Patterns and Variations in Phytoplankton Pigment and Nutrient Compositions in Harpswell Sound, ME

Siena Wiedmann, Class of 2020

Phytoplankton support marine trophic systems and biogeochemical cycles in aquatic environments. However, the species composition of phytoplankton changes in response to light and nutrient limitations which can ultimately affect fishing industries and our consumption of seafood. Thus, it is important to monitor the changes in phytoplankton community structure and nutrients over time in response to variations in oceanographic properties. In Harpswell Sound (HS), phytoplankton communities vary in composition throughout the year which allows for a diverse marine trophic environment and a robust fishing industry. The seasonal cycle is most often dominated by diatoms and dinoflagellates. Diatoms dominate the bloom while silicate is present and dinoflagellates follow after the diatoms, using the remaining nitrate and phosphate. The complexities of the community structure underlying the seasonal cycle are not fully understood. Using a time series of phytoplankton pigments (a proxy for phytoplankton taxonomy) and nutrient data in HS from 2008-2017, I analyzed the changes and patterns in phytoplankton pigments and nutrients over time to gain an understanding of the complexity within the phytoplankton community structure in HS.

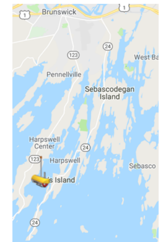
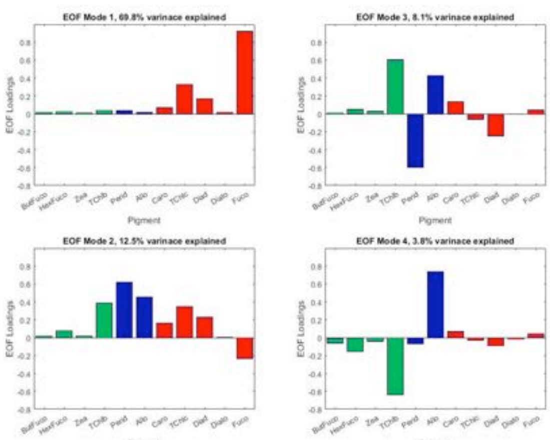


Figure 1: Map of Harpswell Sound estuary with the location of the LOBO buoy marked (yellow buoy).

Water samples were collected about once per week from February to November (monthly data changes with each year) from the LOBO buoy in HS (Figure 1). Water samples were then filtered at Bowdoin College and filters were sent to NASA for filtrate analysis, generating nutrient data and High Pressure Liquid Chromatography (HPLC) analysis, generating pigment concentration data (each pigment correlates with specific phytoplankton taxa). Both raw data and mean centered data for pigment and nutrients were analyzed. Cluster, Empirical Orthogonal Function (EOF), and other analyses were performed on MatLab version 9.2.

A hierarchical cluster analysis was performed using a correlation distance 1-R (R=Pearson's correlation coefficient between pigments) and Ward's linkage method to further explore the co-variance of pigments in time. The cluster analysis generated three clusters of co-varying pigments: (1-green) green algae, pelagophytes, haptophytes, and cyanobateria, (2-blue) dinoflagellates and cryptophytes, and (3-red) red algae and diatoms. These results matched the results of the pigment EOF analysis.



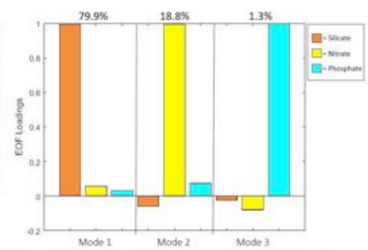


Figure 2: EOF pigments (left) and nutrient (right) analyses results. The bars for the pigment EOF are color coded based on the results from the cluster analysis. The percent variance explained by each mode are displayed above each plot. The legend for the nutrient EOF describes which nutrient dominates each mode (shown as subplots).

The EOF analysis identifies temporal covariance between variables (pigment/nutrient) with each mode contributing to the total variability (Figure 2). Each mode is represented by loading numbers assigned to each pigment/nutrient, conceptually showing how much each contributes to each mode. The pigment EOF showed that diatoms explain the largest proportion of variance. The other modes were significant, but explained less variance. Each mode matched the cluster analysis with Mode 2 dominated by dinoflagellates, green algae, and cryptophytes, Mode 3 dominated by cryptophytes and green algae, and Mode 4 dominated by cryptophytes. The nutrient EOF showed silicate describing the largest variance (matching Mode 1 from the pigment EOF dominated by diatoms) followed by nitrate, and finally phosphate. The results from both EOF analyses and the cluster analysis determined the overarching variation in the phytoplankton community structure in HS and confirmed the tripartite nutrient regime in the estuary.

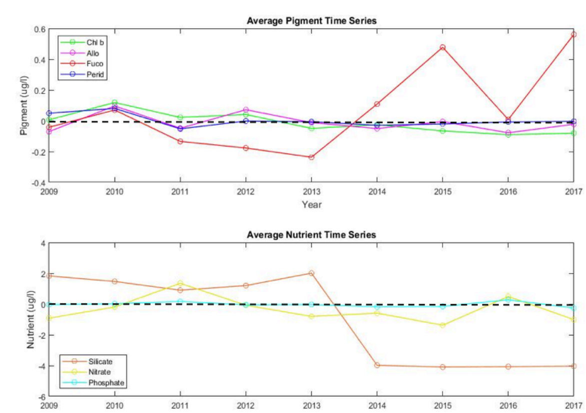


Figure 3: Annual average pigment values and nutrient values from 2009-2017. Each data point represents the average from that year. Lines between data points help to distinguish trends.

After determining the phytoplankton community structure and nutrient regime in HS, I examined the change in this phytoplankton community structure over time by looking at annual averages of the four dominant pigments (mean centered values) identified in the EOF analysis from 2009-2017. Based on the annual averages, diatoms have been increasing in concentration since 2013, excluding a decrease in concentration in 2016 while other pigments have been decreasing in concentration. This indicates a loss in biodiversity in the phytoplankton community. This significant increase in diatoms also caused a decline in silicate values, remaining well-below the mean from 2014-2017. For future analyses the loss in biodiversity in the phytoplankton community should be compared with potential loss in biodiversity within upper marine trophic levels. Shifting nutrient regimes should also be expanded outside of the GOM to see if lower silicate levels expands beyond HS. Additionally, analyses should be conducted on the secondary and tertiary pigments to determine taxonomic trends underlying the primary pigment analyses.

Faculty Mentor: Collin Roesler
Funded by the Kibbe Science Fellowship

Reference: Catlett, D., and D. A. Siegel. "Phytoplankton Pigment Communities Can Be Modeled Using Unique Relationships With Spectral Absorption Signatures in a Dynamic Coastal Environment." *Journal of Geophysical Research: Oceans,* vol. 123, no. 1, 2018, pp. 246-264