COMPLETED PROJECT CASE STUDY

BIOMARKERS FOR EARLY DISEASE DETECTION IN SCOTTISH SALMON

PARTNERS

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BACKGROUND

Salmon aquaculture is pivotal in Scotland's rural economy and contributes to the nation's food exports. Scotland is the largest producer of farmed salmon in the European Union and ranks third globally, behind Norway and Chile.

Health monitoring in farmed salmon populations is not only vital for animal welfare but also for maintaining economic viability and public trust. Early and accurate detection of diseases allows farmers to intervene promptly, enhancing survival rates, limiting the spread of infection, and minimising the use of antibiotics.

This project was led by the University of the West of Scotland (UWS), with research support from the University of Aberdeen and Bakkafrost Scotland. UWS collaborated with Environment Canada on nanogold sensor research and the University of Waterloo (Canada) on multiplex immunoassays.

AIMS

The project aimed to develop innovative, high-throughput, and cost-effective diagnostic tools to improve health monitoring in Atlantic salmon, particularly on immunoturbidimetric assays for identifying biomarkers indicative of bacterial and viral infections. By leveraging automated analysers, the project sought to create a platform for efficient, large-scale fish health surveillance.

Key objectives included optimising antibody-based assays for high specificity, sensitivity, and reproducibility, transitioning existing enzyme-linked immunosorbent assays (ELISAs) to automated turbidimetric formats, and validating these new methods using serum samples from both health-challenged and experimentally infected salmon.

INVESTIGATING IMMUNE BIOMARKERS IN SALMON

The research centred on developing salmon-specific turbidimetric assays compatible with high-throughput automated instrumentation. Building on prior work from the feasibility study, four promising immune biomarkers in Atlantic salmon were selected for further investigation, including acute phase proteins and muscle biomarkers. These biomarkers reflect the salmon's immune response to the most prevalent pathogens in the Scottish industry and had previously been validated using ELISA formats with serum from challenged fish.

The broader goal was to transition these ELISA-based assays onto a turbidimetric immunoassay platform to create a robust, scalable system capable of differentiating between pathogen types. By assessing multiple immunological markers, the system aimed to distinguish infection-driven responses from stressors such as handling, nutritional deficiencies, or environmental conditions.

However, access restrictions to laboratory instruments created a significant barrier, prompting a shift in strategy. While the project's goals remained unchanged, the team adapted by exploring alternative detection platforms and innovative methods for early disease detection.

These alternative approaches included a plate-based assay using gold nanoparticles (AuNPs) for rapid immunoglobulin M (IgM) detection, a nitric oxide (NO) assay based on the Griess reagent for measuring oxidative stress, and a lateral flow immunoassay (LFIA) using IgM antibodies for rapid on-site testing.

RESULTS

The project delivered several innovations that could significantly enhance salmon health monitoring through biomarker detection.

Among the most promising outcomes was the development of the plate-based assay employing nanogold sensors. This approach was followed by lateral flow testing, offering a practical, cost-effective diagnostic solution for field use. While the lateral flow format has lower sensitivity than the plate-based assays, ongoing refinements, such as quantifying band intensity, could increase its effectiveness in detecting early-stage infections. In parallel, the plate-based assay proved highly quantitative and specific, making it well-suited for biomarker detection.

Notably, the project validated the use of troponins as biomarkers of salmon health, marking a major milestone in non-invasive health monitoring. Validation work is also progressing on haptoglobin as an additional biomarker, further expanding the toolkit for disease management in aquaculture.

The Griess reagent was successfully applied to assess nitric oxide levels, an important oxidative stress indicator. This provided new insights into the inflammatory responses in salmon, contributing to a more holistic understanding of fish health. Meanwhile, a Luminex-based multiplex immunoassay, capable of detecting multiple biomarkers in a single assay, is being developed to offer an efficient and scalable solution for comprehensive health assessments.

IMPACT

This project has deepened our understanding of salmon immune responses and led to the development of novel diagnostic tools that will improve early disease detection and health management in aquaculture settings. The focus on biomarkers such as IgM and troponins has enabled the detection of bacterial and viral infections with greater accuracy and efficiency.

The validation of troponin biomarkers is nearly complete, with plans to introduce them as a commercial diagnostic product in 2025. Efforts to validate haptoglobin continue, promising to enrich the range of available health indicators further.

Lateral flow tests offer a promising route to rapid, on-site diagnostics that are both affordable and scalable. This technology could benefit producers needing immediate feedback to guide disease control measures. These tools not only support farm-level management but also contribute to broader goals of seafood sustainability and biosecurity.

Through this work, the project team has established a strong foundation for future growth, commercialisation, and collaborative innovation. The diagnostic tools and methodologies developed here offer practical benefits for Scotland’s salmon farming industry and lay the groundwork for smarter, more sustainable aquaculture worldwide.

FURTHER READING

Visit the case study page on the Seafood Innovation Fund website.