APPLICATION NOTE A2.2:
Elevated Dissolved CO_2 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_2 problems. More commonly measured parameters, including oxygen, pH, and ammonia, 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

SOURCES OF CO_2 IN RECIRCULATING AQUACULTURE SYSTEMS

- Fish respiration as a source of CO_2 increases with increasing stocking densities
- Source water itself (especially well water) can contain high levels of CO_2.
- CO_2 production in the biofilter can make up a large percentage of total system CO_2 production.
- Changes in water temperature can lead to changes in solubility and lead to elevated CO_2 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_2, approximately 15 times atmospheric concentrations).

Increased CO_2 in water reduces the rate at which CO_2 from the fish's own metabolism can be released from the blood through the gills. CO_2 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 in done. In the long-term, exposure to high CO_2 concentrations can have a profound effect on the health of the fish.

High dissolved CO_2 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_2.

PRO OCEANUS

Dissolved Gas Sensors

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MEASUREMENT OF DISSOLVED CO_2

Measurement of dissolved CO_2 is an effective method of ensuring that concentrations are within a healthy range for fish. Each aquaculture system is unique, making continuous in situ dissovled 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, using a liquid indicator dye that is monitored spectrophotometrically, and in situ measurement via diffusion across a membrane into an infrared gaseous CO_2 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_2 sensors utilize infrared detection and provide continuous long-term in situ measurements that allow for real-time monitoring of changes in CO_2 in aquaculture systems.

Continuous in situ monitoring of key water quality parameters including CO_2 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_2 SENSORS

Pro-Oceanus offers several ranges of pCO_2 sensors for use in aquaculture settings, including the Solu-Blu CO_2, CO_2-Pro FT and Mini CO_2. 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_2 Sensor

PRO OCEANUS Dissolved Gas Sensors

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