Coastal Acidification Varies Seasonally, Daily, and Among Locations in Casco Bay

Scientists Are Investigating Local Patterns and Causes of Acidification

WHY IT MATTERS

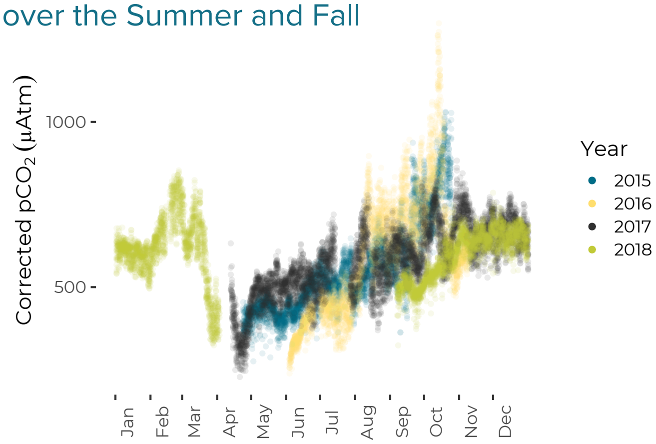
Lobsters, clams, and many other marine species build their shells out of carbonate minerals that they extract from seawater. Acidification of the water can make it more difficult for them to build their shells, or even cause shells to dissolve. Four out of every five dollars in Maine fisheries comes from shell-building species. Lobster represents about 75 percent of the fisheries' total value, and clams, oysters, urchin, and scallops account for another five or six percent.

In offshore waters, the primary cause of acidification is carbon dioxide (CO_2) from the atmosphere dissolving into the water. One quarter of the carbon dioxide released to the atmosphere by human activity annually is absorbed by the ocean, making ocean acidification a global concern. Near the coast, however, other localized sources such as rivers and nutrient pollution are major contributors to acidification, which refers to changes in not only pH but also availability of carbonate ions. Coastal acidification interacts with other environmental stressors like climate change, invasive species, and poor water quality to affect the ecosystem.

STATUS & TRENDS

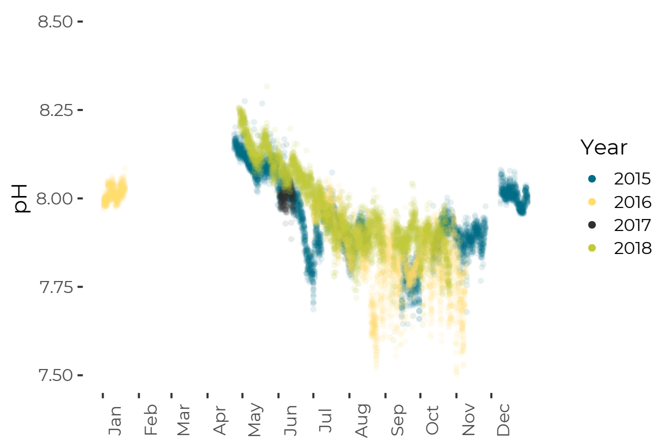
Data are limited, especially for the winter months, but about ten percent of all observations in Casco Bay show conditions corrosive enough to dissolve carbonate minerals like clam shells. Scientists from the University of New Hampshire, with funding through Casco Bay Estuary Partnership, have monitored coastal acidification near Southern Maine Community College (SMCC) in South Portland for five years. The monitoring reveals seasonal and daily variations reflecting biological activity in the ecosystem. Carbon dioxide levels fluctuate seasonally and daily, in synchrony with cycles of photosynthesis, respiration, and decomposition. In late summer and fall, levels of carbon dioxide hit their peak, pH drops, and acidification reaches levels of concern. For most of the year, levels of carbon dioxide dissolved in the Bay's waters are higher than atmospheric levels, meaning the Bay seldom absorbs carbon dioxide from the atmosphere.

Dissolved Carbon Dioxide Rises over the Summer and Fall



Carbon dioxide levels in the Bay (temperature-corrected) are at their lowest in the spring, and climb steadily through the fall. Levels are above atmospheric concentrations (~ 400 µAtm) most of the year.

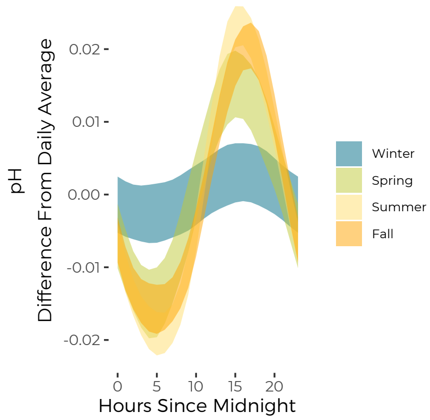
pH Decreases from Summer to Fall



At SMCC, pH shows a clear seasonal pattern, dropping over the course of the year by as much as a half of a pH point. pH is measured on a logarithmic scale, so that difference in pH represents a change in acidity by a factor of 3.

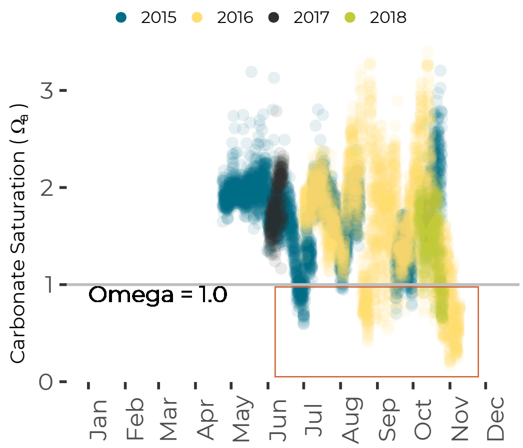
pH Fluctuates Through Day and Night Reflecting Biological Activity

Biological activity in the Casco Bay ecosystem drives small but detectable daily fluctuations in pH (shown on graph) and dissolved carbon dioxide (not shown). Colored bands on the graph represent the daily fluctuations by season. Fluctuations peak in the late summer (yellow) and fall (orange), when the waters are warmest and the ecosystem most active. Photosynthesis removes carbon dioxide during the day, increasing pH. At night, respiration and decomposition release carbon dioxide, causing a decline in pH overnight. In winter (blue), when daylight is shorter, waters are cold, and fewer data are available, the effect appears weaker.



Potential for Shell Corrosion in Late Summer and Fall

Although familiar, pH is not the only indicator of acidification's potential impacts on marine organisms. Scientists also use a measurement called omega (Ω_a) to determine how corrosive the water is to the carbonate mineral aragonite, a constituent of shells of many marine organisms. When omega falls below 1.0, shells tend to dissolve (although slowly). As indicated by the orange box, periods of low omega (below 1.0) tend to occur in Casco Bay each year, during late summer and fall.

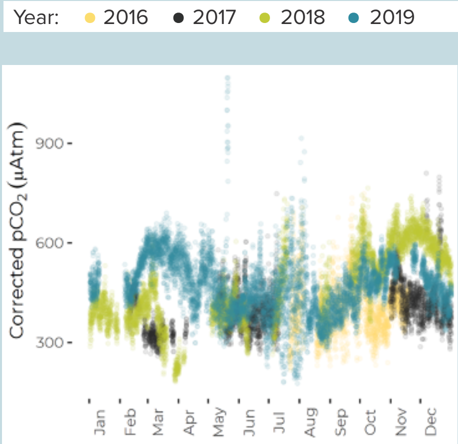


SUCCESSES AND CHALLENGES

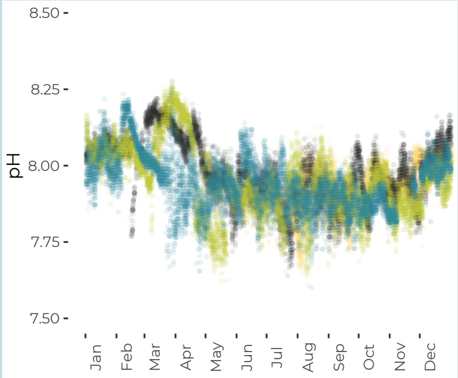
- The Gulf of Maine, including Casco Bay, is especially vulnerable to acidification because of its cooler waters and the low alkalinity of the region's freshwater inputs.
- Coastal acidification is already affecting shellfish aquaculture in Maine, especially in the Damariscotta River, where freshwater inflows make the system vulnerable.
- Monitoring of acidification in Casco Bay and other estuaries is revealing how local conditions affect acidification. In Casco Bay, data suggest that acidification may be affected by tides and by river discharge, but the science remains inconclusive for now.
- Laboratory experiments have demonstrated that levels of acidification that are observed from time to time in Casco Bay can affect behavior and reproduction of softshell clams and quahogs. However, it is not yet known whether present-day conditions affect shellfish living in the wild.
- Monitoring in other estuaries with more nutrient pollution than Casco Bay has revealed high levels of dissolved carbon dioxide and more dramatic daily and seasonal fluctuations. Reducing nutrient pollution could help protect coastal ecosystems from acidification.

MONITORING BY FRIENDS OF CASCO BAY

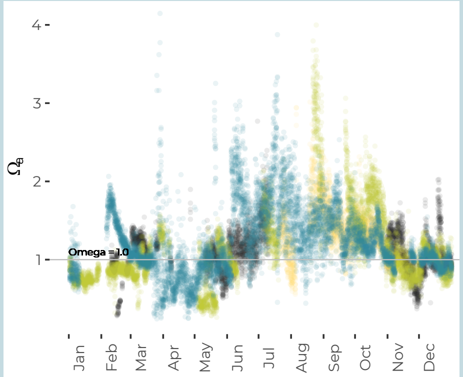
Since 2016, Friends of Casco Bay (FOCB) has monitored acidification parameters from a location on Cousins Island in Yarmouth. Results are similar, but not identical, to findings from SMCC.



The Cousins Island data do not show the strong seasonal pattern of carbon dioxide observed at SMCC. It is not clear whether that reflects location, or the additional years of winter and spring data collected by FOCB.



While the total range of pH at Cousins Island is similar to what was observed at SMCC, pH at Cousins Island tends to be somewhat lower and the seasonal pattern less pronounced.



Conditions at Cousins Island are more corrosive (shells are more likely to dissolve) than at SMCC. More than one third of all observations fell below levels of concern. In contrast to what was observed at SMCC, corrosive conditions were most common during winter and spring.