Investigating the relationship between phytoplankton fluorescence and bloom composition in Harpswell Sound

Caitlin Stratton, Class of 2013

Phytoplankton are single-celled aquatic photosynthesizers, which use Chlorophyll a (chl a) to convert light into energy. Because chl a cannot absorb green underwater light, phytoplankton produce taxonomically-unique green-absorbing accessory photosynthetic pigments that can. These pigments change the absorption spectra and associated fluorescence response, allowing for taxonomic identification. My project focuses on using the 3X1M, an instrument which measures chl a fluorescence in response to excitation at three wavelengths (435nm, 470nm, 532nm). The goal is to use these observations to identify taxonomic changes in phytoplankton blooms, based upon their pigmentation and fluorescence response difference. The specific application is to identify transitions between the common, harmless diatoms and the potentially Red-Tide-causing dinoflagellates, by looking at changes in their characteristic pigments, fucoxanthin and peridinin, respectively.

The first step I took was to convert the fluorescence data into two usable forms: a ratio, (to compare to pigment ratios), and chl a concentrations, (to compare to other chl a concentrations). Determining the chl a concentration involved applying calibration coefficients determined from monospecific phytoplankton cultures (Proctor, 2008; P. Thibodeau, pers. Comm.). Then, I compared the chl a concentration from the pigment analysis to the concentration calculated from fluorescence. The overall trends were very similar, as were the timings of peaks in concentration, although the relative peak heights were not consistent. Specifically, I encountered two major peaks, with some areas where the two concentrations appeared dissimilar. (Figure 1) We hypothesize that these variances may be due to fluorescence quenching, as high light levels can inhibit cell fluorescence, causing the cell to emit less fluorescence per molecule of chl a, which leads to the fluorescence underestimating the amount of chl a present. Other sources of variations between the measurements might be due to changes in species composition.

The next step I took was to determine a fluorescence ratio by dividing the reading at 435nm by the reading at 470nm. Then, using the ratios characteristic of diatom versus dinoflagellate species in the laboratory, I was able to estimate a value above which the phytoplankton population changed from dinoflagellate-dominated to diatom-dominated. (Figure 2) Then, we compared the fluorescence ratio to a ratio of the concentrations of two indicator pigments: fucoxanthin, a pigment found in diatoms but not in dinoflagellates, and peridinin, a pigment found in dinoflagellates but not in diatoms. I hoped to see that, when the fluorescence ratio went up (indicating a higher relative concentration of diatoms) we would see an increase in the fucoxanthin:peridinin ratio (indicating an increase in diatoms and/or a decrease in dinoflagellates), and vice versa. We chose to focus on the seven sampling days between June 29th and July 20th, when the pigment concentrations showed separate blooms of both dinoflagellates and diatoms. When these seven days were graphed on their own axis, a clear visual correlation was present between the fluorescence ratio and the pigment ratio (Figure 3). To assess the validity of this visual connection, I used nonparametric statistics to graph how well a change in one predicted a change in the other, and found a strong correlation, indicating that it is possible to use fluorescence ratios as a proxy for changes in pigments, and thus, for changes in phytoplankton community composition. (Figure 4)

The next step of this project is to add cell counts determined by microscopy to further validate the mathematical relationship, and to deploy a 3x1m sensor on the buoy. Then, we could record fluorescence taken hourly for the entire 9-month deployment of the buoy, allowing us to get a full picture of phytoplankton in the sound throughout the year, and to use fluorescence as an early warning system for dinoflagellate-rich blooms, and thus, Red Tide.

Faculty Mentor: Collin Roesler
Funded by the Howard Hughes Medical Institute Fellowship