INTRODUCTION

The United States’ largest estuary, the Chesapeake Bay, is home to a vast and complex ecosystem, which supports a diverse range of habitats and provides a crucial economic role for local communities. Every year, predominantly in the summer months, harmful algal blooms (HABs) occur, negatively impacting economic, ecological, and human health. HABs occur when colonies of algae grow rapidly, fueled by warm water temperatures and excess nutrients such as phosphorus and nitrogen. Tracking and monitoring HABs is very challenging, as they are highly variable in nature and can pop up and disappear in a number of hours. We used MODIS and AVHRR satellite data as a method to track blooms over the course of July through September 2014-16, and analyzed the effectiveness of using chlorophyll and sea surface temperature as a proxy for these blooms. By linking past records of HAB events with locations of agriculture facilities and their phosphorus and nitrogen watershed outputs, we were able to combine remote sensing techniques with GIS, and ultimately provide a product that displays a time series trend of HAB hotspots in the Chesapeake Bay. Research questions: Can we remotely sense HABs using chlorophyll and SST as a proxy? Where and when are HABs most likely, and what other factors are blooms contingent upon?

PROCEDURES

This project utilized available MODIS Aqua A Level 3, 8-day chlorophyll-a imagery for July through September of 2015-16, as well as NOAA AVHRR daily 2km SST imagery. Statistical analysis of these data sets were performed and compared to in-situ water measurements and records of blooms, in order to assess the accuracy of remotely sensing these phenomena. 

- Using PCA, a Region of Interest was created to isolate the lower Chesapeake.
- Subset of ROI to extract statistical. A mask was created in the statistics to ignore superfluous values. Data input range of 0.5 – 150 mg m^-2 for chlorophyll-a imagery and 5 – 35°C for SST were set to obtain reasonably accurate statistical output.
- Histogram was analyzed, and max and mean values were derived from statistics for each day. These values were graphed to determine a correlation between dates of recorded blooms and dates with high sea surface temperature and chlorophyll-a values.

In situ water quality data obtained from Chesapeake Bay Water Quality Database. Chlorophyll, water temperature, total dissolved nitrogen, and total dissolved phosphorus graphed over time. These values were compared to values derived from remote sensing data to assess accuracy, and help see if there is a correlation between high values and bloom data.

In ArcMap, Chesapeake Bay phosphorus and nitrogen output data, point sources of nutrient pollution outputs and priority agriculture watersheds, as well as HAB reports from Virginia Institute of Marine Science, and Eyes on the Bay, were digitized.

HABs were then appropriately classified based on date recorded, species, and concentration in salinity. Qualitative symbology was applied to degrade marks by size and value. This data was overlaid on chlorophyll concentration rasters for each month within the studied time periods. This provides us with accurate insight about the influence nutrient outputs from agriculture has on bloom events.

Kernel density performed based off HAB event.

This study helps predict HAB prone areas, but also portrays the complications associated with detecting, identifying, and tracking blooms using remote sensing data. It is of high importance to facilitate improvements in our research.

- Most blooms occur where chlorophyll concentrations are highest.
- Different species thrive in different regions of the Bay as well as times of the year.
- One of the main overlooked constituents of HABs is location of agricultural facilities and their relative phosphorus and nitrogen outputs. All blooms observed occur within an agricultural watershed, or next to a source facility where nutrient concentrations are highest.

The remote sensing of blooms generally requires sensors with a 4-day temporal resolution, as well as 4km spatial resolution and 7-10 key spectral bands in the “red edge,” or the red to near infrared portion of the spectrum. The key spectral bands used to sense algal blooms are around 443-555 nm.

MODIS-Aqua has adequate temporal resolution at 2-3 days, but suffers in its lack of key spectral bands in the red edge, as well as its 24km spatial resolution. This prevents it from distinguishing between cyanobacteria and the other species that make up harmful algal blooms. Moving forward, The European Space Agency has launched Sentinel 3-a, which has adequate spatial and temporal resolution, and has begun seeing our study area using a band range incorporating a “cyanobacteria index” that will enable more accurate remote sensing of bloom species.

CONCLUSIONS

Can we use MODIS chlorophyll and AVHRR SST imagery to accurately track and sense HABs?

Figure 5. Region of interest for statistical study of area with the most frequent and clustered HAB events over our time period of interest. VRSS 750m satellite imagery.

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Average Chlorophyll Concentration in Surface from Jul.- Sep. 2016

Average Surface Water Temperature from Jul.- Sep. 2016

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Average Surface Water Temperature from Jul.- Sep. 2016

REFERENCES

1. US & Canada: 1-800-790-4001

2. HABs in the Chesapeake Bay database.

3. “Marine Ecosystems and human health.”


• Statistical analysis showed a strong correlation between chlorophyll-a concentrations and recorded blooms.

• Kernel density map based on clustering of bloom events. Darkest red areas show where blooms have occurred most often for the given month 2014-16.

• This can be used to help predict which species will occur as well as where and when based off of past events.

Using HABs as a proxy to chlorophyll, we further hypothesized that HAB events would have occurred on days with the highest values of Chlorophyll-a.

There are events where these conditions hold true, however there are HAB events where the statistics are very low instead. This graph shows the high variability in chlorophyll-a from day to day by month portraying the difficulties in sensing and tracking blooms as a proxy to chlorophyll.

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