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Examining carbon sequestration in seagrass meadows using an array of low-cost CO_2 flux sensors

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Motivation

Worldwide, submerged aquatic vegetation (SAV) is responsible for 10% of the carbon stored by the ocean, also known as "blue carbon."[1] In just the Albemarle-Pamlico (AP) Sound in NC, SAV sequesters an estimated 164,000 tons of C each year.[2] However, SAV is a vulnerable habitat. From 2007-2013, the AP Sound lost 5,686 acres of SAV and is projected to lose 0.5-5% annually for the next decade.[3] Losing 5% annually would result in the estimated loss of $88.75 million in ecosystem services, primarily due to loss of carbon (C) sequestration.[3]

Currently, C cycling in aquatic environments can be measured by expensive CO_2 flux chambers (up to $10,000) or by taking sediments cores for organic C estimates, which can be especially destructive to the SAV and may prove to be unnecessary when trying to generalize aquatic areas as a C source or sink. This is possible through the development and long-term distribution of an array of low-cost CO_2 flux sensors.

A more accessible CO_2 Flux Sensor → Deploy more sensors and gain spatial resolution → Provide data to managers to support SAV conservation

Methods

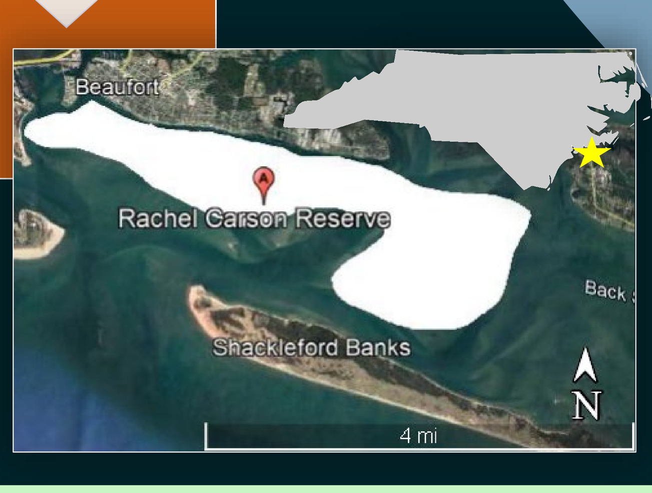
How can we make measuring CO_2 flux more accessible and accurate? How strongly does seagrass act as a carbon sink throughout various seasons?

Prototype of ΔpCO2 sensor was created by Michael Tydings, a former undergrad in the COAST lab, for ~$1800 based off of methods from Wall 2014 (4) and Hunt et al. 2017 (5).

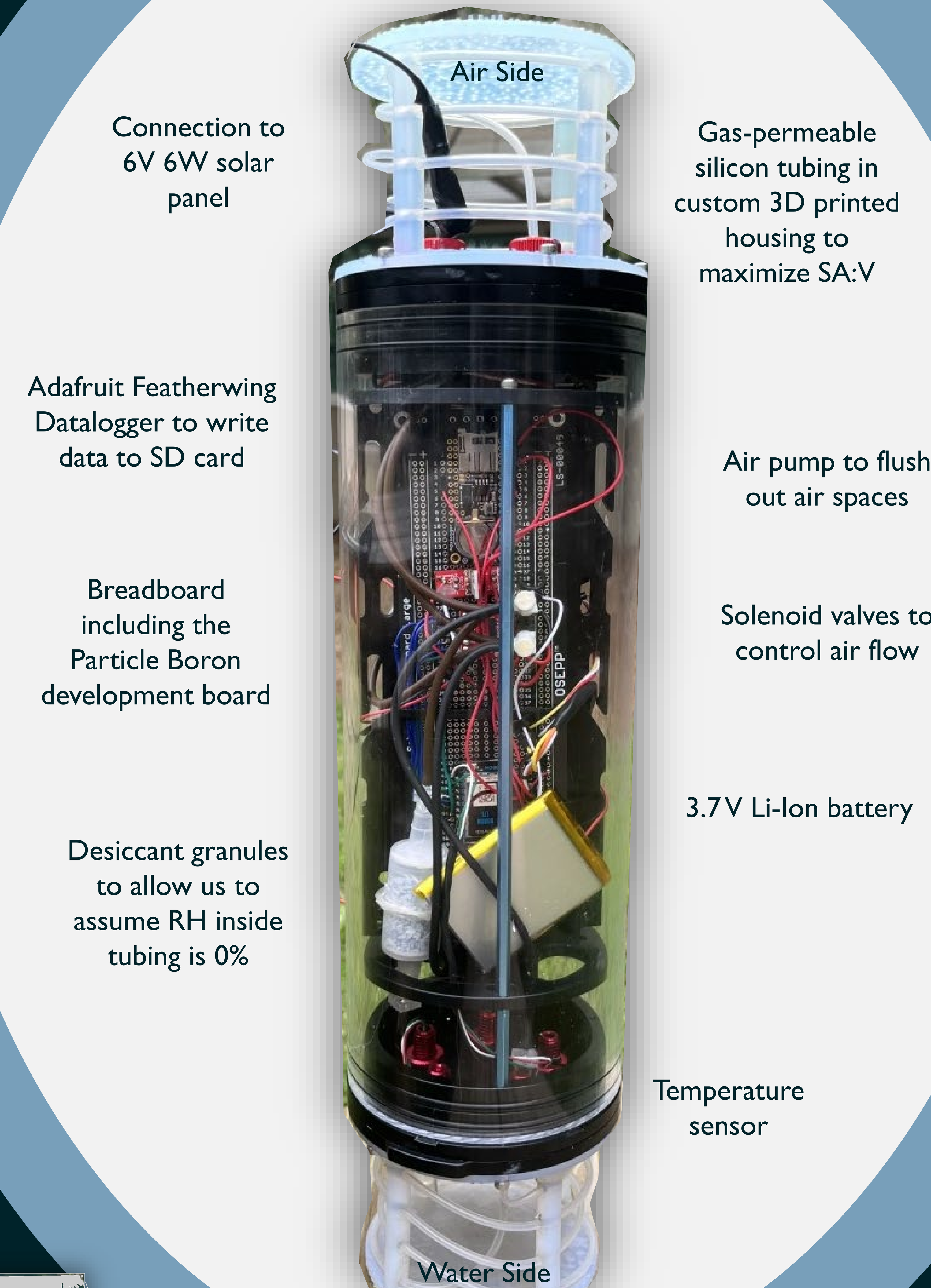
Now, we are refining the sensor (e.g., decreasing response time, increasing deployment time by hooking up a solar panel and installing anti-biofouling components).

We will also characterize working specifications at different temperatures/settings and estimate error through comparison to our LI-850 gas analyzer

Later, we will build 4 of the refined sensors and deploy them in seagrass meadows at the Rachel Carson Reserve, NC for 9 months to estimate CO2 fluxes

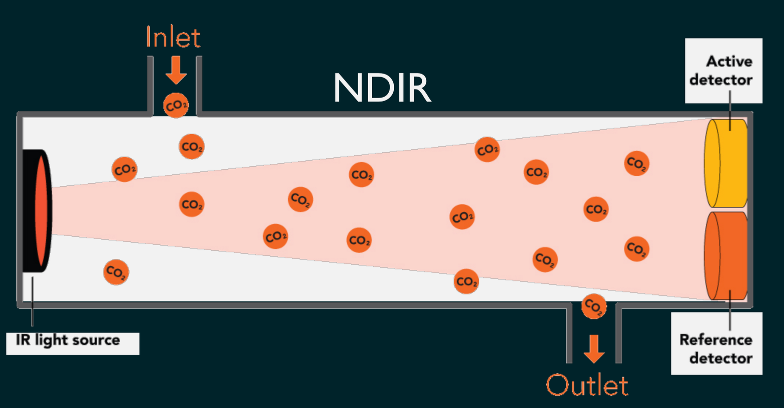


Protype of ΔpCO_2 Sensor



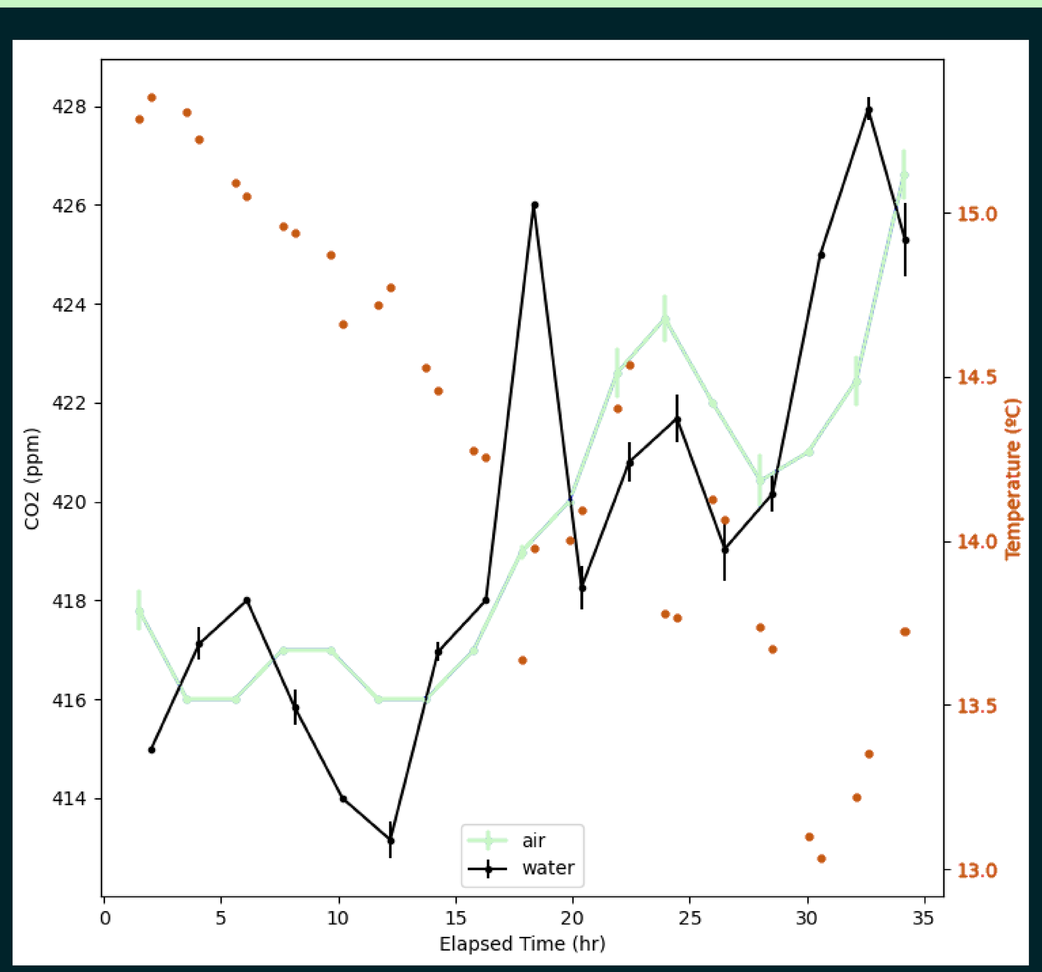
How it works

Using the K30 CO_2 sensor as the central component of our device, we can program the device to switch between measuring the pCO_2 of the air and the pCO_2 of the water. The difference of these values is our ΔpCO_2, which we can then to estimate CO_2 flux.



The K30 is a non-dispersive infrared (NDIR) sensor. It works by passing infrared light through a sample chamber and measuring the absorbance of that light, which is proportional to the concentration of CO_2 in the sample.

Preliminary Results/Future Directions



In a deployment off the floating dock at CMS, our team was able to obtain proof-of-concept data, as shown above. The average and standard deviation of the last 50 points of each sample is shown. ΔpCO_2 is the difference between lines.

Future work will focus on characterizing the work specifications of our device, determining how robust the observed ΔpCO_2 is, and deploying an array of them in the Rachel Carson Reserve. Firmware and designs will be later made available on a repository in Github, an open-source community.

References
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3. Field, D., Kenworthy, J., & Carpenter, D. (2021). Why Is the Extent of Submerged Aquatic Vegetation Important Within the Albemarle-Pamlico Estuarine System?.
4. Wall, C. M. (2014). Autonomous in situ measurements of estuarine surface PCO_2: instrument development and initial estuarine observations. *Oregon State University.* Thesis Dissertation. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/zg64tr497
5. Hunt, C. W., Snyder, L., Salisbury, J. E., Vandemark, D., & McDowell, W. H. (2017). SIPCO2: a simple, inexpensive surface water pCO2 sensor. *Limnology and Oceanography: Methods, 15*(3), 291-301.
NDIR Diagram Image: https://atlas-scientific.com/blog/how-does-an-ndir-co2-sensor-work/
6. Michael Tydings: mst1903@uncw.edu