Society of Lake Management Professionals Scholarship Application

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Project title: Testing the application of two remote sensing platforms for water quality monitoring of residential stormwater ponds in coastal South Carolina

Background:

Cultural eutrophication, or human-caused increased nitrogen and phosphorus in the water, is a worldwide phenomenon that leads to water quality degradation (Dodds et al. 2009; Lapointe et al. 2015). Eutrophic conditions are a primary trigger of algal blooms (Lapointe et al. 2015). While some algal blooms can be beneficial, harmful algal blooms (HABs) can be damaging ecologically, economically, and to public health. Some of the primary concerns regarding HABs are drinking water contamination, habitat loss and wildlife mortality, and significant decreases in tourism and property values (Cotti-Rausch et al. 2019).

Stormwater ponds in the Southeastern United States are prone to eutrophic levels of nitrogen and phosphorus present in stormwater runoff, which can spur growth of algae including HABs during warm summer months (Lewitus et al. 2008; Delorenzo et al. 2012). In South Carolina, levels of microcystins up to 100 times the drinking water limit set by the World Health Organization have been found in stormwater ponds (Cotti-Rausch, 2019). Raphidophytes dominated in 40 blooms in coastal South Carolina documented in 2014 and 2015 (Greenfield et al. 2019), and four species have been documented in South Carolina (Liu et al. 2008). Additionally, *Pseudo-nitzchi*, the diatom that produces the neurotoxin domoic acid, has been observed in South Carolina ponds with increasing frequency (Greenfield et al. 2019). The reported increase in HAB-causing microorganisms and conditions demonstrates a major need for the monitoring, rapid detection, and reporting of blooms in these ponds for protection of both ecological and human health.

The majority of current assessment methods of HABs recommended by the U.S. EPA are based on *in situ* measurements (USEPA, 2019). Although these measurements provide accurate data, they are labor intensive, costly and lack the spatial and temporal coverage to better understand changes in such a highly dynamic environment (Mouw et al. 2015). Remote sensing offers relatively cheap, repetitive and quantitative methods to monitor water quality and can provide timely and spatially explicit information regarding changes in aquatic systems once the data is calibrated using *in situ* measurements (Ali and Ortiz, 2016; O’Reilly and Werdell, 2019).

Significance:

According to the SC Sea Grant Stormwater Ponds in Coastal South Carolina: 2019 State of Knowledge Report, there are 21,594 ponds in the 8 coastal counties in South Carolina, with 5,073 residential ponds as of 2013 (Cotti-Rausch et al. 2019). While not all ponds have been installed for stormwater purposes, those present in developed areas such as the golf, commercial, and residential are assumed to be constructed for stormwater control (Cotti-Rausch et al. 2019). With nearly 24% of all ponds existing in residential areas, the occurrence of harmful blooms in ponds could affect a large number of South Carolina residents.

There are existing state-of-the-art remote sensing platforms that enable detection of spectral signatures linked to key water quality parameters like algae (i.e. *chlorophyll a* and other pigments). However, previous work on HAB remote sensing monitoring using the Sentinel-2 platform is limited to only significantly large open water bodies such as the Great Lakes or oceans (Ali and Ortiz, 2016). Access to higher resolution Planet Scope data could allow extension and calibration of previously derived water quality models to water bodies with smaller surface area, such as ponds. The potential for real-time monitoring of algal blooms over a broad geographic range would provide a tool that can be used for multiple purposes, such as describing temporal trends of algal bloom frequency, or creating a real-time system for rapid public health notification that could help mitigate the negative impacts of the bloom.

Project Goals:

The objectives of this project are to combine GIS, remote sensing, field sample collection, and *in situ* and lab water quality analyses to: 1) develop water quality band ratio models to associate remote sensing data from two different satellite platforms, Sentinel-2 (public; ESA) and PlanetScope (private), to water quality of select residential stormwater ponds in coastal South Carolina and 2) to improve understanding of the current limitations of remote sensing for these smaller water bodies.

Research Methods:

ArcGIS Pro was used to screen an existing South Carolina pond inventory layer based on land use classification (residential) and size (m^2). The ArcGIS Pro fishnet tool was used to create a $60m^2$ grid that geographically aligned with a 60m resolution Sentinel-2 image. The grid was intersected with the filtered pond layer, and ponds with at least one full $60m^2$ pixel were selected for potential field study to minimize edge effects.

Of 3,186 ponds in the residential inventory for the six coastal counties selected for the study, 2.4% were found to have a size and shape that could allow for remote sensing using Sentinel-2 based on the $60m^2$ pixel fishnet. The application of PlanetScope data, which has a higher spatial resolution (3m compared to Sentinel-2's 10m and 20m), could increase this percentage significantly. Fifty of the ponds identified had property owners with contact information online or in county parcel data. We were granted access to 17 ponds total in Charleston, Berkeley, Dorchester, and Beaufort counties. Remote sensing of water quality requires nearly cloudless conditions. The Sentinel Explorer time selector tool was used to find imagery in Charleston County with zero or low cloud cover for June-September 2021. Out of 25 overpass days, 40%, 20%, and 8% of images had 0-25%, 0-10% and 0-2% cloud cover, respectively. These findings express some limitations of remote sensing.

Field work was conducted in September 2022 in 14 residential ponds on nearly cloudless days corresponding with Sentinel-2 acquisition. Samples were collected from a kayak within the approximate area of a full Sentinel-2 pixel. Duplicate grab water samples were taken from each pond at elbow depth and packed on ice for transport to the laboratory. Analyses were conducted using established methods: USEPA Method 445 for Chlorophyll-a (chl-a), Kasinek et al. 2015 for phycocyanin, ASTM D 2974-87 for suspended solids (TSS) and loss on ignition (LOI), and USEPA Method 415 for dissolved organic matter (DOM), specific UV absorbance at 254 nm (SUVA-254) and dissolved organic carbon (DOC).

Research will continue with water quality model development using satellite imagery and the water quality data collected.

Proposed Budget:

Proposed Project Budget	
Category:	**Projected Cost:**
Materials and Supplies	$700
Services	$500
Domestic Travel	$1,000
Total	**$2,200**

The materials and supplies budget includes supplies for field and laboratory work such as filters, standards and reagents, sampling bottles, centrifuge vials, cuvettes, and pipettes. The services budget covers the GIS Lab fee. The domestic travel budget will provide the cost of registration to attend conferences as well as fieldwork travel.

While many of the costs associated with this project have been covered by the South Carolina Space Grant Graduate Research Fellowship, the funding period ends May 2023. This research is projected to continue through Summer 2023, and scholarship funding would be put towards the cost of a large storage capacity external hard drive for the remote sensing and GIS portion of the research. Any remaining funding would be used as a student stipend to help cover the cost of tuition and other school and living expenses.

Career Goals and Special Interests:

I initially became interested in harmful algal blooms when I took a marine botany course at the College of Charleston. The level of destruction a single-celled organism can cause on a community and ecosystem is astounding. After I adopted my dog Fig 2 years ago, I became especially engrossed in learning more about HABs and water quality. Fig loves to swim, but I knew that the water quality in Charleston water bodies varies significantly. I started using GIS maps to check water quality before taking him to the beach or park, but the maps do not use real time data. This is what made me wonder if using remote sensing to detect or even predict HABs in smaller water bodies was possible, which led to the topic of my research.

I would like my career in the future to involve remote sensing and GIS work, potentially with environmental consulting. I think remote sensing of water quality is an interesting and powerful tool, and I would like to continue to learn more about it so that I can work in this field.

References

Dr. Barbara Beckingham – beckinghamba@cofc.edu

Dr. Norman Levine – levinen@cofc.edu

Dr. Adem Ali – alika@cofc.edu

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