Safeguarding Salmon: *Tackling Health Challenges in a Growing Aquaculture Industry*

As the global demand for seafood continues to rise, aquaculture has emerged as a vital contributor to food security and economic development. Among the most valuable aquaculture species is the Atlantic salmon, with Scotland alone producing over 205,000 tons annually (source Scottish Government Marine Directorate). However, the rapid expansion of salmon farming has brought with it a host of health and welfare challenges. Infectious diseases, environmental stressors, and the limitations of traditional treatment methods threaten both fish welfare and industry sustainability.

This article explores the most pressing health issues affecting farmed salmon, the innovative solutions being developed, and the future directions for research and industry collaboration.

The Health and Welfare Landscape in Salmon Aquaculture
Fish health is a cornerstone of aquaculture success. It directly influences productivity, profitability, and animal welfare. However, the intensification of farming practices has increased the prevalence and impact of infectious diseases. Bacterial, viral, fungal, and parasitic pathogens are estimated to cause annual losses of 5–7% in finfish aquaculture, equating to approximately 10 billion USD globally.

Alongside 'traditional,' diseases of farmed salmon, such as (but not limited to) sea lice infection, Piscine Myocarditis Virus (PMCV) and Amoebic Gill Disease (AGD), environmental changes such as rising sea temperatures and shifts in ocean chemistry further exacerbate disease risks by creating favourable conditions for opportunistic pathogens. Among these, micro jellyfish and other gelatinous zooplankton have emerged as significant contributors to gill disease, a condition that compromises respiratory function and overall fish health.

With a move away from using chemical treatments to protect against environmental damage and antimicrobial resistance, research is focusing on alternative methods of disease control and monitoring.

The aquaculture industry is increasingly focused on non-invasive health and welfare monitoring. Technologies such as remote sensing, machine vision, and biosensors are being explored to detect early signs of stress or disease without handling the fish.

In terms of disease control vaccine development is key, however in parallel alternative solutions such as functional feeds, probiotics, and selective breeding are gaining traction. These approaches aim to enhance the innate immunity of fish and reduce reliance on pharmaceuticals.

Vaccination as a Preventive Strategy
Vaccines are a cornerstone of disease prevention in aquaculture. They offer a proactive approach to health management, reducing the need for antibiotics and chemicals, which can contribute to antimicrobial resistance and environmental degradation. Effective vaccines must provide long-term protection with minimal side effects and be cost-effective to produce and administer. Factors such as fish species, life stage, pathogen serotype, and route of administration all influence vaccine design.

Vaccines for aquatic species have seen significant advancement, with commercial options now available for approximately 30 different bacterial and viral pathogens, the majority are tailored for salmon and trout. Multivalent vaccines, formulations that protect against multiple diseases are commonly used. Moreover, there is growing innovation in vaccines for marine fish such as European sea bass, sea bream, turbot, halibut, yellowtail, and grouper. In parallel, numerous vaccines are under development to address a broader range of pathogens and fish species, signalling

continued growth in this important field of aquaculture health.

Vaccination in aquaculture offers a range of benefits that extend beyond individual fish health. By curbing disease transmission, vaccines help protect both vaccinated and non-vaccinated populations, leading to overall lower infection rates. This reduction in disease-related losses directly boosts farm profitability, as fewer fish succumb to illness and productivity increases. With a shift toward preventive strategies rather than reactive treatments, farms can better manage health outcomes while enhancing animal welfare. Additionally, reliance on antibiotics and chemicals diminishes, which helps address the growing concern over antibiotic resistance. This more sustainable approach also translates into decreased environmental impact from aquaculture operations.

Experimental Disease Models: A Research Backbone

To test new treatments and preventive measures, researchers rely on robust experimental disease models. These models simulate real-world conditions and allow for the controlled study of pathogen-host interactions.

Experimental models play a vital role in advancing health surveillance, prevention, and treatment strategies. They are also vital in the development and testing of new vaccines and novel vaccine technologies, as well as for marker-led breeding programs aimed at genetic improvement and disease resistance. They can also be used to evaluate functional feeds and dietary interventions that enhance immunity and overall health as well as validating new medicines and the efficacy of feed and water additives.

A Path Forward for Sustainable Aquaculture

The future of salmon aquaculture hinges on the industry's ability to manage health and welfare challenges effectively. Vaccines represent a major area of growth, offering a sustainable alternative to antibiotics and chemicals. However, their success depends on continued investment in research, innovation, and collaboration between academia, industry, and regulatory bodies.

By embracing advanced disease models, novel vaccine technologies, and holistic welfare strategies, the aquaculture sector can safeguard fish health, protect the environment, and ensure long-term profitability.

As the sector evolves, so too must our approaches to fish health – balancing scientific rigor with practical application to meet the demands of a growing global population.

Moredun Scientific is a contract research organisation that specialises in the use of experimental disease models for the uses described above. They have a range of established experimental models and regularly work towards developing new models.

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