COMPLETED PROJECT CASE STUDY

TRANSFORMING FISH HEALTH MANAGEMENT IN AQUACULTURE: A HIGH-THROUGHPUT, NON-LETHAL DIAGNOSTIC APPROACH

PARTNERS

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BACKGROUND

One of the aquaculture sector's highest priorities is to monitor and maintain fish health, which is critical for ensuring the sustainability and profitability of fish farming. Traditional methods of assessing fish health often involve lethal sampling, which is unsuitable for large-scale operations. To address this issue, a novel diagnostic approach was developed using high-throughput instrumentation, allowing rapid, non-lethal, and holistic assessments of fish health for the first time. This case study explores the development and validation of this approach, focusing on establishing baseline levels of 22 biomarkers in salmonid fish – a requirement for the early indication of health issues – and its implications for the aquaculture industry.

This project was a collaboration between Kames – Scotland's oldest family-run trout farming business – and the University of the West of Scotland, which hosts a research team investigating new diagnostic tools for fish health assessment in aquaculture. Other industry participants include Mowi Scotland (formerly Marine Harvest), Randox Food Diagnostics, and Europharma.

AIMS

The primary aims of this project were threefold:

1. To repurpose and validate existing medical diagnostic techniques for assessing the health of salmonid fish in aquaculture operations;
2. To establish baseline levels of selected clinical chemistry endpoints in Rainbow trout (Oncorhynchus mykiss) and Atlantic salmon (Salmo salar) over 12 months;
3. To measure the chronic impact of various sea lice treatments on these fish species and correlate findings with existing behavioural endpoints and immunodeficiency metrics to optimise sea lice treatment protocols.

PROJECT

Twenty-two biomarkers were identified by project partners, representing diagnostic significance for liver function, kidney function, muscle damage, osmoregulation and gill function, to name a few.

One of the main challenges in developing clinical chemistry-based diagnostic techniques for fish health assessment has been the variability in biomarker expression and the lack of established baseline levels for comparison. To overcome these obstacles, large sample numbers were provided by project partners, and a semi-automated, high-throughput clinical chemistry analyser was employed. This technology enabled the analysis of extensive samples, facilitating the establishment of reliable baseline biomarker levels.

Considerable effort was devoted to standardising the methodology for collecting blood from the fish, processing the blood for serum collection, transporting samples, and storing samples within the lab. Consequently, a series of protocols were developed to produce more consistent samples for biochemical analysis.

Samples were collected following chemical treatment with Alphamax (deltamethrin) and Salmosan (Azamethiphos), freshwater treatment, and physical treatment with Hydrolicer and Thermolicer systems for salmon and trout.

Using existing technology in this approach ensured no intellectual property (IP) issues related to the instrumentation. However, the data generated from the project represented valuable IP and was covered under a project agreement. The diagnostic approach developed during this project has been widely embraced by the industry. Building on the project's success, plans emerged to establish a commercial fish diagnostic laboratory, potentially through a university spin-out company under the Scottish Enterprise High Potential Spinout Programme. These plans have since materialised into the internationally successful business Wellfish Tech, which at the time of writing employs 17 professionals located in Scotland, Norway and North America.

RESULTS

The project not only met but exceeded its main objectives, yielding two significant outcomes:

1. The development of a biomarker database: Over 11 months, baseline levels for 22 clinical biomarkers were established for both Atlantic salmon and Rainbow trout. This database allows for biomarker-level comparison in fish suffering from health issues against normal ranges, facilitating the early detection of health problems before they result in organ or tissue injury. This advancement is crucial for integrating high-throughput biomarker approaches into routine health assessments.

Biomarker analysis on the samples taken post-chemical treatment demonstrated the detection of tissue damage caused by severe haemolysis (Figure 1). Specifically, increases in biomarkers related to kidney function, such as bilirubin, haemoglobin, iron, creatinine, and phosphate, indicated the destruction of red blood cells.

2. Impact on fish husbandry practices: The data generated on the impact of sea lice treatment revealed a significant health decline in fish 10 days post-treatment. This finding prompted partners to adjust protocols, increasing the recovery time between exposures. This change not only improves fish welfare but also has economic benefits, as healthier fish are less likely to succumb to infection.

IMPACT

This work resulted in substantial impacts and its success has paved the way for several new initiatives, including an application for Knowledge Transfer Partnership (KTP) to implement the developed diagnostic approach into a new fish health strategy at Kames Fish Farming Ltd.

Another impact includes a grant from SAIC to investigate the causes of impaired growth in Rainbow trout, incorporating information on broodstock, genetics, husbandry, life cycle, anatomy, physiology and biochemistry to develop nutritional solutions.

This project has also led to a research grant from the British Biological Sciences Research Council (BBSRC) to develop high-throughput immunology and haematology techniques for fish health assessment, focusing on diagnosing anaemia in salmon for better understanding of the disease, rapid diagnosis, and increased fish welfare.

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