Can we monitor the pH over Coral Reefs in the Florida Keys using only Remote Sensing?

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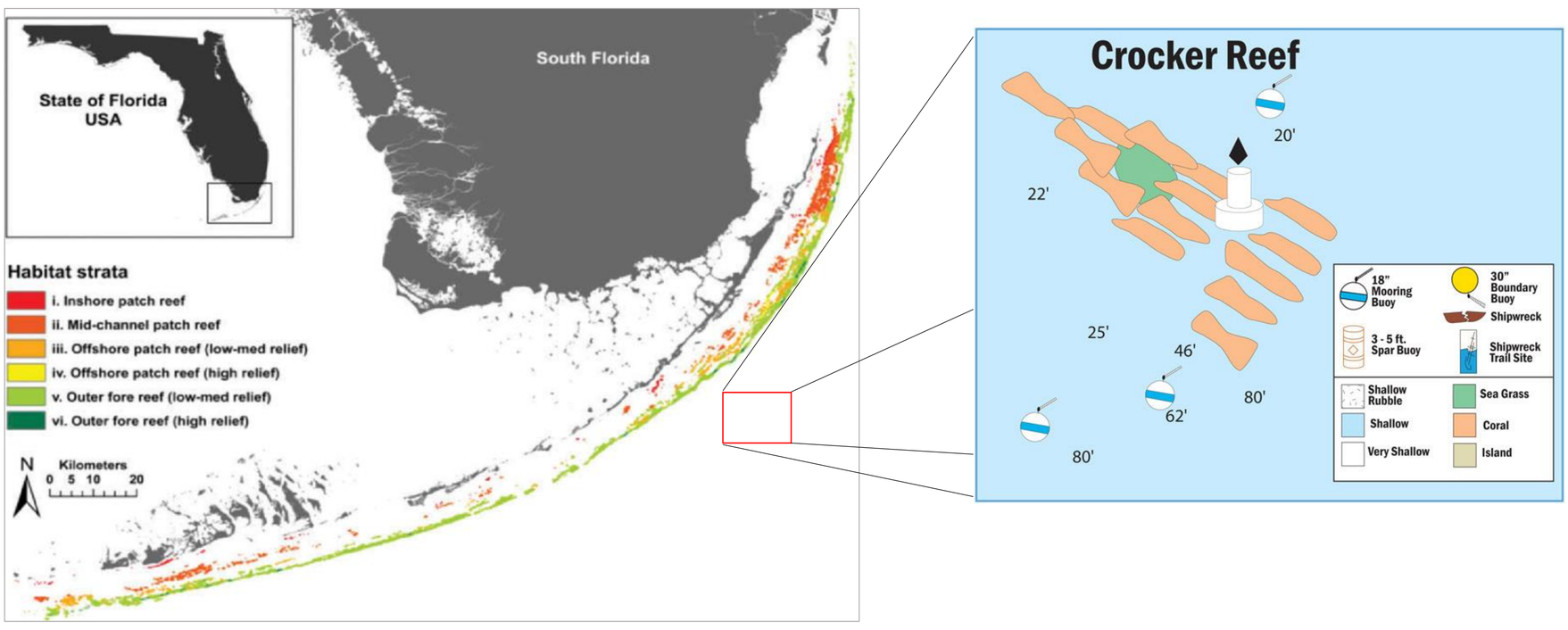
Introduction:

The coral reef ecosystem in the Florida Keys is vital to marine animals, protection against storm surge, and to provide humans with a variety of jobs. The addition of CO_2 into these ecosystems is leading to what we know as ocean acidification in our waters which is causing disease, bleaching, and death to increase in these ecosystems. Monitoring the carbonate system is the best way to see the impacts of ocean acidification. The carbonate system is changing and impacting these reefs, and I would like to see how it is impacting the corals using only remote sensing.

Study area:

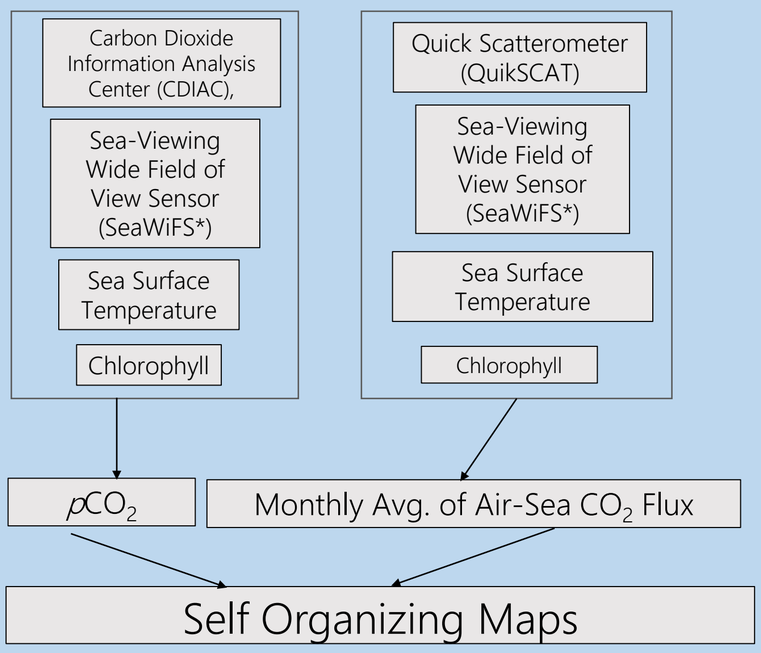


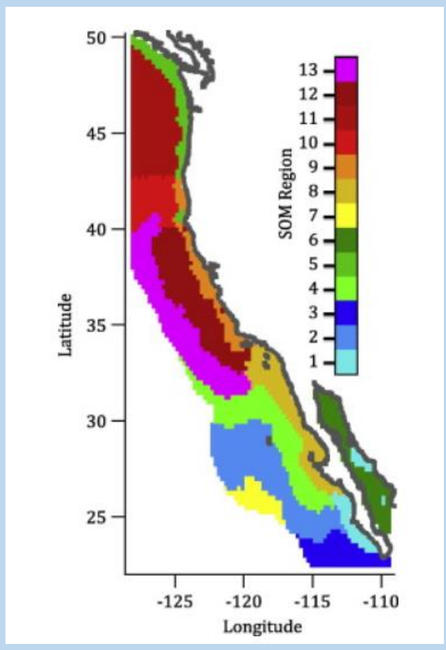
Research:

This project will derive pH measurements and saturation states over Crocker reef in the Florida Keys. Through a series of linear regression analysis we will assess the relationship between pH and saturation state. Satellite remote sensing will be used to estimate these values along with estimating how much atmospheric CO_2 is sinking into the study area. These results would allow us to better monitor ocean acidification and the flux of CO_2 as it pertains to coral reefs in the Florida Keys.

Methods:

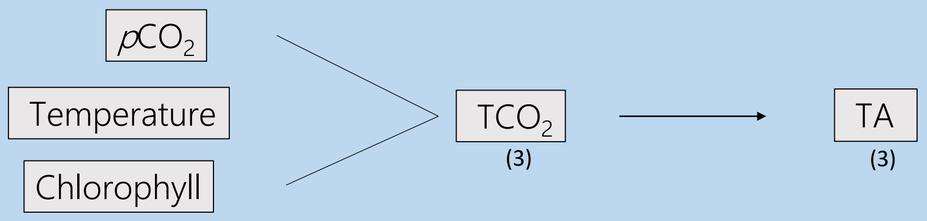
1. The first step of my research will be to create self organizing maps (SOM) to find habitats that are similar in the study area. The similarities will allow me to use specific parameters to analyze the flow of carbon in and out of the system. I will need calculate partial pressure of CO_2 (pCO_2) and the monthly average of air-sea CO2 flux from different sources (see below)[1].



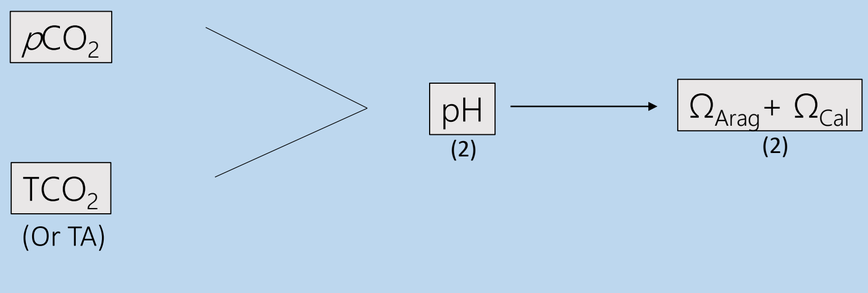


Example SOM map in California[1]

2. Once I have calculated the pCO_2, I can use mechanistic nonlinear models and predict the Total CO_2 in the area[1]. Using simple ratios I can also calculate Total alkalinity (TA) from the Total CO_2. The SOM will allow me to input different environmental parameters[3] for each habitat to accurately asses the total CO_2.



3. After I have calculated 3 of the 4 main parameters to monitor the carbonate system (pCO_2, TCO_2, and TA) I can calculate the pH of the habitat[2]. All of this information can lead me to the aragonite saturation state of the coral reef.



Predicted Results:

The results of this study will help to more accurately monitor the quickly changing carbonate system at coral reefs (<10m depth) in the Florida Keys. We would be able to describe the rate at which CO_2 enters and exits the system in different types of reefs. The next phase of my research will look at how changes in the carbonate system impact biodiversity as a part of the Marine Biodiversity Observation Network (MBON). There are studies that indicate the changes in pH is arguably the biggest impact to the disappearance of coral reefs. The changes in pH have shown to slow mutation rates of bacteria in the corals biome which makes them more at risk for disease, bleaching, and death[4]. The diversity among reefs (even at the microbial level) is important to maintain and monitor.

References:

[1] Hales, B.E., Strutton, P.G., Saraceno, M., Letelier, R., Takahashi, T., Feely, R.M., Sabine, C.L., & Chávez, F. (2012). Satellite-based prediction of pCO 2 in coastal waters of the eastern North Pacific.

[2] Department of Ecology State of Washington.

[3] Yasunaka, S., Siswanto, E., Olsen, A., Hoppema, M., Watanabe, E., Fransson, A., Chierici, M., Murata, A., Lauvset, S. K., Wanninkhof, R., Takahashi, T., Kosugi, N., Omar, A. M., van Heuven, S., and Mathis, J. T.: Arctic Ocean CO_2 uptake: an improved multiyear estimate of the air–sea CO_2 flux incorporating chlorophyll *a* concentrations, Biogeosciences, 15, 1643-1661, https://doi.org/10.5194/bg-15-1643-2018, 2018.

[4]Strauss, C., Long, H., Patterson, C.E., Te, R.L., & Lynch, M. (2017). Genome-Wide Mutation Rate Response to pH Change in the Coral Reef Pathogen Vibrio shilonii AK1. mBio.

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Harford, W. J., S. G. Smith, J. S. Ault, and E. A. Babcock. 2016. Cross-shelf habitat occupancy probabilities for juvenile groupers in the Florida Keys coral reef ecosystem. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science [online serial] 8:147–159

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IOOS Integrated Ocean Observing System