# Supplementary Information
# Indicator K: Coastal Acidification
# State of Casco Bay 6th Edition

## References

Takahashi, T., S. C. Sutherland, C. Sweeney, A. Poisson, N. Metzl, B. Tilbrook, N. Bates, R> Wanninkhof, R.A. Feely, C. Sabine, J. Olafsson, and Y. Nojiri. (2002). Global sea-air CO2 flux based on climatological surface ocean pCO2, and seasonal biological and temperature effects. Deep Sea Research Part II: Topical Studies in Oceanography. 49. 1601-1622. 10.1016/S0967-0645(02)00003-6.

Weiss, RF. 1974. Carbon dioxide in water and seawater: the solubility of a non-ideal gas. Marine chemistry 2 (3), 203-215.

## Further Reading

Gledhill, D.K., M.M. White, J. Salisbury, H. Thomas, I. Mlsna, M. Liebman, B. Mook, J. Grear, A.C. Candelmo, R.C. Chambers, C.J. Gobler, C.W. Hunt, A.L. King, N.N. Price, S.R. Signorini, E. Stancioff, C. Stymiest, R.A. Wahle, J.D. Waller, N.D. Rebuck, Z.A. Wang, T.L. Capson, J.R. Morrison, S.R. Cooley, and S.C. Doney. 2015. Ocean and coastal acidification off New England and Nova Scotia. Oceanography 28(2):182–197, http://dx.doi.org/10.5670/oceanog.2015.41.

This article details the effects of ocean acidification that are specific to New England and Nova Scotia due to the significant freshwater input and heavy precipitation events in the region.

Maine State Legislature; Maine Office of Policy and Legal Analysis; Bentley, Curtis; and Schneider, Deirdre, "Report of the Commission to Study the Effects of Coastal and Ocean Acidification and its Existing and Potential Effects on Species that are Commercially Harvested and Grown Along the Maine Coast" (2015). Office of Policy and Legal Analysis. 145. https://digitalmaine.com/opla_docs/145

The Commission to Study the Effects of Coastal and Ocean Acidification and Its Existing and Potential Effects on Species That Are Commercially Harvested and Grown Along the Maine Coast was established in 2014. Their goal was to develop mitigation strategies and increase public awareness of the issue. The Washington State Blue Ribbon Panel of Ocean Acidification report was examined to see if their recommendations could be appropriate in Maine.

*Science*. Friends of Casco Bay. (2021, July 6). Retrieved from https://www.cascobay.org/our-work/science/.

Information about Friends of Casco Bay's work collecting data on water quality through continuous monitoring stations and volunteer efforts.

*Shell Day: A snapshot of Coastal Water Conditions*. Northeast Coastal Acidification Network. Retrieved from http://necan.org/ShellDay.

Shell Day was a single-day monitoring event that took place on the coast from Long Island Sound to Downeast Maine. 500 samples were collected across 86 sites to measure salinity, temperature, and pH. Included is a list of participating organizations and a map of monitoring sites.

The Maine Ocean and Coastal Acidification Partnership. (2019). (rep.). *An Action Plan to Address and Adapt to Ocean Climate Change in Maine*. Retrieved from https://seagrant.umaine.edu/wp-content/uploads/sites/467/2019/11/MOCA-Action-Plan-2019.pdf.

A report to the Maine Climate Council published by the Maine Ocean and Coastal Acidification Partnership (MOCA). MOCA is comprised of 220 volunteers and includes scientists, fishermen, aquaculturists, advocates, legislators, and concerned citizens. Since this group cannot officially fundraise, research, or make policy decisions, the goal of this report is to implore the Maine Climate Council to consider their recommendations.

## Methods and Data Sources

Ocean acidification data was collected by staff from Joe Salisbury's lab at University of New Hampshire (UNH), with funding from the Casco Bay Estuary Partnership. Data was collected from the Southern Maine Community College pier. Automated sensors were deployed in a protective cage, resting on the bottom in approximately 2.5 meters of water. The instruments were deployed periodically from 2015 through 2020. Equipment was maintained, QA/QC samples collected, and data downloaded approximately monthly. Data was provided to CBEP directly by UNH staff.

Data from the Cousins Island site managed by Friends of Casco Bay (FOCB) was obtained directly from FOCB, which has been collecting continuous data on ocean acidification parameters at that site since 2016.

The measured parameter, $pCO_2$ is not a direct measure of the concentration of carbon dioxide (and other carbonate compounds) in the water column, largely because of temperature dependence. We calculated a "temperature corrected" $pCO_2$ value, based on observed $pCO_2$ and temperature. "Temperature corrected" $pCO_2$ is more directly correlated with the abundance of $CO_2$, and thus more closely tied to mechanisms of photosynthesis, respiration, and diffusion that add or remove $CO_2$ to the water column. We felt the temperature-corrected values were likely to be more readily understood by a public audience, so all $pCO_2$ values shown on this page are temperature-corrected values.

The calculation followed the methods of Takehashi et al. 2002, cited above. The Weiss citation provides more technical detail, and (apparently different, much more complex) formulae that in practice produce similar results under reasonable simplifying assumptions. Details of the Takehashi et al. 2002 approach are described in the GitHub repositories.

Analysis of data on Coastal and Ocean Acidification parameters has many complexities. To avoid error due to misunderstandings, we relied on UNH and FOCB to calculate derived values, especially the omega aragonite values (using CO2SYS) we reported. UNH and FOCB regularly coordinate on methods, so values should be comparable.

The UNH monitoring effort collected pH data on the "Total" pH scale, while FOCB data is collected on the "NBS" scale. To facilitate comparison, CBEP converted the FOCB pH data from the NBS scale, by

running the FOCB data through CO2SYS. We used the python version, via a python package known as PyCO2SYS). We used PyCO2SYS to estimate the Total-scale pH based on the FOCB data.

Data presentation emphasized displays that show all data, but we also tested for relationships between Ocean Acidification parameters and several possible predictors, including salinity, temperature, rainfall, river flow, time of day, time of tide, and time of year. Statistical analysis was based on linear models and GAMMs, with an autocorrelated (*AR(1)*) error structure. Final presentation of results emphasized the strong diurnal and seasonal patterns, each of which were robust to reasonable alternative model selection.

Access to data and summary of data analysis can be found at https://github.com/CBEP-SoCB. For a full archive of data and all analyses steps head to https://github.com/CBEP-SoCB-Details.