Using Aquamonitrix® Real-Time Nitrite and Nitrite Monitor to Maximise Biomass Gain and Feed Conversion Efficiency in a New R&D Recirculating Aquaculture System (RAS)

Pictured: Dr Jamie Downes, Marine Institute

Introduction

In many ways, recirculating aquaculture systems (RAS) are no different from any other type of livestock farming. They share the aim of increasing biomass gain while protecting animal health and ensuring that product attributes such as taste, texture and appearance are within acceptable consumer parameters.

Too little nutrition and the producer fails to maximise growth potential. On the other hand, too much feed is wasteful. Not only that, but in an RAS system, it is counter-productive, due to the impact on water quality.

This is, of course, where an RAS diverges from a conventional farm. If the load from uneaten feed or increased excretion exceeds the design capacity of the RAS, the bacteria that power the biofilter will become overwhelmed and struggle to complete the two-step process of converting ammonia to nitrite and, in turn, to less harmful nitrate. Mass mortalities as a result of toxic ammonia or nitrite poisoning are the worst-case scenario. But even a small deterioration in water quality may stop the fish from feeding – or reduce the feed rate. Equally, mitigation strategies, such as water exchange, to restore water quality will introduce a sharp shock to the system, with a similar potential to impact on feeding.

Background

On the understanding that a stable ambient environment – without too many shocks to the system – supports healthy, hungry fish, an RAS facility on Ireland's Atlantic coast is using real-time nitrite and nitrite monitoring to ensure the biofilter is operating correctly at all times and achieving complete conversion to nitrate.

The monitoring is being carried out using an Aquamonitrix® real-time nitrite and nitrate analyser, with the aim of achieving that 'sweet spot' where feed rates and water quality are optimised, so that the fish are feeding well and achieving maximum feed conversion efficiencies.

The RAS, located close to Clew Bay on the Atlantic coast, is operated by the Marine Institute – Ireland's state agency for marine research and development. The system comprises eight x 5.5 cubic-meter tanks, with a total capacity to produce up to 12,000 Atlantic salmon pre-smolts.

Marine Institute RAS facility on Ireland's West Coast

The facility was developed for collaborative research between academic, public sector and industry partners. Currently, the RAS environment is being used in a project aimed at producing larger and more robust pre-smolts than conventional flow-through systems while adhering to organic salmon production standards.

Organic certification is required as all Atlantic salmon produced in Ireland are geared towards the organic market.

"The aim is to reduce the length of time that farmed Atlantic salmon spend at sea so we can maximise Ireland's limited offshore licensed capacity," explains Dr Jamie Downes, who heads the project.

Lehanagh Pool Marine Research Site

The Marine Institute also operates a 21.7 hectare off-shore integrated multi-trophic aquaculture research site, with capacity for six 50m-circular fish pens. So, it will be possible to continue monitoring the fate of smolt following their transfer to sea.

Real-time nitrite and nitrate monitoring

Aquamonitrix® has been used for real-time nitrite and nitrite monitoring in the Institute's RAS facility since the start-up, allowing the team to test the tolerances of the biofilter and optimise conditions.

"During the first couple of weeks, we wanted to ensure that the bacterial communities were establishing and the biofilter was operating correctly – that the toxic ammonia was being broken down to nitrite and then nitrate. Now, on an ongoing basis, we are using the analyser to manage water quality in the system to optimise the feed conversion rate," Dr Downes explains.

A new breed of analyser

The current standard within the RAS sector is to perform nitrite analysis by spectrophotometry – a technique that requires time-consuming sample preparation in the laboratory, using hazardous reagents to create a colorimetric reaction.

While some autonomous analysers are marketed for nitrite measurement, their applicability is limited in real-world aquaculture systems, because the turbid environment, presence of organics and high nitrate concentrations can cause interference and undermine instrument reliability.

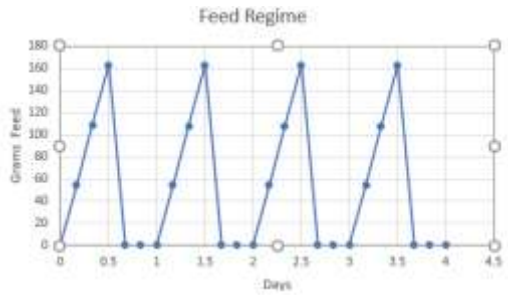
Aquamonitrix® overcomes these challenges by combining the separation capabilities of ion chromatography with UV-LED detection. This allows for a highly specific and accurate reading of nitrite, even when nitrate concentrations are high. The column also acts as a 'trap' for colour, organics and air bubbles, which can adversely affect the performance of conventional analysers based on ISE, colorimetric or standard UV / UV-LED methods.

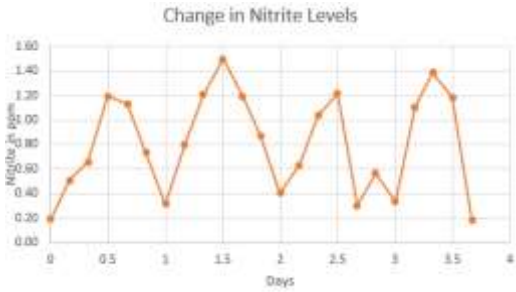
Aquamonitrix® real-time nitrite and nitrate analyser

Benefits for RAS operation

One of the obvious boons of automated nitrite and nitrate monitoring is the potential to reduce the need for analytical chemists and laboratory time. Aquamonitrix® is easy to set up, operate and service, with minimal intervention requirements and long intervals between services.

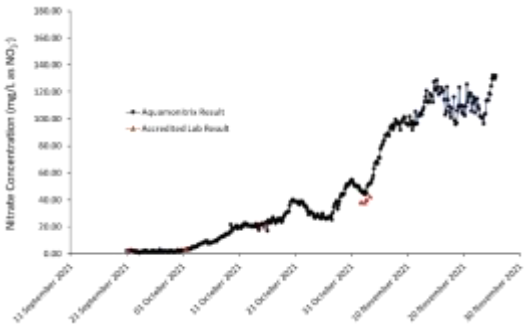
However, the bigger game-changer is the higher temporal resolution of data and the availability of results in real-time. "We can observe the fluctuations in nitrite levels corresponding with feed input throughout the day," Jamie says. "Feeding starts at 8.30 am every day, with 20.4 grams added to the system every 90 seconds for 12 hours. Once feeding starts in the morning, you see a build-up in nitrite throughout the day as the fish feed and metabolise the food. Then overnight, the bacteria break this down to nitrate."





Graphs 1 & 2 (above): Nitrite levels follow a daily cycle, closely tracking the feeding regime

"That is the daily cycle. Over time, we can also see the nitrate increase as it accumulated in the system with the increasing fish biomass. We use this to determine our water exchange rates," Dr Downes says.



Graph 3: Over time, accumulated nitrate levels have increased with biomass gain (See graph 4 below).

Graph 4: Biomass gain over time

It is also interesting to see the close correlation between biomass gain and total feed input (See graph 5 below). This indicates very effficient feed conversion, as would be typical in salmon species. But it also underscores the stress-free, high water-quality environment that the Marine Institute's pre-smolts have enjoyed.

Graph 5: Total feed input

User-friendly interface

"For us, the user interface is excellent," Dr Downes adds. "I can log in remotely and look at the nitrate and nitrite levels any time, day or night. This informs our operation strategy – whether nitrite peaks at an acceptable level, or we have reached the limits of the biofilter, or we need to increase our water exchange rate.

Datamonitrix user interface,

The Datamonitrix user interface, accessible via PC, allows users to store & analyse data; assign users and email distribution lists; set up alerts and alarms, and receive analyser self-diagnosis warnings

In terms of the overall benefits of Aquamonitrix®, Dr Downes says: "It has allowed us to be really on-point with our water quality. By the end of the year, we expect the RAS salmon to have achieved double the weight gain of their counterparts outdoors."

For further information

For further information about Aquamonitrix® in Aquaculture and RAS environments

Visit our website

Or contact us at info@aquamonitrix.com

For further information about the RAS facility in Newport, County Mayo, visit the Irish Marine Institute website

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