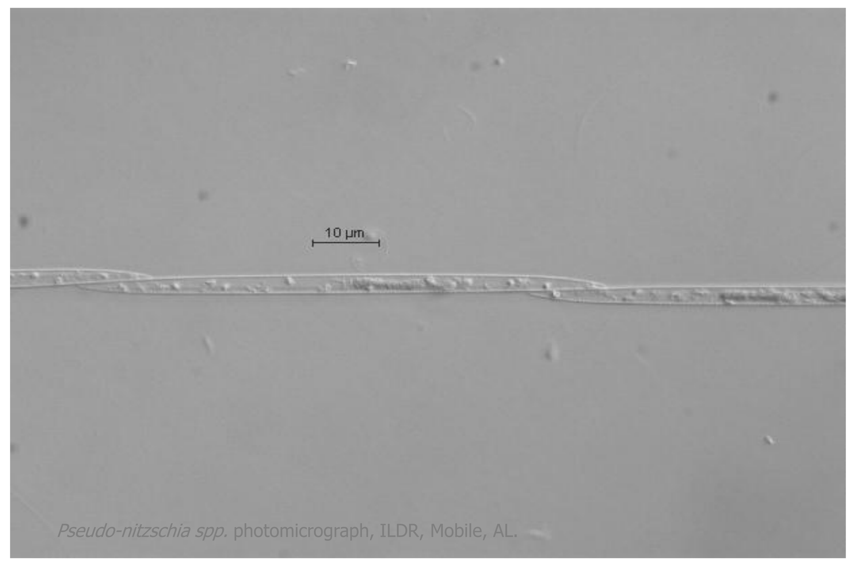


# USING SEAWIFS AND IN SITU DATA FOR HAB PREDICTION IN THE NORTHERN GULF OF MEXICO: DECISION TREE ANALYSIS

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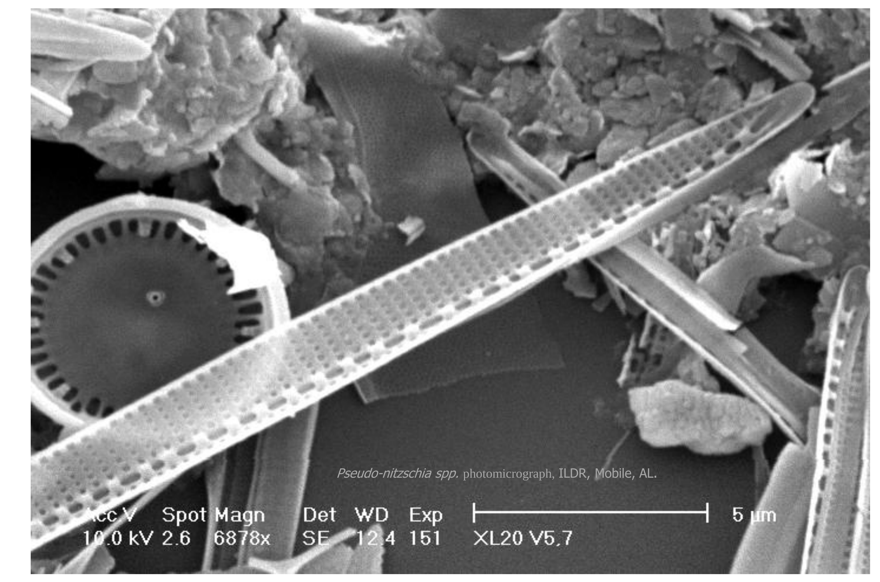




## ABSTRACT

To date, 13 potential HAB species have been detected in coastal waters of Mississippi and Alabama, including representatives of the diatom genera *Pseudo-nitzschia* and *Chaetoceros*, and dinoflagellate genera *Karenia*, *Gonyaulax*, *Akashiwo*, *Karlodinium*, and *Prorocentrum*. This study investigates the potential of satellite remote sensing (SeaWiFS) to predict environmental conditions leading to the formation of HABs in these turbid coastal waters. Phytoplankton populations and water quality were monitored in situ at 3 to 6 week intervals and 17 locations in Mobile Bay and the Mississippi Sound from December, 2004, through June, 2006. SeaWiFS imagery corresponding with in situ collections was acquired. Non-parametric multivariate analyses determined relationships between phytoplankton cell counts and in situ or satellite-derived water properties, including surface temperature, salinity, concentrations of chlorophyll, total suspended solids, colored dissolved organic material, and nutrient levels. This paper will describe an expert system decision tree analysis approach to prediction of ecological conditions necessary for the formation of HABs. The model assumes unique ranges of remote sensing reflectance ratios, Chl *a*, and total suspended solids must exist within the environment are conducive in the formation of HABs.

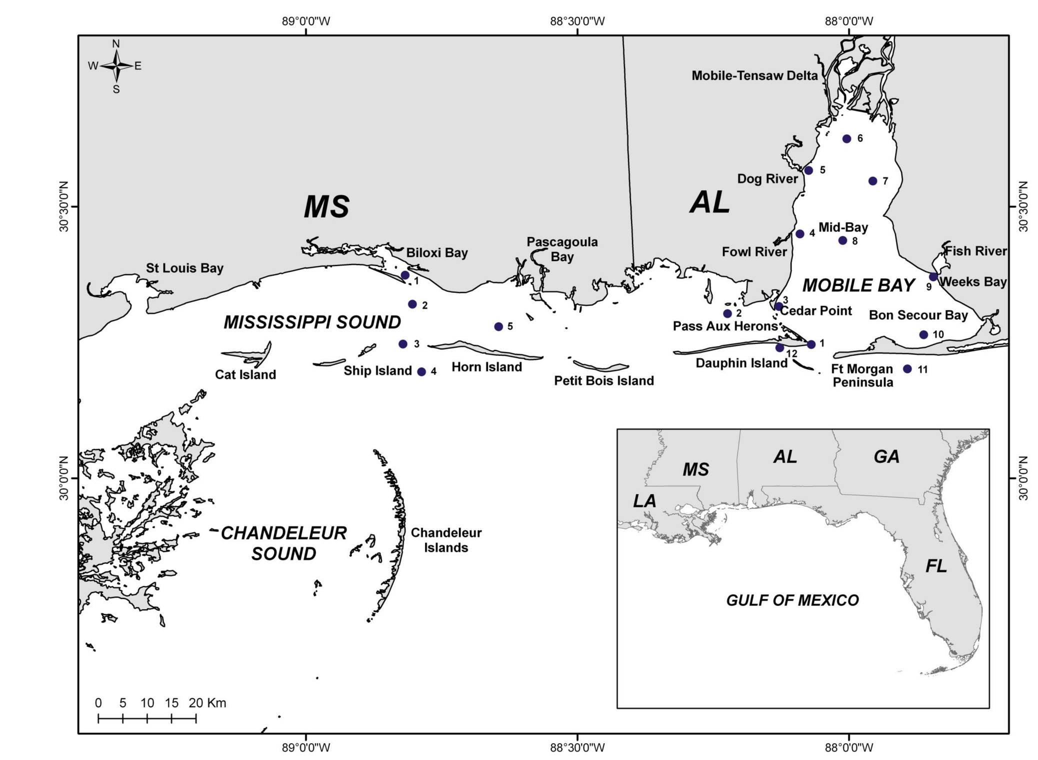


Fig. 1. Location of 17 monitoring sites, 12 in Mobile Bay and 5 in the Mississippi Sound.

## METHODS

- Microalgal populations were sampled at 3-6 week intervals.
- 17 sites, 12 in the Mobile Bay area and 5 in the MS Sound. Stations encompass major hydrologic regimes of Mobile Bay and MS Sound (Fig.1).
- Data were collected from December 2004 through June 2006.
- Taxa and cells/L data analyzed by Bill Smith and Carol Dorsey of the Alabama Department of Public Health in Mobile, AL.

In situ water data from DISL included-

- Sea surface temperature, Chl *a*, total suspended solids, and $NO_3$, $NO_2$, $NH_4$, $PO_4$, DON, DOC, DIC, DOP, PC,PN, PP.

SeaWiFS 1-km satellite data from NRL included-

- Chl *a*, Total Suspended Solids concentration (TSS), CDOM absorption (at 443 nm), detrital absorption (at 412 nm), phytoplankton absorption (at 443 nm), remote sensing reflectance at six wavelengths (412, 443, 490, 510, 555, and 670nm), and Rrs ratios of 670/555, 555/443, and 555/490.
- Principle Component Analysis within SPSS and cluster analysis, multi-dimensional scaling, ANOSIM and SIMPER analysis tests within Primer v6 software used to determine relationships among in situ, remotely sensed, and population data (results not shown).

- ENVI v4.3 used to develop and test decision tree analysis. Pixel classification and results created graphically using ENVI and ArcGIS for final graphic representation.

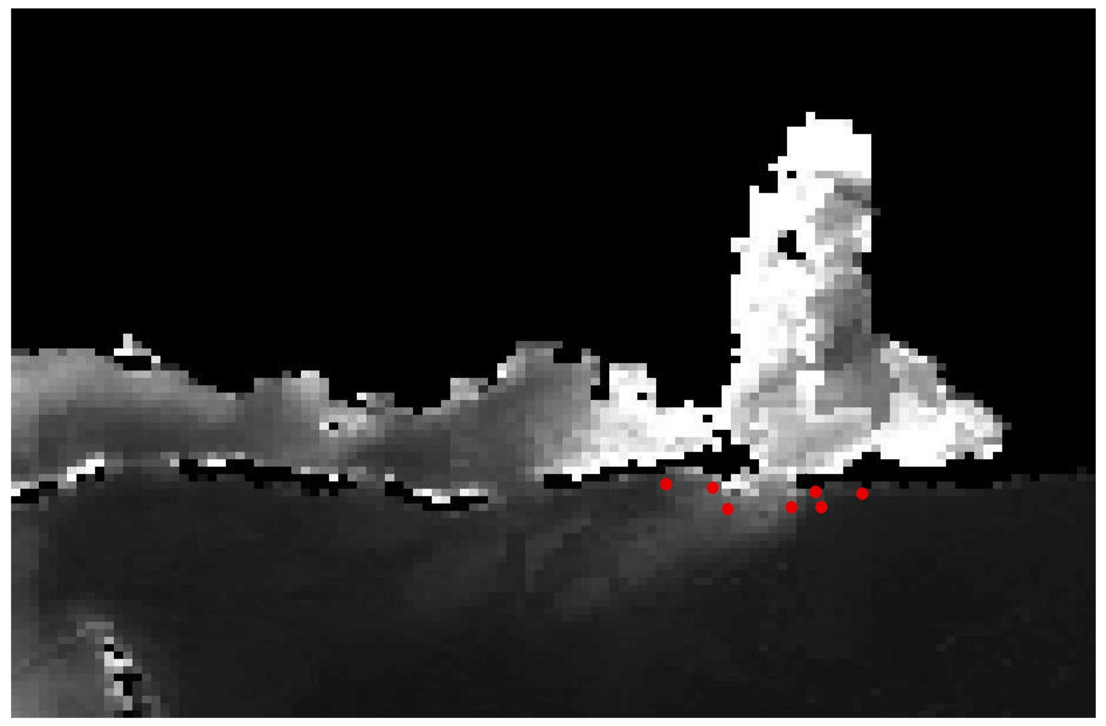

Figure 1. SeaWiFS image from May 6, 2005. Shown is remote sensing reflectance at 670 nm, 1 km resolution. Red dots indicate locations of in situ collections.

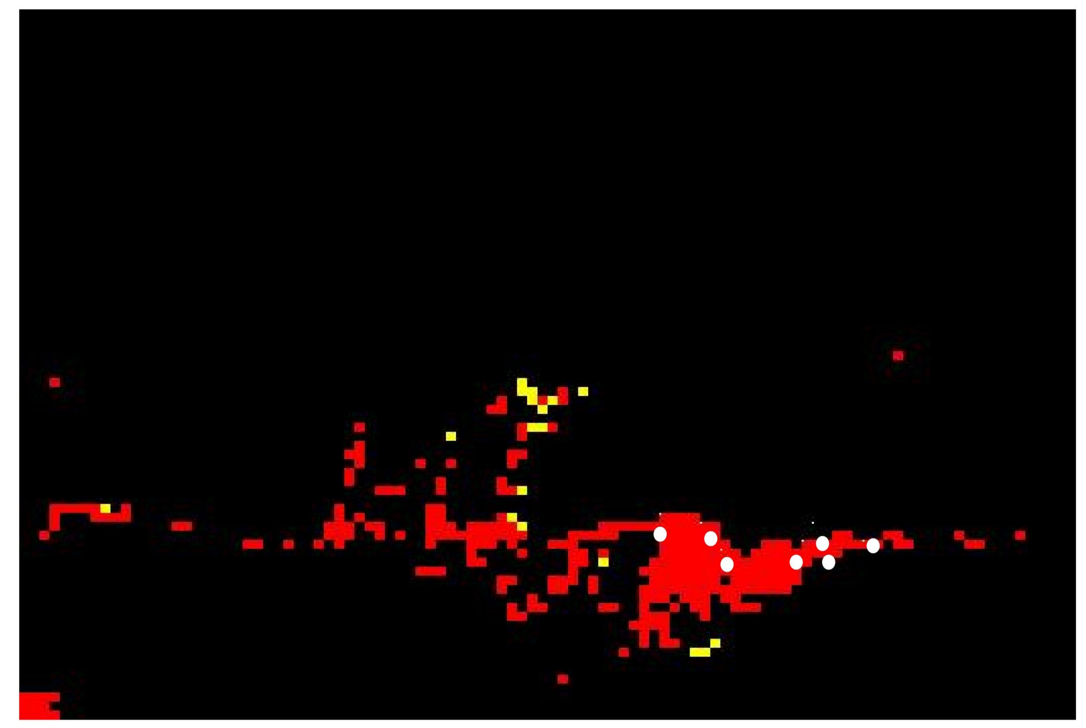

Figure 2. Results from decision tree analysis, using *Pseudo-nitzschia spp.* counts from May 6, 2005. White dots indicate location of in situ collections.

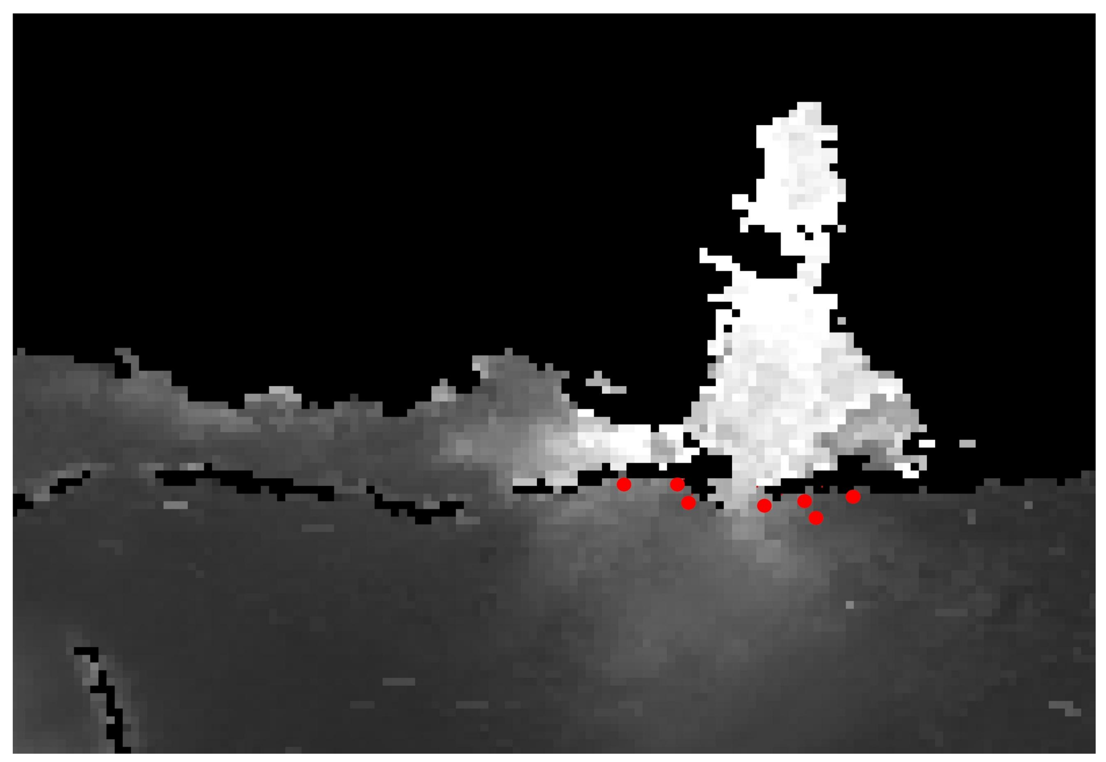

Figure 3. SeaWiFS image from April 4, 2005. Shown is remote sensing reflectance at 670 nm, 1 km resolution. Red dots indicate locations of in situ collections.

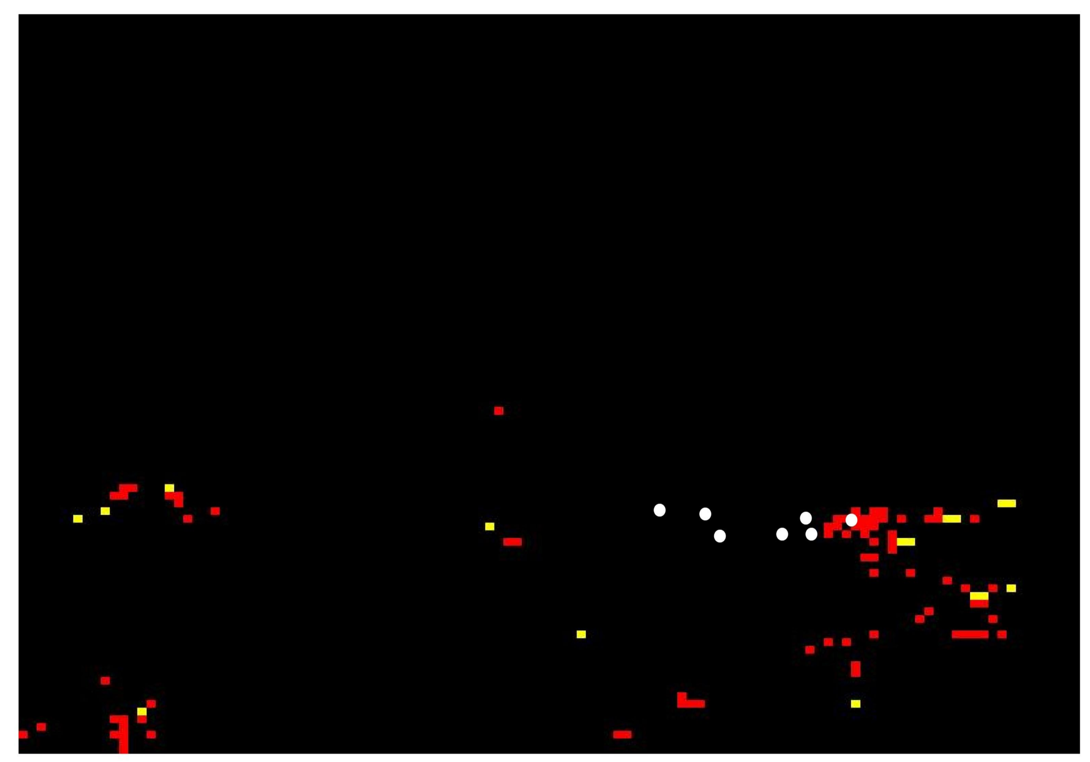

Figure 4. Results from decision tree analysis , using *Pseudo-nitzschia spp.* counts from April 4, 2005. White dots indicate location of in situ collections.

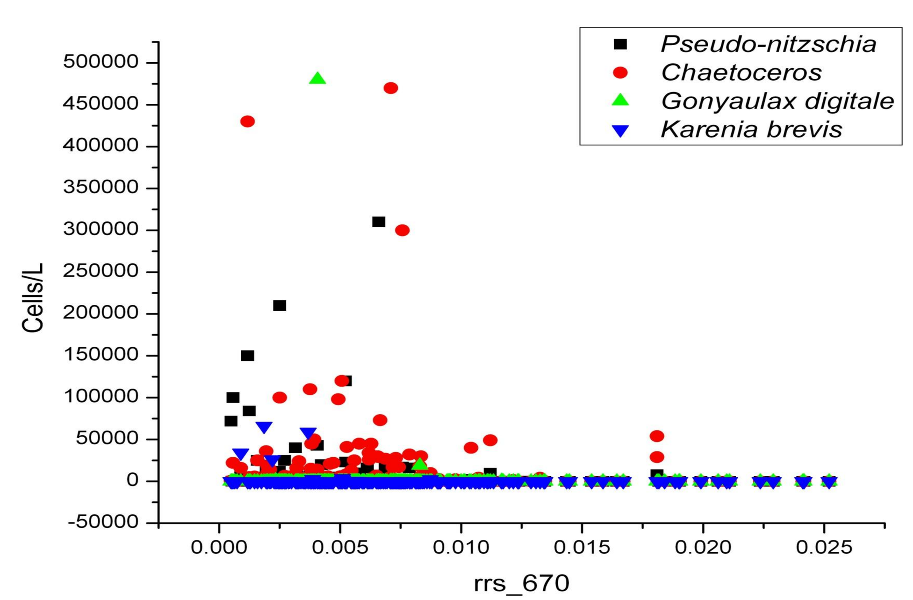


Figure 5. Graph showing the distribution of phytoplankton species when compared with remote sensing reflectance at 670 nm measured by the SeaWiFS sensor.

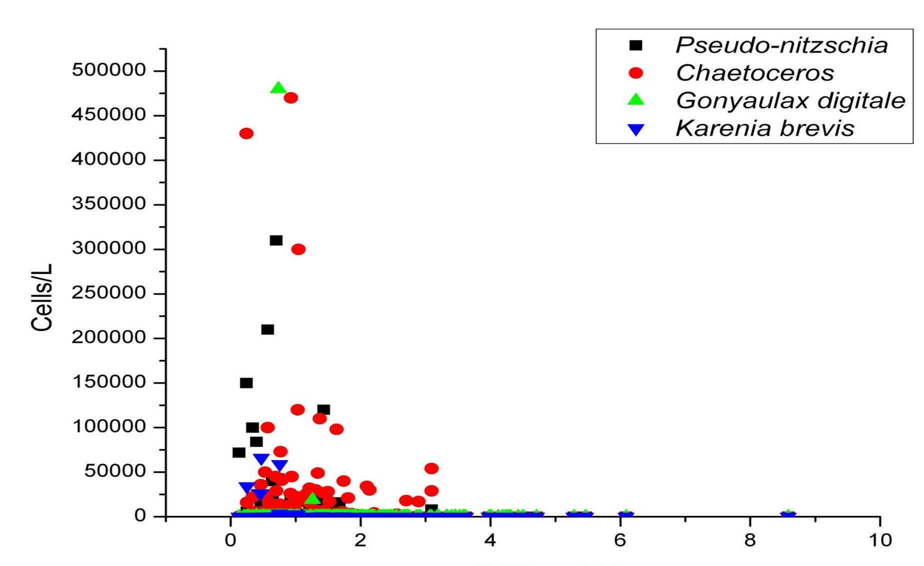


Figure 6. Graph showing the Gaussian distribution of phytoplankton species cell counts with remote sensing reflectance ratios at 670 and 443 nm. Note difference in ratio values.

## RESULTS

Phytoplankton population surveys showed high diversity, with samples often being comprised of tens of genera and more than 100 species. Collections represented 13 phyla and 79 genera. However, some species were observed at notably higher numbers. Post-Hurricane Katrina *Pseudo-nitzschia spp.* bloom collections in May of 2005 were chosen for testing due to high numbers of cell counts per unique water sample (>1 X $10^6$ cells/liter) and corresponding clear skies for sensor data retrieval (Figures 1 and 2). SeaWiFS imagery used as a test for negative *Pseudo-nitzschia spp.* collection periods (i. e. few (<20,000) or no *Pseudo-nitzschia spp.* within samples) was from collection of April, 2005 (Figures 3 and 4). SeaWiFS-derived values exhibited poor linear relationships when directly compared with in situ measurements, expected in turbid near-shore waters of the northern Gulf of Mexico. However, peak population counts of *Pseudo-nitzschia spp.* exhibited Gaussian relationships when comparing cell counts and ocean color measurements such as Chl *a*, TSS, and remote sensing reflection at 412, 443, 490, 555 and 670nm wavelengths. Ratios of these values also showed narrow range values correlated with high population cell counts (Figures 5 and 6). Final decision tree analyses used for the purpose of this presentation used minimal data class inputs for clarity. Factors used for the nodes, or branches of the decision tree, were remote sensing reflectance at 412 and 443 nm, and ratios of remote sensing reflectance at 555/490, 555/443, and 670/555 nm (Figure 7). In back testing accuracy of the decision tree analysis with in situ collections, a 78% accuracy of recorded in situ collection sites to decision tree predicted sites was achieved using eight separate sets of unique images and in situ data collections.

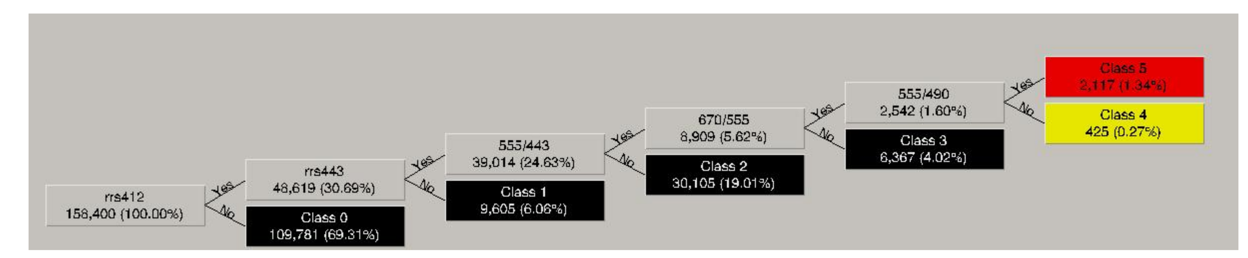

Figure 7. Branches of decision tree as developed within ENVI v4.3. Remote sensing reflectance values were downloaded from imagery processed at the Naval Research Laboratory (NRL) at Stennis Space Center, MS. Data were extracted from NRL image files using the SeaWiFS data analysis software v5.1 (SeaDAS) from NASA Goddard Space Flight Center Ocean Biology Processing Group, converted to ENVI image files, and exported to Microsoft Excel spreadsheets. Ratios were created using Table Curve 2D v5.1 and MS Excel.

## Conclusions

These *preliminary* results show potential in allowing an elegant and relatively simple decision tree analysis model system to predict the geographical location and movement of phytoplankton species within the turbulent waters of the Mississippi Sound and Mobile Bay area. This decision tree analysis allows unique data value inputs from sensor-derived, synoptic spatial coverage at broad spatial scales to be used as rapid inputs to the model rather than traditional and costly (in time and funding costs) in situ data collections from ship or shore transect collections. When used in conjunction with field data collections such as those carried out by state and regional marine resource programs, it is a potential tool for understanding the likelihood of locating phytoplankton populations at locations with high cell per liter counts. This example used *Pseudo-nitzschia spp.* as the base for the model due to the potential of this species as a toxin producing harmful algal species to cause wide-scale problems in the future. In May of 2005, the domoic acid produced by this genus caused a closure of Alabama shellfish beds for the first time in the history of the region. Tools such as this may allow a supplemental appraisal for managers to monitor conditions leading to potential formation of harmful algal blooms of phytoplankton populations in these turbid waters.

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