Timescales of carbonate chemistry variability as observed in sensor pH, pCO2, and chlorophyll fluctuations in comparison to a pH reconstruction in the Gulf of Maine

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Purpose:

Investigating Gulf of Maine seawater responses to natural and anthropogenic forces is critical because it is one of the fastest-warming bodies of water on Earth (Reum, 2014; Pershing et al., 2015). Coastal communities rely on ocean ecosystem services and fisheries, clam, and mollusk flats are at risk due to increasingly stress-inducing conditions. High environmental variability from seasonal changes in temperature, riverine inflow, and primary productivity alongside limited water parameter observations, lead coastal waters to be a major area for research. This project set out to first validate the Schiller Coastal Studies Center (SCSC) seawater sensor system in Harpswell Sound (HS) with seasonal sampling campaigns of pH and total alkalinity (TA). I then calculated 2 carbonate chemistry parameters, TA and aragonite saturation states, using exact measurements from the lab in comparison to measurements from the sensors. This allowed me to identify the limitations of using either data set in these calculations. Next, I graph timescales of sensor data (daily, seasonally, and yearly) to visualize parameter changes of pH and pCO2 and I used linear regression plots of chlorophyll, oxygen concentrations, pCO2, and pH to identify possible sources of variability. Finally, I compare my results and put them in the context of a longer time scale by graphing Crustose Coralline Algae (CCA) proxy pH and temperature data since ~1920.

Methods:

Conducting the sensor validation included first sampling in HS for TA and pH in August and November 2020. These samples were then run in the lab to produce very accurate measurement values. I then calculated a calibration factor by comparing the lab vs. sensor pH to determine its offset and accuracy as identified by McLaughlin et al. (2017). Once the calibration factor was calculated, I applied it to the sensor pH values. Next, I used CO2SYS in Excel to calculate TA and aragonite saturation states with both sensor and exact lab values, comparing both to determine offsets. I then accessed the sensor data that is accessible online (http://scsc-pier-data.s3-website-us-east-1.amazonaws.com) to graph pH and pCO2 on the timescales listed above with the public access RStudio coding platform. I also plotted linear regressions from sensor data of chlorophyll and oxygen with pH and pCO2. Finally, I accessed previously collected pH and temperature data from the CCA to graph them over time since ~1920 in Excel.

Results:

Conducting the validation significantly reduced sensor pH value error to produce measurements that were accurate to 0.000038 pH units in August and to 0.000008 pH units in November, in line with acceptable uncertainty as defined by the EPA (Pimenta et al., 2018). Once graphed, the data suggest that HS

Images:

Picture 1. Eugen Cotei conducting a sampling campaign in November 2020 for TA and pH. The sampling was done on the pier of the Schiller Coastal Studies in Harpswell, ME.

Picture 2. Collected pH (left) and TA (right) samples from the Schiller Coastal Studies Center in Haprswell

References

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