**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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Chad Smith (Team Lead)

Jelly Riedel

Keith Benjamin

Daniel Wozniak

Matthew Carter

U.S. Geologic Survey North Carolina Water Science Center,

Dr. Michelle Moorman, Biologist, (Science Advisor)

Albemarle-Pamlico National Estuary Partnership

Dr. Bill Crowell, Dean Carpenter, & Jim Hawhee, (Science Advisors)

NASA DEVELOP National Program

Dr. Kenton Ross, (Science Advisor)

# 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 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 (Mallin et al., 2008). SAV plays a vital role in the sound by providing habitats for fish and aquatic invertebrates (Paerl, H.W. and T.G. Otten, 2013). 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 during the 1980s led to a decline in tobacco farming which was promptly succeeded by an expansion of commercial swine production (Mallin et al., 2008). Together, these activities have increased the introduction of chemical and physical stressors from urban and agricultural runoff into the delicate estuarine ecosystem (EPA, 2007). Excessive eutrophication from anthropogenic sources alters natural relationships between primary producers and creates an optimal environment for Harmful Algal Bloom (HAB) activity (Paerl, H.W. and T.G. Otten, 2013; Fu et al., 2012).

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). The synergistic effect of nutrient pollution and reduced light availability in the water column has caused damage to previously healthy areas of SAV throughout the Albemarle and Pamlico Sounds (Mallin et al., 2008). 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* were detected. Harmful phytoplankton are capable of producing neurotoxins and hepatotoxins in concentrations lethal to wildlife and domestic animals (Lopez et al., 2008; Mallin et al., 2008). 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; Trevino-Garrison, 2015).

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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, addressing 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. 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 a Linux operating system. The data was cropped to only include the immediate area surrounding the Albemarle and Pamlico Sounds. The data layers were then reprojected from their original sinusoidal form to the NAD83 projected coordinate system.

Data from Landsat 5, 7, and 8 were included to provide reference base maps and higher resolution floating algae maps for informational purposes during periods of known HAB activity.

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

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# VIII. Appendices

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