Seasonal Variations in Phytoplankton Community Structure in the Gulf of Maine near Cape Ann, MA

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Phytoplankton are primary producers that support marine ecosystems including oceanic fisheries around the world. However, rapid growth of some phytoplankton species can result in harmful algal blooms which are toxic to fish, shellfish, birds, marine animals and humans. Therefore, monitoring and understanding changes in the species composition of phytoplankton populations provides information critical to the development of healthy marine ecosystems and coastal communities.

Phytoplankton taxa contain a characteristic composition of pigments in their chloroplasts such that each taxon displays a unique absorption spectrum. These pigments ultimately pass their absorbed energy to chlorophyll, which fluoresce proportional to the magnitude of the transmitted energy. Consequently, phytoplankton taxa fluoresce with varying intensities in response to different wavelengths of light due to variations in pigment concentration and composition. Thus, fluorescence ratios provide unique signatures represented by different regions in a fluorescence ratio-ratio space plot that can function as a proxy for phytoplankton taxonomic composition[1]. The variance to mean ratio[2] (VMR) also functions as a proxy for cell size. For the same biomass concentration, a few large cells with large signal exhibit more variance than more, uniformly concentrated small cells with lower fluorescence signals, such that larger cells yield a larger VMR.

Three wavelength fluorometer (F3WB) on the Northeast Regional Association of Coastal Observation System's Buoy A near Cape Ann, MA collected ~35 fluorescence measurements (DC) in response to 435nm, 470nm, 532nm excitation every hour from July 2016 – June 2017. The variance to mean ratio was calculated over each burst of samples and the median values of each burst were used to compute the fluorescence ratios. Taxonomic data, collected monthly by Doug Hirsh of the Massachusetts Water Authority, quantified the abundance of each phytoplankton species identified in water samples. Taxonomic data were used to identify diatom and dinoflagellate regions in ratio-ratio space. Diatom, dinoflagellate and microflagellate regions were defined by the range of fluorescence ratios exhibited by phytoplankton populations that were classified as > 50% diatoms, dinoflagellates or microflagellates, respectively.

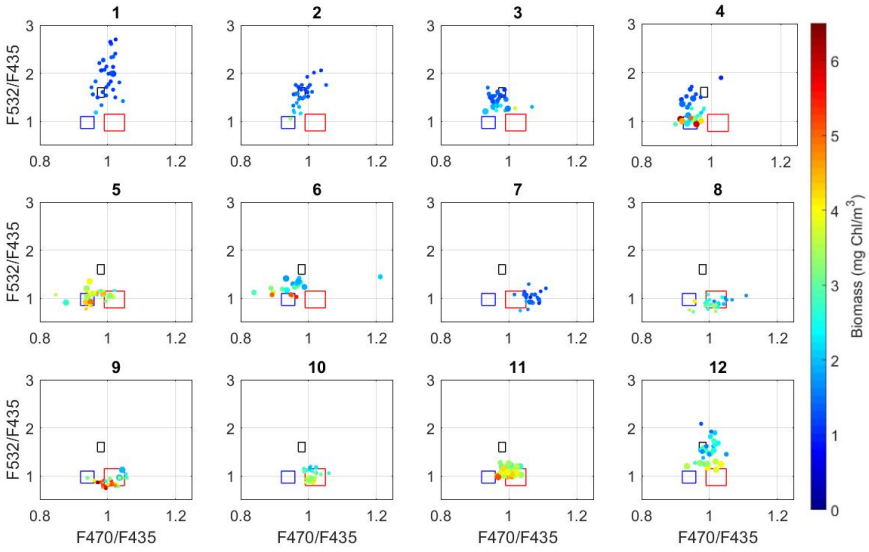

Figure 1. Monthly F470/F435 vs F532/F470 plots for Jul7 2016 – June 2017 derived from daily median fluorescence values. Symbol color represents biomass (mg Chl/m^3). Symbol size represents phytoplankton cell size. Red, blue and black boxes represent dinoflagellate, diatom and microflagellate regions, respectively, identified using taxonomic data. Number above each graph indicates month.

Movement through ratio-ratio space over time (Fig. 1) indicates an evolving pigment-based phytoplankton community composition and therefore a changing phytoplankton community composition[3]. Fluorescence signatures suggest that diatoms dominate the spring bloom, dinoflagellates dominate the fall bloom and microflagellates comprise part of the low biomass winter community in the Gulf of Maine near Cape Ann, MA (Fig 1). The variance to mean ratios suggest that the spring diatom bloom is composed of mostly large cells and the fall phytoplankton bloom is dominated by small dinoflagellates from September to October. However, the dominant phytoplankton cell size increases in November and December. Additionally, cell size decreases in July and August after the spring bloom. These results are consistent with the concept that larger phytoplankton will dominate the community when the surface nutrient concentration is high and smaller phytoplankton will dominate when the surface nutrient concentration is low. Extending the fluorescence time series would reveal whether the phytoplankton species composition follows a similar evolution every year. Monthly or weekly pigment data at Buoy A would also allow for a more robust validation of fluorescence signatures of different phytoplankton taxa.

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