APPLICATION NOTE A2.3:
Effects of increased dissolved CO_2 on Shellfish

Introduction

In shellfish aquaculture, a delicate balance of the carbonate system must exist for not only optimal growth, but also survival of shell-bearing organisms. Dissolved carbon dioxide is one of the major determinants in the carbonate system and changes in CO_2 levels can dramatically alter this balance.

More commonly measured parameters including oxygen, ammonia, and pH can at best, only provide an estimate of dissolved CO_2 levels. There are many instances where correlations between various parameters are not valid and carbon dioxide levels can reach elevated concentrations, with other water quality parameters remaining in a normal range.

An Acidifying Ocean

Since the beginning of the industrial age, ocean pH has decreased by 30%. It is decreasing at such a rate that it does not allow for natural buffering within the system to compensate. In many sheltered embayments where harvesters typically grow shellfish, pCO_2 can change from levels less than 200 µatm to more than 1200 µatm within a single tidal cycle. These large changes, dependent on many factors and interactions, are compounded with increasing atmospheric CO_2 levels to increase the frequency and severity of unfavorable conditions for shellfish growth.

Elevated pCO_2 levels cause a shift in the carbonate chemistry of ocean water, leading to less CO_3^{-2} available for shellfish to use to build their $CaCO_3$ shells.

Oyster Hatchery Collapse

Ocean acidification has been definitively linked to oyster seed production collapse at a hatchery in Oregon by researchers at OSU. Earliest larval stages are particularly sensitive to ocean acidification. Increased CO_2 leads to a decrease in saturation state of ocean water. If the saturation state is too low, larvae have difficulty building their shells, causing them to divert too much energy away from swimming and feeding which often leads to increased mortality rates.

Monitoring water intake allows workers in shellfish hatcheries to strategically buffer incoming water or regulate inflow and outflow to take advantage of natural variability of coastal waters.

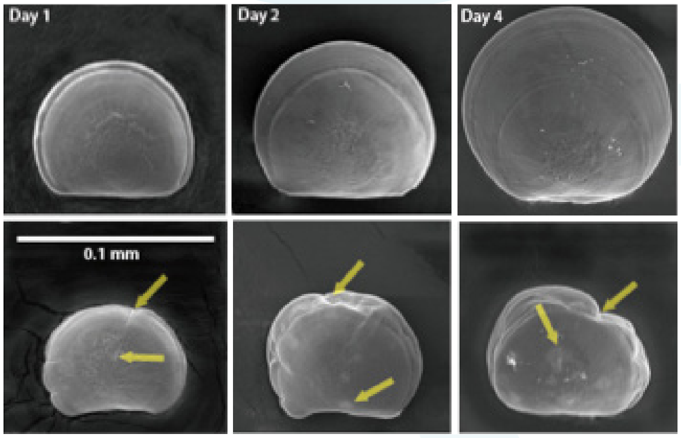

Figure 1.
Pacific oyster larvae in favorable (top) and unfavorable acidic (bottom) water (Elizabeth Brunner and Dr. George Waldbusser of Oregon State University)

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Stability in a sea of change.

Pro-Oceanus.com
sales@pro-oceanus.com

80 Pleasant Street,
Bridgewater, Nova Scotia
Canada B4V 1N1

T +1-902-530-3550
F +1-902-530-3551
Toll-Free (Canada/US) 1-855-530-3550

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Measurement of Dissolved CO_2 and the Carbonate System

Measurement of dissolved CO_2 is an effective method of ensuring that levels are within a healthy range for shellfish. Each aquaculture system is unique, making continuous in situ dissolved CO_2 measurements a key element to any operation.

Dissolved CO_2 can be measured in a number of ways, including chemical laboratory analysis of water samples and in situ measurements via diffusion across a membrane into a gas infrared CO_2 detector. Larger in situ systems utilize a gas head space equilibration technique.

Figure 2.
The Mini-CO_2 Sensor with flat membrane technology.

The cost and complexity of each method varies, with water sampling being labor intensive and generating a substaintial time lag between the sampling and the measurement results.

Dissolved CO_2 Sensors

Pro-Oceanus offers several ranges of pCO_2 sensors for monitoring conditions in shellfish habitats, ranging from sensors with high accuracy to others that feature low cost. These sensors can be standalone with internal logging and battery power, or can be easily integrated into automated systems with feedback control. The right equipment choice to keep shellfish happy and healthy is easy with consultation with the Pro-Oceanus Scientific Team.

Figure 3. The CO_2-Pro CV has industry leading accuracy and stability for submersible instruments

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