Analyzing Absorption Spectra to Quantify the Source and Concentration of Dissolved Organic Matter in 4 Rivers in Maine

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For my Rusack Coastal Studies Fellowship, I used optical properties of dissolved carbon to analyze the quantity and quality of carbon in the major rivers in Maine and New Brunswick, Canada. To do this, I examined how the absorption spectra of water samples changed along each river and across all four rivers. I spent two weeks of my fellowship in the field taking water samples and fluorescence measurements from the sixty sites along four rivers, the St. John, the Androscoggin, the Penobscot and the Kennebec. Beyond my time in the field, I spent about half of my time processing the absorption spectra in lab and the other half analyzing my results. Absorption spectra are created when a spectrophotometer is used to shine individual wavelengths of light through a water sample. A detector on the opposite side of the water sample measures how much light was not absorbed by the dissolved carbon in the water sample and, by subtracting the detected light from the incident ray, creates a spectrum of how much light the dissolved carbon absorbs at all of the wavelengths between 200 and 900 nm. As there is more dissolved carbon in the sample, more light will be absorbed and the absorption spectra will be shifted upwards. As the material is more broken down and refractory, the slope of the spectra will increase. Using MatLab, a computer programing and data analysis software, I created a program to fit an exponential curve to each spectra and used that curve to determine the slope of the spectra and the absorption of the samples at 374 nm for each water sample. I did this analysis on water samples from every site on all four rivers from the first sampling in April, 2011 through July, 2012.

With this data, I looked for seasonal and geographic patterns in the concentration of dissolved carbon and in the degree of microbial processing. The dissolved carbon in the Saint John River has the largest variation between sites for each month, as the sample from the most downstream site had an absorption at 374 nm of almost 40 m$^3$ for several months, whereas the most upstream site had absorption measurements under 5 m$^3$ for all of the months measured. Throughout all four rivers, the concentration of colored organic carbon increased from the upstream sites to the downstream sites, perhaps indicating that agricultural areas downstream cause an increase in organic carbon.

In terms of the degree of degradation or processing of the carbon along each river, I found that the magnitude of the slopes decreased from the headwaters to the mouth of each river, meaning that the material is more processed and broken down near the headwaters of the river and fresher and less refractory near the mouth of the river. Similar to my analysis of carbon concentration, this could suggest that there are more agricultural areas near the mouths of the rivers, where fresh soil runs off into the rivers. Looking at larger geographic patterns, I found that the highest concentration of dissolved carbon was in the most northern river, the St. John, and the lowest concentration of dissolved carbon was in the most southern watershed, the Androscoggin. I struggled to deduce seasonal patterns in my data, as the effects of the run off from early snowmelt this year may not have been captured by the April sampling. A comparison between the 2011 and 2012 results do not show a clear pattern, but hopefully the 2013 results will help clarify whether there is little seasonal variation or 2012 was a unique year.

In the future, I hope to convert my measurements of absorption into the concentration of dissolved carbon in mg/L. With this data along with USGS’s measurements of the discharge of the rivers at each site, I will calculate the flux of dissolved carbon to determine whether sites near tributaries with particularly high or low concentrations of carbon have a significant impact on the main stem of the river. I spent three days of my summer attending an Introduction to Geographic Information Systems, a powerful mapping software that can be used to map land use, watersheds and many other land cover properties. In the future, I hope to obtain the land use analysis of the four watersheds from scientists from Michigan Tech, who are collaborating with Professor Roesler on the NASA study. With this information, along with my calculation of the flux of CDOM, I will be able to confirm my hypothesis that the increase in concentration and the decrease in the refractivity of the dissolved carbon is caused by an increase in agricultural land. I also hope to use this analysis to determine how much urban or manufacturing areas effect the concentration of carbon in the rivers.

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