Ocean acidification time-series mooring at Grays Reef National Marine Sanctuary

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Abstract

Operation of the Grays Reef time-series mooring has been a multi-organization effort which has successfully collected high-resolution data since 2006. The mooring is located in the South Atlantic Bight (SAB) offshore Georgia, USA and within the boundaries of Gray's Reef National Marine Sanctuary (GRNMS). It sits along the divide between the inner and middle shelf with water depths of 20 m. Water chemistry is primarily controlled by the middle shelf oceanic dynamics, but during heavy rain events, it can be affected by freshwater plumes coming from the numerous rivers along the Georgia and South Carolina coast. Temperature, salinity and biological activity also play a major role in the pCO_2 variability with seasonal changes being apparent. During summer months, GRNMS acts as a CO_2 source to the atmosphere while during winter months it is a CO_2 sink. The benthic community at GRNMS has proven to be hardy enduring large seasonal swings of seawater CO_2 and pH. Research planned for the sanctuary will be aimed at determining how these organisms cope with the seasonal changes and how they will adapt to rising seawater CO_2 over time.

Monitoring

The NOAA Pacific Marine Environmental Lab (PMEL), The University of Georgia (UGA), The University of Delaware (UDEL) and GRNMS have been involved in monitoring pCO_2 offshore Georgia for many years (Figure 1; organizational chart and Figures 2 and 3). The NOAA Ocean Acidification Program provides the funding for the monitoring efforts while SECOORA provides oversight. PMEL and UGA coordinate the operational systems and monitor data that is transmitted daily. The National Data Buoy Center provides the mooring where the sensors are housed and maintains additional weather sensors on the mooring. The Coast Guard is charged with maintenance related to recovery and deployment of the buoy. GRNMS provides vessel and diver support for sensor maintenance. UDEL is charged with discreet sampling and analysis for quality control purposes as well as underway pCO_2 mapping in the SAB.

The region that encompasses GRNMS is controlled by a complicated mix of mid shelf oceanic dynamics including storm generated freshwater plumes coming from the numerous rivers along the Georgia and South Carolina coast and Gulf Stream intrusions. Temperature, salinity and biological activity play major roles in the SAB pCO_2 variability with seasonal changes being apparent. Recent research along the mid-outer shelf has suggested that the SAB is a CO_2 net sink and the inner shelf acts as a net source releasing CO_2 to the atmosphere.

In an effort to understand this region and its role in the global carbon budget, a monitoring station was established at GRNMS and has successfully collected high-resolution data since 2006. The station currently collects pCO_2 at the air-sea interface and in the atmosphere; seawater pH; surface seawater temperature; and salinity. Surface water samples have also been collected at the site and analyzed for dissolved inorganic carbon (DIC), total alkalinity, (TA), dissolved oxygen (DO), pH and salinity to gain a concept for the TA-salinity relationship. As a result of these research efforts, it has been noticed that there is a distinct relationship between the pCO_2 concentrations and water temperature and salinity. As the seawater temperature increases, so does the pCO_2 (Figure 4) while salinity decreases. This phenomenon has been replicated every year since data collection began in 2006. The average atmospheric pCO_2 as measured at GRNMS is approximately 400 micro-atmospheres (μatm). This concentration is typically exceeded in the water column during the warm summer months forcing CO_2 out of the water into the atmosphere. This data demonstrates the cyclical nature of the middle SAB cycling from serving as a place where CO_2 is stored to becoming a CO_2 source to the atmosphere.

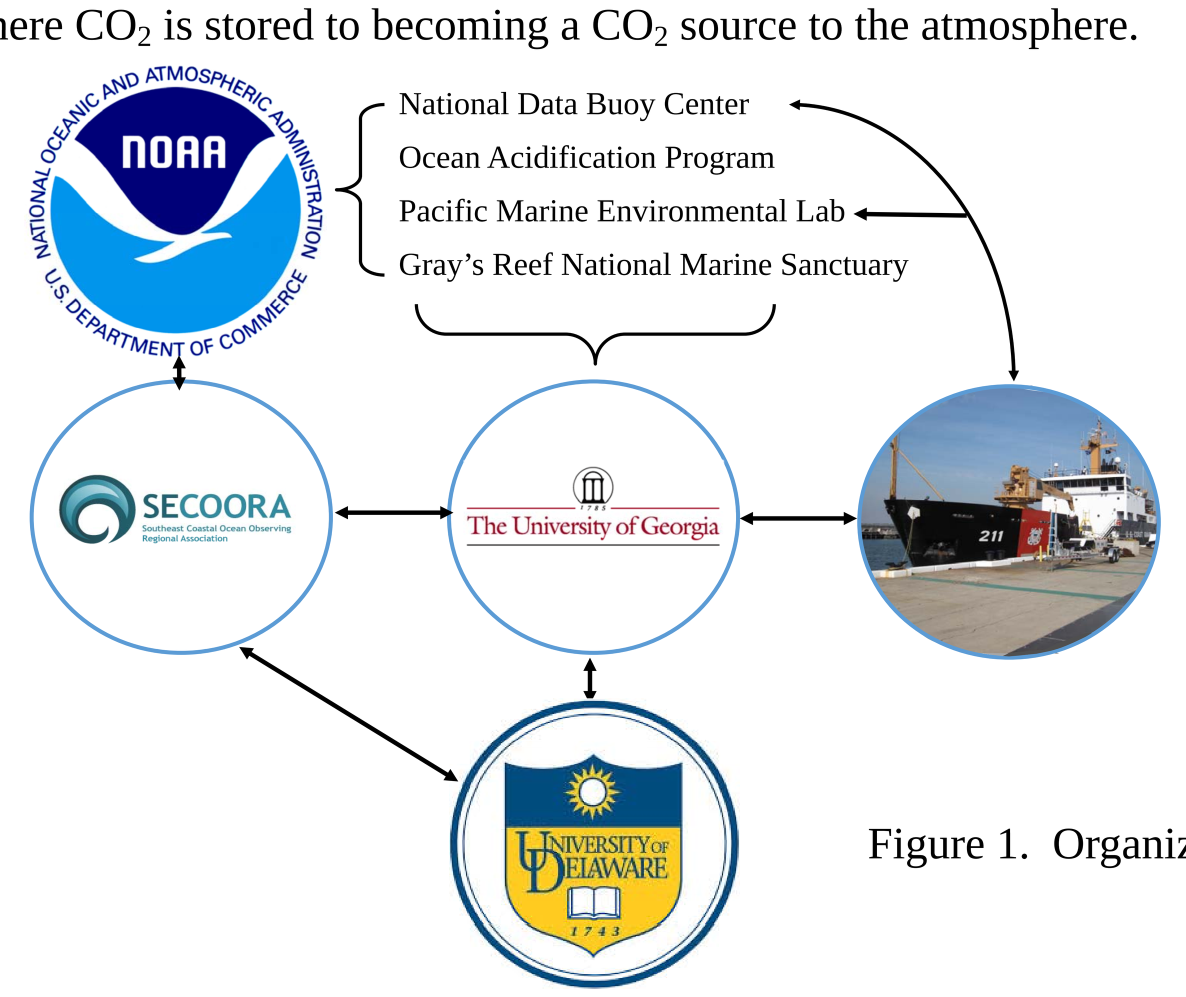

Figure 1. Organizational chart.

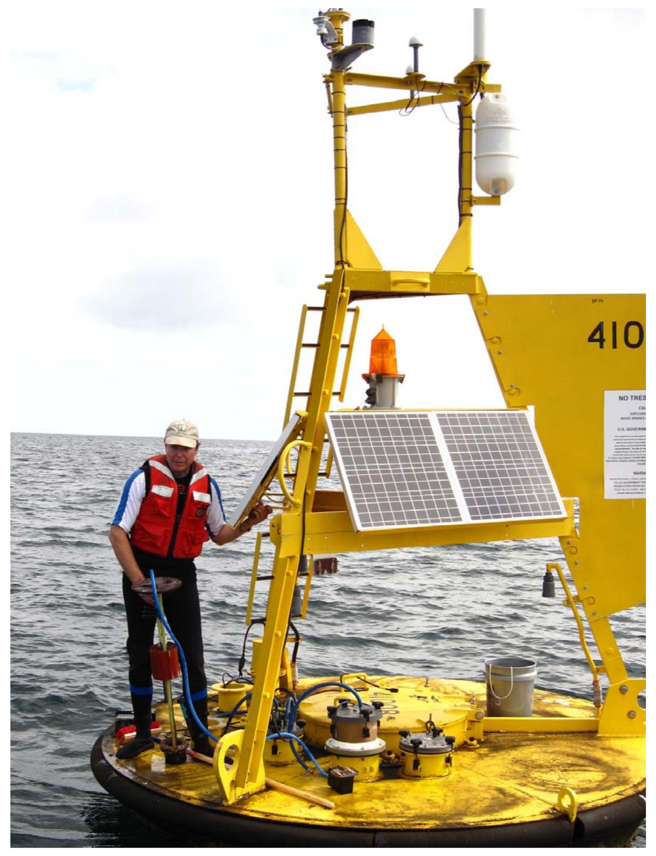

Figure 2. GRNMS buoy.

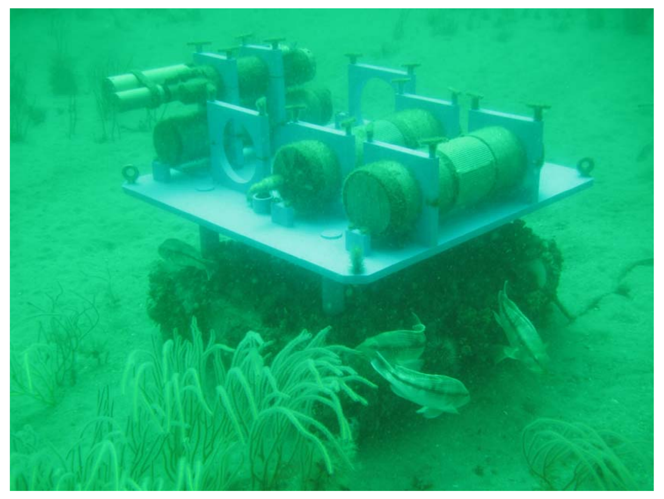

Figure 3 Seafloor sensors.

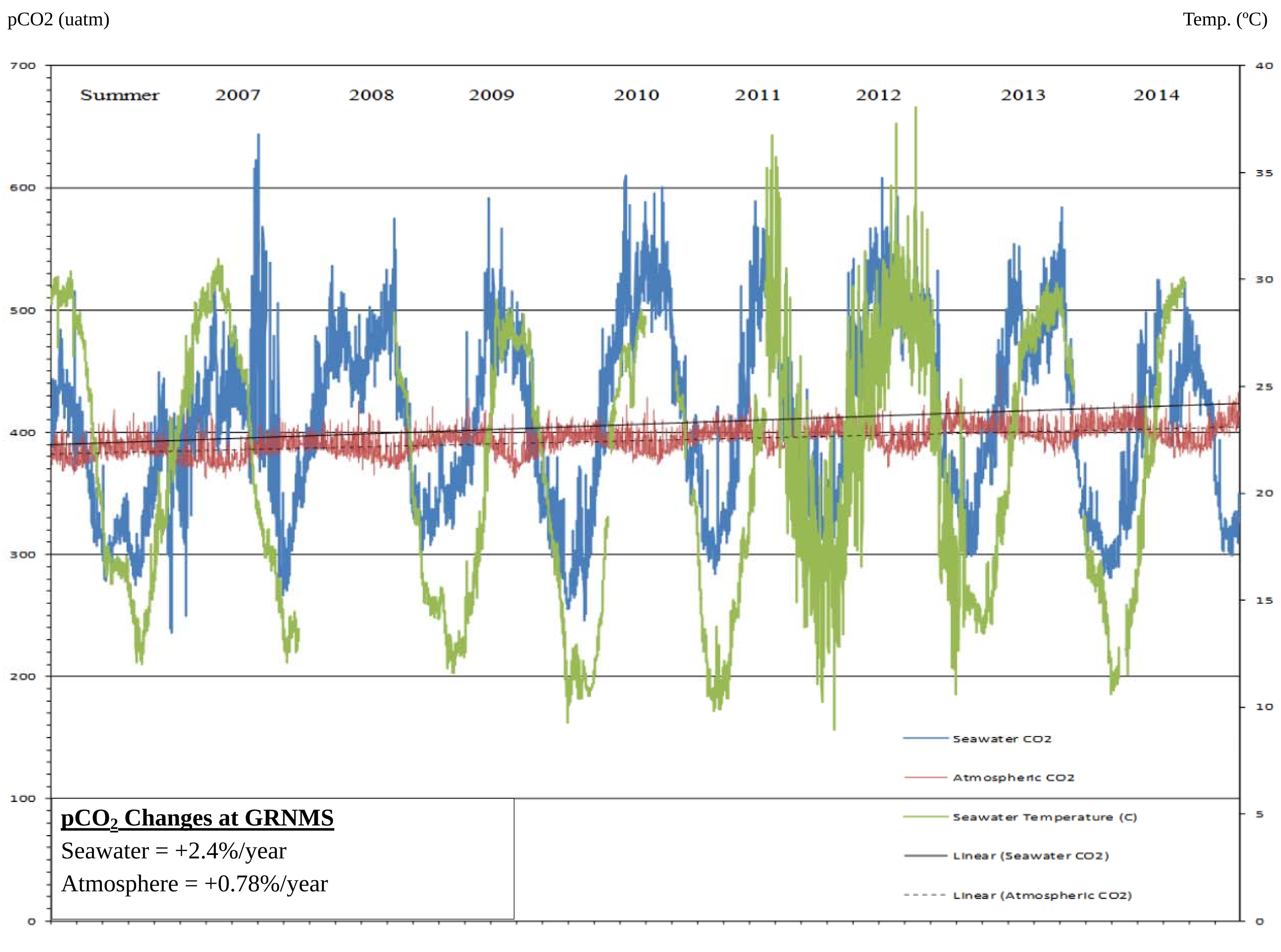

Figure 4. GRNMS time-series data.

Data can be accessed at http://cdiac.ornl.gov/oceans/Moorings/

Results

To date, eight and a half years of mostly continuous monitoring data have been collected at GRNMS (Figure 4). Seasonal swings in seawater and atmospheric pCO_2 are apparent throughout the time series. Elevated seawater pCO_2 concentrations and decreased atmospheric pCO_2 are present during the summer months when the SAB becomes a CO^2 atmosphericsource. In winter months, just the opposite occurs as seawater pCO_2 is lower and atmospheric pCO_2 is higher. At this time, the SAB becomes a CO^2 sink taking in excess atmospheric carbon dioxide. However, aside from the seasonal cyclical pattern, there is an overall upward trend in both seawater and atmospheric pCO_2. Seawater pCO_2 has increased 60 uatm over the time series resulting in an average of 2.4% increase per year. The atmospheric pCO_2 has increased by approximately 20 uatm over the time series resulting in an average of 0.78% increase per year. As part of the ocean acidification network, pH was also monitored. As expected, the pH decreased with the increase in seawater pCO_2 giving an annual seasonal variation of approximately 0.2 on the pH scale (Figure 5).

The annual atmospheric pCO_2 increase at GRNMS is in line with that measured at the Mauna Loa Observatory in Hawaii, however the annual seawater pCO_2 increase was higher than expected. The overall trend for seawater temperature at GRNMS has been flat to slightly negative. Higher summer water temperatures have been offset by lower winter temperatures.

Quality assurance (AQ) measures in place include discrete sample collection for laboratory analysis of DIC, TA, and salinity. In addition, UDEL also installed an underway pCO_2 system on the RV Savannah and collected insitu pCO_2 measurements for several hours at the mooring (Figure 6). Six of these cruises were completed during 2014 and the data is being incorporated into the QA process.

The GRNMS mooring has proven to be a vital and sustainable monitoring station in the coastal mooring program with almost a decade of data collected. In addition, GRNMS is now well positioned to study organismal response to increasing CO_2 and decreasing pH in the environment. With sensors on both the sea surface and seafloor, the benthic community can be assessed for how they will react to an ever changing environment.

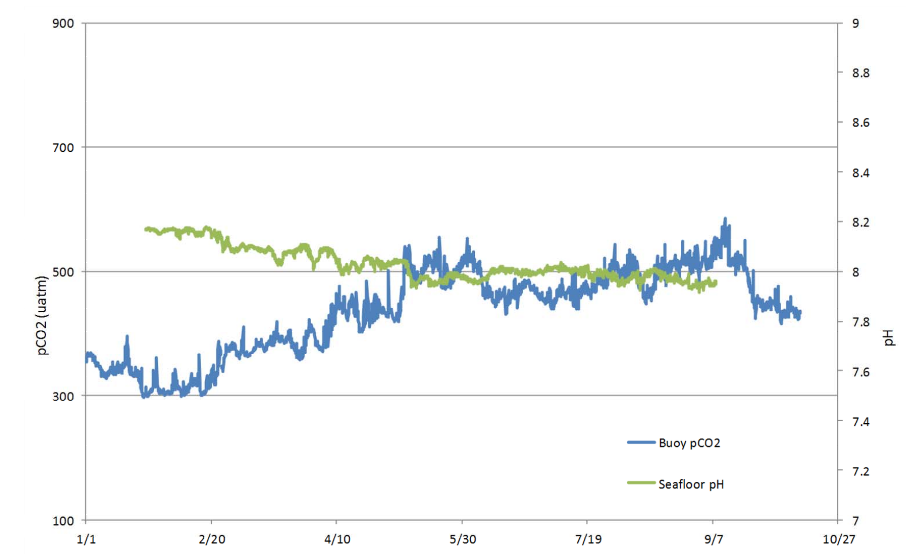

Figure 5. pH and pCO_2

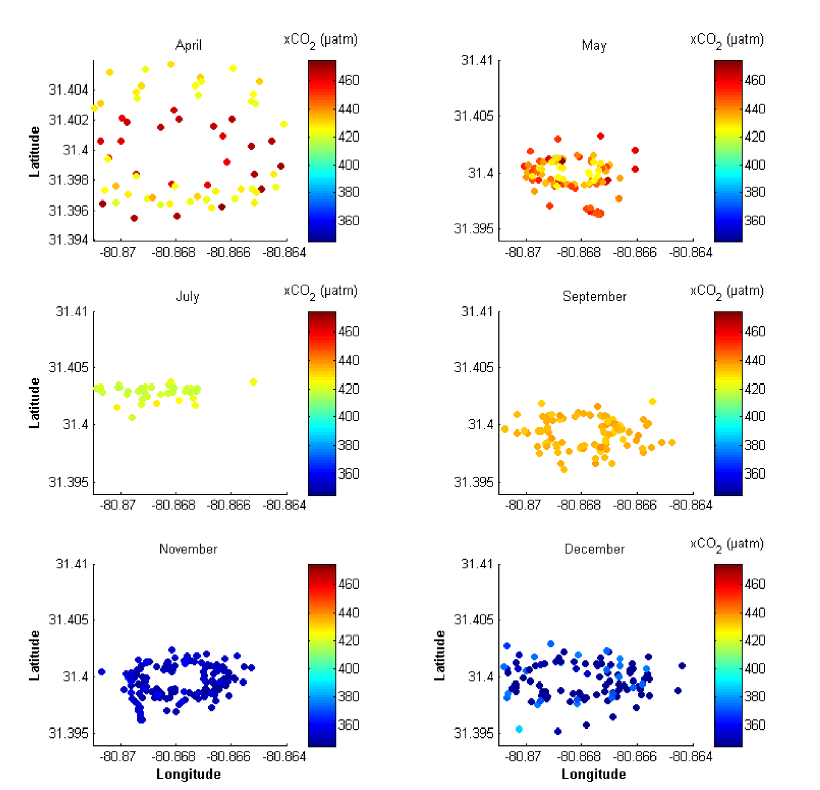

Figure 6. Underway pCO_2 measurements collected at the GRNMS mooring during 2014.