

Shellfish face an uncertain future in a high CO₂ world

May 27 2009

Overfishing and disease have decimated shellfish populations in many of the world's temperate estuarine and coastal ecosystems. Smithsonian scientists, led by Whitman Miller, ecologist at the Smithsonian Environmental Research Center in Edgewater, Md., have discovered another serious threat to these valuable filter feeders—rising levels of atmospheric carbon dioxide that contribute to the acidification of open ocean, coastal and estuarine waters. Their findings are being published in the open-access, peer-reviewed journal *PLoS ONE*, May 27.

For shellfish and other organisms that have calcium carbonate shells and structures, the problem begins when atmospheric CO₂ dissolves in seawater and creates carbonic acid that is then rapidly transformed into carbonate and bicarbonate ions in the water. Increased acidity tips the balance toward bicarbonate formation and away from carbonate. Less carbonate in the water means that shellfish have fewer building blocks to generate their shells. If the water is acidic enough, shells can even begin to dissolve.

"Estuarine and coastal ecosystems may be especially vulnerable to changes in water chemistry caused by elevated CO₂ because their relative shallowness, reduced salinity and lower alkalinity makes them inherently less buffered to changes in pH than in the open ocean," said Miller. For many calcifying organisms, CO₂-induced acidification poses a serious challenge because these organisms may experience reduced rates of growth and calcification that "when combined with other environmental stresses, could spell disaster."

Larval oysters are thought to be particularly susceptible to acidification since larvae produce shells made of aragonite, a crystalline form of calcium carbonate that is prone to erosion at low pH. Adult oysters continue to build shell but generate calcite, a more durable form of calcium carbonate. In Miller's study, the larvae of Eastern oysters (*Crassostrea virginica*) and Suminoe oysters (*Crassostrea ariakensis*) were cultured in estuarine water that was held at four separate CO₂ concentrations, reflecting atmospheric conditions from the pre-industrial era, the present, and those predicted in the coming 50 and 100 years. To test the effects of acidification, Miller monitored their growth and measured the amounts of [calcium carbonate](#) deposited in larval shells over the course of one month.

Miller and his team found that Eastern oysters experienced a 16 percent decrease in shell area and a 42 percent reduction in calcium content when specimens in the pre-industrial CO₂ treatment were compared with those exposed to the levels predicted for the year 2100. Surprisingly, the closely related Suminoe oysters from Asia showed no change to either growth or calcification.

The results reported suggest that the impacts of acidification may be tied to a species' unique evolutionary history and environmental setting, implying that predictions may be more complex than previously thought. "In the Chesapeake Bay, oysters are barely holding on, where disease and overfishing have nearly wiped them out. Whether acidification will push Eastern oysters, and the many species that depend on them, beyond a critical tipping point remains to be seen" said Miller.

With numbers so critically low—the oyster population in the Chesapeake Bay today stands at just 2 percent of what it was in colonial times—future losses could have dire consequences, both environmentally and economically. Indeed, the recently enacted Federal [Ocean](#) Acidification Research and Monitoring Act of 2009 recognizes

the urgent need to begin addressing impacts of acidification on estuaries and their biota.

With the continued burning of fossil fuels, further acidification is unavoidable. Miller's team is keenly interested in what the biological and ecological responses will be in order to better inform current and future environmental restoration efforts. "In a high CO₂ world, calcifying organisms may well begin to lose out to competition with non-calcifiers, a situation that could fundamentally change benthic communities. Understanding how such changes may play out in estuaries and coastal waters, which teem with calcifying biota, and which are also the centers of many commercial fisheries and human activities, seems especially urgent" said Miller.

More information: Miller AW, Reynolds AC, Sobrino C, Riedel GF (2009) Shellfish Face Uncertain Future in High CO₂ World: Influence of [Acidification](#) on Oyster Larvae Calcification and Growth in Estuaries. *PLoS ONE* 4(5): e5661. doi:10.1371/journal.pone.0005661, dx.plos.org/10.1371/journal.pone.0005661

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