**NASA DEVELOP National Program**



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North Carolina Water Resources

Utilizing NASA Earth Observations to Monitor Harmful Algal Blooms in the Albemarle Sound of North Carolina



**Technical Report**

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# I. Abstract

**Keywords**

North Carolina, Remote Sensing, Harmful Algal Blooms (HAB), Albemarle Sound, Pamlico Sound, bio-toxins, submerged aquatic vegetation (SAV), Earth Observations

# II. Introduction

The objective of this project is to monitor the extent of harmful algal blooms (HAB) in the Albemarle and Pamlico Sounds in North Carolina using NASA Earth Observation imagery and ancillary data gathered between 2004 - 2014. This project addresses the Water Resources application area by giving end-users a tool to assess water quality as it relates to HAB extent on a large scale.

The Albemarle and Pamlico Sounds are part of the Albemarle-Pamlico Estuarine Complex, the largest lagoonal estuarine system in the United States. This system receives drainage from approximately 30,000 square miles of watershed including discharge from the Chowan, Roanoke, Pasquotank, Neuse, and Tar-Pamlico Rivers (EPA, 2007). As the nation’s second largest estuary, the Albemarle-Pamlico system supports a diverse sea grass and submerged aquatic vegetation (SAV) population as well as rich fishery characterized by a mix of estuarine and pelagic species. SAV plays a vital role in the sound by providing habitats for fish, absorbing wave energy and nutrients, and settling suspended sediments. The biodiversity and overall health of the estuary has become imperiled over recent decades due to increased urbanization and industrialization in response to rapid population growth along the North Carolina coast. Shifting agricultural interest led to a decline in tobacco farming during the1980s which was promptly succeeded by an expansion of commercial swine production. Together, these activities have introduced chemical and physical stressors from urban and agricultural runoff into the delicate estuarine ecosystem. Although SAV declines in the 1990s had been attributed to reduced light availability from eroded sediments, newer research suggests SAV is more affected from excessive nutrient loading from agricultural runoff (Mallin et al., 2000).

Artificial eutrophication of naturally nutrient-rich waters is known to promote Harmful Algal Bloom (HAB) activity. While only certain species of phytoplankton produce deadly chemicals, all HABs deplete dissolved oxygen, alter water chemistry, and prevent sunlight from reaching the bottom of the sound (Paerl, H.W. and T.G. Otten, 2013). In the Albemarle and Pamlico Sounds, nearly a quarter of water samples conducted by North Carolina’s Water Science Center during the summer of 2012 contained dangerous, toxin-producing phytoplankton. Several species of *Anabaena, Anabaenopsis, Aphanizomenon, Aphanocapsa, Microcystis, Pseudanabaena,* and the particularly aggressive *Cylindrospermopsis raciborskii* (Mallin et al., 2007) were detected. Harmful phytoplankton are capable of producing neurotoxins and hepatotoxins in concentrations lethal to wildlife and domestic animals. They can also manufacture endotoxins and dermatotoxins, causing serious irritation and various sublethal effects (Cercin, 2012). Humans who inhale toxins that HABs release into the air, drink water contaminated by HABs, or eat affected fish or shellfish may manifest gastrointestinal, neurological, dermal, or respiratory symptoms varying in severity from mild to fatal depending on the amount and type of HABs present (Seltenrich, 2014).

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Currently, the state of North Carolina performs limited monitoring of HABs in the Chowan and Pasquotank rivers, and Chlorophyll-a is routinely monitored on a monthly basis at 15 stations in the Albemarle Sound. The USGS North Carolina Water Science Center and the Albemarle-Pamlico National Estuary Program are interested in the 10-year history of algal bloom activity throughout the estuary system for the identification of patterns in HAB extent as it relates to seasonal and climatic fluctuations. They will use the results to expand their current knowledge of HABs and later predict HAB extent with further statistics, passing the information to the State of North Carolina.

# III. Methodology

Data Acquisition:

Aqua MODIS ocean color products will be used to estimate an overview of chlorophyll-a extent throughout the Albemarle-Pamlico Estuary. Landsat 5, 7, and 8 will be used to provide higher resolution informational maps during known periods of intense HAB activity. *In situ* water quality data provided by USGS North Carolina Water Science Center and additional data downloaded from the National Water Quality Monitoring Council will provide a standard to compare with our satellite-based HAB extent.

Data Processing:

Aqua MODIS Level 2 Data was downloaded from NASA Goddard Space Flight Center’s Ocean Color SeaDAS website using LINUX

Data Analysis:

Data acquisition occurred using a proprietary Python script which accessed [...]

# IV. Results & Discussion

* Analysis of Results:

[Currently empty.]

* Errors & Uncertainty:

[Currently empty.]

* Future Work:

[Currently empty.]

# V. Conclusions

[Currently empty.]

# VI. Acknowledgments

Dr. Kenton Ross-National Program Science Advisor

Jeffry Ely- Geoinformatics Scientist

Nathan Owen-Center Lead

# VII. References

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* ”[Maps on this page] show Water Quality Index Scores (WQI) at the water quality monitoring stations within the APNEP region. Also shown are maps of the scores of the WQI componant indices (Dissolved Oxygen, Dissolved Inorganic Nitrogen, Dissolved Inorganic Phosphorus, Chlorophyll and Water Clarity).”]

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* This is kind of like NDVI but takes into account blue and green bands. NDVI has been used to map surface algae since it does show active chlorophyll, however, SABI is supposed to be able to show just-below-the-surface algae too. Was applied to several different bodies of water showing advantages over NDVI. We can try to use this with our Landsat data since our Landsat maps are going to be for making higher resolution algae maps during known HAB events.

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# VIII. Appendices

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