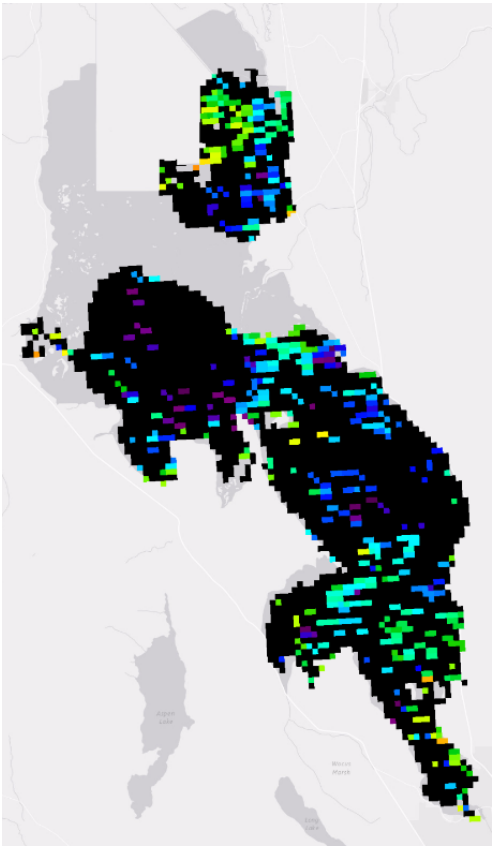




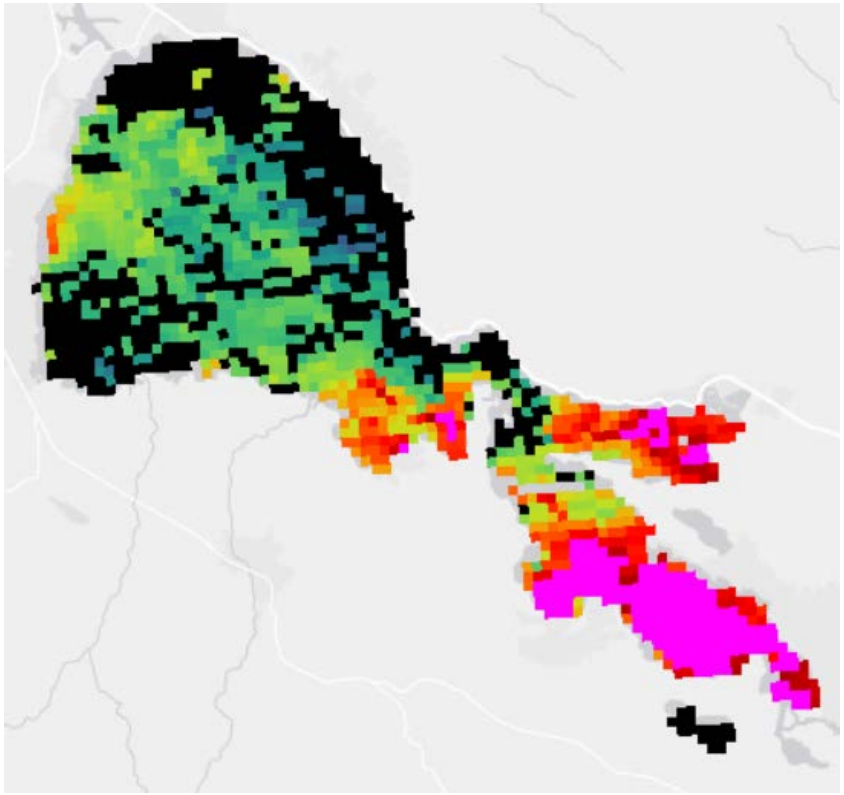


Satellites: Limitations

- Clouds and glare
- Estimates all cyanobacteria (not just toxin producers)
- Doesn’t measure toxins
- False positives
- Large waterbodies only



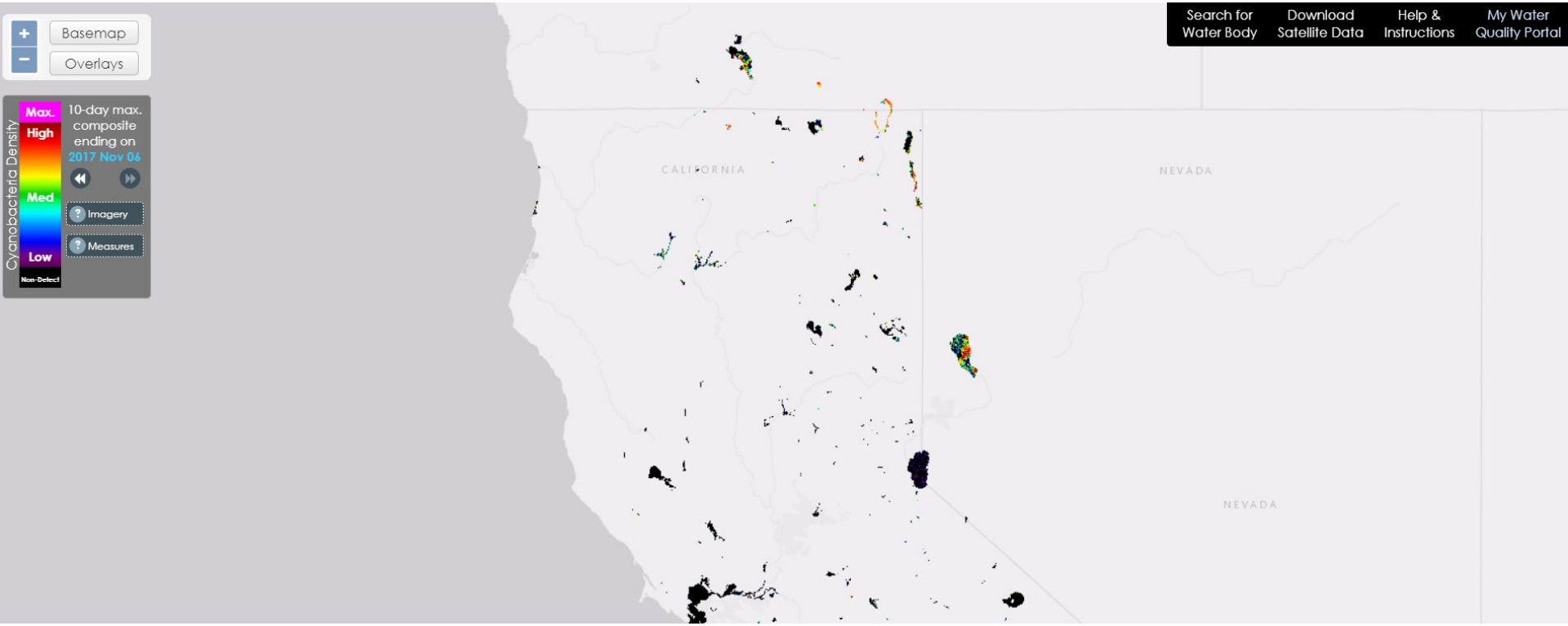
Cyano Index (CI) - Quantify bloom



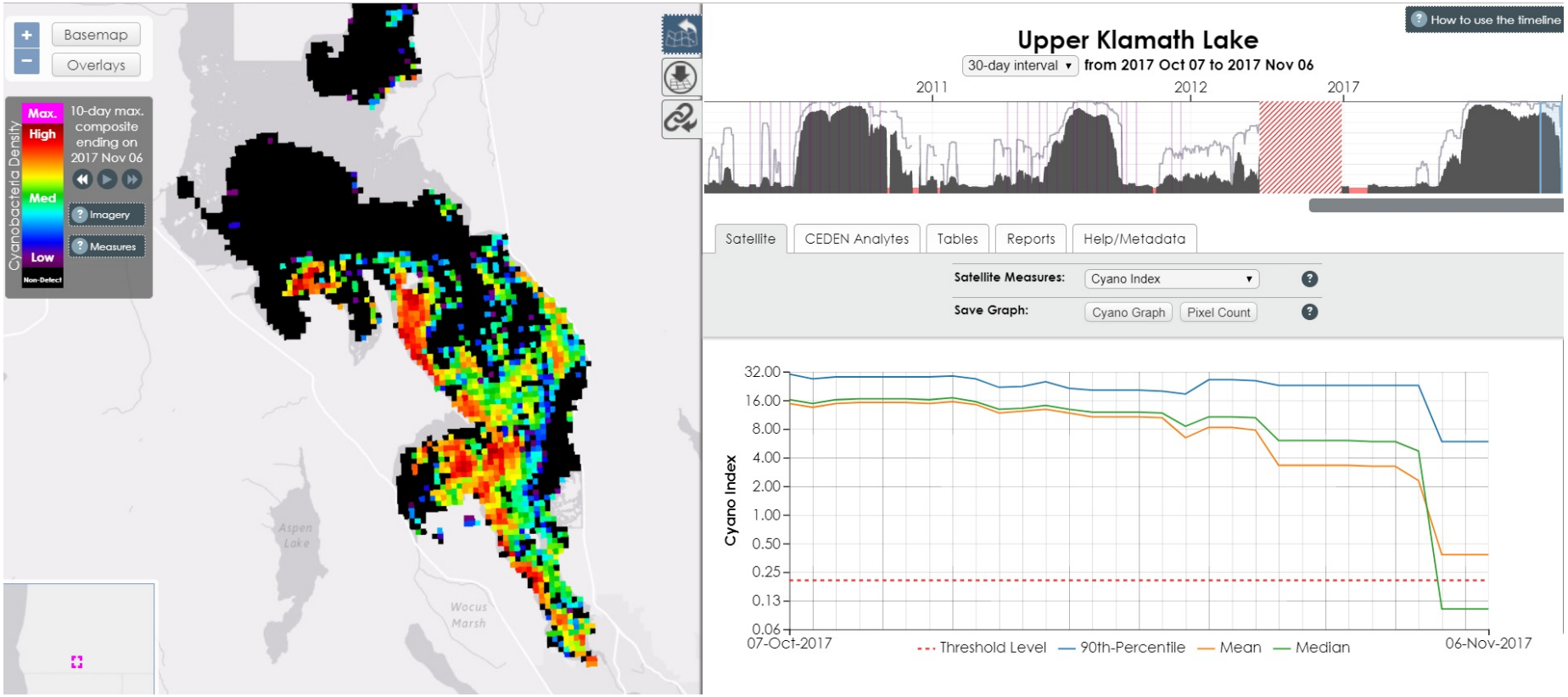
Color	Cyano Index (C.I.) x10,000	Comments
	>309	*Maximum Detectable Level*
	309	
	200	
	129	
	83	
	54	
	35	
	22	
	14	
	10	*'High' Estimated Abundance Threshold*
	6.5	
	4.2	
	2.7	
	2.0	*'Moderate' Estimated Abundance Threshold*
	1.3	
	1.0	
	≤1.0	*Background Level / Non-Detect*

CyanoHAB Satellite Imagery Analysis Tool

- Satellite Imagery Analysis Tool at cchab.sfei.org
- Soon to be on CA's HAB Portal
- All data are currently provisional

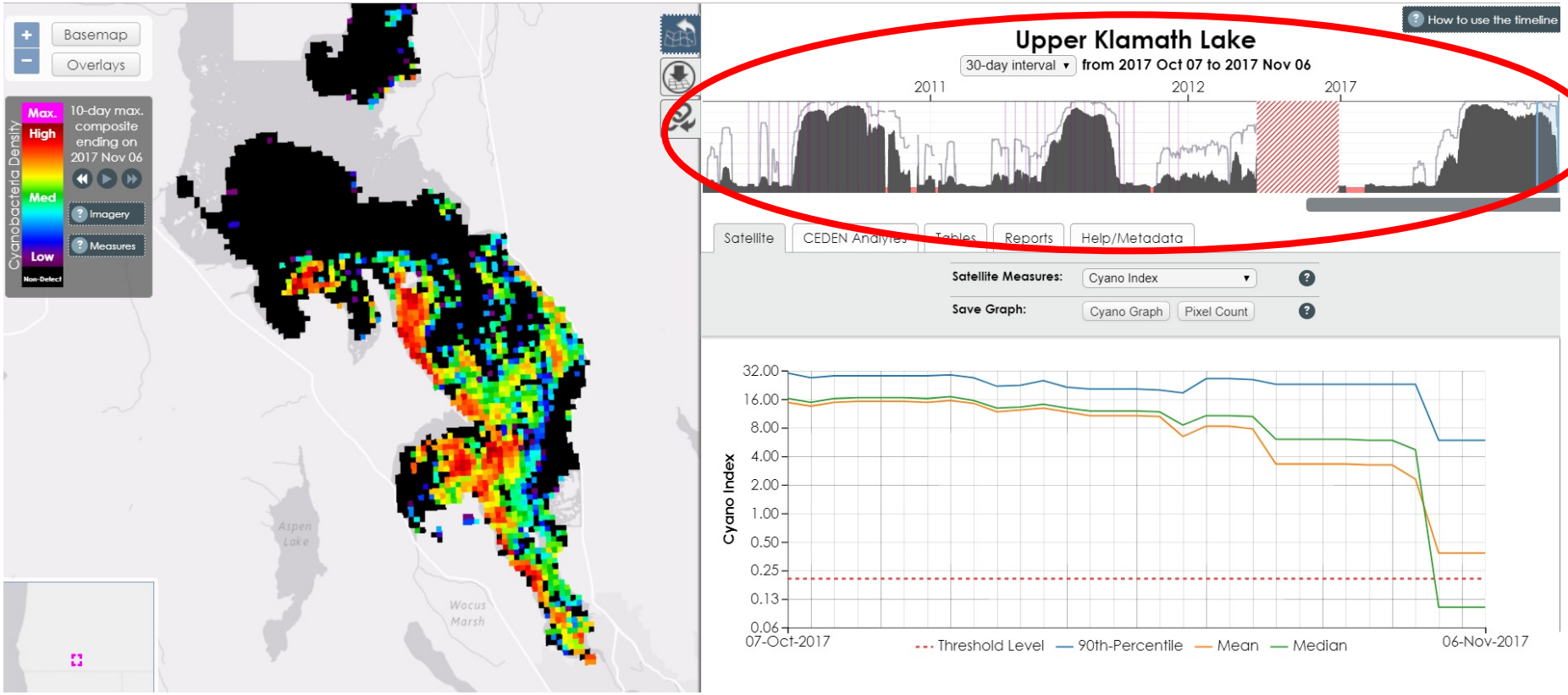


CyanoHAB Satellite Imagery Analysis Tool

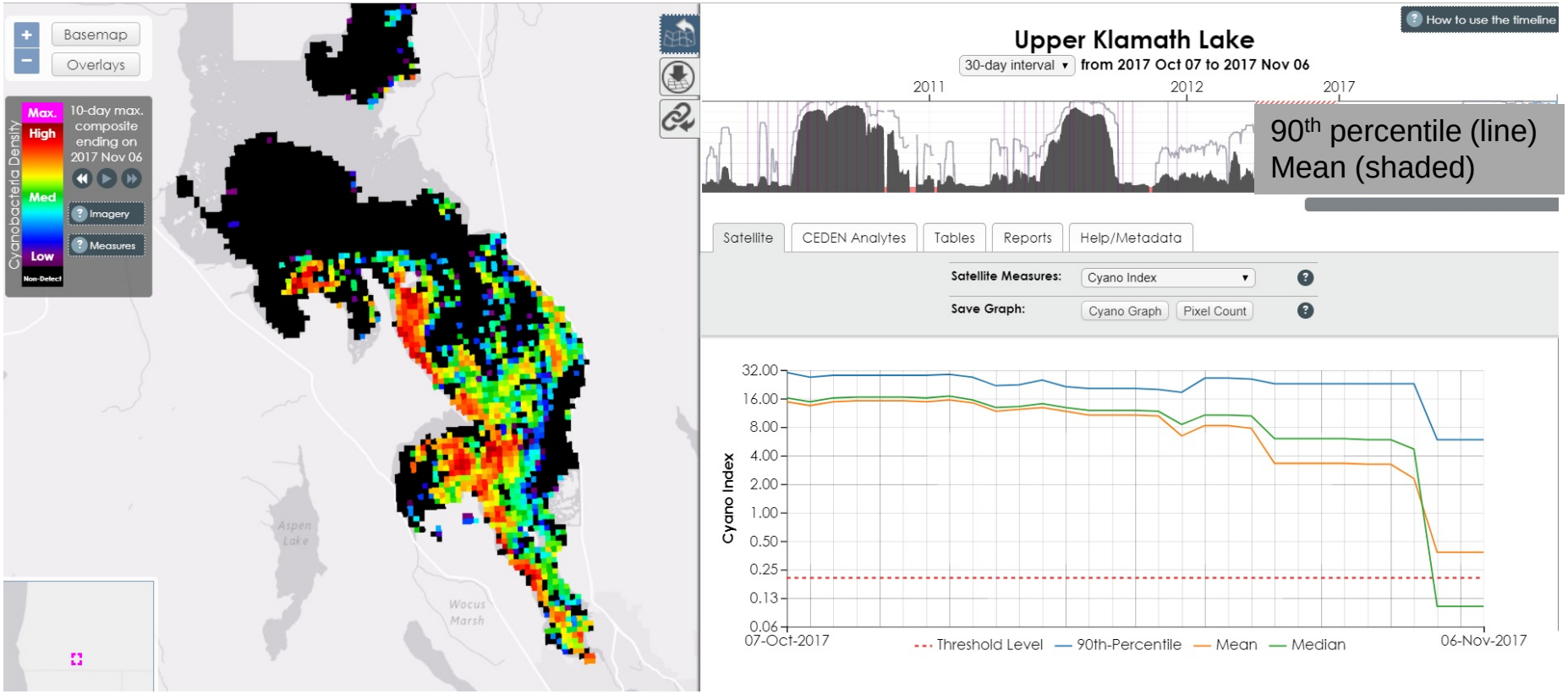


CyanoHAB Satellite Imagery Analysis Tool

Long Time Series

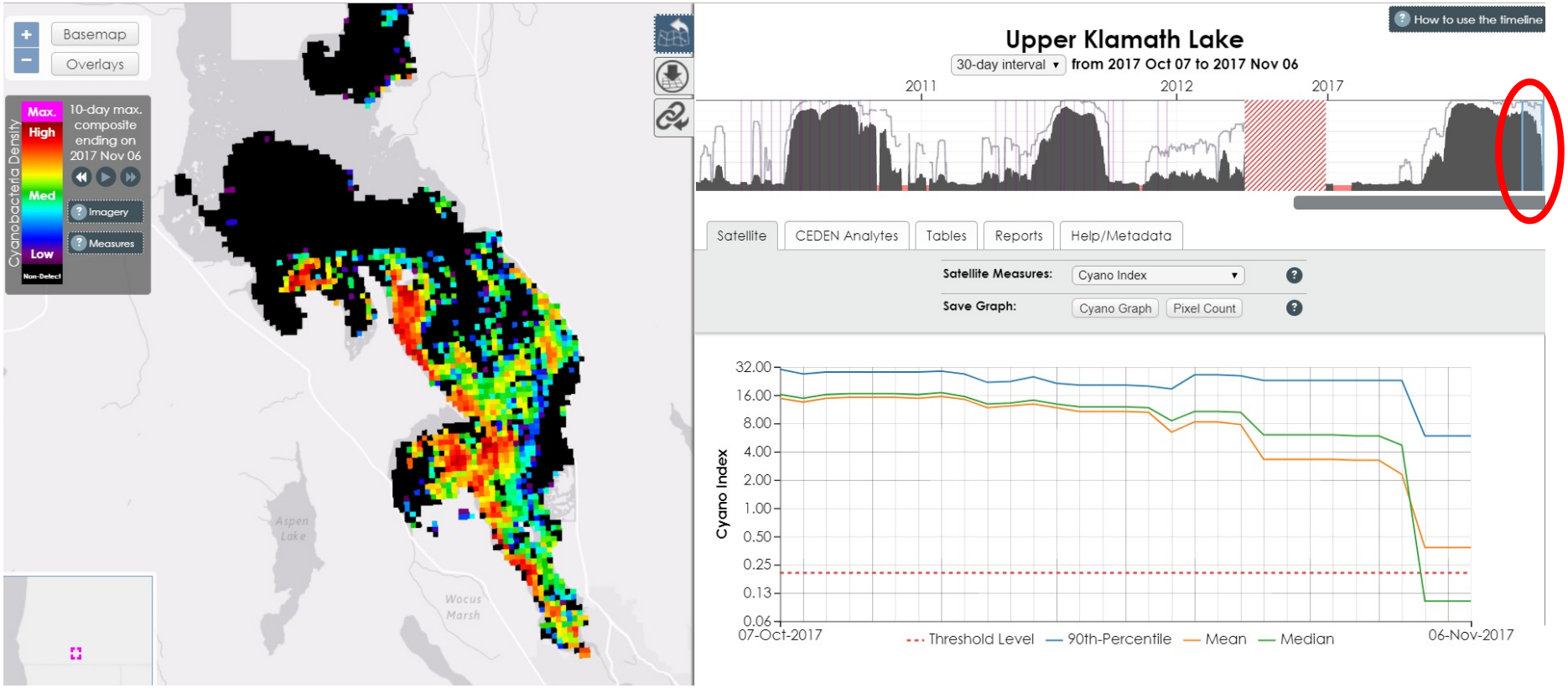


CyanoHAB Satellite Imagery Analysis Tool



CyanoHAB Satellite Imagery Analysis Tool

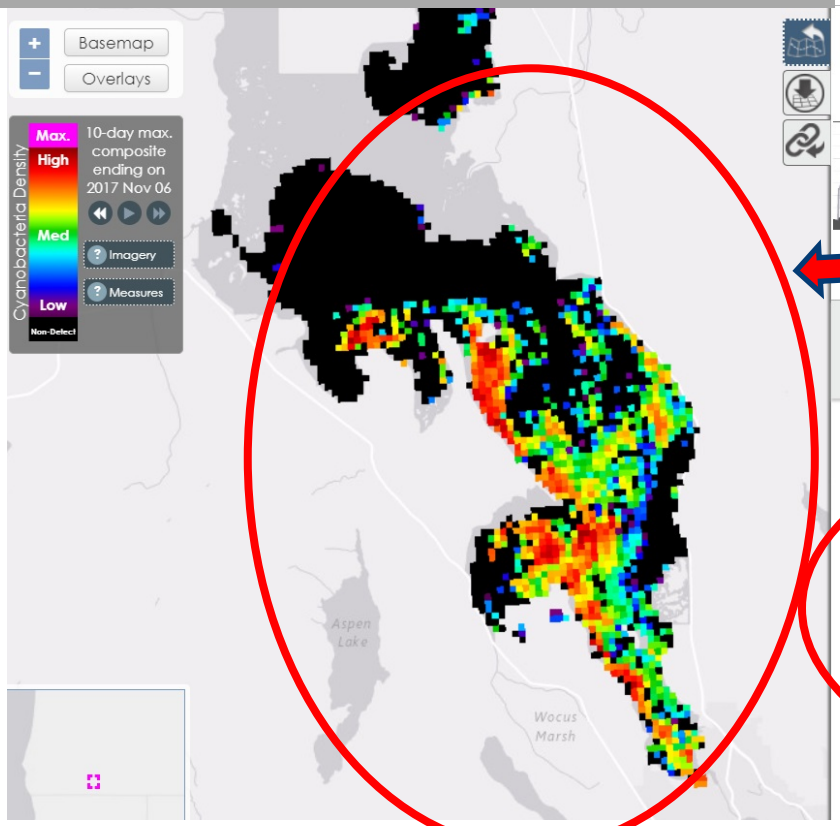
Movable timeline 'window'

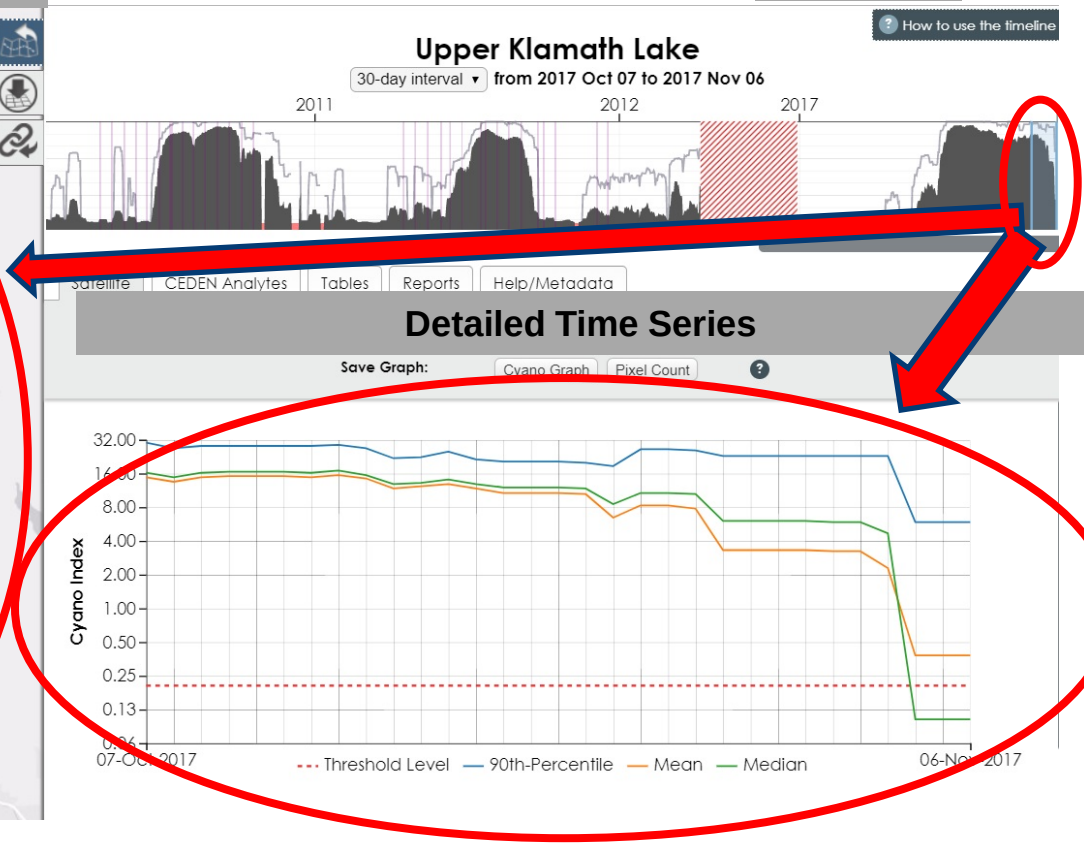


CyanoHAB Satellite Imagery Analysis Tool

Spatial Data

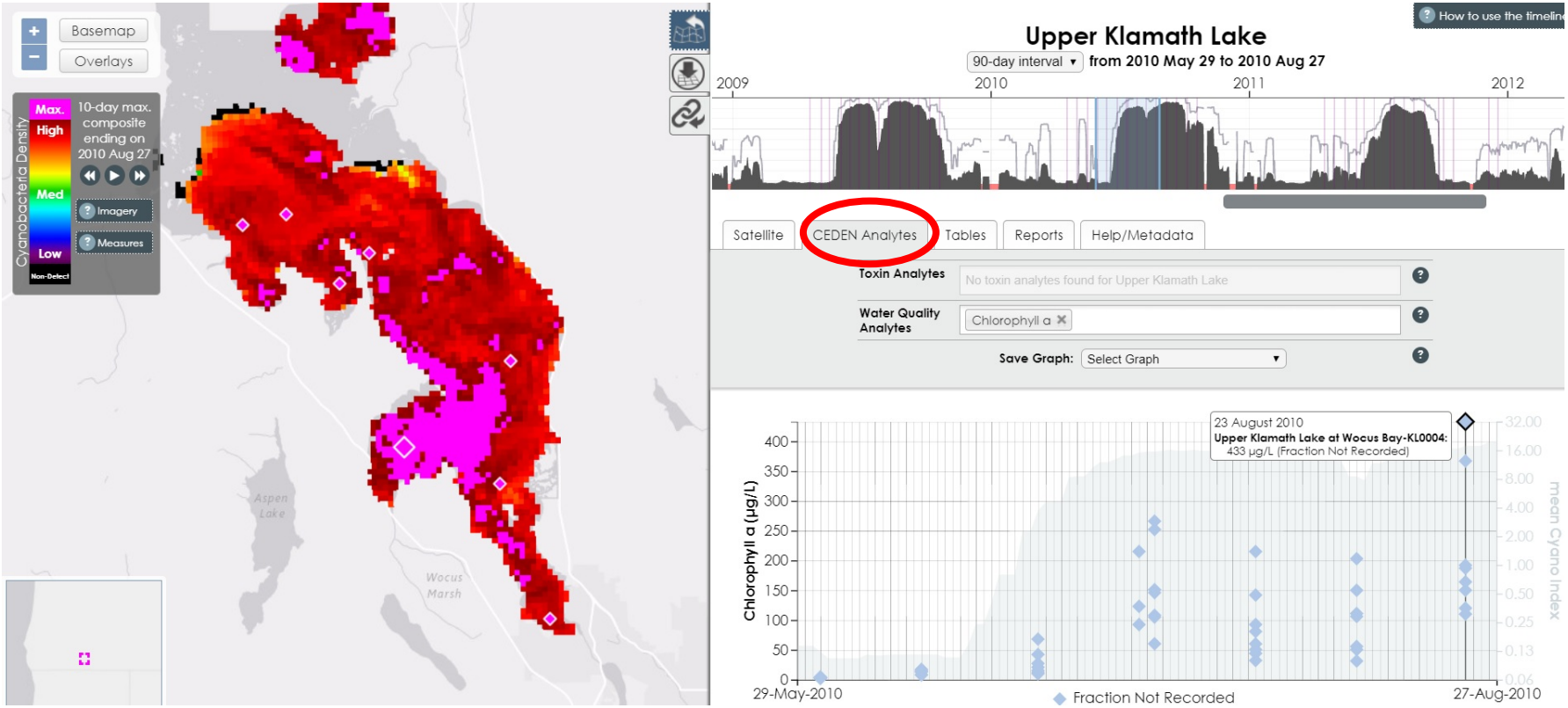
Movable timeline 'window'





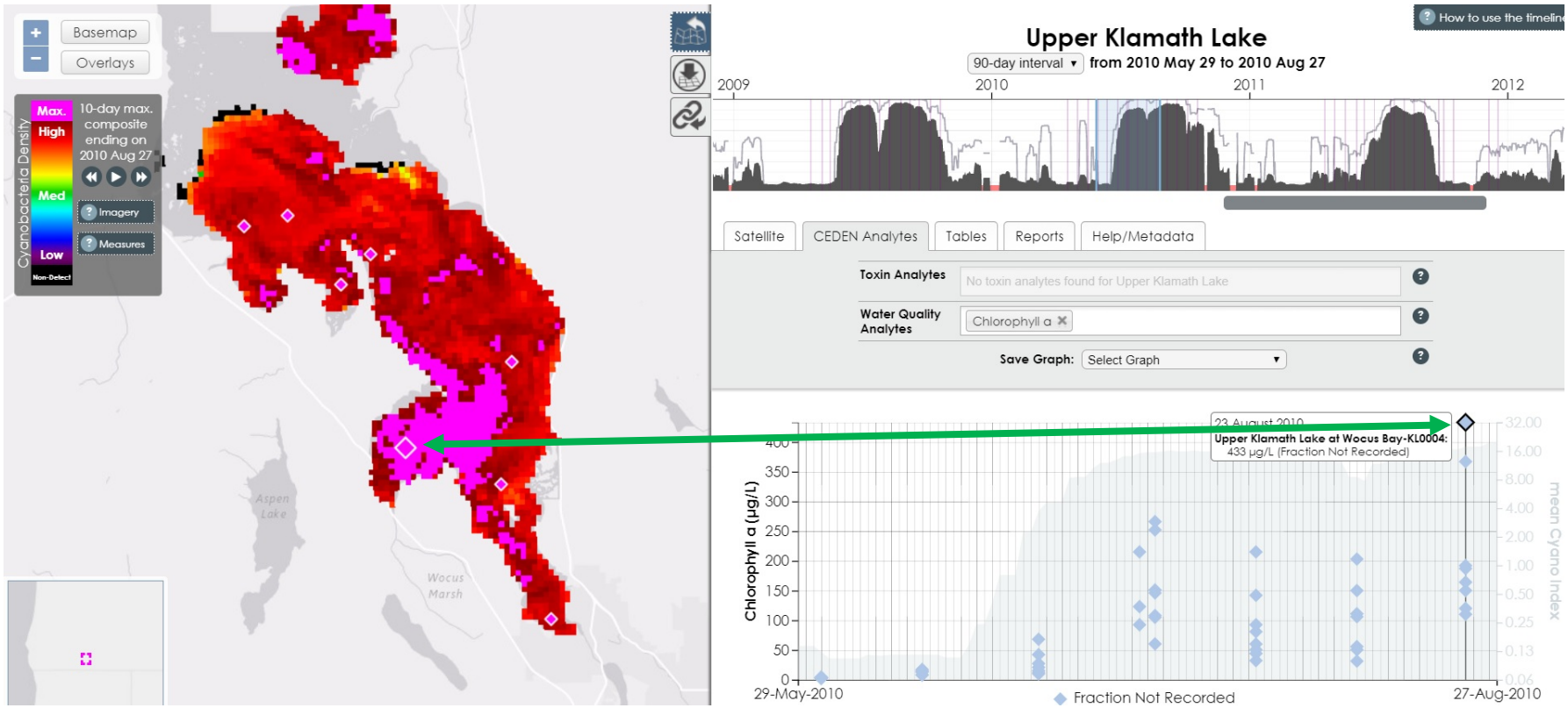
CyanoHAB Satellite Imagery Analysis Tool

- Compare to WQ and HAB data in CEDEN



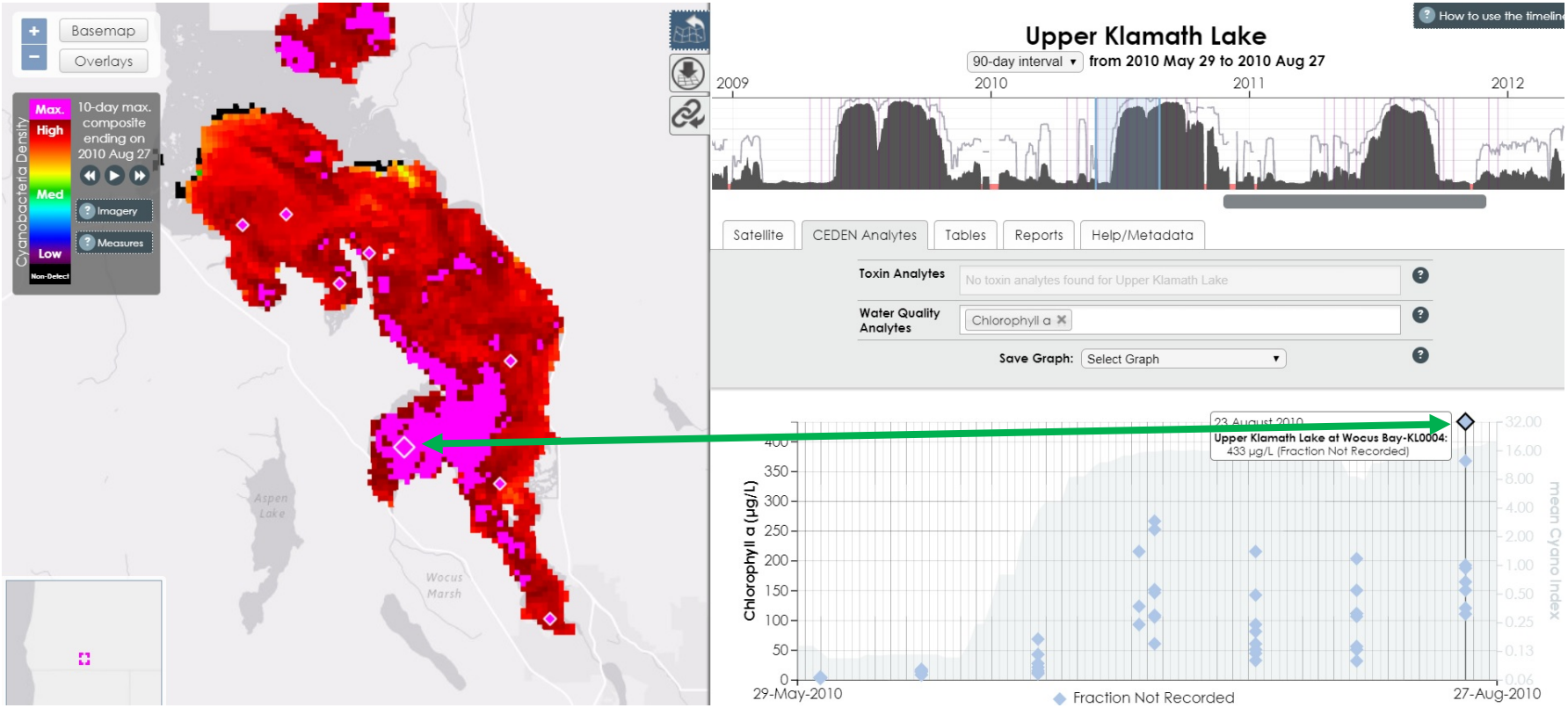
CyanoHAB Satellite Imagery Analysis Tool

- Compare to WQ and HAB data in CEDEN



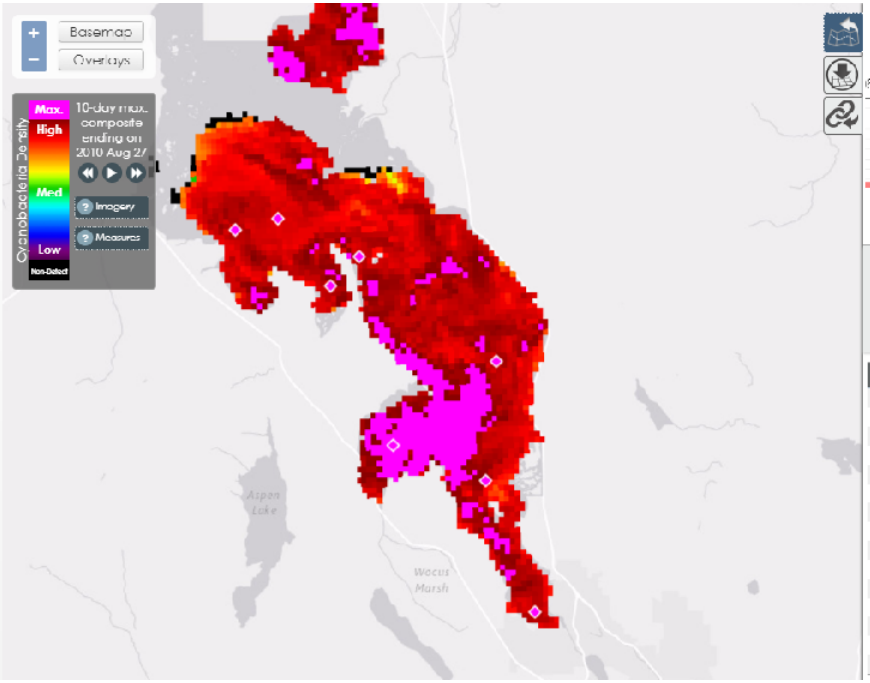
CyanoHAB Satellite Imagery Analysis Tool

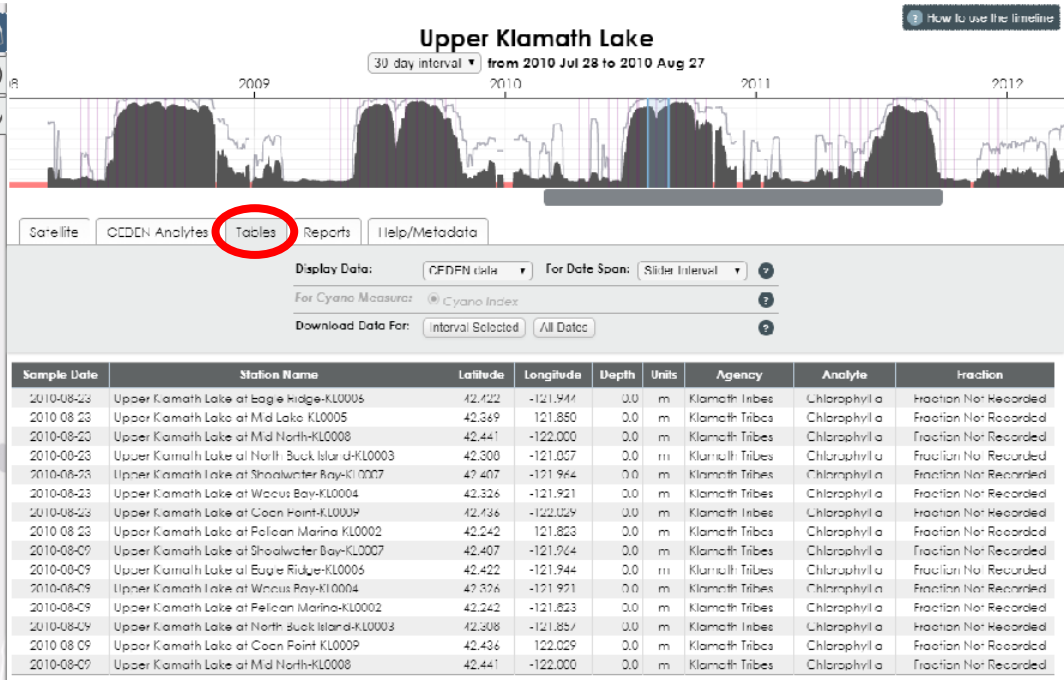
- Compare to WQ and HAB data in CEDEN
- If you have data, please upload to CEDEN!



CyanoHAB Satellite Imagery Analysis Tool

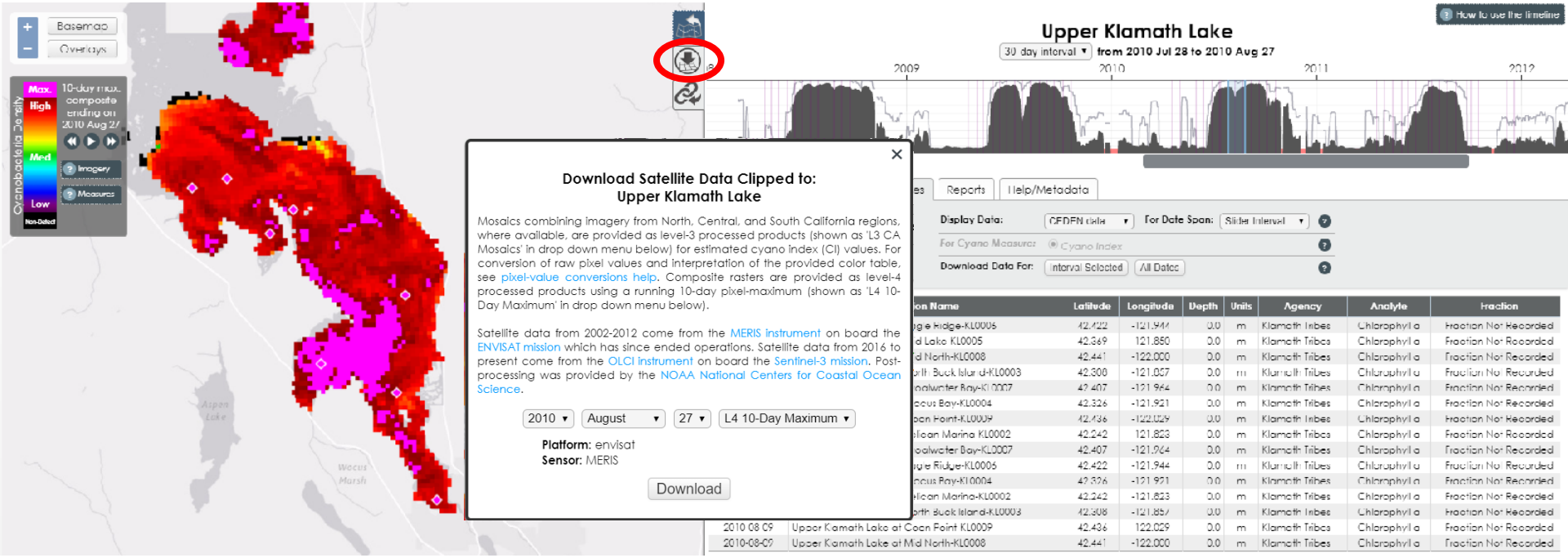
- Download tabular data from satellite or CEDEN





CyanoHAB Satellite Imagery Analysis Tool

- Download tabular data from satellite or CEDEN
- Download spatial data from satellite



Satellite Data

- 11+ years of spatial data for 255 waterbodies
  - ~150 w good data availability
- Waterbody-wide statistics and rasters available on tool
- GIS files can be requested
- Valuable dataset for:
  - Resource Agencies
  - Water Managers
  - Researchers
  - NGOs

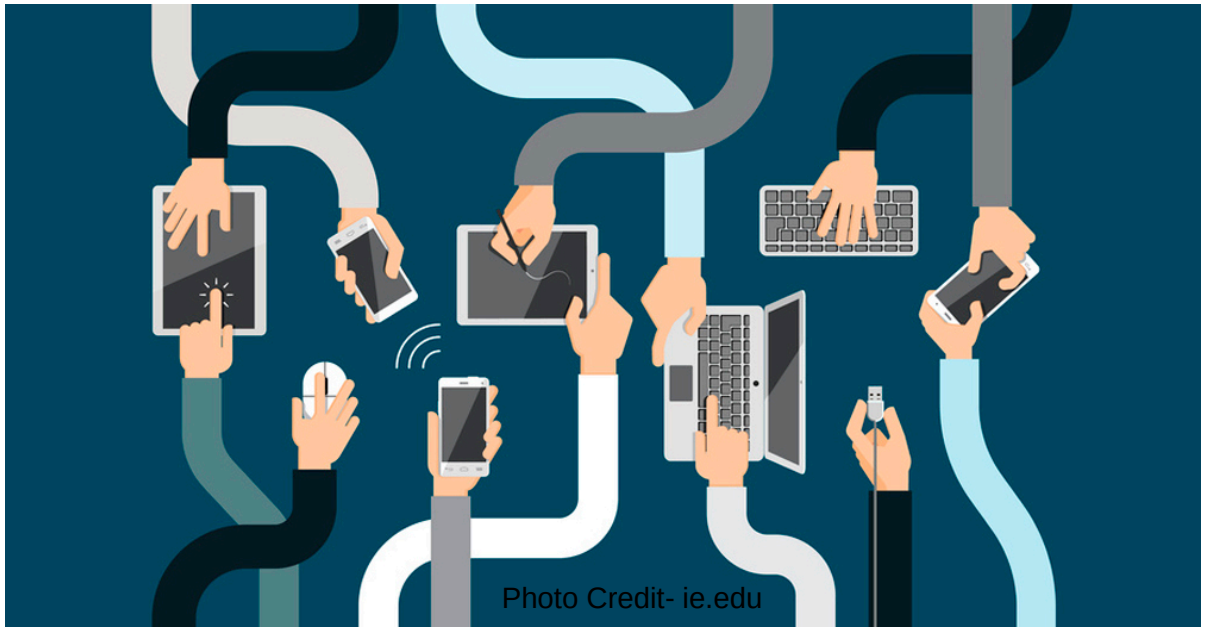


Photo Credit- ie.edu

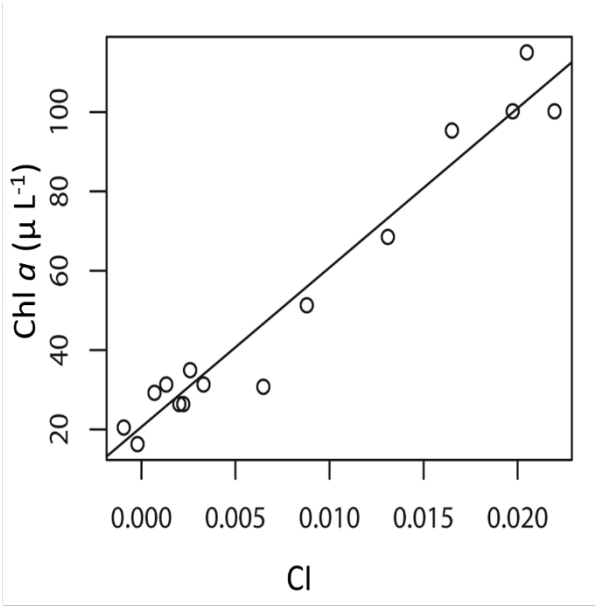
Potential Uses of Satellite Data

- **Screening tool to guide public health monitoring**
- TMDL compliance
- Linkages to nutrients and biostimulatory conditions
- FERC relicensing
- Drinking water intakes/treatment
- Impacts from fire and landscape change
- Fish tracking/fish kills
- Nutrient and algae monitoring
- Bloom control efforts
- Climate change impacts

Next Steps

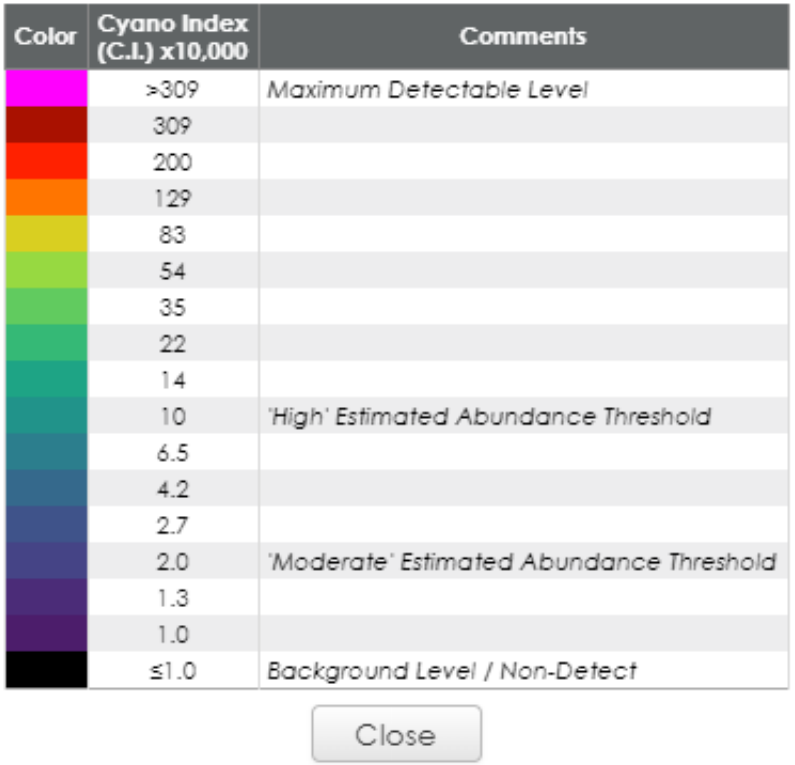
- Pursue collaborations in federal CyAN project
  - Expand tool to support other regions

- Satellite field verifications in 2018
  - Collect data in field at time of satellite flyover
  - Assess general accuracy of satellite data and algorithms
  - Evaluate potential false positives and interference



Next Steps: In-Progress Tool Improvements

- Text/Instructions
  - Refine and simplify language in tool and notification emails
- Visualizations
  - Convert to CyAN-preferred color palette
  - Add color-blind palette option
  - Incorporate WHO thresholds
- Data Updates
  - Incorporate NOAA revisions for historic data (2002-2012)



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	≤1.0	*Background Level / Non-Detect*

Next Steps: Future Tool Improvement

Expand/pursue:

- Statistical analysis
- Visualizations
- Query capabilities
- Secured user functionality

Questions?

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