SHELLFISH
AND THE PROBLEM OF OCEAN ACIDIFICATION

Over that last two decades there has been growing concern by the scientific community about global carbon dioxide emissions.

*By Michael A. Rice**

For the most part this concern has manifested itself as a vigorous debate among political factions as to whether our manmade greenhouse gas emissions are the major cause of global warming or whether the problem is severe enough that should be altering our habits with the use of fossil fuels. One thing is for certain and it's that atmospheric carbon dioxide concentrations in the atmosphere are much higher now than they have been in the last 650,000 years. Data compiled by the U.S. Environmental Protection Agency based largely on sampling trapped air in Antarctic ice cores and direct atmospheric measurement in recent years has shown that the current atmospheric CO_2 concentrations of about 380 ppm are about 36% higher than the 18th Century pre-Industrial Revolution concentration of about 280 ppm and about 69% higher than the average of about 225 ppm over the last 650,000 years. The CO_2 concentrations had been fluctuating over this time between 200 and 280 ppm in a rough cycle of about 100,000 years in duration. Thus atmospheric CO_2 levels are now remarkably high.

Carbon dioxide readily dissolves into water creating what is known as carbonic acid, and atmospheric CO_2 dissolving into oceanic seawater is no exception. Pre-industrial pH of seawater as a measure of acidity was about 8.2, but it has been lowered now to about 8.1 indicating more acid conditions. To many it seems that a fraction of a pH unit is very small, but since pH is on a logarithmic scale, the actual change in acidity as measured by hydrogen ion concentration is an increase of about 30% over pre-industrial times, which is in the same ballpark as the atmospheric increase of CO_2. This increase in pH of seawater is extremely important to shellfish growers, because pH is a major factor affecting carbonate chemistry, especially as it applies to shell formation in oysters, clams and other bivalve mollusks. For several years there has been reduced oyster seed production in oyster hatcheries in the U.S. Pacific Northwest that have been attributed to upwelling waters from the Pacific ocean that are high in CO_2 at the critical time of larval shell formation.

In a recent paper by George Waldbusser and several colleagues at Oregon State University in *Geophysical Research Letters* they report their research findings that acidic seawater is not necessarily dissolving the shells as some scientists have previously suspected, but rather the oyster larvae use more of their energy stores at a critical time of their development that causes the larvae to grow slower or even die (Fig. 1). The implication of this study is that shellfish hatcheries should be monitoring the pH of their seawater supply and if necessary, introduce measures to raise the pH if necessary with the addition of an alkaline solution such as sodium carbonate. Two oyster hatcheries in the Pacific Northwest, *Whiskey Creek Hatchery* in Tillamook, Oregon and the *Taylor Shellfish Hatchery* in Quilcene, Washington have adopted this technique of treating their seawater prior to use in the hatchery and have much greater oyster larval growth and survival as a result. However, as carbon dioxide levels in the atmosphere continue rising the problem of low pH seawater in hatcheries may become an issue in areas outside the Pacific Northwest region where this larval development impairment syndrome has been first described.

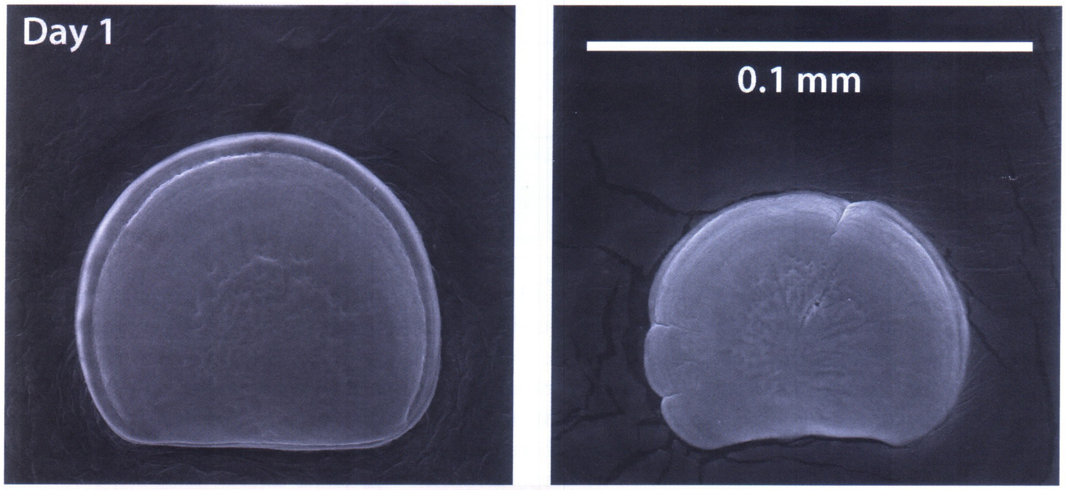


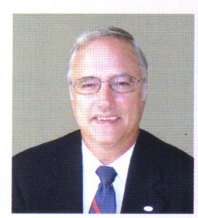
Fig. 1. This image shows 1-day old Pacific oyster larvae from the same parents, raised by the *Taylor Shellfish Hatchery* in natural waters of Dabob Bay, Washington. The larvae on the left were reared in treated seawater with favorable carbonate chemistry; on the right raw water proved to have an unfavorable chemistry. Photo by: George Waldbusser and Elizabeth Brunner, of Oregon State University.

Water monitoring and vigilance by hatchery managers is the best policy.

Another issue associated with low pH is the shell loss of freshly set bivalves such as oysters and clams into sediments that may have localized areas of low pH that may be exacerbated by the global acidification of the oceans. Mark Green from St. Joseph's College in Maine and colleagues in 2009 published research in *Limnology and Oceanography* of their research on the survival of juvenile clams in sediments with low pH that affected the amount of calcium carbonate that can be dissolved in the sediment pore waters. As pH lowers, the more calcium can dissolve into the sediment waters and shells of bivalves dissolve faster. When Green and his colleagues buffered the sediments with a calcium carbonate source affecting the sediment chemistry, they there were able to demonstrate greater survival of their juvenile clams.

For many decades, a number of shellfish researchers, including John Kraeuter of the Haskin Lab in New Jersey, Michael Castagna of the Virginia Institute of Marine Sciences and Clyde MacKenzie of the National Marine Fisheries Service, have experimented with means to increase survival of seed clams and other shellfish in field plots. Their findings had shown that placing gravel into nursery beds had the effect of lowering predation losses of clams and other shellfish, but they also found that crushed shell often worked better than the gravel in increasing juvenile shellfish survival. Green and colleagues have provided a chemical explanation for the efficacy of the well-known practice of seedbed shelling. It is not just clams being able to hide from their predators.

The entire issue of rising carbon dioxide concentrations in the atmosphere and oceans should be of concern to shellfish producers if not any reason more than possible rising costs associated with water management and controlling pH and calcium saturation levels in hatchery and juvenile rearing operations. But in a more global sense, larval and juvenile shellfish may well be one of the best "environmental sentinels" in the shifting planetary carbon cycle and should be more than just a minor footnote in the discussion of carbon emissions management. am



Michael A. Rice, PhD, is a Professor of Fisheries, Animal and Veterinary Science at the University of Rhode Island. He has published extensively in the areas of physiological ecology of mollusks, shellfishery management, molluscan aquaculture, and aquaculture in international development.
rice@uri.edu