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EPA Tools and Resources webinar: Monitoring Cyanobacteria with Satellites

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Outline

- Overview of satellites and data
- Introduction to Cyanobacteria Assessment Network (CyAN)
- Satellite data
- Software
  - SeaDAS Software
  - Remote Sensing (RS) Tools for ArcGIS
  - Android mobile app
- Case studies at UT Department of Environmental Quality (DEQ) and US Army Corps
- Future applications and impacts

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Opportunities for States

→ Test and provide feedback on provisional CyAN satellite data

→ Access Remote Sensing (RS) Tools for ArcGIS

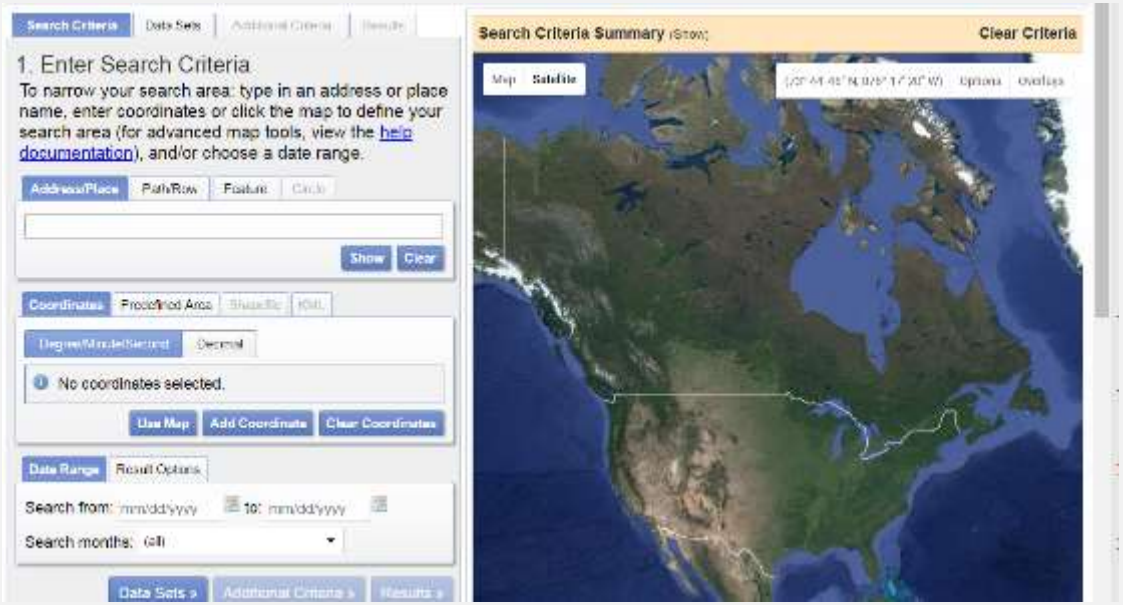
→ Beta test CyAN Android mobile application

Free Operational Satellite Platforms

- European Space Agency
  - Envisat satellite
    - MEdium Resolution Imaging Spectrometer (MERIS)
    - 2002-2012
  - Sentinel-3A satellite
    - Ocean and Land Colour Instrument (OLCI) 2016+
    - 3B scheduled 2018
  - Sentinel-2A satellite 2015+, 2B 2017+
    - Multi-Spectral Instrument (MSI)
- US Geological Survey (USGS)/NASA
  - Landsat 8 2013+
  - Landsat 9 scheduled 2020

Original Data Sources

- NASA's Ocean Color Web
  - MERIS 2002-2012
  - OLCI 2016+
- USGS Earth Explorer
- Landsat 1980-present; Sentinel-2 A&B 2015-present



Source: https://oceancolor.gsfc.nasa.gov/

Satellite Sensors

- 30m Land
  - Landsat 1980-present
  - Senintel-2 MSI
    - 10-to-16 day revisit
    - Higher spatial resolution
    - Limited bands
    - Bulky data
- 300m Ocean
  - Envisat MERIS
  - Sentinel-3 OLCI
    - 2-3 day revisit
    - Optimal bands
    - Limited spatial resolution

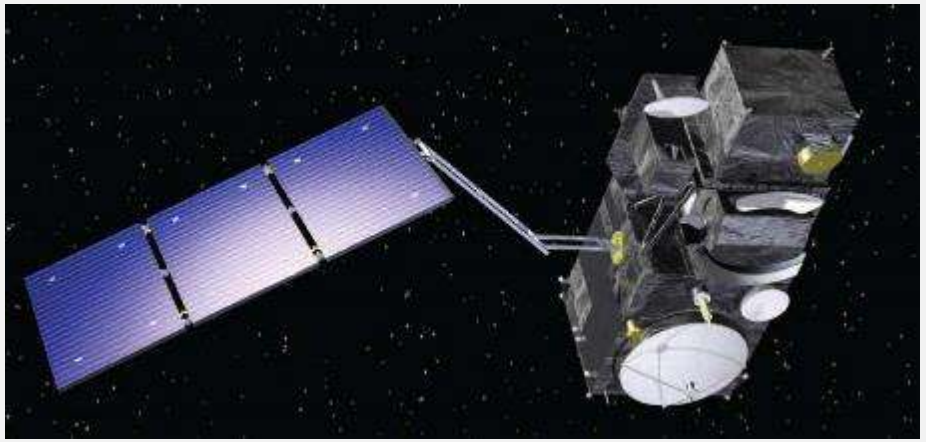


Image Source: European Space Agency

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Satellite Derived Water Quality Products

- Turbidity
- Chlorophyll-a
- Harmful algae
  - i.e. phycocyanin, cyanobacteria
- Sediment
- Submerged habitat
- Temperature

Cyanobacteria Assessment Network (CyAN)

- **Problem**: How to support the use of U.S. waters with satellite monitoring?
- **Opportunity**: Water quality indicators can be monitored with satellites and used to protect public health and environment
- **Approach**: Strengthen cross-agency research to mainstream satellite capabilities for water quality management decisions
- **Results**: New methods and tools to monitor cyanobacteria harmful algal blooms (HABs)
- **Impact**: Scalable information across any geo-political boundary, and ability to prioritize locations for management actions

Schaeffer et al. 2015. Agencies collaborate, develop a cyanobacteria assessment network. Eos. 96:16-20.

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Agency Roles

- **EPA**: Satellite application methods for management of freshwater HABs and water quality
- **NASA**: Satellite data processing, evaluation/validation, quality control
- **NOAA**: Satellite algorithms to detect and forecast HABs for marine systems and Great Lakes
- **USGS**: Field freshwater HAB monitoring, ecological expertise, and Landsat satellite management

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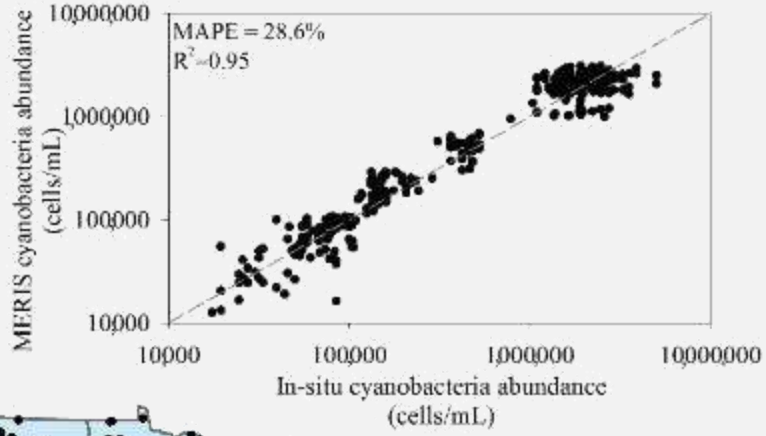
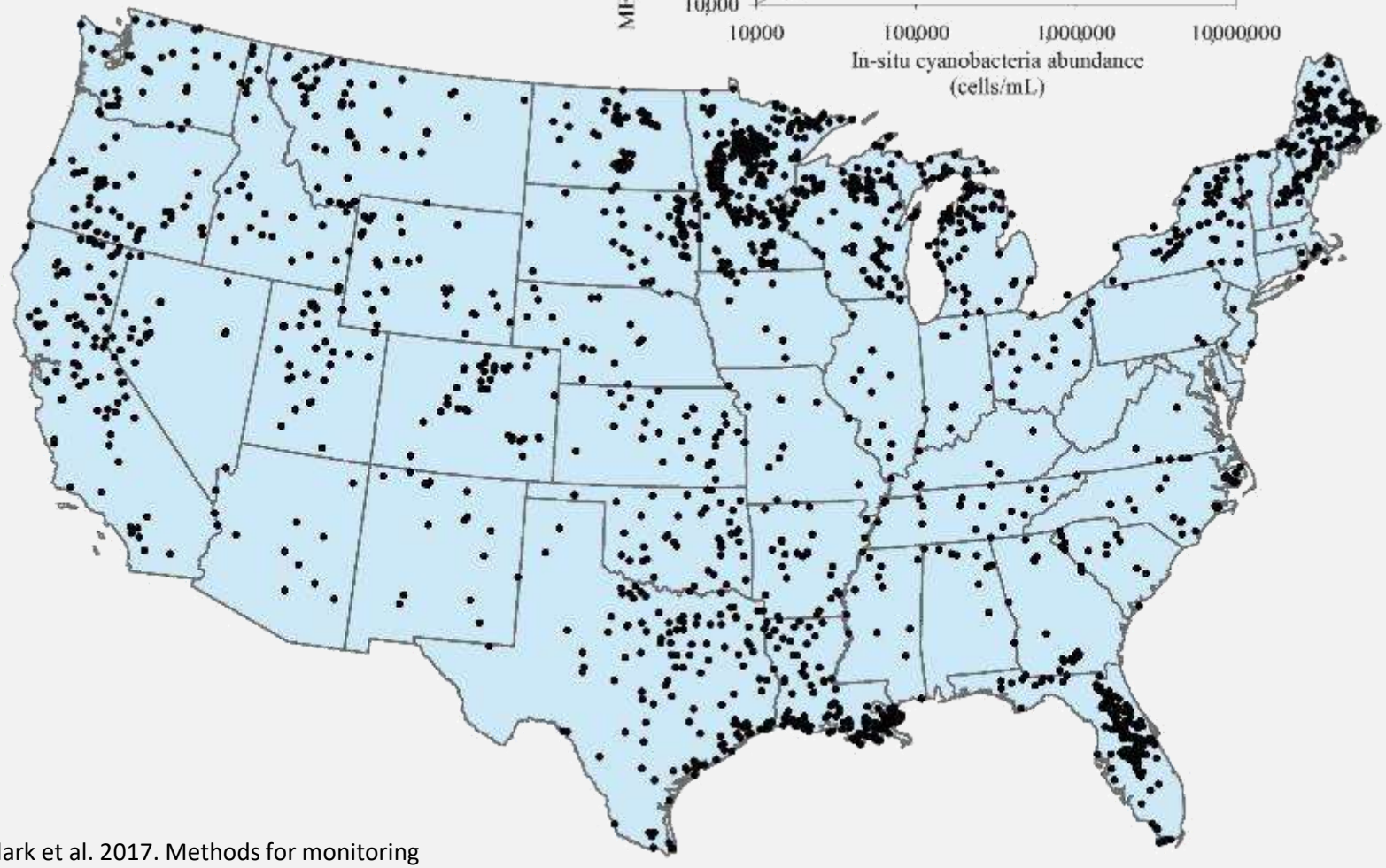
Lakes





Source: Clark et al. 2017. Methods for monitoring cyanobacteria harmful algal blooms in recreational waters and drinking source waters with satellites. Ecological Indicators. 80:94-95.

CyAN data processing details

- MERIS
  - 2002-2007 2-week maximum value
    - Sensor irregularly viewed the US
  - 2008-2012 1-week maximum value
    - Sensor regularly collected data over the US
- Sentinel-3 OLCI
  - 2017+ 1-week maximum value
- Data are validated in Stage 2 of 4
  - NASA's data maturity level details: https://go.nasa.gov/2zk8BET

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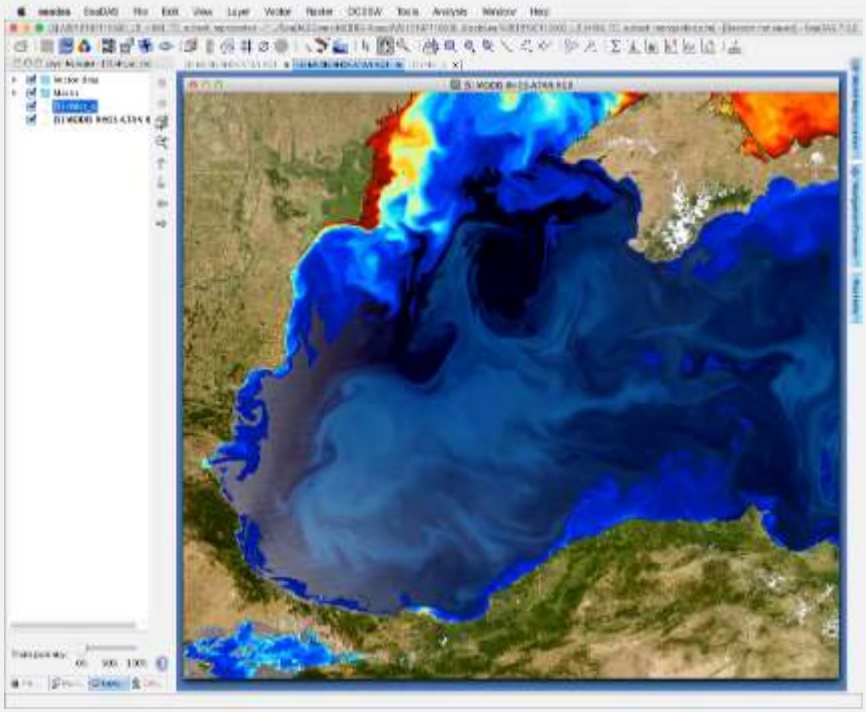
Known Issues

- Ice can potentially register as high cyanobacteria concentrations
- The land mask may cover dry lakes, and may exclude other lakes
- Caution should be used where mixed pixels may occur at land/water interface
- Land mask does not have an accurate representation of Rhode Island's coastline
- Undetected thin clouds can potentially register as high cyanobacteria concentrations
- Retrievals are considered more robust for lakes ≥ 900 m, or 3 x 3-pixel array; smaller water bodies and rivers are not masked and may be erroneous
- Satellite data processing does not account for changes in water levels due to cycles, such as drought and flood

SeaDAS Software



YouTube

http://bit.ly/2hMkSdR

- Free and open source
- Processing, display, analysis, and quality control of a wide array of satellite data
- User community forum
- Basic tools
  - Time series composites
  - Pixel extract by points
  - Pixel extract by polygon
  - Statistics by polygon

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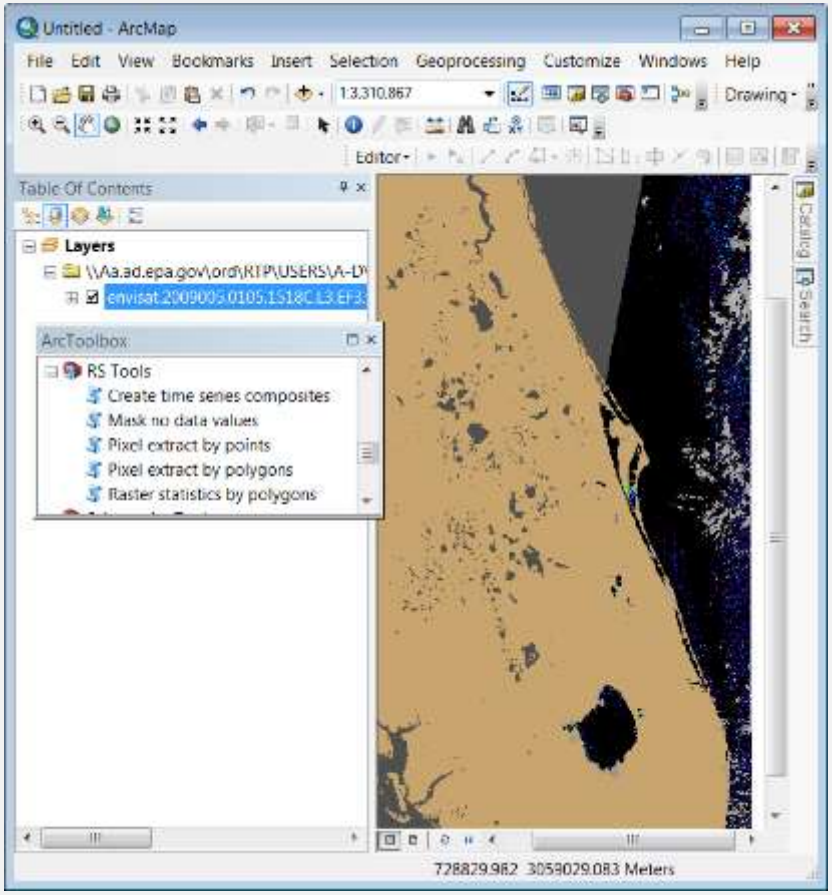
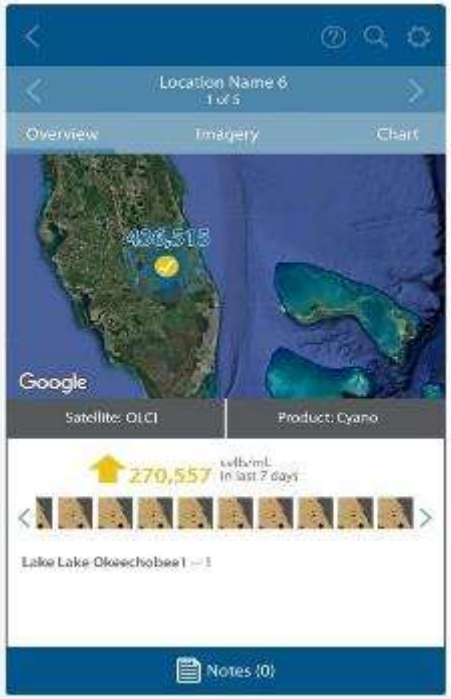
Remote Sensing Tools



- ArcGIS Toolbox
- Basic tools
  - Time series composites
  - Pixel extract by points
  - Pixel extract by polygon
  - Statistics by polygon

Android Mobile Application

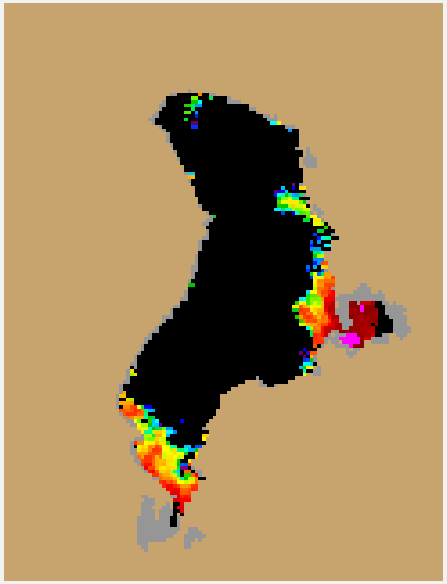


http://bit.ly/1KqBMUL

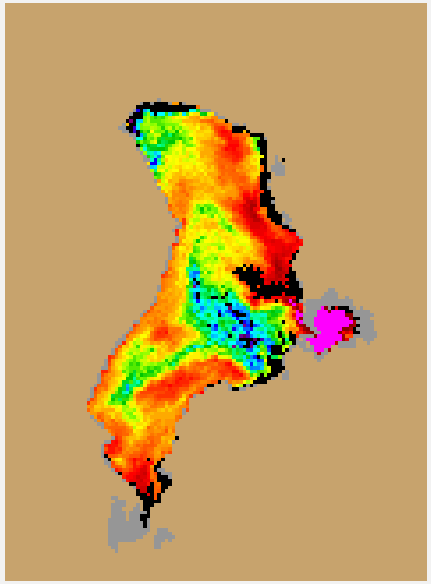
- CyAN app provides intuitive satellite data handling and allows for passive reception of data
- Reduces time investment and daily burden of searching for satellite images
- Quick quantitative reporting, time series analysis, and view of synoptic images
- Supports a comprehensive management strategy through synoptic monitoring

Source: Schaeffer et al. (*In Review*). Mobile device application for monitoring cyanobacteria harmful algal blooms using Sentinel-3 satellite Ocean and Land Colour Instruments. Environmental Modelling and Software.

Utah DEQ Case Study



June 18, 2017



July 3, 2017

- UT DEQ and Department of Water Quality (DWQ) conducted routine monthly sampling, June 12, 2017
- Satellite imagery the following week indicated a bloom was developing
- DWQ scientists returned to the area, June 22, 2017
- June 29, DEQ issued an advisory, warning the public and pets to stay out
- Ben Holcomb, Utah DEQ statement:
  - "…provides UDWQ confidence that our in-situ, bloom-response data are representative…."
  - "…better target field sampling and more efficiently use our limited resources."
  - "…images are easily shared with response agencies as a useful visual communication aid."

Sentinel-3 OLCI imagery from ESA and processed by NOAA

US Army Corps of Engineers Florida Case Study

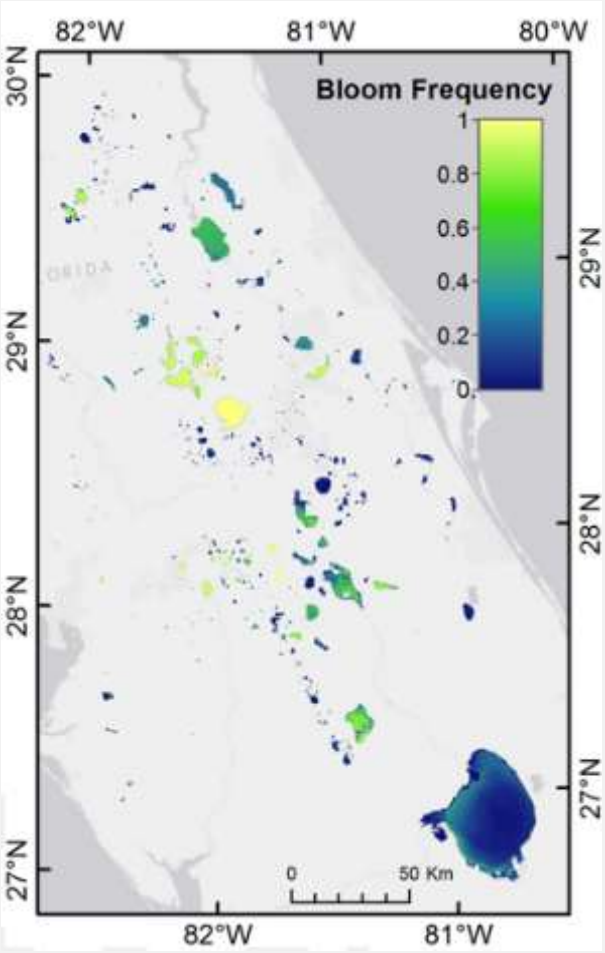
- Lake Okeechobee
- CyAN app near real-time monitoring beta test case
- Rich Botta - South Florida Water Management Division

  Jim Riley - US Army Corps of Engineers

  Frank Baker - EPA Region 4
- Testing app functionality for weekly (standard) and daily images

Sentinel-3 OLCI imagery from ESA
CyAN app supported by NERL/CED/WEB & OSIM

Quantifying Cyanobacteria *Frequency*



- How do we quantify bloom frequency?
- *S*ite-specific frequencies >100,000 cells/mL
- Derive relative exposure risk profiles from frequency data
- Ability to prioritize locations for management actions, e.g. surface water intakes or recreational waters

Source: Clark et al. 2017. Methods for monitoring cyanobacteria harmful algal blooms in recreational waters and drinking source waters with satellites. Ecological Indicators. 80:94-95.

Quantifying Cyanobacteria *Extent*

- How do we quantify the spatial extent of cyanobacteria?
- Time series analysis evaluated overall trend
- 2008-2012 and 2017+ for the continental US (CONUS)
- Each year report on status of HABs in the US by state

Source: Urquhart et al. 2017. A method for examining temporal changes in cyanobacteria harmful algal bloom spatial extent using satellite remote sensing. Harmful Algae. 67: 144-152.

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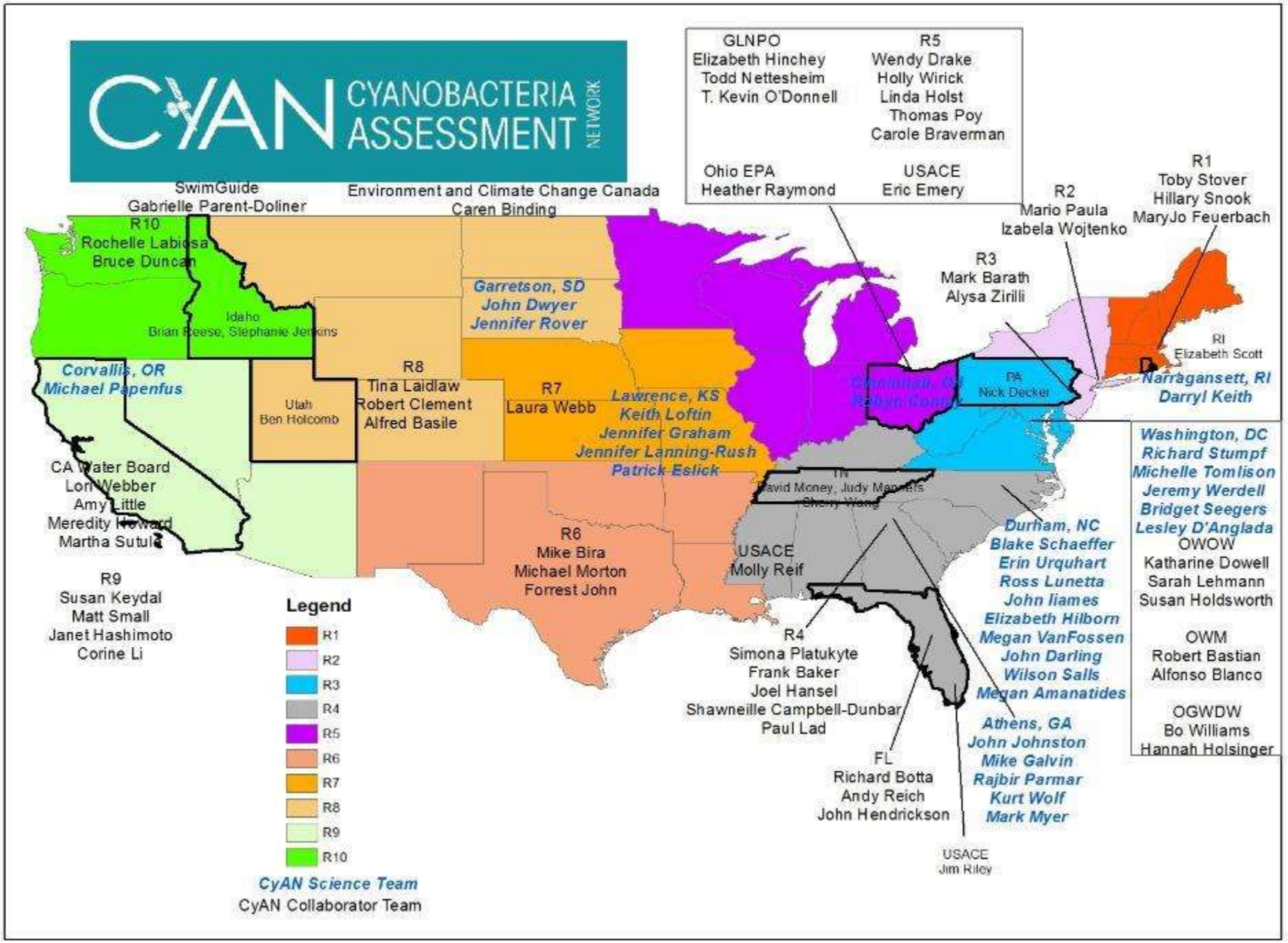
Summary

- Harmful Algal Bloom and Hypoxia Research Control Act (HABHRCA) 2014
  - EPA responsible for monitoring of HABs in freshwater
- 2016 HABHRCA report identified:
  - Monitoring challenges: Sustaining monitoring programs and maintaining consistency of methods across monitoring programs
  - Recommendation: Ability to strengthen long-term HAB monitoring

CyAN Impacts:

- Consistent approach for determining CyanoHAB change, year-to-year, with long-term operational satellites
- Quantify cyanoHAB spatial extent and frequency of occurrence
- Support recreational waters and drinking water sources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