

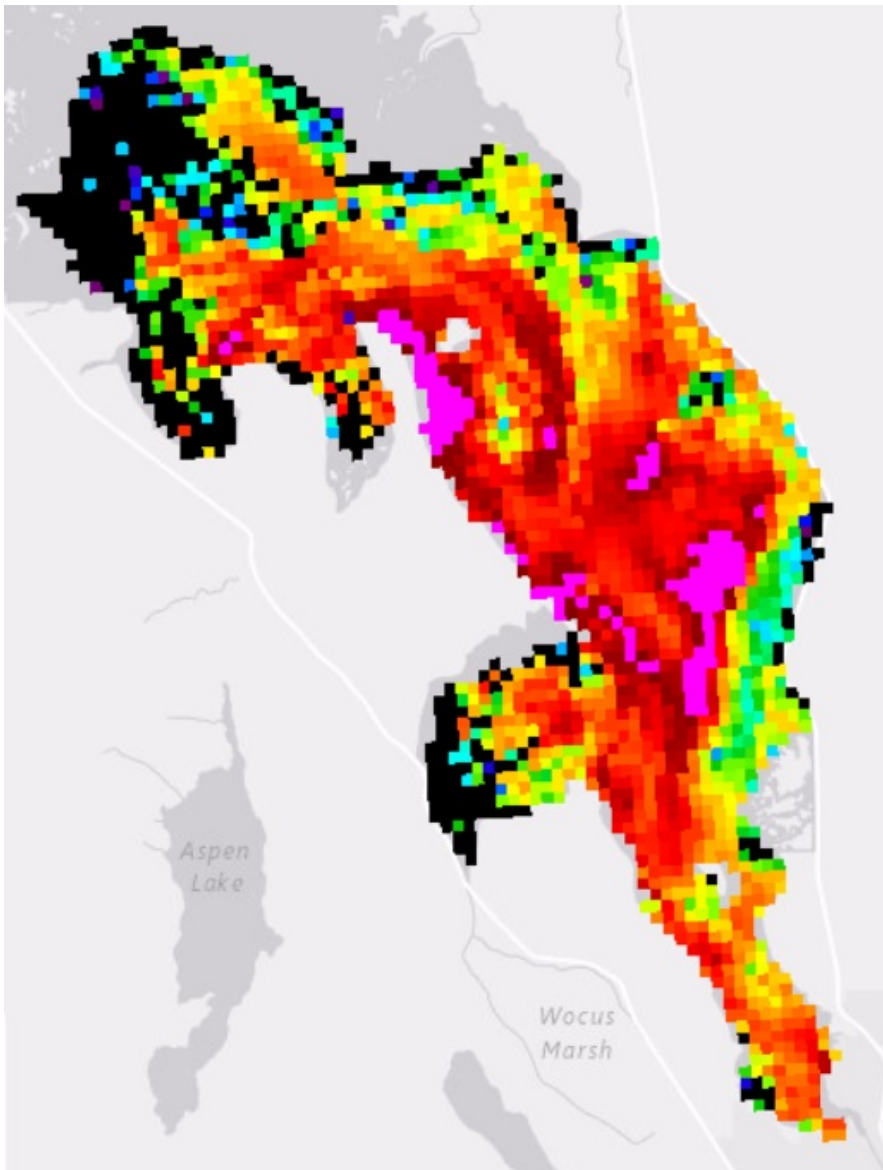
Remote Sensing of Cyanobacteria Blooms: Next Steps in Utilizing Satellite Imagery

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2018 Water Boards
Science Symposium

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SAN FRANCISCO ESTUARY INSTITUTE

REGION-WIDE SCIENCE FOR ECOSYSTEM MANAGEMENT

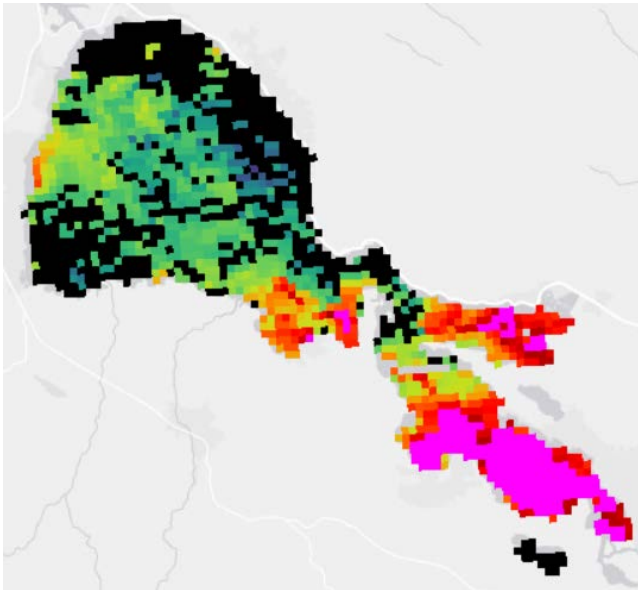
Background and Challenges



- 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

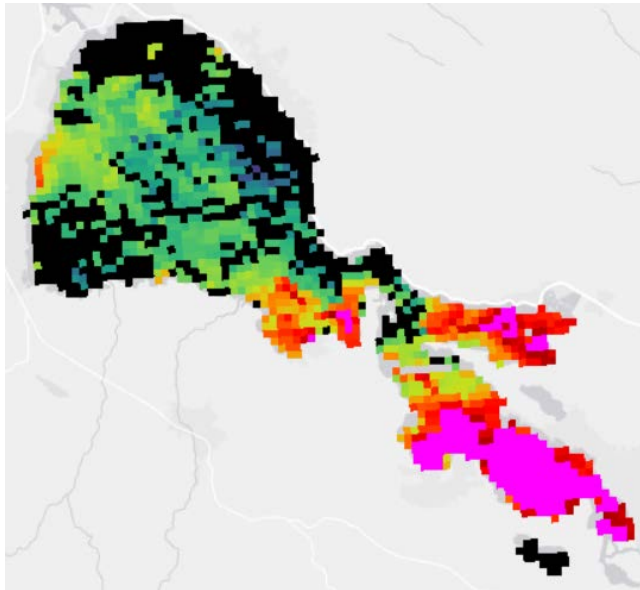
Satellite Project Goals

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



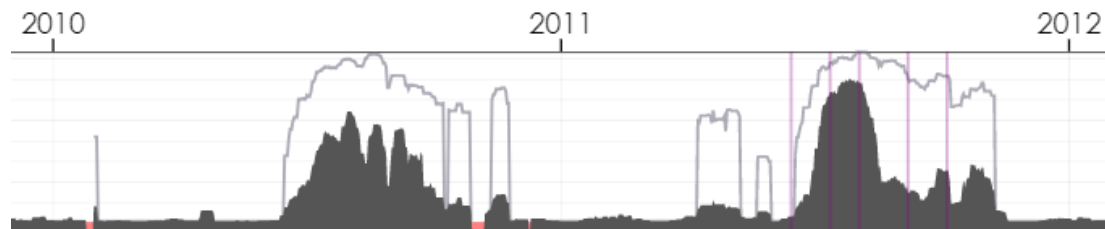
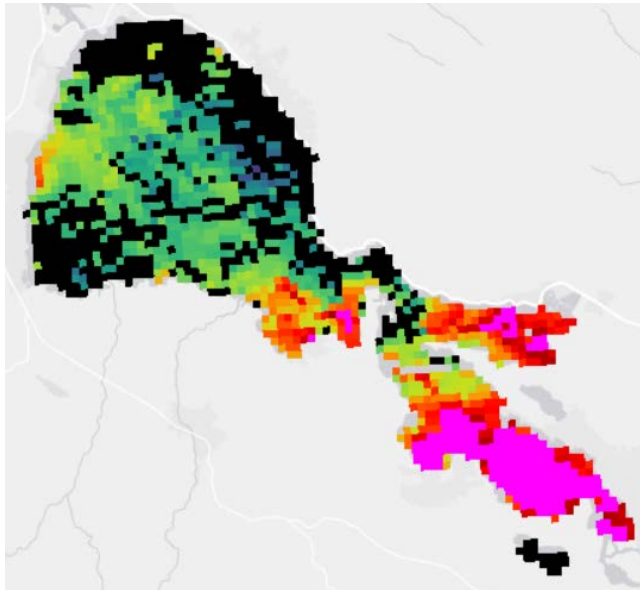
Satellite Project Goals

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



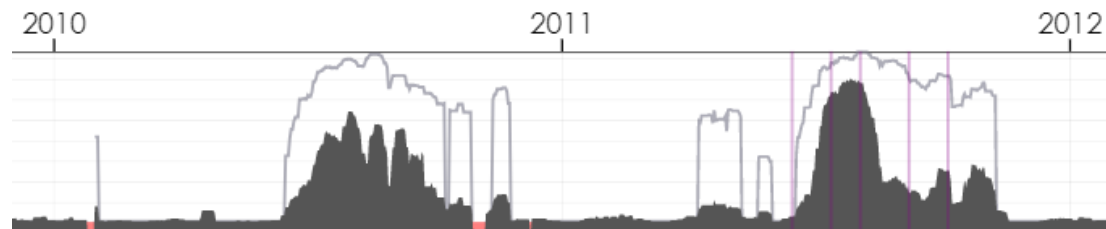
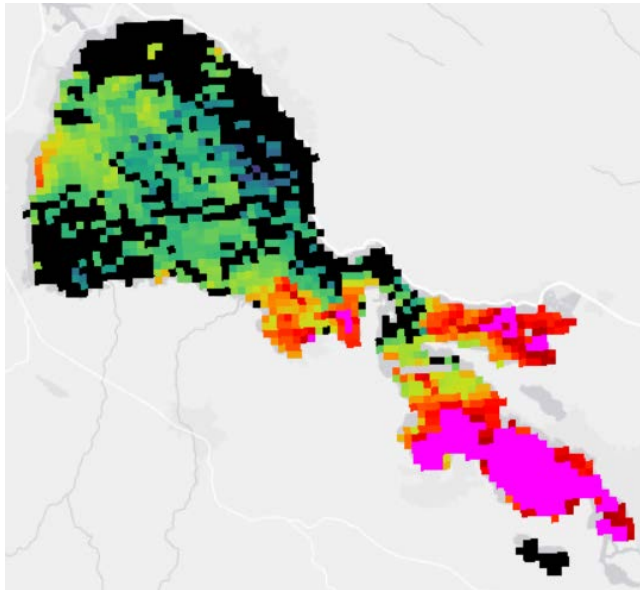
Satellite Project Goals

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



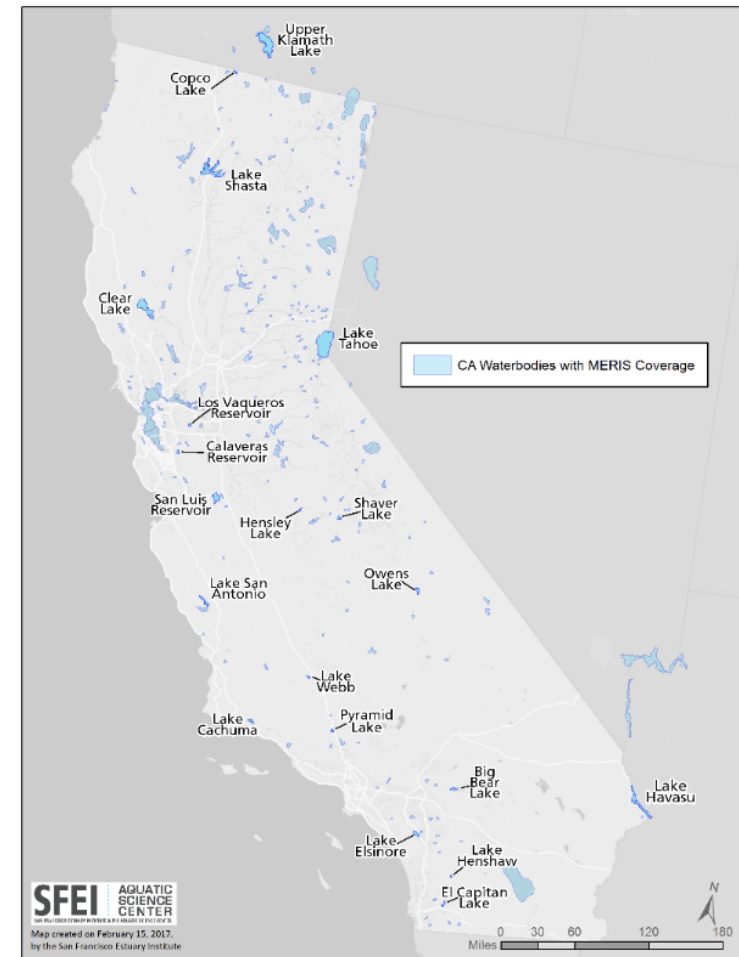
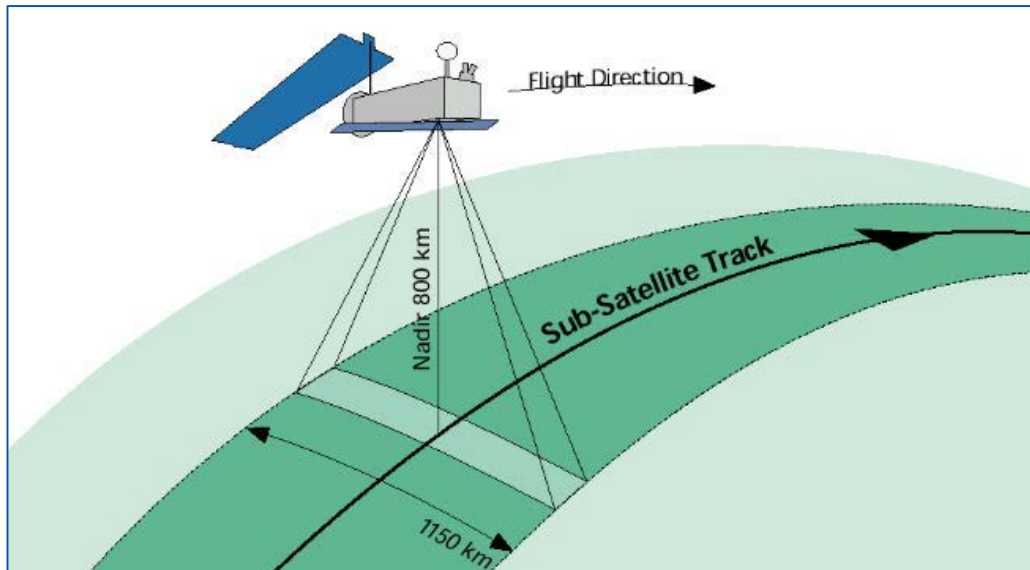
Satellite Project Goals

- 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



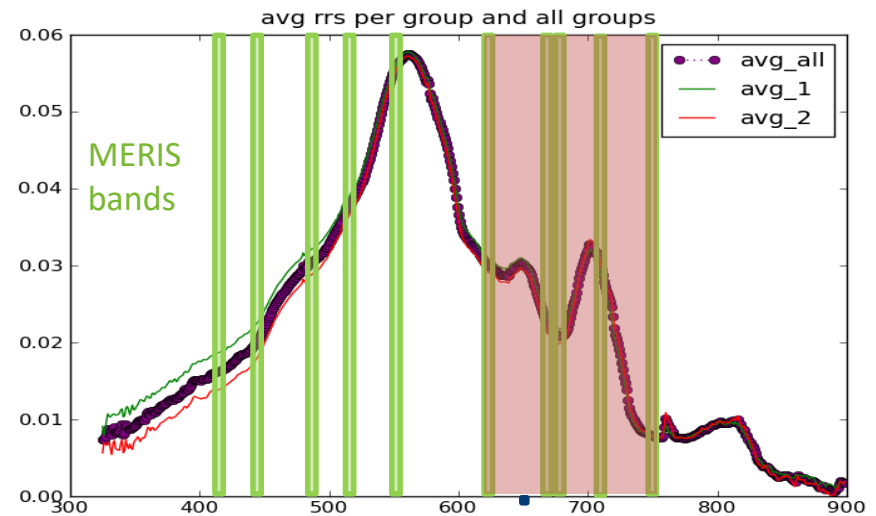
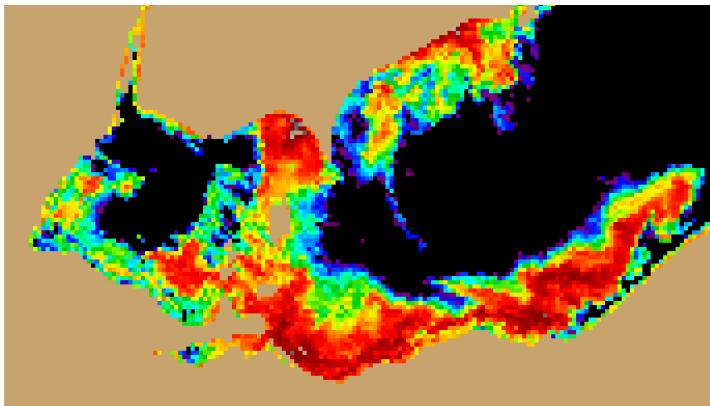
CA Surface Water Ambient Monitoring Program (SWAMP)

- 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



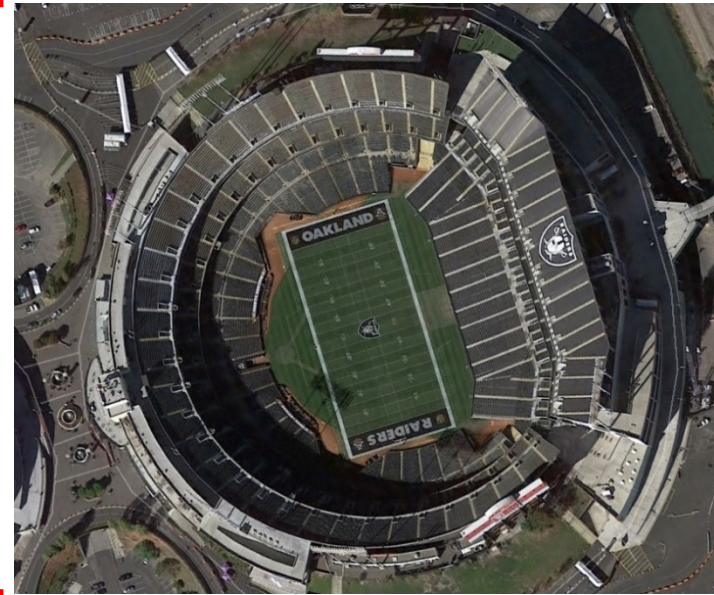
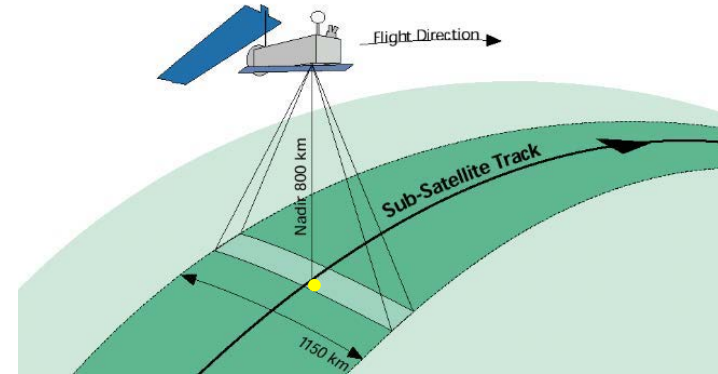
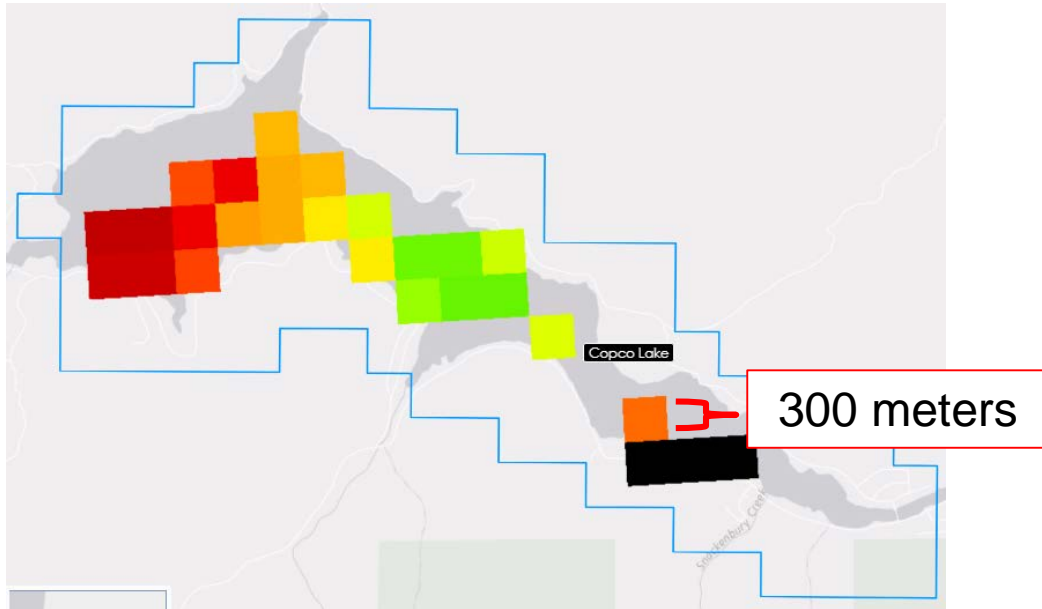
Satellite Imagery

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



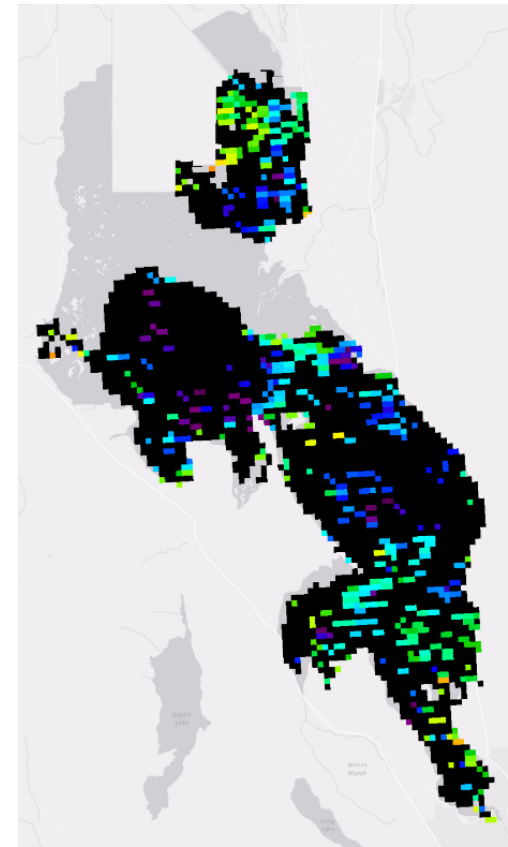
Pixels

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

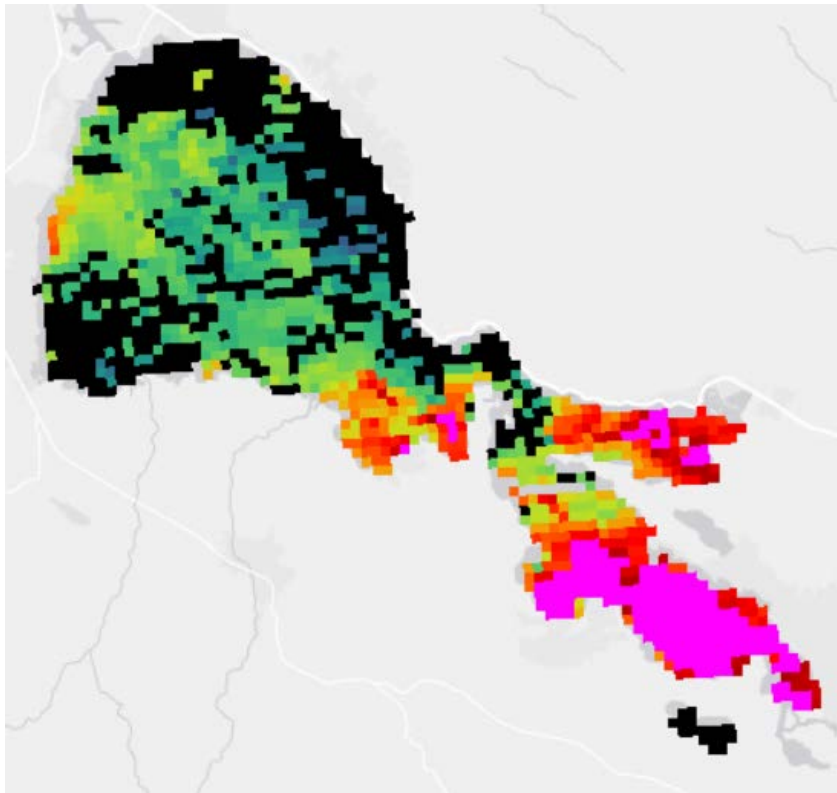


Satellites: Limitations

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



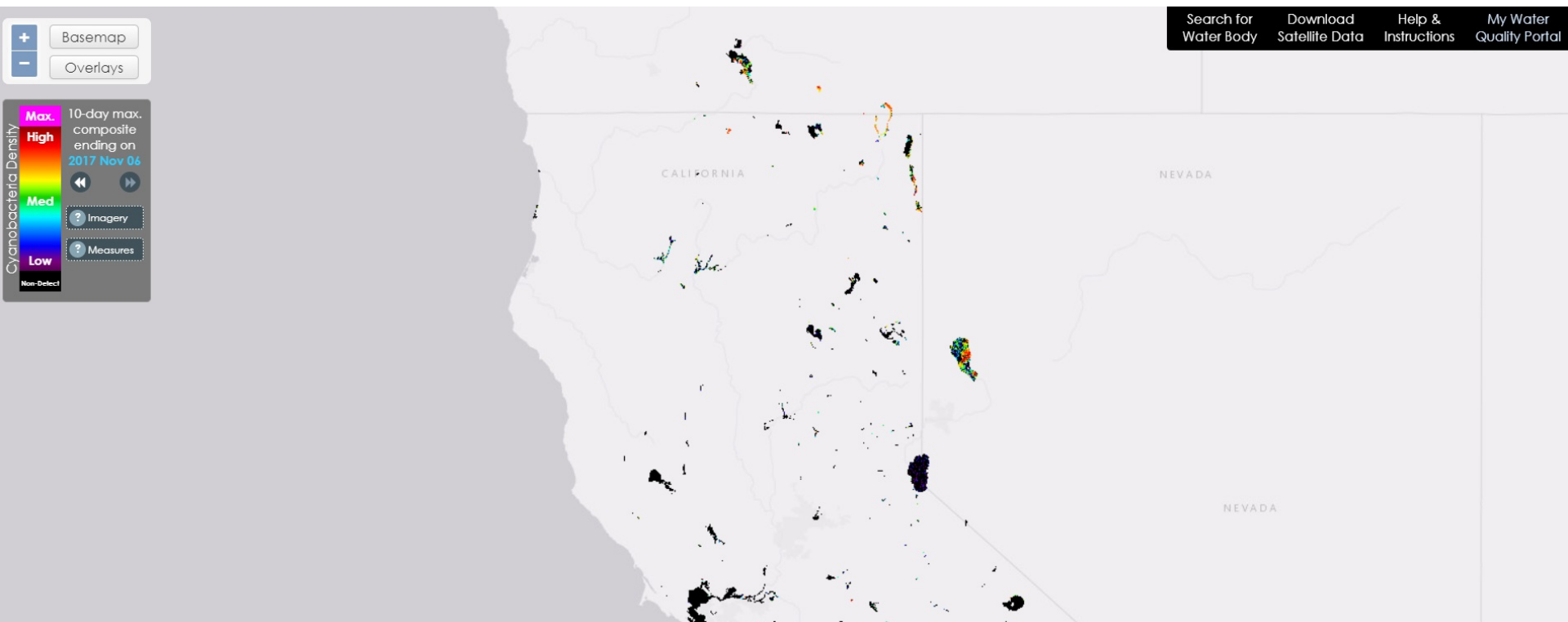
Cyano Index (CI) - Quantify bloom



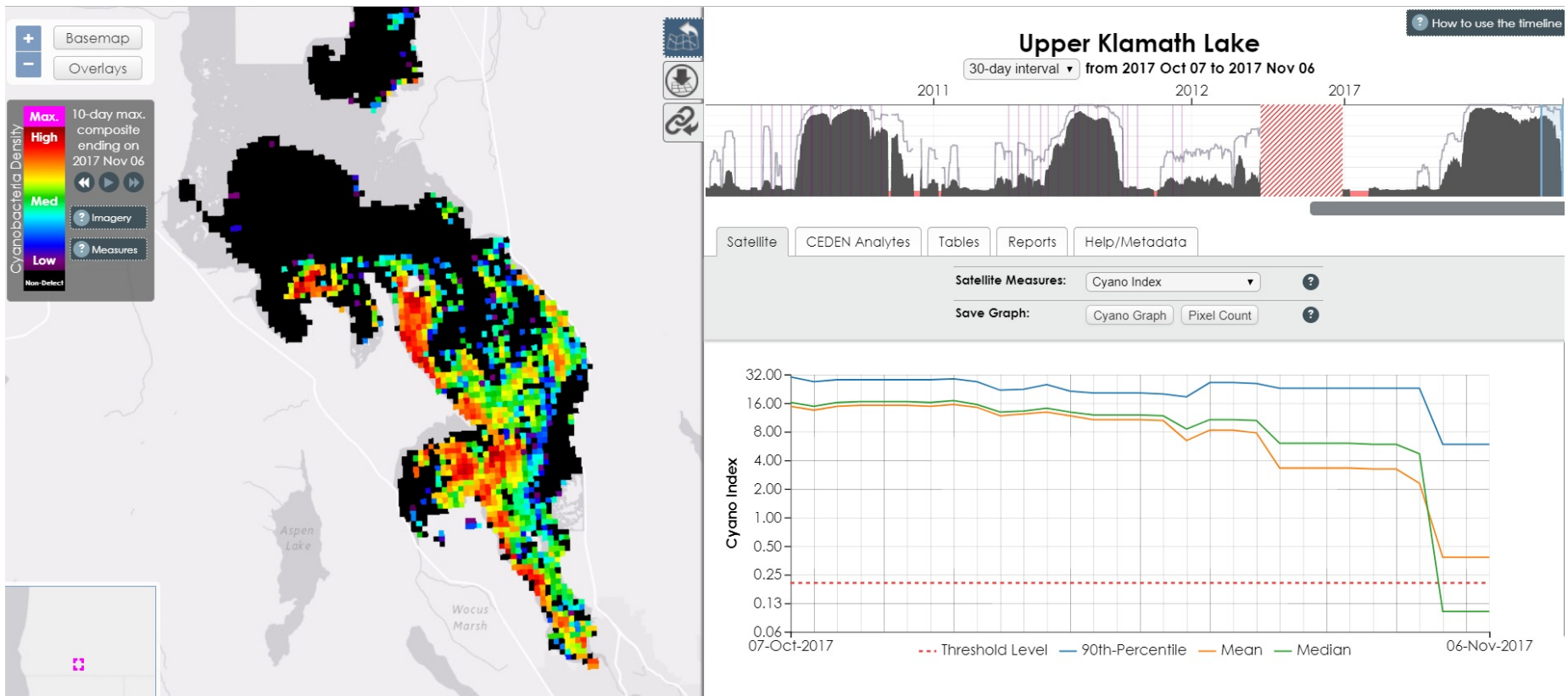
Color	Cyano Index (C.I.) x10,000	Comments
Magenta	>309	Maximum Detectable Level
Dark Red	309	
Red	200	
Orange	129	
Yellow	83	
Light Green	54	
Green	35	
Teal	22	
Dark Teal	14	
Blue-Teal	10	'High' Estimated Abundance Threshold
Dark Blue	6.5	
Medium Blue	4.2	
Dark Blue	2.7	
Very Dark Blue	2.0	'Moderate' Estimated Abundance Threshold
Dark Purple	1.3	
Black	1.0	
Black	≤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

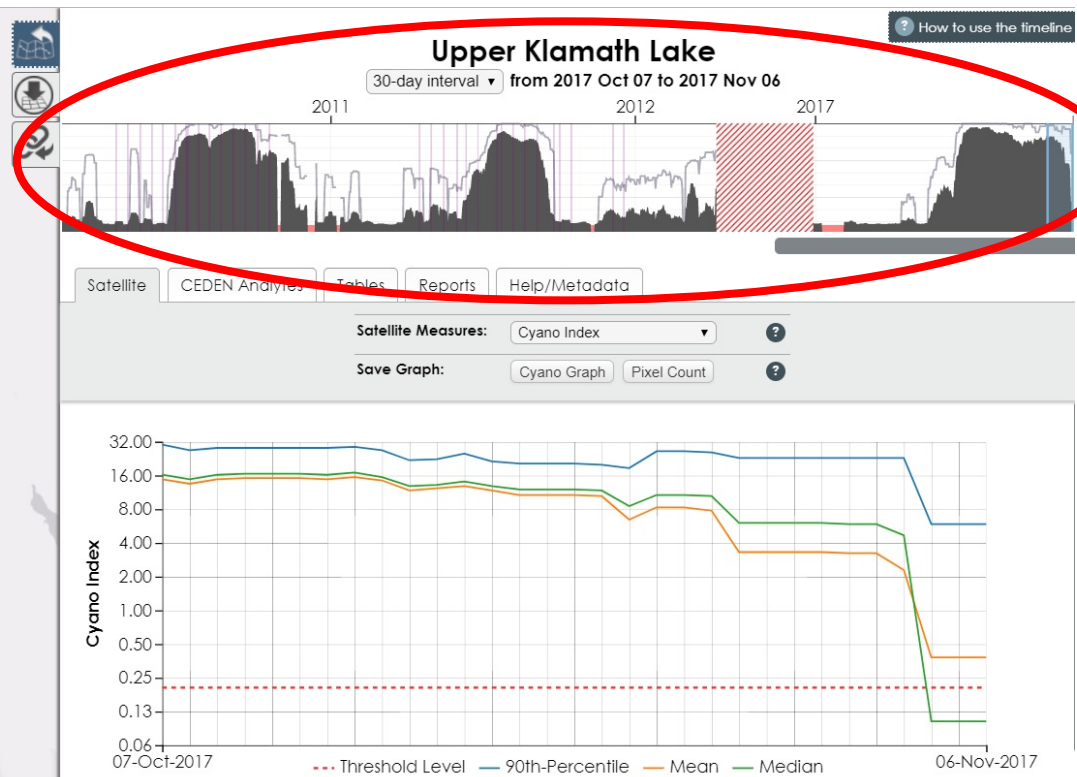
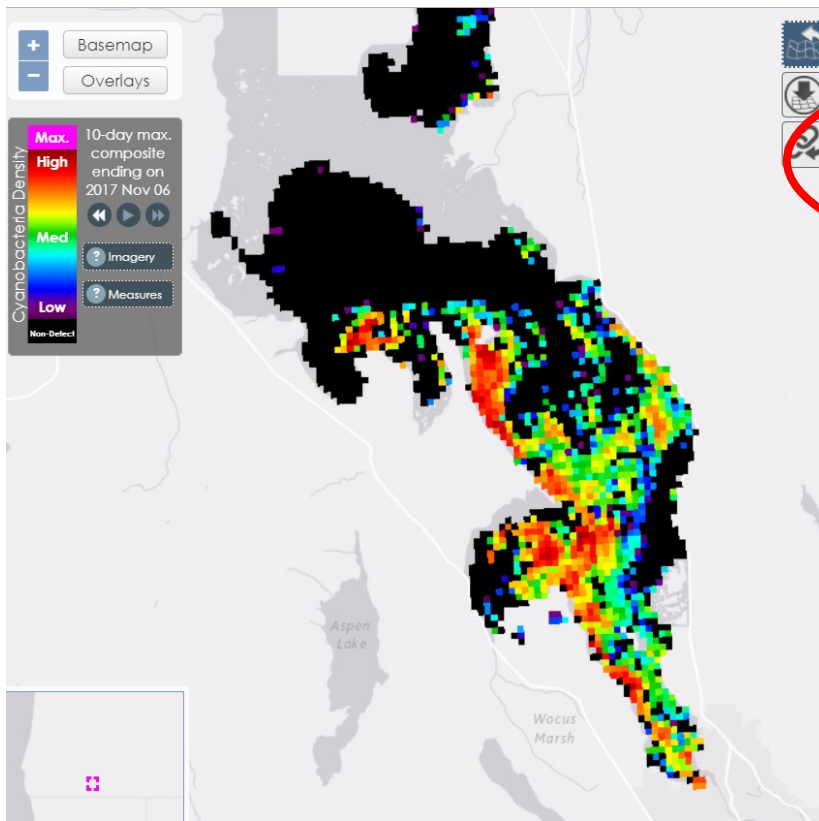


CyanoHAB Satellite Imagery Analysis Tool

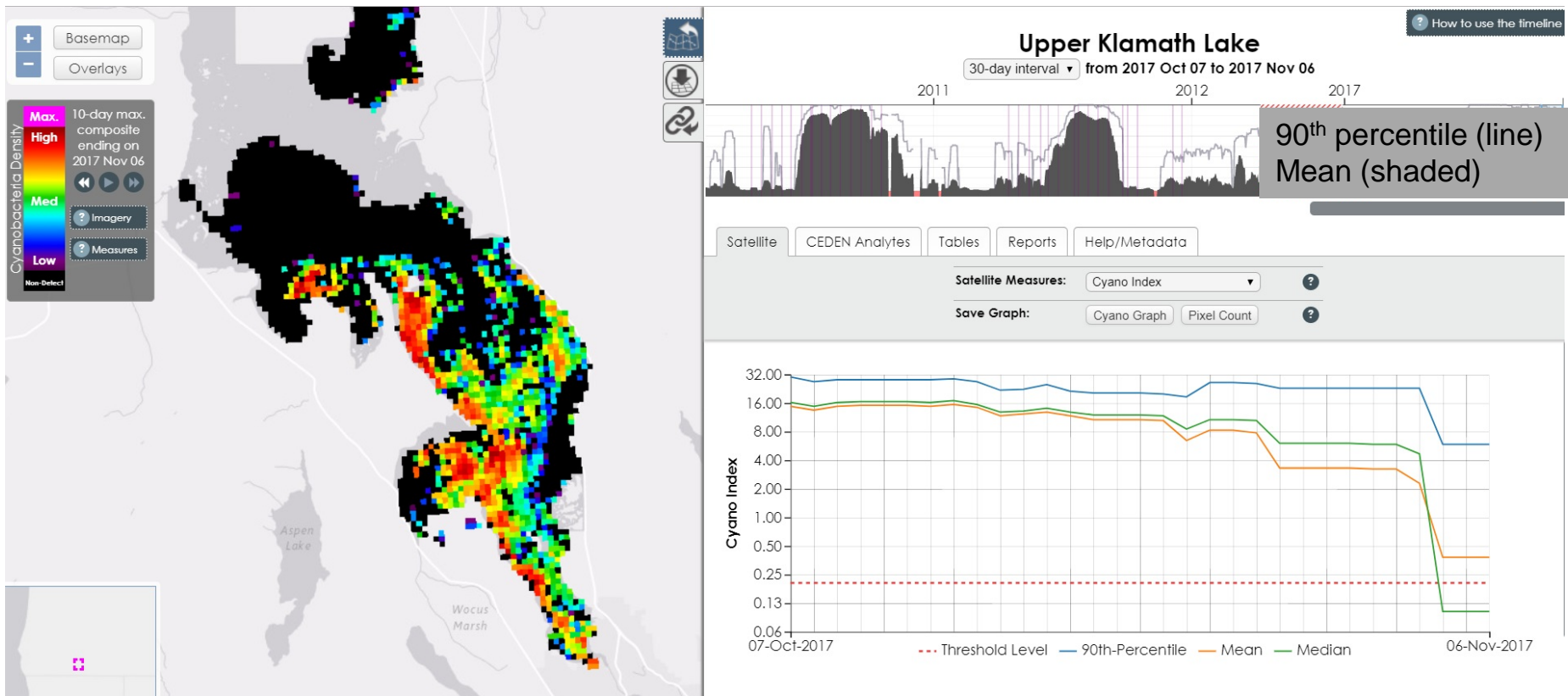


CyanoHAB Satellite Imagery Analysis Tool

Long Time Series

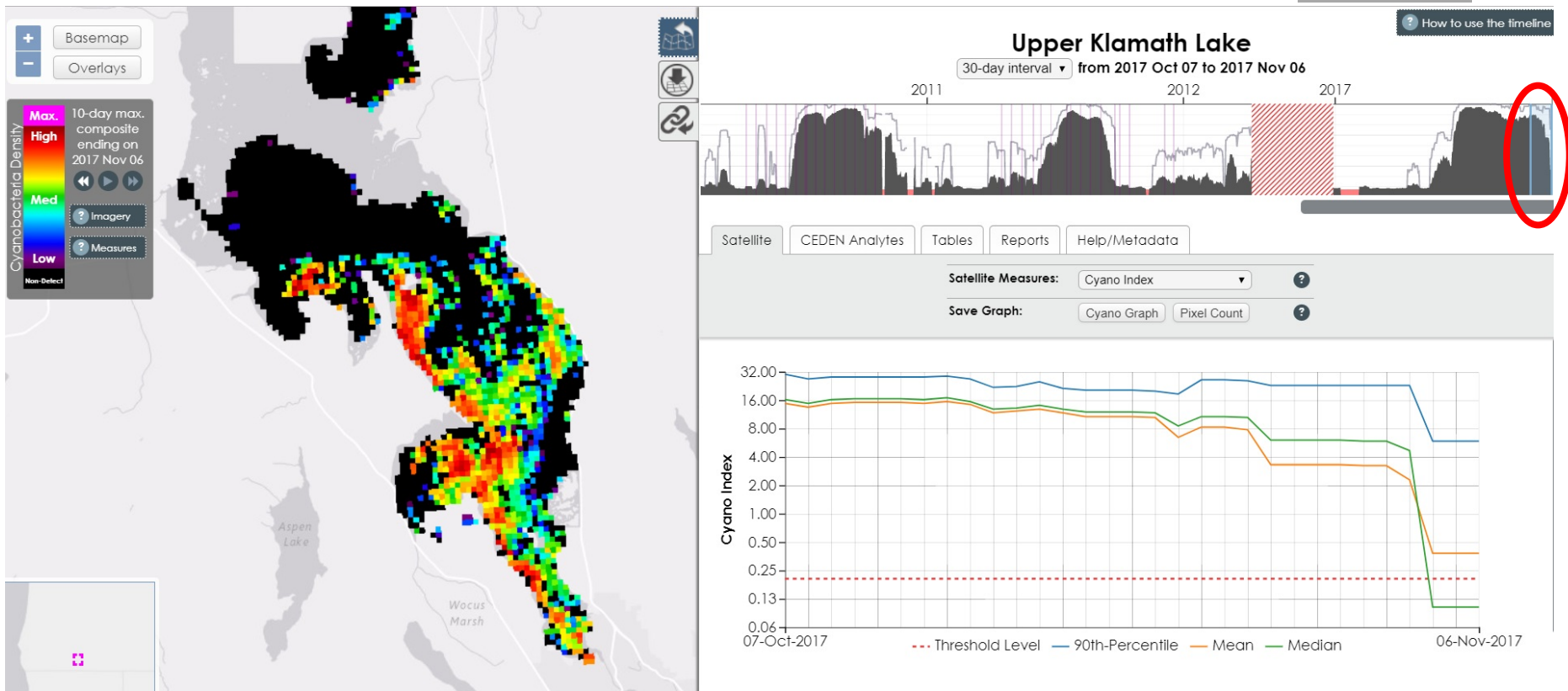


CyanoHAB Satellite Imagery Analysis Tool



CyanoHAB Satellite Imagery Analysis Tool

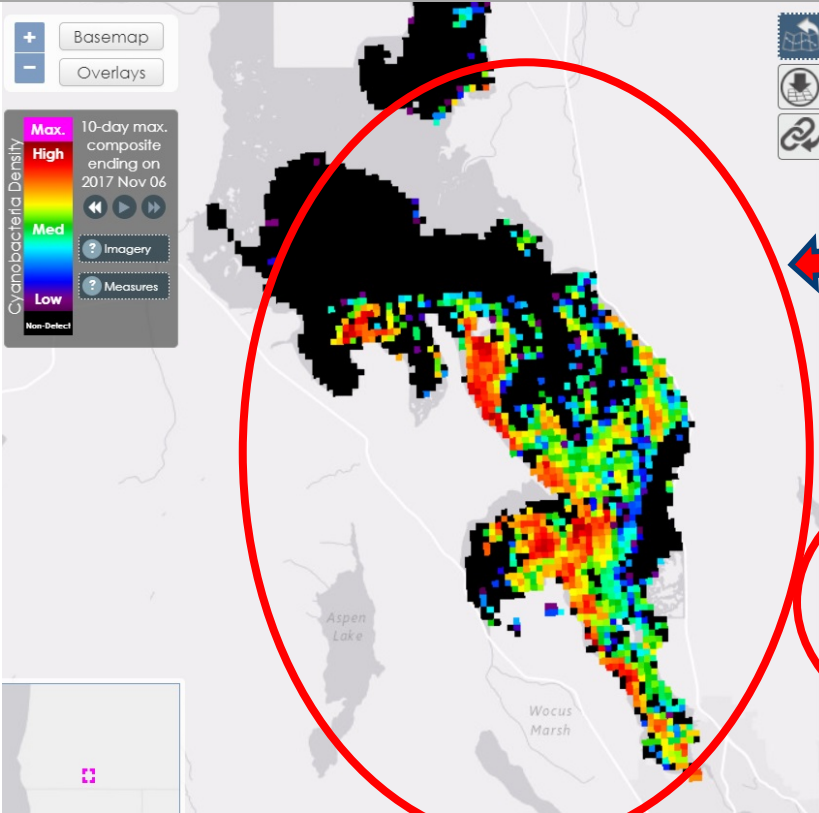
Movable
timeline
'window'



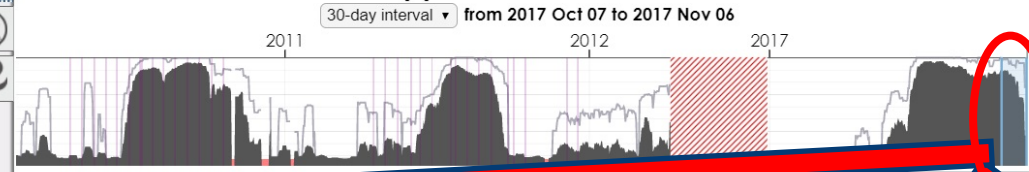
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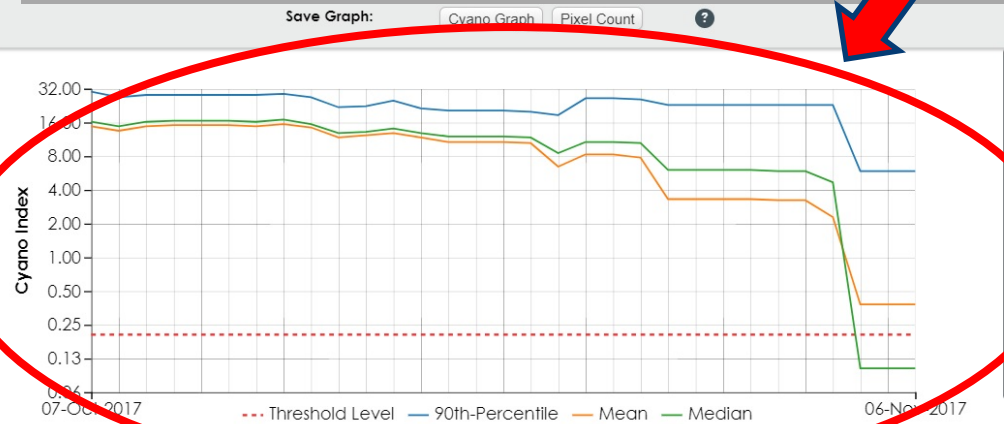
Spatial Data



Upper Klamath Lake

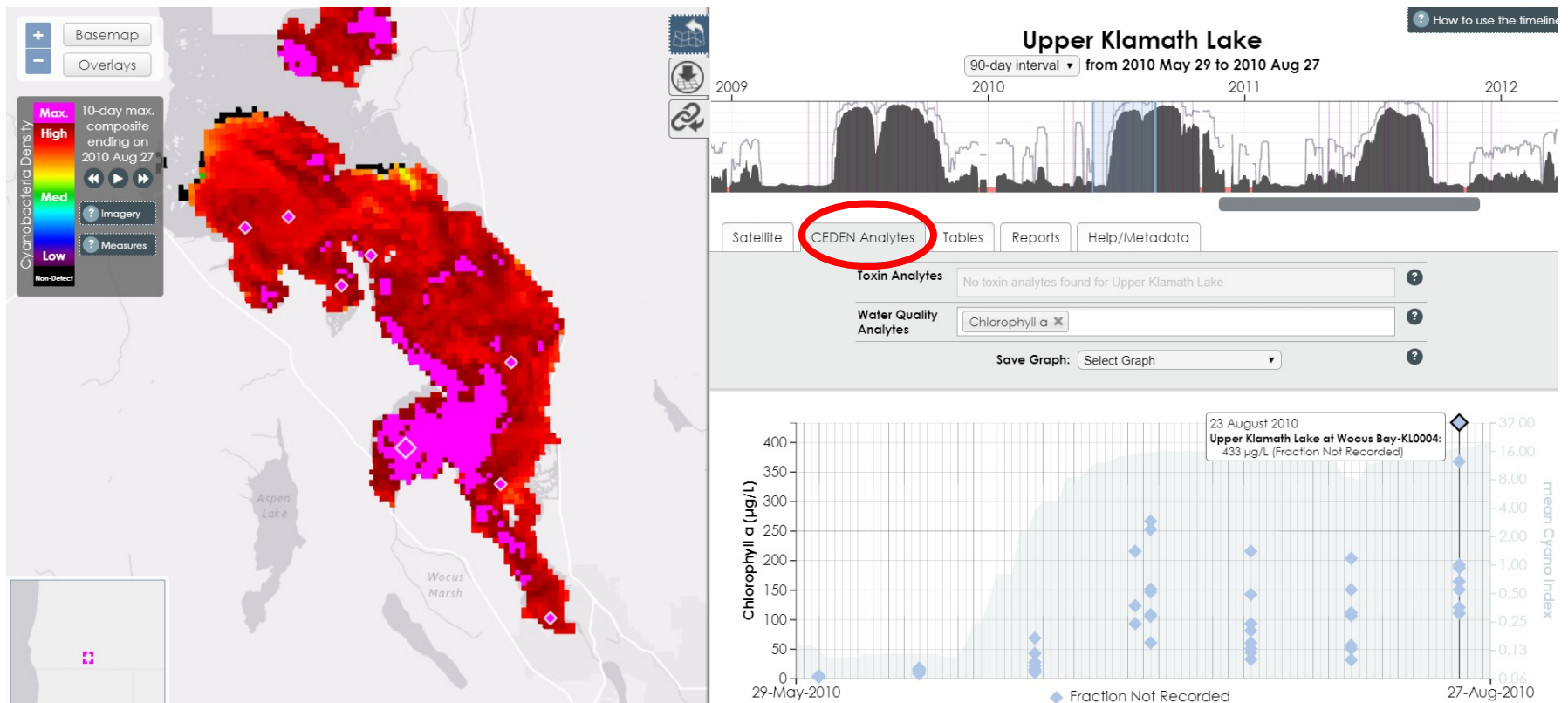


Detailed Time Series



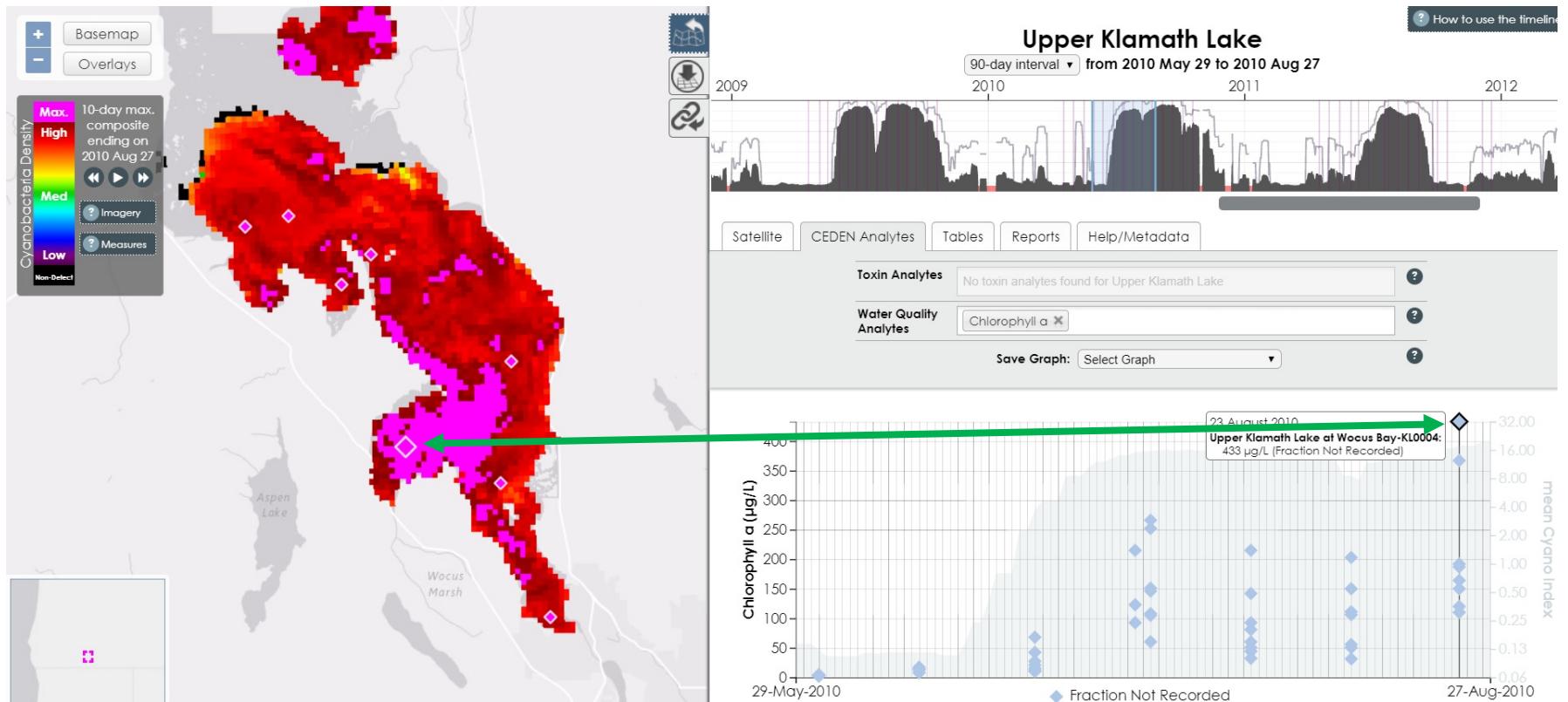
CyanoHAB Satellite Imagery Analysis Tool

- Compare to WQ and HAB data in CEDEN



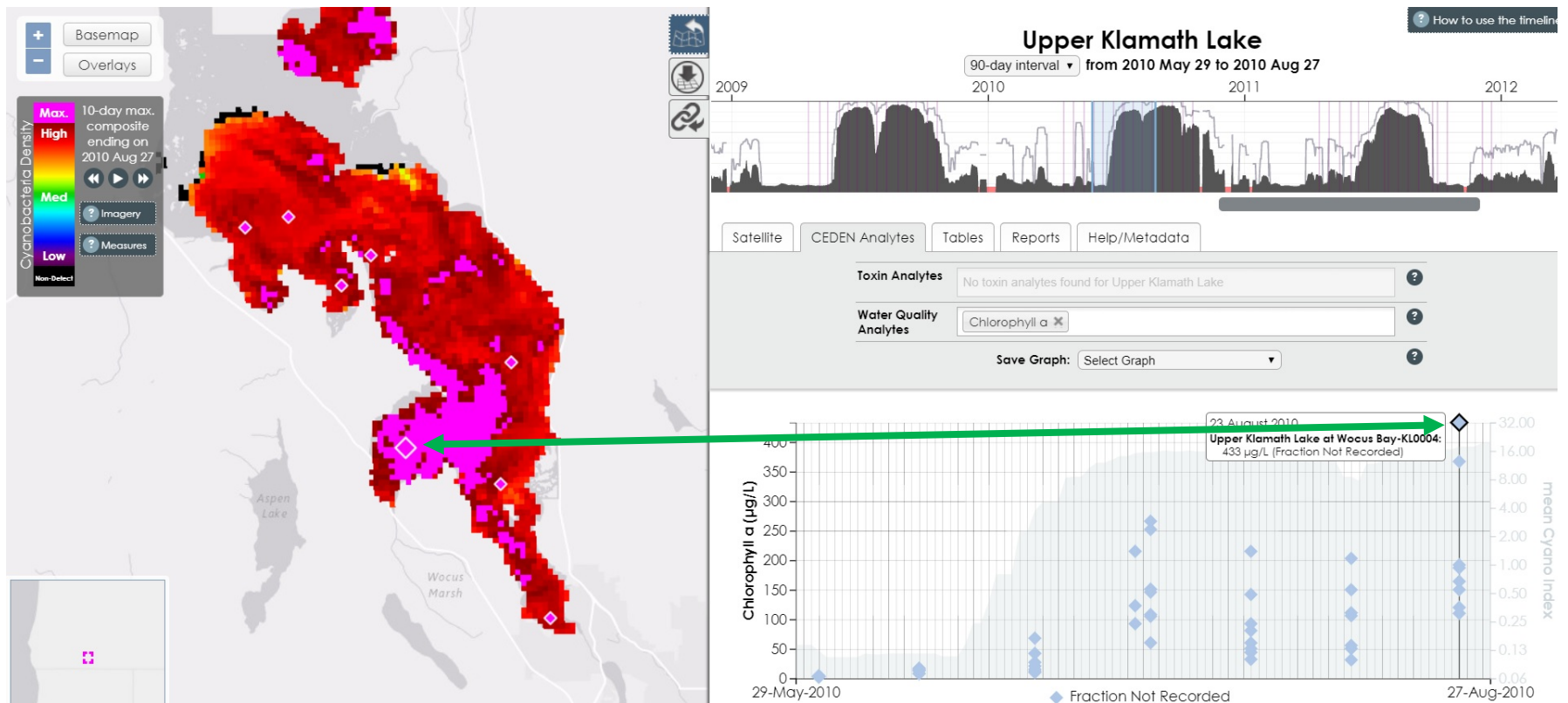
CyanoHAB Satellite Imagery Analysis Tool

- Compare to WQ and HAB data in CEDEN



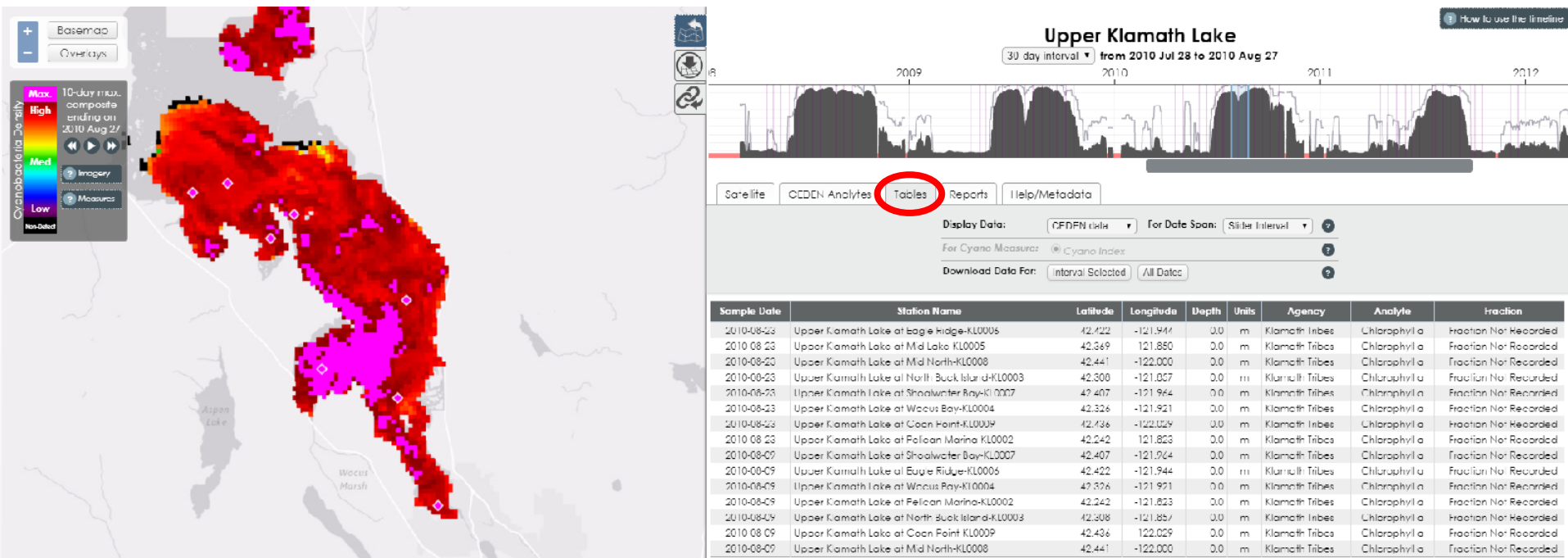
CyanoHAB Satellite Imagery Analysis Tool

- 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

Download Satellite Data Clipped to: Upper Klamath Lake

Mosaics combining imagery from North, Central, and South California regions, where available, are provided as level-3 processed products (shown as 'L3 CA Mosaics' in drop down menu below) for estimated cyano Index (CI) values. For conversion of raw pixel values and interpretation of the provided color table, see [pixel-value conversions help](#). Composite rasters are provided as level-4 processed products using a running 10-day pixel-maximum (shown as 'L4 10-Day Maximum' in drop down menu below).

Satellite data from 2002-2012 come from the [MERIS Instrument](#) on board the [ENVISAT mission](#) which has since ended operations. Satellite data from 2016 to present come from the [OLCI Instrument](#) on board the [Sentinel-3 mission](#). Post-processing was provided by the [NOAA National Centers for Coastal Ocean Science](#).

2010 | August | 27 | L4 10-Day Maximum

Platform: envisat
Sensor: MERIS

Download

Station Name	Latitude	Longitude	Depth	Units	Agency	Analyte	Fraction
Bigge Ridge-KL0006	42.422	-121.944	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Bigge Lake-KL0005	42.369	-121.850	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Mid North-KL0008	42.441	-122.000	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Smith Buck Island-KL0003	42.308	-121.857	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Coalwater Bay-KL0007	42.407	-121.964	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Coacus Bay-KL0004	42.326	-121.921	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Coan Point-KL0009	42.436	-122.029	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
Coan Marina-KL0002	42.242	-121.823	0.0	m	Klamath Tribes	Chlorophyll a	Fraction Not Recorded
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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

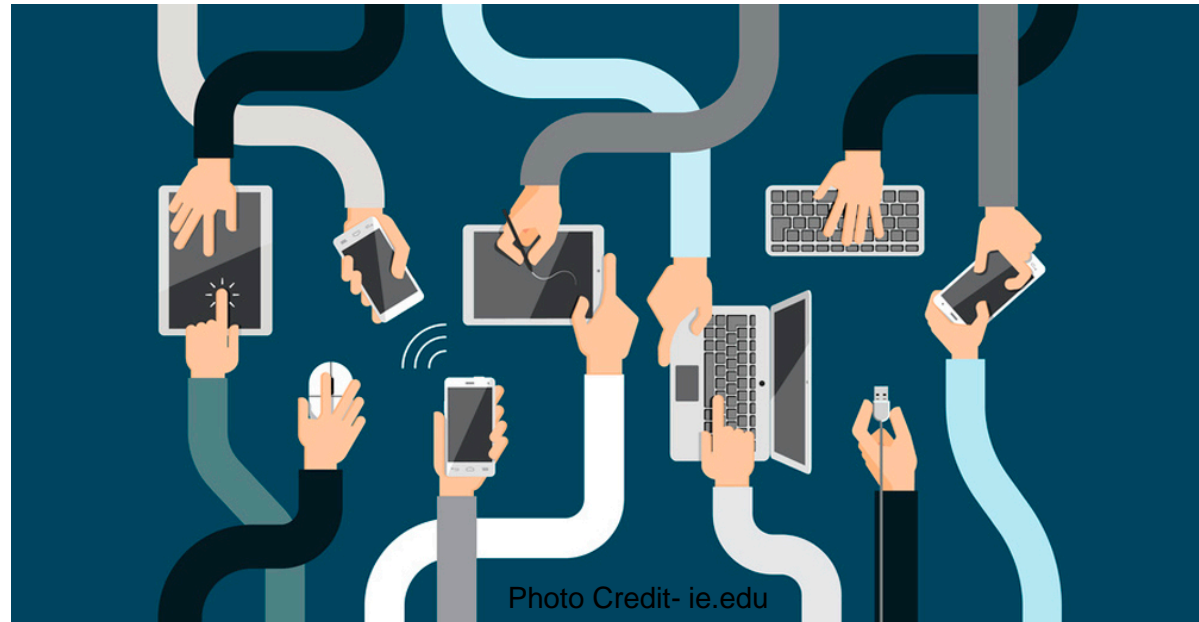


Photo Credit- ie.edu

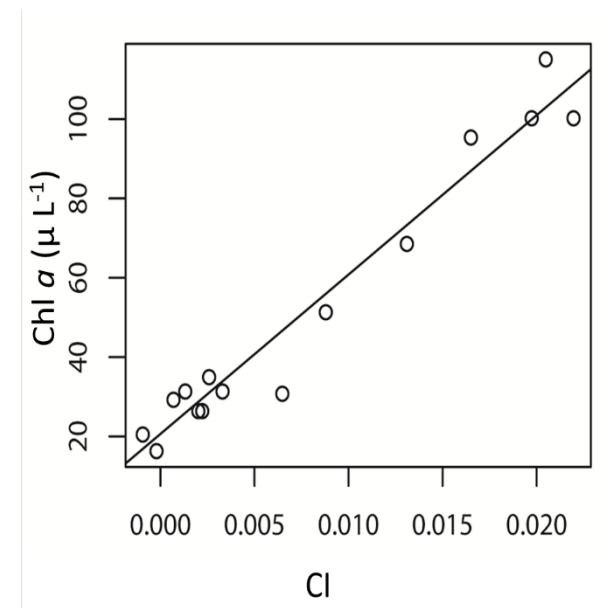
Potential Uses of Satellite Data

- **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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	2.0	'Moderate' Estimated Abundance Threshold
	1.3	
	1.0	
	≤1.0	Background Level / Non-Detect

Close

Next Steps: Future Tool Improvement

Expand/pursue:

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



Questions?



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