How accurately does CyAN represent cyanobacteria cell counts in Oregon Lakes?

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Research Questions and Objectives

1. **Does CyAN accurately measure cell counts in Oregon Lakes?**
   - Verification of CyAN app calculated counts versus physical cell counts
2. **How well do satellite-derived data compare with in situ measures of cyanobacteria harmful algal blooms (cyanoHABs)?**
   - Comparison of CyAN derived data to sonde collected data; benefits and limitations to each
3. **How well can time series analysis for early detection of cyanoHABs be applied to satellite data?**
   - Apply early warning detection methods to real-time data
   - Is there the possibility of substituting real-time data with CyAN or satellite data

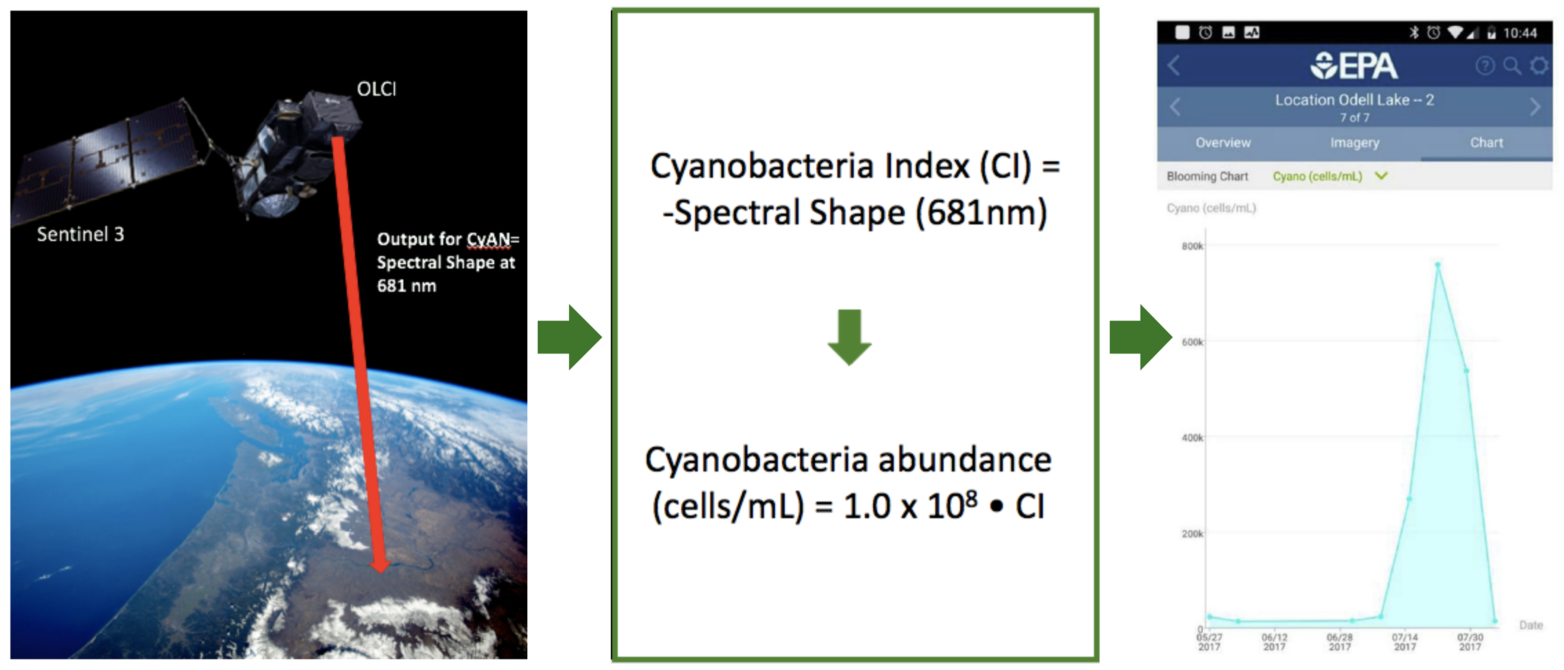

Figure 1. Schematic of how the CyAN application uses Sentinel 3 Ocean Land Colour Instrument (OCLI) data to calculate cyanobacteria abundance, using calculations in Schaeffer et al. (2018).

CyAN

The Cyanobacteria Assessment Network (CyAN) is an android mobile application created by the EPA (Figure 1). This app uses satellite imagery from European Space Agency Sentinel-3 satellite Ocean and Land Colour Instrument and SeaDAS software to calculate cyanobacteria cell counts (cells/mL). Little verification has been done on the app, especially in Oregon. Schaeffer et al. (2018) performed a verification using CyAN reported cell counts and OHA cyanoHAB advisories (Figure 2), however there are no verifications of cell counts.

Limitations:

- Minimum surface area of 300m x 300m without shoreline (Schaeffer et al. 2018)
- Cloud coverage, smoke from wildfires, solar reflection can interfere with output
- Does not have the ability to detect toxin levels/ species identification

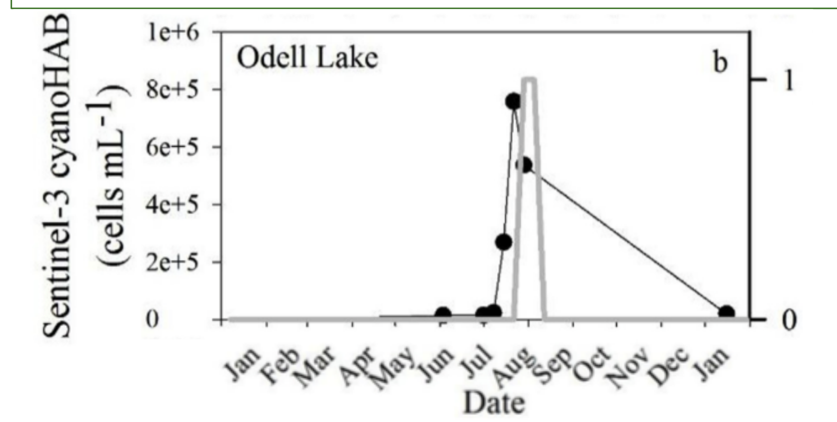

Figure 2. A verification of the CyAN application on Odell Lake by comparing satellite derived cyanobacteria abundance results with presence/absence of an Oregon Health Authority Bloom advisory from Schaeffer et al. 2018.

Study Location

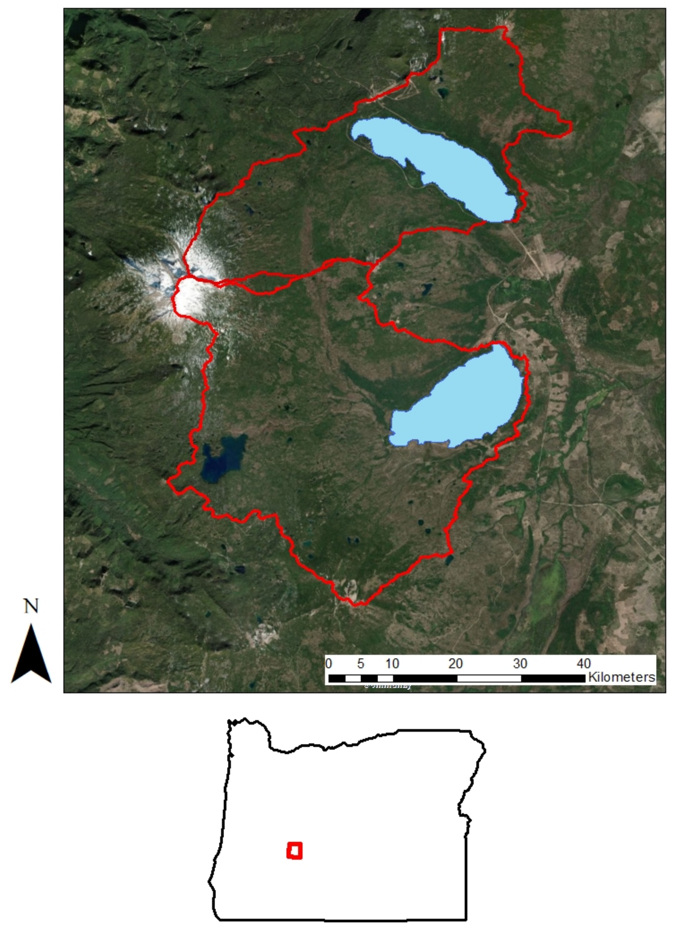

Figure 3. Watersheds of Odell and Crescents shown in red (a), and their location in Oregon (b). Odell Is the Northern most lake and watershed, while Crescent lake is the Southern most lake and watershed.

Table 1. Comparison of the two study sites, Crescent Lake and Odell Lake.

	Crescent Lake (reference)	Odell Lake (experimental)
Area (km^2)	14.9	13.9
Elevation (m)	1,475	1,459
Max Depth (m)	81	86
Land cover	Evergreen Forest(83%) Developed (0.08%)	Evergreen Forest (80%) Developed (1.01%)
Inlet	Summit Lake	Trapper Creek
Outlet	Crescent Creek	Odell Creek
cyanoHAB	**No Recorded History**	**Recent OHA Recreational Advisories**

Materials and Methods

Field Verification

- Weekly grab samples taken and preserved from June 21st to September 21st for cell count enumeration and and taxa identification
- Sondes placed in each lake, recording dissolved oxygen saturation, pH, temperature, and specific conductance, chlorophyll concentrations and phycocyanin as relative fluorescence (RFU)
- Monthly spatial and depth integrated analysis of both lakes

Early Warning Signal

Quickest detection method will be used for analyzing changes in lag-1 autocorrelation and standard deviation in 14 and 21 day rolling windows of chlorophyll a, phycocyanin RFU, and dissolved oxygen between the two lakes (Scheffer et al. 2009; Carpenter et al. 2014; Wilkinson et al. 2018).

Figure 4. Crescent Lake (left) and Odell Lake (right) on July 23rd/24th, 2019 during the peak bloom at Odell, according to CyAN app (a). *Dolichospermum* has been detected in grab samples taken from this day (b).

Preliminary /Expected Results

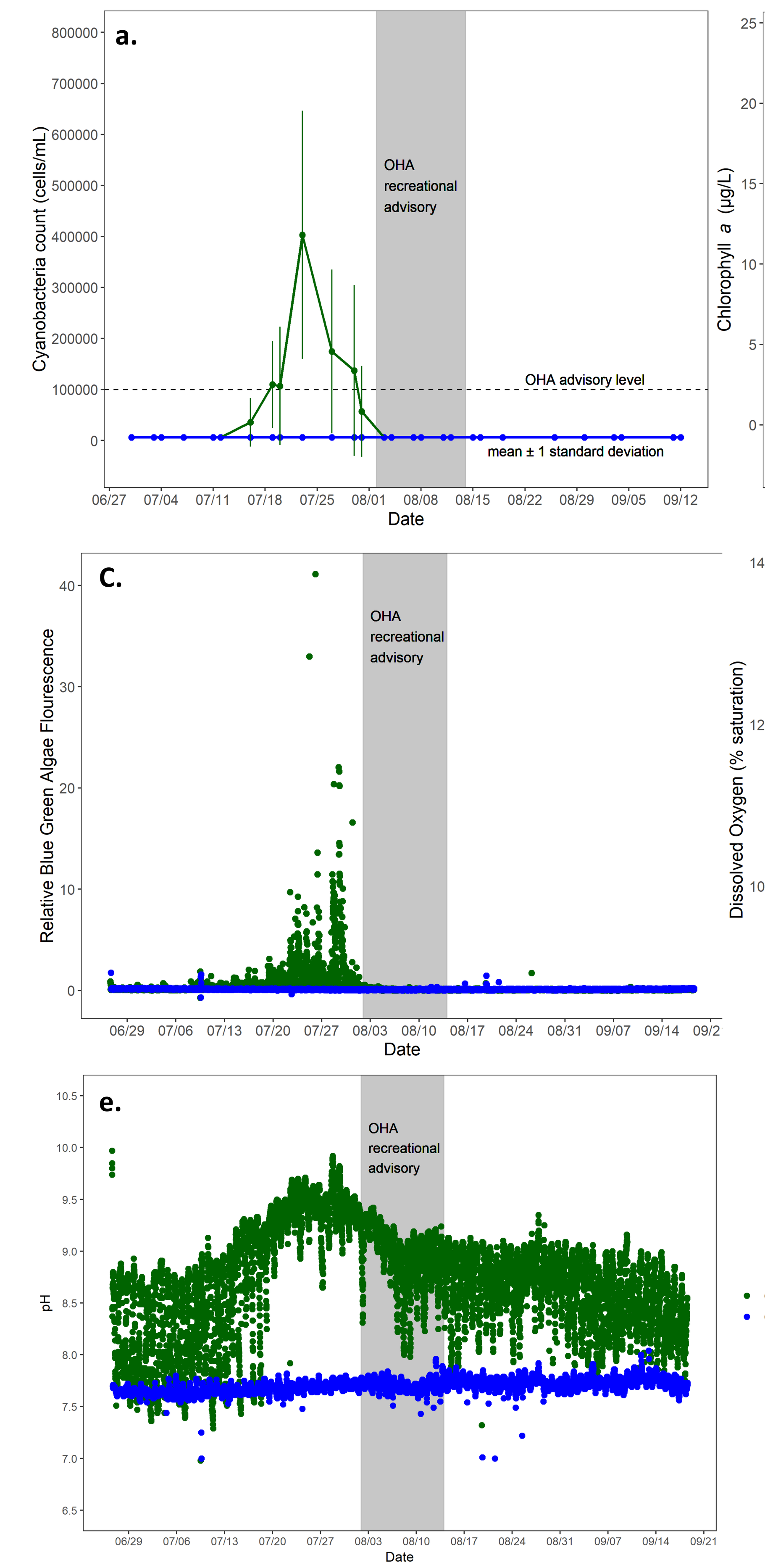

Figure 5. The mean and standard deviation of cell counts calculated by the CyAN app for both lakes. The cell counts peak at 403,168 ± 243035 cells per milliliter for Odell on July 23rd, 2019 (a).The sondes located in Odell and Crescent Lake recorded concentration of chlorophyll a (b), relative fluorescence of blue-green algae (c), percent saturation of dissolved oxygen (d) and pH (e) every 15 minutes. Values for Odell Lake are shown in green and values for Crescent lake are shown in blue.

Next Steps

Cyanobacteria Taxa Identification

- Identify and analyze taxa that are present in each lake
- Look for changes in community compositions before blooms
- Does CyAN favor a specific species?

Cyanobacteria cell counts

- Cell enumerations for samples at both lakes
- Statistical analysis/ comparison to CyAN derived cell counts and

Early warning detection

- If cell counts are accurate, apply cell counts from CyAN to early warning detection method described in Wilkinson et al. (2018)
- If cell counts are not compatible, try using spectral shape or other satellite derived patterns
- Do historical cell counts from CyAN show the same patterns of detection?

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