

# APPLICATION NOTE A2.2: Elevated Dissolved CO<sub>2</sub> in Aquaculture

## Introduction

Ensuring the health of fish in aquaculture settings requires careful monitoring and control of water quality parameters. Intensive water re-use systems and well-boats are particularly susceptible to CO<sub>2</sub> problems. More commonly measured parameters, including oxygen, pH, and ammonia, can at best only provide an estimate of dissolved CO<sub>2</sub> 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.

## Sources of CO<sub>2</sub> in Recirculating Aquaculture Systems

- Fish respiration as a source of CO<sub>2</sub> increases with increasing stocking densities
- Source water itself (especially well water) can contain high levels of CO<sub>2</sub>.
- CO<sub>2</sub> production in the biofilter can make up a large percentage of total system CO<sub>2</sub> production.
- Changes in water temperature can lead to changes in solubility and lead to elevated CO<sub>2</sub> levels.



Figure 1. Recirculating aquaculture tank.

## Effects on Finfish

Most species of fish are able to tolerate dissolved carbon dioxide levels of below 10 mg/L (~6000 µatm pCO<sub>2</sub>, approximately 15 times atmospheric concentrations).

Increased CO<sub>2</sub> in water reduces the rate at which CO<sub>2</sub> from the fish's own metabolism can be released from the blood through the gills. CO<sub>2</sub> in the blood increases, resulting in a drop in blood pH (acidosis). This leads to a reduction in oxygen carrying capability of the hemoglobin (hypercapnia). In the short term, the physiology of the fish can counteract the effects and little harm is done. In the long-term, exposure to high CO<sub>2</sub> concentrations can have a profound effect on the health of the fish.

High dissolved CO<sub>2</sub> levels have been associated with formation of mineralized deposits in the kidneys of salmonids (nephrocalcinosis). Slowed growth, reduced efficiencies in feed conversion, susceptibility to pathogens, and interference with sense of smell leading to erratic swimming have all been documented to be direct results of increased dissolved CO<sub>2</sub>.



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## Measurement of Dissolved CO<sub>2</sub>

Measurement of dissolved CO<sub>2</sub> is an effective method of ensuring that concentrations are within a healthy range for fish. Each aquaculture system is unique, making continuous in situ dissolved CO<sub>2</sub> measurements a key element to any operation.

Dissolved CO<sub>2</sub> can be measured in a number of ways, including chemical laboratory analysis of water samples, using a liquid indicator dye that is monitored spectrophotometrically, and in situ measurement via diffusion across a membrane into an infrared gaseous

CO<sub>2</sub> detector. Water sampling and laboratory analysis is labor intensive and generates a substantial time lag between the sampling time and the measurement results. Pro-Oceanus pCO<sub>2</sub> sensors utilize infrared detection and provide continuous long-term in situ measurements that allow for real-time monitoring of changes in CO<sub>2</sub> in aquaculture systems.

Continuous in situ monitoring of key water quality parameters including CO<sub>2</sub> reduces the burden of manual testing, maximizes the efficiency of degassing systems and water pumps, and allows for prompt alerts to adverse conditions.

## Dissolved CO<sub>2</sub> Sensors

Pro-Oceanus offers several ranges of pCO<sub>2</sub> sensors for use in aquaculture settings, including the Solu-Blu CO<sub>2</sub>, CO<sub>2</sub>-Pro FT and Mini CO<sub>2</sub>. Pro-Oceanus sensors utilize an advanced flat membrane technology that allows for the sensors to be continuously deployed for long periods of time. This leads to less equipment downtime and less maintenance, resulting in better reliability and lower cost of ownership.

The sensors can be standalone with internal logging and battery power, or can be easily integrated into automated systems with feedback control with 4-20mA, 0-5V and RS232 outputs. Flow-through and in-line adaptors are also available for simple integration into water circulation systems. The right equipment choice to keep fish happy and healthy is easy with consultation from Pro-Oceanus' Scientific Team.

Pro-Oceanus  
Solu-Blu CO<sub>2</sub> Sensor



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