PHYTOPLANKTON COMMUNITY COMPOSITION IN INLAND WATERS FROM REMOTELY SENSED HYPERSPECTRAL DATA

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INTRODUCTION

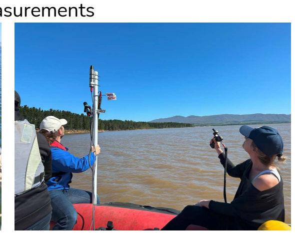
Phytoplankton Community Composition (PCC) is an important measure of the aquatic health of inland water bodies. Globally, PCC in inland waters is shifting towards Cyanobacteria dominance, resulting in toxic Harmful Algal Blooms. As such, tools for monitoring PCC are important for management of these water resources. More readily available hyperspectral data from imaging spectrometer missions will allow for PCC identification. This study evaluates the performance of the PCC classification algorithm Phytoplankton Detection with Optics (PHYDOTax) [1] with new application to inland waters in California and South Africa.

METHODS

In situ measurements

- Surface water samples – High Performance Liquid Chromatography (HPLC) pigment analysis and phytoplankton identification
- In situ spectroradiometer measurements


Clear Lake, CA, USA


Theewaterskloof, South Africa

Airborne and satellite hyperspectral imagery

- DESIS data for Clear Lake
- PRISM, AVIRIS-NG, EMIT data for South African Inland Waters (BioSCape field campaign)
- Atmospheric correction using ISOFIT

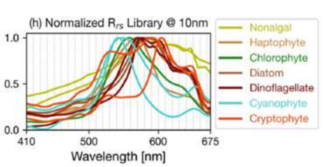
HPLC-derived PCC

- PCC derived from HPLC pigment data using CHEMTAX [2] and *phytoclass* [3]
- Five phytoplankton classes common to inland water bodies were determined: Chlorophytes, Cryptophytes, Cyanophytes, Diatoms, and Dinoflagellates
- HPLC-derived PCCs were compared to PCC determined by microscopy for Clear Lake

Hyperspectral imagery-derived PCC

- PCC derived from both the in situ R_{rs} and from the pre-processed hyperspectral scenes using the bio-optical approach PHYDOTax [1]
- The PCC results were compared between those derived from the in situ R_{rs} and the hyperspectral imagery as well as between the PCC derived from PHYDOTax verses the in situ HPLC measurements

PHYDOTax Spectral Library (McKibben et al., 2024)

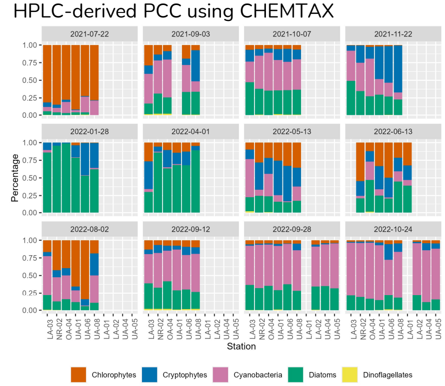


PRELIMINARY RESULTS

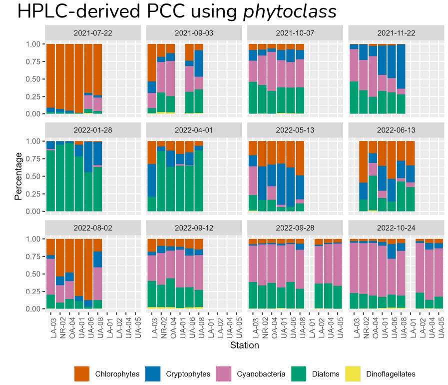
HPLC-derived PCC using CHEMTAX and *phytoclass* shows strong correlation for Diatoms, Chlorophytes, and Cyanobacteria. Cryptophytes had a weaker relationship and Dinoflagellates had poor correlation, likely due to their overall low concentrations.

Phytoplankton group	Pearson correlation coefficient, r		
	CHEMTAX PCC vs Microscopy	Phytoclass PCC vs Microscopy	CHEMTAX PCC vs Phytoclass PCC
Diatoms	0.7 ($p < 0.0001$)	0.67 ($p < 0.0001$)	0.99 ($p < 0.0001$)
Chlorophytes	0.74 ($p < 0.0001$)	0.69 ($p < 0.0001$)	0.99 ($p < 0.0001$)
Cryptophytes	0.34 ($p = 0.0036$)	0.32 ($p = 0.0069$)	0.97 ($p < 0.0001$)
Cyanobacteria	0.64 ($p < 0.0001$)	0.58 ($p < 0.0001$)	0.98 ($p < 0.0001$)
Dinoflagellates	0.13 ($p = 0.28$)	0.14 ($p = 0.25$)	0.93 ($p < 0.0001$)

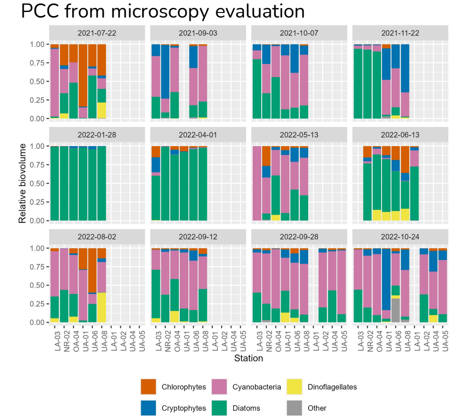
HPLC-derived PCC using CHEMTAX



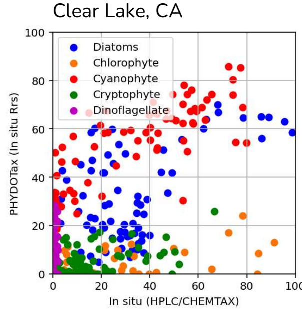
HPLC-derived PCC using *phytoclass*



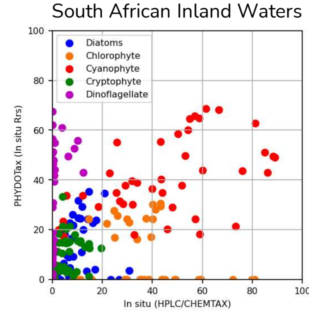
PCC from microscopy evaluation



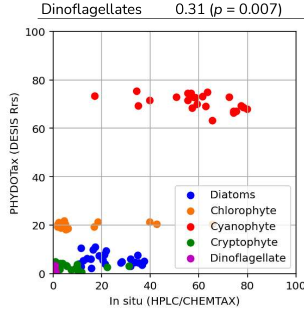
Clear Lake, CA



South African Inland Waters



Phytoplankton group	Pearson correlation coefficient, r	
	Clear Lake, CA	South African sites
Diatoms	0.54 ($p < 0.0001$)	0.63 ($p < 0.0001$)
Chlorophytes	0.52 ($p < 0.0001$)	0.46 ($p < 0.0001$)
Cryptophytes	0.44 ($p < 0.0001$)	0.12 ($p = 0.32$)
Cyanobacteria	0.79 ($p < 0.0001$)	0.63 ($p < 0.0001$)
Dinoflagellates	0.31 ($p = 0.007$)	0.006 ($p = 0.98$)



Phytoplankton group	Pearson correlation coefficient, r
Diatoms	-0.24 ($p = 0.27$)
Chlorophytes	0.32 ($p = 0.14$)
Cryptophytes	-0.13 ($p = 0.57$)
Cyanobacteria	-0.50 ($p = 0.02$)
Dinoflagellates	0.34 ($p = 0.11$)

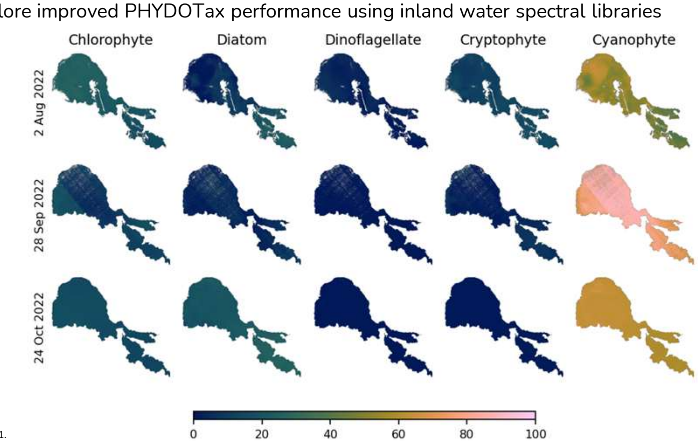
PHYDOTax-derived PCC from in situ R_{rs} compared with HPLC-derived PCC (CHEMTAX):

- Strongest performance with identifying Cyanobacteria
- Slightly better performance for Clear Lake vs. South African inland water sites

PHYDOTax-derived PCC from DESIS imagery of Clear Lake compared with HPLC-derived PCC (CHEMTAX) showed weak performance

Next Steps:

- Explore DESIS atmospheric correction – poor performance of PHYDOTax with DESIS imagery vs. in situ R_{rs}
- Complete analysis of PHYDOTax application to BioSCape hyperspectral imagery
- Explore improved PHYDOTax performance using inland water spectral libraries



References

[1] McKibben, S. M., S. Schollaert Uz, and Sherry L. Palacios. "Testing a hyperspectral, bio-optical approach to identification of phytoplankton community composition in the Chesapeake Bay estuary." *Earth and Space Science* 11.5 (2024): e2023EA003244.
[2] Wright, S. "CHEMTAX for calculating the taxonomic composition of phytoplankton populations, Ver. 1.95." (2017).
[3] Hayward, Alexander, Matthew H. Pinkerton, and Andres Gutierrez-Rodriguez. "phytoclass: A pigment-based chemotaxonomic method to determine the biomass of phytoplankton classes." *Limnology and Oceanography: Methods* 21.4 (2023): 220-241.